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DOCKET
08-AFC-2
DATE MAR 18 2010
RECD. MAR 22 2010

March 18, 2010

Via Overnight Mail

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 08-AFC-2
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

Re: Application for Certification, Beacon Solar Energy Project, 08-AFC-2

Dear Docket Clerk:

Enclosed are an original of CALIFORNIA UNIONS FOR RELIABLE ENERGY THIRD AMENDED SEQUENTIAL LIST AND ADDITIONAL EXHIBITS, one paper copy of Exhibits 638 through 656, and 2 CDs containing Exhibits 638 through 656. Please process the documents and return a conformed copy of this letter in the envelope provided.

Thank you for your assistance with this matter.

Sincerely,

/s/

Tanya A. Gulesserian

TAG:bh
Enclosures

2162-086a

printed on recycled paper

STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the BEACON SOLAR ENERGY PROJECT	Docket No. 08-AFC-2

CALIFORNIA UNIONS FOR RELIABLE ENERGY THIRD AMENDED SEQUENTIAL LIST AND ADDITIONAL EXHIBITS

March 18, 2010

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Attorneys for the CALIFORNIA UNIONS FOR RELIABLE ENERGY

2162-085a

California Unions for Reliable Energy ("CURE") provides the attached third amended sequential exhibit list concerning the Beacon Solar Energy Project ("Project"). The third amended sequential list includes CURE Exhibits 638 through 656.

EXHIBIT NUMBER	DATE	DOCUMENT
638	11/9/09	Office of the Governor for the State of California, 2009 Comprehensive Water Package Special Session Policy Bills and Bond Summary and Laurain Declaration
639		Office of the Governor for the State of California, Fact Sheet, Governor Calls for Comprehensive Plan to Fix California's Water Crisis and Laurain Declaration
640	1999	Hailey J, and D Bainbridge. 1999. Desert Restoration: Do something or wait a thousand years? [abstract] Mojave Desert Science Symposium; 1999 Feb 25-27, Las Vegas. USGS, Western Ecological Research Center [internet]
641	2009	US Fish and Wildlife Service. 2009. Preparing for any action that may occur within the range of the Mojave desert tortoise (*Gopherus agassizii*)
642	1992	US Fish and Wildlife Service. 1992. Field survey protocol for any non-federal action that may occur within the range of the desert tortoise
643	2006	Boarman WI, WB Kristan. 2006. Evaluation of Evidence Supporting the Effectiveness of Desert Tortoise Recovery Actions. Scientific Investigations Report 2006-5143. US Geological Survey, Sacramento (CA)
644	2002	Boarman WI. 2002. Threats to Desert Tortoise Populations: A Critical Review of the Literature. U.S. Geological Survey, Western Ecological Research Center. Sacramento (CA)

645	1986	Schamberger ML, FB Turner. 1986. The application of habitat modeling to the desert tortoise (*Gopherus agassizii*)
646	2003	Klute DS, LW Ayers, MT Green, WH Howe, SL Jones, JA Shaffer, SR Sheffield, TS Zimmerman. 2003. Status assessment and conservation plan for the western Burrowing Owl in the United States. Bio Tech Pub FWS/BTP-R6001-2003. Washington: US Fish and Wildlife
647	6/1994	Desert Tortoise (Mojave Population) Recovery Plan, U.S. Fish & Wildlife Service
648	4/7/03	Petition to the State of California Fish and Game Commission and Supporting Information for Listing the California Population of the Western Burrowing Owl (Athene Cunicularia Hypugaea) as an Endangered or Threatened Species Under the California Endangered Species Act
649	2004 6/2005	Home-Range Size and Use of Space by Adult Mohave Ground Squirrels, Spemophilus Mohavensis, John H. Harris and Philip Leitner, Journal of Mammalogy 2004; Long-Distance Movements of Juvenile Mohave Ground Squirrels, Spermophilus Mohavensis, John H. Harris and Philip Leitner, the Southwestern Naturalist, June 2005
650	1972	Hoyt DF. 1972. Mohave Ground Squirrel Survey. California Department of Fish and Game. Sacramento (CA): Special Wildlife Investigations Report
651	6/2/01	CNPS Botanical Survey Guidelines, California Native Plant Society
652		Current Status of the Mohave Ground Squirrel, Philip Leitner
653	3/17/10	Declaration of Michael A. Bias Regarding Exhibits 640-652

654	3/17/10	Los Angeles Department of Water and Power's website for the Barren Ridge Renewable Transmission Project and Marcus Declaration
655	3/17/10	Email from Sudath Edirisuriya to Tanya Gulesserian and Marcus Declaration
656	8/21/09	Edwards Air Force Base Request for Environmental Analysis and Laurain Declaration

CURE intends to offer Exhibits 638 through 656 and declarations into evidence.

Dated: March 18, 2009

Respectfully submitted,

_____/s/_____

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STATE OF CALIFORNIA

Energy Resources Conservation and Development Commission

In the Matter of: The Application for Certification for the BEACON SOLAR ENERGY PROJECT	Docket No. 08-AFC-2

PROOF OF SERVICE

I, Bonnie Heeley, declare that on March 18, 2010 I served and filed copies of the attached **CALIFORNIA UNIONS FOR RELIABLE ENERGY THIRD AMENDED SEQUENTIAL LIST AND ADDITIONAL EXHIBITS** The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at www.energy.ca.gov/sitingcases/beacon. The document has been sent to both the other parties in this proceeding as shown on the Proof of Service list and to the Commission's Docket Unit via overnight mail addressed as provided on the Proof of Service. An original paper copy and one electronic copy, together with a CD, were sent via overnight mail to the Docket Office.

I declare under penalty of perjury that the foregoing is true and correct. Executed at South San Francisco, CA on March 18, 2010.

_____/s/_____
Bonnie Heeley

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STATE OF CALIFORNIA
California Energy Commission

In the Matter of:

The Application for Certification for the BEACON SOLAR ENERGY PROJECT

Docket No. 08-AFC-2

THIRD AMENDED
CALIFORNIA UNIONS FOR RELIABLE ENERGY
SEQUENTIAL EXHIBIT LIST

Exhibit No.	Date	Title	Subject	Sponsor
600	11/12/2009	Testimony of Scott Cashen On Biological Resources	Biological Resources	Scott Cashen
601	11/11/2009	Declaration of Scott Cashen	Biological Resources	Scott Cashen
602	11/12/2009	Exhibit 1: Resume of Scott Cashen	Biological Resources	Scott Cashen
603	2003	Exhibit 2: California Department of Fish and Game. Mohave ground squirrel survey guidelines.	Biological Resources	Scott Cashen
604	1993	Exhibit 3: Gustafson JR, State of California, Department of Fish and Game. A status review of the Mohave ground squirrel.	Biological Resources	Scott Cashen
605	5/21/2008	Exhibit 4: Conference Call Agenda for May 21, 2008, BSEP CEC Proceeding 08-AFC-2.	Biological Resources	Scott Cashen
606	02/2008	Exhibit 5: AFC, Bio Tech Report: Figure 11	Biological Resources	Scott Cashen
607	1993	Exhibit 6: The California Burrowing Owl Consortium. Burrowing Owl Survey Protocol and Mitigation Guidelines	Biological Resources	Scott Cashen

608	1995	Exhibit 7: State of California, Department of Fish and Game. Staff Report on Burrowing Owl Mitigation	Biological Resources	Scott Cashen
609		Exhibit 8: AFC, Figure BR 78-1	Biological Resources	Scott Cashen
610	07/17/2009	Exhibit 9: Applicant's "Response to Select CURE Comments at CEC's Request"	Biological Resources	Scott Cashen
611	06/19/2008	Exhibit 10: Memorandum from the California Department of Fish and Game to California Energy Commission, Subject: Beacon Solar Energy Project Application for Certification	Biological Resources	Scott Cashen
612	11/12/2009	Testimony of Matt Hagemann on Soil Resources and Waste Management	Soil Resources and Waste Management	Matt Hagemann
613	11/12/2009	Declaration of Matt Hagemann	Soil Resources and Waste Management	Matt Hagemann
614	11/12/2009	Attachment 1: Resume of Matt Hagemann	Soil Resources and Waste Management	Matt Hagemann
615	1987-2008	Attachment 2: Spill Reports – SEGS III - VII	Soil Resources and Waste Management	Matt Hagemann
616	11/12/2009	Testimony of David Marcus on Transmission Engineering and Water Resources and Alternatives	Water Resources, Alternatives, and Transmission Engineering	David Marcus
617	11/10/2009	Declaration of David Marcus	Water Resources, Alternatives and Transmission Engineering	David Marcus
618	08/2009	Exhibit 1: Resume of David Marcus	Water Resources, Alternatives, and Transmission Engineering	David Marcus

619	2009	Exhibit 2: LADWP Barren Ridge Renewable Transmission Project	Transmission Engineering	David Marcus
620		Exhibit 3: Projection Engineering Statement of Qualifications	Transmission Engineering	David Marcus
621		Exhibit 4: NRG SCE Filing	Transmission Engineering	David Marcus
622	11/11/2009	Exhibit 5: CEC List of Siting Cases	Transmission Engineering	David Marcus
623	02/01/2008	Exhibit 6: WorleyParsons: FPLE – Beacon Solar Energy Project Dry Cooling Evaluation	Water Resources and Alternatives	David Marcus
624	06/2009	Exhibit 7: CPUC 33% Renewables Portfolio Standard Implementation Analysis Preliminary Results	Water Resources and Alternatives	David Marcus
625	3/8/10	Rebuttal Testimony of Matt Hagemann on Hazardous Materials and Waste Management	Hazardous Materials and Waste Management	Matt Hagemann
626	3/8/10	Declaration of Matt Hagemann	Hazardous Materials and Waste Management	Matt Hagemann
627	2/23/09	Attachment 1: Hazardous Materials Business Plan, February 23, 2009, Luz Solar Partners, III-VII.	Hazardous Materials and Waste Management	Matt Hagemann
628	5/16/09	Attachment 2: Material Safety Data Sheet for Therminol VP-1, May 16, 2009	Hazardous Materials and Waste Management	Matt Hagemann
629	11/1/05	Attachment 3: Letter from FPL Energy to RWQCB re: SEGS III HTF spill, October 21, 2005	Hazardous Materials and Waste Management	Matt Hagemann
630	10/25/05	Attachment 4: Notice of Violation, Issued by San Bernardino County Fire Department to FPL Energy	Hazardous Materials and Waste Management	Matt Hagemann

631	1/30/06 6/10/08	Attachment 5: Recyclable Materials Reports, FPL Energy to San Bernardino County Fire Department, 2004-2005 and 2006-2007	Hazardous Materials and Waste Management	Matt Hagemann
632	3/8/10	Rebuttal Testimony of Michael A. Bias on Biological Resources	Biological Resources	Michael A. Bias
633	3/8/10	Declaration of Michael A. Bias	Biological Resources	Michael A. Bias
634	3/8/10	Adopted Declaration	Biological Resources	Michael A. Bias
635	3/8/10	Exhibit 1: Resume of Michael A. Bias	Biological Resources	Michael A. Bias
636	10/22/09	BESP FSA Soil and Water Resources and Alternatives	Water Resources and Alternatives	David Marcus
637	10/22/09	BESP FSA Alternatives Confidential Appendix C [Confidential]	Alternatives	David Marcus

ADDITIONAL EXHIBITS AND DECLARATIONS

638	11/9/09	Office of the Governor for the State of California, 2009 Comprehensive Water Package Special Session Policy Bills and Bond Summary and Laurain Declaration
639		Office of the Governor for the State of California, Fact Sheet, Governor Calls for Comprehensive Plan to Fix California's Water Crisis and Laurain Declaration
640	1999	Hailey J, and D Bainbridge. 1999. Desert Restoration: Do something or wait a thousand years? [abstract] Mojave Desert Science Symposium; 1999 Feb 25-27, Las Vegas. USGS, Western Ecological Research Center [internet]
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646	2003	Klute DS, LW Ayers, MT Green, WH Howe, SL Jones, JA Shaffer, SR Sheffield, TS Zimmerman. 2003. Status assessment and conservation plan for the western Burrowing Owl in the United States. Bio Tech Pub FWS/BTP-R6001-2003. Washington: US Fish and Wildlife
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STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the BEACON SOLAR ENERGY PROJECT	Docket No. 08-AFC-2

CALIFORNIA UNIONS FOR RELIABLE ENERGY EXHIBITS 657 and 658

March 18, 2010

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California Unions for Reliable Energy ("CURE") identifies the following additional Exhibits that CURE intends to offer into evidence for the Beacon Solar Energy Project ("Project").

Exhibit 657: Rosamond Community Services District Letter of Intent dated August 14, 2009 and posted August 20, 2009 available at: http://www.energy.ca.gov/sitingcases/beacon/documents/other/2009-09-14)_Revised_Rosamond_Commnty_Servcs_Dist_Letter_of_Intent_TN-53088.PDF

Exhibit 658: California City Recycled Water Supply Proposal dated and posted August 13, 2009 available at: http://www.energy.ca.gov/sitingcases/beacon/documents/other/2009-08-13_California_City_Recycled_Water_Supply_Proposal_NT-52865.PDF

CURE reserves the right to supplement its exhibit list with additional documents, analyses and other information at any time up to and including the close of the evidentiary hearings.

Dated: March 18, 2010

Respectfully submitted,

_____/s/_____

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Attorneys for the CALIFORNIA UNIONS FOR RELIABLE ENERGY

STATE OF CALIFORNIA

Energy Resources Conservation and Development Commission

In the Matter of: The Application for Certification for the BEACON SOLAR ENERGY PROJECT	Docket No. 08-AFC-2

PROOF OF SERVICE

I, Bonnie Heeley, declare that on March 18, 2010 I served and filed copies of the attached

CALIFORNIA UNIONS FOR RELIABLE ENERGY
EXHIBITS 657 and 658

The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at www.energy.ca.gov/sitingcases/beacon. The document has been sent to both the other parties in this proceeding as shown on the Proof of Service list and to the Commission's Docket Unit via email and by U.S. Mail with first-class postage thereon, fully prepaid and addressed as provided on the Proof of Service list to those addresses NOT marked "email preferred." An original paper copy and one electronic copy, mailed and emailed respectively, was sent to the Docket Office.

I declare under penalty of perjury that the foregoing is true and correct. Executed at South San Francisco, CA on March 18, 2010.

_____/s/_____
Bonnie Heeley

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EXHIBIT 638

Water Management:
Protecting California's Water Supply

2009 Comprehensive Water Package

11/9/2009

2009 Comprehensive Water Package
Special Session Policy Bills and Bond Summary

November 2009

California Department of Water Resources

Governor Schwarzenegger and state lawmakers successfully crafted a plan to meet California's growing water challenges. A comprehensive deal was agreed to, representing major steps towards ensuring a reliable water supply for future generations, as well as restoring the Sacramento-San Joaquin Delta and other ecologically sensitive areas.
The plan is comprised of four policy bills and an $11.14 billion bond. The package establishes a Delta Stewardship Council, sets ambitious water conservation policy, ensures better groundwater monitoring, and provides funds for the State Water Resources Control Board for increased enforcement of illegal water diversions. The bond will fund, with local cost-sharing, drought relief, water supply reliability, Delta sustainability, statewide water system operational improvements, conservation and watershed protection, groundwater protection, and water recycling and water conservation programs.

Senate Bill No. 1
Delta Governance / Delta Plan

SB 1 establishes the framework to achieve the co-equal goals of providing a more reliable water supply to California and restoring and enhancing the Delta ecosystem. The co-equal goals will be achieved in a manner that protects the unique cultural, recreational, natural resource, and agricultural values of the Delta. Specifically, this bill:

- Creates the Delta Stewardship Council, consisting of seven members with diverse expertise providing a broad statewide perspective. The Chairperson of the Delta Protection Commission is a permanent member of the Council. The Council is also tasked with:
  - Developing a Delta Plan to guide state and local actions in the Delta in a manner that furthers the co-equal goals of Delta restoration and water supply reliability;
  - Developing performance measures for the assessment and tracking of progress and changes to the health of the Delta ecosystem, fisheries, and water supply reliability;
  - Determining if a state or local agency's project in the Delta is consistent with the Delta Plan and the co-equal goals, and acting as the appellate body in the event of a claim that such a project is inconsistent with the goals; and
  - Determining the consistency of the Bay-Delta Conservation Plan (BDCP) with the co-equal goals.
- Ensures that the Department of Fish and Game and the State Water Resources Control Board identify the water supply needs of the Delta estuary for use in determining the appropriate water diversion amounts associated with BDCP

2009 Comprehensive Water Plan

RELATED CONTENT:

11/17/2009
Department of Water Resources Director Lester Snow Holds Web Discussion

10/22/2009
Gov. Schwarzenegger Speaks at Southern California Water Committee's 25th Annual Meeting

9/2/2009
Gov. Schwarzenegger Sends Letter Demanding Obama Administration to Intervene in Water Crisis

8/28/2009
Governor Schwarzenegger Issues Statement on Federal Board's Assistance to Fresno Drought Victims

8/24/2009
Gov. Schwarzenegger Breaks Ground on Critical Flood Safety Project in Sutter County

8/18/2009
Gov. Schwarzenegger Sends Letter to Democrat Leaders Urging Comprehensive Water Reform

8/4/2009
Governor Schwarzenegger Issues Statement on Democratic Water Proposal

Archive

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- Establishes the Sacramento-San Joaquin Delta Conservancy to implement ecosystem restoration activities within the Delta. In addition to the restoration duties the Conservancy is required to:
  - Adopt a strategic plan for implementation of the Conservancy goals;
  - Promote economic vitality in the Delta through increased tourism and the promotion of Delta legacy communities;
  - Promote environmental education about, and the public use of, public lands in the Delta; and
  - Assist in the preservation, conservation, and restoration of the region's agricultural, cultural, historic, and living resources.
- Restructures the current Delta Protection Commission (DPC), reducing the membership from 23 to 15 members, and tasks DPC with the duties of:
  - Adopting an economic sustainability plan for the Delta, which is to include flood protection recommendations to state and local agencies;
  - Submitting the economic sustainability plan to the Delta Stewardship Council for inclusion in the Delta Plan.
- Appropriates funding from Proposition 84 to fund the Two-Gates Fish Protection Demonstration Program, a project in the central Delta which will utilize operable gates for protection of sensitive species and management of water supply.

Senate Bill No. 6
Groundwater Monitoring

SB 6 requires, for the first time in California's history, that local agencies monitor the elevation of their groundwater basins to help better manage the resource during both normal water years and drought conditions. Specifically, this bill:

- Requires the Department of Water Resources (DWR) to establish a priority schedule for the monitoring of groundwater basins and the review of groundwater elevation reports, and to make recommendations to local entities to improve the monitoring programs.
- Requires DWR to assist local monitoring entities with compliance with this statute.
- Allows local entities to determine regionally how best to set up their groundwater monitoring program, crafting the program to meet their local circumstances.
- Provides landowners with protections from trespass by state or local entities.
- Provides that if the local agencies fail to implement a monitoring program and/or fail to provide the required reports, DWR may implement the groundwater monitoring program for that region.
- Provides that failure to implement a monitoring program will result in the loss of eligibility for state grant funds by the county and the agencies responsible for performing the monitoring duties.

Senate Bill No. 7
Statewide Water Conservation

SB 7 creates a framework for future planning and actions by urban and agricultural water suppliers to reduce California's water use. For the first time in California's history, this bill requires the development of agricultural water management plans and requires urban water agencies to reduce statewide per capita water consumption 20
percent by 2020. Specifically, this bill:

- Establishes multiple pathways for urban water suppliers to achieve the statewide goal of a 20 percent reduction in urban water use. Specifically, urban water suppliers may:
  - Set a conservation target of 80 percent of their baseline daily per capita water use;
  - Utilize performance standards for water use that are specific to indoor, landscape, and commercial, industrial and institutional uses;

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  - Meet the per capita water use goal for their specific hydrologic region as identified by DWR and other state agencies in the 20 percent by 2020 Water Conservation Plan; or
  - Use an alternate method that is to be developed by DWR before December 31, 2010.
- Requires urban water suppliers to set an interim urban water use target and meet that target by December 31, 2015 and meet the overall target by December 31, 2020.
- Requires DWR to cooperatively work with the California Urban Water Conservation Council to establish a task force that shall identify best management practices to assist the commercial, industrial and institutional sector in meeting the water conservation goal.
- Requires agricultural water suppliers to measure water deliveries and adopt a pricing structure for water customers based at least in part on quantity delivered, and, where technically and economically feasible, implement additional measures to improve efficiency.
- Requires agricultural water suppliers to submit Agricultural Water Management Plans beginning December 31, 2012 and include in those plans information relating to the water efficiency measures they have undertaken and are planning to undertake.
- Makes ineligible for state grant funding any urban or agricultural water supplier who is not in compliance with the requirements of this bill relating to water conservation and efficient water management.
- Requires DWR to, in 2013, 2016 and 2021, report to the Legislature on agricultural efficient water management practices being undertaken and reported in agricultural water management plans.
- Requires DWR, the State Water Resources Control Board, and other state agencies to develop a standardized water information reporting system to streamline water reporting required under the law.

Senate Bill No. 8
Water Diversion and Use / Funding

SB 8 improves accounting of the location and amounts of water being diverted by recasting and revising exemptions from the water diversion reporting requirements under current law. Additionally, this bill appropriates existing bond funds for various activities to benefit the Delta ecosystem and secure the reliability of the state's water supply, and to increase staffing at the State Water Resources Control Board to manage the duties of this statute. Specifically, this bill:

- Provides a stronger accounting of water diversion and use in the Delta by removing an exemption from reporting water use by in-Delta water users.
- Redefines the types of diversions that are exempt from the reporting requirement.
- Assesses civil liability and monetary penalties on diverters who fail to submit the required reports, and for willful misstatements, and/or tampering with monitoring equipment.
- Appropriates $546 million from Propositions 1E and 84, in the following manner:
  - $250 million (Proposition 84) for integrated regional water management grants and expenditures for projects to reduce dependence on the Delta;
  - $202 million ($32 million Proposition 84 and $170 million Proposition 1E) for flood protection projects in the Delta to reduce the risk of levee failures that would jeopardize water conveyance;
  - $70 million (Proposition 1E) for stormwater management grants; and
  - $24 million (Proposition 84) for grants to local agencies to develop or implement Natural Community Conservation plans.
- Appropriates $3.75 million from the Water Rights Fund to the State Water Resources Control Board for staff positions to manage the duties in this bill relating to water diversion reporting, monitoring and enforcement.

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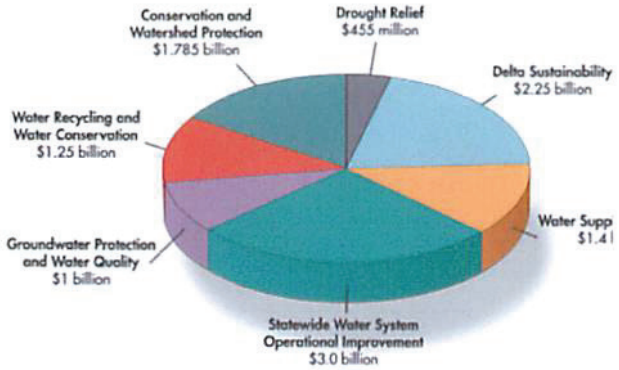
The Safe, Clean, and Reliable Drinking Water Supply Act of 2010 is an $11.14 billion general obligation bond proposal that would provide funding for California's aging water infrastructure and for projects and programs to address the ecosystem and water supply issues in California. The bond is comprised of seven categories, including drought relief, water supply reliability, Delta sustainability, statewide water system operational improvement, conservation and watershed protection, groundwater protection and water quality, and water recycling and water conservation.

Total: $11.14 billion



Drought Relief - $455 million. This funding will be available for local and regional drought relief projects that reduce the impacts of drought conditions, including the impacts of reductions to Delta diversions. Projects will include water conservation and water use efficiency projects, water recycling, groundwater cleanup and other water supply reliability projects including local surface water storage projects that provide emergency water supplies and water supply reliability in drought conditions. Funds will be available to disadvantaged communities and economically distressed areas experiencing economic impacts from the drought for drought relief projects and programs. Funds will also be available to improve wastewater treatment facilities to protect water quality or prevent contamination of surface water or groundwater resources.

Delta Sustainability - $2.25 billion. This bond will provide funds for projects to assist in maintaining and restoring the Delta as an important ecosystem. These investments will help to reduce the seismic risk to water supplies derived from the Delta, protect drinking water quality and reduce conflict between water management and environmental protection.

Water Supply Reliability - $1.4 billion. These funds would be in addition to prior funding provided by Proposition 50 and Proposition 84 and would support the existing Integrated Regional Water Management (IRWM) program. IRWM is designed to encourage integrated regional strategies for management of water resources that will protect communities from drought, protect and improve water quality and improve local water security by reducing dependence on imported water. The bond would provide funds for water supply projects in 12 regions throughout the state and would also be available for local and regional conveyance projects that support regional and interregional connectivity and water management.

North Coast	$45,000,000
San Francisco Bay	$132,000,000
Central Coast	$58,000,000
Los Angeles subregion	$198,000,000
Santa Ana subregion	$128,000,000
San Diego subregion	$87,000,000

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Sacramento River	$76,000,000
San Joaquin River	$64,000,000
Tulare/Kern	$70,000,000
North/South Lahontan	$51,000,000
Colorado River Basin	$47,000,000
Mountain Counties Overlay	$44,000,000
Interregional Projects	$50,000,000

Statewide Water System Operational Improvement - $3.0 billion. This funding would be dedicated to the development of additional water storage, which, when combined with other water management and flood system improvement investments being made, can increase reliability and offset the climate change impacts of reduced snow pack and higher flood flows. Eligible projects for this funding include surface storage projects identified in the CALFED Bay-Delta Record of Decision; groundwater storage projects and groundwater contamination prevention or remediation projects that provide water storage benefits; conjunctive use and reservoir reoperation projects; local and regional surface storage projects that improve the operation of water systems in the state and provide public benefits.

The bond provides that water suppliers who would benefit from new storage will pay their share of the total costs of the project while the public benefits of new water storage can be paid for by this general obligation bond.

Groundwater Protection and Water Quality - $1 billion. To protect public health, funds will be available for projects to prevent or reduce the contamination of groundwater that serves as a source of drinking water. Funds will also be used to finance emergency and urgent actions on behalf of disadvantaged communities and economically distressed areas to ensure that safe drinking water supplies are available to all Californians.

Water Recycling and Water Conservation - $1.25 billion. Funds will be available for water recycling and advanced treatment technology projects that recycle water or that remove salts and contaminants from water sources. Funds will also be available for urban and agricultural water conservation and water use efficiency plans, projects, and programs. These funds will assist urban water users in achieving water conservation targets.

Conservation and Watershed Protection - $1.785 billion. Funds will be available, through a 50-50 cost share program, for ecosystem and watershed protection and restoration projects in 21 watersheds throughout the state, including coastal protection, wildlife refuge enhancement, fuel treatment and forest restoration, fish passage improvement and obsolete dam removal.

Coastal counties and watersheds

Wildlife Conservation Board

San Gabriel and Lower Los Angeles River watersheds

Santa Monica Mountains Conservancy

Baldwin Hills Conservancy

Santa Monica Bay watershed

Coastal salmonid restoration

Lake Tahoe watershed restoration

Farmland Conservancy Program

River parkways and urban streams restoration

Sierra Nevada Conservancy

Salton Sea restoration

Watershed climate change impacts and adaptation

Watershed education facilities

Waterfowl habitat preservation

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Forest restoration
Klamath dam removal
Siskiyou County economic development offset
Agricultural water use efficiency research
Ocean protection
CVPIA fish passage improvement

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Declaration

I, Janet M. Laurain, declare as follows:

1. I am a paralegal at Adams Broadwell Joseph & Cardozo. I make this declaration from my personal knowledge. If called as a witness, I could testify competently to facts stated in this declaration.

2. Exhibit 638 is a true and correct copy of the Office of the Governor for the State of California, 2009 Comprehensive Water Package, 2009 Comprehensive Water Package Special Session Policy Bills and Bond Summary (11/9/2009). I downloaded and printed this document on March 15, 2010 from http://gov.ca.gov/issue/water-supply, a website purporting to be maintained by the State of California.

3. Exhibit 639 is a true and correct copy of the Office of the Governor for the State of California, Fact Sheet, Governor Calls for Comprehensive Plan to Fix California's Water Crisis. I downloaded and printed this document on March 15, 2010 from http://gov.ca.gov/index.php?/fact-sheet/6958/, a website purporting to be maintained by the State of California.

4. I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed this 18 day of March, 2010, at South San Francisco, California.

Janet M. Laurain

Janet M. Laurain

EXHIBIT 639

Fact Sheet

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PHOTO ESSAY

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Governor Calls for Comprehensive Plan to Fix California's Water Crisis

Governor Schwarzenegger visited the San Luis Reservoir in Merced County to address crisis water conditions throughout the state and outline his long-term water strategy for California. In January the Governor called for a comprehensive solution that combines conservation, conveyance and storage. He is urging the Legislature to move this critical plan forward.

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California is facing a long-term water crisis. We must act now.
Since January, the U.S. Agriculture Department has declared drought disasters in 17 California counties. A hot summer on the heels of a dry winter is forcing communities across the state to take action. Some have already started mandatory rationing.

JULY

- Water officials in San Diego County ask residents to curtail unnecessary water use during daylight hours, following a June call to cut daily water use by 20 gallons/person.

JUNE

- Water officials in Kings and Tulare County water districts declare a water supply emergency. Soon after the Governor declares a water State of Emergency in Kings County.
- Sonoma County water officials impose mandatory 15 percent water conservation.
- Water officials in Kern County declare a state of emergency due to the San-Joaquin Delta pump shutdown.
- Water officials in Alameda and Contra Costa County ask customers to reduce water use by 10 percent. The Southern California Metropolitan Water District—which provides water to 18 million people in Southern California—calls for users to reduce water consumption.
- Los Angeles Mayor Antonio Villaraigosa asks residents to reduce their personal water use by 10 percent.

MAY

- Tuolumne County's largest water district puts water conservation measures into effect and cuts back water to farmers by 20 percent.
- Water officials in Santa Cruz impose mandatory restrictions on water irrigation.

APRIL

- The San Francisco Public Utility District asks residents to reduce water use by 15 percent. This is the first water conservation action the district has taken in 15 years.

Another dry season could have disastrous results.
The Colorado River basin, which supplies water to parts of California is in its eighth consecutive year of drought conditions. We could face a disaster if there's another dry season.

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- *We're vulnerable now because we couldn't capture last year's abundant rain.* If the two reservoirs proposed as part of the Governor's plan existed in 2006, when torrential storms resulted in flood conditions, we could have captured 2.7 million additional acre feet of water. But we couldn't capture this water—which would have provided water for millions of households—because we simply don't have enough surface water storage. As a result, today we're struggling to meet demand.
- *California's last drought had a devastating economic impact.* As a result of our last drought between 1987-1992, California's farmers suffered an $800 million economic loss; Californians paid $500 million more for energy as utilities substituted hydroelectric power with more expensive forms of energy. Employers suffered too—the landscape and gardening industry alone lost $460 million and cut 5,600 jobs.
    - 82 percent of the state's rangeland is currently in "abysmal" condition. "According to the National Agricultural Statistics Services, 82 percent of California's rangeland is in poor or very poor condition, largely due to the lack of rainfall, with some areas of the Central Valley getting as little as 40 percent of normal forage growth this past winter." (Ching Lee, "Drought presses California ranchers," Central Valley Business Times, 6/20/07)
- *Our water system can't support California's booming population.* The existing system, built in the mid-60s, was never designed to meet the needs of a 37-million strong population. As a result, the state's decision last month to shut down the San Joaquin-Delta pumps for just 9 days forced communities to tap into their emergency water supplies.
    - The state's population will reach 60 million by 2050. "The number of people in California, already the most populous U.S. state, will rise to 60 million by 2050 from 36 million...California's population boom will put increased strains on already overstretched public works and natural resources." ("California's population to hit 60 million by 2050," Reuters, 7/9/07)

The Governor's comprehensive water plan will keep California strong and prosperous. It:

- Protects the environment. The plan will restore the Delta's delicate ecosystem and preserve this critical water resource for the future.
- Supports our economy. The plan upgrades to the state's water system, which supports a $300 billion share of California's economy.
- Preserves safe, reliable drinking water. The plan's investment in Delta restoration will help ensure drinking water for 25 million Californians. It will also provide new surface water storage.
- Helps communities conserve. The plan funds grants to California communities. These grants will conserve the equivalent of water supplies for 400,000 families.

THE GOVERNOR'S PLAN FOR CALIFORNIA'S WATER FUTURE

Surface and Groundwater Storage: $4.5 billion

- If we can't store rainwater and snowmelt, we're more vulnerable during dry spells. The Governor's plan invests $4.5 billion to develop additional surface and groundwater storage, so we can capture more water from storms and snowmelt run-off and supply cities, farmers and business with water even during drought-conditions.
- Global warming means more floods and droughts. Global warming is producing more and more severe weather in California, meaning California's water system must be prepared to deal with too much or too little water.

Delta Sustainability: $1 billion

- The Delta's ecosystem is on the brink. The Governor's plan invests $1 billion to protect California's most significant drinking water source, a vital ecosystem and an important center of agriculture.
- Delta Vision is leading the charge. The Governor directed the Delta Vision Blue Ribbon Commission Task Force to develop a Delta management plan. The task force will present its findings and recommendations by January 1, 2008 and its Strategic Plan by October 31, 2008. The Bay Delta Conservation Plan is also underway. The $1 billion will be used to fund their recommendations.

Restoration and Conservation: $450 million

- Conservation is a critical part of the Governor's overall plan. $250 million will support restoration projects on the Klamath, San Joaquin and Sacramento rivers, the Salton Sea project, and the Delta. $200 million will provide water grants to California communities to help conserve water for about 400,000 families.

On The Record:

Larry Minor, owner of Agri-Empire in San Jacinto – "We Don't Have Enough Water": "'I am not just concerned as a farmer but as a third-generation resident,' Minor said. 'We don't have enough water. They need to control the growth.'" (Kimberly Trone, "Drought emergency declaration to be sought," Riverside Press-Enterprise, 7/13/07)

Robert Twiss, UC Berkeley Environmental Planning Professor – "We Can't Maintain" Delta Long Term: "Robert Twiss, an environmental planning professor at UC-Berkeley, says, 'There is growing recognition that the present layout of the levees and delivering fresh water out of the Delta is something we can't maintain long term.'" (OpEd, "It's time to reconsider peripheral canal," Fremont Argus, 6/23/07)

Ronald Robie, Former Director, Department Of Water Resources – Delta Getting "Worse And Worse": "Ronald Robie, a state appellate court judge in Sacramento and a former director of the California Department of

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Water Resources, laments that in 'the last 25 years...the Delta has gotten worse and worse. Nothing they have done has helped.'" (OpEd, "Stop dredging this up," Stockton Record, 6/20/07)

Matt Byrne, Executive Vice President, California Cattlemen's Association – Industry In Trouble "If Things Continue" : 'I've talked to people who've sold a great number of cattle far beyond their normal amount and who have says that if things continue as they are now, they will be completely out of the industry at least for the time being,' Mr. Byrne says." (Ching Lee, "Drought presses California ranchers," Central Valley Business Times, 6/20/07)

Larry Massa, Glenn County Rancher– Drinking Water "A Real Challenge": "For Glenn County cattle rancher Larry Massa, who had to ship his cattle a month early to their summer pastures in Shasta County, the bigger problem now is not having enough drinking water to keep his cattle where they are...'That's been a real challenge,' he says. 'I've had to pump water all spring and all winter. Normally we'd have groundwater in ponds or reservoirs. So it changed the way we operated this year.'" (Ching Lee, "Drought presses California ranchers," Central Valley Business Times, 6/20/07)

Riverside Press Enterprise OpEd – Delaying A Water Fix "Irresponsible And Dangerous": "California can no longer afford to ignore the endangered Sacramento-San Joaquin Delta. The state needs to find a new way to manage the West Coast's largest estuary, or reconcile itself to water shortages, environmental catastrophe and destructive flooding...Delta issues are a complex tangle of conflicting interests. But delay in finding a solution is irresponsible and dangerous, and the consequences of failure unacceptable." (OpEd, "Delta danger," Riverside Press Enterprise, 3/15/07)

Fresno Bee OpEd – California Is Facing "Increasing Scarcity": "The future of water supplies in California can be described in one simple phrase: increasing scarcity. As population grows and demand increases, climate change is almost certain to reduce supplies. That will dramatically alter the landscape, in more ways than one." (OpEd, "Water will be scarce; We can't ignore the looming crisis of diminishing supplies," Fresno Bee, 3/4/07)

LA Times OpEd – "The State's Water System Is In Trouble": "But make no mistake: The state's water system is in trouble...The Sacramento-San Joaquin Delta provides water for 25 million Californians — including 60% of Southern California's supply — and supports $400 billion of economic activity, including fishing and farming. And demands on it will only grow. California's population is expected to jump 30% in the next 20 years, while global warming could reduce the state's snow pack (and the water flows it creates) by the end of the century." (OpEd, "Don't take the delta for granted," LA Times, 3/2/07)

Chico Enterprise-Record OpEd – "There Has To Be A Fix": "The status quo will not survive. Nature has the trump card, and it could be played at any time, whether we're ready on not. A peripheral canal might be the fix, or some other option might be the fix, but there has to be a fix." (OpEd, "Bold changes needed in delta," Chico Enterprise-Record, 2/19/07)

Bakersfield Californian OpEd – "Best And Perhaps Last Chance" For Action: Californians cannot afford to blow what may be our best and perhaps last chance to develop a rational water policy in California before disaster strikes. The critical finding in the PPIC study is that geographic, environmental and population conditions have changed so much in the past 25 years that the entire system teeters on the brink of disaster. (OpEd, "California's water system on brink of disaster," Bakersfield Californian, 2/17/07)

San Jose Mercury News OpEd – Delta "On Edge of Catastrophe": "The Sacramento-San Joaquin Delta is teetering on the edge of catastrophe. Its aging levees are failing, and the land they protect is sinking. Native fish populations are plunging, with some in danger of extinction." (OpEd, "Delta's problems need action now," San Jose Mercury News, 02/15/07)

Stockton Record OpEd – "Radical Change" Needed: "Without some kind of radical change in the amount of water the state stores, California faces an uncertain date with an unpleasant destiny...Without some costly improvements, it's not a question of if - but when - a time arrives when there won't be enough water for everyone." (OpEd, "Saving water," Stockton Record, 1/21/07)

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4. I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed this 18 day of March, 2010, at South San Francisco, California.

Janet M. Laurain

Janet M. Laurain

2162-078a

EXHIBIT 640

DESERT RESTORATION: DO SOMETHING OR WAIT A THOUSAND YEARS

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UNDERSTANDING DISTURBANCE

Impacts to the desert can be loosely divided into local and widespread impacts. There is rarely a complete distinction between the two but in general the local impacts include such things as mining, pipelines, roadways, off-highway vehicle impacts, military operations and localized ranching impacts. Widespread impacts to the Mojave Desert include overgrazing, feral animal grazing and trailing, the invasion of non-native plant species, urbanization and its related affects, and the atmospheric deposition of nitrogen from pollution related dryfall. It is unfortunate, but adverse impacts usually lead to further impacts. For example, the increase in surface nitrogen on the desert's surface favors the establishment of exotic plant species, and exotic plant species may increase fire frequencies and intensities with very detrimental effects on native plant communties.

While historical photos, written descriptions and air photos can provide a good first look at above ground disturbance patterns, some of the most important impacts of human activities are the often unseen effects at and below ground level. There are physical, hydrologic, chemical and biological changes after disturbance which make conditions much less favorable for soil microbes and plants. These changes include reduced infiltration and fertility, increased compaction and soil strength, increased erosion and reduced biological activity.

Physical Changes

Construction activities, equipment operation, agriculture, animal trampling and off-road vehicle operation can remove soil surface armor including crusts and gravel mulches. This can dramatically increase wind and water erosion. These activities also degrade soil structure. Even minimal activity can have significant adverse effects on soil structure. Loamy soils are more sensitive to compaction than sandy soil and wet soils are much more vulnerable than dry soils. The strength of soils that have been compacted increases much more quickly than undisturbed soil as the soil dries out. Penetrometer resistance, a measure of soil strength, is as much as 155% higher in single tank tracks than in adjacent, undisturbed soils, and most desert military camp

roads from WWII remain extremely compacted even after 40 years. This increase in soil strength inhibits root growth and limits water and air exchanges at the soil/air interface.

Increasing soil strength reduces root growth and survival and adversely affects soil microbes. The changes in soil structure can reach much deeper than might be expected. Significant adverse changes were observed at 25 cm depth from as little as three passes with a four wheel drive vehicle over moist soil. In some cases soil strength can be significantly increased by one pass, but more commonly the soil strength increases with repeated passes. Values of soil strength after 10 passes of a four wheel drive vehicle on one test day all exceeded 67 kg/cm2, more than three times the minimum amount causing serious reduction in root growth.

Hydrologic Changes

Compaction leads to the destruction of larger soil pores with related, detrimental changes in infiltration. Compaction and tracks also reduce surface storage and often increase the rate of runoff and gully initiation. Soil compaction and modification of the ground surface by tracked vehicle movement and roads leads to long-term changes in drainage patterns and infiltration. Infiltration rates were reduced 56% in a former vehicle parking lot at one desert military camp after more than 30 years.

The removal of vegetation can also reduce infiltration as the plant mediated infiltration benefits (stem flow, litter, etc.) are eliminated. Infiltration in dry creosote bush soil was double that of dry bare soil and infiltration in wet creosote bush soil was almost five times higher than wet bare soil. During intense summer rains these changes in infiltration are accentuated. Areas with good plant cover may hold and save much of the rain that falls in intense storms while areas that have been disturbed experience sheet flow, flash floods and severe erosion. This suggests that fine soil particles and organic matter accumulating beneath the plant canopies improve the water and nutrient retention capacity of desert soils.

Disturbance most commonly limits water infiltration into the soil, reduces surface roughness and surface retention, reduces soil moisture storage for water that makes it into the soil and increases runoff intensity and flood frequency. These can increase gully or stream cutting and lower water tables over extensive areas. Disturbance that removes plants affects soil development and changes soil moisture and structure for soil microbes and plants.

Chemical Changes

Disturbance can also dramatically change soil chemistry. Construction activity or severe erosion can remove the often very thin layer of fertile topsoil, leaving subsoil that is nutrient limited. Disturbance can also add nitrogen, changing the competitive balance between perennials and annuals, exotics and native species. These, in turn, affect soil microbes.

Chemicals that are poisonous to many species may also be introduced. Contamination of agricultural soils and illegal dump-sites with biocides is common. Farmlands may also have excessive nitrate levels. Available phosphorous and other biologically mediated nutrients may be depressed by disturbance and this may limit establishment and growth.

Biological Changes

Disturbance commonly decreases soil organic matter. In plowed field agriculture, repeated tillage, increased soil temperatures and added nitrogen tend to burn off soil organic matter. Less dramatic but equally important changes occur with lower intensity disturbance. Disturbance also eliminates or reduces populations of soil burrowing organisms. Ants, burrowing lizards and mammals may be particularly important for recovery of degraded areas. Compaction and disturbance can also reduce soil organism populations. Total numbers of fungi, bacteria, nematodes and arthropods are much lower on compacted soils. Pathogens were common on the compacted soils and rarely isolated on control plots.

Removal of plants can remove symbiotic soil organisms critical for plant survival. Compaction can also limit infection by mycorrhizae which are unable to extend hyphae into the compacted soil. Changes in soil moisture caused by reduced infiltration and lower moisture holding capacity may make nodulation by rhizobia difficult or impossible. Changes in soil structure and elimination of soil burrowing organisms can limit movement of inocula in the soil.

Surface disturbances also remove cryptobiotic crusts which, when in place, reduce wind and water erosion and evaporative water loss. Crusts also form catchment sites for seed and safe-sites for seedling establishment.

UNDERSTANDING RECOVERY

Extreme temperatures, intense solar radiation, limited moisture and the low fertility of desert soils combine to make natural recovery of disturbed desert sites very slow after disturbance. In addition, conditions for plant establishment are rare and it may take 60 years to reach predisturbance biomass and 180 years for reasonable recovery of species diversity on non-compacted soils. Recovery times for compacted and severely disturbed soils may reach 1000 years or more.

RESTORATION DECISIONS

Often the most difficult step in restoration is removal of the source of the impact. This often means changes in current land use patterns and can include the removal of feral animals, grazing restriction or removal, route designation for off-highway vehicles and road closures.

Once the source of the impact has been removed, site rehabilitation can proceed. However, tough choices have to be made in most desert restoration projects. The cost of comprehensive rehabilitation including site preparation, seed collection, plant propagation and care, outplanting and site maintenance may well exceed $10,000 per acre. This far outweighs the value of the land ($300/acre). Except in rare cases, the best that can be done is a modest rehabilitation to facilitate natural recovery. This would typically include decompaction, adding weed free compost to some spots, it may also include pitting and surface roughening, seeding with site collected seeds, and very limited container planting with tree shelters and supplemental deep pipe irrigation (as a future seed source and resource island). For $500 - $2000 an acre these strategies can improve visual appearance and speed recovery.

Other restoration strategies include removal of exotic species with the use of herbicides and/or fire and visual restoration using an artificial surficial coloring compound. However, it should be recognized that with all rehabilitation efforts, even the most limited is costly, labor intensive and time consuming. It is also true that even after site rehabilitation is complete it may still take decades or longer for a site to recover all of its components and functions. For these reasons, it is always better to prevent disturbance than to attempt to restore a damaged site.

CHALLENGES IN RESTORATION

Many organizations in the Mojave Desert have demonstrated the desire and ability to restore damaged lands. However, desert restorationists face several significant challenges. First, there is no complete understanding of the extent and type of disturbances that exist in the desert. Without this information, it is difficult to assess the highest priority restoration needs. Second, there is very limited funding available for restoration projects. Third, there are currently only a few skilled restoration specialists in the desert either in private industry or in government employment. Fourth, the most affective and cost efficient restoration techniques have not been determined. Lastly, there is only a limited supply of appropriate seed and plant material for restoration projects. Two regional working teams, the Desert Lands Restoration Task Force and the Southern Nevada Restoration Team, are working collaboratively and across management boundaries to address these restoration needs.

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EXHIBIT 641

PREPARING FOR ANY ACTION THAT MAY OCCUR WITHIN THE RANGE OF THE MOJAVE DESERT TORTOISE (*Gopherus agassizii*)

The Mojave population of the desert tortoise (*Gopherus agassizii*) was listed by the U.S. Fish and Wildlife Service (USFWS) as threatened on April 2, 1990 (USFWS 1990) and by the State of California on August 3, 1989. Subsequently, proposed actions within the range of the desert tortoise fall under purview of the Endangered Species Act 1973, as amended (ESA), in addition to State regulations, including the California Endangered Species Act (CESA). For detailed information on the ecology of the Mojave desert tortoise, please see USFWS (2009).

This protocol provides recommendations for survey methodology to determine presence/absence and abundance of desert tortoises for projects occurring within the species range on Federal and non-Federal lands, and to provide a standard method for reporting survey results. Information gathered from these procedures will: 1) help determine the appropriate level of consultation with USFWS and the appropriate state agency; 2) help determine the incidental take of desert tortoises resulting from proposed projects as defined by the ESA and CESA; and 3) help minimize and avoid take.

This guidance includes:

- Site Assessment
- Pre-project Field Survey Protocol for Potential Desert Tortoise Habitats
- USFWS 2009 Desert Tortoise Pre-project Survey Data Sheet

This guidance is subject to revision as new information becomes available. Before initiating the protocols described below, please check with your local USFWS and appropriate state agency offices to verify that you are implementing the most up-to-date methods. To ensure quality and reduce the likelihood of nonconcurrence with survey results, we recommend that the names and qualifications of the surveyors be provided to USFWS and appropriate state agency for review prior to initiating surveys.

In Arizona:

U.S. Fish and Wildlife Service
Arizona Ecological Services
323 N. Leroux St., Suite 201
Flagstaff, AZ 86001
(928) 226-0614

In California, for Inyo, Kern, Los Angeles, and San Bernardino Counties:

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003
(805) 644-1766

In California, for Imperial and Riverside Counties, and Joshua Tree National Park and the San Bernardino National Forest in San Bernardino Co:

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
6010 Hidden Valley Road
Carlsbad, California 92009
(760) 431-9440

In Nevada:

U.S. Fish and Wildlife Service
Southern Nevada Field Office
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130
(702) 515-5230

In Utah:

U.S. Fish and Wildlife Service
Utah Ecological Services Field Office
2369 West Orton Circle
West Valley City, Utah 84119
(801) 975-3330

State Agencies

Arizona Game & Fish Department
State Headquarters--Nongame Branch
5000 W. Carefree Highway
Phoenix, AZ 85086
623-236-7767

California Department of Fish and Game (CDFG)
For Fresno, Kern, Kings, Madera, Mariposa, Merced, Monterey, San Benito, San Luis Obispo, Stanislaus, Tulare and Tuolumne Counties:
Central Region Headquarters Office
1234 E. Shaw Avenue
Fresno, CA 93710
(559) 243-4005 ext. 151

For Imperial, Inyo, Mono, Riverside and San Bernardino Counties:
Inland Deserts Regional Office
3602 Inland Empire Boulevard, Suite C-220
Ontario, CA 91764
(909) 484-0167

For Los Angeles, Orange, San Diego, Santa Barbara and Ventura Counties:
South Coast Regional Office
4949 Viewridge Avenue
San Diego, CA 92123
(858) 467-4201

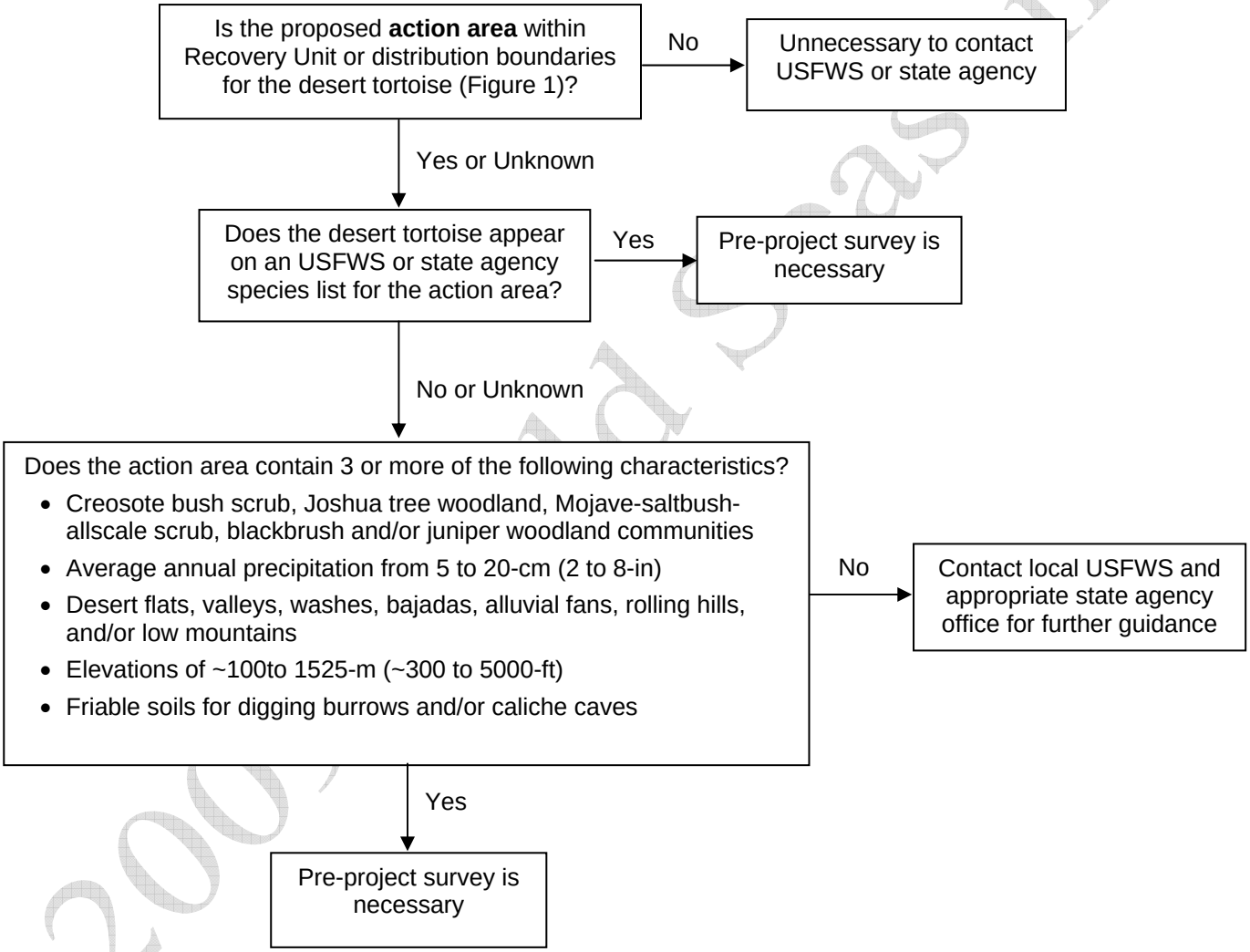
Nevada: Department of Wildlife:
Southern Region
4747 Vegas Dr.
Las Vegas, NV 89108
(702) 486-5127

Utah Division of Wildlife Resources:
Southern Region
1470 N Airport Rd
Cedar City, UT 84720
(435) 865-6100

2009 Field Season

Site Assessment

Use the below key to assess if desert tortoises may be present within or near the action area and determine survey and consultation requirements[1]. The **action area** is defined by regulation as all areas to be affected directly or indirectly and not merely the immediate area involved in the action (50 CFR §402.02). The extent of the action area is not limited to the "footprint" of the action nor is it limited by the authority of the Federal, state, or local agency or any other entity proposing the project. The environmental baseline, the analysis of the effects of the action, and the amount or extent of incidental take are based upon the action area. If you cannot access the entire action area during your surveys for some reason (e.g. access to private property is unavailable), please note that in your survey report.



[1] If determined that the proposed project is not likely to adversely affect the desert tortoise and a tortoise or tortoise sign (shells, bones, scutes, limbs, burrows, pallets, scats, egg shell fragments, tracks, courtship rings, drinking sites, mineral licks, etc.) is found in the action area during implementation of the proposed project, the proposed action should *immediately* stop and then it must be determined whether further or formal consultation is necessary to comply with the ESA or CESA in California. It is recommended that the USFWS and CDFG in California be notified in writing within three days of the discovery. This short notification period will help ensure a prompt response by USFWS and CDFG to facilitate ESA and CESA compliance.

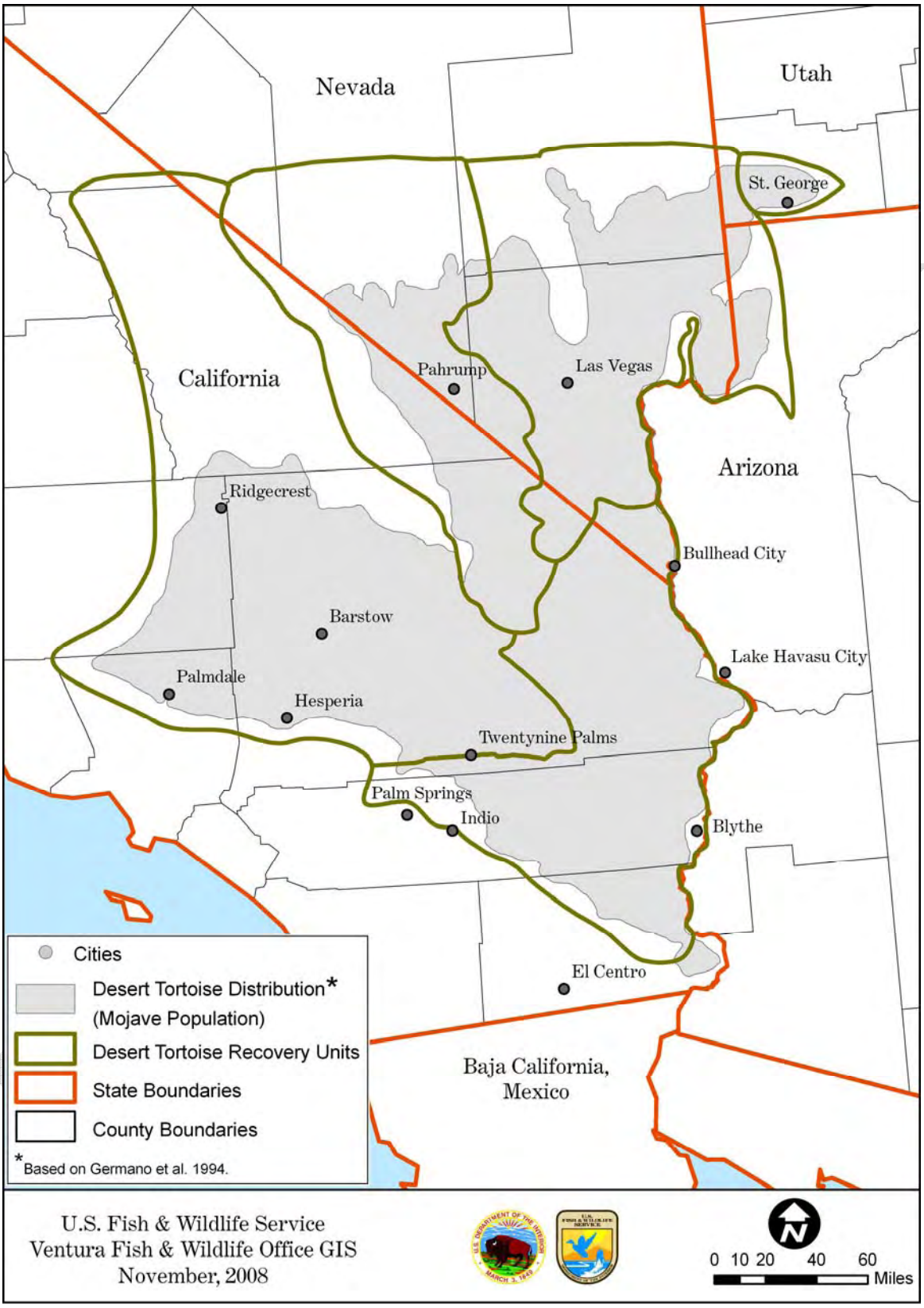


Figure 1: Known Range of the Desert Tortoise (Mojave Population)

Pre-project Field Survey Protocol for Potential Desert Tortoise Habitats

Objectives of survey

- Determine presence or absence of desert tortoises within the action area
- Estimate the number of tortoises (abundance) within the action area
- Assess the distribution of tortoises within the action area to inform take avoidance and minimization

The **action area** is defined by regulation as all areas to be affected directly or indirectly and not merely the immediate area involved in the action (50 CFR §402.02). The action area is not limited to the "footprint" of the action or jurisdiction. Rather, it is a biological determination of the reach of the proposed action on listed species.

Field Methods

This protocol takes into account the fact that not all tortoises within the action area are seen by the surveyor. Provided is an equation which accounts for tortoises that are below ground at the time of surveys and for above-ground tortoises that are cryptic and may be missed.

$$\begin{pmatrix}\text{Estimated number of tortoises}\\ \text{within action area}\end{pmatrix} = \frac{\begin{pmatrix}\text{Number of tortoises}\\ \text{observed above ground}\end{pmatrix}}{\begin{pmatrix}\text{Probability that}\\ \text{a tortoise is}\\ \text{above ground } (P_a)\end{pmatrix}\begin{pmatrix}\text{Probability of}\\ \text{detecting a tortoise,}\\ \text{if above ground } (P_d)\end{pmatrix}}\begin{pmatrix}\dfrac{\text{Action area}}{\text{Area surveyed}}\end{pmatrix}$$

Surveys of 100% coverage, or probabilistic sampling where appropriate, should utilize this equation to estimate the number of tortoises within the action area (see below; Table 1, P_a and P_d).

- Information to determine presence/absence *and* estimate number of tortoises within the action area is collected during the same survey effort. Surveyed objects include all tortoises that are above ground (both out of burrows and within burrows but still visible), as well as all tortoise sign (burrows, scats, carcasses, etc). Record all locations of tortoises and sign encountered during the survey effort using the USFWS 2009 Desert Tortoise Pre-Project Survey Data Sheet (attached). Please submit a copy of the original datasheets with results of the survey to your local USFWS office.
- Surveys should be conducted during the tortoise's most active periods (April through May or September through October) (Nussear and Tracy 2007; Inman 2008; USFWS 2009). Surveys outside these time periods may be approved by USFWS, and CDFG in California (e.g., warm weather in March or rainfall in August stimulating increased tortoise activity).
- Desert tortoises utilize burrows to avoid daily and annual thermal extremes (Woodbury and Hardy 1948). Therefore, surveys should take place when air temperatures are below 40°C (104°F) (Zimmerman et al. 1994; Walde et al. 2003; Inman 2008). Air temperature is measured ~5-cm from the soil surface in an area of full sun, but in the shade of the observer.
- Ten-meter (~30-ft) wide belt transects should be used during surveys. For all projects, surveys which cover the entire project area with the 10-m belt transects (100% coverage) are always an acceptable option. For very large action areas, probabilistic sampling may also be an option, such that the appropriate proportion of the action area is surveyed (Table 2). If probabilistic sampling is an option for the project site, each transect should be chosen either systematically or randomly ensuring that the entire action area has an equal probability of being included in the sample. Transects should be completed in a random order, oriented in a logistically convenient pattern (e.g., lines, squares, or triangles). Any sampling design other than simple systematic or random sampling must be approved by USFWS (e.g. stratification). See *Frequently Asked Questions* section for a discussion of 100% coverage and probabilistic sampling.
- USFWS considers the results of a pre-project survey to be valid for no more than one year. If survey results are older than one year, please contact the local USFWS office.

2009 Field Season

Presence or absence of desert tortoises within the project vicinity

- Occurrence of either live tortoises or tortoise sign (burrows, scats, and carcasses) in the action area indicates desert tortoise presence and therefore requires formal consultation with USFWS.
- If neither tortoises nor sign are encountered during the action area surveys and the project, or any portion of project, is ≤ 0.8 km^2 (200 acres) or linear, three additional 10-m (~30-ft) belt transects at 200-m (~655-ft) intervals parallel to and/or encircling the project area perimeter (200-m, 400-m, and 6000-m from the perimeter of the project site) should be surveyed. These transects are employed only as part of the presence/absence determination; they are not included in the estimation of tortoise abundance. See *Frequently Asked Questions* section below for an explanation of why additional surveys are needed.
- If neither tortoises nor sign are encountered during the action area surveys, as well as project perimeter surveys where appropriate, please contact your local USFWS office. Informal consultation with the USFWS may be required even though no desert tortoises or sign are found during surveys.

Number of tortoises within the action area

The attached Table 3 spreadsheet will estimate the number of adult tortoises (>160 mm MCL) within the action area using the "Number of tortoises within the action area" equation from above.

Enter the requested information into the Table 3 spreadsheet, as follows:

1. Enter the total project area.
2. Enter the appropriate value from Table 1 for the term "probability that a tortoise is above ground" (P_a).
3. Enter the number of adult tortoises (>160-mm midline carapace length) found during the survey of the action area for the term "number of tortoises observed above ground" (n).

Table 1. Probability that a desert tortoise is above ground (P_a) relative to the previous winter's rainfall (October through March)

Use amount of rainfall from the winter preceding the pre-project survey to determine which value of P_a *is appropriate for the project*

To find this amount of rainfall, go to the Western Regional Climate Center site: http://www.wrcc.dri.edu/summary/Climsmsca.html; click on your location and scroll down to "monthly totals"

Previous Winter Rain	Probability (P_a)	Variance(P_a)
<40 mm (~1.5 inches)	0.64	0.08
≥40 mm (~1.5 inches)	0.80	0.05

The estimate for the term "probability of detecting a tortoise if above ground (P_d)" is already included in spreadsheet Table 3 (P_d = 0.63; variance = 0.011). See *Frequently Asked Questions* section below for how P_a and P_d and their associated variances were estimated.

See *Appendix 1* for a detailed description of the method used to estimate desert tortoise abundance.

2009 Field Season

100% Coverage or Probabilistic Sampling?

100% coverage surveys are always an acceptable option, regardless of the size of the action area. For very large action areas, probabilistic sampling may be an additional option, such that the appropriate proportion of the action area is surveyed as detailed below.

For the 2009 field season, probabilistic sampling is not an option for desert tortoise pre-project surveys in California due to the requirement of CESA to avoid, minimize, and fully mitigate (CDFG code section 2081).

Table 2. Is probabilistic sampling an appropriate option for the proposed action area?

Is your action area smaller than the area given below for the recovery unit in which the project occurs?

Recovery Unit	Threshold Action Area to Allow Sampling
Western Mojave	7.2 km^2 (1777 acres)
Eastern Mojave	10.8 km^2 (2676 acres)
Colorado Desert	6.4 km^2 (1573 acres)
Northeastern Mojave	23.3 km^2 (5764 acres)
Upper Virgin River	2.0 km^2 (490 acres)

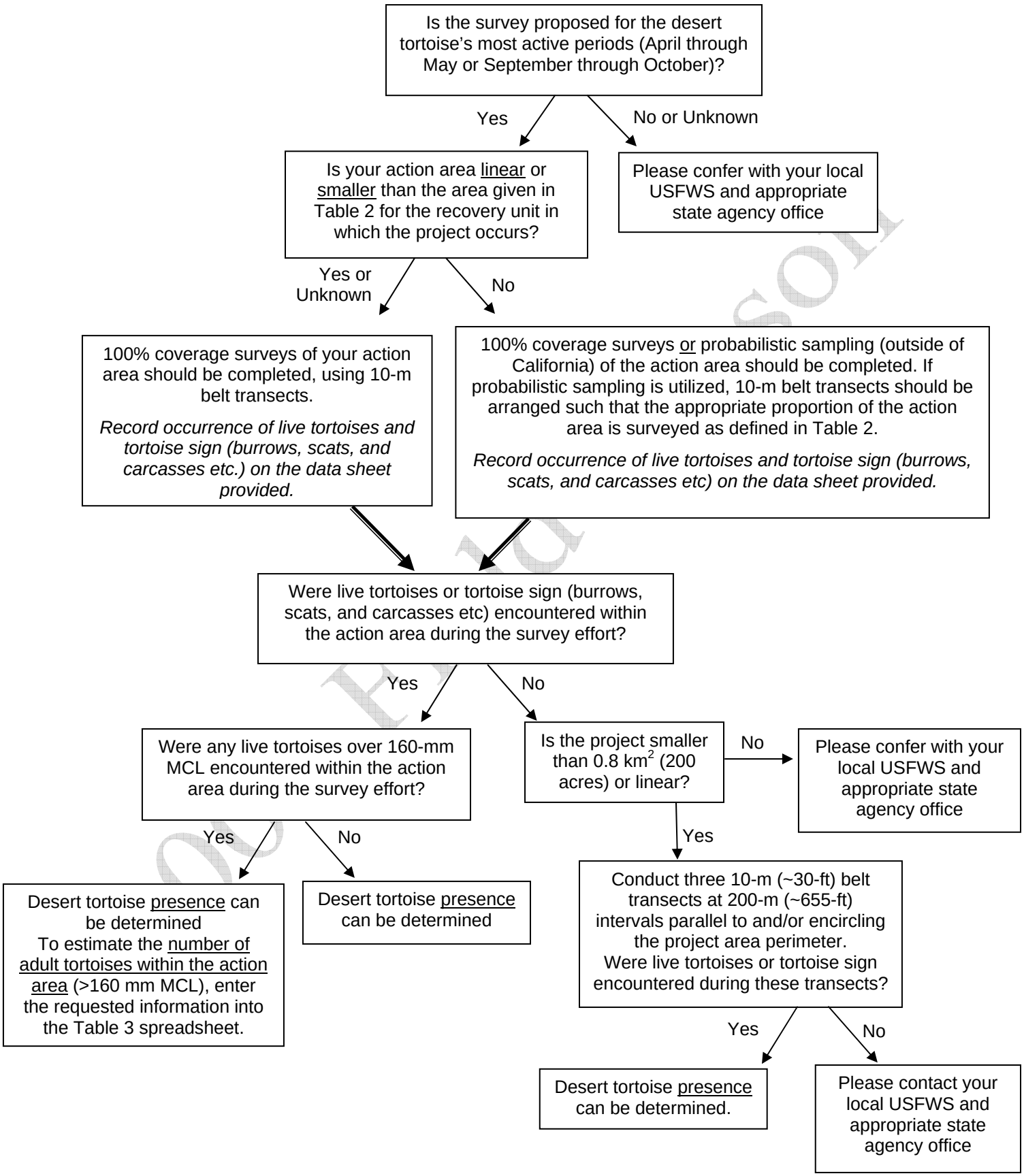
If yes: 100% coverage surveys of your action area must be completed.

If no, total transect lengths that must be surveyed are given below. 100% coverage surveys are also an option, regardless of the size of the project.

Recovery Unit	Total Transect Length (km) to Sample
Western Mojave	719
Eastern Mojave	1083
Colorado Desert	637
Northeastern Mojave	2333
Upper Virgin River	198

2009 Field Season

Decision Tree for Pre-project Field Survey Protocol for Potential Desert Tortoise Habitats



Frequently Asked Questions: Desert Tortoise Pre-project Field Survey Protocol

Why did USFWS revise the 1992 USFWS Desert Tortoise Pre-project Survey Protocol?

Desert tortoises occur at low densities across most of the Mojave Desert (USFWS 2006). They are cryptic and spend much of their time underground in burrows (Burge 1977; Nagy and Medica 1986; Bulova 1994) and therefore not all animals within an area will be seen by even the best trained surveyors. Tortoises underground in burrows, as well as individuals hidden above ground, need to be included in estimates.

The 1992 USFWS Desert Tortoise Pre-project Survey protocol was based on a Bureau of Land Management protocol from the mid-1970s, which utilized the best available information at the time, but did not take into account that some tortoises will be underground and missed during the survey effort. The data collected during the extensive USFWS range-wide monitoring program (currently <7,000-km of transects each year; USFWS 2006) have allowed us to improve pre-project survey methods. Data about the proportion of tortoises underground in burrows, as well as the probability that an above-ground tortoise will be observed by the surveyor are included in the estimate of the number of tortoises within the action area (P_a and P_d).

This protocol also addresses the potential for using probabilistic sampling when the action area is above the size limits given in Table 2. 100% coverage surveys are *always* an acceptable option, regardless of the size of the action area. For very large action areas, sampling may be an additional option, such that the abundance estimates can be calculated when an appropriate proportion of the action area is surveyed. Estimates of tortoise densities within recovery units from the range-wide monitoring program have been used to calculate how many km^2 of a project site must be surveyed to produce a statistically robust abundance estimate (Table 2).

What happened to the zone of influence transects recommended in the 1992 protocol?

This revised protocol requires that the entire action area, rather than just the project footprint, be included in the survey effort. The **action area** is defined by regulation as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 CFR §402.02). The action area is therefore not limited to the "footprint" of the project nor is it limited by the Federal agency's authority. Rather, the action area is a biological determination of the reach of the proposed action on listed species, which must, by definition, encompass the zone of influence of the project.

How did USFWS determine the values for the “probability that a tortoise is above ground”?

The USFWS range-wide monitoring program estimated the proportion of the desert tortoise population that is visible using telemetered animals from focal areas in spring 2001-2005 (USFWS 2006). This probability is related to the previous winter’s rainfall, as illustrated in Table 1. The range of fall above-ground activity is similar to spring numbers, but the variability is much higher (Nussear and Tracy 2007; Inman 2008). Until more robust estimates of fall above-ground activity are available, spring estimates based on the previous winter’s rainfall (October through March) are used for surveys conducted in either active period.

How did USFWS establish the value for the “probability of detecting a tortoise, if above ground”?

For the past five years, surveyors in the USFWS range-wide monitoring program have undergone training on established transects with artificial tortoises. Trained surveyors detected an average of ~63% of model tortoises that were within 5-m of either side of the transect center-line (USFWS unpublished).

Why are only tortoises over 160-mm MCL used to estimate the number of tortoises within the action area?

The values of P_a and P_d used in the equation to estimate the number of tortoises within the action area are based on USFWS range-wide monitoring data collected for adult tortoises ≥160-mm MCL.

2010 Field Season

What is the purpose of 100% coverage surveys versus probabilistic sampling?

The purpose of surveying is to determine presence/absence and estimate the abundance of desert tortoises within the action area. For 100% coverage surveys, transects are placed across the entire action area; thus, the entire area for which abundance is estimated is surveyed. A probabilistic sampling approach, on the other hand, uses data from randomly or systematically placed transects to draw inferences about locations where surveys are not conducted. All locations for which abundance will be estimated *must* have an equal probability of being included in the sample.

How were the threshold project sizes calculated for determining whether 100% coverage or probabilistic sampling is appropriate?

The validity of probabilistic sampling requires that all locations for which abundance will be estimated have an equal probability of being included in the sample, as well as the expected sample size. Estimating the number of tortoises within the project area using probabilistic sampling is limited by the number of tortoises encountered during the survey effort. Therefore, whether or not the project area must be surveyed using 100% coverage or can be probabilistically sampled is based on the area expected to yield a survey count of 20 tortoises (Krzysik 2002). Table 2 uses tortoise densities and detection probabilities estimated from 2001-2005 range-wide line-distance sampling efforts for each tortoise Recovery Unit (USFWS 2006) to calculate that area of a project site that must be surveyed to produce a statistically robust estimate. If the project area is large enough to allow the option of probabilistic sampling, Table 2 provides the minimum transect kilometers (10-m wide) that must be surveyed.

What if the minimum length of 10-m wide transect kilometers are completed but 20 tortoises were not found in the action area?

If probabilistic sampling is used and < 20 tortoises are found after surveying the total transect length prescribed by Table 2, number of tortoises within the action area may be estimated using number found.

Do I keep surveying if 20 tortoises are found before the minimum transect kilometers that must be surveyed are completed?

If probabilistic sampling was used and the transects have been completed in a random order, project area surveys may be considered complete when 20 tortoises have been found or the specified number of kilometers have been sampled, whichever happens first. It is okay if more that 20 tortoises are found, this will decrease the width of the 95% confidence interval for the abundance estimate.

Why do small and linear projects where no tortoises were found have to do additional surveys at 150-m (~500-ft) intervals parallel to the project area perimeter?

Even though neither tortoises nor tortoise sign were found within the action area at the time of the survey, the area may be part of an animal's home range. The home range of a female desert tortoise averages around 0.15 to 0.16 km^2 (35 to 40 acres), about one third the size of male home ranges, which are variable and can be > 2 km^2 (O'Conner et al. 1994; Duda et al. 1999; Harless et al. In press). Therefore, projects that are ≤ 0.8 km^2 (200 acres) or linear may overlap only part of a tortoise's home range and the possibility that a resident tortoise was outside the project area at the time surveys were conducted must be addressed. In these cases, USFWS recommends three additional 10-m (~30-ft) belt transects at 200-m (~655-ft) intervals parallel to and/or encircling the project area perimeter (200-m, 400-m, and 600-m from the perimeter of the project site). Record any tortoises or sign encountered during these surveys. These transects are employed only as part of the presence/absence determination; they are not included in the estimation of tortoise abundance within the project area.

What does the 95% confidence interval for the number of tortoises within the action area mean?

Confidence intervals are used to indicate the reliability of an estimate. The interval gives an estimated range of values, calculated from a set of sample data, which is likely to include an unknown population parameter (in this case, the true number of tortoises within the action area). A wider confidence interval indicates that less certainty is associated with the estimate (see Appendix 2). The Table 3 spreadsheet calculates the abundance and associated 95% confidence interval for the estimated number of tortoises within the project area (Buckland et al. 2001).

Spring Field Season

Acknowledgments

The USFWS Desert Tortoise Recovery Office is grateful to the many individuals and agencies that were instrumental in development and review of this revised protocol. Specifically, we thank Jim Nichols (USGS) and Tony Krzysik (Prescott Audubon Society) for assistance with concept design; Alice Karl (independent tortoise biologist) and Andrew Thompson (USFWS) for development discussion, and Kirk Waln (USFWS) for GIS support.

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2009 Field Season

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2009 Field Season

Appendix 1. Detailed description of desert tortoise abundance and CI estimation

The estimated abundance of adult desert tortoises within the action area is given by:

$$\begin{pmatrix}\text{Estimated number of tortoises}\\ \text{within action area}\end{pmatrix} = \frac{\begin{pmatrix}\text{Number of tortoises}\\ \text{observed above ground}\end{pmatrix}}{\begin{pmatrix}\text{Probability that}\\ \text{a tortoise is}\\ \text{above ground}\end{pmatrix}\begin{pmatrix}\text{Probability of}\\ \text{detecting a tortoise,}\\ \text{if above ground}\end{pmatrix}}\begin{pmatrix}\dfrac{\text{Action area}}{\text{Area surveyed}}\end{pmatrix},$$

which is equivalent to:

$$\hat{N} = \left[\frac{(n)}{(Table2)(0.63)}\right]\left[\frac{(A)}{(a)}\right],$$

where $\hat{N}$ = estimated abundance within entire action area, *n* = number of tortoises observed above ground, *A* = total action area, and *a* = actual area surveyed (= total # km surveyed * 0.01). For 100% coverage surveys, *A/a* = 1.

Table 3 uses the following equations to calculate the 95% confidence interval for the estimate of tortoise abundance within the action area (Buckland et al. 2001), assuming all replicate transect lines are the same length, 10-km.

$$\hat{\text{var}}(n) = L\sum_{i=1}^{k} l_i\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2 /(k-1)$$

where $\hat{\text{var}}(n)$ = the spatial variation in the number of tortoises detected through the total transect length L, n_i = the number of tortoises seen on transect *i*, l_i = the length of individual transect *i*, and *k* = total number of transects walked.

Putting the sources of variability together, the variance of density is:

$$\text{var}\,\hat{D} = \hat{D}^2\left[\frac{\text{var}(n)}{n^2} + \frac{\text{var}(\hat{P}_a)}{(\hat{P}_a)^2} + \frac{\text{var}(\hat{P}_d)}{(\hat{P}_d)^2}\right]$$

Because the tortoise density sampling distribution is positively skewed, the confidence interval is calculated using a log-distribution for density and built with division and multiplication, rather than addition and subtraction from the mean as with a symmetrical interval (Buckland et al. 2001).

Thus, the 95% confidence interval for $\hat{N}$ is:

$$\left(\hat{N}/C_N, \hat{N}\cdot C_N\right),$$

where $C_N = \exp\left[z_\alpha\sqrt{\text{var}(\log_e \hat{D})}\right]$ and $\text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{\text{var}(\hat{D})}{\hat{D}^2}\right]$.

Given the simplifying assumptions in this protocol, the 95% confidence interval around the estimated number of tortoises within the action area will be wide (e.g., the estimate of the number of tortoises will be imprecise). While this level of imprecision would not be appropriate for recovery planning and decision making at large scales, this protocol provides estimates at local scales that most efficiently utilize the best information that is available to provide statistically defensible results.

2009 Field Season

Appendix 2. Example

Project location = near Beatty, NV (within the Eastern Mojave RU)

Action area = 12 km^2 (3,000 acres)

According to this protocol's Site Assessment key, the proposed action is within the known range of the desert tortoise. The local USFWS and appropriate state agency offices were contacted and a species list, which includes the desert tortoise, was obtained for the action area. Therefore, pre-project survey and consultation are necessary.

The project footprint is only 10 km^2, but since the project will include blasting, the reach of the proposed action on listed species extends to 12 km^2. Thus, the action area (and therefore the area which needs to be surveyed for desert tortoises) is 12 km^2 (which is more inclusive than the 10 km^2 project footprint).

According to Table 2 of the pre-project survey protocol, the project size of 12 km^2 is above the threshold project area to allow probabilistic sampling in the Western Mojave RU (10.8 km^2 threshold). Therefore, at a minimum, 1,083 km of transects must be walked. For this example, 108 10-km transects (10-m wide) were placed systematically across the project site and were completed in a random order. Surveys of 100% coverage in which 10-m wide transects were placed across the entire 12 km^2 action area would also have been acceptable.

Transects totaling 1,083 km were conducted and 19 adult tortoises (> 160 mm carapace length) were found (as well as tortoise sign, both of which were catalogued using the USFWS 2009 DT pre-project survey protocol data sheet). If 20 adult tortoises had been encountered before the 1,083 km of transects were completed, and transects were conducted in a random order, then surveys could have been considered complete after the 20th tortoise was catalogued.

Data collected from the108 transects (live animals encountered <160-mm MCL)

Number of tortoises (n_i)	Number of transects on which n_i tortoises were seen
0	93
1	11
2	4

Using the Western Regional Climate Center website, it was determined that the Beatty area had received 97-mm (3.8 inches) of rain in the October through March preceding the survey effort, which is above the 40-mm (1.5 inches) in Table 1. Therefore, P_a of 0.80 will be used in this estimation.

Thus, from

$$\hat{N} = \left[\frac{(n)}{(Table2)(0.63)}\right]\left[\frac{(A)}{(a)}\right]$$, we get $$\hat{N} = \left[\frac{(19)}{(0.80)(0.63)}\right]\left[\frac{(12\,km^2)}{(10.8\,km^2)}\right]$$, or $\hat{N} =\sim 42$ tortoises

$$\text{Density} = \frac{(\hat{N})}{(A)}$$, we get $$\hat{D} = \frac{(42)}{(12\,km^2)}$$, or $\hat{D} =\sim 3.5$ tortoises/km^2

2009 Field Season

To calculate the 95% confidence interval for our abundance estimate, we use:

$$\hat{\text{var}}(n) = L\sum_{i=1}^{k} l_i\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2 /(k-1)\,,$$

we get $\hat{\text{var}}(19) = 1080\left[(93)(10)\left(\frac{0}{10} - \frac{19}{1080}\right)^2 + (11)(10)\left(\frac{1}{10} - \frac{19}{1080}\right)^2 + (4)(10)\left(\frac{2}{10} - \frac{19}{1080}\right)^2\right]/(108-1)$, or

$\hat{\text{var}}(19) = 23.88$

And for,

$\text{var}\,\hat{D} = \hat{D}^2\left[\frac{\text{var}(n)}{n^2} + \frac{\text{var}(\hat{P}_a)}{(\hat{P}_a)^2} + \frac{\text{var}(\hat{P}_d)}{(\hat{P}_d)^2}\right]$, we get $\text{var}\,\hat{D} = 3.5^2\left[\frac{23.88}{19^2} + \frac{0.05}{0.80^2} + \frac{0.011}{0.63^2}\right]$, or $\text{var}\,\hat{D} = 2.107$

Using our log-transformation because the tortoise density sampling distribution is positively skewed,

$\text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{\text{var}(\hat{D})}{\hat{D}^2}\right]$, we get $\text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{2.107}{3.5^2}\right]$, or $\text{var}(\log_e \hat{D}) = 0.15$

Then,

$C_N = \exp\left[z_\alpha\sqrt{\text{var}(\log_e \hat{D})}\right]$, we get $C_N = \exp\left[(1.96)\sqrt{0.15}\right]$, or $C_N = 2.18$

And,

$\left(\hat{N}/C_N, \hat{N}\cdot C_N\right)$, we get $\left((42/2.18), (42\cdot 2.18)\right)$, or ~$(19, 92)$.

Summary

Using the Site Assessment key, it was determined that survey and consultation were necessary for the proposed action. Thus, the pre-project field survey protocol was implemented. In this case, probabilistic sampling with equal length transects (10-km long) was used and 19 adult tortoises and tortoise sign were found during the sampling of the action area, indicating presence. Using the equations and data presented in Appendix 1 of this protocol, Table 3 estimated the actual number of tortoises within the project was estimated to be ~42, with a 95% confidence interval of ~(19, 92).

2009 Field Season

USFWS 2009 DESERT TORTOISE PRE-PROJECT SURVEY DATA SHEET

Date of survey: _____ Survey biologist(s): _____
(day, month, year)

Site description: _____
(project name and size; general location)

County:_____ Quad:_____ Location:_____
(UTM coordinates, lat-long, and/or TRS; map datum)

Transect #: ____ Transect length: _____ Type of survey: _____
(project area size to be surveyed; 100% coverage/probabilistic sampling)

GPS Start-point: _____ _____ Start time: _____am/pm
(easting, northing, elevation in meters)

GPS End-point: _____ End time: _____am/pm
(easting, northing, elevation in meters)

Start Temp: _____ºC Weather: _____

End Temp: _____ºC

Live Tortoises

Detection number	GPS location Easting	Northing	Time	Tortoise location (*in burrow*: all of tortoise beneath plane of burrow opening, or *not in burrow*)	Approx MCL >160-mm? (*Yes, No or Unknown*)	Existing tag # and color, if present
1						
2						
3						
4						
5						
6						
7						
8						

Tortoise Sign (burrows, scats, carcasses, etc)

Detection number	GPS location Easting	Northing	Type of sign (*burrows, scats, carcass, etc*)	Description and comments
1				
2				
3				
4				
5				
6				
7				
8				

Page: _____of_____

Date of survey: _____

Transect number: _____

2009 Field Season

EXHIBIT 642

FIELD SURVEY PROTOCOL FOR ANY NON-FEDERAL ACTION THAT MAY OCCUR WITHIN THE RANGE OF THE DESERT TORTOISE

The Mojave population of the desert tortoise was listed as a federally endangered species on August 4, 1989 by emergency rule and as a threatened species by final rule on April 2, 1990. section 9 of the Endangered Species Act prohibits the "taking" of any federally listed threatened or endangered species without first obtaining necessary authority from the Fish and Wildlife Service. "Take" includes "harming, harassing, pursuing, hunting, shooting, wounding, killing, capturing, collecting, or attempting to engage in any such conduct" (section 3(19), Endangered Species Act 1973, as amended). Harm includes "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or shelter" (50 CFR 17.3(c)). "Take" also includes modification of habitat that would result in harm to the desert tortoise.

In response to a demand for information and/or guidance on compliance with the Endangered Species Act, the Fish and Wildlife Service has developed a protocol for surveys within the range of the Mojave population of the desert tortoise which is listed as federally threatened. The purpose of this protocol is to provide technical assistance to entities to determine presence or absence of this animal and thus avoid "take" of the desert tortoise. Where avoidance is not possible, this protocol will provide information from which the project proponent can develop a "conservation plan" with guidance from the Fish and Wildlife Service. The conservation plan is the primary component of a section 10(a) (1) (B) permit application intended to obtain the necessary authorization to incidentally "take" a federally listed species as specified in the Endangered Species Act.

Please note that the presence of a desert tortoise within the project boundary is not necessary for the project to result in the take of the desert tortoise. Please see the Survey Need section below for more information.

If part or all of the project will be authorized, funded, or carried out by a federal agency or located on federal land, the project proponent, through the federal agency, will need to comply with section 7 of the federal Endangered Species Act rather than section 10. If you believe your project may have such a federal "connection", we urge you to contact the Fish and Wildlife Service for confirmation. Please see the "Field Survey Protocol for Any Federal Action that May Occur within the Range of the Desert Tortoise". If there is no federal "connection" in any part of the proposed project, you must ensure that your project either will not result in a "take" of the desert tortoise or obtain a section 10(a) (1) (B) incidental take permit from the Fish and Service prior to implementing your project.

We also recommend that you obtain a copy of "Procedures for Endangered Species Act Compliance for the Mojave Desert Tortoise" before you begin planning your project. This document is available from any of the five Fish and Wildlife Service offices listed below and provides more information on sections 7, 9, and 10 of the

Endangered Species Act.

This survey protocol is subject to revision as new information becomes available. Before initiating the survey protocol described below, we recommend checking with the Fish and Wildlife Service to verify that you are implementing up-to-date survey methods.

In Arizona:

Fish and Wildlife Service
Phoenix Field Office
3616 West Thomas, Suite 6
Phoenix, Arizona 85019
(602) 379-4720

In California, for Inyo, Kern, Los Angeles, and San Bernardino Counties:

Fish and Wildlife Service
Ventura Office
2140 Eastman, Suite 100
Ventura, California 93003
(805) 644-1766

In California, for Imperial and Riverside Counties:

Fish and Wildlife Service
Carlsbad Office
2730 Loker Avenue West
Carlsbad, California 92008
(619) 431-9440

In Nevada:

Fish and Wildlife Service
4600 Kietzke Lane, Building C-125
Reno, Nevada 89502
(702) 784-5227

In Utah:

Fish and Wildlife Service
2078 Administration Building
1745 West 1700 South
Salt Lake City, Utah 84104-5110
(801) 524-4430

Survey protocol includes six parts: (1) survey need, (2) survey types, (3) survey quality, (4) survey time period, (5) qualifications of the surveyor, and (6) reporting survey results.

Survey Need: The desert tortoise may occupy numerous habitat types within its range in the Mojave and Colorado deserts and below an elevation of 5000 feet. In these areas there is a likelihood of encountering desert tortoises or tortoise sign. Activities such as land clearing are likely to result in "take" of desert tortoises or tortoise habitat, unless site specific information indicates that no take of desert tortoises or tortoise habitat would occur.

The Fish and Wildlife Service recommends that the project proponent conduct a Presence-or-Absence Survey for tortoises and tortoise sign over the entire project area and the Zone of Influence adjacent to the project area. The Zone of Influence is defined as the area where tortoises on adjacent lands may be directly or indirectly affected by project exploration, construction, maintenance, operation, monitoring, dismantlement, enhancement, and project abandonment. The survey information would be part of the requirements of the federal Endangered Species Act section 1O(a)(1)(B) permit application. Tortoise sign would include shells, bones, scats, limbs, burrows, pallets, scats, egg shell fragments, tracks, courtship rings, drinking sites, mineral licks, etc.

Depending on the type of project, a Clearance Survey immediately prior to construction (see below) in recently occupied tortoise habitat may also be necessary. The Fish and Wildlife Service requests that all survey results, including copies of the completed transect forms, be submitted to the appropriate Fish and Wildlife Service office within 30 days. This information is vital to the ongoing management for recovery of the desert tortoise. Providing this information to the Fish and Wildlife Service will help ensure that the survey has been correctly completed and the data have been properly assessed. Submittal of survey results also allows the Fish and Wildlife Service to advise you of the appropriate requirements, if any, in accordance with the definition of "take" in the federal Endangered Species Act. This definition includes take of habitat.

Please note that all free-roaming desert tortoises located north and west of the Colorado River are protected under the Endangered Species Act. For example, the desert tortoise that on occasion occurs above 5000 feet or in pinyon-juniper woodland would be protected under the Endangered Species Act.

As mentioned above, the presence of a desert tortoise within the project boundary is not necessary for the project to result in the take of the desert tortoise For example, a desert tortoise may be present in the Zone of Influence and may use the project site for feeding, breeding, or shelter. Destruction of tortoise habitat used for feeding, breeding, or shelter is considered take under the Endangered Species Act.

Also note that planning agencies or other local or state agencies have not been delegated authority to determine if or when a section 10(a) (1) (B) incidental take permit is needed under the federal Endangered Species Act. The Fish and Wildlife Service is available to answer inquiries and make determinations on the need for an incidental take permit based on the submission of survey results.

Before initiating any activity that will result in surface disturbance within the range

of the desert tortoise including overland driving for land surveying or other forms of take, the Fish and Wildlife Service recommends that you contact one of the five offices listed above to determine if your action may require a section 1O(a)(1)(B) permit.

All requirements of the Endangered Species Act should be completed prior to the initiation of any part of the proposed project. Failure to submit survey forms to and coordinate directly with the Fish and Wildlife Service on the proposed project may result in delay or modification of the proposed project. We strongly suggest coordinating with the Service early in the planning process.

Projects that would not result in take of desert tortoises or tortoise habitat are not subject to the prohibitions of take of the desert tortoise as defined in the federal Endangered Species Act. However, in the event that a desert tortoise or tortoise sign (shells, bones, scats, limbs, burrows, pallets, scats, egg shell fragments, tracks, courtship rings, drinking sites, mineral licks, etc.) are found in the project area during construction, all surface disturbance should immediately stop. The Fish and Wildlife Service recommends that the project proponent notify us and the local planning and zoning department in writing within 3 days of the discovery. This short notification period will help ensure a timely response by the Fish and Wildlife Service to facilitate compliance with the federal Endangered Species Act and avoid unauthorized take.

If tortoise sign is found, a Presence-or-Absence Survey of the project area and a Clearance Survey immediately prior to construction may be necessary. Please see the discussion on Presence-or-Absence and Clearance surveys below.

Fish and Wildlife Service Survey Protocol for Desert Tortoises and Bureau of Land Management Categories of Desert Tortoise Habitat: The Bureau of Land Management has developed category maps for desert tortoises to assist the Bureau in managing public lands for the tortoise within the Bureau's multiple use mandate. Bureau maps were not developed to provide information on how to avoid take of the desert tortoise or comply with the federal Endangered Species Act. The Bureau has assigned three categories to their maps on desert tortoise habitat. These categories reflect the quality of tortoise habitat, quantity of tortoises present, and the Bureau's ability to manage these areas for the desert tortoise while minimizing resource conflicts. For example, Category 1 is considered better for tortoises than category 2. However, category 3 areas may contain high quality tortoise habitat and high density of tortoises, but because of resource conflicts the Bureau has assigned the area to category 3.

If an area is not classified on the Bureau's maps as category 1, 2, or 3, this does not mean that this area does not contain desert tortoises or is not considered desert tortoise habitat. The Bureau did not categorize lands that it does not manage such as military reservations or private lands. Also, the Bureau did not categorize lands in many areas that have densities of desert tortoises less than 20 per square mile. Thus, if a proposed project is not located in an area categorized as category 1, 2, or 3 by the Bureau, the project may still be located in desert tortoise habitat if it is in the desert and below 5000 feet.

Survey Types: Two types of surveys are recommended: 1) Presence-or-Absence and 2) Clearance. Neither survey utilizes the 1.5-mile triangular transect survey method developed by the Bureau of Land Management. The Bureau of Land Management's triangular transect method does not provide reliable information on the number of desert tortoises that would be taken as a result of implementation of the proposed project and thus is not adequate for meeting the requirements of the federal Endangered Species Act. Alternative methods for surveying for desert tortoises and their sign over very large areas may be submitted to the Fish and Wildlife Service for consideration.

Presence-or-Absence Survey: This survey type is recommended for areas below 5000 feet and within the known range of the desert tortoise. The purpose of this survey is to determine impacts of potential land disturbance activities to the local tortoise population. This includes identifying the number and location of all tortoises and tortoise sign that occur within a given project area and if any tortoises occur in adjacent areas (Zone of Influence) whose home range may overlap into the project area and thus be taken or lost by the proposed action.

The project area is defined as any area that will be cleared or partially cleared, with vehicles on or adjacent to it, temporarily or permanently used for equipment or materials storage, loading or unloading, or sites where soils/vegetation is damaged, fragmented, or disturbed (e.g., driving overland).

The entire project area is surveyed using belt transects 10 yards or 30 feet wide (100 percent coverage). In some locations, belt transects less than 30 feet wide may be appropriate (see below). In addition, the Zone of Influence is surveyed. The Zone of Influence is defined as the area where tortoises on adjacent lands may be directly or indirectly affected by project exploration, construction, maintenance, operation, monitoring, dismantlement, enhancement, and project abandonment. As a minimum, the belt transects in the Zone of Influence are located at 100, 300, 600, 1200, and 2400-foot intervals from and parallel to the edge of the project boundaries (See Figures 1 and 2.) All tortoise sign (live tortoises, shells, bones, scats, limbs, scats, burrows, pallets, tracks, egg shell fragments, courtship rings, drinking sites, mineral licks, etc.) within the project area and sign located on transects within the Zone of Influence should be mapped.

The extent of the Zone of Influence is dependent on the type of habitat alteration/development and its proximity to other developments. The extent of the Zone of Influence increases as the probability of increased use by domestic predators, potential human use in the Zone, road use, littering, waste disposal, etc. These uses result in increased take of desert tortoises through predation, collection as pets, vandalism, road kills, and attracting predators such as ravens, coyotes, and feral dogs to the area.

Additional transects may be recommended at 3600- and 4800-foot intervals from the perimeter of the project area for developments 1) located in or within one mile of categories 1 or 2 habitats as defined by the Bureau of Land Management or 2) associated with residential development, new or increased road use, landfills, or projects that would result in increases in human Use or litter.

Figure 1. Example of a proposed transmission line including areas with full (100 percent) survey coverage for desert tortoises (construction area) and locations of transects within the Zone of Influence.

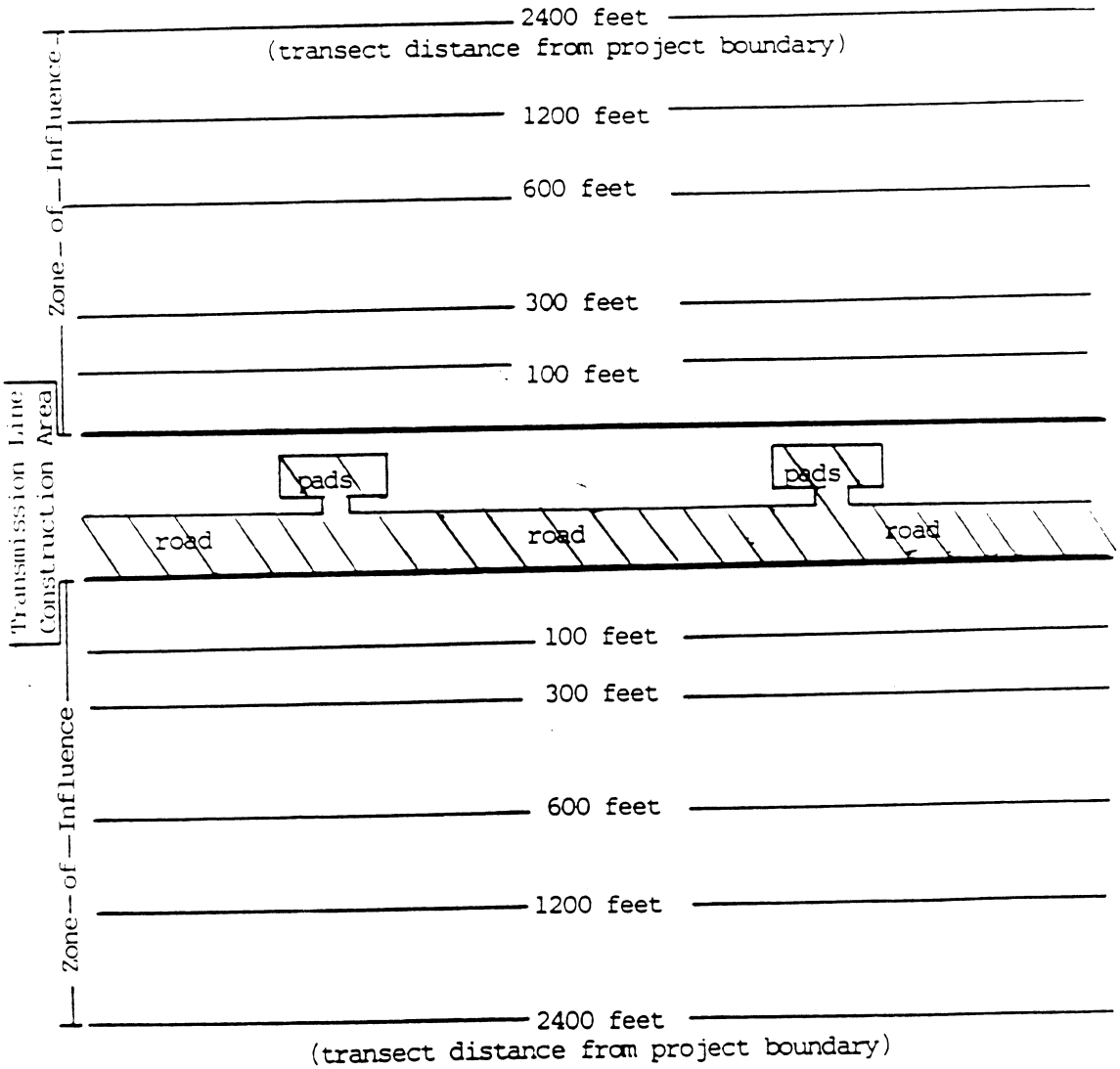
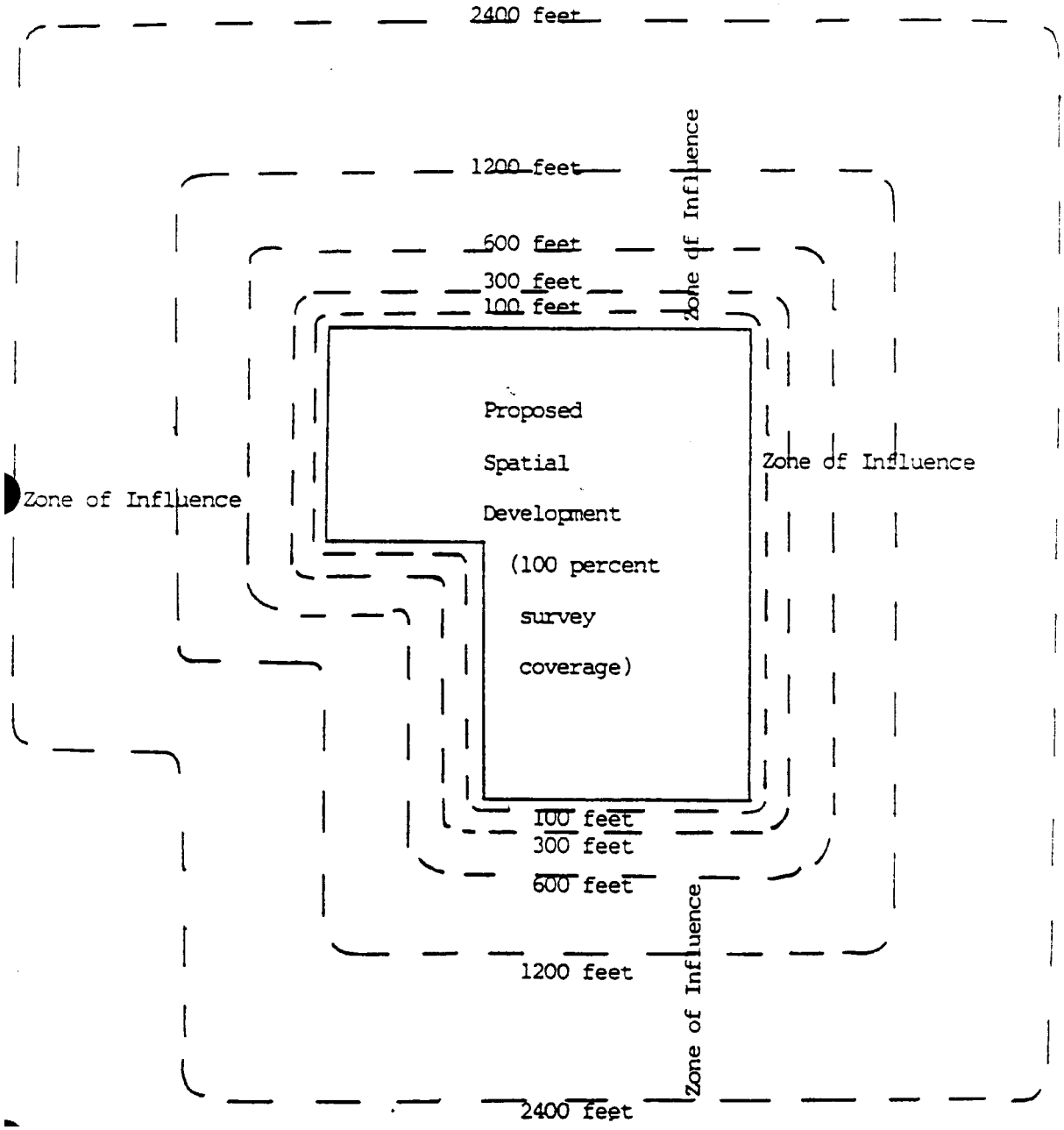


Figure 2. Example of a proposed spatial development (e.g., residential development, commercial development) with full (100 percent) survey coverage for desert tortoises and locations of transects within the Zone of Influence.



For example, if a project area is 640 acres or one square mile, 176 parallel transects each one mile long and 30 feet wide would be necessary to provide 100 percent coverage of the project area. Additional transects would be necessary to survey the adjacent areas or Zone of Influence.

If the project area contains locations with vegetation or topography that obscures or reduces that surveyor's ability to see tortoise sign at distances of up to 15 feet on the ground, the width of the survey should be reduced to 10 feet, that is, 5 feet on either side of the surveyor. Some examples of situations where a 10-foot wide transect should be conducted instead of a 30-foot wide transect would be: 1) foothills and slopes of mountains which contain rocks, boulders, and/or vegetation that obstruct the surveyor's view of the ground at distances greater than 5 feet, and 2) areas in which the vegetation density is greater than that of typical creosote or creosote/sage flats or bajadas in the Mojave Desert such as desert wash scrub or woodlands and ecotones between habitat types. In these areas the surveyor's view of the ground and tortoise sign, if present, would be obstructed and a 30-foot wide transect would not be acceptable.

When mapping tortoise sign, the recommended map scale is 1 inch = l00 feet, for plans involving ground; disturbance and 1 inch = 1000 fee t for preliminary planning (master-planning or specific planning). These map scales are based on those frequently required by city or county planning departments. The map should include locations and specific types of all tortoise sign found on the project area and Zone of Influence including the number live tortoises, reference to the corresponding transect form with additional information on tortoise sign found, significant landmarks, legal description of the project area, survey dates, and the range of elevation within the project boundaries. Please note that a federal Fish and Wildlife License/Permit is required before a surveyor can capture, touch, or "harass" a live desert tortoise even for the purposes of taking measurements or determining its sex. A permit may also be required from the appropriate state wildlife resource agency (e.g., Arizona Game and Fish Department, California Department of Fish and Game, Nevada Department of Wildlife, Utah Division of Wildlife Resources). The Fish and Wildlife Service emphasizes that the surveyor should only estimate the size of all live desert tortoises encountered.

If the surveyor wishes to use a fiber-optic scope or video camera that is placed inside a tortoise burrow instead of or in addition to a hand-held mirror to investigate the desert tortoise shelter sites, you should contact the Fish and Wildlife Service at one of the offices listed above. We will need information on the type of equipment you will be using and your qualifications to use it. Improper use of such equipment may disturb or injure tortoises, damage shelter sites, and may promote the spread of disease. These actions may be considered as take under the Endangered Species Act. You should refer to the Desert Tortoise Handling Protocols for information on when and how to utilize these scopes to avoid the possible transmission of disease between tortoises.

The following format is recommended for recording transect data. (See Figure 3.) This format has been modified from the Bureau of Land Management's Interim

Figure 3 - Desert Tortoise Survey Form For Presence-or-Absence and Clearance Surveys

nuary 1992

a 4 X 6 photograph showing the
where the transect was conducted)

is form should be completed for those
ansects that contain one or more desert
rtoise sign. After the project site and
ne of Influence have been surveyed for
rtoise sign, the results from the transect
rms should be compiled on a summary form.

no tortoise sign occurs on the project site
Zone of Influence, the summary form should
completed. Please fill in all sections on
e top 2/3 of the page of the summary form.

M/D/Y
Date _____
Transect No. _____
State _____
County _____
City _____
Recorder _____
Address _____
Project Name _____
Type of Project _____
_____
Quad Name _____
Scale _____
Site Name _____
T_____ R_____ Sec____
¼ Sec_____ ¼¼ Sec_____
UTM Zone _____
Northing _____
Easting _____
Parcel No. _____

DESERT TORTOISE HANDBOOK 1992:
FORM FOR PRESENCE-OR-ABSENCE AND CLEARANCE SURVEYS

Project Site | | Zone of Influence | | _____ft from Project Site
ansect Length: _____ft Width: 30 ft Other _____ft Time _____
ather: Airtemp at: 5 cm_____°C Surface_____°C Cloud cover_____%
Rainfall_____in Wind speed_____ Rainfall in last 30 days_____in
r Form (e.g., mesa, bajada, wash)_____
% Slope: high_____ low_____ Aspect_____ Elevation_____ft
its_____
getation: dominant perennials_____
_____
dominant annuals_____
_____
jacent Land Use: up to 1 mi_____
Soils_____
Vegetation_____

Corrected Sign	Live Tortoises Adult/Juv.	TOTAL NUMBER OF Shelter Sites Pallet/Burrow/Den Active/Inactive [1]	Scats [2]	Shell Remains [3]
	A= J=		M= F= Unk=	A= J= Unk=

Tracks	Eggshell Fragments	Drinking Sites	Courtship Rings	Other	Neotoma Middens w/sign	:w/o sign
					:	

SIGNS OF HUMAN DISTURBANCE - NUMBER AND TYPES SEEN

Tire Tracks	Human Footprints	Dog Sign	Trash	Dump Sites	Shotgun/ Rifle Shells	Blading	Ravens	Other

January 1992

M/D/Y
Date_____
Transect No._____
State_____
County_____
City_____
Recorder_____
Project Name_____
_____
Parcel No._____

==========

INFORMATION ON SHELTER SITES

(Please indicate why you believe a shelter site is active or inactive[1])

Sign No.	Type	Location	Width	Estimated Length	Other Sign

Condition of Shelter Site[1]/Comments

==========

CONDITION OF SCATS[2] - COMMENTS (See below)

==========

CONDITION OF SHELL REMAINS[3] - COMMENTS (See below)

==========

SIGNS OF HUMAN DISTURBANCE-COMMENTS

January 1992

Show locations of types of tortoise sign on transect line below:

Drawing: Scale 1 in = _____ft Drawing or Map Reference No._____ Transect No. _____

Recorder_____ Date_____ Parcel No._____ Location_____

Techniques Handbook for Collecting and Analyzing Data on Desert Tortoise Populations and Habitats. One form is used for each transect where tortoise sign occurs. Pages 1, 2, and 3 of the form would be completed for each transect in the project site and the Zone of Influence where tortoise sign occurs. If additional space is needed, more forms may be used for each transect and stapled together.

If no tortoise sign is located during Presence-or-Absence Surveys for a proposed project, we recommend that the surveyor complete and submit a summary form (Figure 4) to the appropriate Fish and Wildlife Service office listed above.

Clearance Survey: For projects located in areas with habitat used by desert tortoises, especially those projects with a linear band of disturbance (e.g. pipelines, roads, transmission lines), a Clearance Survey may be required as part of a section 10 (a) (1) (B) permit. The purpose of the survey would be to temporarily relocate or salvage tortoises from the area of construction and any other areas deemed necessary to avoid or minimize the death of desert tortoises that may be caused by the project. A Clearance Survey would require full coverage of the project area and would focus on locating all desert tortoises above and below ground within the project area. The removal of tortoises would be conducted immediately prior to surface disturbance within the project area. The survey period would be stipulated in a section 10(a) (1) (B) permit.

Survey Time Period: Survey time for Presence-or-Absence Surveys is limited to the following approximate activity period of the desert tortoise, March 25 to May 31. This survey time may be extended by the Fish and Wildlife Service if tortoises on or near the project area have been observed above ground prior to March 25 or after May 31.

This survey window is based on the activity period for the desert tortoise throughout its range during a typical year and equates to the period of time when a tortoise is not brumating or aestivating. During dry years this activity period may be shorter and in wet years it may be longer. Desert tortoises may also become active during and after summer rains.

Surveys conducted outside this window will be subject to close scrutiny by the Fish and Wildlife Service. The Service may consider the results of these surveys as under-representing the number of tortoises on and use of the project site by desert tortoises.

Presence-or-Absence or Clearance surveys should only be conducted during daylight hours. Please do not collect any desert tortoise sign. Tortoise scats may be used by tortoises to mark or identify travel areas and shelter sites. Tortoise shells may be an important source of minerals for reptiles and mammals.

Qualifications of Surveyor: The Fish and Wildlife Service does not endorse any individual or company with respect to their abilities to conduct satisfactory surveys. We recommend the following criteria for selecting someone to conduct surveys to determine presence or absence of desert tortoises in a given area or recent use of the area by the desert tortoise.

Figure 4 - Desert Tortoise Survey Form For Presence-or-Absence and Clearance Surveys

January 1992

(Place a 4 X 6 photograph showing the area where the transect was conducted)

If no tortoise sign occurs on the project site or Zone of Influence, the summary form should be completed. Please fill in all sections on the top 2/3 of the page of the summary form.

M/D/Y
Date _____
Transect No. _____
State _____
County _____
City _____
Recorder _____
Address _____
Project Name _____
Type of Project _____
_____
Quad Name _____
Scale _____
Site Name _____
T_____ R_____ Sec__
¼ Sec_____ ¼¼ Sec___
UTM Zone _____
Northing _____
Easting _____
Parcel No. _____

SUMMARY FORM
FOR PRESENCE-OR-ABSENCE AND CLEARANCE SURVEYS
FOR DESERT TORTOISE SIGN

% Slope: high_____ low_____ Aspect_____ Elevation_____ft.
Land Form (e.g., mesa, bajada, wash)_____
Soils_____
Vegetation: dominant perennials_____
other species_____
dominant annuals_____
other species_____
Adjacent Land Use: immediate_____
Within 1 mi._____
Soils_____
Vegetation_____

Weather: Temperature - Air at 5 cm_____°C Surface_____°C Cloud cover_____%
Wind speed_____ Rainfall_____in. Rainfall in last 30 days_____in.

Corrected Sign	Live Tortoises Adult/Juv.	TOTAL NUMBER OF Shelter Sites Pallet/Burrow/Den Active/Inactive [1]	Scats [2]	Shell Remains [3]
	A= J=		M= F=	A= J= Unk= Unk=

Tracks	Eggshell Fragments	Drinking Sites	Courtship Rings	Other	Neotoma Middens w/sign	:w/o sign
					:	

SIGNS OF HUMAN DISTURBANCE - NUMBER AND TYPES SEEN

Tire Tracks	Human Footprints	Dog Sign	Trash	Dump Sites	Shotgun/ Rifle Shells	Blading	Ravens	Other

January 1992

SUMMARY FORM (continued)
FOR PRESENCE-OR-ABSENCE AND CLEARANCE SURVEYS
FOR DESERT TORTOISE SIGN

Comments/Drawings

As a general rule, a qualified desert tortoise surveyor is a biologist with a bachelors degree or graduate degree in biology, ecology, wildlife biology, herpetology, or related fields. He/she must have demonstrated prior field experience using accepted resource agency techniques to survey for desert tortoises. Field experience may mean a minimum of 60 days field experience searching for desert tortoises and tortoise sign.

The surveyor should have the following qualifications for the survey results to be accepted by the Fish and Wildlife Service:

1) ability to recognize and accurately identify all types of desert tortoise sign listed above, and 2) ability to carefully, legibly, and completely record all sign including size of shelter sites, shells, and estimated size of live tortoises.

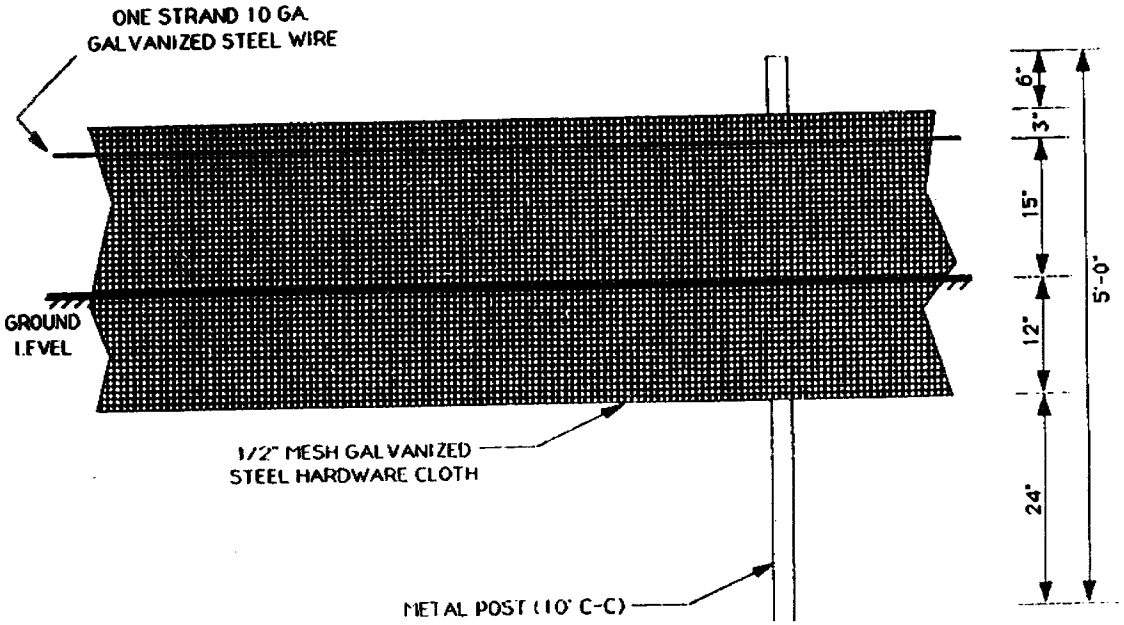
Reporting Survey Results (Survey Quality): To determine the accuracy of the surveyor in locating desert tortoise sign during Presence-or-Absence Surveys for each project area, the Fish and Wildlife Service recommends that the surveyor conduct an intensive survey in a portion of the project area following completion of the 100 percent survey. The size of the intensive survey area is 5 percent of the size of the project area. The intensive survey area would also receive 100 percent coverage using transects 10 feet wide rather than 30 feet or 5 feet wide rather than 10 feet wide. The location of the intensive survey would be plotted on the map and a comparison made between the sign recorded in this area during the 100 percent survey effort and the intensive survey effort. The quality or accuracy of the survey for the project area will be determined by comparing these two data sets for this area.

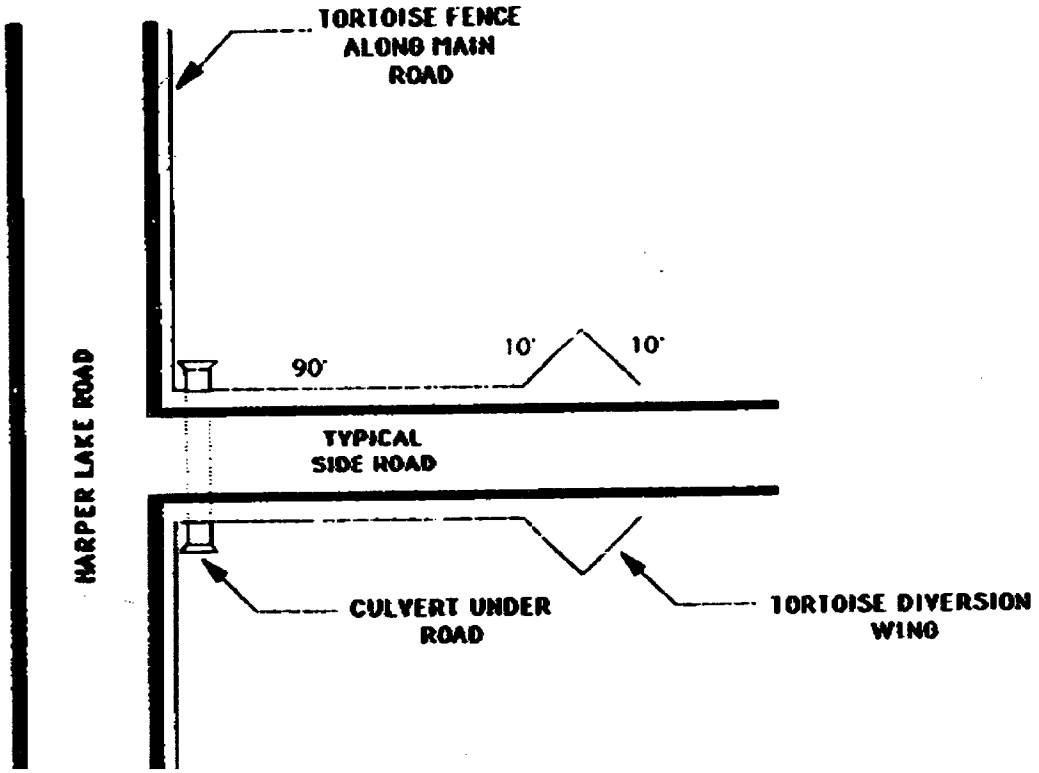
If the surveyor does not meet the minimal qualifications stated below or if there is a major difference in number of sign recorded between the intensive survey effort and the 100 percent survey effort, the survey may not be deemed adequate by the Fish and Wildlife Service.

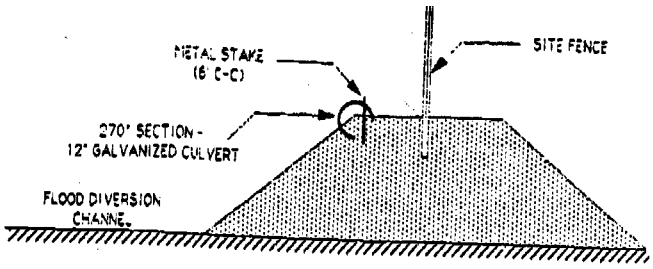
If the survey results do not include the Zone of Influence, the Fish and Wildlife Service may not concur with the survey results.

Tortoise Fence and Barrier Design

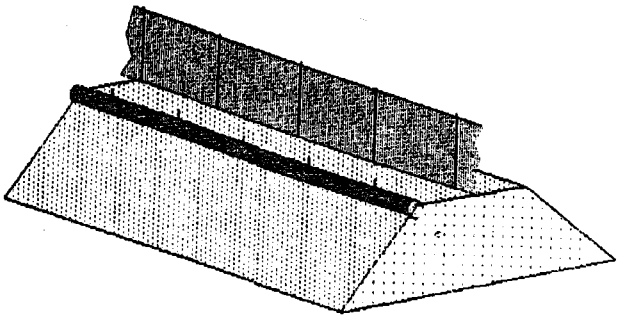
TORTOISE FENCE DESIGN





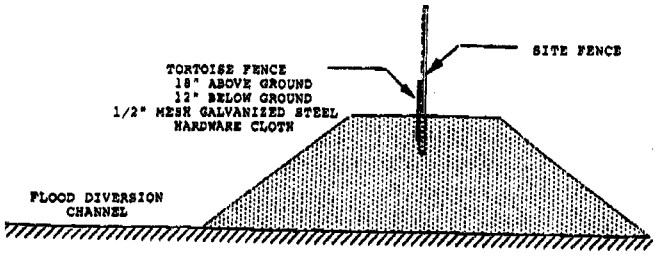


CROSS SECTION OF BERM

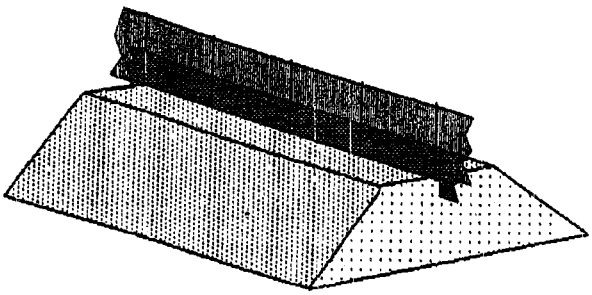


FLOOD DIVERSION BERM TORTOISE BARRIER

OPTION 1 - CULVERT BARRIER



CROSS SECTION OF BERM



FLOOD DIVERSION BERM TORTOISE BARRIER

OPTION 2 - TORTOISE FENCE

EXHIBIT 643

Evaluation of Evidence Supporting the Effectiveness of Desert Tortoise Recovery Actions

Scientific Investigations Report 2006–5143

U.S. Department of the Interior
U.S. Geological Survey

Inside cover page, blank.

Evaluation of Evidence Supporting the Effectiveness of Desert Tortoise Recovery Actions

By William I. Boarman[1], and William B. Kristan[2]

Scientific Investigations Report 2006–5143

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Sacramento, California
2006

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Contents

1. Introduction 1
1.1. Statement of problem 1
1.2. Need for scientific basis for management actions 1
1.3. Specific questions addressed 2
1.3.a. How much information is available to support recovery actions, and what kind of information is it? 2
1.3.b. Is the effectiveness of recovery actions well supported by scientific evidence? 2
2. Conceptual approaches 2
2.1. Variables examined 2
2.1.a. Classification of kinds of information 2
2.1.b. Tenets of reliable study design 3
2.1.c. Generality of results: Effectiveness at action and project levels 4
2.1.d. Ecological level of effectiveness: Individual or population 4
2.1.e. Sources of scientific information 4
2.2. Desert tortoises have a life history that greatly complicates studies of the effectiveness of recovery 5
2.3. Demonstration of effectiveness and tortoise recovery relationships 6
3. Methods 7
3.1. Kinds of information collected 7
3.2. Document assessment 8
3.3. Kinds of information not evaluated 9
4. Results 9
4.1. Kinds of information available 9
4.2. Reserves 12
4.2.a. Actions 12
4.2.b. Limits to our knowledge 12
4.3. OHV use 14
4.3.a. Actions 14
4.3.b. Limits to our knowledge 15
4.4. Grazing 15
4.4.a. Actions 15
4.4.b. Limits to our knowledge 16
4.5. Road mortality and barrier fencing 17
4.5.a. Actions 17
4.5.b. Limits to our knowledge 17
4.6. Mortality from construction activities 18
4.6.a. Actions 18
4.6.b. Limits to our knowledge 18
4.7. Habitat restoration 18
4.7.a. Actions 18
4.7.b. Limits to our knowledge 19
4.8. Translocation 19
4.8.a. Actions 19
4.8.b. Limits to our knowledge 19
4.9. Predator control 19
4.9.a. Actions 20
4.9.b. Limits of our knowledge 20

4.10. Other threats....20
4.11. Summaries of interviews with desert managers....20
5. Conclusions....21
5.1. Few studies have been designed specifically to evaluate the effectiveness of recovery actions....21
5.2. Recovery actions are necessary, but may not be sufficient....22
5.3. Strengths and weaknesses of available information....22
5.4. The absence of proof of effectiveness is not proof of ineffectiveness....22
6. Recommendations....23
6.1. Implement more scientifically-based monitoring of actions....23
6.2. Coordinate monitoring activities among projects to facilitate meta-analysis of effectiveness....23
6.3. Pursue peer-reviewed publication of effectiveness studies....23
6.4. Commission studies to assess tortoise population responses to recovery actions....23
7. Acknowledgments....23
References....24

Tables

1. Recovery actions and the threats that these actions are expected to reduce or eliminate....6

2. The relationship between observations of particular measures of effectiveness of a recovery action, and the assumptions that must be made to consider the action effective at the project level or at the action level. The rows in are arranged in order of increasing reliability....7

3. Offices visited by E. LaRue for document collection, and key personnel providing assistance and verbal input....8

4. Numbers of documents found in biologists' files pertaining to recovery actions that were either designed studies, or other forms of information....9

5. Characteristics of assessed documents....10

6. Possible threats to desert tortoises (from Boarman 2002), strength of the supporting evidence, and best-supported possible impacts....13

Abbreviations

BLM, U.S. Bureau of Land Management
BO, biological opinions
CMBC, Circle Mountain Biological Consultants
DMG, Desert Managers Group
DTNA, Desert Tortoise Natural Area
DTRPAC, Desert Tortoise Recovery Plan Assessment Committee
EAFB, Edwards Air Force Base
ESA, Endangered Species Act
Exper, Experimental
GAO, General Accounting Office
NA, not available
NPS, National Park Service
Observ, Observation
OHV, off-highway vehicles
RMP, resource management plan
USFWS, U.S. Fish and Wildlife Service

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1. Introduction

1.1. Statement of problem

As a federally threatened species, the desert tortoise's (*Gopherus agassizii*) recovery is required under the Endangered Species Act (ESA). According to the criteria established by the Desert Tortoise Recovery Plan (U.S. Fish and Wildlife Service 1994) for delisting the tortoise from ESA protection, the species as a whole will be considered recovered when tortoises have exhibited a statistically significant upward trend for at least one tortoise generation (25 years), enough habitat is protected to allow persistence, provisions are in place to maintain discrete population growth rates at or above 1.0, regulatory measures are in place to ensure continued management of tortoise habitat, and there is no longer reason to believe that the species will require ESA protection in the future. Just as species extinction can be thought of as the cumulative extinction of all populations, species recovery can be thought of as recovery of constituent populations; management efforts for recovery generally are implemented and assessed at the population level. A recent review of the Desert Tortoise Recovery Plan, including an exhaustive literature search, has been compiled by the Desert Tortoise Recovery Plan Assessment Committee (Tracy et al. 2004).

An important step in recovery planning is to identify known causes of mortality or reductions in fecundity, and to propose actions that will reduce or eliminate these threats to population persistence. Because populations change in size as individuals are added (through births or immigration into a population) or subtracted (through deaths or emigration out of a population), threats are identified by establishing that they cause reductions in births, increases in deaths, or changes in movements into or out of a population. However, once a threat has been identified there are several sources of uncertainty in formulating recovery actions. First, the severity of a threat may not be well established. For example, roads can be identified as a threat to tortoises by observing road-killed tortoises on highways, but the amount of road mortality observed may or may not be sufficient to reduce populations. If road mortality is not sufficient to cause a population decline, then reducing road mortality may have no effect on population recovery. Second, even if a threat is known to be sufficiently severe to cause tortoise population declines, there may be more than one possible approach to reducing the threat. For example, if road mortality is shown to be associated with reduced population size, building tortoise-proof fencing along highways is one possible (and commonly used) approach to reducing this threat. Other approaches are also possible, however. Roads could be closed, speed limits could be reduced, tortoise monitors could be employed to safely move tortoises across roads, or underpasses could be constructed to allow safe crossing. Each approach involves some investment of resources, and some may be more effective than others. Additionally, some approaches, such as speed limits and road closures, involve imposing changes on human behavior that may not be welcomed by the public.

Because of the diversity of possible approaches to desert tortoise recovery, it is important to assess whether the effectiveness of recovery actions is well supported. Additionally, because every recovery action entails costs (in dollars, time, resources, or public goodwill), it is important to evaluate whether actions are achieving the intended benefit. It also is important to evaluate how well managers' needs for scientific support are being met by the current state of knowledge. These issues were identified by a General Accounting Office (GAO) report in 2002, and remain issues today.

This current (2006) report was commissioned by the Desert Managers Group (DMG) to evaluate the state of knowledge about the effectiveness of desert tortoise recovery actions. To do this, we gathered and then critically examined the best available evidence of the effectiveness of recovery actions related to major threats to desert tortoises. This document can be viewed as an extension of Boarman's (2002) report in which the major threats to desert tortoise populations were described based on a thorough review of the literature.

1.2. Need for scientific basis for management actions

Population-level responses to recovery actions are intrinsically difficult to study in desert tortoises owing to their long generation time and low detectability (Tracy et al. 2004). However, recovery actions are likely to be most effective when they are based on scientific principles and reliable data. There are two typical situations in which knowledge about the effectiveness of recovery actions would be beneficial to resource managers. The first situation is that in which a manager must decide among several possible recovery actions. If studies of the effectiveness of various management options had been conducted, they would provide invaluable information in making such decisions, as well as in explaining and justifying the management action to line employees and the public. The second situation is one in which a recovery action has already been implemented, but the expected recovery has not occurred. Lacking reliable information about the effectiveness of the action, the manager cannot tell whether the action does not work in general, or has failed in the particular context because of other problems, such as additional threats that have not been addressed. However, if the effectiveness of the action has been conclusively documented, then the lack of recovery can be treated as de facto evidence that other threats are present, and the manager can immediately direct attention to identifying and reducing them. For example, if fencing along a road does not help in increasing tortoise populations (studies have shown that fencing reduces the incidence of road kills), then it becomes clear that other factors, such as disease, predation, or collecting, may be derailing the recovery. To have this level of confidence in a recovery action, however, ample supporting evidence must exist.

The GAO drew the distinction between demonstration of threat and demonstration of effectiveness of recovery (General Accounting Office 2002), and pointed out that the effectiveness of recovery actions already implemented was not known. In the absence of this knowledge, it was not possible to know if the limited resources were being wisely spent (General Accounting Office 2002). The effectiveness of particular recovery actions should be tested scientifically whenever possible. Pullin and Knight (2001) describe the "effectiveness revolution" in the British health-care system in which analysis of the effectiveness of different treatment courses is advocated to improve future decision-making. The authors point out a parallel to conservation biology, in which science and statistical analysis of the effectiveness of historic practices should serve as a guide for future efforts. The parallels they cite between medical and conservation practitioners are strong and bear repeating. Doctors treat their patients' critical health conditions under time pressure with limited information. Treatment decisions are based on an understanding of the relevant science (such as human anatomy and physiology), but prior to the effectiveness revolution there often was little basis for choosing the best treatment from among a range of possibilities. Personal experience was an important driver of treatment choices under these circumstances. However, personal experience may be of little use in detecting treatments that are ineffective because a patient's health can spontaneously improve, even in the absence of treatment; conversely, treatments effective in a majority of cases may fail to work for a given patient. Additionally, personal memory can subjectively review only a limited number of cases, which are probably an inadequate number of cases on which to draw conclusions, especially without filtering the data through statistical methods that eliminate biases. Similarly, resource managers must decide which recovery actions to implement from a range of possibilities and how to implement them, in spite of uncertainty. Basing management decisions on sound ecological principles is helpful, but more than one possible approach may be defensible.

1.3. Specific questions addressed

1.3.a. How much information is available to support recovery actions, and what kind of information is it?

One measure of whether resource managers are receiving adequate guidance from scientists in their management decisions is the number and type of studies that address the effectiveness of recovery actions. We searched available literature to determine whether studies of effectiveness were being conducted and to assess whether the information available to managers is based on scientific evidence. In the process, we attempted to gauge whether effectiveness evaluation and monitoring efforts taking place at local levels could be performed in a manner more conducive to scientific interpretation.

1.3.b. Is the effectiveness of recovery actions well supported by scientific evidence?

The results of well-planned scientific studies ultimately will be more useful in guiding management actions than will reports of an observational or anecdotal nature. Therefore, we rated the supporting evidence for the effectiveness of recovery actions and the reliability of the evidence relative to the scientific principles outlined in sections 2.1.a–d.

2. Conceptual approaches

2.1. Variables examined

Evaluating the effectiveness of management actions is a complicated process, with two important issues for managers to consider. The first issue to consider is the reliability of studies used to demonstrate effectiveness, which depends on the experimental methods employed. Before implementing an action based on previous studies, a manager should decide if the conclusions of the studies are justified based on the methods used to collect and analyze the data. The second issue is can effectiveness be evaluated at different levels? On the basis of the measures of impact that an investigator chooses, a study can document effects at the individual level or at the population level. The generality of the results can also be evaluated: results can be reliable at the level of a particular project ("project level") and at the level of the action in general ("action level"). If studies are to meet the needs of managers, the difference between action and project levels should be carefully considered at the experimental design stage, as demonstrating effectiveness at one level does not imply effectiveness at another (see section 2.1.c, below). In other words, a management action may reduce impacts to tortoises at a particular project site, but one cannot assume that the action will be effective for the entire population of tortoises that may be subject to that action.

2.1.a. Classification of kinds of information

Managers have a wide range of information available to employ in their decision-making. Boarman (2002) classified this information by type and by source as a guide to judging its scientific validity and reliability. Data types, described below, include experiments, correlations, descriptions or observations, anecdotes, and speculations.

Experiments: Experiments involve changing one or more variables and observing the result on one or more other variables. Experiments are widely considered to be the most reliable form of scientific information because direct manipulation gives the investigator greater certainty that the results are due to the manipulation, and not to some other unknown factor. Though experiments are the most reliable form of study, they are often impractical or impossible at the spatial and temporal scales required for population-level assessments and may be considered unethical or illegal for endangered species. For example, studying mortality factors on desert tortoises experimentally could require exposing tortoises to predators, a practice that would be at odds with recovery goals. Furthermore, experiments are often open to the criticism that their manipulations are not sufficiently similar to naturally-occurring situations to allow their conclusions to be readily applied to real populations.

Correlations: Correlational studies make observations of sets of variables that are not under the investigator's control, and infer the relationships among the variables based on patterns observed. Because the investigator does not make direct manipulations of variables, it is logically impossible to determine which variables are causing changes in others. For example, if A and B are correlated, it is possible that A causes change in B, that B causes change in A, or that changes in both A and B are caused by changes in another unmeasured variable, but have no causal relationship with one another. In practice this limitation is dealt with by applying additional biological knowledge to the system (for example, it is logical to hypothesize that raven predation could cause a decline in tortoise population sizes, but it is not logical to hypothesize that tortoise population declines are causing raven predation), and by studying problems from multiple perspectives with multiple independent data sets. A great advantage of correlational studies is that they capture and reflect natural variation, so that their applicability to real populations is easy to justify. Generally, it is considered best to conduct experiments when they are possible, to use correlational studies when experiments are not feasible, and ideally to use each to complement the other.

Description/observation: Observations are fundamental to science, but isolated observations made outside of a designed study are of limited value. Observations play a prominent role in developing scientific theories and testable hypotheses, and good, objective, detailed observations can make unique contributions to the descriptive scientific knowledge base (for example the first description of a new species). However, tests of hypotheses require designed studies.

Anecdotes and speculation: Anecdotes are stories, usually including both observations and conclusions about the meaning of the observations. Anecdotes are intrinsically less reliable than designed studies. Speculation is an unsupported, untested assertion, and clearly cannot substitute for designed studies as the basis for reliable management.

2.1.b. Tenets of reliable study design

Whether scientific studies are experimental or correlational, their reliability increases when they follow certain tenets of study design. These include control of extraneous variables, use of control groups, isolation of effects, and replication. Each of these practices addresses particular problems.

Controlling extraneous variables: From a purely theoretical perspective, the ideal experimental subjects are completely homogeneous and have identical reactions to experimental manipulation. However, real experimental subjects differ for a variety of reasons. At best, differences among experimental subjects make results less clear (and require statistics to detect experimental effects), and at worst, differences among subjects can be inadvertently confounded with an experimental treatment so that the apparent effect of the treatment is actually due to unrelated differences among subjects. Scientists deal with this problem by holding as many variables constant as possible, randomly assigning subjects to experimental groups, and by measuring variables that cannot be controlled so that their effects can be accounted for statistically. Field studies of wild populations must compromise on several of these guidelines; environmental variables cannot be held constant, but major sources of variation can be controlled by the experimental design. For example, the potentially confounding effects of habitat differences among sites can be minimized by careful site selection; likewise, temporal effects can be controlled by making observations of different treatments over an identical time frame. Environmental variation that cannot be eliminated through design choices can often be measured and removed statistically as "covariates" or "block effects."

Controls: In ecological studies "control" is used interchangeably with the term "comparison group," and is generally meant to signify the group that is not subjected to an experimental treatment. For example, in a study of the effects of fencing on road mortality, areas with fences would be designated "treatment" areas, and areas without fences would be the controls. Though this classic experimental concept of a control can be found in some scientific studies, there are also many variations. Sometimes it is logical to substitute "before and after" for "control and treatment," that is, to use the conditions before a treatment is applied as the control. However, this design does not control for changes over time, which in a temporally highly-variable environment such as the Mojave Desert, can cause problems of interpretation. Some studies have more than one type of control; for example, making comparisons between treated and untreated sites before and after a treatment is applied provides a control both for spatial and temporal differences among subjects. Finally, it is also valid to compare subjects that have received different levels of a treatment without a true untreated control.

Isolation of effects: Just as it is necessary to control extraneous variables, multiple variables of interest can interfere with one another and make results difficult to interpret. For example, a fence that simultaneously reduces road mortality, removes off-highway vehicles (OHVs), and removes livestock may increase tortoise population size, but it will not be possible to tell whether the improvement is due to the removal of one single threat or due to some combination of the three; only a general treatment effect can be claimed. If the desired effect is achieved in a management context, this problem may not be viewed as important; for example, if fencing always reduces the same set of threats, and desert tortoises always respond positively, then the details of how the effect was achieved may be uninteresting. However, studies that fail to isolate effects can provide little guidance if the action is applied and a recovery does not occur. Additionally, when effects are not isolated, studies provide little basis for resolving disputes among stakeholders who may only be responsible for an unknown proportion of the overall problem.

Replication: Different experimental subjects may respond differently to treatments. The best way to ensure that observed results are reliable is to apply the treatment to a number of different subjects, in other words to "replicate" the experiment. Although this is conceptually straightforward, what constitutes replication changes depending on the question being asked or the population about which conclusions are to be drawn. This problem was highlighted by Hurlburt (1984), who coined the term "pseudoreplication" to describe replication at the wrong level. For example, repeated observations (e.g., multiple transects, multiple individual tortoise home ranges, etc.) of the effects of a single project on a population can be considered replicates only if the conclusions are limited to the population of individuals exposed to that particular project (i.e., "project level"; see 2.1.c, below). However, to draw general conclusions about the effectiveness of the action (i.e., "action level"; see 2.1.c, below), the projects themselves are considered replicates, and although multiple observations within a project may increase the precision of measurement, only observations of additional projects are truly replicates that can be used to statistically assess the action.

2.1.c. Generality of results: Effectiveness at action and project levels

The effectiveness of recovery actions can be demonstrated at two levels: action level and project level. Action level refers to the broad area in which an action is applicable (e.g., all tortoise habitat can be subject to an action such as removal of grazing); project level refers to a specific place or study area (e.g., the Pilot Knob grazing allotment). To determine effectiveness at an action level, studies of the effects of the action must be conducted across a variety of conditions, with the action serving as the experimental unit (Hurlburt 1984). For example, a study of the effectiveness of 1 cm^2 hardware cloth used as a tortoise-proof fencing material can be conducted, and the results can then be generalized to any case in which conditions are expected to match those of the study. However, conditions at a project site may be sufficiently different from those of the original study so that the fencing material may work poorly; for example, the material may degrade and develop holes too rapidly, local populations may exhibit a different behavioral response to the material, or the material may clog with debris so that animals can climb over it. At a specific project level, then, the material may prove not to be effective. Conversely, studies of single projects can show that actions were effective under conditions present at the site, but may not generalize well to other circumstances. For example, studies of the effects of fencing at a single location with a single fence type, based on measurements of mortality at several locations within the fenced area, can yield reliable information about the effectiveness of that particular project, but the results may not generalize well to fencing as an overall recovery action, and thus may be weak evidence of effectiveness at the action level. As Pullin and Knight (2001) point out, results from several project-level studies can sometimes be combined (using a statistical technique called "meta-analysis") to demonstrate effectiveness across a variety of conditions, and collectively the results may form strong evidence of effectiveness at an action level.

2.1.d. Ecological level of effectiveness: Individual or population

Individuals die, mate, reproduce, and encounter barriers, whereas populations increase, decrease, or remain stable. Removal of threats that are known to impact individuals is a logical approach to species recovery, but whether reduction in individual impacts actually translates into increased population size depends on multiple factors (see section 2.3). Studies of individual impacts, therefore, can be well-designed and reliable, but not qualify as a demonstration of effectiveness at a population level. For example, experimental studies of effectiveness of barrier fencing at blocking tortoise movements and reducing tortoise road mortality may be highly reliable, but without additional data on changes in population size or demographic health of a fenced population, such studies cannot indicate effectiveness at the population level.

2.1.e. Sources of scientific information

Outlets for scientific information are numerous and diverse. Following the classification used by Boarman (2002), sources of information include (1) peer-reviewed open literature, (2) technical books, (3) theses and dissertations, (4) non peer-reviewed open literature, (5) technical reports, (6) unpublished data, (7) professional judgment, and (8) "science lore." The first major division among these sources of information is between information that is based on designed scientific

studies (sources 1 to 5, possibly 6) and information that is based on personal opinion (sources 7 and 8). Sources 1 through 6 differ primarily in the degree of peer review. Peer review is the primary mechanism by which the quality of scientific information is judged and controlled. Though peer review is a highly individualistic exercise, reviewers are expected to evaluate whether the methods employed were appropriate, the samples sizes were adequate and the conclusions drawn follow logically from the experimental results. Although peer review does not guarantee quality, knowing that other experts have found the methods to be appropriate and that the conclusions are supported by the data substantially enhances confidence in a study, particularly if it is outside of one's area of expertise.

2.2. Desert tortoises have a life history that greatly complicates studies of the effectiveness of recovery

The most definitive evidence of the effectiveness of a recovery action is the demonstration that a population has recovered after an action was implemented. Although this level of support for recovery is desirable, desert tortoise managers frequently either will have to accept less stringent support for an action or be paralyzed by uncertainties. Demonstrating effectiveness of a recovery action is complicated by the life history of the desert tortoise. Tortoises are slow-growing and have delayed sexual maturity (Woodbury and Hardy 1948). Mortality, fecundity (summarized by Doak et al. 1994), physiology (Naegle 1976), and movements (Coombs 1977, Berry 1978) are all age and size dependent, yet younger, smaller tortoises are notoriously difficult to study (Berry and Turner 1986). Viability analysis requires large amounts of data, but the necessary parameters are rarely available for single populations that are exposed to a recovery action (Doak et al. 1994). Sensitivity of population growth to changes in demographic parameters varies by size class, and in desert tortoises, survival of older, reproductive individuals is most important for population growth (Doak et al. 1994). Consequently, reducing a threat to juveniles may have little effect on population recovery unless accompanied by a reduction in adult mortality (Congdon et al. 1993). Finally, tortoise populations grow slowly, and thus population-level responses to recovery actions may not be observed until many years after the action is taken, which is in sharp contrast with studies documenting threats (Boarman 2002). Many threats to tortoises, such as mortality and habitat damage, can be documented as they are occurring. It is often possible to observe immediate changes in levels of a threat after a recovery action is implemented (for example, tortoise-proof fencing should immediately reduce road mortality), but to document population-level recovery, data must be collected and analyzed for longer time periods. In this sense, it is intrinsically more difficult to measure the effectiveness of recovery actions on desert tortoises than it is to identify threats.

Another reason that documenting the effectiveness of recovery actions for desert tortoises is difficult is that they are subject to multiple threats simultaneously in many parts of their range, making the effectiveness of actions designed to address single threats difficult to gauge (Tracy et al. 2004). When multiple threats are affecting a population, removing a single threat will not increase the population size if other limiting factors remain; removing a single threat may be necessary to increase population size, but it alone may not be sufficient. As Leibig's Law of the Minimum (Huston 2002) states, a population will increase only to the point that the most limiting factor allows; consequently, removing a threat that is not the limiting factor will not increase the population size. Under these circumstances, the effectiveness and necessity of removing a single threat would be masked. For example, desert tortoise populations have continued to decline in the Desert Tortoise Natural Area (DTNA) in spite of perimeter fencing, with disease possibly being the leading cause of the decline (Berry 1997). The lesson from the DTNA is not that perimeter fencing was an unnecessary action, but that it was not sufficient in the face of other uncontrolled threats to the population. Similarly, the concept of compensatory mortality is commonly used in wildlife population biology to explain how mortality from harvesting can be sustained without reducing population size in a density-dependent population (Nichols et al. 1984). Under this paradigm, when animals die from human causes that would have died anyway from density-dependent natural causes, human-caused mortality is considered "compensatory" and will not reduce population size. Applied in the context of population recovery, compensatory mortality implies that if one mortality factor is removed there may be no net gain if other factors remain in place. Under both Leibig's Law and compensatory mortality, it is conceivable that a recovery action could reduce a threat without recovering the population. In either case, known threats should not be left in place. Multiple threats should be addressed simultaneously and as many threats as possible removed to affect population recovery.

Table 1 lists recovery actions that are commonly used or that have been proposed for use for desert tortoises. Many actions, such as fencing, affect multiple threats simultaneously (e.g., vehicle traffic and grazing), whereas other actions, such as predator control, are targeted at specific threats. For still other threats, such as disease, there currently are no recovery actions available to remove the threats, though preventative measures, such as safe handling procedures and public education, may be implemented (Berry 1997). Finally, threats may interact, such that removing anthropogenic threats could hypothetically reduce disease mortality by reducing stress on the tortoises.

Table 1. Recovery actions and the threats that these actions are expected to reduce or eliminate.

Action	Threat
Fencing (for animals)	Grazing, wild horses and burros, road mortality, wild dog or coyote mortality, utility corridors
Stocking level reduction	Grazing
Closures (to humans, seasonal or permanent)	OHVs, mining, military operations, agriculture, recreation, waste disposal, poaching, utility corridors, noise and vibrations
Habitat restoration	Grazing, OHVs, construction, mining, recreation, wild horses and burros, utility corridors, invasive plants, drought
Reduction of vehicle speed limits	Construction, mining, recreation, waste disposal
Translocation	Construction, mining, low population size or local extirpation, disease, military activities
Choosing prescribed burn season	Fire-caused mortality
Predator control	Mortality from feral dogs, ravens, or coyotes.
Feral animal control	Wild horses and burros, feral dogs
Law enforcement	Poaching, handling, collection, unauthorized OHVs
Culvert installation	Road mortality, population fragmentation
Land acquisition	Inadequate protection from many of the threats listed above

Taken together, the slow response of desert tortoise populations to recovery actions, along with the compounding effects of having multiple threats acting in concert or multiple recovery actions implemented simultaneously, make the effectiveness of individual recovery actions difficult to discern. These complexities should be taken into account when interpreting data, with sophisticated statistical methods used to isolate effects.

2.3. Demonstration of effectiveness and tortoise recovery relationships

It is important to define the goals of recovery actions so that their effectiveness can be assessed. For example, the recovery action of fencing the perimeter of the DTNA, which provides protection from OHVs and grazing and habitat destruction, is meant to maintain existing, fairly healthy populations. Successfully implementing actions and maintaining closed areas may be sufficient for success in this instance. In contrast, other recovery actions, such as habitat restoration and individual animal translocation, are meant to increase the size of a previously reduced population, and in these cases, success is judged by whether the population increases in response to the action.

Pullin and Knight (2001) describe a hierarchical system of judging the reliability of evidence of effectiveness based on study design criteria. For this current study, in addition to considering design issues, we also considered whether previous studies addressed individual-level effects or population-level effects. *Table 2* identifies the necessary assumptions in considering a result to be a demonstration of effectiveness of a recovery action, by combining both the reliability of studies and the level (individual vs. population) at which effectiveness is assessed. To illustrate, the intended outcome of fencing a road with hardware cloth designed to exclude tortoises is to increase the tortoise population by reducing road mortality. If the fence is constructed but the effects are not monitored, then confidence that the action is effective depends on (1) the assumption that road mortality is a real threat to tortoise populations; (2) that this mortality is the primary factor limiting a local tortoise population increase; and (3) that this recovery action effectively removes or reduces the limitation (Table 2, rows 2 and 3). If a declining incidence of road mortality is observed by follow-up monitoring, then fewer assumptions are needed to consider the fence effective. The action of fencing thus represents a step toward recovery only if road mortality was previously known, or can be assumed, to reduce the tortoise population in the first place (Table 2, row 3). If road mortality has been demonstrated to be associated with reduced tortoise populations, then confidence that reducing road mortality is necessary for recovery is increased (Table 2, row 4). However, this step alone may not be sufficient if other threats are limiting population recovery. Adding information about population size behind the fence increases confidence that the action has released the population from a limiting factor (Table 2, row 5). However, increases

in population size could be due to changes in movements and immigration rather than to changes in mortality rates. Demographic monitoring can demonstrate that local mortality rates have declined, and estimates of the expected effects on population growth rate can be estimated (Table 2, row 6). The assumptions necessary to conclude that the fence has been effective become much less stringent, but might include the assumption that improvements in local demographic performance are contributing to local recruitment rather than to increasing emigration rates. If increased demographic performance is coupled with increased population sizes, then the only remaining assumption would be that the population is viable (Table 2, row 7). Finally, if the assumption that the population is viable is supported by a population viability analysis, this confirms that the population has recovered as a result of the action taken (Table 2, row 8).

Table 2. Relationship between observations of measures of effectiveness and the assumptions made.

[The rows are arranged in order of increasing reliability. Each successive row includes additional observations that more strongly support the effectiveness of an action. See section 2.3 for further explanation]

Observation	Assumptions needed to conclude action was effective
An action is implemented to address a putative threat, but effect is not observed	Putative threat is really a threat, is the limiting factor, and the action removes the limitation.
An action is implemented to address a known threat, but effect is not observed	Threat is the limiting factor, and the action removes the limitation.
Reduction or elimination of a putative threat	Putative threat is a real threat and is the limiting factor.
Reduction or elimination of a known threat	Threat is the limiting factor.
Increased population size	Increased numbers are due to improved demographic performance, rather than re-distribution of tortoises, changes in observability, etc.
Improved demographic performance	Assumes that the change in survival and/or fecundity will increase the population, rather than increasing emigration, etc.
Improved demographic performance and increased population size	Assumes that the improvements create a viable population.
Improved demographic performance, increased population size, and viable population (Population Viability Analysis, PVA, observations over time)	None (recovery is observed)

3. Methods

3.1. Kinds of information collected

Information was collected from a variety of sources. We searched peer-reviewed journals and books for studies that dealt with the effects of recovery actions on desert tortoises or with the effectiveness of recovery methods in general that might be applied to desert tortoise recovery. These included title and keyword searches in the BIOSIS Previews database (which covers materials published from 1969 to the present), and Web of Science searches for articles that cited papers dealing with desert tortoise recovery (coverage from 1975 to the present). We looked through all proceedings of symposia published by the Desert Tortoise Council, which is the primary source of scientific information about desert tortoise management. Additionally, Ed LaRue (U.S. Bureau of Land Management) visited biologists' offices at the U.S. Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS), the National Park Service (NPS), the California Department of Parks and Recreation, the U.S. Marine Corps, and the U.S. Navy, which are located throughout the Mojave Desert in California (*Table 3*). During these visits, biologists' files were examined, and two kinds of documents were obtained. The first type of document reported on scientific studies that could be used as support for the effectiveness of recovery actions. These included published articles, unpublished reports, and monitoring reports that were based on a designed sample (as opposed to qualitative observations). Reviewers of drafts of this current report suggested additional documents that could be used for support. These documents were assessed for reliability (see section 3.2 below). The second type of document detailed monitoring efforts at a particular management unit, such as memos and internal reports of permit compliance. These documents were not assessed individually, but were used as a measure of the observation effort expended on desert tortoises across the region. Ed LaRue also interviewed representatives at each office to determine whether any additional monitoring was conducted that would be useful that had not been documented or that was documented elsewhere (for example, by independent researchers conducting studies within the management unit). The entire bibliographic database of these documents is available in the U.S. Department of Interior, BLM files.

Table 3. Offices visited by E. LaRue for document collection, and key personnel providing assistance and verbal input.

Agency, City	Key Personnel Providing Input
Bureau of Land Management, Barstow	C. Sullivan, A. Chavez, C. Burns
Bureau of Land Management, Needles	G. Meckfessel, K. Allison, L. Smith
Bureau of Land Management, Ridgecrest	J. Aardahl, B. Parker, J. McEwan
California Department of Parks and Recreation	M. Faull
U.S.Marine Corps, Marine Corps Air-Ground Combat Center	R. Evans, B. Husung
U.S. Navy, China Lake	T. Campbell
U.S. Air Force, Edwards Air Force Base	M. Hagan
U.S. Army, Fort Irwin	M. Quillman
National Park Service, Joshua Tree National Park	A. Fesnock, C. Collins
U.S. Fish and Wildlife Service, Carlsbad	M. McDonald, D. Miles
U.S. Fish and Wildlife Service, Ventura	R. Bransfield

3.2. Document assessment

For each document collected, we recorded the kind of action taken, following categories described by Boarman (2002), and the findings and conclusions of the study. Documents reporting on designed studies were evaluated for reliability and on whether the individual study assessed the "project" or the "action" level of effectiveness. Reliability of the study results was assessed by determining whether the following tenets of experimental design were included in the study: experimental manipulation, use of controls, and replication. The level of effectiveness assessed by a study was determined by observing the replication level (project, action) and the level at which the observations were made (e.g., individual tortoises, tortoise populations, tortoise habitat). Some documents reported on more than a single measure of effect (e.g., effects of grazing on diet breadth and on population size), and thus the number of documents evaluated was less than the number of studies. Multiple documents could be produced from studies of a single population over time. To avoid inflating the document count, we evaluated only final reports, when available, or the most recent draft reports from long-term studies. Follow-up studies were considered separate studies (for example, studies at grazing exclosures in the Ivanpah Valley that were separated by 10 years were considered two different studies).

3.3. Kinds of information not evaluated

We concentrated on studies related to changes following a recovery action so as not to repeat Boarman's (2002) analysis of threats; thus, reports of tortoise mortalities due to known threats were not evaluated. Furthermore, we did not evaluate popular articles, information circulars, and pamphlets because they were intended as interpretive tools for the general public and therefore did not present new results that would be useful to our efforts. Finally, for logistic reasons, we limited our search of offices to California. Although documents were collected regardless of study location, papers and reports from Nevada, Arizona, and Utah are underrepresented in our sample.

4. Results

4.1. Kinds of information available

Of the 395 documents obtained in our search of biologists' files and published literature, 151 were directly relevant to recovery actions. Of these, 45 were reports of designed studies and 104 were other kinds of relevant information (*Table 4*), such as permit compliance reports, letters, memos, and other materials that dealt with implementation of recovery actions. Several of these 45 documents addressed more than one treatment or more than one measure of effectiveness, such that we assessed 54 measures of the effectiveness of recovery actions (*Table 5*). Although not designed as an exhaustive enumeration of the individual study materials found, collected data indicate little information on implementation of recovery actions arising from designed scientific studies. This impression was further reinforced by interview data that showed that many agency biologists knew that recovery action implementation was occurring without any follow-up monitoring.

On the basis of Boarman (2002), we selected several significant issues related to desert tortoise recovery. These are listed in sections 4.2 through 4.9 below, along with (1) a description of the related management actions; (2) an assessment of the strength of the evidence that the actions are effective in reducing threats; and (3) a discussion of the limits to our current knowledge on the subject.

Table 4. Numbers of documents found in biologists' files pertaining to recovery actions that were either designed studies, or other forms of information.
[See Table 5 for list of documents of designed studies]

Topic	Other documents	Designed study	Total
Construction compliance	30	4	34
Grazing	15	5	20
Guzzlers	1		1
Habitat change	1		1
Habitat restoration	7	2	9
Headstarting		1	1
OHV closure	14	3	17
OHV route marking	8	14	22
Perimeter fence	8	1	9
Predator control	1	1	2
Reserve establishment		3	3
Road closure	1		1
Shooting	1		1
Tortoise fencing	2	5	7
Translocation	15	6	21
Total Result	104	45	149

Table 5. Characteristics of assessed documents.
[Explanations of terms are in text. OHV = off-highway vehicles, Observ. = Observation, Exper. = Experimental]

Author	Action	Measure	Finding	Study type	Replication	Replication level	Control
Avery 1998, Avery and Neibergs 1997	Exclude grazing	Habitat	Positive	Exper.	Replicated	Project	Yes
	Exclude grazing	Tortoises	Positive	Exper.	Replicated	Project	Yes
Baxter 1986	Translocation	Homing	Negative	Exper.	Replicated	Project	No
Berry et al. 1999	Fencing reserve	Population	Positive	Observ.	Replicated	Project	Yes
Boarman and Sazaki 1996	Tortoise fencing	Tortoises	Positive	Exper.	Replicated	Project	Yes
	Tortoise fencing	Population	Positive	Exper.	Replicated	Project	Yes
Bowser et al. 1997	Restore habitat	Habitat	Positive	Exper.	Unreplicated		No
Brooks 1995	Fencing reserve	Habitat	Positive	Exper.	Replicated	Project	Yes
Burge 1986	Post routes	Habitat	Negative	Observ.	Replicated	Project	Yes
Bury and Luckenbach 2002	OHV	Habitat	Positive	Observ.	Replicated	Project	Yes
	OHV	Tortoises	Positive	Observ.	Replicated	Project	Yes
Campbell 1981, 1985	Fencing reserve	OHV use	Positive	Observ.	Replicated	Project	Yes
	Fencing reserve	Shooting	Positive	Observ.	Replicated	Project	Yes
	Fencing reserve	Hunting	Positive	Observ.	Replicated	Project	Yes
Circle Mountain Biological Consultants 1994	Post routes	Tortoises	Positive	Observ.	Replicated	Project	No
	Post routes	Burrows	Positive	Observ.	Replicated	Project	No
	Post routes	Habitat	Positive	Observ.	Replicated	Project	No
EnviroPlus Consulting 1995	Tortoise fencing	Tortoises	Positive	Exper.	Replicated	Action	Yes
Everett et al. 2001	Predator control	Capture rate	Negative	Exper.	Replicated	Project	No
Field et al. 2002	Translocation	Survival	Positive	Exper.	Replicated	Action	Yes
	Translocation	Tortoises	Uncertain	Exper.	Replicated	Project	Internal
Fusari et al.1981	Tortoise fencing	Tortoises	Positive	Exper.	Replicated	Action	No
Goodlett and Goodlett 1993	Post routes	OHV use	No effect	Observ.	Replicated	Project	Yes
Guyot and Clobert 1997	Tortoise fencing	Tortoises	Positive	Exper.	Replicated	Project	No
	Translocation	Tortoises	Positive	Exper.	Replicated	Project	No
Kazmaier et al. 2001	Exclude grazing	Population	No effect	Exper.	Replicated	Action	Yes
	Exclude grazing	Tortoises	No effect	Exper.	Replicated	Action	Yes
Kutiel 1999	OHV	Habitat	Positive	Observ.	Replicated	Project	Yes

Table 5. Characteristics of assessed documents–Continued.
[Explanations of terms are in text. OHV = off-highway vehicles, Observ. = Observation, Exper. = Experimental]

Author	Action	Measure	Finding	Study type	Replication	Replication level	Control
Larsen et al. 1997	Exclude grazing	Habitat	Uncertain	Exper.	Replicated	Project	Yes
LaRue and Dougherty 1999	Construction	Tortoises	Positive	Observ.	Replicated	Meta analysis	No
Medica 1994a	Post routes	Habitat	Negative	Observ.	Replicated	Project	Yes
Medica 1994b	Post routes	Habitat	Negative	Observ.	Replicated	Project	Yes
Medica et al. 1982, Turner et al. 1981	Exclude grazing	Habitat	Uncertain	Exper.	Replicated	Project	Yes
	Exclude grazing	Tortoises	Positive	Exper.	Replicated	Project	Yes
Miller-Allert 2000	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
Miller-Allert 2001	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
Morafka et al. 1997	Protect hatchlings	Hatchling survival	Positive	Exper.	Replicated	Project	Yes
Mullen and Ross 1996	Translocation	Tortoises	Positive	Exper.	Replicated	Project	Yes
Musser 1983	Post routes	Habitat	Positive	Exper.	Replicated	Project	No
Nicholson and Humphreys 1981	Exclude grazing	Habitat	Negative	Observ.	Unreplicated		Yes
Olson 1996	Construction	Tortoises	Uncertain	Observ.	Unreplicated		No
Olson et al. 1992	Construction	Survival	Mixed	Observ.	Replicated	Project	No
Ruby et al. 1994	Tortoise fencing	Tortoises	Positive	Exper.	Replicated	Action	Internal
Sazaki et al. 1995	Tortoise fencing	Tortoises	Positive	Observ.	Replicated	Project	No
Stewart 1993	Translocation	Weight change	Positive	Exper.	Replicated	Project	Yes
	Translocation	Survival	Positive	Exper.	Replicated	Project	Yes
Stewart and Baxter 1987	Translocation	Survival	Positive	Exper.	Replicated	Project	No
BLM 1984	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
Walker and Mastin 1999	Post routes	Habitat	Positive	Observ.	Replicated	Project	Internal
BLM 2000a	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
BLM 2001b	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
BLM 2002	Post routes	Habitat	Mixed	Observ.	Replicated	Project	No
Woodman 1986	Post routes	Habitat	Negative	Observ.	Replicated	Project	No
	Post routes	Tortoises	Positive	Observ.	Replicated	Project	No

4.2. Reserves

4.2.a. Actions

Dedicated reserves are areas in which public access is controlled or eliminated, and in which management is directed solely to protection of the desert tortoise. Establishment of dedicated reserves provides increased protection for tortoise populations against multiple threats (e.g., OHVs, mining, military operations, agriculture, etc.; *Table 1*). The 1994 USFWS Desert Tortoise Recovery Plan emphasized effectively protecting large areas containing healthy tortoise populations as a significant recovery action. Protecting habitat is perhaps the least controversial action from an ecological perspective, in the sense that a species' dependence on suitable habitat for persistence is true by definition. However, design of a reserve is a complex issue, requiring a great deal of basic information on life history, ecology, and population genetics of the species. A great deal of research effort has been expended to build the necessary knowledge base for successful reserve design; reviewing this information was beyond the scope of this report. Landscape-scale planning is proceeding (Tracy et al. 2004), but the effectiveness of an entire reserve network ultimately is judged by the recovery of a species. At a finer scale, the effectiveness of a reserve network depends on the effectiveness of its components at maintaining populations, and at this scale, data on effectiveness are available.

Before completion of the recovery plan, the DTNA (established in 1980) was the only dedicated reserve for desert tortoises and has been the focus of intensive study. Much is known about the tortoise population, habitat, and behavior there (Berry 1997, Brooks 2000). Reserve fencing and patrolling of the DTNA perimeter has reduced human use of the area, and thus reduced threats such as shooting and unauthorized OHV travel within its boundaries (Campbell 1981). Fencing of the reserve has also reduced unauthorized livestock grazing and improved tortoise habitat characteristics (Brooks 2000). In addition, it has increased (1) annual and perennial plant biomass, cover, and diversity of natives, (2) soil seed biomass, (3) nocturnal rodent density and diversity, (4) breeding bird abundance and species richness, and (5) lizard abundance and species richness (Brooks 1992, 1995, 1999a, 1999b). Fencing also has decreased (1) biomass of alien annual plants, and (2) an abundance of black-tailed hares (*Lepus californicus*). The DTNA perimeter fence is not tortoise-proof, so individuals that move outside of the reserve are still subject to impacts.

The DTNA illustrates two vexing points about measuring the effectiveness of recovery. First, it is impossible to assess the relative effects on tortoises of each of the several changes that occurred in the DTNA as a result of establishing it as a reserve. A change in population size could be attributed to the "treatment effect" of fencing, but the relative contribution of factors such as reduced grazing versus reduced OHV use could not be determined without additional studies that isolate these effects. Second, although there are no known detrimental effects of establishing reserves, the tortoise population in the DTNA has, in fact, declined (Berry et al. 1999). Uncontrolled threats, such as disease, drought, and predation, may explain this paradoxical outcome (Berry 1997). Similarly, following establishment of the Red Cliffs Desert Reserve within the Upper Virgin River Recovery Unit, Utah, in 1996, tortoise populations were stable for several years (McLuckie et al. 2002). However, after a drought year in 2002, tortoise populations declined by 40%. This population has also been subject to URTD infection, which may have contributed to the decline in numbers (K. Berry, pers. comm.). These two well-studied cases demonstrate the complexities of studying population responses to multiple factors. These declines in the tortoise population have made it difficult for researchers to use the DTNA as evidence of the general importance of establishing reserves.

4.2.b. Limits to our knowledge

Of all of the recovery actions taken, establishing reserves is the one most likely to receive unanimous agreement among biologists as an appropriate measure to undertake. Experiences at the DTNA and Red Cliffs have shown that even the best-supported practices can fail to produce the expected result if other threats are not controlled. Reserves theoretically have the advantage of simultaneously reducing multiple threats, but inferences about the importance of particular threats and the effects of implemented actions to address these threats can be difficult. Furthermore, whether desert tortoise reserves protect isolated populations and/or function as part of a network of interacting populations is not currently known.

Table 6. Possible threats to desert tortoises (from Boarman 2002), strength of the supporting evidence, and best-supported possible impacts.
[OHV, off-highway vehicle; NA, not available]

Individual threats	Strength of evidence	Best supported possible impact
Agriculture	Weak	Habitat loss
Collecting	Weak	Direct mortality[1]
Construction	Strong	Habitat loss, burrow damage, direct mortality
Disease	Weak	Direct mortality
Drought	Weak[2]	Dehydration, predation[3]
Energy and mineral developments	Strong	Habitat loss, direct mortality during construction
Fire	Strong	Habitat loss, habitat degradation, direct mortality
Garbage and litter	Weak	Direct mortality
Handling and deliberate manipulation	Weak	Water loss
Invasive plants	Strong	Habitat degradation[4]
Landfills	Strong	Direct mortality[5]
Livestock grazing	Strong	Direct mortality[6], burrow damage[7], habitat degradation[8], food competition
Military operations	Strong	Habitat loss, direct mortality
OHV	Strong	Reduced tortoise density, habitat degradation, direct mortality, soil compaction, soil erosion
Predation/raven predation/subsidized predators	Strong[5]	Direct mortality
Non-OHV recreation[9]	NA	NA
Roads, highways, and railroads	Strong	Habitat loss, habitat degradation, direct mortality, population fragmentation
Utility corridors	Strong	Habitat loss, direct mortality, increased predation risk[10]
Vandalism	Strong[11]	Direct mortality
Wild horses and burros	Unstudied	

[1]Removal of animals from the population (functional mortality, if not actual mortality).
[2]Tortoises are expected to be adapted to drought, but it may make them more susceptible to other stressors.
[3]Coyotes may increase predation on tortoises as preferred prey become less common.
[4]That grasses are less nutritious than forbs is well established, but the effects of introduced grasses on tortoise habitat quality and population size is less well studied.
[5]Increased raven numbers and increased risk of raven predation are well-established. Consequences of raven predation to tortoise population size are less well-studied.
[6]Few mortalities observed, but damage to styrofoam tortoise models indicates rates can be high.
[7]Rates of burrow damage depended on tortoise size, with juvenile and immature burrows more susceptible to damage than adult burrows.
[8]Changes in soils and in vegetation structure and composition.
[9]Largely unstudied as a group, though several possible activities (such as target shooting) are included in other categories.
[10]Transmission towers may facilitate raven population growth in areas previously lacking nesting substrates.
[11]That tortoises are killed is well supported, but the population-level consequences are not known.

4.3. OHV use

4.3.a. Actions

Boarman (2002) identified several studies that measured impacts of OHVs on desert habitat; he cited the study by Bury and Luckenbach (1986) as the best evidence of the impacts of OHVs on tortoise density. This work has now been published (Bury and Luckenbach 2002). Although both habitat damage and direct mortality may occur, habitat damage is the most strongly established effect (Boarman 2002). Evidence that OHVs are a threat to desert tortoises is therefore considered strong because of well-documented alterations to tortoise habitat (*Table 6*). The relative importance of direct mortality and habitat alteration is not well understood, however, and cannot be inferred from Bury and Luckenbach (2002). Studies of response by desert tortoise populations following the exclusion of OHV use from an area were not found.

If habitat damage is the primary cause of reduced densities of tortoises in these referenced instances, then the slow recovery of desert plant diversity (Lovich and Bainbridge 2003) may make such studies impractical. Habitat restoration may be applied in damaged areas, however. Recent applied restoration strategies are showing promise in accelerating desert vegetation recovery, such that post-restoration tortoise responses may be observed in experimentally tractable time periods (T. Egan, pers. comm.).

Although we did not find studies of the before and after effects of OHV closures on tortoises, several studies were found that examined the relative effectiveness of Federal agency permitting and relevant resource management plan (RMP) requirements, such as vehicle route designation, for minimizing impacts of competitive races on tortoise habitat (Musser 1983; Woodman 1986; Burge 1986; U.S. Bureau of Land Management 1984, 2000a, 2001a; Goodlett and Goodlett 1993; Circle Mountain Biological Consultants (CMBC) 1994; Medica 1994a,b; Walker and Mastin 1999; Miller-Allert 2000, 2001; Sullivan 2002). These studies are only indirectly related to the effects of OHV "free-play" areas, but they provide examples of a before/after design that yielded detailed information about impacts of OHVs on these areas. Although only Woodman (1986) and Circle Mountain Biological Consultants (1994) stated that they searched for dead desert tortoises, all the referenced studies were conducted in a way that such mortalities could have been detected (i.e., either pre- and post-event surveys were done, or monitors were present on race day). Although the experience of personnel monitoring tortoise habitat for these studies varied considerably, no injured or dead tortoises were detected. All the studies assessed habitat damage, in the form of either route widening, new OHV track formation, or damage to vegetation adjacent to established routes.

Although some form of damage was observed in all studies, the actual amount reported differed substantially. For example, Federal agency monitoring of the 1983 Barstow to Vegas motorcycle race (U.S. Bureau of Land Management 1984) showed minimal change in vegetation occurring in 22 plots. In contrast, Medica (1994a) found approximately one damaged shrub per 60 m of race event course in one transect, for an estimated 225 shrubs damaged during one particular event. Course widening and new tracks along posted routes were commonly observed in all reports evaluated. Explanations for race entrants straying from the designated route included (1) poor route marking (particularly at sharp turns or at unauthorized trails connected to the official race event); (2) lack of race monitors; (3) race vehicle passing; and (4) "silt avoidance" by event riders, who moved to more solid, outer portions of a route once its interior became unstable. Several referenced reports cited problems with permit compliance by event spectators (Medica 1994b). Compliance with event-use limitations generally was good when vehicle routes were well-posted and the Federal agency established some form of presence. Problems reported for the most recent events (U.S. Bureau of Land Management 2000a) were similar to those reported for earlier events. Interpretation of damage resulting from race events was completely subjective, based only on authors' personal judgment (that is, they did not refer to a standard for how much damage is acceptable; to our knowledge, no such standard exists).

The effectiveness of route network reductions, area closures and completed route designations as a means of reducing inappropriate OHV traffic has also been studied. One such study, conducted in Israel (Kutiel 1999), involved comparing the development rate of vehicle and pedestrian tracks in protected and unprotected areas over a 50-year period; the comparison was based on air photo interpretation techniques. Reported results indicated that the rate of change in track length per square kilometer was four times greater in the unprotected area than in the protected area. The number of "area cells", or habitat areas between tracks, increased in number geometrically in the unprotected area but increased linearly in the protected area, indicating rapid habitat fragmentation in the unprotected area. Consequently, the number of area cells in the unprotected, non-designated area increased with time as their size decreased. A similar approach was taken by Matchett et al. (2004) in a study of the Dove Springs Open Area in the western Mojave Desert, although comparisons were limited to change over time with no comparison with the closed area. Matchett et al. (2004) reported that track densities continued to increase from the 1960s through the 2000s within this area of unlimited OHV use. This increase was highest between 1965 and 1982 when OHV recreation began to dramatically increase; the increase continued through 2001. The total length of OHV routes increased from 49 to 576 km between 1965 and 2001, and the amount of land exhibiting some form of OHV disturbance increased from 7 to 30%. In addition, heavy OHV use did not stop at the

boundaries of the Open Area, but spread into surrounding public land managed as "limited use," where vehicles were supposed to stay on designated routes. The most concentrated OHV use occurred near large washes and utility rights-of-way.

In another study of route network formation conducted within desert tortoise habitat, Goodlett and Goodlett (1993) found that posted, but unrestored closed areas in Rand Mountain and Fremont Valley, Calif., had similar numbers of new vehicle tracks as the unposted areas closed to vehicle use. In addition, the number of OHV tracks observed increased with proximity to open vehicle-use areas, suggesting that posted vehicle route closures alone were not effective at eliminating all unauthorized OHV use. In contrast, the regularly maintained perimeter fence at the DTNA has been effective at reducing OHV use (Campbell 1985). It should be noted, however, that the relatively longer-term effectiveness along the DTNA fence-line came about only after an initial period when vandalism was high and that maintenance of the fence continued until the vandalism problem subsided. Further, all the above instances were aimed at understanding route network development, and whether the level of the threat or impact could be reduced; the effects of threat reduction on wildlife populations were not assessed.

Restoration of routes may further reduce unauthorized use of closed areas by obscuring the route from view (Egan 2000). A rapid, inexpensive process called "vertical mulching" has been proposed (U.S. Bureau of Land Management 2001b) for closed route restoration in desert tortoise and other special status species' habitats (National Applied Research Science Center 2000). Vertical mulching involves placement of boulders and vegetation (living or dead) across a closed route so that it visually blends in with the surrounding landscape. The *West Mojave Route Designation, Ord Mountain Pilot Unit, Biological Resource Screening Components* (U.S. Bureau of Land Management 1997) identified route closure as a high-priority objective, and the U.S. Fish and Wildlife Service (2001) concurred with the BLM that vehicle route designation and closed route restoration using "vertical mulching" as outlined above would not adversely affect, and might benefit, the federally listed desert tortoise and the Ord-Rodman Critical Habitat Unit. Egan (2000) reports that the BLM has demonstrated that this technique can be economically implemented, although tests of its effectiveness were not cited.

4.3.b. Limits to our knowledge

Although it is logical to conclude that excluding or restricting OHV use will reduce damage to tortoise habitat and that higher-quality habitat will promote healthier populations, we did not find any studies that removed only OHV use before measuring responses of a desert tortoise population. Several of the studies we identified may be prime candidates for further research by removing OHVs then measuring tortoise responses, particularly since a number of years have passed since actions were initiated in these areas such as the actions at the Ord Mountain Project (U.S. Bureau of Land Management 2000b, 2001b).

There is correlative evidence that OHV use and dirt road densities promote exotic plant invasions (Brooks 1999b, Brooks and Esque 2002, Brooks and Berry accepted), but whether excluding OHVs prevents invasions in impacted areas has not been studied. Studies comparing the rates of exotic plant invasion in open areas, in impacted areas that have been closed, and in areas that have not been impacted by OHV use would be valuable.

We also did not find any studies that tested whether measures reducing OHV use, short of complete area closures, are effective at recovering desert tortoise populations. It is relatively well-established (Boarman 2002) that unrestrained OHV use over time reduces tortoise densities; however, no studies were found that test how much habitat loss to OHV use can be sustained by the species, or whether limited vehicle use is less destructive than unrestricted use to desert tortoise habitat. Lacking such studies, it is difficult to extrapolate what is currently known to a population level. For example, monitoring requirements for race events have produced a relative wealth of information about the effectiveness of vehicle route marking for protecting tortoises and habitat. However, although some degree of habitat damage was observed in all cases, different investigators reached different conclusions about the extent and acceptability of the damage. Population-level studies would be needed to determine how much damage a tortoise population could withstand if objective criteria for acceptable damage are to be devised.

4.4. Grazing

4.4.a. Actions

Boarman (2002) identified several ways in which cattle grazing impacts tortoise habitat, particularly near water sources (*Table 6*). Sheep grazing, on the other hand, has hardly been studied (Nicholson and Humphreys 1981). Direct impacts of livestock grazing to tortoises have not been well-documented, and little research has been conducted on the effectiveness of grazing restrictions on tortoise populations. We found only one case (in the Ivanpah Valley of California) in which researchers removed cattle and then tracked changes in tortoise populations (Turner et al. 1981, 1985; Avery and Neibergs 1997). Turner et al. (1981, 1985) found no differences in plant species composition within and outside an exclosure in the 2 years following cattle removal. Plant biomass was greater in grazed areas than in ungrazed areas. No differences in home range size or number of clutches between tortoises in grazed and ungrazed areas were found in this instance, suggesting that cattle grazing has no effect on tortoises or tortoise habitat. However, there are three reasons to be cautious about this literal reading of Turner

et al.'s results. First, this study utilized only one exclosure and one comparison plot, which makes comparisons at the level of the action tenuous. Second, the above study was conducted over the 2-year period following exclosure, and although they did concentrate on measurements that would be expected to respond quickly to removal of cattle, such as cover of annuals and tortoise reproductive output, the study duration may have been too short for a slowly recovering vegetation type and a slowly growing population of tortoises. Third, this study reported that grazing intensity declined substantially as the exclosure was being established, so that the grazed plot was not heavily grazed at any time during the study. It is thus questionable as to whether their findings can be applied to real-life allotments where grazing levels may be consistently high for extended periods.

Between 1991 and 1993 Avery and Neibergs (1997) and Avery (1998) studied the same cattle exclosure established 10 years earlier by Turner et al. (1981, 1985). This more recent study found greater cover of *Hilaria rigida*, a palatable perennial grass, where cattle were excluded, as well as increased desert dandelion (*Malacothrix glabrata*), whereas grazed areas had more compacted soils. In addition, 50% of actively-used burrow entrances were damaged by grazing cattle, which contributed to a 2.5-fold increase in tortoises remaining above ground overnight. Although predation rates were not measured, burrows are thought to provide tortoises protection from predators, and predation risk may have been greater in grazed areas as a consequence. Dead or dormant *Ambrosia dumosa* were more common in grazed plots. Unpalatable shrubs, such as *Hymenoclea salsola* and *Larrea tridentata* were favored by grazing; *L. tridentata* had greater canopy areas, aboveground volumes, and estimated biomass, and *H. salsola* was also more abundant in grazed areas. Furthermore, diet composition overlapped between tortoises and cattle in the late spring when forage dried out, suggesting that these two herbivorous species may compete for food at these times. Conclusions drawn in Avery and Neibergs' study are similarly restricted because of a lack of replication at the action level. Although the study did extend the timeframe for recovery from 2 to 12 years, they still were not certain that enough time had passed for plant or animal population recovery to be detected.

Larsen et al. (1997) studied exclosures that had been established for long periods. Two exclosures were located at an abandoned gunnery range (time of closure not reported); a third exclosure had been closed since the early 1940s. Livestock grazing outside of the exclosures was reported to be "light" to "moderate," though the moderate livestock-use sites had been recently rested for 2 to 6 years. Changes in vegetation were small and idiosyncratic, with no clear, consistent effect of livestock grazing apparent. No differences in soil compaction or abundance of tortoises or tortoise sign were observed. Although the study included replicate sites, grazing intensity was not quantified, and site-specific differences dominated the results. Additionally, these results were preliminary, and the authors considered definitive conclusions to be unwarranted.

Studies at the DTNA provide some insight into the effects of sheep grazing. Although fenced exclusions of livestock also excluded OHV use of the area, the observed increases in annual plant biomass (Brooks 1995, 1999b) and soil seedbank densities (Brooks 1995) inside of the DTNA were likely due to protection from forage utilization by livestock.

Livestock activity and their effects are often concentrated around watering sites. In a study of nine watering sites at the Pilot Knob Grazing Allotment in the central Mojave Desert, Brooks et al. (accepted) documented patterns of vegetation responses that are useful in developing management plans for watering sites. These authors found that absolute and proportional cover of alien annual plants increased with proximity to watering sites, whereas cover and species richness of native annual plants decreased. Not all alien species responded the same: the alien forb Erodium cicutarium and the alien grass Schismus spp. increased with proximity to watering sites, whereas the alien annual grass Bromus madritensis ssp. rubens decreased. Perennial plant cover and species richness also declined with proximity to watering sites, as did the structural diversity of perennial plant cover classes. Significant effects of livestock activity were focused within 200 m of the watering sites, suggesting that efforts to control alien annual plants and restore native plants should optimally be focused within the central part of the disturbance gradient.

4.4.b. Limits to our knowledge

Livestock grazing-related impacts to desert tortoise habitat are well-established, but whether there is a threshold stocking level below which tortoise populations are unaffected is not known. Larsen et al. (1997) did not find grazing effects at three sites with light to moderate cattle grazing, but without more careful quantification of the grazing level this result should be considered suggestive rather than confirmatory. The question –whether there is a threshold stocking level–is complicated by the fact that impacts of livestock presumably vary annually with changes in precipitation and primary productivity (Avery 1998). When tortoise populations are low and forage is abundant, livestock grazing may have little or no effect on tortoises. But, when forage is less abundant, livestock and tortoises may be forced to compete. Additional research is needed to establish whether limited livestock grazing can be done without detrimental effects on desert tortoises. Studies of other species may be of limited use for desert tortoise management. Kazmaier et al. (2001) studied the effects of grazing on the Texas tortoise and found no effects of grazing on growth or survival of this species. However, they expressed reservations about extrapolating the results of their study to desert tortoises and the more arid, low-productivity environments of the Mojave Desert. A recent synthesis of the grazing literature by The Nature Conservancy reached similar conclusions (The Nature Conservancy 2005) about the lack of information needed to set environmentally safe grazing regulations in the Sonoran Desert, and recommended more research into the efficacy of ephemeral allotments, based on seasonal patterns of rainfall and plant growth.

4.5. Road mortality and barrier fencing

4.5.a. Actions

Tortoise mortality along unfenced roads has been well-documented (Boarman 2002). Reduced densities of tortoises along roads suggest that road mortality is sufficient to affect population sizes (von Seckendorff Hoff and Marlow 2002). The size classes of tortoises killed by traffic include larger, reproductive individuals (Boarman et al. in prep.) which are most important for population viability in this species (Doak et al. 1994). Support for considering roads a threat to desert tortoises, therefore, is strong at the individual and population levels (*Table 6*).

Boarman and Sazaki (1996) compared fenced and unfenced sections of Highway 58 and found that fencing with tortoise-proof materials reduced the number of road-killed tortoises by 93% (Boarman and Sazaki 1996). Radio-transmittered tortoises making long-distance movements were not able to cross the fence (Sazaki et al. 1995), supporting the interpretation that reduced road kill was due to the reduction in tortoises crossing the road, rather than to a difference in population density between fenced and unfenced areas. A similar reduction in the incidence of road kill was observed in a study of the Hermann's tortoise in southern France (Guyot and Clobert 1997), which further supports the overall effectiveness of fencing for reducing tortoise mortality.

The major criticisms of fencing are that it fragments populations into smaller units that are more prone to local extinction, and it genetically isolates tortoise populations. Isolation is a risk to long-term viability as it may reduce the genetic diversity within the species. As a solution to this problem, culverts have been used in combination with fencing to allow tortoises to disperse safely (*Table 1*). Fusari et al. (1981) and Fusari (1985) found that tortoises use culverts made of corrugated steel or panelboard in combination with barrier fences under experimental conditions. Boarman et al. (1998) found that desert tortoises use existing culverts running under Highway 58 that are associated with fenced sections of highway. It is unlikely that tortoises preferentially use culverts in the absence of barrier fencing, but in concert with fencing projects they may prove effective at allowing some degree of movement across roads without excessive risk of mortality.

Effectiveness of different kinds of fencing materials has been studied under controlled experimental conditions (Fusari 1985, Spotila et al. 1993, Ruby et al. 1994, EnviroPlus Consulting 1995). These studies generally support the use of 1-cm hardware cloth as fencing material (EnviroPlus Consulting 1995 recommended 1×2 inch welded wire). Tortoises were less likely to fight against this material than materials with larger mesh sizes because they were able to see that the hardware cloth formed a barrier. Solid barriers also prevented tortoises from struggling against the fence, but discouraged them from moving along the barrier to find openings. Hardware cloth appeared to balance the need to provide a visual stimulus to encourage searching for passage through the fence, and the need to prevent tortoises from wasting time trying to breach, and possibly becoming ensnared in, the barrier.

4.5.b. Limits to our knowledge

Fencing reduces the incidence of tortoise road kills, but it is not known whether this protection is sufficient to recover the population. Analysis of distances of marked tortoises from a fenced section of Highway 58 (Boarman, unpubl. data) reveals that tortoise numbers near the road increased slightly between 1991 and 1997, but then declined again in 1998. Whether this was the beginning of a full recovery is not known, as insufficient time had elapsed to draw such a conclusion. Also, interpretation of results is complicated by other possible effects of roads that are not controlled by fencing, such as increased predation risk and exotic plant invasion. Future studies should attempt to quantify these effects to properly account for them in judging the success of individual recovery efforts. Furthermore, fencing is expected to isolate populations compared with unfenced, roadless areas, but it is not known whether fences increase isolation of tortoise populations compared with unfenced sections of road. Roads, particularly heavily traveled ones, are already a barrier to movements, so this is an empirical, not a theoretical, question. Mortality is logically expected to increase with traffic volume and vehicle speeds, but this has not been tested with tortoises. The thresholds for which roads become safe for tortoise populations are not known.

The culverts that are put in place to alleviate the isolating effects of fences and roads may carry their own element of risk to tortoises. Culverts are used not only by tortoises, but by a variety of species, including those that are potential threats to tortoises (e.g., dogs, coyotes, people; Boarman unpubl. data). Additional research is necessary to determine whether the risk of predation is elevated at culverts, as well as to quantify the population-genetic benefits of culverts so as to determine if any such benefits are outweighed by risk of mortality. At this time, no studies of population-level effects of culvert use have been conducted that would help select roads needing culverts and the culvert densities required.

Roads can also have direct local, indirect local, and dispersed landscape effects on ecosystems (Brooks and Lair 2005). Most studies of the effects of roads on desert tortoises have focused on their direct effects (e.g., mortality), whereas most management decisions related to roads (aside from fencing) are focused on determining acceptable densities per unit area as it related to habitat fragmentation. Future research on the ecological effects of roads needs to focus on their dispersed landscape effects to best match the needs of land managers.

4.6. Mortality from construction activities

4.6.a. Actions

Construction activities have a variety of effects on individual tortoises, tortoise habitat, and tortoise populations (Boarman 2002; *Table 6*). Direct habitat loss, mortality, burrow damage, and fugitive dust have all been identified as possible problems (Boarman 2002). As part of their compliance with the Federal ESA, agencies and entities that are undertaking construction projects where desert tortoises are likely to be killed operate under the provisions of section 7(a)(2) consultations or section 10(a)(1)(B) permits; in both cases, project proponents are required to report any tortoises that are killed during construction operations. These reporting requirements have generated information about both the impacts of construction and the effectiveness of terms and conditions.

Actions designed to minimize the impacts of construction activities are specified in biological opinions (BOs), along with required compliance reporting. Measures imposed are a heterogeneous mix and include fencing of construction areas and roads, physically moving tortoises out of harm's way, conducting on-site biological monitoring, implementing reduced vehicle speed limits at construction sites, and others. These measures are primarily aimed at preventing tortoise mortality during construction (*Table 1*). Biological opinions and incidental take permits attempt to anticipate the number of desert tortoises that may be killed during implementation of the project, and the number of animals killed during construction is reported by the permittee. LaRue and Dougherty (1999) analyzed 171 BOs that had been implemented in California or Nevada, and found a small fraction of the number of tortoises that could have legally been killed (1,096 anticipated) were actually killed (59, or 5.4% of allowable take). LaRue and Dougherty (1999) concluded that the terms and conditions attached to construction permits by BOs were effective at protecting desert tortoises because the actual take was well below anticipated take. Although not a formal meta-analysis, this study addressed effectiveness at an action level across many independent projects, and is a positive step in the direction of effectiveness evaluation. Confidence in the study would increase to the extent that BO compliance reporting could be shown to be a reliable method of data collection. Additionally, the conclusion that tortoises were adequately protected was based on the assumption that anticipated take numbers specified in BOs are harmless to tortoise populations, an assumption that, to our knowledge, has not been tested.

Linear construction projects, such as pipelines, fiber optic cable lines, and transmission lines, have the potential to impact large numbers of tortoises, as they stretch across many hundreds of miles of tortoise habitat and may intersect many different tortoise populations (Olson et al. 1992, Olson 1996). The effectiveness of tortoise protection measures during construction was assessed by comparing the number of tortoises killed (29 on the 646 mile-long Kern River pipeline, and 9 on the 384 mile-long Mojave pipeline) with the total number that were moved out of harm's way (401 on the Kern River pipeline, 158 on the Mojave pipeline), under the assumption that some large, but unknown, fraction of the tortoises would have been killed if they had been left in the construction zone. Gas pipelines have a wider construction impact zone than fiber optic lines, such that gas pipelines are expected to have greater impacts. Conclusions about the reduction in impact are difficult to evaluate because the number of tortoises that would have been killed is not known (that is, the study lacks a control). Additionally, the fate of the tortoises moved is not known, and whether they later died or impacted other tortoises was not studied, though these problems have not been found in translocation studies (see section 4.9, "Translocation").

Not all linear construction projects impact tortoise populations in the same way. Comparisons among project types show that gas pipelines kill more tortoises than fiber optic lines or transmission lines, a fact attributed to differences in construction practices among the project types (Olson et al. 1992). As in the example above, the number of tortoises that would have been killed if none were moved is unknown; although increased mortality is a reasonable assumption, the amount of increased mortality cannot be measured.

4.6.b. Limits to our knowledge

Available studies demonstrate that direct mortality to individual tortoises is reduced by adherence to permitting requirements. Although comparing mortality with allowable take is straightforward, setting allowable take numbers is not. It is generally best to consider allowable take to be a hypothesis, rather than a definitive statement, about the amount of mortality that a population can withstand. Because this hypothesis has always been assumed and not tested, no studies on the effectiveness of measures for protecting tortoise populations from construction activities have been performed.

Linear construction projects may also be a source of habitat fragmentation. Although the footprint of the construction may persist for long periods, it is not known whether populations are subdivided as a result. Whether such projects have long-term effects on the genetic structure of a population or the probability of extinction is not known.

4.7. Habitat restoration

4.7.a. Actions

A recent review of natural recovery and habitat restoration in southern California deserts is available from Lovich and Bainbridge (2003). They found that revegetation efforts have

been attempted at small spatial scales, but that most efforts have had limited success and are labor-intensive and expensive. Some natural recovery has been observed in protected areas (Brooks 2000) in which grazing and OHVs have been removed. In contrast, unrestored tank tracks from military maneuvers have persisted for more than 55 years (Belnap and Warren 2002). The need for revegetation thus depends on the severity of impact. Natural recovery of severely degraded habitat is expected to occur over centuries, not decades (Belnap and Warren 2002). Restoration may be facilitated by placement of vertical structure (National Applied Research Science Center 2000), even in severe situations, which may help prevent additional degradation. It is not known whether this type of restoration leads to re-formation of soil crusts and recovery of natural nitrogen cycling.

4.7.b. Limits to our knowledge

Successful revegetation has been demonstrated in the Mojave Desert over the years in a wide variety of studies, resource notes, and pipeline/transmission line project reclamation plans (Clary 1983, University of California Davis Agronomy and Range Science Department 1977, 1978, University of California Davis Cooperative Extension 1990). Some restoration approaches are unlikely to be practical at large spatial scales, because of the cost or logistical difficulties involved (Lovich and Bainbridge 2003). It is also not known whether revegetated areas provide high-quality habitat for desert tortoises, or what degree of restoration is necessary to achieve success.

4.8. Translocation

4.8.a. Actions

We did not find any published studies that used translocation to re-introduce tortoise populations, although ongoing studies by Field et al. (e.g., Field et al. 2000, 2002) are investigating whether pet tortoises can be repatriated to the wild to augment existing populations. For example, Field et al. (2002) compared survivorship between released tortoises that were formerly pets to tortoises that were wild caught and found no difference in survival. Nussear et al. (2002) found no difference in survival or reproduction between resident and translocated tortoises in Nevada. Rainfall increased survival and reproduction in both groups. Stewart (1993) also reported no substantial differences in survival between wild and translocated tortoises, although differences were not statistically tested. Field et al. (2000) found that removal of *ad-libitum* water prior to release also had no effect on survival, but that males given supplemental water prior to release moved more than twice as far in their first season post-release. Translocated tortoises had more variable movements in their first year post-release, but not their second (Nussear et al. 2002). Thus, the initial experiments indicate that translocations and repatriations can be done without negative impacts to wild populations (Tracy et al. 2004).

Several studies followed tortoises that had been moved out of construction zones to assess their survival and movements. For example, Mullen and Ross (1996) reported that relocated individuals (guests) had similar condition index values (a measure of mass corrected for differences in length) to individuals that had not been moved. Furthermore, “residents” that did not have tortoises introduced to their area and “hosts” that did have tortoises released in their area had similar condition index values, suggesting that translocating tortoises did not negatively impact hosts. Irrigation increased the condition index for tortoises during the driest period of the 3 years of the study. High mortality rates in translocated tortoises were attributed to a lower initial pre-release condition index (mortality rate was not reported). This study, which focused on an index of health of individual tortoises, supported the contention that tortoises can survive translocation without impacting tortoises already present at the release point.

4.8.b. Limits to our knowledge

Studies by Field et al. (2000), Nussear et al. (2002), and Mullen and Ross (1996) have shown that tortoise translocation can work and that resident tortoises are not negatively impacted by the practice in the short term. Moving tortoises out of harm’s way at construction sites generally involves shorter displacements that may not even remove tortoises from their home ranges; whether this practice has the same effects as longer-range translocations is not known. Whether releasing tortoises augments long-term population size also is not known, but may depend on characteristics of the site (e.g., habitat quality, tortoise population density, etc.). Releasing pet tortoises and handling tortoises is considered a risk factor because of the potential for disease transmission (Berry 1997). Translocation efforts, therefore, would need to observe rigorous protocols to avoid harming target populations (for example, testing for an immune response to *Mycoplasma agassizii* prior to release to avoid release of infected but asymptomatic individuals; Tracy et al. 2004). It is not known how many individuals would need to be released to establish new populations or to have a positive effect on extant populations. Population-level effects would be expected to be greatest for releases of sexually mature individuals, given that population growth is most sensitive to changes in this age class (Doak et al. 1994). Headstarting programs show promise for protecting hatchlings (Morafka et al. 1997), but would probably have a smaller positive impact on tortoise population growth.

4.9. Predator control

4.9.a. Actions

Both native predators, such as common ravens, coyotes, and mountain lions (P. Medica, unpubl. data), and exotic predators, like feral or domestic dogs, have been implicated as threats to desert tortoises (Boarman 2002). Predator control is controversial and has not been attempted on a large scale. Raven control is notoriously difficult because they are believed to learn quickly to avoid most lethal control methods. Breeding pairs and large aggregations of non-breeding ravens at landfills and other resource sites are threats to tortoises (Kristan and Boarman 2003). Changes in landfill management can reduce raven abundance at the landfill site (Boarman et al., in prep.), but effects on breeding pairs and regional population size are not known. Targeting breeding pairs can be problematic because removing one individual alerts the other, and shooting generally is effective at removing only one member of a breeding pair (Boarman, unpubl. data). In Iceland, 9 years of removing ravens has not reduced population abundance (Skarphédinsson et al. 1990). Local reductions in predation risk, however, may be achievable (Boarman 2003).

Pilot efforts to live-trap feral dogs have had limited success, with only a single individual trapped during a pilot program at the Marine Air Ground Task Force Training Command,Twentynine Palms, Calif. (Everett et al. 2001). During the 158 six-hour trapping periods conducted, 1 coyote and 6 kit foxes were also captured, raising concerns about non-target species impacts. Shooting was offered as an alternative, humane removal method, but without supporting data.

4.9.b. Limits of our knowledge

Both the extent and importance of raven predation on juvenile tortoises is not fully understood. Raven predation on juvenile desert tortoises alone may have little effect on the population levels of tortoises compared with other sources of mortality (Ray et al. 1993, Doak et al. 1994). However, in declining populations, reducing juvenile mortality may be very important in promoting recovery (Congdon et al. 1993, Boarman 2002).

Raven populations are not uniformly distributed across the desert tortoise's range, thus predation risk is mixed (Kristan and Boarman 2003). Where ravens are abundant, the risk of predation approaches 100%, but areas of great raven abundance are restricted to sites of human resource subsidies where groups of primarily non-breeding individuals aggregate. Breeding ravens are also a threat, and though they distribute more evenly over open desert, they still aggregate near human developments (Kristan and Boarman, in prep.). The regional effects of ravens on population levels of desert tortoises is not fully understood, and thus it is not yet known whether raven control should be expected to be an effective recovery action. The most effective methods for raven population control have not been well-studied. Predators of adult tortoises, such as feral dogs and coyotes, are expected to have a larger impact on population levels than that of ravens, but no data are available to test this hypothesis. Effects of canid removal on tortoise populations were not found.

4.10. Other threats

Boarman (2002) found that some commonly accepted threats to tortoises have not been studied sufficiently to establish them as such, and we found that the effectiveness of actions to control these unproven threats also has not been studied. For example, competition for forage between tortoises and wild horses and burros may occur, but its impact on tortoises is unknown. Several threats treated as separate categories by Boarman (2002) all led to habitat loss or degradation (e.g., military maneuvers, agricultural development, construction). Habitat loss is clearly a threat to desert tortoises, but there are many practices that fall short of causing complete habitat destruction. It is likely that their effects on tortoises vary depending on their intensity, but we did not find any studies that undertook an assessment of how varying degrees of habitat degradation affect tortoises. Finally, several possible or demonstrated threats to tortoises, such as disease and invasive exotic plants, are not currently under direct control of resource managers (although this may change with future research) and so are not addressed here. Indirect effects and synergistic effects of threats on tortoise populations were also not specifically addressed by Boarman (2002), but are interesting and important areas for further research. For example, as one reviewer of this current report (P. Medica) suggested, predation on tortoises may depend on an abundance of alternative prey, such as rodents and rabbits, which in turn are strongly affected by drought. Drought conditions may thus increase the intensity of threats to tortoises, thus impacting them in both direct and indirect ways. Although drought is not under the control of managers, managing threats so that tortoises can withstand drought conditions may be necessary and will require additional research.

4.11. Summaries of interviews with desert managers

As part of the search for documents at field offices of desert tortoise managers, Ed LaRue interviewed key personnel (listed in *Table 3*) who had firsthand knowledge of management activities in their resource areas. Although these interviews have to be treated as anecdotal, they indicate that many recovery actions are currently being implemented and that unpublished monitoring data exists that may be useful in assessing the effectiveness of these actions at reducing tortoise threats.

One example of a recovery action is livestock fences, which were reported to be in use by most of the units we visited (BLM, U.S. Navy, U.S. Marine Corps, U.S. Army, and U.S. Air Force). Many of these fences also serve as boundary fences, meant to exclude trespassing by OHVs and livestock. Monitoring levels at Ridgecrest, a BLM site, varied from routine maintenance of fences to periodic vegetation monitoring and photograph documentation. Fencing generally is viewed as effective at keeping livestock out of sensitive areas, provided that the fences are in good repair and gates are kept closed. Smooth wire fence, used at the BLM Needles site because of concerns about harm to native ungulates, is less effective than barbed wire, as cattle are reported to cross over and under it (K. Allison, pers. comm.). Two-strand barbed wire fencing is reported to be less effective than four-strand wire fencing at keeping sheep off of Edwards Air Force Base (M. Hagan, pers. comm.). However, no cattle have entered Fort Irwin National Training Center from the Cronese Lakes Allotment since a two-strand wire fence was completed (M. Quillman, pers. comm.). An 11 mile, three-strand wire fence has been effective at keeping livestock and burros from entering China Lake Naval Air Weapons Station from the Grass Valley area (T. Campbell, pers. comm.).

Another action that has been recommended by managers for implementation across the desert is emergency closures of OHV-use areas, enforced and not, as well as a variety of projects on restoration of closed routes. Managers reported that area closures are difficult to maintain, although livestock fencing can help to discourage OHV use (A. Chavez, pers. comm.). Areas closed to OHV use with only simple barbed-wire fencing often are subject to vandalism. Cut fences have allowed initial trespass access by OHV users into closed areas, followed by unrelated subsequent vehicle trespass, as evidenced at Red Rock Canyon State Park (M. Faull, pers. comm.). Similarly, the perimeter fence at EAFB, in proximity to the El Mirage OHV Use Area, has been breached in several spots and trespassing by OHV users occurs often there (M. Hagan, pers. comm.). In contrast, solid barrier fencing along roads, construction sites, or other hazards has been used frequently, and appears to work well in these applications. For example, at EAFB, tortoises were occasionally found in mine shafts before fencing, but not after (M. Hagan, pers. comm.). Along U.S. Highway 395, areas lacking "K-rail" tortoise barriers during 1990s highway expansion work resulted in the take of desert tortoise on at least one occasion, whereas areas with barriers placed between potentially-occupied tortoise habitat and work activity did not (T. Egan, pers. comm.).

The frequently-recommended management action of vehicle route rehabilitation appears to have had mixed results. For example, vehicle route rehabilitation in the Kingston Range, the Shadow Valley area of the east Mojave Desert, has apparently had positive results, though quantitative data have not been collected (L. Smith, pers. comm.). At Red Rock Canyon State Park, rehabilitation with one particular technique has resulted in minimal natural recruitment of shrubs along closed routes (M. Faull, pers. comm.). Vehicle routes in the Kramer Hills of the west Mojave Desert also have been rehabilitated, but no follow-up data are available (C. Burns, pers. comm.). However, the rate of native plant establishment and closed vehicle route compliance garnered just 4 years after the technique of "vertical mulching" was first applied in the Ord Mountain (National Applied Research Science Center 2000) is promising (T. Egan, pers. comm.). Many of these formerly used vehicle routes are no longer visible, and contain native plant communities. Similar success has been observed by National Park Service route restoration efforts in Death Valley and Joshua Tree National Parks.

5. Conclusions

5.1. Few studies have been designed specifically to evaluate the effectiveness of recovery actions

Given that the early emphasis in desert tortoise research has been on characterizing threats, filling gaps in knowledge of desert tortoise ecology and life history, and estimating the population status and trends, it is not surprising that relatively few studies have been conducted to evaluate the effectiveness of recovery actions. Studies of threats are useful for directing recovery efforts, but they may not be helpful for selecting the best recovery action to implement. For example, knowing that road mortality is a threat to desert tortoises does not provide information to managers about how to alleviate the problem. Once fencing is selected as a preferred method, it is still necessary to decide how much road must be fenced, the kind and spacing of culverts needed to allow passage across the road, and how much maintenance is needed to preserve the fence's effectiveness. Additionally, although it may be possible to isolate the single effects of threats through careful experimental design, recovery actions usually have multiple effects and may be exposed to multiple confounding variables that prevent tortoise population response. Because of these complicating factors, studies of threats may not provide much guidance to managers seeking the best way to recover tortoise populations.

5.2. Recovery actions are necessary, but may not be sufficient

Recovery actions must be done in the face of uncertainty about which threat, or threats, are limiting. Although removal of a single known threat does not guarantee recovery, it is most conservative to assume that a population cannot recover until all known threats are removed. Short of removing all threats, as many known threats as possible should be eliminated. In this sense, removal of each known threat is supported as a necessary condition for recovery, although removing single threats may prove to be insufficient. Theoretically, one of the most comprehensive recovery actions is to set aside a dedicated reserve, but as the DTNA has demonstrated, the tortoise population can still decline if threats remain after a reserve is established. Consequently, lack of recovery because of disease, drought, or predators does not prove that excluding OHVs and livestock was unnecessary. If this level of certainty is desired, studies of these individual effects must be conducted.

5.3. Strengths and weaknesses of available information

This report compares desert tortoise research with an experimental ideal. It would be difficult to find an ecological field study in any publication that met all the criteria of an ideal study. For example, lack of random allocation of subjects to treatment and control groups is extremely common, and replication becomes difficult as the spatial scale of the study increases. Because we did not expect to find ideal studies, we identified the assumptions necessary to apply the results from a variety of studies to populations of wild tortoises (*Table 2*). This approach is meant to encourage prudent interpretation of studies, rather than to dismiss those that failed to match the ideal.

The rows in *Table 2* are arranged in ascending order of reliability, with each successive row adding additional observations that more strongly suggest the effectiveness of an action. For example, removing wild horses or burros from desert tortoise habitat without any follow-up monitoring would fall into the first row because competition with wild horses and burros has not been established as a threat to tortoises (although it is a logical extension of related work on cattle), and if no information was collected about the effects of the removal, there is little to support a conclusion that this was a successful recovery effort. If the threat has been well-established, such as the threat of mortality along an unfenced road, then observations of a reduction of the threat is an indication of success. The latter does not, however, imply that the action is sufficient to recover the population. Most of the studies we reviewed were those in which an assessment was conducted following implementation of a management action taken to reduce a threat. We did not find many examples of assessment of population-level responses to recovery actions, probably because a reduction in threat often can be assessed immediately following implementation of an action, whereas population responses can be assessed only over longer time periods. There may be no easy solution to this problem because the final test of effectiveness of recovery actions is whether these actions result in an increase in population size, which is a slow process for this long-lived species.

Most of the previous studies of effectiveness took place in concert with construction activities or recreational vehicle racing events or after area fencing of tortoise habitat. Because of this, most of these studies were a form of field experiment, the most reliable type of scientific evidence. However, these studies were aimed at measuring the effect of a single project, so they were not replicated at the level of the recovery action. Generalizing results becomes difficult under these circumstances, and such studies would be difficult to publish in peer-reviewed outlets. One approach to this problem is to analyze results from a number of project-oriented studies to evaluate action-level effectiveness. When done using formal, rigorous statistical procedures, this is called “meta-analysis” (Pullin and Knight 2001). LaRue and Dougherty (1999) attempted an informal, non-statistical version of this type of analysis, but formal attempts to integrate results across studies have not been reported.

In addition, most of the studies that we examined also lacked formal peer review or were not widely available to the managers who would benefit from their findings. Publishing studies in peer-reviewed outlets not only encourages high-quality work, it increases the availability of the work. The large amount of information found in biologists’ files that is unpublished, and thus not widely available, suggests that opportunities to improve implementation of recovery actions are being missed.

5.4. The absence of proof of effectiveness is not proof of ineffectiveness

Pullin and Knight’s (2001) analogy between studies of the effectiveness of conservation efforts and medical treatments for humans suggests that the effectiveness of the methods used will improve if an effectiveness evaluation is approached with a critical eye, using scientifically rigorous methods. However, given that such a system is not currently in place, it is important to bear in mind that the current practice of making decisions based on established conservation principals is much better than using no scientific input whatsoever. By analogy, the fact that medical treatment of humans has improved by quantitatively testing effectiveness is encouraging, but it does not show that medical treatments were ineffective before the program was implemented. We assert that the same is true of desert tortoise recovery actions: they are based on logical applications of principles of ecology and population biology, and, although we have concluded that recovery actions can improve with better information, current practices should not be considered baseless.

6. Recommendations

6.1. Implement more scientifically-based monitoring of actions

Actions that lack effectiveness monitoring will be difficult to defend, particularly if they cannot be assumed 100% effective. Scientific monitoring allows the effectiveness of particular actions to be demonstrated quantitatively at the project level, and repeated, consistent demonstration of effectiveness at the project level can collectively establish effectiveness at the action level. Additionally, greater emphasis on population-level responses will ultimately yield the most definitive answers, although these studies are the most difficult, require the greatest commitment of time and money, and have the greatest chance of failure. The need for ongoing effectiveness monitoring may decline as certainty of an action's effectiveness increases.

6.2. Coordinate monitoring activities among projects to facilitate meta-analysis of effectiveness

Follow-up monitoring of recovery actions should be a routine part of implementation. Monitoring efforts are generally site-specific and unreplicated at the level of the action, and thus are difficult to publish. To make maximal use of the information, it should be collected using standardized methods, and then submitted to a central location where it can be incorporated into formal statistical analysis using meta-analysis methods. The recently established Desert Tortoise Recovery Office (Tracy et al. 2004) could coordinate data collection from follow-up monitoring.

6.3. Pursue peer-reviewed publication of effectiveness studies

Studies that have relevance to effectiveness of recovery action should be published in peer-reviewed outlets. Peer review is important to increase reader confidence in the work, and publication increases accessibility of the results. Electronic indexing and document availability has had the positive effect of making papers published even in regional journals with small readerships available, but it may also decrease the likelihood that unpublished work will be found.

6.4. Commission studies to assess tortoise population responses to recovery actions

Recommendation 6.1 in this report is intended to improve our ability to learn from our collective experience with desert tortoise management. However, this recommendation would not eliminate the need for carefully designed studies of effectiveness, given that projects often produce complex "treatment effects" that can be confounded by uncontrolled variables like drought, disease, and predation. The desert tortoise research community has appropriately concentrated on establishing the status and trend of the species and on identifying threats to its persistence. However, a study of threats does not necessarily provide managers with guidance about how best to recover populations. Studies should be commissioned that specifically address the effectiveness of protective measures in recovering the desert tortoise population in question. The DTRPAC report (Tracy et al. 2004) includes detailed recommendations for data needs along these lines.

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Threats to Desert Tortoise Populations: A Critical Review of the Literature

Prepared for:

West Mojave Planning Team,
Bureau of Land Management

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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TABLE OF CONTENTS

INTRODUCTION **1**

USE OF DATA TO MAKE MANAGEMENT DECISIONS **2**

TYPES OF DATA 3
Experiment *3*
Correlation *4*
Description/Observation *4*
Anecdote *5*
Speculation *5*
SOURCE OF DATA 5
Peer Reviewed Open Literature *6*
Technical Books, Theses, and Dissertations *6*
Non-peer Reviewed Open Literature *6*
Technical Reports *7*
Unpublished Data *8*
Professional Judgement *8*
Science Lore *8*
TWO FINAL CAVEATS 9
DESERT TORTOISE BIOLOGY **9**

SPECIFIC THREATS TO TORTOISE POPULATIONS **10**

RELATIVE IMPORTANCE OF THREATS 11
AGRICULTURE 11
COLLECTING BY HUMANS 12
CONSTRUCTION ACTIVITIES 13
DISEASE 14
DROUGHT 17
ENERGY AND MINERAL DEVELOPMENTS 18
FIRE 19
GARBAGE AND LITTER 21
HANDLING AND DELIBERATE MANIPULATION OF TORTOISES 21
INVASIVE PLANTS 24
LANDFILLS 26
LIVESTOCK GRAZING 27
Reduce Tortoise Density *27*
Direct Impacts *28*
CRUSHING TORTOISES 28
CRUSHING BURROWS 29
Indirect Effects *30*
SOIL COMPACTION 30
CHANGES IN SOIL TEMPERATURE 31
CHANGES IN VEGETATION 32

Trampling of Vegetation and Seeds 32
Plant Community Changes 33
Invasive Plants 35
Competition 36
Cow Dung as a Food Source 38
Summary *38*
Military Operations 39
Construction, Operation, and Maintenance of Bases and Support Facilities *39*
Development of Local Support Communities *40*
Field Maneuvers *40*
Distribution of Chemicals *40*
Nuclear Weapons Testing *41*
Noise and Vibration 41
ORV Activities 43
Reduce Tortoise Density *43*
Direct Effects *44*
Crushing Tortoises and Burrows 44
Indirect Effects 45
Compaction of Soil 45
Destruction of Cryptogamic Soils 46
Changes in Vegetation 47
Erosion and Loss of Soil 48
Light ORV Use 50
Summary *51*
Predation/Raven Predation/Subsidized Predators 51
Non-ORV Recreation 53
Roads, Highways, and Railroads 54
Utility Corridors 55
Vandalism 56
Wild Horses and Burros 57
Cumulative Threats to Tortoise Populations 57

Human Access to Tortoise Habitat 57
Habitat Loss, Degradation, and Fragmentation 58
Urbanization and Development 60
ACKNOWLEDGMENTS 61

LITERATURE CITED 62

INTRODUCTION

Decisions in resource management are generally based on a combination of sociopolitical, economic, and environmental factors, and may be biased by personal values. These three components often contradict each other resulting in controversy. Controversies can usually be reduced when solid scientific evidence is used to support or refute a decision. However, it is important to recognize that data often do little to alter antagonists' positions when differences in values are the basis of the dispute. But, supporting data can make the decision more defensible, both legally and ethically, especially if the data supporting all opposing viewpoints are included in the decision-making process.

Resource management decisions must be made using the best scientific information currently available. However, scientific data vary in two important measures of quality: reliability and validity. The reliability of the data is a measure of the degree to which the observations or conclusions can be repeated. Validity of the data is a measure of the degree to which the observation or conclusion reflects what actually occurs in nature. How the data are collected strongly affects the reliability and validity of ecological conclusions that can be made. Research data potentially relevant to management come from different sources, and the source often provides clues to the reliability and, to a certain extent, validity of data. Understanding the quality of data being used to make management decisions helps to separate the philosophical or value-based aspects of arguments from the objective ones, thus helping to clarify the decisions and judgements that need to be made.

The West Mojave Plan is a multispecies, bioregional plan for the management of natural resources within a 9.4 million-acre area of the Mojave Desert in California. The plan addresses the legal requirements for the recovery of the desert tortoise (*Gopherus agassizii*), a threatened species, but also covers an additional approximately 80 species of plants and animals assigned special status by the Bureau of Land Management, U. S. Fish and Wildlife Service, and California Department of Fish and Game. Within the planning area, 28 separate jurisdictions (counties, cities, towns, military installations, etc.) seek programmatic prescriptions that will facilitate stream-lined environmental review, result in expedited authorization for development projects, and protect listed and unlisted species into the foreseeable future to avoid or minimize conflicts between proposed development and species' conservation and recovery. All of the scientific data available concerning the biology and management of these approximately 80 species and their habitats must be evaluated to develop a scientifically credible plan.

This document provides an overview and evaluation of the knowledge of the major threats to the persistence and recovery of desert tortoise populations. I was specifically asked to evaluate the scientific veracity of the data and reports available. I summarize the data presently available with particular focus on the West Mojave Desert, evaluate the scientific integrity of those data, and identify major gaps in the available knowledge. I do not attempt to provide in-depth details on each study or threat; for more details I encourage the reader to consult the individual papers or reports cited throughout this report (many of which are available at most university libraries and at the West

Mojave Plan office in Riverside, California). I also do not attempt to characterize or evaluate the past or present management actions, except where they have direct bearing on evaluation of threats, nor do I attempt, for the most part, to acquire, generate, or evaluate new or existing, but uninterpreted data.

Two Important Caveats

Lack of scientific evidence supporting a purported impact should not be confused with automatically supporting the alternative, that there is no impact, and vice versa. Or as it is sometimes said: "absence of evidence is not evidence of absence." It may just mean that credible or definitive studies testing the hypothesized effects have either not been conducted or not been reported adequately.

Additionally, when I critique a particular study I am neither criticizing the scientist's ability or intent. Often, studies have inherent weaknesses that are completely or largely out of the control of the researcher. For example, as discussed below, it is often very difficult to have a proper control for a study in nature and it is often too expensive or impossible to adequately replicate a natural study. Rather than abandoning the questions altogether, scientists forge ahead with the study in spite of its limitations and collect data that hopefully are useful for managers. I point out the weaknesses here so managers will understand the limitations of such data, not to criticize the researchers not to render the studies useless. Virtually all studies have some inherent value, but their utility falls at different points on the continuum of risk to managers depending in part on how they were conducted and reported.

USE OF DATA TO MAKE MANAGEMENT DECISIONS

Scientific investigations follow an orderly, repeatable process. Many such investigations begin with anecdotes from ranchers, recreationists, or casual observers of nature. These might include issues of concern to managers, such as "I'm seeing fewer tortoises these days" or "tortoises and cattle can coexist." Anecdotes are useful for pointing out to researchers what critical problems may need to be solved through scientific investigation. Most scientific research follows up anecdotes that seem plausible with more craftily constructed hypotheses and direct observation by experienced observers. If such observations warrant further investigation, scientifically based observational studies are initiated. Most studies pertaining to desert tortoises fall into this category. However, observational studies may have problems, such as lack of adequate controls, insufficient sample sizes, or researcher bias in study design or interpretation. In a few cases, experiments are used to objectively test hypotheses that were developed from anecdotal or observational data. Experiments or carefully designed observational studies may lead to development of conceptual or mathematical theories that can then be

used to predict responses of valued resources to management actions. Theory can then be tested with further experimentation or well-designed observations. Very little theory has been applied to problems related to land-management practices in the Mojave Desert.

Types of Data

The quality of data depends on how the questions were formulated and how the data were collected. Research questions in tortoise biology and management rarely employ a standard scientific method called "strong inference" (Platt 1964). For strong inference, progress is generally made by devising clear, falsifiable alternative hypotheses and conducting experiments designed to test competing predictions of these hypotheses. The strongest support for one alternative comes from experimental results that exclude other alternatives. Studies that test only one hypothesis are weak because they fail to show that the same results cannot be explained by other hypotheses. In tortoise research we generally see studies that are designed to support a pre-determined "ruling theory" or "working hypothesis" (Chamberlin 1965) or to simply describe nature. Such studies do little to explicate the phenomenon and to truly advance the management objectives supported by the research.

There are several types of studies that vary by how the data were collected. These categories are listed below in descending order from those generally providing the strongest, most valid conclusions to those providing the weakest, least reliable information. Value specifically refers to the level of risk a manager is taking when making a decision based on the data. The lower the value, the higher the risk. The actual conclusion may be right on target, but if it is from a risky type of data collection, the manager runs a higher risk of making an unsound decision.

Experiment

The strongest scientific data, those demonstrating cause and effect relationships, are generated via well-controlled and replicated experiments (Hairston 1989, Lubchenco and Real 1991). Such experiments involve manipulating one variable (treatment, such as presence of cattle) while holding all other variables constant (such as tortoise density or soil type). Such a design must have a control (or reference site) wherein ideally the only difference is the lack of the treatment. Any resultant change in the treatment area is likely to be caused by the particular treatment. However, one of many uncontrollable factors may occur that could result in a change independent of the treatment. These uncontrollable features, called random error, can fatally compromise the results. To reduce the effects of random errors (or chance), a properly designed study must have replicates - two or more sites that serve as control and two or more sites that serve as the treatment sites (Hurlbert 1984). The more replicates there are, the lower the chance that differences observed between treatment or control sites can be caused by random error. Another source of error that is mitigated by replication is uncontrollable (or unrecognized) differences among study sites (e.g., soil type, grazing history, and slope).

Any experiment that fails to have an adequate number of replicate treatment and control sites fails to satisfy an essential requisite for strong inference. Admittedly, it is often difficult or even impossible in natural settings to establish true control sites where the only difference is the lack of a treatment, not to mention have multiple replicates of the treatment and control. But having a proper control is an important feature and conclusions drawn from studies that lack a control suffer as a result.

Furthermore, the strength of any experiment, its ability to be broadly applicable, is bolstered by sample size. However, when comparing a given treatment with a given control, the sample size is the number of replicate study sites, not the number of measurements taken within each site. It is all too common for studies, particularly non-peer reviewed ones, to artificially inflate their sample sizes thus often reporting a significant effect (i.e., difference between treatment and control caused by the treatment factor) when in fact one did not occur or when the study was inadequately designed or carried out to discern a difference if one indeed existed. For example, when studying the effect of a factor like off-road vehicle (ORV) activity on desert habitat, it is common to measure number of plants and plant species within an ORV area versus outside of the area. If the researcher measured number of plants and plant species along ten transects within a single plot inside and ten transects within a single plot outside, the sample size is not 10 (nor 20) rather it is 1, because there is only one pair of plots being compared. Any differences observed may actually be caused by other factors such as different elevation or vegetation type. To avoid the random error of non-replication, multiple plots should be studied and these should be inside and outside of several ORV areas.

Correlation

Many studies in natural environments measure how a given factor (e.g., animal density) varies at different levels of some treatment (e.g., intensity of cattle grazing). This type of experiment can only show a correlation between the two factors. It provides no evidence that one factor causes a change in the other. Any correlation may just as well be from some unmeasured feature of the environment that affects both factors measured or it may be caused by chance. A cause and effect relationship can only be demonstrated if it can be shown that varying one factor (the independent variable) causes a predictable and consistent change in the other factor (dependent variable). Unfortunately, this is often the only means we have to study phenomena in the natural environment.

Description/Observation

Many studies simply describe a particular physical state or phenomenon (e.g. amount of trash or number of tortoises in a study area). The description can be simply qualitative (e.g., “a lot” or “many”) or may be quantitative involving complex statistics (e.g., means, standard deviations, confidence intervals). Such studies may provide excellent descriptions, but cannot test for cause and effect relationships.

Anecdote

Generally, a non-quantitative description limited in scope (usually a single observation of the given phenomenon) and depth of detail is considered an anecdote. An example of an anecdote is: “in 1978 I saw a tortoise eat a balloon.” Anecdotes usually lack any formal documentation and are most often made by untrained, casual observers, but professionals often report anecdotal observations. Sample sizes are extremely limited. Anecdotes are highly risky for basing management decisions because of their lack of rigor, repeatability, and objectivity.

Anecdotes need to be properly evaluated using sound scientific methodology. They can often form the basis for more formal observations, hypothesis development, or experimentation. Occasionally, there are attempts to legitimize anecdotes by compiling many into a single report and attempting a quantified or statistical treatment. These are misguided attempts because the extreme weakness and subjectivity of the basic data limit entire analyses: the anecdote. An appropriate expression is “the plural of anecdote is not data” (Green 1995).

Speculation

People will often make guesses about possibilities for which there are no hard data. When those guesses are based on clearly stated and well-founded assumptions, the guesses are called hypotheses and can help to direct future conceptual and experimental pursuits (Resnik 1991). When assumptions are weak or unstated the guesses are speculations. An example of a speculation is that fallout from nuclear tests in Nevada in the 1950s is responsible for the prevalence of disease in tortoises today. There is no evidence that fallout from nuclear testing can cause the diseases harming tortoises and no reports detailing the amount of fallout that occurred in tortoise habitat. There are no attempts to correlate probable fallout amounts with incidence of disease. The assertion is strictly a speculation because, on the face of it, it makes some sense.

Speculations may be seductive; often they present a series of progressively dependent statements that have an internal logic of their own. The logic may appear compelling and is often bolstered by attempts to provide "proof" through analogies. Such argumentation often collapses when primary assumptions are nullified or when they are tested against real data, but too often the test is never made. Although they may sometimes form the basis for hypotheses and experiments, speculations are risky to base management decisions on because there is essentially no way to evaluate them and their predictive value is low.

Source of Data

Data sources fall into several categories with varying probabilities of adequate reliability and validity. The source of data provides some indication of its quality. However, it is possible that a particular conclusion based on data from a less reliable

source is more true or accurate than one from a more reliable source, but the likelihood of this being the case is low. Thus it is less risky to base judgements on data obtained from more reliable sources. The basic sources of data follow, in order of increasing risk to management (i.e., decreasing reliability):

Peer Reviewed Open Literature

Open literature refers to articles readily available in university and public libraries and published in professional, publicly available outlets. Easy availability allows anyone to obtain and evaluate the data on which decisions are made.

Peer review is a cornerstone of the scientific process. Rigorous peer review has two essential components: 1) thorough review by two or more scientists (generally anonymous) knowledgeable on the topic and 2) the possibility of rejection if the report does not meet generally accepted scientific standards. The latter component is an important feature that is lacking in less reliable data sources. The review process helps to ensure (but does not guarantee) that: 1) only reliable data with valid conclusions are published because the reviewers make certain that data are presented in sufficient detail to allow adequate evaluation of the conclusions; 2) the collection and analysis methods followed modern scientific standards and were appropriate for making the tests reported, 3) were reported in sufficient detail to allow someone to adequately evaluate and repeat the study; 4) the conclusions follow logically from the data; and 5) relevant related data (e.g., peer-reviewed publications), whether supporting or contradicting the study's conclusions, are cited. Most professional scientific journals (e.g., Ecology, Range Management, Journal of Wildlife Management, Herpetologica, Bulletin of the Wildlife Society) are peer reviewed. The Desert Tortoise Council is now implementing an external review process for its annual symposium proceedings.

Technical Books, Theses, and Dissertations

Most technical books are peer reviewed, but often without the true possibility of rejection. They are often reviewed by an in house editor or panel of editors who may or may not be experts in the particular field. Opinions differ on whether master's theses and doctoral dissertations should be considered peer reviewed. They do not undergo the same blind review that papers in scientific journals do, but they probably receive a much higher level of scrutiny than most papers. Furthermore, there is much more at risk if the thesis or dissertation fails review: the student is not awarded the Masters or Ph.D. In this report, they are treated as technical books being reviewed by a panel (i.e., the student's graduate committee).

Non-peer Reviewed Open Literature

Articles from this source are often used to support decisions or recommendations probably because there are many of them available, the sources are widely available, and

the fact that they have been published adds a perception of respectability. However, there are often risks of using this type of data source. The authors and editors may not be specialists in the field they are writing about or are not scientists. Additionally, there is often no attempt at a logical, unbiased, rationally supported presentation. Occasionally, special interest groups that are pushing a specific interest and land ethic (e.g., Audubon Society, Rangelands, Desert Tortoise Council) publish outlets cited.

By definition, non-peer reviewed sources do not follow the established methods of peer review: there is usually no independent, objective evaluation of the data presentation and no guarantee that articles will be rejected if they fail to meet accepted scientific standards. Often missing is information necessary to allow the reader to evaluate the reliability of data collection and analysis. Statements such as "many tortoises were killed by vehicles" or "tortoises depend on cow dung for nutritional needs" are made without details about how the author determined if a vehicle killed a tortoise, how often tortoises actually eat cow pies, or what are the nutritional needs of tortoises.

Most proceedings of meetings (e.g., past issues of the Proceedings of the Desert Tortoise Council Symposium -) as well as abstracts from meetings are incompletely or not peer reviewed, and contents are usually printed verbatim with little or no editing and no possibility of rejection. Proceedings papers and abstracts often contain preliminary analyses of data and conclusions may change following the final complete analysis and rigorous peer review. The same criticisms holds for many official bulletins and newsletters of professional societies (e.g., Bulletin of the Ecological Society of America, Rangelands).

Technical Reports

Technical reports are generally written by agency and contract scientists and biologists and sometimes individuals untrained in the practices of science and biology. Technical reports are probably the most commonly used source of data for basing management decisions. Many agency biologists do not have the time, opportunity, encouragement, need, or training to publish their data. Sometimes reports are generated for the purpose of providing a quick analysis for management decisions that cannot wait for the one to two years often necessary to become published in a peer reviewed outlet. Such reports may not be subjected to review by competent scientists and are rarely rejected. "Draft" reports may never be finalized and become widely used even though they may be incomplete or fatally flawed. Because they do not appear in the open literature, refutations or critiques of the reports are rarely available. Finally, they may be difficult to locate, which prevents independent evaluation of their findings.

Reports by government biologists and biological consultants are variable in quality. Many are well designed, researched, and written and draw adequately on the existing body of scientific knowledge. Others demonstrate a lack of knowledge of tortoise biology and common management practices; fail to properly cite previous studies, particularly when contrary to the conclusions or recommendations being made in the report; make recommendations that are untested or unwarranted; and have not been

peer reviewed. Such reports form the basis of many management decisions that have or are being made and may result in implementation of non-standard mitigation measures and speculative conclusions that were not tested for their efficacy.

Unpublished Data

There are many data sets (e.g., raw data, tables of compiled data, GIS maps, etc.) that are cited and used even though they may not have been checked for errors, analyzed, or adequately documented (e.g., data collection methods may be unknown). Reliance on such data for making decisions is risky particularly when there is no documentation (e.g., metadata) of how the data were collected and limitations of the data are not discussed.

Professional Judgement

When the proper research has not been conducted or completed, or time or expertise is not readily available, managers often rely on the professional judgement of staff biologists or other scientists. Reliance on professional judgement requires managers to use data that are unreliable if only because they cannot necessarily be independently evaluated or examined. The judgement may involve unsupported speculation, data that have been improperly or incompletely analyzed, or may involve faulty recall of the facts. On the other hand, professional judgements may be very sound, reliable, and based on an objective evaluation of the information available. The manager may not be able to separate good from poor judgements because there is generally too little information to evaluate. Judgements solicited from several competent professionals is advisable when possible. Also, the professionals chosen to provide input should provide citations and critical analyses of the data they are using to make the judgement. They should clearly state where the strengths and weaknesses in their judgements lie. Following steps like these can help to ensure the value of professional judgement.

Science Lore

Science lore, best defined as being the collective knowledge of the scientific, resource professional, or layperson community, is often based more on observation, assumption, and speculation than on scientifically-collected and analyzed data. Facts entrenched in science lore are not necessarily incorrect. They are unreliable because the connection between the hard data and the interpretation may be unknown. Common sources of Science Lore include Television programs, hobbyist journals, newsgroups, and casual conversations with professionals and laypersons.

A common example of Science Lore is the statement that “tortoises live to be 100 years old or more.” This may be true, but in fact the oldest tortoises for which any documentation exists were two captive animals; one was at least 67 years old and maybe in its mid seventies and the other was probably at least 74 and maybe older (the former was adult-sized when first captured 52 years earlier, Jennings 1981; and the later was

adult-sized when captured and grew little in the 59 years before it died, Glenn 1986). No one has followed marked animals in the field long enough to know the average or maximum longevity. In the pair of studies usually cited as evidence for long life, six marked tortoises, recorded as adults by Woodbury and Hardy (1948) in the early 1940's, were refound still living in the 1960's (Hardy 1976). They may have been over 100 or perhaps as young as 30 - 50 years when refound. Since they were of unknown (or unreported) age at the time of capture, we do not know their true age. Using scute annuli (age rings), Germano (1992) estimated that most desert tortoises live 25-35 years, but some live more than 40 years. The cohort of tortoises reported on in Turner et al. (1987a) is still being followed; these known-aged animals are now 40-41 years old (Medica pers. comm.).

The onus is on the scientific community to identify statements that fall into this category. Researches should then investigate the underlying assumptions, find or collect supporting or refuting data and publish the results. Then, fact-based science lore can be elevated to known facts, and unsound lore can be modified or dropped from our lexicon of apparent facts.

This report identifies the quality of the data available on the major threats confronting desert tortoise populations in the hope that the scientific-based components of the final decisions can be clearly separated from the value-based components.

Two Final Caveats

The citation of draft reports or completed but unpublished ones is not normal scientific practice. Because this is a critique of all data that may be relevant to decision making for the West Mojave Plan, draft and incomplete reports are cited. This was done because such documents are often relied upon heavily for making management decisions.

Second, this report includes some papers and observations that are highly speculative or made by laymen, sometimes only in casual conversation. These were included here because they are often pervasive parts of the lore of the tortoise or desert communities and deserve some evaluation even if they were not made in scientific literature.

DESERT TORTOISE BIOLOGY

Knowledge of many characteristics of the basic biology of an organism is essential for making informed decisions concerning the management of that organism. Many aspects of tortoise biology are well known. The reader is referred to the following papers for general summaries of what is known: Berry (1978), Hohman and Ohmart (1980), Bury (1982), Bury and Germano (1994), USFWS (1994), Ernst et al. (1994), Grover and DeFalco (1995), and Boarman (2002). No comprehensive critical summary

of tortoise biology exists and is sorely needed. A recent summary of anthropogenic impacts to desert habitat is Lovich and Bainbridge (1999).

SPECIFIC THREATS TO TORTOISE POPULATIONS

Threats occur under two major categories, direct and indirect, although they are not necessarily mutually exclusive. Direct threats are those that affect the survival or reproduction of tortoises (e.g., road mortality, illegal collecting, disease, predation). Indirect threats affect tortoise populations through their effect on other factors, primarily habitat (e.g., drought, habitat alterations from livestock grazing, recreational activities, global warming, etc.). Direct threats are usually more easily measured and therefore more easily evaluated than indirect effects.

To determine the impact of a specific threat on tortoise populations, it is insufficient to measure the threat solely (e.g., number of cars or density of mines in an area.) One must determine the effect the threat has on some aspect of tortoise reproduction or survival. Many parameters of tortoise biology can be measured when attempting to determine impacts of threats. Sometimes, the easiest and most intuitive response is mortality. It is difficult to deny that a motorized vehicle killed a fresh, smashed tortoise found on a paved highway. When tortoises die they leave behind a shell that can last for four years or more (Woodman and Berry 1984). Often that shell bears evidence of the cause of death (e.g., tooth marks, conchoidal fractures, fracture from blunt trauma, etc.). However, interpreting these signs is subjective and little scientific work that can aid interpretation has been conducted (but see, Berry 1985, 1986a) and most assumptions made in interpreting the evidence are not reported. Reproduction is more problematical, but at least clutch size and frequency can be measured with x-rays or sonograms or by locating nests and monitoring hatching success (Gibbons and Greene 1979; Turner et al. 1986, 1987b; Rostal et al. 1994). Survival of the young is an essential component to understanding the effect of threats on tortoise populations, but is very difficult to measure (e.g., Turner et al 1987b, Morafka 1994). Growth (Medica et al. 1975, Germano 1988, Turner et al. 1981, Patterson and Brattstrom 1972), behavior (Ruby and Niblick 1994, Ruby et al. 1994), and physiology (Nagy and Medica 1986, O'Connor et al. 1994a, Christopher et al. 1994) vary with environmental conditions and may be useful parameters for measuring the effect of impacts, but their efficacy at doing so has yet to be demonstrated. Modeling population demography (i.e., age-specific survival and reproduction), when using accurate measures from the population, can be an excellent way of evaluating the effects of threats and management actions on population growth (Congdon et al. 1993, Heppell 1998).

Relative Importance of Threats

The rating of relative importance of different threat factors is a challenging undertaking for several reasons. First, it is very hard to determine the cause of death of animals and it is even harder to determine how much decline is really attributable to the various indirect causes of mortality (e.g., habitat alteration). Educated guesses can be made about causes of death (Berry 1984, 1985, 1986a, 1990 as amended), but most of the methods used have not been described or subjected to experimentation, independent evaluation, or peer review. Second, not enough is known about several potential threats to evaluate their absolute or relative impact. For example, it has been suggested that toxic chemicals may be responsible for a disease of the shell affecting some populations. However, it is not known if chemicals are the causative agent, which chemicals are the problem, or the source of chemicals. Also, little is known about neither the epidemiology of the disease nor how much mortality is actually caused by it. Third, which mortality factors are functioning is very site specific. Highway mortality is an important factor for populations along highways; it may drain populations two miles or more away (von Seckendorff Hoff and Marlow 1997). On the other hand, for populations away from highways, this may be a very low or non-existent threat. Regional differences occur, also. Urbanization and development are major factors in portions of the west Mojave, but are probably relatively unimportant in much of the east Mojave (outside of the Las Vegas and St. George areas). Finally, as discussed above, factors that caused the declines (e.g., disease) may not be the same factors that are preventing recovery (e.g., genetic or demographic consequences of small populations, fragmentation, and raven predation). For all of these reasons the controversial and subjective task of ranking impacts was avoided here.

Specific threats are easy to discuss and identify, but more pervasive problems often exist when multiple threats interact to make for larger environmental problems. The three largest of these broader impacts affecting tortoise populations are habitat loss, degradation, and fragmentation; urbanization and development; and access by humans to tortoise habitat. I will first focus on specific threats then discuss three broader, more cumulative types of threats. There are virtually no published studies looking specifically at the effect of these general factors on tortoise populations.

Agriculture

Probably the greatest affect agriculture has on tortoise populations is through loss of habitat: when tortoise habitat is converted for agricultural use it becomes mostly unusable by tortoises for foraging or burrowing. Indirect impacts could include facilitation of increases in raven population, drawdown of water table, production of fugitive dust, possible introduction of toxic chemicals, and introduction of invasive plants along corridors and when the fields go fallow.

I found no substantiated references in the literature indicating that desert tortoises use agricultural fields, although alfalfa, with its high nitrogen content, could be a healthy source of food for tortoises (Bailey, 1928, provides an anecdotal account from untrained

observers of "tortoises eagerly eating alfalfa."). Berry and Nicholson (1984a) cited one anecdotal report from an individual with unreported credentials as evidence that "tortoises are known to enter...alfalfa fields" (p. 3-21). Disking, plowing, mowing, and baling would destroy burrows and kill tortoises (as they do the marginated tortoise, *T. marginata*, in the Mediterranean region; Stubbs 1989). There are no reports of desert tortoise burrows in agricultural fields.

The Common Raven, a predator on juvenile desert tortoises, makes considerable use of agricultural fields in the west Mojave Desert (Knight et al. 1993, 1999, Knowles et al. 1989). Agricultural fields probably are important sources of food (i.e., insects, rodents, and seeds) and water for ravens during times of the year when those resources are generally in low abundance elsewhere, thus resulting in more ravens surviving the summers and winters (Boarman 1993, unpubl. data). See "Predation," below, for more discussion.

Pumping of ground water for irrigation can result in a major change in vegetation or habitat type. Koehler (1977) reported that the drawing of water for irrigation from Koehn Dry Lake, near Cantil in the Western Mojave, lowered the water table by 240 ft between 1958 and 1976. Berry and Nicholson (1984a) state that this lowering of the water table has approached the Desert Tortoise Natural Area (DTNA) and imply that it may affect tortoise habitat, although no data were presented to support the implication. Closer inspection of the maps provided in Koehler (1977) show that the water-level decline is lower (30 - 180 ft) near tortoise habitat south and southeast of Koehn Dry Lake. There are no data to indicate what effect this lowering of the water table has on mesquite, other vegetation, or tortoise habitat in the area, but there are data on the effect water table lowering has on mesquite in other arid regions (Nilsen et al. 1984).

Agricultural fields cause dust storms, called fugitive dust (Wilshire 1980). Fugitive dust coats plants, which in turn may reduce photosynthesis and water-use efficiency (Sharifi et al. 1997). The end result is lower productivity of forage plants. Their study did not specifically look at agricultural dust, but the results are probably generalizable.

The finding of "hundreds of...tortoise shells" (with no indication of how long the tortoises had been dead) was reported anecdotally and second hand by Berry and Nicholson (1984a) and was correlated with application of an unspecified pesticide to kill jackrabbits in a nearby (distance unspecified) alfalfa field. Aside from this single unsupported speculation, there are no references to possible toxic effects on tortoises of pesticides, herbicides, and other chemicals used in agriculture. Pesticide use, particularly aerial applications apparently are now very limited in the desert.

Collecting by Humans

Humans collect turtles and tortoises for several reasons, and these activities are responsible for population declines in several of the threatened and endangered species throughout the world (Stubbs 1991). Collecting desert tortoises for pets was probably a

major activity in the recent past (Berry and Nicholson 1984a), although most evidence is anecdotal in nature. Since 1961, it has been illegal under State law to collect tortoises in California and since 1989 collecting has been a Federal offense (USFWS 1994). The Desert Tortoise Recovery Plan (USFWS 1994) cites several documented instances of illegal collecting more recent than those in Berry and Nicholson (1984a), including the unauthorized removal of marked study animals from known study areas. It must be cautioned that some of the examples cited in the Recovery Plan are circumstantial or speculative. For instance, Stewart (1993) reported one strongly supported (tortoise found in a car in Idaho) and one speculative (transmitter and human footprints found on ground and tortoise was missing) example of poaching. Berry (1990 as amended) gives purely speculative and circumstantial evidence for poaching (namely, marked drop in estimated density on a study plot over a 5-year period with relatively few carcasses being found coupled with observations of possibly human-excavated burrows nearby and other evidence for poaching several miles away). The available evidence suggests that collecting for pets is still occurring, but perhaps at a level lower than previously, although this statement is speculative at present. Evaluating the extent of the problem is very difficult because of the cryptic nature of the activity.

A newly documented problem is the collection of wild tortoises by recent immigrants for cultural observances (USFWS 1994, Berry et al. 1996). Berry et al. (1996) reported that 7.7% of tortoise burrows found showed evidence of being excavated by humans and that the number of such burrows is greater near versus far from dirt roads. Their study suggests that poaching tends to occur near roads, even lightly maintained ones, thus the presence of roads may help to facilitate poaching. However, there was no statistically significant difference in distance from roads for disturbed versus undisturbed burrows and the method for determining if a burrow was excavated was circumstantial and subjective.

The bottom line is that there is little evidence to suggest that illegal collecting is currently a widespread problem, but there is also little evidence to the contrary.

Construction Activities

Construction activities here refer specifically to the generally short-term effects of actual construction (clearing land, movement of heavy equipment, presence of construction crews, etc.). The lasting effects of the constructed facility, once in place, are discussed in “Urbanization and Development,” “Energy and Mineral Development,” “Utility Corridors,” and “Habitat Loss, Degradation, and Fragmentation” sections below. In many ways, most construction projects have similar impacts on tortoises and their habitat, regardless of what is being constructed. Those impacts may include: loss of habitat by the project footprint; incidental destruction of habitat in a buffer area around the footprint; damage to soil and cryptogams on the periphery; incidental death of unseen tortoises along roads, beneath crushed vegetation, or in undetected burrows; destruction of burrows; handling of tortoises; entrapment of tortoises in pits or trenches dug for transmission or fiber optic lines, water, and gas pipelines and other utilities; attraction of ravens and facilitation of their survival by augmenting food or water; and fugitive dust

(Olson et al. 1992, EG&G 1993, Olson 1996). There are little data on the extent of these potential impacts. But, Olson (1996) reported that a construction of a natural gas pipeline had the greatest impact on tortoises and habitat, construction of a transmission line had intermediate impacts, and a fiber optic line was the most benign. The differences are largely related to the scale of the project, ability of crews to avoid disturbing burrows, and timing of construction to avoid peak activity periods of tortoises (e.g., spring). In an analysis of 171 Biological Opinions issued by the USFWS in California and Nevada, Circle Mountain Biological Consultants (1996, see also LaRue and Dougherty 1999) found that the majority of tortoise mortality occurred along linear construction projects (e.g., pipeline, fiber optic, and transmission lines) with the extensive Mojave-Kern Pipeline causing the greater number of deaths (38). Tortoise mortality also occurred on mining, landfill, and military projects. The total number of deaths reported on the projects was well below the level authorized by the USFWS (59/1096 = 5.4%). This study was strictly an evaluation of known tortoise mortalities occurring during projects authorized by the USFWS under Section 7 of the Endangered Species Act. It therefore likely underestimates actual tortoise mortality (e.g., tortoises buried during construction or otherwise not found, accidentally killed but not reported, etc.) that occurred.

Disease

Disease in general is a normal and natural phenomenon within wild animal populations. Diseases can weaken individuals, reduce reproductive output, and cause mortality. Epidemic outbreaks of some diseases can become catastrophic, particularly in small or declining populations (Dobson and Meagher 1996, Biggins et al. 1997, Daszek et al. 2000). Sometimes disease can be controlled by wildlife managers by attacking the pathogen; isolating diseased from non-diseased individuals, populations, or species; immunizing healthy individuals; or facilitating habitat conditions that increase individual's immune systems. Other times there may simply be nothing a manager can do. It is important to understand disease etiology and epidemiology before effective management actions, if any, can be determined.

Two diseases have been identified as possibly affecting the stability of some desert tortoise populations: Upper Respiratory Tract Disease (URTD; Jacobson et al. 1991) and cutaneous dyskeratosis affecting the shell (Jacobson et al. 1994). A third disease, a herpesvirus, was recently identified and may have population-level consequences, but very little is known about it (Berry et al. 2002, Origgi et al. 2002). URTD has been found in several populations that have experienced high mortality rates, including some in the west Mojave (Jacobson et al. 1996, Berry 1997). Much is published in peer reviewed journals about the etiology of this disease, which has been found in captive turtles of this and several other species (Jacobson et al. 1991) and in wild populations of the gopher tortoise (*Gopherus polyphemus*; Jacobson 1994). Brown et al. (1994a) showed definitively that URTD can be caused by a bacterium, *Mycoplasma agassizii*. It is likely transmitted by contact with a diseased individual or through aerosols infected with *M. agassizii*. The organism attacks the upper respiratory tract causing lesions in the nasal cavity, excessive nasal discharge, swollen eyelids, sunken

eyes, and in its advanced stage, lethargy and probably death (Jacobson et al. 1991, Schumacher et al. 1997, Homer et al. 1998, Berry and Christopher 2001). It must be noted, however, that some of these clinical signs may also be characteristic of other health condition such as dehydration, allergy, or infection with herpesvirus or the bacteria *Chlamydia* or *Pasteurella* (e.g., Pettan-Brewer et al. 1996, Schumacher et al. 1997).

Malnutrition is known to result in immunosuppression in humans and turtles (Borysenko and Lewis 1979) and is associated with many disease breakouts. It is possible that nutritional deficiency in tortoises caused by human-mediated habitat change and degradation may be partly responsible for the apparent spread of URTD and its perceived impact on tortoise populations (Jacobson et al. 1991, Brown et al. 1994a). Short-term droughts may temporarily reduce immune reactions and increase susceptibility to URTD (Jacobson et al. 1991), although this is speculative. Whereas animals may become debilitated by chronic immune stimulation, no biochemical indicators of stress have been identified in diseased compared to non-diseased turtles (Borysenko 1975, Grumbles 1993, Christopher et al 1993, 1997).

Although evidence indicates a correlation between high rates of mortality and incidence of URTD within populations (Berry 1997), there is little direct evidence that URTD is the cause of the high rates of loss. In two preliminary analyses (Avery and Berry 1993, Weinstein 1993), animals exhibiting clinical signs of (both studies) or testing positively for (latter study) URTD were no more likely to die over a one year period in the west Mojave than were those not exhibiting signs or testing positive. This may be because factors other than disease caused much of the mortality or many animals not showing clinical signs of disease in the field were still infected. A serological test for presence of antibodies against *M. agassizii* has been developed and is now being used to document presence and spread of the disease (Schumacher et al. 1993). But, the test, an enzyme-linked immunosorbent assay (ELISA) does not indicate present infection, only a probability of past exposure. A polymerase chain reaction (PCR) test, which has been developed for *M. agassizii* is more effective for determining active infection (Brown et al. 1995). Lance et al. (1996) reported that infected tortoises had significantly lower testosterone and estradiol levels and that diseased females tended to lay eggs less often. Finally, there is some evidence that animals at the DTNA, where URTD breakout has been particularly intense, may recover from infection (Brown et al. 1994a, b). Interestingly, Berry (2002) reported that none of 119 wild tortoises tested at 9 locations throughout the California deserts in 2000 and 2001 tested positive for URTD. No discussion of this result was provided. A thorough epidemiological study is badly needed to identify the factors involved in the incidence, spread, and virility of the disease in wild populations (D. Brown pers. comm.).

A shell disease, cutaneous dyskeratosis (CD), has been identified in desert tortoise populations (Jacobson et al. 1994). CD consists of lesions along scute sutures of the plastron and to a lesser extent on the carapace. Over time, the lesions spread out onto the scutes. This disease may be caused by the toxic effect of chemicals in the environment, but evidence is lacking to test this hypothesis. Naturally-occurring or human-introduced toxins such as selenium, chlorinated hydrocarbons, organophosphates, nitrogenous compounds, and alkaloids have all been implicated (Homer et al. 1998), but there are no

data showing a direct link. The disease may also be caused by a nutritional deficiency (Jacobson et al. 1994). It is not known whether or not CD is caused by an infectious pathogen or if secondary pathogens act to enhance the lesions (Homer et al. 1998, Homer pers. comm.). It is unclear if the disease is actually lethal or responsible for declines in infected tortoise populations (Homer et al. 1998). Only one documented case of CD from the West Mojave Desert was found in the literature (Homer et al. 1998).

If the shell diseases are toxicoses, toxic responses to environmental toxins (e.g., heavy metals, chlorinated hydrocarbons, organophosphates, and selenium), then there may be a direct link between these diseases and human activities unless the toxin is a natural component of the physical environment. Chaffee et al. (1999) found no significant correlation between elevated levels of metals in organs of ill tortoises and in the soil where the tortoises came from. If there is a link to human activities, then we can consider solutions that would reduce levels of input of the toxic chemical. However, this link is currently highly speculative.

There is some recent, albeit weak, preliminary evidence linking heavy metals to disease in tortoises. In necropsies of 31 mostly ill tortoises, Homer et al. (1994, 1996) found elevated levels of potentially toxic metals and minerals in the liver or kidney of one or more of the animals. Since most of the animals were ill to begin with, an association was made between the presence of the toxicants and presence of the disease. However, that study is strictly correlative, and fails to demonstrate a cause and effect relationship. Berry (1997) claims that "the salvaged tortoises with cutaneous dyskeratosis had elevated concentrations of toxicants in the liver, kidney, or plasma...and/or nutritional deficiencies." However, closer examination of the data presented in Homer et al. (1994, 1996) and cited in Berry (1997) reveals a remarkably low association with only 1 out of 12 tortoises with CD having at least one toxicant concentration greater than two standard deviations above the mean. Four other animals also had unusually high levels of at least one toxicant, but did not suffer from CD. Furthermore, Homer et al. (1994, 1996) identified abnormally high levels as being those concentrations that are greater than two standard deviations from the average concentration found in the 31 tortoises. In a normally distributed set of 20 randomly selected values, 1 will, by definition, fall outside of 2 standard deviations from the mean, because 2 standard deviations is defined as including only 95% of the samples. So if 100 comparisons are made, then 5 levels will be considered abnormally high or low just by chance. In the study, 689 values would be reported, thus 34 (or 95%) would be expected to be greater than twice the standard deviation from the mean just by chance. In fact, 32 were identified as falling outside this range of two standard deviations. These data are in need of a thorough statistical analysis. Homer (pers. comm.) has found significantly higher levels of iron (in liver) and cadmium (in kidneys and liver) of tortoises with URTD compared to those in a control group. It is not known if the levels identified by Homer et al. (1994, 1996, pers. comm.) as being abnormally high are biologically significant. Homer (pers. comm.) has found significantly reduced levels of calcium in the livers of tortoises with CD, which suggests a nutritional deficiency may be involved in the disease.

Several other diseases and infections have been identified in desert tortoises (Homer et al. 1998). These include a poorly known shell necrosis, which can result in sloughing of entire scutes; bacterial and fungal infections; and urolithiasis, a solid ball-like deposition of urate crystals in the bladder (i.e., bladder stones; Homer et al. 1998). There is no evidence to suggest that any of these diseases are at this time widespread, threatening population stability, or hindering population recovery.

Beyond taking precautions to avoid spreading the disease when handling many animals (Rosskopf 1991, Berry and Christopher 2001), educate the public against releasing potentially-diseased captive animals (Berry 1997), include only healthy individuals in translocation efforts (Brown 1994a), the practical management implications of the disease data are unclear. Tully (1998) states, without explanation, that URTD infections are not likely to be controlled by immunizations. Improving habitat conditions may help reduce stress-induced immunosuppression (Brown 1994a), but the link between stress from poor habitat quality and susceptibility to URTD is only speculative.

Drought

A drought is an extended period of abnormally low precipitation. Unlike kangaroo rats and some other desert vertebrates, tortoises acquire much of their water, and maintain and overall positive energy balance, from standing sources (Peterson 1996). O'Connor et al. (1994a) showed that water deprivation in a group of semi-wild tortoises caused higher levels of physiological stress (using several blood assay profiles) compared to a group of semi-wild tortoises with water supplements and a group of free-ranging tortoises. Peterson (1994a) recorded abnormally high levels of mortality in two tortoise populations (west and east Mojave) during a three-year period of an extended drought. The deaths in one population (Ivanpah Valley) were attributed to drought-induced starvation and dehydration and occurred in the third year of study. Ken Nagy (pers. comm.) has stated that tortoises can probably survive 1-2 years without drinking water but will start dying of dehydration after that. The primary source of mortality, which occurred throughout the three-year study, at the DTNA was coyote predation. The coyotes may have switched to the less desirable tortoises following hypothesized drought-induced reduction in coyotes' normal prey (black-tailed jackrabbits; see also Jarchow 1989). Alternatively, tortoises may have been in a weakened condition due to URTD, but Peterson (1994a) found little evidence of disease in his study animals. Low rainfall can also reduce reproductive output with tortoises producing fewer eggs or suspending egg-laying altogether in low-rainfall years (Turner et al. 1984, Lovich et al. 1999). Avery et al. (2002) documented higher survival and reproduction among females at higher elevation site that received more rain than a lower one in Ivanpah valley. Tortoises may survive drought periods by eating less nutritious cacti and shrubs (Turner et al. 1984, Avery 1998).

Much of the desert experienced short-term drought conditions in the late 1980s (Corn 1994a, Hereford 2002), a period when rapid declines and high mortality were reported in some tortoise populations (Berry 1990 as amended, Corn 1994a, Peterson

1994a). However, Corn (1994a) reported that, between 1977-1989 there was no correlation between winter precipitation and relative abundance of large (≤ 180 mm median carapace length [MCL]) or small (<180 mm MCL) tortoises, but there was a significant correlation between summer precipitation and relative abundance of small tortoises. Some reports exist of dehydrated and emaciated tortoises being found (Berry 1990 as amended, Peterson 1994a, Homer et al. 1996).

Drought is a normal phenomenon in the Mojave Desert (Peterson 1994a, Hereford 2002). Desert tortoises have lived in the Mojave Desert for over 10,000 years and probably have evolved under similar boom-bust conditions (Peterson 1994 a,b, 1996; Henen 1997; Nagy and Medica 1986). It is possible that drought can cause episodic mortalities punctuated by periods of low mortality during years with more abundant rainfall. It is reasonable to speculate that drought-induced stress in concert with other threats (e.g., disease, predation) resulted in significant mortality (Peterson 1994a), but there are little data to test this hypothesis. An epidemiological study is needed to evaluate the effect drought has on tortoise populations.

Energy and Mineral Developments

Energy and mineral development includes: presence of utility lines, transmission lines, and gas pipelines; development of land for oil and gas leases; geothermal and solar energy generation; and digging exploratory pits for and extraction of minerals. Impacts from energy and mining developments can include habitat destruction and direct mortality from off-road travel to explore and access sites; habitat loss to road and development construction, leachate ponds, tailings, rubbish, etc.; introduction of toxins; fugitive dust and soil erosion; and urban-type developments to support large mining operations. The extent of area directly affected by energy and mining is difficult to assess because the data are not readily available. According to Luke et al. (1991), as of 1984, 41% of high density tortoise habitat rangewide was leased or partially leased for oil or gas and 2% was directly impacted by mining operations or leased for geothermal development. However, no indication was given for how these figures were obtained. Most mining operations are point sources of disturbance with potentially little effect beyond the immediate site of development. The greatest effect may come from the cumulative impact of many relatively small mining-related disturbances combined with facilitation of rural or urban development (e.g., Randsburg) to support the mining operations in a given area. However, large-scale operations that depend on frequent haul trucks to transport excavated minerals may also present vehicle-related impacts such as increased road kills and air pollution.

There are few data on the effects of energy and mineral development on tortoise populations. Mortalities have occurred in association with mining activities (LaRue and Dougherty 1999). Hard rock mining, particularly pit mining and operations in dry lakebeds, can be a major source of fugitive dust (Wilshire 1980). Loss of habitat and soil and vegetation disturbance can be substantial and major, depending on the size of the area. Although illegal, cross-country travel to drill and access test pits, stake claims, and

evaluate mineral potentials still occur (pers. obs.) and needs to be properly documented and evaluated.

Energy development has similar impacts, particularly direct and indirect loss of habitat, fragmentation of habitat and population, and effects of access roads, which are likely to be relatively light once construction has ended (Brum et al. 1983). Construction of transmission lines requires grading of new roads for construction of towers and maintenance of the lines, and clearing or terracing of habitat for tower placement. Not only is habitat lost (0.16 to 0.24 mi^2 per mile of transmission line; Robinette 1973, cited in Luke et al. 1991), but the new road may help to fragment the population and provide access to areas for other human-related impacts (see "Utility Corridors" section, below). The access roads are also an important source of windblown dust and attendant erosion (Wilshire 1980). The presence of new utility lines, necessary to distribute the electricity, may help facilitate nesting by ravens in specific areas they did not nest in before, if those areas did not have adequate nesting substrates before the new towers were erected (Boarman 1993, Knight and Kawashima 1993). For more discussion, see "Utility Corridors" section, below.

Aside from loss of habitat and other consequences associated with access roads and transmission lines, there is little evidence that energy generation negatively impacts tortoise populations. If designed and managed properly, wind generation may be compatible with tortoise populations (Lovich and Daniels 2000). Tortoises made extensive use of wind turbine pads for burrow cover and, by restricting access, the wind park served as a de facto reserve that minimized several other harmful human activities such as ORV travel, vandalism, and illegal collections. The only study found on solar energy impacts showed that here were only very small changes in air temperature, wind speed, and evaporation rates downwind from a solar power plant in the western Mojave Desert (Rundel and Gibson 1996). They did not study impacts to tortoise populations.

Fire

Fire, once considered a rare event in the Mojave Desert (Humphrey 1974), now occurs with ever-increasing frequency causing a greater threat to tortoises and their habitat (USFWS 1994, Brooks 1998). Fire frequency has increased with the proliferation of introduced plants, particularly the grasses, red brome (*Bromus rubens)* and split grass (*Schismus barbatus* and *S. arabicus*), which provide fuel for fires (Brown and Minnich 1986, Brooks 1999b). These plants help to spread fire because they are often common, tend to grow in large relatively dense mats, and fill the intershrub spaces, which are largely devoid of native vegetation (Brown and Minnich 1986, Rundel and Gibson 1996, Brooks 1999b). Fires cause direct mortality when tortoises are burned or inhale lethal amounts of smoke, which can happen both in and out of burrows. Documented cases of tortoises being burned by fires are uncommon, but do occur (e.g., Woodbury and Hardy 1948 - circumstantial, secondhand account of 14; Homer et al. 1998, reports 1; Esque et al. in press, reports 5, which is 4-13% of the study population; Lovich, pers. comm., found 1). Fires are probably most hazardous to tortoises when they occur during the

active season for tortoises (e.g., spring in the West Mojave). Previously rare, frequency of spring fires are now on the increase (Brooks 1998).

There are several possible indirect impacts of fires. Fires remove dry and some living forage plants. They facilitate proliferation of non-native grasses (Brown and Minnich 1986, Brooks and Berry 1999). The effect this has on tortoises is as yet unresolved. There is some evidence that tortoises may selectively avoid exotic grasses (Jennings 1993, Avery 1998), but Esque (1994) showed that tortoises may choose to eat a majority of non-native plants, particularly in drier years. The physiological consequences of foraging on non-native grasses is also not entirely known, but, in a manipulative study with semi-captive tortoises, Nagy et al. (1998) showed that grasses, native and non-native) provided tortoises with much less nitrogen than did forbs and tortoises tended to loose water when eating them. Avery (1998) also showed that tortoises eating only split grass lost weight, assimilated less protein, and were in a negative nitrogen balance, whereas those that were fed a native forb (*Camissonia boothii*) maintained their weight and experienced a positive nitrogen balance. Those tortoises that fed on both plat types maintained their weight but experienced a net loss of protein. By removing vegetation, fires may alter the thermal environment by increasing temperature extremes experienced by seeds, plants, and burrowing tortoises (Esque and Schwalbe 2002). Soil erosion is enhanced by the loss of stabilizing vegetation, roots, and cryptogamic crusts (Ahlgren and Ahlgren 1966). Fires fragment tortoise habitat by creating patches of unusable habitat, at least over the short term. There is some evidence of an increase in availability of nitrogen and other nutrients for a short while following fires (Loftin 1987), but none demonstrating that plant growth is stimulated by this nutrient flush. Overall effects on vegetation are variable, and may depend in large part on the intensity of the fire, characteristics of the plants, and post-fire precipitation (Esque and Schwalbe 2002). Brown and Minnich (1986) found an increase in annual vegetation following a fire during an unusually rainy period. On the other hand, O'Leary and Minnich (1981) found no difference during a drier year.

The structural characteristics of vegetation in years following fires has been studied. Following burns in creosote scrub community in the Colorado Desert, Brown and Minnich (1986) found 23% higher cover by annual forbs, most of which were exotics. Cover by some native forbs, including ones preferred by tortoises, were also higher in burned vs. unburned areas. They also found that perennial plants, particularly creosote bush, were damaged and exhibited low levels of stump sprouting and germination following more intense fires. A change in dominant shrub type resulted, but the study only reported on 3-5 years post-burn; no data were presented on possible long-term successional changes or recovery. Dense cover by annuals, particularly introduced grasses, provides higher fuel loads, which results in more fires that are also hotter (Brown and Minnich 1986, USFWS 1994, Brooks 1999b).

The amount of tortoise habitat burned by recent fires is relatively low, but increasing. For example, between 1980 and 1990, 243,317 acres burned in the Mojave Desert in California, which is an average of 38 mi^2 per year (USFWS 1994). The increase in number of fires per year over the ten-year period was statistically significant. Tracy (1995) reports that fires occur much more frequently near roads and towns, but no data

were presented in this abstract. Duck et al. (1995) reported that tortoises may be killed by fire-fighting activities, including by large fire trucks driving off of roads in tortoise habitat, and recommended training and fire management techniques to reduce the problem.

Through its destructive effect on woody shrubs, fire has been used to manage (i.e., improve for cattle foraging) desert grasslands. In desert grassland of southern Arizona, fire removed 9-90% of targeted shrubs (i.e., mesquite, *Prosopsis juliflora*; burro-weed, *Aplopappus tenuisectus*; prickly pear cactus, *Opuntia occidentalis*; and cholla, *Opuntia* sp.; Reynolds and Bohning 1956). This work was not conducted in tortoise habitat and the efficacy of using fire in similar ways has not been tested in the Mojave Desert nor has its effectiveness at improving habitat for tortoises been tested.

Garbage and Litter

Garbage illegally dumped in the desert is unsightly, may cause local habitat alteration, and may affect individual tortoises. Indeed, in a popular article, Burge (1989) cited an instant of a tortoise losing its leg after getting it caught in the string of a disposed balloon. She also reports finding foil and glass chips in tortoise scat. No details were provided. There are no data to suggest that litter is a widespread or major problem for tortoise populations. The relationship between organic litter and raven predation on tortoises is covered under "Predation," below.

Illegal dumping of hazardous wastes is an increasing problem in the California deserts (John Key, pers. comm.) Toxins are known to cause a myriad of problems for wildlife (Jacobson et al. 1994), and presumably elevated levels (see "Disease" section, above) of certain metals (e.g., cadmium, copper, molybdenum, mercury, lead) have been found in the tissues of desert tortoises (Homer et al. 1994, 1996, 1998). The distribution and limited size of illegal dumps and hazardous spills suggests that this is a minor problem for tortoise populations as a whole, but they may be of concern on a localized basis. Metals and other pollutants may enter the environment from other sources including mining and air pollution, but their effects on tortoise populations remain speculative.

Handling and Deliberate Manipulation of Tortoises

Handling and deliberate manipulation of tortoises includes curious members of the public picking them up and sometimes removing them from the wild, biologists relocating and translocating them to new sites, pet owners releasing captive tortoises into the wild, and researchers manipulating tortoises for scientific experimentation. The effects can be manifold, depend on the type of handling, and remain largely unstudied.

Members of the public will sometimes pick up tortoises when they find them on roads or alongside trails. They do so out of curiosity or to remove the animal from harm's way (Ginn 1990; picking up a tortoise to cause harm is covered in the

"Vandalism" section, below). Any such handling or even disturbance of a tortoise is illegal under the Endangered Species Act, although it is unlikely that USFWS would prosecute a person who moves a tortoise out of harm's way (pers. obs.).

There are several possible effects of this type of well-meaning handling, but most of them fit into the realm of speculation or science lore. First, when tortoises are handled they sometimes void the contents of their bladder, which may represent loss of important fluids and it is thought this loss could be fatal (Averill-Murray 1999). Averill-Murray (1999) provided some evidence that handling-induced voiding may jeopardize survivability, although usually relatively small amounts of fluid are discharged. Smaller animals were more likely to void, but, if the animal was recaptured at a later date, its growth was not inhibited as a result of voiding previously. The statistical significance of his results may be compromised by his decision not to adjust the level of significance to account for making multiple tests (a problem similar to that noted about Homer 1994, 1996, in the "Disease" section above). Nonetheless, the results suggest there may indeed be a trend towards voiding affecting tortoise survival, particularly in drought years, and this should be followed up with more experimentation.

Other problems with handling tortoises can occur. Diseases might be transferred between tortoises if people handle more than one tortoise without sterilizing their hands or using different clean or sterilized gloves for each handling (Rosskopf 1991, Berry and Christopher 2001). It is claimed that turning over a tortoise to look at its underside will harm its internal organs, break eggs, or cause shock (Rosskopf 1991), but there is no evidence to support this contention. It may be detrimental to a handled tortoise if it is released outside of its home range, far from known burrows, or away from shade (e.g., Stewart 1993). This could be particularly hazardous during hot, dry weather or late in the afternoon, but again no data exist to support this likely speculation. Finally, the disruption of behavior by handling or just approaching the tortoise could be harmful if the disruption causes the animal to withdraw into its shell long enough to prevent it from being able to eat, drink, or retreat to a safe cover site (e.g., burrow, pallet, or shrub) for the night, thus leaving it exposed to predators or harsh environmental conditions. The probability of this disruption being hazardous to the tortoise is likely low, unless disruptions occur extremely frequently. Tortoises can go many months without eating or drinking (Peterson 1996), so a few minutes of disruption is not likely to alter their nitrogen, energy, or water balance. All of these claims need further study to substantiate their validity.

Relocation of animals to a new area is frequently recommended, and is occasionally implemented to save tortoises from construction and other ground disturbing activities. Possible problems with translocation efforts include increased risk of mortality, spread of disease, and reduced reproductive success. There have been a few studies of the effectiveness of relocation efforts, and most of the relocations generally have been marginal to unsuccessful. A study summarized in Berry (1986b) found that 22% (13/43) of the animals translated 16 to 88 km from their capture sites stayed at their relocation sites for more than several days, but only five remained for 15 months to 6 years. Few mortalities were observed, but many disappearances from unknown causes occurred; these animals may have died or wandered away. In another relocation effort,

91% (10/11) stayed within the relocation area, which was only about 450 m from where they were moved, for at least 3 months and at least 36% (4/11) were present after 16 months (Stewart and Baxter 1987). In a third effort, 56% (9/16) of relocated tortoises stayed in the area (5.6 km from their original home ranges) for at least 1.5 years (Stewart 1993). At least 25% (4/16) died within about 2.5 years. A fourth relocation effort was conducted in Nevada. Several tortoises were moved to an area immediately adjacent to a development site (Corn, 1994b, 1997). These 13 animals were moved to areas 2 km away, which was still within or very close to their pre-translocation home ranges. There was no difference in survival, but displaced animals had larger home ranges than did the residents. A preliminary analysis of a fifth study showed that mortality was significantly greater among guests (tortoises moved to a pen immediately adjacent to their capture sites) than hosts (resident tortoises; Weinstein 1993). All of these relocation studies covered short time periods and only measured movements and survival. None of them looked at reproductive success or long-term survival, two of the most important measures of success.

An ongoing project translocating tortoises many miles from their capture site apparently is showing success, but no reports or publications (other than abstracts) are available. Apparently, survivorship and reproduction are equivalent between relocated tortoises and resident tortoises (Nussear et al. 2000). Relocated tortoises did move more during their first year in the new site, but after that their movements were not significantly different than those of resident tortoises. Tortoises released in Utah also moved more than did resident tortoises there (Wilson et al. 2000). Both of these studies need further analyses and complete presentations before their results can be adequately evaluated. The success of desert tortoise relocations probably depends on distance of relocations, habitat quality, density of host population, rainfall, and health condition of the relocated and host animals.

Probably tens of thousands of desert tortoises are held in captivity throughout southern California, Nevada, and elsewhere, some were taken from the wild, others were reared in captivity. There are several documented cases of captive tortoises being released into the wild (Howland 1989, Ginn 1990), an activity that is now illegal. Release of captives may be detrimental to both captives and resident tortoises. Released captive tortoises may die (Berry et al. 1990) because they do not know how to fend for themselves in the wild; will not initially know where to find cover sites, good forage, sources of water, or essential minerals; and may not have genetic adaptations necessary to survive in the particular area. However, 25 formerly-captive tortoise were released in Nevada (Field et al. 2000). The animals were equipped with radio transmitters and followed for 14 months. The unpublished results indicate that movements and weights did not differ between released and resident tortoises. No adults died (released or resident) and 2 (out of 8) released juveniles died compared to neither of the two residents studied.

Of greater concern for the stability or recovery of tortoise populations is the possible impact of the released captives on resident (host) tortoises. The greatest likely effect is the introduction of disease to the wild population. URTD, the disease presently believed by many to have detrimental effects on several wild tortoise populations (see

"Disease" section, above), is commonly found in captive tortoises (Berry et al. 2002, Johnson 2002). Releasing into the wild tortoises that are infected with URTD may introduce the disease-causing bacterium, *Mycoplasma agassizii*, to previously uninfected individuals and populations. There is some evidence that the incidence of disease is greater in areas of known releases of captives and around urban areas where release or escape of captives is likely to be relatively frequent (Jacobson 1993, Berry pers. comm.). However, data on the rangewide incidence of disease have not been peer reviewed and are not generally available, so it is not possible to evaluate this hypothesis.

Desert tortoises have been manipulated in many ways as part of scientific studies. They have been probed, stuck with needles, affixed with transmitters, implanted with transponders, weighed, measured, pulled and sometimes dug out of burrows, tom name a few. All manipulative research involving desert tortoises must be permitted by USFWS to ensure that risk of harm to the tortoises is minimized. USFWS closely evaluates methods and qualifications of researchers before issuing a permit. There is very little written on the effects of research manipulation. In a preliminary analysis from one study, Weinstein (1993) reported that significantly fewer animals whose blood was sampled on a regular basis subsequently died compared to those whose blood was not sampled. In an evaluation of the possible effects of one research tool, Boarman et al. (1998) summarized from the literature on possible impacts to turtles of different ways of attaching radio transmitters. They concluded that there is little evidence of negative impacts of transmitters on turtles and particularly tortoises. Their concluded this partly because of paucity of published accounts of problems experienced. There are a few undocumented reports of individual animals dying from excessive bleeding following blood extraction and possible excessive mortality of animals that had blood extracted 3-4 times per year for several years, but none of this is reported in the literature and thus remains anecdotal. Kuchling (1998) hypothesized that X-rays, used to measure reproductive success, are hazardous to turtles. Using empirical data, Hinton et al. (1997) argued that x-rays are safe when extremely low dosages of radiation are employed, which can be accomplished with use of rare earth screens.

Invasive Plants

The introduction and proliferation of invasive plants is a continuing and increasing problem in the desert. The most common invasive plants found in tortoise habitat in the west Mojave Desert are cheatgrass (*Bromus tectorum*), red brome (foxtail chess, *Bromus madritensis rubens*), split grass (*Schismus barbatus*, and *S. arabicus*), redstem filaree (*Erodium cicutarium*), Russian thistle (tumbleweed, *Salsola tragus*), Sahara mustard (*Brassica tournefortii*), and fiddleneck (*Amsinckia tessellata*; Kemp and Brooks 1998). Fiddleneck is a native species to the U. S., but others are natives to Eurasia, Africa, or South America (Kemp and Brooks 1998, Esque et al. in press). By one estimate, alien annuals comprised 9-13% of all annual plant species but 3 species (red brome, split grass, and redstem filaree) comprised 66% of all annual plant biomass in one wet year (Brooks 1998, 2000). Other less common weedy species are listed in USFWS (1994, p. D21) and Kemp and Brooks (1998).

Invasive grass species (e.g., split grass) tend to have thin, filamentous roots that spread quickly and easily through shallow compacted soil where the surface crust has been broken (Adams et al. 1982a, b). The root structure allows plants with filamentous roots to quickly take advantage of small amounts of water in the soil following light rains and may allow them to outcompete native, non-weeds, which often grow slower, have thicker tap roots that are less efficient at pushing through dense, compacted soil (Adams et al. 1982a, b). There is some empirical evidence that split grass and red brome inhibit or prevent the growth of native plants, including fiddleneck (Brooks 2000), indicating that competition may be occurring and that the native plants are less available to foraging tortoises. However, in Nevada, Hunter (1989, cited in USFWS 1994, p. D22) found no correlation between native plant density and density of red brome.

In general, invasive plants tend to proliferate in areas of disturbance (Hobbs 1989), but the effect of disturbance may be weak compared to that of rainfall and soil nutrient levels. Density or biomass of weedy plants in the Mojave Desert may be higher in areas disturbed by ORVs (Davidson and Fox 1974), livestock (Webb and Stielstra 1979, Durfee 1988), paved roads (Frenkel 1970, Johnson et al. 1975), and dirt roads (Brooks 1998, 1999a). In a strictly correlative study, Brooks (1999a) found that the biomass of two annual exotic plants was weakly associated with levels of disturbance (disturbance was from ORVs and sheep grazing). Biomass of the introduced plants was also positively associated with soil nutrient levels and the proportion of total biomass and species richness (number of species in a given area) comprising exotic species was negatively associated with annual rainfall (i.e., relative proportion of exotic annuals was greater in years with low annual rainfall).

An additional factor that may facilitate proliferation of alien plants is increased nitrogen deposition from airborne pollutants (Allen et al 1998). Nitrogen, in the form of nitric acid and nitrate from automobile exhaust, deposits on plants and soil downwind from urban areas (Fenn et al. 1998) and perhaps from roads. Brooks (1998) has shown experimentally that the addition of nitrogen to west Mojave soil increases the biomass of brome and split grass thereby potentially increasing their competitive advantage over native plants (Eliason and Allen 1997). The effect ORV-based exhaust has on desert vegetation has not been established.

It is often stated that non-native plants are of lower nutritional quality than native species preferred as forage by tortoises, but this is not always the case. The difference in nutritional quality may have more to do with the type of plant (e.g., grass versus forb, Nagy et al. 1998) or annual differences in nutritional quality related to precipitation (Oftedal 2001). For example, the non-native split grass, which is often eaten and sometimes preferred by tortoises (Esque 1994), has been shown empirically to deplete tortoises of nitrogen and phosphorus and water and cause weight losses (Avery 1998, Nagy et al. 1998, Hazard et al. 2001), but so does the native Indian rice grass (*Achnatherum hymenoides*, Nagy et al. 1998). Avery (1998) also demonstrated that split grass was lower in overall quality, crude protein, essential amino acids, water, and vitamin concentrations and higher in fiber and heavy metal concentrations than three non-grass species measured (one introduced and two native forbs). The introduced forb, redstem filaree, had higher aluminum and iron concentrations, but was otherwise similar

to native forbs. Where lower-quality weedy grasses can outcompete preferred higher-quality forbs (Brooks 2000), forbs may be less available to tortoises, tortoises would have to eat the lower quality invasives, and they would then suffer from a nitrogen and phosphorus (or other nutrient) deficiencies (Hazard et al. 2001). This speculation requires further testing.

Mechanical injury from invasive grasses has been observed with instances of the sharp awn of *Bromus rubens* being stuck in the nares of tortoises as well as impacting the food in the upper jaws of the tortoises (Medica, pers. comm.). The interactive effect that invasives and fires have on tortoises was discussed in the "Fire" section, above.

Landfills

There are approximately 27 authorized sanitary landfills and an unknown number of unauthorized, regularly used dumpsites in the California deserts. In the West Mojave Desert, there are 11 authorized landfills. The potential impacts landfills have on tortoise populations include: loss of habitat, spread of garbage, introduction of toxic chemicals, increased road kills from vehicles driving to or from the landfill, proliferation of predatory raven populations, and possible facilitation of increases in coyote and feral dog populations. Other than for raven predation, there are virtually no data to evaluate most of these possible threats.

Loss of habitat to landfills is relatively minor except when viewed in the context of habitat degradation and fragmentation caused by the myriad of human developments that are proliferating in the desert. Spread of garbage probably poses a very small problem for tortoise populations (see “Garbage and Litter” section, above), but there are no data available to evaluate this. The possible effect of toxic chemicals in general is treated in the “Disease” section, above, but toxins from sanitary landfills are likely to have very little effect on tortoise populations. Modern sanitary landfills are designed to prevent the seepage of toxic chemicals and present a very low level (or probability) of risk, and any seepage from these or less optimally operated landfills would probably affect a very small proportion of tortoises. Landfills do generate methane gas, but because desert landfills are so dry, the generation of methane is extremely low and not likely to affect tortoises. Fugitive dust is probably a localized problem and generally minimized through frequent sprinkling of the dirt. Increase in road kills is probably proportional to the level of traffic, speed of vehicles, density of tortoises, and length of road. For most landfills, these factors are relatively low, so the impact of road kills on tortoise populations from vehicles going to landfills is probably relatively minor, but they do happen (LaRue and Dougherty 1999). However, several landfills are slated to be closed and converted to transfer or community collection stations. The garbage would be deposited into dumpsters or large compactors at these stations, then transported to a small number of larger regional landfills. This activity could increase the amount of traffic at these fewer landfills thereby increasing the number of road kills.

The greatest potential impact landfills have on tortoise populations is through their probable role in facilitating increased predation by ravens, and perhaps coyotes.

Ravens make heavy use of landfills for food (Engel and Young 1992, Boarman et al. 1995, Kristan and Boarman 2001). The food eaten probably helps ravens to survive the summer and winter, when natural sources of food are in low abundance (Boarman 1993, in prep.). As a result, more ravens are present at the beginning of their breeding season (February - June) to move into tortoise habitat, nest, raise young, and feed on tortoises. Healthier ravens are more likely to raise chicks successfully, who in turn will move to the landfills and experience higher than normal levels of survival, and the cycle continues. Predation by ravens is probably relatively low immediately around landfills where tortoise populations are relatively low, but increase as ravens disperse to distant nest sites (Kristan and Boarman 2001). See the "Predation" section, below, for more details.

Livestock Grazing

Grazing by livestock (cattle and sheep) is hypothesized to have direct and indirect effects on tortoise populations including: mortality from crushing of animals or their burrows, destruction of vegetation, alteration of soil, augmentation of forage (e.g., presence of livestock droppings, and stimulation of vegetative growth or nutritive value of forage plants), and competition for food.

Reduce Tortoise Density

There are very few data available to determine if grazing has caused declines in tortoise populations. The Beaver Dam Slope, Utah, was grazed heavily by sheep until 1950's and cattle are still grazing there today (Oldemeyer 1994). Tortoise populations on the Beaver Dam Slope were estimated at 150 tortoises/mi^2 (Woodbury and Hardy 1948), but, using very different methods, the population apparently dropped to 34-47/mi^2 in 1986 (Coffeen and Welker 1987, cited in Bury et al. 1994). The reductions have been attributed to grazing, but another cause may include the potential spread of disease from captive tortoises released in the area (Luke et al. 1991). High mortalities and population declines in Piute Valley, Nevada, have also been attributed to grazing (Mortimer and Schneider 1983, and Luke et al. 1991), but 1981 was a drought year and a high level of recent mortalities may have occurred. Such was the case in Ivanpah Valley where 18.4% of radio-transmittered tortoises died (Turner et al. 1984). It is interesting to note that there appeared to be more tortoise mortalities in the section of the Piute Valley study area that experienced lower levels of recent cattle grazing (Mortimer and Schneider 1983), but the data are insufficient to make a definitive judgement. No population trends in California have been attributed with hard data to livestock grazing.

An alternative hypothesis, proposed by Bostick (1990), is that tortoise population declines paralleled declines in cattle grazing throughout the West that began in 1934 with the implementation of the Taylor Grazing Act. Unfortunately, there are no reliable data to test this hypothesis. But its underlying assumption, that tortoises depend on cattle dung for protein, has no empirical support (see "Cow Dung as a Food Source" section, below).

Direct Impacts

CRUSHING TORTOISES

Some observations of tortoises being crushed by livestock exist in the literature, but often with little or no data to allow in-depth evaluation. Berry (1978, p. 28) stated that "smaller tortoises can be crushed easily by cattle or sheep," but provided no data to support the statement. Berry (1978, pp. 19-21) also reported that "a small two-to-three-year old tortoise with a hole through its shell was found near a temporary watering trough near the DTNA. It appeared to have been killed by sheep within the last few days; the hole in the shell was about the size and shape of a sheep's hoof." Ravens also peck holes in the shells of young tortoises; insufficient information was provided to know if the hole was inconsistent with raven predation. Ron Marlow (pers. comm., cited in Berry 1978) described the disappearance of a marked juvenile tortoise and its small burrow by the trampling by sheep. Apparently the marked tortoise was never observed again, so Marlow determined the sheep killed it. The tortoise may have been killed when sheep trampled the burrow. However, marked juveniles are often never seen again, so the tortoise either survived or died from one of many causes. Any one of these anecdotes may be a true indicator of the nature of tortoise-cattle interactions, but the information provided is inadequate to allow for rigorous evaluation and are very susceptible to alternative explanations.

Sheep and cattle may not step on tortoises because they are very cautious of stepping on uneven ground (rocks, bushes, etc.) for fear of losing their footing. This view is supported by the paucity of documentation of tortoises being crushed by cattle and sheep. One published paper (Balph and Malecheck 1985) reported a test of a related hypothesis: cattle will avoid stepping on clumps of bunchgrass because the clumps form an uneven surface that may cause the cow to trip. Cattle significantly avoided crested wheatgrass (*Agropyron cristatum*) tussocks, avoidance was independent of cattle density, and taller tussocks were less apt to be trampled than short ones. Out of 288 hoofprints recorded, 15 (5%) were on tussocks. This well designed study lends support to the contention that cattle will try to avoid stepping on tortoises, at least large tortoises, but clearly tortoises are not grass tussocks. However, this speculation can be countered by the equally plausible contention that the study's results only shows that cattle will avoid stepping on food; they have no bearing on the propensity for sheep to step on non-food items (e.g., juvenile tortoises).

Sheep, on the other hand, may step on many juvenile tortoises, but appear to avoid stepping on subadult and adult tortoises. Tracy (1996) provides an analysis of data from an aborted BLM study. Without providing details of methods, Tracy (1996) reported that 20% of the Styrofoam model juvenile tortoises placed in natural habitat were trampled by sheep, 87% of those trampled models were crushed. Sheep damaged only about 3% of the subadult models and about 2% of the adult models.

CRUSHING BURROWS

No one has rigorously evaluated whether livestock crush a significant proportion of tortoise burrows. Few cases in the literature document livestock trampling actual burrows and a small number of studies shows increased number of collapsed burrows following grazing. Nicholson and Humphreys (1981) measured impacts of sheep grazing immediately after a band of 1000 sheep passed through their West Mojave study site for 12 days. Sheep trampled and partly collapsed a burrow with an adult female inside; apparently the tortoise was unharmed. Sheep completely destroyed the burrow of a juvenile tortoise while the animal was inside; the field workers extracted the unharmed tortoise. The burrow of an adult male was damaged probably with no tortoise inside. On re-examination of burrows found prior to grazing, 4.3% (7/164) were totally destroyed and 10% were damaged after sheep grazed in the area. Most damaged burrows (86%) were in moderate to heavily grazed areas and were relatively exposed. Most burrows placed beneath shrubs escaped damage (Nicholson and Humphreys 1981). This was an observational study. Webb and Stielstra (1979) reported observing crushed tortoise burrows on the south slope of the Rand Mountains in the western Mojave, but gave no data or additional details. In a report on grazing near the DTNA, Berry (1978) reported that sheep trampled most shallow burrows and pallets that were in the open (no numbers were given), and they also crushed and caved in those near the edges of or within shrubs. Berry (1978) also reported that "cattle and sheep frequently trample shallow tortoise burrows," but provided no data. She further speculated that damage to burrows might be deadly to a tortoise that reaches it on a hot morning only to find it unusable. This is a reasonable expectation based on tortoise behavior and thermal ecology, but no supporting data are available. Avery (1997) found significantly more damaged burrows outside of a cattle exclosure versus inside and also found that tortoises outside the exclosure spent more nights in the open, presumably because many of their burrows were collapsed. There is one account of a tortoise burrow being collapsed by a cow in Utah (Esque pers. comm.). A tortoise was found crushed inside.

Tracy (1996) provided an analysis of data from 2 unpublished BLM studies on the effects of sheep grazing on tortoise burrows: the Tortoise and Burrow Study (TABS study) and Styrofoam model tortoise study (Goodlett unpubl.). The TABS study (cited in Tracy 1996) evaluated the condition of tortoise burrows before and after grazing inside and outside of areas grazed by domestic sheep in the Mojave Desert. They found that 2.5% (8/315) of the tortoise burrows were completely destroyed, which was significantly more than before grazing and more than were destroyed outside the grazing area. In the Goodlett study (unpubl.; cited in Tracy 1996), 3.7% (36/969) of the artificial burrows dug to look like desert tortoise burrows were destroyed after grazing. Significantly more juvenile and immature burrows were destroyed compared to adult burrows and destruction was greatest in the open spaces between shrubs. The proportion of burrows destroyed in these two studies and Nicholson and Humphreys (1981) were not significantly different (Tracy 1996).

Indirect Effects

A commonly held assertion is that the Mojave desert plant species and communities evolved in the presence of, and are probably adapted to, a rich fauna of Pleistocene herbivores (Edwards 1992a, 1992b). Therefore, the argument continues, livestock grazing is compatible with present day plant assemblages, in part because Mojave plants respond to grazing by producing more vegetative material, thus becoming more vigorous in the presence of grazing. This argument has several flaws. First, most large herbivores that coexisted in the Mojave desert region 10,000-20,000 years ago likely primarily browsed leaves from woody shrubs, they did less grazing of grasses and herbaceous annual vegetation, like cattle, sheep, and tortoises primarily do (Edwards 1992a). Second, the mammals of the Late Pleistocene and Early Holocene Mojave existed under considerably different vegetative and climatic conditions ago (Van Devender et al. 1987). A major climatic and vegetative transition occurred between 11,000 and 8,000 years ago. It was more mesic and the area was not a desert. The present vegetation assembly, dominated by creosote shrub, did not arrive in the Mojave Desert region until approximately 8000-10,000 years ago (Van Devender et al. 1987). Third, no one has any idea what density the Pleistocene grazers existed at, so grazing intensity is completely unknown. Thus, there is little justification for arguing that tortoises evolved in the presence of grazers and their survival is thus dependent on cattle, as a surrogate for their coevolved grazing species.

SOIL COMPACTION

Grazing can affect soils by increasing soil compaction and decreasing infiltration rate, the capacity of the soil to absorb water. A lower infiltration rate means less water will be available for plants and more surface erosion may occur. In a review of studies investigating the hydrologic effect of grazing on rangelands, Gifford and Hawkins (1978) concluded that grazing at any intensity reduces the infiltration rate of the soil. Heavy grazing reduced infiltration rate by 50% and light to moderate intensities reduced infiltration by 25% over ungrazed; the differences are statistically significant. Contrarily, Avery (1998) found significantly greater compaction at a livestock water source, but no difference between protected and grazed areas away from the water source.

Soil compaction affects vegetation by reducing water absorption (thereby availability to plants) and making it more difficult for plants to spread their roots, particularly tap roots (Adams et al. 1982a, b). Growth and perhaps spread of split grass (*Schismus barbatus* and *S. arabicus*) is facilitated by compaction because of root structure. This may lead to a conversion in the vegetation community type and increased fire hazard. Although, fire spreads slowly and discontinuously with split grass compared to *Bromus* grasses (Brooks 1999b).

Empirical evidence shows that infiltration is higher in grazed areas. , Rauzi and Smith (1973) conducted a comparative experiment in the central plains of Colorado. They demonstrated that infiltration rate was significantly reduced by heavy grazing (vs. moderate and light grazing). Infiltration rate was significantly correlated with total plant

material on the surface (standing crop) in two of the three soil types tested. Species composition was different. Experimental water run-off tests showed moderate grazing areas had 7 times the runoff of light grazing areas and heavily grazed areas had 10 times the runoff as lightly grazed areas. In the Mojave Desert of Nevada and Arizona, signs of increased soil compaction were evident in grazed areas compared to ungrazed areas between highway and highway right-of-way fences (Durfee 1988). Avery (1998) measured soil type, bulk density, and infiltration in an exclosure that cattle were excluded from for approximately 12 years and compared them to grazed areas outside the exclosure. He demonstrated that soil in heavily trampled areas near water tanks was coarser, had higher bulk density, greater penetration resistance, and lower infiltration rates (all are measures of compaction) than in the protected area.

Although they did not measure compaction or infiltration, Nicholson and Humphreys (1981) quantified the proportion of soil disturbed after a band of 1000 sheep spent 12 days foraging and bedding within a 1.6 km^2 study plot. They estimated that 80% of the soil in bedding areas was disturbed, 67% in watering areas, 37% in grazing areas, and 5% in areas not used by sheep. Soil was considered disturbed if the surface crust was broken or missing and was independent of cause. This non-replicated observational study had a control, did not document what effect the measured disturbance had on vegetation or soil parameters, but did suggest the extent of surface disturbance caused by the grazing.

In a comparison of soil conditions following sheep grazing in the Western Mojave, Webb and Stielstra (1979) noted disruption of soil crusts in intershrub spaces and on the coppice mounds of creosote bushes. Surface strength (a measure of compaction) was significantly greater in grazed vs. ungrazed areas, particularly in the upper 10-cm of the soil. Bulk density and moisture content did not differ, perhaps because of the high gravel content of the soil or compaction in both areas from grazing activity in previous years.

CHANGES IN SOIL TEMPERATURE

Another potential indirect effect of livestock grazing on tortoise habitat is alteration of soil temperature due to change in vegetation structure or soil compaction. Steiger (1930 cited in Luke et al. 1991) measured a significant increase in soil temperature at depths of 2.5, 7.5, and 15 cm in clipped versus unclipped plots. Browsing of shrubs may also alter soil temperature, but in unexpected ways. Using models that accurately duplicated the thermal profiles of desert tortoises, Hillard and Tracy (1997), a graduate student from University of Nevada, Reno, found that soils were cooler beneath shrubs with sparse and open undercanopies and hotter when the undercanopy was entirely closed. Apparently, the open undercanopy allowed cooling by both shade and wind, whereas closed undercanopies trapped hot air. Hence, if livestock browse, graze or otherwise reduce density of the undergrowth of a shrub while leaving the canopy with intact shading properties, then soil temperatures may be reduced. Alternatively, if grazing also reduces the shrub's canopy, then soil temperatures may increase. It is unknown what effect grazing-induced changes in soil temperature might have on

tortoises. The temperature during incubation (Spotila et al. 1994) determines sex of tortoises: incubation temperatures above 89.3°F result in females, and below result in males. Although this has not been tested in the field, it is possible that significant increases in soil temperature resulting from grazing-induced vegetation changes may significantly skew the sex ratio of the tortoise population in favor of females and vice versa. Also, Spotila et al. (1994) found that hatching success was highest for eggs incubated between 78.8°F and 95.5°F.

CHANGES IN VEGETATION

Grazing by cattle can alter vegetation in several ways: damage from trampling, change in species composition perhaps resulting in type conversion (change in plant community type), and introduction of invasive plants.

TRAMPLING OF VEGETATION AND SEEDS

Livestock may cause direct damage to vegetation when they step on or push into shrubs and herbaceous annuals, and this impact was measured in a few studies. In the west Mojave Desert, none of the perennials on plant transects where sheep grazed were trampled, whereas 17% found in the bedding area were trampled (Nicholson and Humphreys 1981). Webb and Stielstra (1979) reported that sheep trample creosote bush when seeking shade to bed in. Annuals, which are prevalent on coppice mounds beneath creosote, were also trampled or eaten. As noted above, Balph and Malechick (1985) provided empirical evidence that cattle usually avoided stepping on clumps of crested wheatgrass, but still stepped on them 5% of the time.

Trampling by livestock may help to bury seeds and improve germination through their trampling action. In sagebrush scrub of northern Nevada, Eckert et al. (1986) found that light trampling increased germination of perennial grasses, but not perennial forbs, and heavy trampling decreased emergence of perennial grasses while increasing emergence of sagebrush and perennial forbs. Cattle grazing in Chihuahua Desert grassland enhanced revegetation by non-native grasses, but rain may have confounded the results (Winkel and Roundy 1991). Unfortunately, no similar studies from the Mojave Desert are available. However, biomass of seeds in the soil seed bank was significantly higher inside compared to immediately outside the DTNA, a 38 mi^2 fence enclosed preserve, where sheep grazing and ORVs had been excluded for 15 years (Brooks 1995); this in spite of there being more seed-eating rodents inside the DTNA. The biomass of annual vegetation, including the introduced species, was also greater inside the DTNA, but the total biomass of natives was proportionally higher inside than outside. Several other uses occurring outside the DTNA were absent from inside the preserve, thus the differences cannot be attributed solely to grazing. However, the changes noted are the expected effect of removal of surface disturbance from the reserve.

Near the DTNA, sheep trampled and uprooted perennial shrubs, such as burrobush (*Ambrosia dumosa*), goldenhead (*Acamptopappus sphaerocephalus*), and

Anderson thornbush (*Lycium andersoni*). "Even large creosote bushes (*Larrea tridentata*) were uprooted" (Berry 1978, p 512). "In many areas near stock tanks [in Lanfair Valley, California] the ground is devoid of vegetation for hundreds of meters. Trailing is heavy and damage extensive within 4.6 to 6.4 km of the tanks" (Berry 1978, p. 512). These reports are anecdotal; no data or additional details were provided.

PLANT COMMUNITY CHANGES

As early as 1898, range scientists observed that cattle ranges in the southwest were becoming overgrazed and urged that restorative actions were necessary (Bentley 1898). Since then, several studies have documented vegetation changes over the past century by comparing photographs or field notes taken in both centuries (Humphrey 1958, Humphrey 1987). The dominant change was a conversion from grass- to shrub-dominated communities (type conversion). Whereas livestock grazing has been implicated as an important cause for these changes, separation of the effect of grazing from the effects of fire suppression, rodents and other herbivores, competition, and climate changes is difficult (Humphrey 1958, 1987). Several studies compared grazed areas to nearby ungrazed areas particularly in southeast Arizona. They generally show a similar reduction in grass species in the grazed areas. Unfortunately, none of these studies occurred in the Mojave Desert and, because the grass-dominated ecosystem of southeast Arizona is very different from the non-grass deserts of California, there is little value in extrapolating from one to the other.

In 1980, the BLM created a 672-hectare cattle exclosure in Ivanpah Valley, eastern Mojave Desert of California, to determine the effects of cattle grazing on desert tortoises and their habitat. In the study establishing baseline data for a long-term comparison, Turner et al. (1981) found no significant differences between plots in biomass of annuals, weight or length of tortoises, proportion of reproductively active females, and tortoise home range sizes. Sex ratios and size classes of tortoises were comparable between the two plots. The lack of differences could be attributed to: (1) low use by cattle of the non-excluded area in both years of the study; 2) tortoise and vegetation recovery, if they are to happen, are likely to take much longer to be observable; and (3) sample size (n=1) too small to detect differences. Changes in tortoise weight with time, estimated clutch sizes, and concentrations of some nutrients in some plant species differed between plots, indicating that some differences existed between control and treatment at the start of the study. Over so short a time frame, differences are likely due to prior spatial differences in habitat or populations rather than grazing treatment. There was a similar level of differences between control and treatment plots one year later (Medica et al. 1982).

Avery (1998) conducted a follow up study at the Ivanpah study plot in the early 1990's. Avery (1998) compared vegetation inside and outside the exclosure. Compared to the ungrazed exclosure, the grazed area had significantly larger creosote bushes, more dormant or dead burrobush, *Ambrosia dumosa* (a perennial shrub), fewer and smaller, galleta grass, *Pleuraphis [=Hilaria] rigida* (a native, perennial grass) representing less biomass, more of the disturbance-loving shrub, *Hymenoclea salsola*, and lower diversity

of winter annuals. They found significantly more desert dandelions (*Malacothrix glabrata*), a plant preferred by both cattle and tortoises, and a greater increase in basal area but not density of the native perennial galleta grass, *P. rigida*, in the protected area. *P. rigida* did increase in basal area over a 12 year period in the grazed area, indicating that level of grazing (0.31 - 2.60 animal unit months) does not cause mortality in *P. rigida*. Biomass, cover, density, and species richness of annuals did not differ. Recovery of Mojave Desert vegetation following alteration by cattle grazing could be very slow (Oldemeyer 1994), so 12 years of exclusion may be insufficient to detect a more significant effect.

A recent study compared soil characteristics, vegetation, and tortoise density within and around three exclosures in the Mojave Desert, including 2 in the west Mojave (Larsen et al. 1997). They reported finding few differences between "grazed" and "ungrazed" plots in percent canopy cover, and the differences found were relatively minor. Grazing reduced native forb density and increased soil compaction. Numbers of live tortoises, tortoise carcasses, and tortoise burrows were no different between grazed and ungrazed areas. Details provided were insufficient to adequately evaluate the methods or results and virtually no statistical analyses were provided.

Durfee (1988) compared structural features of the plant community between ungrazed areas along fenced highways and grazed areas outside of the right-of-way fences. A greater proportion of introduced plants, more bare ground, fewer perennial grasses, and lower spatial heterogeneity in species composition occurred in the grazed areas (see also Waller and Micucci 1997).

As cited above, Brooks (1995) found significantly higher annual plant and seed biomass in the DTNA, an area protected from sheep grazing, compared to an area outside the preserve. Berry (1978) characterized the qualitative effect of sheep grazing near the DTNA: "sheep removed almost all traces of annual forbs and grasses; the desert floor appeared more devoid of herbaceous growth than in drought years." No further data were provided in the latter report.

In all of these studies, spatial differences obtained in soil, weather, and vegetation may be independent of cattle grazing. Furthermore, the size of exclosures may be insufficient to allow the ecosystem to function independent of grazing activities outside the exclosure (which is probably not a big problem at the DTNA, studied by Brooks 1992). Furthermore, many of the above studies, particularly the older and observational ones, were reporting on the effects of long-term heavy grazing, whereas grazing regimes being implemented today are generally much lighter (Oldemeyer 1994).

Water for cattle is usually provided at specific points, at either springs or troughs. Because they will only wander a certain distance from the water source, affect of cattle on the environment will be greatest immediately around the water source and will decrease with distance (e.g. Avery 1998). Fusco (1993), Fusco et al. (1995), Bleecker (1988), and Soltero et al. (1989) recorded significant increases in biomass and density of grasses and other species with distance from water sources. Changing the location of water sources would have the effect of reducing the intensity of impact around each water

source, but may increase the impacts at other sites. It is unknown if impacts would be below the (unknown) threshold for significant effect on the environment.

The impact of sheep grazing has been studied only once. In an observational study, Nicholson and Humphreys (1981) noted that areas not grazed by sheep had 2.3 times more cover and 1.6 times higher frequency of annual plants than in sheep bedding areas and 1.8 times more cover and 1.3 times higher frequency than grazed areas. Annual plant cover decreased by 70% in a heavy-use area compared to 50% in a light-use and 40% in a non-use area before grazing versus after grazing one month later. They also found a 96-99% reduction in annual plant cover between April and June in areas receiving heavy and light grazing by sheep. None of the perennials on plant transects where sheep did not graze showed damage after sheep left the area; 18% in the grazed area were damaged and 91 to 99% in the bedding areas were damaged. Apparently, trampling caused most of the damage in the bedding areas whereas most in the light-use area was from browsing. However, differences may be caused by other factors such as soil that may have differed between the sites independent of grazing pressure. Rather than using exclosures, the sheep and herder were allowed to select the areas they grazed. Hence, the sheep avoided ungrazed treatments for this study. This may have biased the results since there may be inherent differences in these areas that caused the sheep to avoid them.

An often cited benefit of grazing is "compensatory growth," growth of plant tissue following clipping, removal, or damage to plants resulting in increased growth or vigor (e.g., Bostick 1990, McNaughton 1985, Savory 1989). The concept is controversial, has gained little empirical support in semi-arid grasslands and ranges (Detling 1988, Bartolome 1989, Weltz et al. 1989, Wilms et al. 1990), may only be viable in wet, fertile, monocultural environments (Painter and Belsky 1993), and has not been tested in the Mojave Desert (e.g., Painter and Belsky 1993). What little evidence exists from the Mojave Desert fails to support the compensatory growth hypothesis. Avery (1998) found that *Pleuraphis [=Hilaria] rigida*, a native grass consumed by both cattle and desert tortoises, was significantly smaller in grazed versus ungrazed areas. More *Ambrosia dumosa*, which is sometimes eaten by cattle in drought years (Medica pers. comm.), was found dead or dormant in the grazed compared to ungrazed plots. Creosote (*L. tridentata*) was larger in grazed areas, but is consumed by neither cattle nor tortoises (Avery 1998).

INVASIVE PLANTS

Grazing has been implicated in the proliferation of invasive plants in the Mojave Desert (Mack 1981, Jackson 1985, Brooks 1995). Webb and Stielstra (1979) noted that *Schismus* and *Erodium* densities remained unchanged between a grazed and ungrazed area probably because they have an adaptive tolerance to environmental disruption such as soil compaction thus giving them a competitive edge over many native annuals. Berry (1978) reported that the heavily grazed Lanfair Valley "now contains a high percentage of weedy, invader, perennial species typical of overgrazed desert lands," but provided no data. Bostick (1990) argued that cattle grazing helped tortoise populations by aiding the

spread of cacti. Some evidence from outside the Mojave suggests that grazing does aid in the spread of cacti, but the evidence is equivocal. Also, tortoises do eat cacti, which may be an important source of water and nutrition during drought periods (Turner et al. 1984, Avery 1998). But, the evidence in support of Bostick's hypothesis is weak.

COMPETITION

An important effect livestock grazing may have on tortoise populations is competition for food. Because of the enormous differences in size and energy requirements of the two species, the competition, if it occurs, is likely to be heavily asymmetric, with cattle affecting the tortoise populations, but probably not the converse. Three conditions must be met for asymmetric competition to occur: overlap in use of some resource (e.g., food), the resource must somehow limit or constrain one or both species in question, and use of the resource by one species must negatively affect the other species (Begon et al. 1990). Some data exist to help determine if competition for forage exists between cattle and tortoises, but less exist for sheep.

Many studies provide qualitative insights into forage species of tortoises (Woodbury and Hardy 1948, Burge and Bradley 1976, Hansen et al. 1976, Hohman and Ohmart 1980, Luckenback 1982, Nagy and Medica 1986) and three major studies quantified diet and forage selection in desert tortoises (Jennings 1993, Esque 1994, and Avery 1998). Tortoises primarily eat annual herbs in the spring and switch to grasses, perennial succulents (cacti), and dried annuals later in spring and early summer (Avery 1998). Tortoises are active again in the late spring and early fall as temperatures cool. As a result of localized late summer rains, sporadic green up of the vegetation can occur. At this time annuals germinate and bunch grasses (e.g., *Hilaria rigida*) green up and set seed. Cattle then eat the bunch grasses (Medica et al. 1992). In a drought year, tortoises in Ivanpah Valley consumed little food other than cacti during the latter part of the season (Turner et al. 1984). Thus, cacti may serve as a reserve supply of energy, more importantly as a potential source of water.

Four studies quantified plant foods eaten by cattle in the Mojave Desert (Coombs 1979, Burkhardt and Chamberlain 1982, Avery and Neibergs 1997). Avery and Neibergs (1997) followed cattle on horseback in the eastern Mojave Desert. By recording the species of plant and number of bites taken by the free-ranging cattle they found that foods chosen by cattle varied with season. In winter cattle primarily ate the perennial grass, big galleta grass (*Pleuraphis* [=*Hilaria*] *rigida*) and dried annuals from the previous spring (Medica et al. 1982, documented that cattle and tortoises eat perennial grasses in fall). Contrarily, Burkhardt and Chamberlain (1982) found perennial shrubs to predominate the diet of cattle in winter, annual grasses and green forbs did so in spring. Coombs (1979) found that cattle in the eastern Mojave of Utah particularly ate *Bromus* sp., *Ephedranevadensis*, and *Eurotia lanata* and ate perennial grasses considerably more often than expected based on their relatively uncommon presence. All of these studies illustrated that cattle in the desert eat diverse foods and that the foods eaten vary with season, locality, and availability.

Several studies provided evidence that tortoise and cattle diets overlap (Coombs 1979, Sheppard 1981, Medica et al. 1982, Avery and Neibergs 1997, Avery 1998), three of which did so quantitatively. Coombs (1979) and Sheppard (1981) used fecal samples, which are biased because they overestimate food items that contain large undigestible parts (e.g., silica-containing stems of grasses) and underestimate items that are highly digestible (e.g., moist forbs). Sheppard (1981) showed that plaintain (*Plantago insularis*), filaree, and *Schismus* experienced the highest levels of overlap , but overlap varied considerably between months and years. Coombs (1979) found that overlap existed, but neither study provided a species-by-species comparison or an explanation of how overlap was calculated. *Camassonia boothii*, *Malacothrix glabrata*, *Rafinesquia neomexicana*, *Schismus barbatus*, and *Stephanomeria exigua* were major forage items of both cattle and tortoises in Ivanpah Valley (Avery and Neibergs 1997, Avery 1998). Diet overlap between the two herbivores was greatest in early spring (38% Vs 16% in late spring, Avery and Neibergs 1997, Avery 1998).

Three studies provide data on forage overlap between sheep and tortoises. Webb and Stielstra (1979) reported that in the western Mojave Desert, sheep primarily ate herbaceous vegetation from the coppice mounds around the base of perennial shrubs. By comparing biomass of plants in a grazed area versus a nearby ungrazed area, they determined that three species were primarily removed: *Phacelia tanacetifolia*, *Thelypodium lasiophyllum*, and *Erodium cicutarium*.. Shrubs browsed by the sheep included *Ambrosia dumosa*, *Grayia spinosa*, *Haplopappus cooperi*, and *Acamptopappus sphaerocephalus*. Cover, volume, and biomass of these shrubs were significantly lower in grazed vs. ungrazed areas. However, because measurements were not taken before grazing it is possible that some differences may have existed before grazing commenced. Hansen et al. (1976) estimated that 15% of sheep diet in the western Mojave was composed of grasses and 52% of desert tortoise diets was composed of grasses. Nicholson and Humphreys (1981) reported several species of plants, particularly flowering annuals and burrobush (*Ambrosia dumosa*), that were highly used by sheep, but provided no quantitative data. Several species eaten by sheep were also eaten by tortoises including: split grass (*Schismus arabicus*), checker fiddleneck (*Amsinckia tessellata*), desert dandelion (*Malacothrix glabrata*), filaree (*Erodium cicutarium*), Fremont pincushion (*Chaenactis fremontii*), Parry rock pink (*Stephanomeria parryi*), chickory ((*Rafinesquia neomexicana*), snake's head (*Malacothrix coulteri*), red brome (*Bromus rubens*).

Only two studies directly tested for competition between tortoises and livestock. In an extensive study, Avery (1998) showed that cattle and tortoise diets overlap (38% in early spring, 16% in late spring). He also demonstrated that tortoise foraging was altered in the area where both species co-occurred. In late spring in the absence of cattle, tortoises primarily ate herbaceous perennials (91% of diet), whereas in the grazed areas, tortoises primarily ate annual grasses (59%) followed by herbaceous perennials (21%). The species of herbs also differed: in the exclosure tortoises preferred desert dandelion (*Malacothrix glabrata*), whereas in the grazed areas they ate primarily the exotic grass, splitgrass (*Schismus barbatus*). The availability of desert dandelion was significantly higher in the ungrazed area, which indicates a response to grazing, and of splitgrass was equivalent in the two areas. In one dry year, tortoises spent significantly more time

(approximately three times more) foraging in the grazed than in the protected areas, presumably in search of nutritionally-adequate food to fill up on. Thus, two of the three conditions necessary to confirm that cattle compete with tortoises for food were clearly supported empirically. The final condition, that one species must negatively impact the other, was also demonstrated, but more indirectly. In a separate, independent study, tortoises eating primarily *Schismus barbatus* have been shown to be put in a negative water and nitrogen balance (Nagy et al. 1998), which could increase mortality particularly during periods of extended drought (Peterson 1994a, Avery 1998). Furthermore, Henen (1997) demonstrated that lower nitrogen intake reduces reproductive output in female tortoises. A long-term comparison of differential survival and reproductive success of tortoises within and outside an exclosure would be an excellent empirical test of the effect cattle grazing has on tortoise populations.

Tracy (1996) found that in years of very low annual productivity, tortoises lay fewer eggs. They also found that cattle foraging reduced tortoise forage abundance enough to cause tortoises to lay fewer eggs than normal. The conclusion is that, in low rain years, cattle may remove enough forage to reduce tortoise reproductive output, thus competition occurs in those years. The authors did not track hatchling success to determine if the fewer eggs still resulted in the same number of successful hatchlings.

COW DUNG AS A FOOD SOURCE

Bostick (1990) argued that declines in tortoise populations is caused by a reduction in the availability of cow dung which has declined with the reduction in numbers of cattle grazing in the southwest. He argued that cow dung is an important source of food for tortoises. However, Avery (1998) studied tortoise foraging behavior where tortoises coexisted with cattle. He observed over 30,000 bites of items and observed only 231 bites of cow dung. Esque (1994) also observed over 30,000 bites on food objects. He reported that 107 of them were of feces, but none were from livestock. Furthermore, Allen (1999) evaluated the nutritional quality of cow dung and found it to be deficient for tortoises. In fact, even when cow pies were their only choice of food for one month, most tortoises (71%) refused to eat. Those that did eat, assimilated virtually none of the nitrogen. Thus, whereas Bostick (1990) presented an intriguing alternative hypothesis for tortoise population declines, there is no empirical support for its basic assumptions.

Summary

Surprisingly little information is available on the effects of grazing on the Mojave Desert ecosystem (Oldemeyer 1994, Rundel and Gibson 1996, Lovich and Bainbridge 1999). Differences in rainfall patterns, nutrient cycling, and foraging behavior of herbivores and how these three factors interact make applications of research from other areas of limited value in understanding the range ecology of the Mojave Desert. The paucity of information is surprising given the controversy surrounding grazing in the

Mojave and the importance of scientific information for making resource management decisions affecting grazing. Studies mostly from other arid and semi-arid regions tells us that grazing can alter community structure, compact soil, disturb cryptogamic soils, increase fugitive dust and erosion. Some impacts to tortoises or their habitat have been demonstrated, but the evidence is not overwhelming.

Military Operations

The California deserts were used for military exercises as far back as 1859 when Fort Mojave was first built (Krzysik 1998). The most extensive use was for World War II training when 18400 mi^2 (47105 km^2) in California and Arizona were designated as the Desert Training Center and used extensively for training with tank and armored vehicles. Today, four major, active military installations occur within the West Mojave and comprise a total of 4165 mi^2 (10663 km^2): Naval Air Weapons Station ("China Lake;" 1731 mi^2, 4432 km^2), National Training Center ("Fort Irwin;" 1016 mi^2, 2600 km^2), Air Force Flight Training Center ("Edwards Air Force Base;" 476 mi^2, 1218 km^2), and Marine Corp Air Ground Combat Center ("MCAGCC" or "Twentynine Palms;" 943 mi^2, 2413 km^2).

As outlined in the Recovery Plan (USFWS 1994), impacts to tortoise populations come from four basic types of military activities:

> "(1) construction, operation, and maintenance of bases and support facilities (air strips, roads, etc.); (2) development of local support communities, including urban, industrial, and commercial facilities; (3) field maneuvers; including tank traffic, air to ground bombing, static testing of explosives, littering with unexploded ordinance, shell casings, and ration cans; and (4) distribution of chemicals." (USFWS 1994, p. D14)

A fifth potential impact is above ground nuclear weapons testing, which took place in Nevada in the 1950s and 1960s.

<u>Construction, Operation, and Maintenance of Bases and Support Facilities</u>

All four major military bases in the west Mojave Desert each have facilitated the growth or development of large internal support communities. The development of these communities destroyed tortoise habitat and likely brought with them all of the other impacts generally associated with large human settlements (fragmentation, ORVs, release of disease, facilitation of raven population growth, domestic predators, etc.), each of which are discussed elsewhere in this report. There is some evidence that the tortoise population around China Lake declined within four decades following development of the base at China Lake (Berry and Nicholson 1984a). However likely this conclusion probably is, the data used were based solely on anecdotal observations (Bury and Corn 1995); and the data only show a correlation, not a cause and effect. Removal (translocation) of tortoises from construction sites, runways, and other heavy use areas to

other parts of the desert occurs and may affect the tortoises moved (Berry and Nicholson 1984a; see "Handling and Deliberate Manipulation" section, above). Another impact is the fragmentation of the habitat by the apparent haphazard placement of facilities throughout major portions of habitat (pers. obs.).

Development of Local Support Communities

The four major military bases in the west Mojave Desert have facilitated the growth or development of large external support communities: Ridgecrest, Barstow, Lancaster, Palmdale, and Twentynine Palms, which each have problems for tortoises typical of large suburban areas in the desert (see "Urbanization and Development" section, below).

Field Maneuvers

Tank maneuvers cause some of the most drastic and long-lasting impacts to the Mojave Desert habitats. Extensive tank training operations were conducted in the 1940's and in 1964 over 17,500 mi^2 of desert (Lathrop 1983, Prose and Metzger 1985, Krzysik 1998) and even more intensive maneuvers are currently taking place within an 819 mi^2 area on Fort Irwin (Krzysik 1998) and on MCAGCC (Baxter and Stewart 1990). Direct mortality to tortoises is relatively rare or not often reported, but does occur (Stewart and Baxter 1987, Quillman pers. comm.). Tanks damage vegetation, compact soil, cause fugitive dust, and run over tortoise burrows and tortoises. The results are largely denuded habitat, and altered vegetation composition, abundance, and distribution (Wilshire and Nakata 1976, Lathrop 1983, Baxter and Stewart 1990, Prose et al. 1987, Krzysik 1998). Natural recovery can take a long time; 55 year old tank tracks can still be seen throughout many parts of the desert (Wilshire and Nakata 1976, Krzysik 1998). Krzysik (1998) reported a significant reduction in tortoise densities (62-81% over six years) in active training areas of Fort Irwin and no change or increases in densities in areas with light and no activity. The effect of tank maneuvers was highest in valley bottoms and progressively less in high bajadas, talus slopes, and rugged mountain ranges where training activities were considerably lower.

Bombing and other explosive ordinance cause impacts in some areas, but no documentation was found of their effect on tortoise populations or habitat.

Distribution of Chemicals

It has been suggested that diseases affecting tortoise shells may be caused by residual chemical remains left over from military operations, but the evidence is highly speculative (See "Disease" section, above).

Nuclear Weapons Testing

Between 1951 and early 1963, the U. S. Atomic Energy Commission detonated 100 atomic devices above ground at the Nevada Test Site, Nevada (U. S. Department of Energy 1994). From mid 1960s to early 1990s only underground tests were conducted. Resource Concepts Inc. (1996) argued that radiation released into the atmosphere during these tests might explain tortoise declines. They cited two anecdotal accounts, one of many sheep getting sick near Cedar City, Utah, and another of high Geiger counter levels around the mouth of a cow in the same area. They suggested that nuclear fallout might explain the presence of disease in tortoise populations. Beatley (1967) found only very low levels of radiation at a plant study plot 8 km east of a below-ground test blast and attributed vegetative defoliation to dust from heavy vehicular traffic on a nearby dirt road.

The University of California, Laboratory of Nuclear Medicine and Radiation Biology conducted experimental radioecology research studies in Rock Valley located along the southern boundary of the Nevada Test Site. These irradiation studies involved the chronic exposure of plants and animals from a centrally located 137 cesium source located atop of a 50-ft tower within a 21-ac fenced plot. Rundel and Gibson (1996) provided a brief summary of the results of the Rock Valley irradiation experiment. Beyond direct mortality from the test blasts, there was very little persistent effect of radiation on the surrounding lizard populations. Little long-term effect on the pocket mouse, *Perognathus formosus*, was found (Turner 1975). On the other hand, female lizards at Rock Valley were found to be sterile several years after the experiment began (Turner 1975, Turner and Medica 1977). There were five adult tortoises present throughout most of the study and four still remained in 2001 (Medica pers. comm.).

I could find no data that bear directly on the potential effects of nuclear weapons testing on tortoise populations. The map in Gallagher (1993) suggests that fallout was nearly nonexistent in the west Mojave (which is consistent with predominant wind patterns), where URTD is rampant (Berry 1997). Therefore, if there is an effect from testing, it probably cannot be a universal explanation for rangewide declines nor can it explain the markedly high losses and levels of disease documented in the west Mojave.

Noise and Vibration

The following is largely paraphrased from my contribution to the Desert Tortoise Recovery Plan (USFWS 1994). Anthropogenic noise and vibrations may impact tortoises in several ways including: disruption of communication, and damage to the auditory system. A body of peer reviewed scientific literature exists demonstrating how background noise may mask important vocal signals in insects and amphibians (e.g., Bushcrickets, *Conocephalus brevipennis*, Bailey and Morris, 1986; Green Treefrogs, *Hyla cinerea*, Ehret and Gerhardt, 1980). Hierarchical social interactions, hearing, and vocal communication have all been identified in desert tortoises (Adrian et al. 1938, Campbell and Evans 1967, Patterson 1971, 1976, and Brattstrom 1974, Bowles et al. 1999). Patterson (1976) identified eleven different classes of vocal signals used by desert

tortoises in various of social interactions, but he did not demonstrate that animals who hear the signals react or change their behavior in any way, a necessary component in identifying communication. The signals are relatively low amplitude, have fundamental frequencies 200 Hz or lower, and harmonics that reach as high as 4500 Hz (Patterson, 1976).

The portions in the following excerpt from USFWS (1994) pertaining to desert tortoises is purely speculative with no direct empirical support for desert tortoises:

> " Many anthropogenic noises, such as automobile, jet, and train noises, cover a wide frequency bandwidth. When such sounds propagate through the environment, the high frequencies rapidly attenuate, but the low frequencies may travel great distances (Lyon, 1973). The dominant frequencies that remain after propagation correspond closely to the frequency bandwidth characteristic of desert tortoise vocalizations. Therefore, masking of these signals may significantly alter an animal's ability to effectively communicate or respond in appropriate ways. The same holds true for incidental sounds made by approaching predators; masking of these sounds may reduce a tortoise's ability to avoid capture by the predator. The degree to which masking by noise affects tortoise survival and reproduction depends on the physical characteristics (i.e., frequency, amplitude, and short- and long-term timing) of the noise and the animal signal, propagation characteristics of the sounds in the particular environment, auditory acuities of the tortoises, and importance of the signal in mediating social or predator interactions. There are no studies to test the masking effect of noise on tortoise behavior, but the effect is likely to be relatively low given that vocal communication is probably not extremely important in mediating social interactions and that noises loud enough to mask sounds important to tortoises are generally uncommon and short in duration. The only place the noise would be continuous enough may be alongside heavily traveled roads, where tortoise abundance is generally quite low.
>
> "Loud noises (and associated vibrations) may damage the hearing apparatus of tortoises. Little research has been performed on tortoise ears, but it is clear that tortoises are able to hear, and the relatively complex vocal repertoires demonstrated by tortoises suggests that their hearing acuity is similarly complex. Brattstrom and Bondello (1983) experimentally demonstrated that off-highway vehicle noise can reduce the hearing thresholds of Mojave Fringe-toed Lizards (*Uma scoparia*). Relatively short, single bursts (500 sec) of loud sounds (95 dBA at 5 meters) caused hearing damage to seven test lizards (Brattstrom and Bondello, 1983). Comparable results were obtained when desert iguanas (*Dipsosaurus dorsalis*) were exposed to one to ten hours of motorcycle noise (Bondello, 1976). It is likely that repeated or continuous exposure to damaging noises will cause a greater reduction in auditory response of these lizards. It is not unreasonable to expect loud noises to similarly impact the auditory performance of desert tortoises."

A study conducted by Bowles et al. (1999) showed very little behavioral or physiological effect on tortoises of loud noises that simulated jet over flights and sonic booms. They also demonstrated that tortoise hearing is fairly sensitive (mean = 34 dB SPL) and was most sensitive to sounds between 125 and 750 Hz, well within the range of the fundamental frequency of most of their vocalizations. The authors concluded that tortoises probably could tolerate occasional exposure to sonic boom level sounds (140 dB SPL), but some may suffer permanent hearing loss from repeated long-term exposure to loud sounds such as from ORVs and construction blasts.

ORV Activities

Like most other threats, off road vehicle (ORV) activities may affect tortoise populations in multiple ways: direct mortality by crushing tortoises on the surface or in burrows, or indirect mortality through habitat alteration from soil compaction, vegetation destruction (direct or indirect via dust), or toxins from exhaust. However, different types of ORV activities will likely have different effects on tortoise populations. There are basically four categories of activity that may have very different impacts: free play where vehicles are not restricted to designated routes and cross travel or off-road and off-trail activity probably occurs regularly; non-competitive recreational uses outside of free play areas are limited to designated roads and trails with any driving off of those routes being illegal; competitive events are organized races that are restricted to designated open areas; and unauthorized cross-country travel for recreational or commercial (e.g., mining exploration) purposes. Hence in this report, ORV refers to motorized vehicle travel off of paved and graded dirt roads whether they are on ungraded dirt roads, trails, or cross country driving. ORVs can include dirt bikes, sport utility vehicles, all-terrain vehicles, sand rails, and any other type of motorized vehicle that travels such roads.

Reduce Tortoise Density

A number of reports document ORVs may directly kill tortoises (see below), however the data are insufficient to evaluate the extent of its overall impact on tortoise populations. We must rely more on other measures such as differences in tortoise densities between areas used by ORVs and those free from such activity. For example, Bury and Luckenback (1986) compared tortoise densities inside and outside of an ORV free-play area. They found 3.8 times more tortoises in a control area lacking ORV activity compared to a nearby open area and the animals were significantly heavier ($p<0.01$) in the control area. They also found 2.8 times the number of burrows, more of which were active, in the control area. Most of the burrows in the ORV area were in the section most lightly used by vehicles. The denser vegetation in the control area made searching much slower, hence 3.6 times more effort was spent searching the control area. The differences in number of tortoises are not likely to be a consequence of differences in search time because identical and consistent methods were used to sample each area (Bury and Luckenbach 1977). As this study was unreplicated (only one control, and one treatment area were surveyed), it is conceivable that the differences detected are due to

causes other than ORV activity (e.g., soil or habitat differences or natural patchiness of tortoise populations).

Berry et al. (1986) compared tortoise populations inside of the DTNA and immediately outside where heavy ORV activity occurs. Using methods that are of questionable validity (Corn 1994a), they noted that significant declines occurred over a six-year period among juveniles and immatures in both areas, but that the declines were significantly greater in the adjacent area with more ORV activity.

Berry et al. (1994; for published abstract see Berry et al. 1996), compared evidence of human activity and tortoise sign (i. e., number of tracks, scat, and burrows, which is positively correlated to tortoise density; Turner et al. 1985) along 100 transects conducted in 1977-79 and 150 in 1990. They found that vehicle trails in 1990 were positively associated with areas classified as having low to medium densities of tortoises, but that numbers of vehicle trails and tracks were not directly correlated to actual number of tortoise sign. In one area, ORV activity had been stopped by BLM one year prior to the study, so vehicle tracks had been obliterated or were aged and did not accurately reflect the level of ORV activity the tortoise population had experienced over the past several years. Furthermore, the study lacked an adequate control site, but it is difficult to have good controls in a broad field study like this.

An indirect piece of evidence that ORVs reduce tortoise population density comes from Nicholson (1978). She reports on the findings of sets of transects walked at varying distances from the edges of several paved roads and highways in the Mojave desert. The study was designed to measure the effects of paved roads, not dirt roads or ORV travel on tortoise populations, thus is of little relevance to evaluating ORV impacts. She found that counts of tortoise sign increased with distance from paved roads. However, along Shadow Mountain Road, she found a reduction in tortoise sign 880 meters from the road edge, in an area with "excessive ORV use." She provided no statistical analysis of this observation, nor did she comment on the presence or absence of ORV activity along any of the 39 other transects she walked.

Direct Effects

CRUSHING TORTOISES AND BURROWS

Several accounts occur in the non-scientific literature of tortoises being crushed by ORVs, but most of these are anecdotal or unique incidents. In a popular account of ORV impacts to the desert environment, Luckenbach (1975) states: "I have personally found horned lizards, whiptails, zebra-tails, sand lizards, and tortoises crushed by ORVs;" no documentation or quantification was provided. Similar anecdotal statements were made in Berry and Nicholson (1984a) and Bury and Marlow (1973).

Berry and Nicholson (1984a) observed dead tortoises that were crushed in burrows that were apparently collapsed by ORVs, but no data or details were provided. Bury and Marlow's (1973) popular article about general impacts of ORVs on tortoises also makes the claim that burrows are crushed by ORVs, but provide no data. Fifteen

burrows found in 1976 and 1977 in an ORV-use area were collapsed in 1985, their collapse being "related to ORV activity from trails through the area" (Bury and Luckenback 1986), although they gave no further indication of how they determined the cause of collapse. Woodman (1986) and Burge (1986) found no crushed burrows following the Parker 400 and Frontier 500 races, respectively.

Four studies quantified vehicle-related mortality on study sites with frequent ORV traffic. In her preliminary analysis of 1357 tortoise carcasses found on 14 permanent study plots for studying tortoise populations, Berry (1990 as amended) attributed approximately 57 (4%) to vehicles (some of the data were presented in Berry et al. 1986). It must be noted that 787 (58%) of the shells were not evaluated or were unclassifiable either because they bore no diagnostic characteristics or were too fragmented to analyze. Campbell (1985) found 2 vehicle-killed tortoises, one apparently killed by a 4-wheel vehicle on a dirt road inside the preserve and another killed outside the preserve by a sheep watering truck. In their comparative study of ORV impacts, Bury and Luckenback (1986) indicated that one immature tortoise was found crushed in a motorcycle trail. In a review of tortoise population dynamics, Marlow (1974) states that "nine recently crushed tortoises were observed in an area supposedly closed to ORVs. From tracks surrounding most of the carcasses there was little question as to the cause of their deaths."

It is the correspondence between tortoise and ORV enthusiasts' habitat preference that is likely responsible for some of the conflicts between the two. Jennings (1997) showed that tortoises spent significantly more time in washes, washlets, and on small hills. This is because their preferred food plants occurred in these habitats and they tend to burrow and travel more in washes and washlets than in other habitats. Jennings (1997) claims these habitats are also preferred disproportionately by ORV recreationists, but presented no supporting data.

Indirect Effects

Compaction of Soil

Soil becomes compacted, at least temporarily, when a motorized vehicle passes over it, and that compaction changes with the weight of the vehicle, soil type, and moisture content of the soil (Webb 1983). But, the affect this compaction has on tortoise populations depends on the lasting effect of compaction, its effect on vegetation and burrow digging abilities, how widespread the compaction is, and the respective effects on tortoise survival and reproduction.

Davidson and Fox (1974) investigated the effect a motorcycle dual sport race had on Mojave vegetation and soil. The soil, which was of similar type at both sites, was significantly denser and less porous at a pit area and alongside a trail than at a control site several hundred meters away. Significantly fewer plant species, fewer individuals, and less cover were found in impacted areas compared to the control site. However, the study was unreplicated. An increase in bulk density of the soil was measured in an evaluation of the impacts of the 1974 Barstow to Vegas Race (BLM 1975). However, many of the

measurements were taken one week after a rain, so, because compaction is intensified on wet and moist soil (Webb 1983), the results may be unreliable.

Babcock and Sons (1973) found 10% or more increase in bulk density in disturbed versus undisturbed sites in alluvial wash, alluvial fan, and desert flat areas, but only a 3% increase in compaction in disturbed sand. Similarly, Wilshire and Nakata (1976) found sand dunes to be more resistant to compaction than playas or alluvial fans. Compaction was relatively light in heavily used dry washes and heavy in well used alluvial fans. Dry playas, which dry out fast after rains, resist compaction more than do wet playas (Wilshire and Nakata 1976), which are moist on or near the surface. Compaction on wet playas was measurable down to 15 cm or more.

In their manipulative experiment on the effect of vehicle type, number of passes, soil type, and soil moisture, Adams et al (1982a, b) measured soil compaction with a penetrometer. They found that compaction by a SUV was greater than that of a motorcycle. The SUV compacted wet soil significantly after only one pass on wet soil and after five passes on dry soil. The motorcycle compacted wet soil after 20 passes. Single passes by motorcycles on wet soil and SUVs on dry soils did not differ significant from the controls. The great variability in environmental conditions makes it difficult to make unambiguous generalizations.

Greater temperature extremes occurred in more compacted soils in heavy ORV use areas, probably from removal of vegetation and changes in soil characteristics from compaction (Willis and Raney 1971, Webb et al. 1978). This possible effect on soil temperature not only affects plant germination and growth, but may have interesting, if unexplored, implications for tortoise growth, development, and morphology. A further likely, but untested potential impact of soil compaction may be to make it difficult for tortoises to burrow, which would not only affect tortoises directly but would also reduce tortoises' role in reducing compaction through soil turnover (Prose et al. 1987).

Infiltration rate is a measure of the soil's ability to absorb moisture. More compacted soils have a lower infiltration rates so less water is available for plants (Webb 1983). Babcock and Sons (1973) found much lower infiltration rates on disturbed versus undisturbed desert sites, except in very sandy areas (dunes and washes). Webb (1983) measured 73% lower infiltration rate compared to a control site after 200 vehicle passes over wet sandy loam. The greatest decrease occurred after the first few passes. Infiltration rates of sands and clays are least affected by compaction, whereas loamy sands and gravelly soils are with a mixture of particle sizes are most affected.

DESTRUCTION OF CRYPTOGAMIC SOILS

Cryptogamic soils are important for reducing soil erosion, controlling water infiltration, regulating soil temperatures, fixing (catching and converting) atmospheric nitrogen, and accumulating organic matter (Cline and Rickard 1973, Pauli 1964, Rogers et al. 1966). Cryptogamic soils are collections of mostly symbiotic bacteria, algae, fungi, and lichen that live on or slightly below the soil surface and create a semi-permeable soil

surface. They often occur in the open spaces between desert shrubs and help to facilitate seedling establishment and plant growth (St. Clair et al. 1984, DeFalco 1995).

ORVs, livestock, and other surface disturbances easily damage cryptogamic soils (Belnap 1996). Damage from compaction, even minor, can greatly reduce nitrogen fixation by the crust, an effect that sometimes increases rather than decreases with time since compaction (Belnap 1996). It is not certain how tortoises are affected by damage to cryptogamic soils and a 1980 review of the effects of ORVs on desert soils was inconclusive (Rowlands 1980). DeFalco (1995) found that, in the one season studied, tortoises selectively avoided foraging on plants growing on crusts. Although crusts fix nitrogen and the nitrogen can then be transferred to plants growing in close proximity to the crusts (Maryland and McIntosh 1966), concentration of nitrogen in tortoise forage plants were generally lower on cryptogamic soils (DeFalco 1995). However, many other nutrients are important to tortoises, and it is unknown if their concentrations are augmentated by cryptogams in associated tortoise forage plants. In non-tortoise habitat in southwest Utah, Belnap and Harper (1995) showed that nitrogen, phosphorus, potassium, calcium, magnesium, and iron concentrations were higher in some plant species growing on encrusted soils compared to those growing where there were no crusts. The primary importance of cryptogamic soils to tortoise populations could be in stabilizing the soils against wind and water erosion (Belnap and Gardner 1993, DeFalco 1995), but more research is clearly needed.

CHANGES IN VEGETATION

Several studies measured the effect ORVs have on vegetation; most of them evaluated damage from competitive events. Burge (1986) described how many perennial shrubs were damaged along the edge of the Frontier 500 competitive race. She counted 1170 uprooted or crushed shrubs (no species identified) after the race. Davidson and Fox (1974) measured plant diversity, number of individuals, and amount of cover in a pit area (where vehicles were parked), alongside a dual sport race trail, and “several hundred yards away” (i.e., control area). They found significantly lower values for all three parameters in the pit area, moderate values alongside the trail, and the highest values at the control site. Woodman (1986) recorded the destruction of several creosote and burrobushes around the periphery of the pit area for the 1981 Parker 400 race. A BLM report detailing damage to vegetation caused by the 1974 Barstow to Vegas Motorcycle Race (BLM 1975) showed that 0 to 76% of the plants, particularly seedlings and small shrubs, were damaged in each of 26 sites.

Berry et al. (1990) measured habitat changes over a six-year period inside and outside of the DTNA where ORV non-race activity occurred. They found a 23% increase in habitat loss around a staging/pit area and that ORV trails increased in width by 130% and 157% in area.

Vegetation is clearly degraded by heavy ORV activity. Bury and Luckenback (1986) compared vegetation inside (treatment) and outside (control) an ORV use area south of Barstow. There were 1.7 times the number of live perennials on control, and 2.4

times number of dead ones (mostly *Ambrosia dumosa*) on the treatment area. Plant cover was 3.9% higher in the treatment area. This study suffers from a lack of replication. Comparing aerial photographs taken at the same points 19 to 25 years apart in six different locations in the Mojave and Colorado Deserts, Lathrop (1983) measured an average of 49% reduction in shrub density in ORV areas. Ground-based transects in control and treatment (disturbed) sites yielded 48-97% reductions in perennial plant cover in the ORV use areas. Thirty-four to 46% reductions in density resulted from single race events at two separate locations (Lathrop 1983). Luckenbach (1975) reports, that "in one Hounds-and-Hare race, an estimated 140,000 creosote bushes (*Larrea tridentata*), 64,000 burro-weed *(Franseria dumosa*), and 15,000 Mojave yuccas (*Yucca schidigera*) were destroyed or severely damaged over a stretch of 100 miles." No additional details were provided.

Rowlands et al. (1980) and Adams et al. (1982b) conducted one of the only manipulative experiments on ORV effects on Mojave desert vegetation. They studied the effect that different numbers of passes over the same area by a motorcycle and a 4-wheel drive sports utility vehicle (SUV) had on plant growth. They also looked at the interactive effects of soil moisture and soil type. Plant density, biomass, and cover generally were reduced following any level of disturbance with motorcycles requiring a greater number of passes to equal the reduction caused by the SUV. Grama grass (*Bouteloua barbata*), appeared to respond positively to light disturbance, but less so to heavy disturbance. The introduced weed, split grass (*Schismus barbatus)*, was significantly more abundant within tracks than in control areas, probably because the fibrous nature of their roots allowed them to become better established than more tap-rooted natives in compacted soil.

Vollmer et al. (1976) found annual plant density to be significantly lower within experimentally created tracks from two 4-wheel drive vehicles compared to the hump between the tracks and in an area randomly covered by the same vehicles. No difference in density occurred between the randomly driven area compared to the control site. Shrubs in the regularly driven area (42 passes by vehicles) suffered twice as much damage as those in the randomly driven area. This study lacked replication and proper controls, but data collection and analysis were well executed.

Kuhn (1974, cited in Lathrop 1983) reported a reduction in plant density of 24% and plant cover of 85% in ORV-disturbed plots compared to undisturbed controls in foredunes at Kelso Dunes. Similarly, comparing aerial photographs taken 21 years apart, Lathrop (1983) measured a 50% reduction in shrub density in the same foredunes.

EROSION AND LOSS OF SOIL

ORV activity can increase erosion, which removes soil nutrients and soil that is penetrable to roots (Adams and Endo 1980a, Wilshire 1980). ORVs modify various features that help to stabilize the soil against erosion including surface crusts, coarse particles, desert pavements, and vegetation (Hinckley 1983). They also alter the configuration of the ground surface thus affecting water runoff patterns (Hinckley 1983).

The net loss of soil at specific ORV-use areas has been documented. Wilshire and Nakata (1976) estimated 150 metric tons of dirt were lost to erosion from one 68-meter long western Mojave hillside trail with a 44-58% slope. Total estimated loss for the portion of hill used for an unspecified number of years was 11,000 metric tons. Snyder et al. (1976) estimated that 150-230 mm of soil was lost per year along transects in an ORV use area over two to five years at Dove Canyon. That amount is compared to estimates of natural erosion rates of 1.0 to 4.6 mm per year in arid areas (reported in Hinckley et al. 1983). No control or low-impact reference sites were established in this study. Webb et al. (1978) reported a loss of 0.3 to 3.0 metric tons per m^2 from an ORV trail in arid land at a heavily used ORV park in central California. They further reported that erosion was greatest on sand loam and gravelly sandy loam and least on clay and clay loam.

In artificial rain trials, Iverson (1979) found greater sediment yield (soil runoff) in vehicle-disturbed versus undisturbed slopes from loosening of soil and alteration of flow patterns. The difference was thought to be from increased water flow velocity and more channeling of the flow, not from reduced filtration. Consequently the effect would be more pronounced during intense thunderstorms than during more mild winter frontal-type storms. Also using artificial rain, Eckert et al. (1977) looked at infiltration and sedimentation rates at two Mojave desert sites in Nevada following single and multiple passes of truck and motorcycle. Single passes made no measurable difference. Multiple passes increased rates of infiltration and sedimentation, particularly in interplant spaces versus beneath plants. However, the artificial rainfall rates were similar to rare very heavy thunderstorms; they were unlike the winter cyclonic rainfall that is more typical of the western Mojave desert. Furthermore, Reicosky (1979) suggested that movement of water towards vehicle tracks compensates for decreased infiltration rates. Hinckley et al. (1983) suggested that water erosion would be the least in areas that are relatively flat, experience short, low-intensity storms, and have a coarse (gravelly) surface.

Fugitive dust, dust blown from the ground by wind and vehicle activity, can potentially be a problem for desert tortoises. Fugitive dust is related to vehicle speed, surface texture, surface moisture, and probably vehicle type (with heavy four-wheel drive vehicles causing the most dust followed by light four-wheel drive vehicles followed by motorcycles; Adams and Endo 1980b). The threshold velocity for wind erosion (TV), the lowest wind speed necessary to create dust, is highest for desert pavement and areas with hard surface crusts. Soils with a large proportion of fine particles will be more susceptible to wind erosion. Disturbances that lower the TV will increase the incidence of dust storms. Disturbance of sand dunes and sandy washes does not alter their TV. Areas protected by cryptogamic soils and desert pavement had greatest reduction in TV following disturbance, and more so with siltier versus sandy soils (Adams and Endo 1980b, Gillette and Adams 1983). Winds of 20-30 mph at 6 ft above ground caused fugitive dust in these areas. Erodibility also varies with width of disturbed area up to about five meters (Wilshire pers comm., cited in Adams and Endo 1980a)

Satellite images taken on January 1, 1973, captured dust storms from Santa Ana wind conditions (Bowden et al. 1974, Wilshire 1980). Many of the dust plumes, which were 10 to 30-km long and covered 300 km^2, originated in areas of intensive ORV

activity in the western Mojave. BLM (1975) measured three to five times more suspended particulate density for fugitive dust during the 1974 Barstow to Vegas race site compared to before the race.

The main effect of wind erosion on productivity is removal and redistribution of surface nutrients, not reduction in soil depth. Loss of soil nutrients found in the top 5 to 10 cm of soil significantly reduced perennial cover in a similar arid environment in Australia (Charley and Cowling 1968). Sharifi et al. (1997, 1999) showed that photosynthesis and plant productivity are hampered by dust on the leaves of desert shrubs, but that the effect may be ameliorated by heavy summer rainfall.

LIGHT ORV USE

Most of the foregoing discussion relates specifically to competitive events and heavy use like what now occurs within open use or freeplay areas. They are of limited applicability to understanding the effect of lighter travel in areas where traffic is legally restricted to designated routes (i.e., dirt roads). Indeed, very little data are available to evaluate these impacts primarily because the focus of most research has been on the effects of heavier ORV use. There are a few studies that demonstrated that occasional vehicles riding off of roads (including for parking or camping within 100 ft of roads, which is currently permitted, Bureau of land Management 1980), can damage the soil and vegetation, the amount of damage being less than heavier off road travel. Webb (1983) found that the greatest increase in compaction occurred the first few time a motorcycle crossed an area and compaction increased with more crossings, but at a lower rate. Similarly, Adams and Endo (1980a) discovered that just a few passes by an SUV were sufficient to significantly increase compaction and a single pass did so in some wet soils. Vollmer et al. (1976) found that there was damage to plants in an area subjected to random four-wheel drive activity, but that damage was higher in areas that were repeatedly driven over. Bury and Luckenbach (1977) reported little difference in the number of creosote shrubs in moderate use versus undisturbed plots, but did find that half were broken or damaged in the moderate use area. Likewise, a “sparsely” used ORV area within the Jawbone Canyon Open Area showed 35% less perennial plant cover than an unused control area (Lathrop 1978). Finally, just stepping on cryptogamic crusts can damage and decrease nitrogen fixing activities of the crusts (Belnap 1996).

All of these studies indicate that some damage is likely to occur when vehicles stray off of established roads. Goodlett and Goodlett (1993) demonstrated that ORV enthusiasts will not always obey signs indicating routes are closed, nor do they always stay on designated routes. However, their study was conducted in an area that had recently changed from an open free play area to a limited use one. Although it is likely that number of tracks will be highest in close proximity to roads (e.g., LaRue, pers obs.), no studies have tested for this pattern. Many of the problems associated with light ORV use likely relate to increased human access the roads and trails afford (see "Human Access to Tortoise Habitat" section, below).

Summary

Although each study comparing tortoise densities inside and outside of ORV areas has limitations, they all lend evidence to reductions in tortoise population densities in heavy ORV use areas. The causes for these declines are less certain. Tortoises and their burrows are crushed by ORVs, although it is difficult to evaluate the full impact this activity currently has on tortoise populations, partly because there are probably relatively few tortoises in most open use areas. ORVs damage and destroy vegetation. Density, cover, and biomass are all reduced inside versus outside of ORV use areas, particularly following multiple passes by vehicles. Split grass (*Schismus barbatus)*, a weedy introduced grass, in particular appears to benefit from ORV activity. Very light, basically non-repeated, vehicle use probably has relatively little long-term impact. Soil becomes compacted by vehicles. The compaction increases with moisture content of the soil, weight of vehicle (particularly high weight to tire surface area ratio), and soil type. Cohesionless sand, such as in sand dunes and washes, are largely immune to compaction while moist soils are much more susceptible than dry ones. Compaction, lower infiltration rates, loss of plants and cryptogamic soils all contribute to increased wind and water erosion and fugitive dust, particularly when such areas are several meters in width. More research is needed to understand the effect light ORV use has on tortoise populations and habitat.

Predation/Raven Predation/Subsidized Predators

Desert tortoises have several natural predators including: coyotes, kit foxes, feral dogs, bobcats, skunks, badgers, common ravens, and golden eagles. The dominant predator probably varies temporally, spatially, and with size of the tortoise (Berry 1990 as amended). Few studies have attempted to quantify or estimate the relative proportion of mortality attributable to the various predators at specific sites, and none attempt to characterize it regionally.

One of the earliest publications reporting that ravens are potentially important predators on desert tortoises was Campbell (1983). He found 140 shells of juvenile tortoises (36 to 103 mm MCL) at the base of fence posts along the 30.5 miles of fencing surrounding the DTNA. He attributed 136 to raven predation, but gave no indication why. Berry (1985) evaluated 403 juvenile tortoise shells found on 27 desert tortoise study plots throughout the Mojave Desert. She determined that ravens killed 35%. Her evaluation was based on circumstantial evidence because the reference collection was shells found beneath perch sites that may have been used by other predators or scavengers. Although the patterns of shell damage she used are consistent with the patterns Boarman and Hamilton (in prep.) obtained from 266 shells collected from beneath raven nests. Also, ravens are scavengers as well as predators, so some of the shells attributable to raven predation may actually have been found and eaten after death (Boarman 1993).

During the first 5 to 7 years of life, the tortoise shell is incompletely ossified; it is soft and easy to puncture and rip open. When pecked open by a raven, the soft shell will

bend then dry in place leaving parts of the shell pushed in or pulled out. Carcasses found in this condition were likely pried open when the tortoise was alive or shortly after death. The shell soon dries after death. Once this happens the shell will fracture when pecked open, giving a different appearance. Although based on sound knowledge of the biology of tortoises, this scenario has not been subjected to quantification or controlled experimentation.

Woodman and Juarez (1988) reported finding 250 shells, probably killed over a four year period, dead beneath one raven nest near the Kramer Hills. Some of the carcasses found were of young animals found alive and individually marked by the same researchers several weeks earlier and apparently in healthy condition. This provided the first hard evidence that ravens almost certainly were killing some tortoises, not just scavenging them. Since that time, several observations have been made of ravens carrying away live juvenile tortoises (Boarman 1993). One researcher reported finding a tortoise eviscerated, but still alive, beneath a raven nest (R. Knight pers. comm.). These reports all remain anecdotal, but, because observing the act of predation by a predatory bird is notoriously difficult, it is unlikely we will ever be able to acquire an adequate number of good hard data on the phenomenon. One published account evaluated food of ravens in the Mojave desert by looking at pellets, indigestible portions of food that were coughed up at their nests (Camp et al 1993). They found tortoise remains in only 1.3% of the pellets. However, they did not report the 19 shells they found at several of those nests because they only reported on pellet contents (Camp pers. comm., Boarman pers. obs.); shell fragments usually are not found in pellets. They also did not establish whether all nests studied were in tortoise habitat.

The fact that ravens do kill some tortoises does not alone indicate that the losses are serious enough to warrant management action. We must understand the extent of predation and if it is having an impact on tortoise populations. Evaluating raven predation is perplexing because of the difficulties in finding small carcasses over such a large area of desert and in monitoring small, hard to find young tortoises (Berry and Turner 1986, Shields 1994). The extent of predation can be estimated by evaluating juvenile tortoise carcasses found throughout the desert. Berry (1985) and Boarman and Hamilton (in prep) analyzed the characteristics of 150 and 266, respectively, juvenile tortoise shells found in the deserts of California. Their reports indicate that primarily animals less than 100 mm MCL (less than approximately 5-7 years old) are taken throughout most portions of the desert in California. Beneath 23 transmission towers in Nevada, McCullough Ecological Systems (1995) found the remains of 78 juvenile tortoises, many showing signs consistent with raven predation.

A common argument made against raven predation being of management concern is that we must concentrate on protecting adult female tortoises (Doak et al. 1994). This is partly because adult females are the ones actually reproducing, thus contributing most to the persistence of the population and partly because juvenile animals typically experience high mortality, so losses to ravens are natural and the population can sustain the losses. This is a correct prediction from life history theory for many animal species, but not for long-lived ones that first reproduce later in life (approaching 20 years), like the desert tortoise (Congdon et al. 1993, 2002). Life history theory predicts that stable

populations of such animals can sustain annual mortality of juveniles of 25%. However, when adult populations are declining, juvenile mortality must be reduced to approximately 5% to ensure recruitment of new individuals into the breeding population (Congdon et al. 1993). This finding is based on well developed life history theory. Therefore, in tortoise populations that are experiencing overall declines, additional losses of juveniles to ravens may decrease the stability or at least prevent recovery.

A survey of tortoise remains found beneath raven nests was recently completed (Boarman and Hamilton in prep.). It showed that ravens prey on tortoises throughout the Mojave Desert in California, but probably not all ravens nesting in tortoise habitat ate tortoises. The most shells found at one nest in one year between 1991 and 1997 was 28, which were found beneath each of two nests in the eastern Mojave Desert. The results are preliminary and conservative because they pertain only to remains dropped beneath or near the raven nests. Many shells are found at locations well away from nests. During the raven breeding season, however, most foraging is probably done near the nest (Sherman 1993) and most food is likely brought back to or near the nest, so the results are probably relatively accurate if conservative.

There are little data available to determine the effect other predators might have on desert tortoise populations. For example, finding shells chewed by mammals, probably canids, and tortoise remains in coyote scat, Berry (1990 as amended) reported evidence of canid or felid predation at four out of twelve study plots in California. Proportion of deaths attributable to mammalian predators over all 12 plots was 53.% (ranged = 1.8% to 45.3% among the 4 plots where mammal-related mortality determined). Turner et al. (1997b) determined that most tortoise nests that failed were dug up by coyotes or kit foxes, but no data were presented. In 1998 and 1999, 47% and 12%, respectively, of nests studied at Twentynine Palms (MCAGCC) were dug up, probably by kit foxes (Bjurlin and Bissonette 2001). Bjurlin and Bissonette (2001) also believed that feral dogs cause a significant amount of mortality among adult tortoises in the area, but presented evidence for only one such death. They did report a high incidence of canid-like shell damage to live tortoises and the presence of feral dogs and dog packs within their study site. The effect that feral dog predation has on tortoise populations appears to be an emerging problem that warrants further documentation.

Non-ORV Recreation

Non-ORV recreation in the Mojave Desert includes camping, nature study, rock collecting, sight-seeing, hunting, horseback riding, mountain biking, and target practice. There are no studies concerning their impacts on tortoise populations: hence, there may or may not be impacts. Likely impacts include handling and disturbance of tortoises; loss of habitat to campgrounds, picnic areas, scenic pull outs, vandalism, and other support facilities; increase in road kills; and support of ravens when organic garbage is left behind. There could also be soil compaction and damage of vegetation and cryptogamic crusts from off-trail travel by mountain bikes, horses, and hikers. All of these impacts are related to the problems with increased access to tortoise habitat (discussed in "Human Access to Tortoise Habitat" section, below). Given the increased interest in non-

motorized recreation in the deserts, this is an important area for future research. There are no studies that directly measured the impacts of non-motorized recreation on tortoise populations or their habitats and only one that showed that hiking off of trails can significantly damage cryptogamic crusts (Belnap 1996).

Hunting and target practicing are two additional recreational activities that may impact tortoises. One of the primary anthropogenic causes for wildfire in the desert is from bullets striking rocks (R. Franklin, BLM Fire Management Officer, pers. comm.), which can occur while hunting or target practicing. The California Department of Fish and Game has constructed an array of small- and big–game guzzlers to help facilitate growth of game species populations. Not only can ravens sometimes access water at the big game guzzlers, but tortoises can get caught and die in some types of small game guzzlers. Hoover (1996) found the remains of 26 tortoises in 89 of the upland game watering devices in California. Finally, people target practicing, which is a very different activity than hunting, might also illegally use tortoises as targets (Berry 1986a, see "Vandalism," below).

Roads, Highways, and Railroads

Roads, highways, and railroads have several impacts on desert tortoises and their habitat. Direct impacts may include mortality through road and train kills and destruction of habitat (including burrows). Possible indirect effects include degradation of habitat because they serve as corridors of dispersal for invasive plants, predators, development, recreation, and other anthropogenic sources of impact. Roads, highways, and railroads also serve to fragment the habitat and populations (see "Habitat Degradation, Fragmentation, and Destruction," below).

Many tortoises fall victim to road kills. For instance, Boarman and Sazaki (1996) reported finding 115 tortoise carcasses along 28.8 km of highway in the west Mojave. This represents a conservative estimate of 1 tortoise killed per 3.3 km of road surveyed per year. This source of mortality primarily affects subadults and adults, although the results are partially skewed by the difficulty of finding smaller carcasses and their quicker loss to scavengers and decay. The figures cannot be extrapolated to all roads and highways to estimate total losses to road kills in the desert because mortality rate likely depends on traffic speed and volume, density and demography of surrounding tortoise population, and perhaps width and age of road. The results also cannot be applied to lightly traveled paved or dirt roads because of a four-way relationship between tortoise density, road conditions, traffic volume, and road kill rate. A tortoise depression zone exists along highway edges and extends to 0.4 km or further (Nicholson 1978, Berry and Turner 1987, Berry et al. 1990, LaRue 1993, Boarman and Sazaki 1996, von Seckendorff Hoff and Marlow 1997, cf. Baepler et al. 1994). The cause is probably primarily road kills, but illegal collections, noise, and other factors may also contribute although there are no data to evaluate their likely or relative effects.

A common mitigation for the impacts of roads and highways is a barrier fence, which has been shown to be highly effective at reducing mortality in tortoises and other

vertebrates in the west Mojave (Boarman and Sazaki 1996). However, fences only increase the fragmenting effects of roads. Preliminary results of an eight-year long study indicate that culverts are used by tortoises to cross highways (Boarman et al. 1998), but it is unknown whether their use is sufficient to ameliorate the fragmenting effects of fenced highways (Boarman and Sazaki 1996).

Roads are also major attractants for common ravens, which are predators on juvenile tortoises (Knight and Kawashima 1993, Boarman 1993). Ravens, being partly scavengers, are known for cruising road edges in search of road kills (Boarman and Heinrich 1999), but risk of predation is not increased near roads (Kristan and Boarman 2001).

The flush of vegetation that grows alongside roads (Frenkel 1970, Johnson et al. 1975) as a result of rainwater runoff and collection may benefit tortoises by providing a more consistent source of food over a more extended period of time, even in relatively dry years (Boarman et al. 1997). Alternatively, the abundance of food may bring them into harms way if (1) they wander onto the road, (2) vehicles pull onto the vegetated shoulder of the road, (3) grading or mowing activities occur during times of tortoise activity, (4) herbicides are applied to control growth of weeds along the road shoulder, or (5) they are seen and caught by passers-by. Brooks (1998) found a significant positive correlation between number of alien annual plant species near roads and density of dirt roads., and the species richness and biomass of alien annuals is higher near roads than away from them (Brooks pers. comm.).

Railroads may also impact tortoise populations through train kills and perhaps by tortoises getting caught between the rails (Mount 1986). No published studies were found that looked for train-killed tortoises along extensive sections of railroad tracks. However, Ron Marlow (pers. comm.) found eight carcasses between the rails along approximately 100 km of railroad tracks in the eastern Mojave. Noise or vibration may also affect tortoises that live alongside railroads, but has not been studied (see “Noise and Vibration,” above). Railroads provide a positive benefit: tortoises regularly build burrows in railroad berms that are not covered with gravel. It is not known if train noise negatively affects the behavior, audition, or reproductive success of these tortoises.

Utility Corridors

Corridors formed by utility and energy rights-of-way cause linear impacts to populations and may have levels of impacts well beyond those of many point sources of impacts. In a retrospective evaluation of results of 234 Biological Opinions issued by USFWS in California and Nevada (LaRue and Dougherty 1999), 80% (47/59) of the tortoises reportedly killed in California and Nevada were killed along utility corridors. Most of those were along the Kern-Mojave Pipeline (Olson et al. 1993, Olson 1996). Considerable habitat destruction or alteration occurs when pipelines and transmission lines are constructed and the impacts are repeated as maintenance operations or new pipelines or power lines are placed along existing corridors. Trenches opened for laying or maintaining pipes may serve as traps for tortoises and other animals (Olson et al.

1993). Dirt roads used for maintenance-related access create dust (Wilshire 1980) and provide access to less disturbed habitat (Brum et al. 1983). The habitat conversions during early stages of post-construction succession along pipeline corridors (Vasek et al. 1975) not only may suppress regular use by tortoises, but may function to reduce dispersal across the corridor thus effectively fragmenting a previously intact population (this view is speculative).

The presence of transmission towers in areas otherwise devoid of other raven nesting substrates (e.g., Joshua trees, palo verdes, cliffs), may introduce heavy predation to an area previously immune to such predation (Boarman 1993). Most raven predation on tortoises appears to occur during the raven breeding season (April - May, pers. obs.). By one estimate, ravens probably do most (75%) of their foraging within 400 m of their nest (Sherman 1993) and raven predation pressure is notably intense near their nests (Kristan and Boarman 2001). Therefore, ravens nesting on transmission towers, where no other nesting substrate exists within about 800 m, may significantly reduce juvenile tortoise populations within 400 m of the corridor, but this effect is quite localized. However, recent unpublished data on the distribution of raven depredated juvenile tortoises suggests that not all ravens nesting within tortoise habitat actually eat tortoises (at least they do not bring the shells back to the nest; Boarman and Hamilton in press).

Data collected along paved highways indicate that road kills can substantially reduce tortoise populations within at least 0.4-0.8 km of such roads (see “Roads, Highways, and Railroads” section, above), and their impact is likely lower along newer and more lightly traveled roads (Nicholson 1978). But, there are no data on the impact of lightly traveled dirt roads (e.g., utility maintenance/access roads) on tortoise population densities.

Vandalism

Vandalism is the “purposeful killing or maiming of tortoises” (Luke et al. 1991, p. 4-61). Reports of tortoises being vandalized include shooting, crushing, running over, chopping off heads, and turning them over (Berry and Nicholson 1984a, Berry 1986a, Bury and Marlow 73). Most reports of specific incidents are anecdotal, but sometimes substantial. The most quantitative accounts are for gunshot deaths (Berry 1986a, 1990 as amended), but are mostly based on postmortem forensic analysis. Berry (1986a) found 91 tortoises carcasses (14.3% of those collected at 11 sites) showing evidence of being shot. The proportion of carcasses showing evidence of gunshots was significantly higher from west Mojave sites (20.7%) than from east Mojave (1.5%) and Colorado (2%) desert sites. Eleven of the 58 (19%) tortoise found dead on the Beaver Dam Slope, Utah, showed signs of traumatic injury. This category included individuals exhibiting gunshot wounds. These ranged from pellet wounds through .22 caliber holes to one individual exhibiting a .44 caliber bullet wound.

Wild Horses and Burros

Wild burro and tortoise ranges overlap in some places, but the overlap is quite low in the West Mojave. No published studies were found that investigated the impact burros or horses (neither of which are native to North America) have on tortoise populations. The primary effect is likely to be habitat alteration through soil compaction and vegetation change. Burro populations are probably not extensive enough in most areas to pose a major threat to tortoise populations, but this is speculative.

CUMULATIVE THREATS TO TORTOISE POPULATIONS

Human Access to Tortoise Habitat

Perhaps the most important general threat to tortoise populations relates to actual human presence in tortoise habitat and thus refers primarily to access. Many of the individual threats discussed above relate to the level of access to tortoise habitat afforded to people. For instance, law enforcement officials have documented illegal collecting of tortoises for food or cultural ceremonies on a few occasions (USFWS 1994). One study supported the intuitive impression that poaching occurs close to roads (Berry et al. 1996), but the methods employed were not very precise (counting burrows that appeared to have been dug up with shovels) making the results weak at best. Since roads likely provide access to poachers, a logical conclusion of their study is that a larger proportion of the tortoise population will be under the risk of being poached where more roads intrude on tortoise habitat.

The presence of a road poses potential harm to tortoises and their habitat and the more roads there are the greater is the proportion of the tortoise population that is under the threat of illegal off-road activity. Boarman and Sazaki (1996) demonstrated that tortoises regularly die from collisions with automobiles and Nicholson (1978) showed that the rate of mortality probably increases with traffic volume. So, road kill is probably proportionally lower on lightly traveled dirt roads, but may still exist. However, because tortoise populations are probably less depressed alongside lightly traveled roads (Nicholson 1978) and if tortoises are less inhibited from crossing narrower, dirt-covered roads (for which there are no data), we may speculate that proportionally more tortoises may cross lightly traveled roads. The possibility does exist that ORVs may crush tortoises or their burrows on or off of roads (Marlow 1974, Bury and Luckenbach 1986, Berry 1990 as amended).

Mortality on roads is not the only type of vehicle-related impact; ORVs sometimes drive off of established routes, including within 100 ft to camp and park (Bureau of Land Management 1980). One study has supported the hypothesis that off-road activity is high near dirt roads even in an area that was heavily signed (Goodlett and Goodlett 1993). For example, they counted an average of one track every 31 feet along transects walked perpendicular to authorized routes. As expected, the density of tracks decreased with distance from the road from an average of 2.1 per 20 ft near the road to 0.5 per 20 feet 250 to 300 feet away. No statistical analyses were made. Goodlett and

Goodlett (1993) also demonstrated that ORV recreationists ignored BLM signs indicating trails and roads were closed to vehicles in the Rand Mountains. An average of 11.5 new tracks was counted along 17 trails 6 to 7 days after the trails were raked. An average of 10.0 tracks was found along 20 unmarked routes (again, no statistical analyses were provided), which suggests that the signs were essentially ineffective at preventing people from riding on closed trails. The motorcycle activity occurred over Thanksgiving weekend, 1991.

Furthermore, there is ample evidence that occasional driving off of roads compacts soil and damages vegetation (Vollmer et al. 1976, Webb 1983, Adams et al. 1982a, b, see also "ORV" section, above). The greatest increase in compaction can occur after a single or very few passes by a vehicle over unimpacted soil (Webb 1983), or at least soil strength (a measure of compaction) is significantly increased after a very few passes by an SUV (Adams et al. 1982a, b). Any driving or even walking over cryptogamic crusts damages the crust (Belnap 1996). As discussed in the "ORV Activities" section, above, there are very little data to indicate how these habitat alterations might affect tortoise populations.).

Other potentially harmful activities that likely occur in greater numbers near roads include: mineral exploration, illegal dumping of garbage and toxic wastes, release of ill tortoises, vandalism, anthropogenic fire, handling and harassing of tortoises, and trailing of sheep (Berry and Nicholson 1984a). Invasive plants also proliferate near roads and where road densities are higher (Brooks 1995, 1999a). The threat posed to tortoise populations by all of these factors likely increases with increased access afforded by the proliferation of roads, even very lightly traveled ones. Furthermore, some of these individual threats may be relatively low, but their cumulative impact may be great. Berry (1990 as amended, 1992), presents data that suggests a correlation between tortoise population declines and density of roads, trails, and tracks on tortoise study plots, but the results have not been treated to statistical analysis. This important association between access and tortoise wellbeing needs further study.

Habitat Loss, Degradation, and Fragmentation

One of the most pervasive problems for desert tortoise populations is also among the most difficult to evaluate: habitat loss, degradation, and fragmentation from the myriad activities that take place in the desert. This is the cumulative result of several of the individual threats discussed above.

Habitat loss is generally quite apparent (e.g., loss of useable habitat when paved for a parking lot or plowed for agriculture), but is sometimes less than obvious (e.g., a given area may be rendered unusable by tortoises after soil is heavily compressed and vegetation is destroyed after many vehicles drive over the area). Previously useful habitat may be rendered unusable, but may appear superficially similar to useable habitat.

Habitat degradation consists of human-mediated changes in habitat characteristics that render an area less valuable to, but still potentially usable by, tortoises. The

degradation may be manifested in altered soil structure, increased exotic plants, lower abundance of preferred forage plants, reduced availability of effective cover sites, or a combination of these traits. The degradation may not directly cause increased mortality in tortoise populations, but may reduce reproductive output or cause some animals to leave the area in search of less degraded habitat. Although these responses have been hypothesized, there have been no studies on tortoise habitat choice or preference patterns changing as a result of habitat changes.

Many of the impacts discussed above fit easily into the category of habitat degradation that may significantly reduce habitat quality for tortoises. A single vehicle driving over a section of ground may have little impact by itself (Adams et al. 1980a, b), but when that is added to a pile of trash nearby, compaction from grazing (Avery 1998), and reduced primary productivity of plants because of dust from a nearby dirt road (Sharifi et al. 1997), the cumulative habitat degradation may significantly reduce quantity or quality of forage for tortoises. The cumulative effects of factors leading to habitat loss and habitat degradation have been implicated as causes in the extirpation and drastic reductions in tortoise populations from the Antelope, Searles, and Indian Wells valleys, and in the vicinity of several other communities in the West Mojave (e.g., Barstow, Mojave, and Victorville; Berry and Nicholson 1984a, Feldmeth and Clements 1990, Tierra Madre Consultants 1991, USFWS 1994).

Fragmentation is the process by which solid blocks of habitat and populations depending on the habitat are broken up into smaller subunits with limited dispersal between habitat blocks (Meffe and Carroll 1997). Rivers, mountain ranges, major changes in soil or habitat type all represent natural causes of fragmentation. Highways, railroad tracks, towns, and other developments, isolated and conglomerated, are examples of anthropogenic factors that fragment desert tortoise habitat in the West Mojave Desert. Smaller populations are more susceptible to local extinctions as a result of both genetic and demographic (population) processes. A smaller population has fewer individuals available for interbreeding, which may result in genetic deterioration: inbreeding depression and loss of genetic diversity within the population (Frankham 1995). Genetic deterioration can result in the inability to adapt to short- or long-term environmental changes, which makes the population more vulnerable to extinction. Small populations are also susceptible to extinctions from random fluctuations in birth rate, death rate, age distributions, and sex ratios (Opdam 1988). Small populations suffer from the Allee Effect, the fact that it is harder to find a mate when there are fewer individuals in a population (Allee et al. 1949). Finally, smaller populations are more vulnerable to catastrophic events (e.g., disease epidemics, earthquakes, and floods) and random environmental fluctuations in such things as food resources. These processes (genetic deterioration and demographic consequences of small populations) are theoretical possibilities, but have not been documented empirically in desert tortoises populations (see USFWS 1994 for a theoretical analysis).

An additional problem associated with fragmentation is that the negative effects of habitat edges are increased considerably (Murcia 1995, Meffe and Carroll 1997). Edges, or boundaries, are problems for ecosystems because the microenvironment in the edge is different than in the interior: temperature, humidity, light, chemical inputs, etc.,

may all differ in edge regions. The distribution and persistence of many plant and animal species are often strongly affected by these microenvironmental conditions, so the communities are usually different along edges. Furthermore, edge conditions often facilitate the introduction, establishment, and spread of exotic species that may become predators or competitors with plants or animals in the interior (Janzen 1986, Wilcove et al. 1986). For desert tortoises, the edge effect is a theoretical possibility, but it has not been well documented in tortoise populations. Furthermore, some edge effects may only function over relatively short distances (e.g., tens of yards) or not at all (Ratti and Reese 1988, Murcia 1995).

There are little data that directly test this hypothesized cumulative effect of multiple impacts on tortoise populations. Berry and Nicholson (1984a) do cite anecdotal evidence of the loss of previously-existing populations in now heavily-populated areas of Antelope, Lucerne, and Yucca valleys. Berry et al. (1994) present correlative data showing that declines in tortoise populations in the Rand Mountains and Fremont Valleys correlate with increases in a suite of human impacts. The Desert Tortoise Recovery Plan (USFWS 1994) provides data that show significant declines occurred in populations exhibiting high rates of human-caused mortality.

Urbanization and Development

Whereas construction activity (treated as an individual threat, above) has impacts specific to the activities of building new structures (e.g., temporary compaction of vegetation and soil, fugitive dust, disturbance and possible death of tortoises), these impacts largely cease once construction has been completed (although for some impacts, such as soil compaction, there is a residual effect caused by delayed recovery, Lovich and Bainbridge 1999). The result of the construction activity is the presence of new structures, which are called here "developments," and which have its attendant impacts. These impacts include long-term or permanent loss or alteration of habitat, impacts from maintenance activities, disruption of tortoise behavior, and road kills (Berry and Nicholson 1984a, Luke et al. 1991).

Developments may be relatively isolated from each other, but “Urbanization” refers to cumulative effects of multiple and nearly contiguous developments including construction of permanent residences that cover large areas. Urbanization has several impacts associated with the presence of many people in the area, not, all of which are well documented. Urbanization results in considerable fragmentation, loss of habitat, and habitat alteration to the point of being largely useless to tortoise populations (Berry and Nicholson 1984a, Feldmeth and Clements 1990, Tierra Madre Associates 1991, section titled “Habitat Loss, Degradation, and Fragmentation”). Some recreational activities may emanate directly from urban areas. Wild dogs may be more prevalent (e.g., Bjurlin and Bissonette 2001) and collecting, handling and vandalism of tortoises could increase where there are more people. Captive tortoises, potentially infected URTD (see "Disease" section, above), are more likely to escape and help spread disease to the native population (Jacobson 1993, Berry pers. comm.). Illegal dumping is prevalent (pers. obs.), raven populations are larger (Knight et al. 1993), and exotic plants predominate

(Humphrey 1987, Brooks 1998) around urban developments. Urban areas and associated flood control channels in the desert are often the source of much fugitive dust (Wilshire 1980). Many of these impacts may be relatively minor by themselves, but their cumulative effects on nearby tortoise populations may be great.

There is some evidence that tortoise populations can persist in the presence of light industrial developments. In the 1980s 460 wind turbines and 51 electrical transformers were erected in tortoise habitat at Mesa, California. Approximately 10-20 years later, there were still tortoises living and reproducing in the same area; some burrow beneath and rest upon concrete support pads for the turbines (Lovich and Daniels 2000). Reproductive output is higher than at any other site studied to date (Lovich et al. 1999). However, there are no data available to determine if the population has increased, decreased, or remained stable since construction. Tortoises may persist in this area because of the relatively low level of actual human activity in the wind park and the high productivity in the area, which is in the ecotone between creosote scrub and coastal sage scrub habitat.

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EXHIBIT 645

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THE APPLICATION OF HABITAT MODELING TO THE DESERT TORTOISE (*GOPHERUS AGASSIZII*)

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ABSTRACT: Habitat modeling offers an approach to understanding some management problems of desert tortoises (*Gopherus agassizii*) and to focusing new research efforts. Modeling can provide (1) a method to organize existing information, (2) a means to identify whether physical habitat or some factor outside the scope of the habitat model is limiting populations, (3) a method to integrate habitat into resource development planning, and (4) a mechanism for focusing research on missing species-habitat information.

Key words: Desert tortoise; *Gopherus agassizii*; Habitat quality; Habitat model; Suitability graphs; Planning; Impact assessment

THE relationship between desert tortoise (*Gopherus agassizii*) abundance and habitat quality is an important factor in making decisions that influence tortoise populations or habitat. A system that discriminates between favorable and inferior tortoise habitats is useful for project planning. For example, when selecting desert areas for human use, it is better to avoid areas of high tortoise abundance or high habitat potential. Occasions also arise when appropriate management could improve habitat quality. In such instances, it is necessary to know which environmental factors are limiting tortoise habitat so that appropriate management measures can be initiated to improve habitat quality.

Another consideration is the California Energy Commission's recommendation to study the feasibility and effectiveness of moving tortoises from power plant sites to other areas. This tactic creates problems, including genetic mixing and possible complications associated with homing behavior by relocated individuals. A related problem is the identification of areas that are underpopulated and capable of supporting additional animals. Tortoise relocation raises several related questions. (1) What factors interact to provide high quality tortoise habitat? (2) Can differences in tortoise habitat quality be identified? (3) What relationships exist between habitats of different quality and tortoise abundance? (4) How will the tortoise respond to changes in specific habitat conditions? (5) Can this information be used in making decisions about where to place facilities?

One method of answering questions of this nature is to use a habitat model. A model uses existing information about critical variables to generate predictions and, using simplifying assumptions, provides testable hypotheses. A good model eliminates extraneous information that could inhibit, rather than contribute to, the development of sound management decisions (Overton, 1977). Model objectives must be established in any modeling exercise. If predictions of animal numbers are desired, a population model rather than habitat model should be developed. There are different kinds of habitat models. One type predicts the presence or absence of a species, whereas other habitat models provide information about habitat suitability over a range of habitat conditions.

Habitat suitability models can be structured in ways based on life requisites, life stages, seasonal habitats, or other criteria. One could develop separate habitat models for (1) habitat for adult tortoises, (2) habitat requirements of reproducing tortoises, or (3) the habitat of immature tortoises. In this paper, we discuss the type of habitat model that is capable of ranking hab-

itat quality of adult desert tortoises over a range of habitat conditions. We define a set of variables that are important in determining habitat quality and provide illustrations to show how habitat quality can be scaled as a function of those variables. This discussion is based on relationships beween habitat features and the distribution, occurrence, and abundance of adult tortoises. We recognize that very young tortoises may have other habitat requirements. The approach is heuristic and is intended to promote thought and help focus research on habitat relationships of desert tortoises.

Relationships between abundance and habitat structure are apt to be clouded by factors that may not be considered as part of the habitat model (Schamberger and O'Neil, in press). For example, in undisturbed areas, one would expect to find an equilibrium between tortoise numbers and the environment. However, the short-term effects of fire, predation, disease, or rainfall could result in short-term changes in abundance that may be unrelated to habitat potential. In addition, grazing, urbanization, road construction, mining, off-road vehicles, trails, and human depredation all have changed the tortoises' habitat and have reduced tortoise density. Thus, habitat models are not intended to be instantaneous predictors of animal abundance, but they attempt to focus on physical environmental factors that may influence habitat quality.

Habitat Suitability Index Models

The concept and use of Habitat Suitability Index (HSI) models have been described and used to model habitat relationships for numerous species (U.S. Fish and Wildlife Service, 1981). For example, the gray squirrel occupies forest communities in the eastern United States. Squirrels consume a variety of plants during the spring and summer, but they subsist almost entirely on nuts during fall and winter. Requirements for cover and reproduction are provided by trees. One underlying assumption in the evaluation of squirrel habitat is that fall and winter food supply always is most limiting. A model by Allen (1982) illustrated how percent canopy closure of trees producing nuts (V_1), tree species diversity (V_2), percent tree canopy closure (V_3), average diameter of overstory trees (V_4), and percent shrub crown cover (V_5) are believed to interact to describe the quality of squirrel habitat. A suitability index was developed for each of these five variables. Two life requisites that represent habitat quality for the squirrel, food and cover, were scored on the basis of the five suitability index values:

$$\text{Winter food} = (V_1 \times V_2)^{1/2}$$

$$\text{Cover and reproduction} = (V_3 \times V_4)^{1/2} \times V_5$$

The geometric mean (parenthetical expressions) is but one of several methods used in computing measures of suitability so that if either of two necessary components is zero the combined variable also is zero. In this example, the HSI for the gray squirrel is taken as the lowest value for the winter food or cover/reproduction components. This prevents a high score for one component from offsetting a deficiency in another limiting environmental requirement.

Elements of an HSI Model for Desert Tortoise Habitat

The ensuing discussion is designed to show how an HSI model might be developed and applied to the evaluation of desert tortoise habitat in California. General thoughts as to how various environmental factors interact to influence tortoise abundance were illustrated by Luckenbach (1982). He based his conclusions on observations along 137 transects (each 6.4 km in length) in southeastern California. Luckenbach discussed qualitative relationships between elevation, soil types, denning potential, vegetation, rainfall, species richness of perennial plants, and productivity of annual plants as related to tortoise habitat quality. Luckenbach's illustration indicated that the most favorable habitats were at elevations ranging from approximately 300–900 m, with sandy loam or light gravel-clay soils (good denning potential), a diversity of peren-

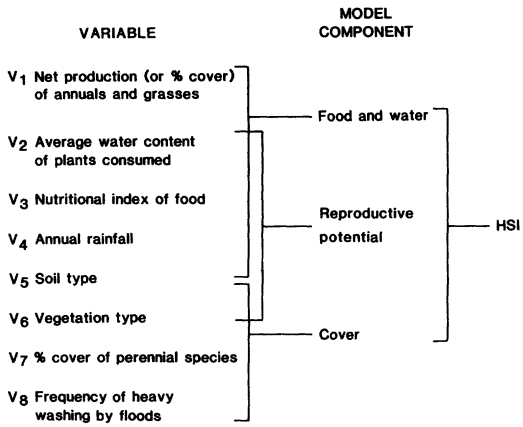

FIG. 1.—Example model structure for desert tortoise habitat.

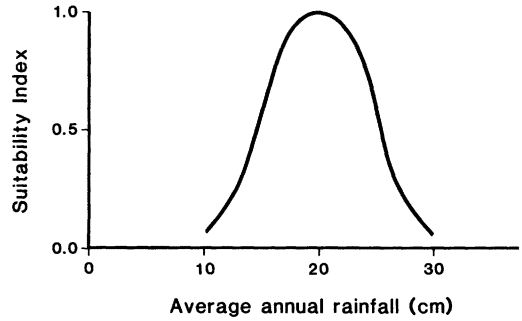

FIG. 2.—Suitability index graph showing the possible relationship between average annual rainfall and habitat quality for the desert tortoise.

nial plants, and a high production of ephemerals. Optimal habitat was dominated by creosote bush scrub (*Larrea tridentata*) in areas having 50–200 mm of annual rainfall. Luckenbach (1982) presented his data in a multi-axis illustration, not as a habitat model. However, some of these data are suitable for use in the HSI model approach.

Data from Luckenbach (1982), Berry (1984), and Turner et al. (1984) were used to structure a draft HSI model based on three model components (Fig. 1). Not all variables are related to tortoise distribution and abundance in the same way. Some are of broad scope and probably control the geographic distribution of the species with little effect on local patterns of occurrence. Others might be expected to exert site-specific influences. The habitat variables discussed below are related to food and water, cover, and reproductive requirements. Water is important to desert species because it provides free water following rainstorms and because the vegetation cycle, and consequently the availability of food and cover, follows precipitation patterns. The variables suggested in this paper are not intended to be a definitive list required to thoroughly describe tortoise habitat. Additional research may identify more useful variables.

Food and Water

Tortoises subsist almost entirely on plant material, which provides energy, minerals, and water. The following variables, some of which are interrelated, describe the food and water value of a site: net production by annual plants and grasses (V_1), water content of plants consumed (V_2), nutrient quality of food (including necessary minerals and caloric content) (V_3), and annual rainfall (V_4). Tortoises in some areas eat dirt, which may be a sign of a mineral deficiency in their diets (Marlow and Tollestrup, 1982). Calcium is an element required by tortoises for shell development and for synthesis of egg shells.

Cover

Tortoises rely both on shrubs and burrows for cover. Important vegetation variables that may be useful in a habitat model include the species of dominant or co-dominant shrubs as indicated by vegetation type (V_6) and total cover by perennials (V_7). In Arizona, tortoises often are found associated with rocky outcrops and may live in holes in or beneath rocks (Burge, 1978). In California, tortoises usually excavate burrows in soil. Hence, as indicated by Luckenbach (1982), soil type (V_5) has an important bearing on the quality of tortoise habitats in California. Frequency and extent of heavy washing by floods (V_8) also may be an important variable.

Reproductive Potential

The energy costs of reproduction are related to the same variables important in determining food value. Requirements for

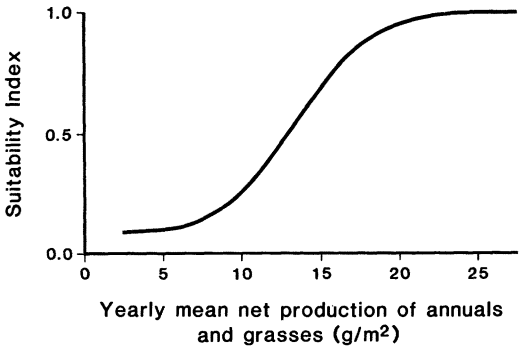

FIG. 3.—Suitability index graph showing the possible relationship between net production of annuals and grasses and habitat quality for the desert tortoise.

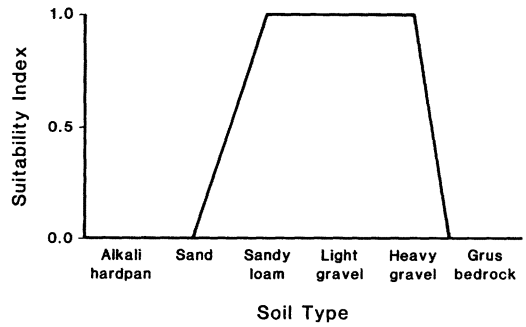

FIG. 4.—Suitability index graph depicting the possible relationship between soil type and habitat quality for the desert tortoise (from Luckenbach, 1982).

nests are the same as those relating to burrows, because tortoises establish nests at the bottom of burrows (Turner et al., 1986). Of lesser importance may be the size and spacing of shrubs, which might have some effect on courtship, if tortoises find each other by visual cues.

Model Variables and Habitat Quality

The foregoing text has identified eight variables believed to be important in describing desert tortoise habitat quality. The relationships between variables and habitat suitability need to be quantitatively defined. The typical HSI model uses mechanistic curves to define ranges of optimum or suboptimum habitat for habitat variables. Figure 2 illustrates how annual rainfall (see Luckenbach, 1982) might be scaled as a conventional HSI variable. The decline in habitat suitability as annual rainfall increases beyond about 20 cm/yr presumably reflects other features such as higher elevation or latitude. Figures 3–5 illustrate possible scalings of three other variables: yearly production of annuals, soil type, and vegetation type. Sometimes such relationships can be found in existing literature. Other times the relationships can only be estimated until more definitive research can be conducted.

Once the variables defining desert tortoise habitat quality are identified and related to habitat suitability, the next step is to determine a method to estimate overall habitat suitability. The simplest approach is to use the lowest value of all variables or the lowest life requisite value as the HSI value for the species. Although numerous methods are available, the method used must accurately represent the habitat relationships between the species and the variables.

DISCUSSION

Habitat models are useful for habitat evaluations, impact assessments, development of management and mitigation plans, and directing research. Actions that would influence one or more of the model variables can be simulated to determine the possible impact on tortoise habitat. For example, if food abundance was determined to be limiting habitat at a site, management options could be developed to increase the abundance of grasses and annual plants, thus increasing the food value of the site and increasing habitat quality.

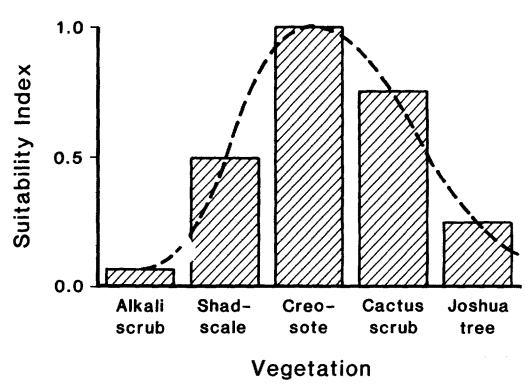

FIG. 5.—Suitability index graph depicting the possible relationship between vegetation type and habitat quality for the desert tortoise (from Luckenbach, 1982).

Research can be focused by use of the habitat modeling approach. The abundance of grasses and annual plants has been reported by Luckenbach (1982) as a factor influencing tortoise habitat quality. Research results could quantitatively relate the abundance of grasses and annual plants to habitat quality. This information would reduce subjectivity of habitat assessments, provide quantitative information that relates habitat to species well-being, and identify criteria for habitat assessment and management.

Previous discussion has emphasized the relationships between single environmental factors and habitat quality. Interactions between variables are more difficult to ascertain and model. How elevation, rainfall, soil type, and vegetation jointly affect tortoise habitat quality is not known. In addition, habitat factors may vary regionally. Earlier discussions by Nagy and Medica (1986) and Turner et al. (1986) showed how rainfall, plant production, and tortoise habitat relationships may vary from area to area; winter rainfall is a dominant influence in the western and northern Mojave Desert, whereas summer rainfall is more important in the eastern Mojave (see also Turner et al., 1984).

Fortunately, habitat suitability models are dynamic and can be modified as new information becomes available. In this paper, we have drawn on information based on counts of tortoises along 137 transects in southeastern California reported by Luckenbach (1982). Between 1976 and 1982, over 1800 additional transects were examined in this area (Berry, 1986). These data are now being used in multivariate analyses designed to clarify further some of the relationships described in this paper.

The habitat model approach provides a mechanism to organize existing habitat information about the desert tortoise, identify data gaps to suggest future research, and provide guidance for decision-making during the planning phase of resource development activities.

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BTP-R6001-2003

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Table of Contents

Table of Contents iii

List of Figures vi

List of Tables viii

Executive Summary 1

Acknowledgments 2

Taxonomy 3

Legal Status 4
United States 4
Canada 4
Mexico 4

Description 6

Distribution 7
Breeding 7
Migration 7
Winter 7

Natural History 10
Breeding 10
- Phenology 10
- Diet 10
- Foraging 10
- Productivity 10
- Territory 10
- Aggregations 10
- Mortality and Predation 11
- Site and Burrow Fidelity 11

Habitat 12
Breeding 12
Migration 12
Winter 12

Populations 13
Population Estimates and Trends 13
- Breeding Bird Survey 13
- Christmas Bird Count 13
- Other Surveys, United States 13
- Other Surveys, Canada 17
- Other Surveys, Mexico 17

Densities 17
Changes in Breeding Season Distribution 17
- United States 17
- Canada 19
- Mexico 19

Re-occupancy Rates 19

Monitoring Activities 20
Range-wide Surveys 20
Local Surveys 20
Proposed Protocols and Surveys 20

Threats 21
Habitat: Breeding 21
Habitat Loss and Fragmentation 21
Burrows 21
Grazing 21
Burning 21
Mowing 22
Habitat: Winter 22
Overutilization For Commercial, Recreational, Scientific, or Educational Purposes 22
Predation and Disease 22
Predation 22
Disease 22
Inadequacy of Existing Regulatory Mechanisms 22
Other Natural or Manmade Factors 22
Disturbance at Nest and Roost Sites 22
Ingestion of Plastics, Lead, Etc. 22
Collisions with Stationary/Moving Structures 22
Shooting, Trapping, and Hunting 22
Population Size and Isolation 22
Introduced Species 22
Indirect Effects of Disease 22
Pesticides and Other Contaminants/Toxics 23

Recommendation on Current Conservation Status 24

Management and Conservation 25
Habitat 25
Habitat Features 25
Fire 25
Mowing 25
Grazing 25
Burrowing Mammals 25
Reintroduction and Relocation 26
Reintroduction 26
Relocations and Artificial Burrows 26
Pesticide Use 26
Monitoring 26
Migration 27
Wintering Areas 27
Education 27
Current Activities and Programs 27
United States 27
Canada 28

Research Needs 29

Literature Cited 30

Appendix A: State Summaries of Burrowing Owl Status **36**
Arizona 36
California 40
Colorado 45
Florida 48
Idaho 53
Iowa 56
Kansas 57
Minnesota 59
Montana 60
Nebraska 63
Nevada 66
New Mexico 69
North Dakota 72
Oklahoma 75
Oregon 77
South Dakota 80
Texas 82
Utah 83
Washington 84
Wyoming 87
Arkansas, Illinois, Missouri, Wisconsin 90

Appendix B: Summary of Conservation Recommendations for Burrowing Owls **91**

Appendix C: Distribution List for the Burrowing Owl Status Assessment and Conservation Plan **94**

Appendix D: Scientific and Common Names of Animals and Plants Mentioned in the Burrowing Owl Status Assessment and Conservation Plan **106**

List of Figures

Fig. 1. Current and historical ranges of the Western Burrowing Owl in North America; modified from the Birds of North America species account (Haug et al. 1993), North American Breeding Bird Survey distribution map (Sauer et al. 2001), individual papers from the Proceedings of the Second International Burrowing Owl Symposium (Journal of Raptor Research 35(4) 2001), and personal communications with local experts. Historical range (pre-1970's) taken from Zarn (1974), Wedgwood (1978), and from personal communications with local experts. In states that lacked detailed distributional data, Burrowing Owls were presumed to be absent from areas of forest or rugged mountains. The historical range is unknown for Mexico (from Wellicome and Holroyd 2001). 8

Fig. 2. Burrowing Owl distribution in Mexico during the breeding (16 April – 15 October) and non-breeding (16 October – 15 April) seasons as determined from 279 museum specimens and literature documentation (Enriquez-Rocha 1997). 9

Fig. 3. Winter distribution of the Burrowing Owls in the United States from Christmas Bird Count (CBC) data (1966-1989). Shading represents the species relative abundance (birds/100 party hours) averaged for each CBC circle and smoothed over the species distribution (Sauer et al. 1996). 11

Fig. 4. Breeding Bird Survey trends for Burrowing Owls in the United States and Canada (1966-96, Sauer et al. 2002). These trends do not necessarily reflect statistical significance (see Table 2). 16

Fig. A-1. Distribution of the Burrowing Owl in Arizona from the Arizona Breeding Bird Atlas project (Arizona Breeding Bird Atlas, Unpubl. data (1993-2001), C. Wise, pers. commun.). 37

Fig. A-2. Distribution of Burrowing Owl Populations in California, 1991-1993 (9,266 breeding pairs, estimate) (DeSante et al. unpubl. ms.). 41

Fig. A-3. Distribution of Burrowing Owls in Colorado from the Colorado Breeding Bird Atlas project (Jones 1998). 46

Fig. A-4. Distribution of Burrowing Owls in Kansas from the Kansas Breeding Bird Atlas project (Busby and Zimmerman 2001). 58

Fig. A-5. Latilong distribution of Burrowing Owls in Montana. B = direct evidence of breeding, b = indirect evidence of breeding, t = species observed, but no evidence of breeding (Montana Bird Distribution Committee 1996). 61

Fig. A-6. Distribution of Burrowing Owls in Nebraska, based on breeding evidence post-1960 (Ducey 1988). 64

Fig. A-7. Distribution of Burrowing Owls in Nevada from the Nevada Breeding Bird Atlas project (Unpubl. data). 67

Fig. A-8. Distribution of Burrowing Owls in North Dakota, prior to 1972. Filled squares = nest or dependent young recorded from 1950 to 1972. Empty squares = nests or dependent young recorded prior to 1950. Filled triangles = territorial males or pairs recorded from 1950 to 1972. Empty triangles = territorial males or pairs recorded prior to 1950 (Stewart 1975). 73

Fig. A-9. Distribution of Burrowing Owls in Oklahoma (Oklahoma Breeding Bird Atlas Project, D. Reinking, pers. commun.). 76

Fig. A-10. Distribution of confirmed (n = 49), probable (n = 9), and possible (n = 37) breeding activity of Burrowing Owls in Oregon from the Oregon Breeding Bird Atlas project (Adamus et al. 2001). 78

Fig. A-11. Distribution of Burrowing Owl breeding activity and observation in South Dakota from the South Dakota Breeding Bird Atlas project (Peterson 1995). 81

Fig. A-12. Distribution of Burrowing Owl observations in Utah (Utah Natural Heritage Program, A. Axel, pers. commun.). 83

Fig. A-13. Distribution of Burrowing Owls burrows in Washington (Washington Department of Fish and Wildlife, Wildlife Resources Data System, J. Brookshier, pers. commun.). 85

Fig. A-14. Historic Burrowing Owl records (dots) from the Wyoming Game and Fish Department Wildlife Observation System and reoccupancy survey sites with Burrowing Owls (diamonds) in 1999 (from Korfanta et al. 2001). 88

Fig. A-15. Numbers of Burrowing Owl records per year in the Wyoming Game and Fish Department Wildlife Observation System. The trend line for the 1986 – 1997 period represents a period of presumed consistent search effort (from Korfanta et al. 2001). 88

List of Tables

Table 1. Legal status and natural heritage status of Burrowing Owls in the United States, Canada, and Mexico. 5

Table 2. North American Breeding Bird Survey trends, significance level (P), sample size (n) and 95% confidence intervals (CI) for the Burrowing Owl during three different survey periods (Sauer et al. 2002). 14

Table 3. Christmas Bird Count trends, sample sizes (n), 95% confidence intervals (CI), significance levels (P), and relative abundance (RA) for the Burrowing Owl in areas with sufficient data for analysis, 1959-1988 (Sauer et al. 1996). 16

Table 4. Burrowing Owl population estimates for states, provinces, and countries. James and Espie (1997) surveyed state/provincial biologists in 1992 to determine approximate total breeding populations. Other populations estimates are presented only for statewide/province-wide estimates; additional local population estimates can be found in Appendix A: State Summaries of Burrowing Owl Status. 18

Table A-1. Comparison of mean density, survival, and reproductive rates of Burrowing Owls at four sites in California.. 42

Table A-2. Estimates of juvenile survival rates necessary for population stability under different adult reproductive and survival rates. 42

Table A-3. Distribution and abundance of Florida Burrowing Owls by major subpopulation and county. . . . 50

Table A-4. Number of occupied, unoccupied, destroyed, and not found Burrowing Owl nests located in Washington during Washington Department of Fish and Wildlife surveys in 1999 and 2000. 85

Table B-1: General categories of conservation recommendations for Burrowing Owls from states for which recommendations were found. 92

Table D-1: Scientific and common names of animals mentioned in the “Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States”. 111

Table D-2: Scientific and common names of plants mentioned in the “Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States”. 113

Executive Summary

The Western Burrowing Owl (*Athene cunicularia hypugaea*) is a grassland specialist distributed throughout w. North America, primarily in open areas with short vegetation and bare ground in desert, grassland, and shrub-steppe environments. Burrowing Owls are dependent on the presence of fossorial mammals (primarily prairie dogs and ground squirrels), whose burrows are used for nesting and roosting. Burrowing Owls are protected by the Migratory Bird Treaty Act in the United States and Mexico. They are listed as Endangered in Canada and Threatened in Mexico. They are considered by the U.S. Fish and Wildlife Service (USFWS) to be a Bird of Conservation Concern at the national level, in three USFWS regions, and in nine Bird Conservation Regions . At the state level, Burrowing Owls are listed as Endangered in Minnesota, Threatened in Colorado, and as a Species of Concern in California, Montana, Oklahoma, Oregon, Utah, Washington, and Wyoming.

Burrowing Owls historically bred from sc. and sw. Canada southward through the Great Plains and w. United States and south to c. Mexico. Although the historical breeding range is largely intact, range contractions have occurred primarily at peripheral regions, in s. Canada, the ne. Great Plains, and parts of California and the Pacific Northwest. Burrowing Owls winter in the sw. and sc. United States, throughout Mexico, and occasionally as far south as Panama.

Populations of Burrowing Owls have declined in several large regions, notably in the ne. Great Plains and Canada. However, estimates of population trends in many regions are generally inconclusive due to small samples sizes and high data variability. Population trends as determined from North American Breeding Bird Survey (BBS) data were inconsistent, with some regions exhibiting positive trends and other regions exhibiting negative trends. When taken as a whole, the BBS indicated an area of generally declining populations in the northern half of the Great Plains, and generally increasing populations in the interior U.S. and in some southwestern deserts. The Christmas Bird Count indicated a significant population decline in California (1966-1989). Local surveys have detected declining populations and/or range reductions in California, Iowa, Kansas, Minnesota, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Washington, and throughout the range of the species in Canada.

Primary threats across the North American range of the Burrowing Owl are habitat loss due to land conversions for agricultural and urban development, and habitat degradation and loss due to reductions of burrowing mammal populations. The elimination of burrowing mammals through control programs and habitat loss has been identified as the primary factor responsible for declines of Burrowing Owls. Additional threats to Burrowing Owls include habitat fragmentation, predation, illegal shooting, pesticides and other contaminants. The types and significance of threats during migration and wintering are poorly understood.

The preservation of native grasslands and populations of burrowing mammals is ultimately critical for the conservation of Burrowing Owls. Efforts to maintain and increase populations of burrowing mammals through reduction of lethal control programs and landowner and land manager education should be undertaken. Burning, mowing, and grazing may be employed to maintain suitable habitat structure for nesting Burrowing Owls, although additional research is needed. Efforts to reintroduce or relocate Burrowing Owls should be critically reviewed to determine efficacy and best methods. Current large-scale monitoring efforts are generally inadequate. Effective programs to better determine actual population trends and demographics of Burrowing Owl populations should be developed and implemented.

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Taxonomy

Two subspecies of Burrowing Owl (*Athene cunicularia*) occur in North America: the Western Burrowing Owl (*A. c. hypugaea*) and the Florida Burrowing Owl (*A. c. floridana*). Although this status assessment is focused on North American populations of the Western Burrowing Owl (henceforth Burrowing Owl), a state summary for the Florida Burrowing Owl is included in this document (Appendix A) to provide complete information on the species in the United States. The Florida state summary is an update of information included in Millsap (1996).

Class: Aves

Order: Strigiformes

Family: Strigidae

Genus: *Athene*

Species: *A. cunicularia*

Subspecies: *A. c. hypugaea*, *A. c. floridana*

Authority: (Molina, Subspp. Bonaparte)

Originally named *Strix cunicularia* by Molina in 1782, the Burrowing Owl received several taxonomic changes until placed in the genus *Speotyto* and now *Athene* (Clark et al. 1997, AOU 1998). *A. cunicularia* occurs as a breeding and/or wintering species throughout w. North America, Central America, and extensive portions of South America with disjunct populations in Florida and the Caribbean Islands. *A. c. hypugaea* occurs in North America to the eastern limits of the Great Plains and from s. British Columbia to Manitoba and into Central America as far south as Panama (Haug et al. 1993). This subspecies occurs primarily in prairies, grasslands, shrub-steppe, desert, and agricultural areas in North America (Haug et al. 1993). *A. c. floridana* occurs in Florida north to Madison and Duval counties (AOU 1998).

Legal Status

United States

From 1994-1996, the Western Burrowing Owl was designated by the U.S. Fish and Wildlife Service (USFWS) as a Category 2 species for consideration to be listed as a threatened or endangered species. In 1996 the Category 2 designation was discontinued. The Burrowing Owl currently is federally protected by the Migratory Bird Treaty Act (1918) in the United States and Mexico. The Western Burrowing Owl is listed by the USFWS as a National Bird of Conservation Concern (U.S. Fish and Wildlife Service 2002). It is also listed as a Bird of Conservation Concern in USFWS Regions 1 (Pacific Region, mainland only), 2 (Southwest Region), and 6 (Mountain-Prairie Region) as well as in Bird Conservation Regions (BCR) 9 (Great Basin), 11 (Prairie Potholes), 16 (S. Rockies/Colorado Plateau), 17 (Badlands and Prairies), 18 (Shortgrass Prairie), and U.S. Portions of BCR 32 (Coastal California), 33 (Sonoran and Mojave Deserts), 35 (Chihuahuan Desert) and 36 (Tamaulipan Brushlands) (U.S. Fish and Wildlife Service 2002). The Burrowing Owl is listed as Endangered, Threatened, or as a Species of Concern in 9 states and 4 Canadian provinces (Table 1). It is given a Global Heritage Status Rank of G4 (apparently secure globally though it may be quite rare in parts of its range) and is listed as a Convention on International Trade in Endangered Species (CITES), Appendix II species (NatureServe Explorer 2001).

Canada

In 1979, the Western Burrowing Owl was listed as "Threatened" based on Wedgwood (1979), reconfirmed in 1991 (Haug and Didiuk 1991), and changed to "Endangered" in 1995 (Wellicome and Haug 1995).

Mexico

In 1994, Burrowing Owls were listed as a federally Threatened (Amenazadas) species (Secretaria de Desarollo Social de Mexico 1994 *in* Sheffield 1997*a*).

Table 1. Legal status and natural heritage status of Burrowing Owls in the United States, Canada, and Mexico

Area	Legal status	Natural Heritage status[a]
United States	None	Apparently Secure
Arizona	None	Vulnerable
California	Species of Concern	Imperiled
Colorado	Threatened	Apparently Secure
Idaho	None	Vulnerable/Apparently Secure
Iowa	Accidental breeder	Unranked
Kansas	None	Vulnerable
Minnesota	Endangered	Critically Imperiled
Montana	Species of Concern	Vulnerable
Nebraska	None	Vulnerable
Nevada	None	Vulnerable
New Mexico	None	Apparently Secure
North Dakota	None	Unranked
Oklahoma	Species of Concern	Vulnerable
Oregon	Species of Concern	Imperiled
South Dakota	None	Vulnerable/Apparently Secure
Texas	None	Vulnerable
Utah	Species of Concern	Vulnerable
Washington	Species of Concern	Vulnerable
Wyoming	Species of Concern	Vulnerable
Canada	Endangered	Vulnerable
Alberta	Endangered	Vulnerable
British Columbia	Endangered	Critically Imperiled
Manitoba	Endangered	Critically Imperiled
Saskatchewan	Endangered	Imperiled
Mexico	Threatened	Unranked

[a]–Global status = Apparently Secure

Description

The Burrowing Owl is a small owl (19.5-25.0 cm, ~150 g), with long slender tarsi covered with short hair-like feathers that terminate in sparse bristles on the feet. The head is rounded, lacks ear tufts, and is chocolate in color with white streaking or spotting. There are buffy-white margins around the eyes and a white throat patch. Eyes are lemon-yellow and the beak is pale horn-colored. The wings are relatively long and rounded, the tail is short, and both are brown with buff-white barring. The undertail coverts are white. The dorsal area including head, back, and scapulars are heavily spotted with buffy-white. The belly of adults is buffy and heavily barred with brown on the sides. Juveniles are similar to adults but are unstreaked to lightly streaked, light to brownish buff below, and have more pale secondary coverts (Haug et al. 1993). The Burrowing Owl is the only North American strigiform not exhibiting reversed size dimorphism (Haug et al. 1993).

Distribution

Breeding

In Canada, the historical breeding range of the Burrowing Owl includes se. British Columbia, s. Alberta, s. Saskatchewan, and sw. Manitoba (Fig. 1, Haug et al. 1993, Wellicome and Holroyd 2001). In the United States the historical breeding range includes e. Washington and Oregon, s., c. and e. California, c. and e. Montana, s. Idaho, Utah, Nevada, Arizona, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, w. and c. Kansas, w. and c. Oklahoma, w. Minnesota, nw. Iowa, and most of w. Texas (Fig. 1). The breeding range has contracted primarily on the eastern and northern edges (Wellicome and Holroyd 2001). Anecdotal observations suggest accidental breeding may have occurred in Wisconsin (R. Domalgalski, pers. commun.). Migrants or vagrants have been documented in Louisiana (B. Vermillion, pers. commun.), Missouri (Haug et al. 1993), Arkansas (James and Neal 1986), and Illinois (Illinois Natural History Information Network 2000). The breeding range extends south to c. Mexico (Fig. 1, Fig. 2) (Enriquez-Rocha 1997, Wellicome and Holroyd 2001).

Migration

Little information exists on migration routes and times. Burrowing Owls migrate north during March and April, arriving the first week of May in Saskatchewan (Haug et al. 1993). The majority of Burrowing Owls that breed in Canada and the n. United States are believed to migrate south during September and October.

Burrowing Owls banded in British Columbia, Washington, Oregon, and California migrated southward along the Pacific coast. Burrowing Owls banded in Alberta, Saskatchewan, Manitoba, Montana, and North Dakota migrated southward through Nebraska and Kansas into Texas. One Burrowing Owl from Manitoba was recovered in the Gulf of Mexico. Burrowing Owls banded in Wyoming, South Dakota, Nebraska, Colorado, Kansas, and Oklahoma have been recovered in Arkansas, Oklahoma, Texas, and Mexico. Recoveries indicate that some Burrowing Owls will winter in California and Baja California, Mexico. Burrowing Owls breeding in North and South Dakota are believed to winter in Texas.

Winter

The small number of banding recoveries (n = 27, 1927 through 1990) provides little information regarding wintering areas (Haug et al. 1993). Burrowing Owls winter regularly from Mexico (Fig. 2) to El Salvador and are casual to accidental to w. Panama (AOU 1998). They are recorded on the Christmas Bird Count (CBC) in Arizona, California, New Mexico, Oregon, Texas, and Mexico (Fig. 3; James and Ethier 1989). They will also winter north of these states, particularly in Oklahoma and Kansas, in very low abundance. They will also winter in low abundance in sc. Nevada (Hall et al. *In review*).

Little information exists on Burrowing Owls in Mexico and breeding and wintering areas have not been well described. Based on museum specimens, the Burrowing Owl is the third most common owl species in the country and sixty-three percent of museum specimens (n = 279) from Mexico were collected in the non-breeding season (Enriquez-Rocha 1997); however, it is unlikely that these collections reflect true relative abundance. These collections documented a wide distribution, occurring in 28 of the 32 Mexican states. Non-breeding data were from the Pacific region, some central states, and from the se. Gulf of Mexico (including the Yucatan Peninsula). Both breeding and nonbreeding records document Burrowing Owls in n. Mexico, Baja California, and some states from the Gulf of Mexico.

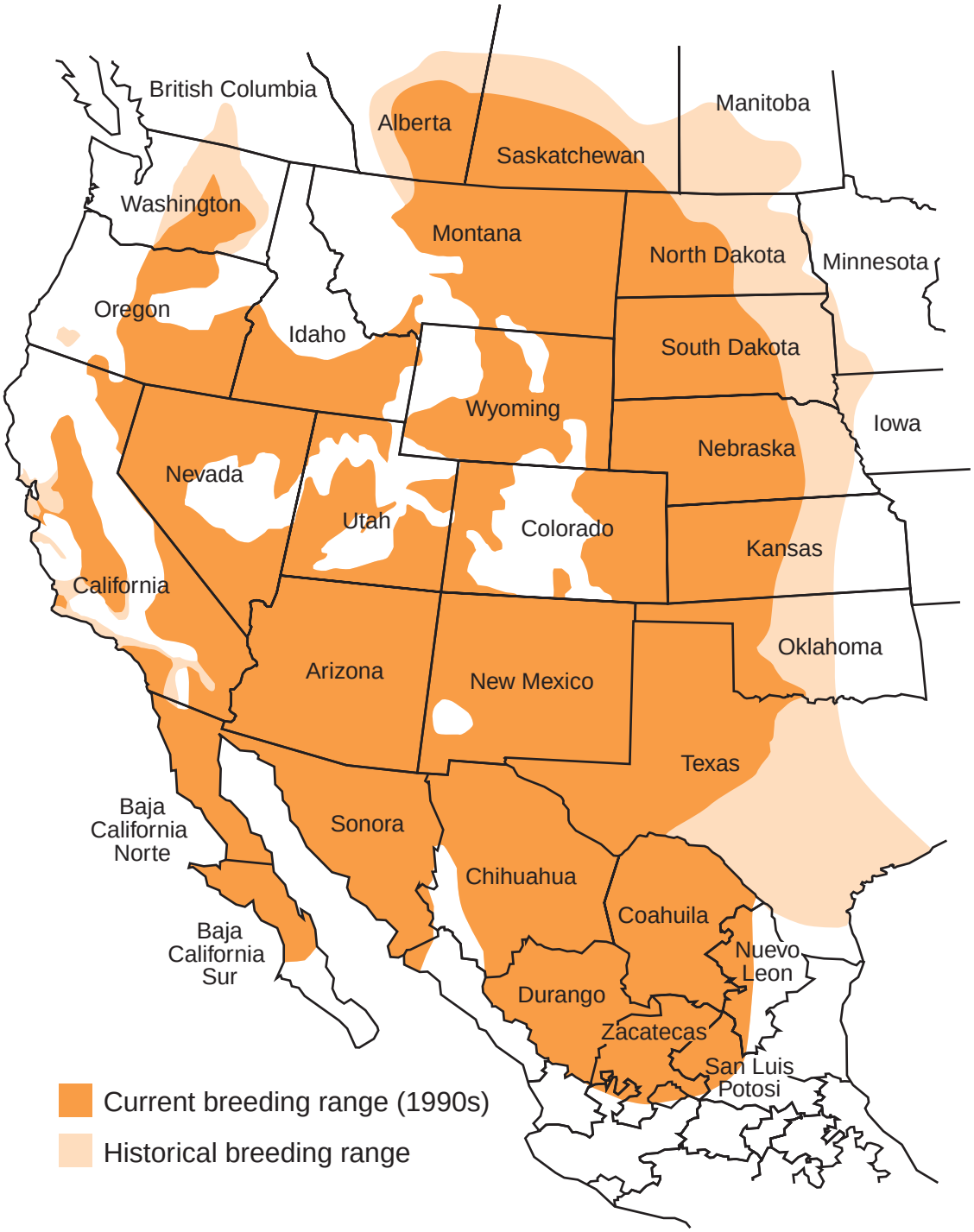

Fig. 1. Current and historical ranges of the Western Burrowing Owl in North America; modified from the Birds of North America species account (Haug et al. 1993), North American Breeding Bird Survey distribution map (Sauer et al. 2001), individual papers from the Proceedings of the Second International Burrowing Owl Symposium (Journal of Raptor Research 35(4) 2001), and personal communications with local experts. Historical range (pre-1970's) taken from Zarn (1974), Wedgwood (1978), and from personal communications with local experts. In states that lacked detailed distributional data, Burrowing Owls were presumed to be absent from areas of forest or rugged mountains. The historical range is unknown for Mexico (from Wellicome and Holroyd 2001).

Fig. 2. Burrowing Owl distribution in Mexico during the breeding (16 April – 15 October) and non-breeding (16 October – 15 April) seasons as determined from 279 museum specimens and literature documentation (Enriquez-Rocha 1997).

Natural History

Breeding

Phenology—Burrowing Owls are generally found on the northern breeding grounds from mid-March through September (Haug et al. 1993). Courtship and pair formation occur in March and April in most areas (Grant 1965, Butts 1973) but may begin as early as late December in California (Thomsen 1971).

Incubation lasts 28-30 days and is performed by the female (Coulombe 1971, Thomsen 1971, Haug et al. 1993). The young begin feathering out at two weeks of age. The young run and forage by four weeks of age and are capable of sustained flight by six weeks. Burrowing Owl families often switch burrows every 10-15 days when the young are three to four weeks old and remain as a loose-knit group until early fall when the young may begin to disperse to nearby burrows (Haug et al. 1993, Dechant et al. 1999).

Diet—Burrowing Owls are opportunistic feeders, primarily taking arthropods, small mammals, birds, amphibians and reptiles (Haug et al. 1993). Seasonal variability in food habits occurs, with vertebrates occurring more commonly in the winter diet and arthropods occurring more frequently in the summer diet (Haug et al. 1993).

Foraging—Burrowing Owls forage in a variety of habitats, including cropland, pasture, prairie dog colonies, fallow fields, and sparsely vegetated areas (Butts and Lewis 1982, Thompson and Anderson 1988, Desmond 1991, Haug et al. 1993, Wellicome 1994). Vegetation >1 m tall may be too tall for Burrowing Owls to locate or catch prey (Haug and Oliphant 1987, 1990; Wellicome 1994).

Productivity—Burrowing Owls are capable of breeding at one year of age. However, some females may not breed the first year after hatching, or may breed away from the natal site the first year after hatching and then return to the natal site in their second year after hatching (Lutz and Plumpton 1999). Second broods have rarely been documented in the Burrowing Owl (Haug et al. 1993). Average clutch size over the range of the species was 6.5 eggs (range 4-12; Haug et al. 1993). In Canada, percent successful reproduction ranged from 45-97% and mean fledging rate ranged from 2.1 to 6.3 young/successful nest (Hjertaas et al. 1995). In British Columbia, 58% (n = 12) of nesting attempts were successful and produced 31 young with a mean brood size of 4.1 ± 1.3 young/successful nest and 2.6 young/attempt (Hjertaas et al. 1995). In Manitoba, average brood size was 5.1 young and overall productivity was 3.4 young/nesting pair (De Smet 1997). In New Mexico, Burrowing Owls produced 3.33 ± 1.49 nestlings and 2.55 ± 1.49 fledglings in human-altered habitats and 1.05 ± 1.23 nestlings and 0.68 ± 0.98 fledglings in natural habitats (Botelho and Arrowood 1996).

Territory—Burrowing Owls generally stay close to the nest burrow during daylight and forage farther from the nest between dusk and dawn (Haug 1985, Haug and Oliphant 1990). Nesting-territory size was 4.8-6.4 ha in Minnesota (n = 2) and 4-6 ha in North Dakota (n = estimated 5-9 pairs) (Grant 1965). Average diurnal ranges of Burrowing Owls in e. Wyoming encompassed 3.5 ha (number of foraging areas not given) (Thompson 1984). Foraging-areas are considerably larger than nesting-areas. In s. Saskatchewan, mean foraging territory size for males ranged from 14 to 481 ha (mean = 241 ha; n = 6) (Haug 1985, Haug and Oliphant 1990). In a heavily cultivated region of s. Saskatchewan, foraging territories for males averaged 35 ha (n = 4) (Sissons et al. 2001).

Aggregations—In nc. Colorado, mean inter-nest distances for Burrowing Owls nesting in black-tailed prairie dog colonies was 101 m (n = 8) (Plumpton 1992). Mean nearest-neighbor distance for Burrowing Owls nesting in 20 American badger excavations in w. Nebraska was 240 m, compared to mean nearest-neighbor distances of 105 m for 118 non-clustered nests in small prairie dog colonies and 125 m for 105 nest clusters in large prairie dog colonies (Desmond 1991, Desmond et al. 1995, Desmond and Savidge 1996). Available excavations may be limiting to Burrowing Owls nesting outside of prairie dog colonies

Within prairie dog colonies, Burrowing Owls have been observed to aggregate their nests into clusters. Mean densities of Burrowing Owls within clusters in larger colonies (≥ 35 ha) were 1.2-1.3 individuals/ha (n = 21). In smaller colonies (<35 ha) with random distributions, mean densities of Burrowing Owls ranged from 1.7 to 5.8 individuals/ha (n = 26). Clustered nest distributions may reduce depredation risks by allowing individuals to alert one another to potential predators (Butts 1973, Desmond 1991, Desmond et al. 1995, Desmond and Savidge 1996).

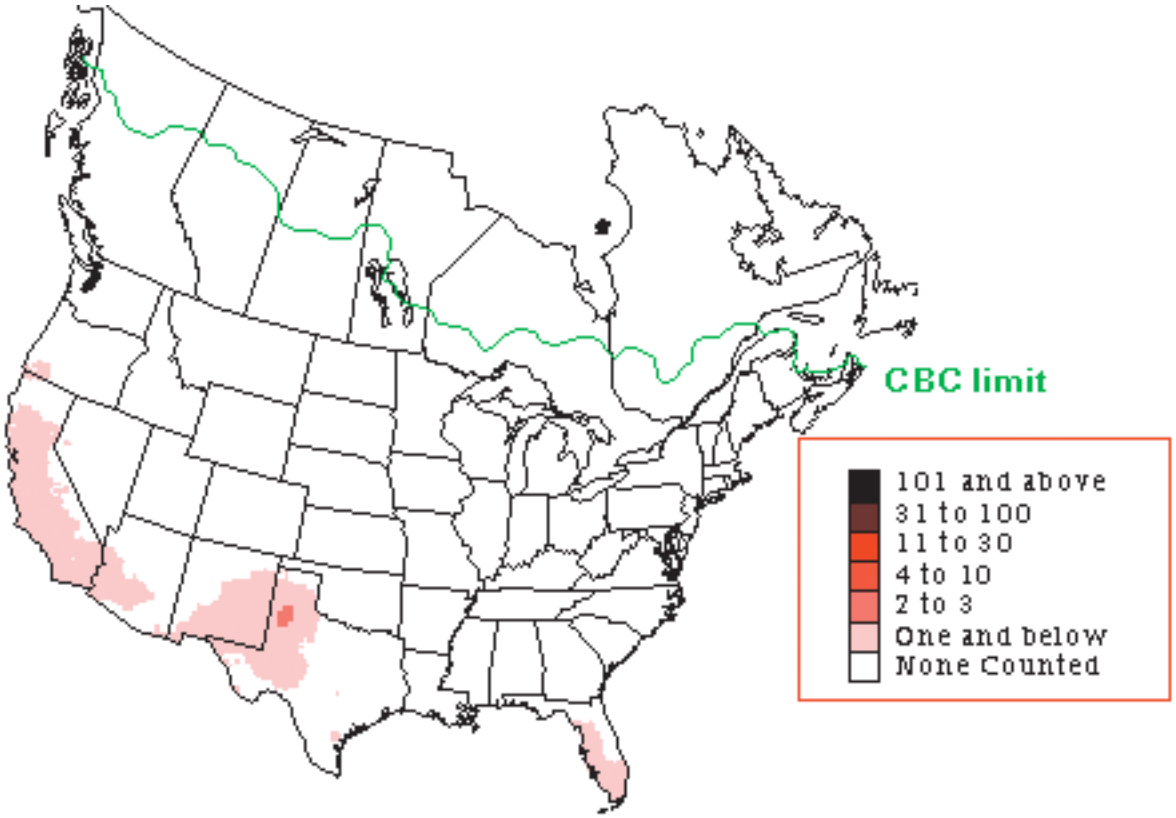

Fig. 3. Winter distribution of Burrowing Owls in the United States from Christmas Bird Count (CBC) data (1966-1989). Shading represents the species relative abundance (birds/100 party hours) averaged for each CBC circle and smoothed over the species distribution (Sauer et al. 1996).

In ne. Colorado, 27 prairie dog colonies with Burrowing Owls ranged in size from 1.9 to 167.6 ha (Hughes 1993). In w. Nebraska, fledging success rates were positively correlated with the size of prairie dog colonies (Desmond 1991).

Mortality and Predation—The annual mortality rate in Oklahoma was estimated at 62% (adults and young combined) (Butts 1973). At two sites in s. Saskatchewan, adult female survival (s) (s = 0.62, n = 12 and s = 1.00, n = 2) was higher than survival for adult males (s = 0.48, n = 11 and s = 0.38, n = 5) or juveniles (s = 0.45, n = 21 and s = 0.48, n = 25) (Clayton and Schmutz 1999).

Predators of Burrowing Owls include badger, domestic cat, weasel, skunk, domestic dog, coyote, Swainson's, Ferruginous, Red-tailed, and Cooper's hawks, Merlin, Prairie, and Peregrine falcons, Great Horned Owl, American Crow (Haug et al. 1993), snakes, bobcats and Northern Harrier (Leupin and Low 2001).

Site and Burrow Fidelity—Individual Burrowing Owls have moderate to high site fidelity to general breeding areas, prairie dog colonies, and even to particular nest burrows. Of 31 adults banded in Colorado in 1990, 39% returned in 1991, whereas only 5% of 369 Burrowing Owls banded as nestlings prior to 1994 returned in one or more years after hatch (Plumpton and Lutz 1993, Lutz and Plumpton 1999). Eight of the remaining 12 returning adults (66%) reused the same prairie dog town as the prior year (Plumpton and Lutz 1993). Adult males and females returned at similar rates (19% and 14%, respectively) (Lutz and Plumpton 1999). Adult males and females nested in formerly used sites at similar rates (75% and 63%, respectively). In Albuquerque, New Mexico, all returning males selected the same burrow they had previously inhabited unless the burrow had been destroyed (n = 9, Martin 1973). In Manitoba, 7% of failed nests (n = 57) were reused in consecutive years but 23% (n = 122) of successful nests were reused (De Smet 1997). Burrow fidelity has been reported in some areas; however, more frequently, Burrowing Owls reuse traditional nesting areas without necessarily using the same burrow (Haug et al. 1993, Dechant et al. 1999). Burrow and nest sites are re-used at a higher rate if the bird has reproduced successfully during the previous year (Haug et al. 1993).

Habitat

Breeding

Burrowing Owl nesting habitat consists of open areas with mammal burrows. They use a wide variety of arid and semi-arid environments, with well-drained, level to gently sloping areas characterized by sparse vegetation and bare ground (Haug et al. 1993, Dechant et al. 1999). Breeding habitats include native prairie, tame pasture, hayland, fallow fields, road and railway rights-of-way, and urban habitats (e.g., campuses, airports, and golf courses) (Dechant et al. 1999). Burrowing Owls do not occupy all apparently available habitat (i.e., prairie dog or ground squirrel colonies). Unused colonies have been documented in virtually all states within the current range of the Burrowing Owl.

Burrowing Owls require a mammal burrow or natural cavity surrounded by sparse vegetation. Burrow availability is often limiting in areas lacking colonial burrowing rodents (Desmond and Savidge 1996). Burrowing Owls frequently use burrows of black-tailed prairie dogs. They nest less commonly in the burrows of Douglas' ground squirrels, white-tailed prairie dogs, Gunnison's prairie dogs, yellow-bellied marmots, woodchucks, skunks, foxes, coyotes, and nine-banded armadillos (Dechant et al. 1999). Where mammal burrows are scarce, Burrowing Owls have been found nesting in natural rock and lava cavities (Gleason 1978, Gleason and Johnson 1985, Rich 1986).

Burrowing Owls may use "satellite" or non-nesting burrows, moving chicks at 10-14 days presumably to reduce risk of predation (Desmond and Savidge 1998) and possibly to avoid nest parasites (Dechant et al. 1999). Successful nests in Nebraska had more active burrows within 75 m of the nest burrow than unsuccessful nests (Desmond and Savidge 1999). Observations made at 15 burrow sites by James and Seabloom (1968) revealed that family units in sw. North Dakota used from one to three satellite burrows, although a few family units used from two to ten satellite burrows. In e. Wyoming, most (actual number not given) nesting areas contained between two and 11 available burrows (Thompson 1984). Three Burrowing Owl families in Iowa used from one to five satellite burrows (Scott 1940). In Oklahoma, black-tailed prairie dog colonies appeared to be the only habitat with a sufficient density of burrows to provide satellite burrows for Burrowing Owls (Butts and Lewis 1982).

Migration

No information is available on migration habitats. They are presumed to be similar to breeding habitats (Haug et al. 1993).

Winter

Little is known about wintering habitat requirements beyond what the species uses during the breeding season, but there seems to be increased use of agricultural fields with culverts in some areas (Haug et al. 1993, W. Howe, pers. commun.). In Louisiana, in winter, Burrowing Owls are typically found in dune vegetation or near woody debris on beaches, in pastures, and in agricultural fields (B. Vermillion, pers. commun.). In sc. Nevada, burrows used in winter were the same as those used during the breeding season (Hall et al. *In review*).

Populations

Population Estimates and Trends

Breeding Bird Survey—The Breeding Bird Survey (BBS) revealed a mixture of population trends throughout the Burrowing Owl breeding range in North America (Table 2, Fig. 4) (Sauer et al. 2002). BBS trends for Burrowing Owls are largely limited by small sample sizes and the species is not adequately sampled over a large part of their breeding range. Trends in nearly all regions are limited by important or potential deficiencies (Sauer et al. 2002). However, when taken as a whole, generally declining populations are present in the northern half of the Great Plains, and generally increasing populations are present in the northwest interior and in some southwestern deserts of the United States (Table 2, Fig. 4).

Christmas Bird Count—Burrowing Owl abundance is poorly monitored by the CBC. Most Burrowing Owls from the Great Plains winter in Mexico where CBC coverage is poor. On the Gulf Coast of Texas, wintering Burrowing Owls are difficult to detect and samples sizes are small. The effort to locate wintering Burrowing Owls has increased in recent years (G. Holroyd, pers. commun.). A significant decreasing trend was observed only in California; trends for other areas were non-significant (Table 3) (Sauer et al. 1996). James and Ethier (1989) detected stable populations in most wintering areas in New Mexico, Louisiana, and Mexico for 1955-85. There were no significant changes in Arizona, New Mexico, Texas, and Louisiana from 1954-86, or in Mexico between 1974 and 1985 (James and Ethier 1989)

Other Surveys, United States—Surveys in California in 1986-91 found population decreases of 23-52% in the number of breeding groups and 12-27% in the number of breeding pairs of owls (DeSante et al. 1997). Populations in w. Nebraska declined 58% (91 to 38 nesting pairs) between 1990-1996 (Desmond and Savidge 1998). Populations in New Mexico have exhibited mixed trends: stable or increasing populations were associated with the presence of suitable habitat and increased precipitation and food availability while decreasing populations were associated with loss of suitable habitat (Arrowood et al. 2001). In Wyoming, only 11% of 86 historical sites were occupied in 1998; however, the importance of this finding is uncertain due to the tendency for Burrowing Owl colonies to move (Korfanta et al. 2001). The Wyoming Game and Fish Department's Wildlife Observation System showed populations generally increasing between 1974-80 and then decreasing between 1981-97 (Korfanta et al. 2001). In North Dakota, Burrowing Owls have disappeared from the eastern third of the state and is uncommon to rare in the best habitats north and east of the Missouri River (Murphy et al. 2001). In sw. North Dakota the current population trend is not clear, but is probably closely tied to populations of prairie dogs (Murphy et al. 2001). Based on questionnaires, literature searches, personal contacts and field observations, Brown (2001) concluded that Burrowing Owls are widespread but uncommon in Arizona. In Oklahoma there are an estimated 800-1000 breeding Burrowing Owls, restricted primarily to the panhandle of the state (Sheffield and Howery 2001). In a survey of National Grasslands, Sidle et al. (2001) found higher occupancy of active prairie dog towns in the southern Great Plains (93%) than in the northern Great Plains (59%).

Table 2. North American Breeding Bird Survey trends, significance level (P), sample size (n) and 95% confidence intervals (CI) for the Burrowing Owl during three different survey periods (Sauer et al. 2002).

	1966–2001					1966–1979			1980–2001		
Area (data credibility)[a]	Trend[b]	P	n	95%	CI	Trend[b]	P	n	Trend[b]	P	n
State/Province											
Alberta (R)	–8.5	0.42	6	–27.2	10.1	51.8	0.26	3	3.9	0.93	3
Arizona (Y)	7.7	0.65	9	–23.8	39.20	—	—	—	–3.1	0.88	8
California (B)	5.9	0.01	32	1.9	9.8	–0.9	0.92	19	5.4	0.03	24
Colorado (Y)	–4.0	0.48	38	–14.9	6.9	–7.8	0.40	9	2.7	0.57	36
Idaho (R)	19.1	0.07	9	1.4	36.8	39.2	0.03	3	28.4	0.06	9
Kansas (Y)	–1.1	0.80	11	–9.1	7.0	10.8	0.34	8	11.7	0.69	8
Montana (R)	–12.6	0.11	10	–26.5	1.3	—	—	—	–14.8	0.19	9
Nebraska (Y)	6.5	0.57	13	–14.9	27.9	33.9	0.11	8	3.8	0.72	8
Nevada (Y)	10.9	0.30	9	–8.2	30.1	0.9	0.97	3	12.1	0.14	6
New Mexico (Y)	0.7	0.85	37	–7.0	8.4	-3.9	0.03	6	2.2	0.77	35
North Dakota (R)	–3.2	0.44	13	–10.9	4.6	19.6	0.15	7	-15.8	0.00	9
Oklahoma (R)	-11.5	0.00	10	-14.1	–8.8	14.2	0.37	6	–4.5	0.34	8
Oregon (Y)	3.8	0.63	11	–11.0	18.5	–14.2	0.66	5	15.5	0.20	8
Saskatchewan (R)	-26.0	0.04	2	-29.3	–22.7	—	—	—	—	—	—
South Dakota (Y)	–7.2	0.16	19	–16.9	2.5	5.2	0.52	14	-11.4	0.08	10
Texas (Y)	–1.9	0.39	28	–6.3	2.4	8.4	0.27	14	–5.2	0.26	24
Utah (Y)	0.9	0.89	14	–11.3	13.0	—	—	—	–6.6	0.14	14
Washington (Y)	–7.8	0.60	7	–35.2	19.7	—	—	—	–19.4	0.20	6
Wyoming (Y)	-23.7	0.04	11	-42.3	–5.2	10.5	0.76	2	5.9	0.53	9
Physiographic strata											
South Texas Brushlands	–3.9	0.46	2	–10.9	3.0	—	—	—	—	—	—
High Plains Border (Y)	5.7	0.45	17	–8.5	19.8	3.1	0.84	11	20.0	0.55	11
High Plains (Y)	–4.0	0.43	50	–14.0	6.0	–1.9	0.85	17	2.4	0.61	46
Drift Prairie (Y)	-26.0	0.01	8	-37.7	–14.3	–13.5	0.40	7	—	—	—

Table 2. Continued

Area (data credibility)[a]	1966–2001					1966–1979			1980–2001		
	Trend[b]	P	n	95%	CI	Trend[b]	P	n	Trend[b]	P	n
Glaciated Missouri Plateau (R)	-11.0	0.04	15	-20.0	–2.0	23.0	0.12	6	–12.8	0.16	10
Great Plain Roughlands (R)	–2.6	0.40	30	–8.6	3.4	16.9	0.03	12	–10.4	0.04	22
Rolling Red Plains (Y)	–0.9	0.77	7	–7.0	5.1	–2.7	0.81	3	1.1	0.75	7
Staked Plains (B)	–2.3	0.39	21	–7.6	2.9	10.3	0.27	10	–4.3	0.38	19
Chihuahuan Desert (Y)	1.8	0.80	22	–12.2	15.8	43.4	0.33	7	–1.1	0.90	20
Great Basin Deserts (Y)	7.3	0.55	8	–15.3	29.9	—	—	—	–1.9	0.83	8
Mexican Highlands (Y)	7.1	0.42	2	–3.6	17.8	—	—	—	–8.1	0.55	2
Sonoran Desert (Y)	6.6	0.03	10	1.6	11.5	–2.6	0.84	5	5.7	0.11	8
Mojave Desert (Y)	–1.4	0.84	6	–14.4	11.6	20.6	0.36	4	–20.2	0.33	4
Wyoming Basin (Y)	-31.0	0.07	4	-53.6	–8.4	10.5	0.76	2	29.0	0.60	2
Intermountain Grassland (Y)	2.8	0.57	27	–6.7	12.3	—	—	—	6.8	0.03	23
Basin and Range (Y)	9.9	0.30	13	–7.8	27.6	0.7	0.96	3	5.8	0.43	10
Columbia Plateau (R)	12.8	0.04	28	1.1	24.4	33.0	0.00	9	21.6	0.01	24
Central Valley (Y)	2.6	0.41	15	–3.3	8.5	–9.6	0.65	9	1.4	0.76	12
USFWS Regions											
Region 1 (Y)	7.1	0.00	68	3.5	10.7	5.7	0.41	31	7.2	0.00	53
Region 2 (Y)	–1.2	0.45	84	–4.4	2.0	–0.5	0.72	29	–1.8	0.63	75
Region 6 (Y)	–4.4	0.29	129	–12.6	3.7	–0.7	0.92	48	–0.2	0.95	103
Country											
Canada (R)	-12.1	0.01	8	-18.4	–5.9	23.8	0.36	4	-18.7	0.02	4
United States (Y)	–1.5	0.57	291	–6.5	3.6	0.0	0.99	113	1.6	0.40	237
Survey-wide (Y)	-1.5	0.57	299	–6.5	3.6	0.2	0.96	117	1.5	0.41	241

[a]–Data credibility measure. (R) = RED: Data with an important deficiency. (Y) = Yellow: Data with a potential deficiency. (B) = BLUE: Data with at least 14 samples in the long term, of moderate precision, and of moderate abundance on routes.

[b]–Mean percent change per year

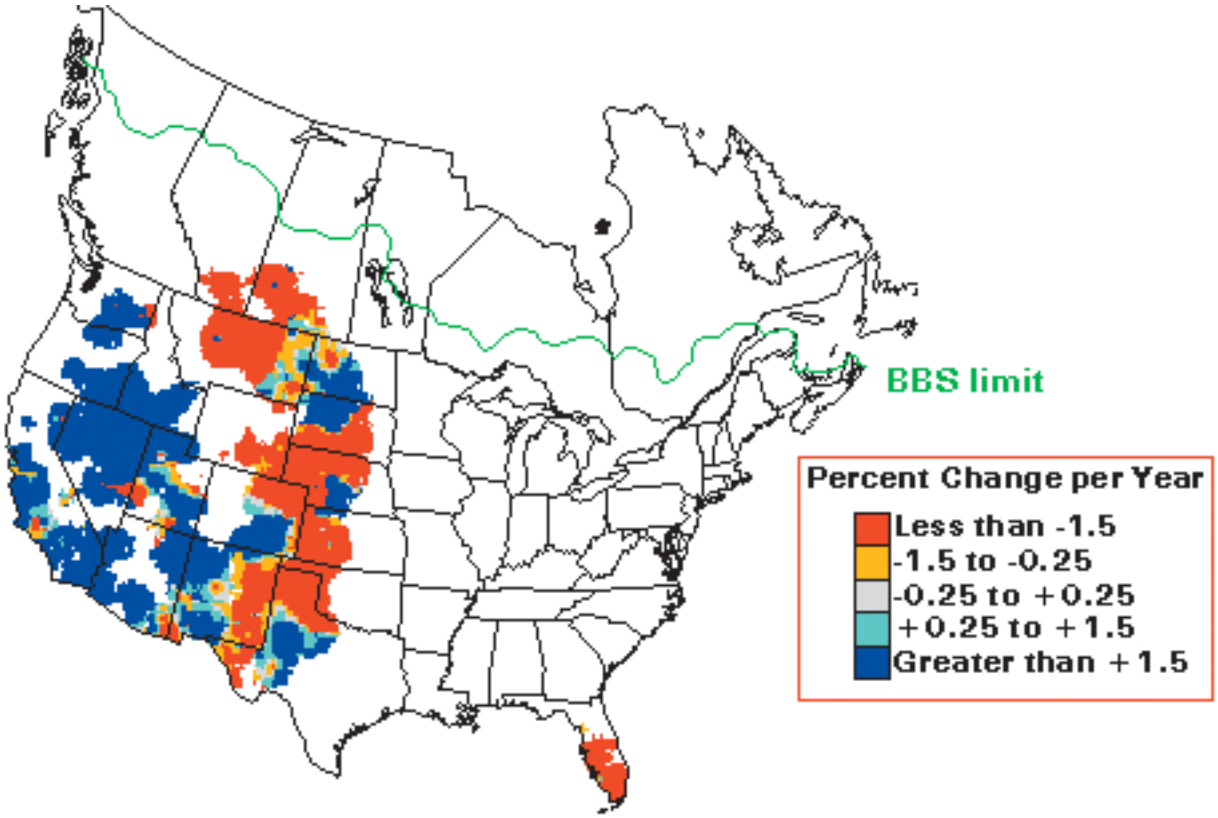

Fig. 4. Breeding Bird Survey trends for Burrowing Owls in the United States and Canada (1966-96, Sauer et al. 2002). These trends do not necessarily reflect statistical significance (see Table 2).

Table 3. Christmas Bird Count trends, sample sizes (n), 95% confidence intervals (CI), significance levels (P), and relative abundance (RA) for the Burrowing Owl in areas with sufficient data for analysis, 1959-1988 (Sauer et al. 1996).

State	Trend[a]	n	95%	CI	P	RA[b]
Arizona	0.2	16	–1.7	2.1	>0.10	0.10
California	–1.2	97	–2.3	–0.1	≤ 0.05	0.29
Texas	1.2	52	–1.3	3.8	>0.10	0.23
Survey-wide	0.2	240	–1.5	1.9	>0.10	0.13

[a]–Mean percent change per year.

[b]–Mean number of birds per 100 party hours.

Field-based, quantitative population estimates do not exist for most states (Table 4). However, James and Espie (1997) submitted surveys to state biologists in 1992 to determine approximate total breeding populations of Burrowing Owls, based on expert opinion and not necessarily based on field investigations of true population levels. Additional population estimates have been made for California, Colorado, Kansas, Montana, and Oklahoma (Table 4).

Other Surveys, Canada—Burrowing Owls declined in Canada from the mid-1970s through at least the early 1990s (Kirk et al. 1994/95) with up to 50% declines in some areas (Dundas and Jensen 1994/95). No complete censuses have been conducted in Canada, but a variety of studies show widespread range contraction and declining density (Hjertaas et al. 1995). Burrowing Owls declined in Alberta, Saskatchewan, and Manitoba at over 20% per year over the past decade (Wellicome and Holroyd 2001). Skeel et al. (2001) documented a 95% decline in Burrowing Owls reported by landowners in Saskatchewan for an average annual decline of 21.5% from 1998-2000. They are effectively extirpated from Manitoba with one pair nesting every second year since 1999 (K. De Smet, pers. commun.). Shyry et al. (2001) reported a significant decrease in the density of Burrowing Owl nests near Hannah, Alberta between 1991 and 2000. The density of nests near Brooks, Alberta did not significantly change from 1991 to 2000.

Based on a survey of biologists, the total breeding population for Canada was estimated as approximately 2,000-20,000 pairs, with the major populations occurring in Alberta and Saskatchewan (Table 4) (James and Espie 1997). In Alberta, the population estimate dropped from 1,500 to 800 birds (47% decline) from 1978-1990 (Wellicome 1997).

Other Surveys, Mexico—Burrowing Owls breed in much of Mexico but the population is unknown. In nw. Chihuahua they occurred on 62% (n = 34) of surveyed prairie dog colonies for a total of 87 owls. Numbers ranged from 0-16 owls/prairie dog colony and 0.00-7.69 owls/ha (VerCauteren et al. *In review*). Two BBS routes in the same area of nw. Chihuahua average 19 and 32 Burrowing Owls per route between 1998 and 2001. As many as 26 adults were visible from a single point on one occasion (W. Howe, pers. commun.).

Densities

In Nebraska, total numbers of Burrowing Owls increased, but density decreased with increasing size of prairie dog towns (Desmond and Savidge 1996). In large (>35 ha) prairie dog towns, distribution was found to be less dense but clumped, and clumping was not related to burrow availability (Desmond et al. 1995). Burrowing Owl density in black-tailed prairie dog colonies was negatively correlated with the density of inactive burrows (Desmond 1991). The density of Burrowing Owls in prairie dog colonies in ne. Colorado was positively related to the percentage of active burrows (Hughes 1993). At least 50% of the burrows were active in 26 of 27 occupied colonies. For prairie dog colonies with over 90% active burrows, mean density was 2.85 owls/ha, and for those with 70-80% active burrows, mean density was 0.57 owls/ha.

Changes in Breeding Season Distribution

United States—The Burrowing Owl has been nearly extirpated from all former breeding range in w. Minnesota, most areas east of the Missouri River in North Dakota, e. Nebraska and Oklahoma, e. and c. Kansas, in large portions of the San Francisco Bay area in California, and in the Rogue Valley in sw. Oregon (DeSante et al. 1997, Martell et al. 2001, Murphy et al. 2001, Sheffield and Howery 2001, Wellicome and Holroyd 2001).

In California, the Burrowing Owl has been extirpated as a breeding species during the last 10-15 years from approximately 8% of its former range (J. Barclay, pers. commun.). They were apparently extirpated as breeding birds during the past decade from Sonoma, Marin, Santa Cruz, and Napa counties, and only one breeding pair apparently still existed in San Mateo County in 1991. The population around the north end of San Francisco, San Pablo, and Suisun Bays was also reduced to a very small remnant. Breeding in central California has been reduced to only three isolated populations: a moderate but declining population of about 720 pairs in the Central Valley; about 143 pairs in the lowlands around the southern arm of San Francisco Bay between Alameda and Redwood City; and a very small, isolated population of about 10 pairs in the Livermore area (DeSante et al. 1997).

In a comparison with historical distributions, Murphy et al. (2001) found that Burrowing Owls were greatly reduced or completely extirpated from nw. and c. North Dakota. Declines in Burrowing Owls may be related to loss of grassland habitat and burrowing rodents in the state (Murphy et al. 2001).

Table 4. Burrowing Owl population estimates for states, provinces, and countries. James and Espie (1997) surveyed state/provincial biologists in 1992 to determine approximate total breeding populations. Other populations estimates are presented only for statewide/province-wide estimates; additional local population estimates can be found in Appendix A: State Summaries of Burrowing Owl Status.

Area	James and Espie (1997)[a]	Other statewide/province-wide estimates (source)
United States	20,000–200,000	
Arizona	100–1,000	None
California	1,000–10,000	9,266 pairs (1991–1993; DeSante et al., unpubl.)
Colorado	1,000–10,000	15,796–20,408 individuals (Hanni 2001)[b]
Idaho	1,000–10,000	None
Iowa	<10	None
Kansas	100–1,000	1,000–10,000 pairs (W. Busby, pers. commun.)
Minnesota	<10	None
Montana	100–1,000	644 + 114 pairs (Atkinson 2000)[c] 300 pairs (Holroyd and Wellicome 1997)
Nebraska	100–1,000	None
Nevada	1,000–10,000	None
New Mexico	1,000–10,000	None
North Dakota	100–1,000	None
Oklahoma	100–1,000	800–1,000 individuals (Sheffield and Howery 2001)
Oregon	1,000–10,000	None
South Dakota	100–1,000	None
Texas	>10,000	None
Utah	1,000–10,000	None
Washington	100–1,000	None
Wyoming	1,000–10,000	None
Canada	2,000–20,000	
Alberta	1,000–10,000	800 birds (in 1990; Wellicome 1997)
British Columbia	<10	<10 pairs (Leupin and Low 2001)
Manitoba	10–100	10–20 pairs (K. De Smet, pers. commun.)
Saskatchewan	1,000–10,000	None
Mexico	Unknown	

[a]–numbers of breeding pairs

[b]–estimates are only for e. Colorado, which represents the majority of breeding habitat in the state.

[c]–estimate is based on surveys of known prairie dog colonies.

In w. Minnesota, Burrowing Owls were considered common in the 1920's; however, significant declines had occurred by the 1960's (Martell et al. 2001). During 1965-1985 only 10 breeding records were recorded. A reintroduction program was attempted from 1986-1990; however no successful nesting has been recorded since 1992.

Canada—The Burrowing Owl has been extirpated from the northern portions of the range in Saskatchewan and Alberta, and all former range in Manitoba and British Columbia (Wellicome 1997, Shyry et al. 2001, Wellicome and Holroyd 2001). Extirpation from all of Canada may occur within a few decades (Wellicome and Haug 1995).

Mexico—Unknown.

Re-occupancy Rates

Of 292 nest burrows that had been occupied in some previous year (1976-83), 39.4% were re-occupied in Idaho in some subsequent year (up to seven years later) (Rich 1984). Burrows in rock outcrops were re-used 48.9% of the time (n = 113) compared to 31.4% (n = 159) for nests in soil mounds. Outcrop sites also were used more often in consecutive years; 23 were used for two years, and 12 were used for three consecutive years. Fifteen mound nests were used for two years, five were used for three years, and one was used four consecutive years. Greater reuse of outcrop sites could be related to their stability as no burrows in outcrops were destroyed. However, nests in old badger burrows were destroyed by plowing, cattle trampling, drifting sand, dredging, and other unknown causes (Rich 1984).

In Colorado, 90% of 18 prairie dog towns and 25% of four nesting burrows were reused between 1990 and 1991 (Plumpton and Lutz 1993). In sc. Idaho in 1994-95, 50% (n = 30) of individual burrows were reused in a subsequent year (Belthoff and King 1997). Of 10 burrows that fledged young in 1994, 70% were reused at least once. Conversely, burrows tended to remain unoccupied in years following nest failures; six nests remained unused in 1995 and 1996 after failing in 1994 (Belthoff and King 1997). In sw. Idaho, low nest reoccupancy was documented (11% from 1991 to 1994, and 42% from 1993 to 1994) (Lehman et al. 1998).

Korfanta et al. (2001) estimated 17% reoccupancy (range: 8-28%) of historic breeding sites in e. Wyoming. The average age of sites reoccupied by Burrowing Owls in 1998 (12.4 years; n = 10) was not significantly different from the average age of all historic observations (13.1 years, n = 86) (Korfanta et al. 2001). In 1999 and 2000, the Rocky Mountain Bird Observatory (RMBO) conducted extensive roadside surveys of potential Burrowing Owl habitat in se. Wyoming. In 1999, they located 71 colonies of Burrowing Owls, totaling 180 individuals (Hutchings et al. 1999). In 2000, they located 107 sites with Burrowing Owls for a total of 575 owls; site reoccupancy was 66% between 1999 and 2000 (T. VerCauteren, pers. commun.).

Monitoring Activities

Range-wide Surveys

There are no ongoing or standardized large-scale monitoring programs that target Burrowing Owls in the United States or Canada other than the BBS and CBC. These surveys do not adequately sample this species throughout its range (Sauer et al. 2002). There are no range-wide monitoring programs in Mexico.

Local Surveys

In Wyoming, Burrowing Owls are voluntarily reported by state and federal biologists, researchers, Audubon Society members, and the general public to the Wyoming Game and Fish Departments (WGFD) Wildlife Observation System (WOS) (Korfanta et al. 2001).

The New Mexico Burrowing Owl Working Group (NMBOWG) has initiated a volunteer monitoring system to collect data on Burrowing Owl populations in the state (C. Finley, pers. commun.).

In e. Colorado, w. Nebraska, w. Kansas, and e. Wyoming, RMBO conducts monitoring of prairie birds, including Burrowing Owls. The objectives are to investigate trends in population and distribution, and to determine local densities of birds (T. VerCauteren, pers. commun.).

Manitoba monitors Burrowing Owl populations through its Threatened Grassland Birds Project (Dundas and Jensen 1994/1995). Monitoring in Saskatchewan and Alberta is conducted through Operation Burrowing Owl (Dundas and Jensen 1994/1995).

Proposed Protocols and Surveys

In California, the California Burrowing Owl Consortium has developed Survey Protocol and Mitigation Guidelines to survey Burrowing Owl populations and to evaluate impacts from development projects. The following web site has the survey protocol and mitigation guidelines (http://www2.ucsc.edu/scpbrg/section1.htm).

In Wyoming, the Arizona Coop. Fish & Wildlife Research Unit conducted standardized population surveys for nesting Burrowing Owls on public lands. The objectives of this project were to determine the factors that influence burrow occupancy, nesting productivity, burrow fidelity, natal recruitment, conduct an annual survival in Wyoming, and to provide a paired comparison between tape and passive surveys in number of birds detected (C. Conway, pers. commun.).

Threats

Habitat: Breeding

Habitat Loss and Fragmentation—Primary threats across the North American range of the Burrowing Owl are habitat loss and fragmentation primarily due to intensive agricultural and urban development, and habitat degradation due to declines in populations of colonial burrowing mammals (Grant 1965, Konrad and Gilmer 1984, Ratcliff 1986, Haug et al. 1993, Dundas and Jensen 1994/95, Rodriguez-Estrella et al. 1998, Sheffield 1997*a*, Dechant et al. 1999). The dramatic reduction of prairie habitat in the United States has been linked to reduction of Burrowing Owl populations (Sheffield 1997*a*).

Fragmentation and isolation may be threats to small and localized populations. Fragmentation of nesting habitat may reduce the opportunity for unpaired owls to find mates (Sheffield 1997*a*). Fragmentation of grassland habitat in Canada has increased the populations of predators that prey on Burrowing Owls (Wellicome and Haug 1995). In contrast, in w. Nebraska landscapes dominated by croplands, Burrowing Owls had higher fledging success (mean of 3.23 fledglings/pair) than owls nesting in rangeland landscapes (mean of 1.49 fledglings/pair) (Desmond 1991). Larger home ranges have been observed in fragmented landscapes (Warnock and James 1997). Higher post-fledging mortality from vehicle collisions occurred in an agricultural landscape with >90% of land area under cultivation compared to an unfragmented rangeland with <20% cultivation (Clayton and Schmutz 1997).

Burrows—Elimination of burrowing rodents through control programs has been identified as the primary factor in the recent and historical decline of Burrowing Owl populations (Butts and Lewis 1982; Pezzolesi 1994; Desmond and Savidge 1996, 1998, 1999; Toombs 1997; Dechant et al. 1999; Desmond et al. 2000; Murphy et al. 2001). Some black-tailed prairie dog colonies have become so isolated through fragmentation that re-population through natural dispersal and colonization is difficult (Benedict et al. 1996). Declines of Burrowing Owl populations in North Dakota north and east of the Missouri River may be related to declines in Richardson's ground squirrel populations (Murphy et al 2001). In w. Nebraska, a 63% decline in Burrowing Owl numbers over a seven year period in 17 black-tailed prairie dog colonies was associated with declines in black-tailed prairie dog densities due to population control activities (Desmond et al. 2000). Burrow habitat in abandoned prairie dog towns becomes unsuitable for Burrowing Owls within one to three years (Butts 1973).

Grazing—Burrowing Owls prefer grasslands moderately or heavily grazed by cattle or prairie dogs (James and Seabloom 1968, Butts 1973, Wedgwood 1976, MacCracken et al. 1985, Bock et al. 1993). The response of Burrowing Owls to cattle grazing is related to the effects of prairie dog grazing and must be evaluated in conjunction with the presence of previously excavated burrows. In sc. Saskatchewan, heavily grazed, poor soils were used frequently by Burrowing Owls, and moderate to heavy grazing on good soils reduced lush vegetative growth and provided suitable habitat (Wedgwood 1976). Burrowing Owls in Saskatchewan and Alberta nested in pastures with shorter vegetation than occurred in randomly chosen pastures, and preferred native or tame pastures over cultivated land (Clayton 1997). In the Oklahoma Panhandle, Butts (1973) suggested that grazing of taller grasses may attract ground squirrels and prairie dogs, thus increasing burrow availability. In North Dakota, Burrowing Owls nested in moderately or heavily grazed mixed-grass pastures, but not in hayed or lightly grazed mixed-grass (Kantrud 1981). Declines in Burrowing Owl populations in North Dakota north and east of the Missouri River may be due to a reduction over the past 20 years in the amount of sheep grazing that occurs in the region (Murphy et al. 2001). In the Platte River Valley of Nebraska, preferred nest sites were in heavily grazed or mowed native grasslands (Faanes and Lingle 1995). Optimal breeding habitat in portions of Colorado, Montana, Nebraska, North Dakota, South Dakota, and Wyoming occurred in heavily grazed areas with aridic ustoll soils and grazed areas with typic boroll soils (Kantrud and Kologiski 1982).

Burning—Little information exists on the response of Burrowing Owls to burning. In nc. Oregon, they were observed nesting in badger excavations in areas that recently had been burned, suggesting that fire may create suitable habitat by reducing vegetation around potential nest sites (Green and Anthony 1989). In nw. North Dakota, post-European settlement fire suppression may be responsible for the development of a taller, denser, and woodier plant community than previously existed (Murphy 1993), and these vegetational shifts may have been responsible for the local extirpation of Burrowing Owls.

Mowing—In nc. Colorado, mowing has been used to control growth of grasses and woody vegetation in areas where black-tailed prairie dogs have been eliminated. Abandoned black-tailed prairie dog colonies that were not mowed were not used by owls (Plumpton 1992). Mowing also may enhance the attractiveness of nest sites for Burrowing Owls returning from the wintering grounds (Plumpton and Lutz 1993). Mowing throughout the breeding season apparently does not adversely affect nesting Burrowing Owls (Dechant et al. 1999).

Habitat: Winter

Threats to Burrowing Owl wintering habitats are largely the same as those to Burrowing Owl breeding habitats; however, documentation and research addressing these threats is much more limited for wintering habitats. VerCauteren et al. (*In review*) reported poisoning of prairie dogs, urban development, and agriculture as the primary threats to prairie dogs and Burrowing Owl habitat in winter. Approximately 50% of the prairie dog colonies resurveyed by VerCauteren et al. (*In review*) were extant, although many of the remaining towns were greatly fragmented.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Not known to be a threat. Burrowing Owls have been trapped and sold in Mexico (G. Holroyd, pers. commun.), although the extent of this practice is unknown.

Predation and Disease

Predation—Cultivation and fragmentation of grassland habitat in Canada have allowed populations of predators that prey on Burrowing Owls to increase (Wellicome and Haug 1995). Burrowing Owls are usually tolerant of human activity but vulnerable to predation by dogs and cats. In Minnesota, high predation rates played a role in the failure of four years of reintroduction efforts (Martell et al. 2001). On Santa Barbara Island, California, a small population of Burrowing Owls (approx. 20) were extirpated by Barn Owls in 1984 and again in 1987 following crashes in the deer mouse population (Drost and McCluskey 1992).

Disease—Not known to be a direct threat (see *Indirect Effects of Disease*, below).

Inadequacy of Existing Regulatory Mechanisms

Burrowing Owls are protected by the Migratory Bird Treaty Act (1918) in the United States and Mexico, which makes it illegal to take, possess, buy, sell, purchase, or barter any migratory bird listed in 50 C.F.R., Part 10. In the United States, the Burrowing Owl was listed as an ESA Category 2 Candidate species until February 1996, when the Category 2 designation was discontinued. Burrowing Owls are listed as Endangered in Canada and as Threatened in Mexico.

Other Natural or Manmade Factors

Disturbance at Nest and Roost Sites—Not known to be a threat.

Ingestion of Plastics, Lead, Etc.—Not known to be a threat.

Collisions with Stationary/Moving Structures—Little information. No Burrowing Owl mortality due to collisions with communication towers was documented (Shire et al. 2000). Burrowing Owls may be susceptible to collisions with vehicles because Burrowing Owls often fly low to the ground. Collisions with vehicles have been cited as a significant source of mortality by several researchers (Haug et al. 1993). Military aircraft have been involved with strikes to Burrowing Owls in e. New Mexico (W. Howe, pers. commun.). Gillihan (2000) documented a Burrowing Owl killed by a collision with a barbed wire fence.

Shooting, Trapping, and Hunting—Illegal shooting may be responsible for substantial mortality in some areas, accounting for 10 of 15 deaths in Oklahoma (Butts 1973). Other studies, however, have not mentioned shooting as a source of mortality (Coulombe 1971, Thomsen 1971, Martin 1973).

Population Size and Isolation—Johnson (1997) reported that a population of Burrowing Owls in California showed a higher genetic similarity than did a collection of geographically separated Burrowing Owl populations. This suggested that some potentially detrimental inbreeding was occurring in the population (Johnson 1997). However, Korfanta (2001) found that populations of Burrowing Owls were genetically indistinguishable, suggesting a high degree of population connectivity and dispersal among populations.

Introduced Species—Not known to be a threat.

Indirect Effects of Disease—Burrowing Owl populations can be negatively impacted, and even eliminated, by epizootics of sylvatic plague that affect prairie dog colonies and thus reduce available habitat for Burrowing Owls (Dechant et al. 1999).

Pesticides and Other Contaminants/Toxics

Based on a survey of biologists, eleven states and provinces reported pesticides as a potential factor in declines (James and Espie 1997). Use of insecticides and rodenticides in Burrowing Owl habitat can be especially detrimental. Pesticides not only reduce the food supply and the number of burrowing mammals, but these chemicals also may be toxic to Burrowing Owls (Ratcliff 1986, James and Fox 1987, James et al. 1990, Baril 1993, PMRA 1995, Hjertaas 1997*a*, Sheffield 1997*b*). Burrowing Owls have been reported to ingest poisoned rodents and to forage on the ground for insects in areas with poison grains also on the ground (Butts 1973, James et al. 1990). In s. Saskatchewan, owls in pastures treated with strychnine-coated grain weighed less than those in control pastures, suggesting a sublethal effect or a reduction in small-rodent prey (James et al. 1990). A breeding population in the Oklahoma Panhandle declined by 71% within one year after sodium fluoroacetate (1080) was applied to the prairie dog colony with nesting owls (Butts 1973). Burrows occasionally are fumigated and sealed in the course of rodent-control programs (Butts 1973). Anti-coagulant rodenticides (e.g., brodifacoum and other second generation [or super-warfarin] compounds) and other types of rodenticides (e.g., strychnine) have been shown to cause mortality in many different owl species, with the ingestion of as few as one poisoned prey item (Sheffield 1997*b*). Burrowing Owls located in proximity to strychnine-coated grain used to control Richardson's ground squirrels were found to have significantly decreased adult body mass and slightly decreased breeding success as compared to control owls (James et al. 1990). Burrowing Owls are known to scavenge dead rodents and other prey items on occasion, making them highly susceptible to secondary poisoning by insecticides and rodenticides (Sheffield 1997*b*).

There have been few studies examining exposure and effects of insecticides on Burrowing Owls; however, available evidence indicates that anti-cholinesterase insecticides can negatively impact Burrowing Owl populations (Sheffield 1997*a*, *b*). In Saskatchewan, reproductive output of Burrowing Owls was not diminished significantly by one or more exposures to carbaryl within 50 or 400 m of the nest burrow; however, spraying of carbofuran within 50 m of the nest burrow caused a 54% reduction in the number of young per nest (James and Fox 1987). When both carbaryl and carbofuran were sprayed within 400 m of the nest, productivity of pairs decreased about 35% more than when carbaryl alone was applied. Direct overspray of carbofuran to the nest burrow resulted in an 83% reduction in brood size and an 82% reduction in nesting success (James and Fox 1987, Fox et al. 1989). Carbofuran application within 50 m of the nest burrow, without direct overspray, resulted in a 17% reduction in brood size and a 27% reduction in nesting success compared with burrows exposed to carbaryl or chloropyrifos. Use of granular formulations of carbofuran is restricted in the United States and Canada (PMRA 1995; L. Cole and P. Mineau, pers. commun.), as is most of its liquid formulations in Canada (PMRA 1995). Liquid carbofuran is still registered for several uses in the United States, and of particular danger to the Burrowing Owls are uses of this chemical in corn and alfalfa fields (Dechant et al. 1999).

Burrowing owl populations in California were sampled for contaminants in the spring of 1996 in the San Joaquin Valley (Lemoore Naval Air Station [NAS]), the Imperial Valley (Sonny Bono Salton Sea National Wildlife Refuge [Salton Sea NWR]), and Carrizo Plain Natural Area (Gervais et al. 2000). Sites were representative of the general agricultural practices in the region; the Carrizo Plain site was a large native grassland. Eggs, blood, feather, and footwash samples were collected from Lemoore NAS and Carrizo Plain, and eggs were collected from Salton Sea NWR. Eggshells from 45 owl nests collected prior to 1937 were obtained from the Western Foundation of Vertebrate Zoology and measured. Eggshell thickness declined 20.58% from Burrowing Owl eggs collected prior to 1937 compared to those collected in 1996. In addition, the eggs from Lemoore NAS were significantly thinner than those from the Salton Sea NWR or Carrizo Plain and contained high concentrations of DDE, ranging from 1.5 to 33 ppm wet weight. Carrizo Plain and Salton Sea NWR eggs contained up to 0.38 and 3.4 ppm DDE, respectively. Feathers from owls nesting at Lemoore NAS also contained levels of DDE, suggesting recent and local exposure. Two Lemoore eggs also contained PCB. Selenium concentrations in eggs were at low concentrations typical of uncontaminated eggs. Footwash samples indicated exposure to the organophosphorus pesticide chlorpyrifos at Lemoore NAS, although no exposure was reported within 1 km of the Burrowing Owl burrows in the months prior to sampling (Gervais et al. 2000). Despite the fact that DDT was banned in 1972, its degradation product DDE clearly remains a threat to wildlife within the San Joaquin Valley. Contaminant loads in these owls also may make them more susceptible to other unrelated stresses, such as weather or exposure to other toxicants (e.g., dicofol), that have similar estrogenic effects as well as thinning effects on eggshells (Gervais et al. 2000).

Recommendation on Current Conservation Status

Data for Western Burrowing Owls in most of the U.S. are insufficient to estimate trends in abundance. Limited data suggest that they are decreasing in some areas, but may be stable or increasing in others. Overall, BBS data (which are reasonably reliable when sample size is adequate) suggest a long-term decline (-1.5%/yr for the U.S.), but this estimate is not statistically significant; the 95% confidence interval for the trend estimate is between –6.5%/yr and +3.6%/yr. Western Burrowing Owls have experienced significant population declines at the northern, western, and eastern fringes of their range, including some local extirpations; however, they continue to occupy the majority of their historical range. Primary threats are habitat loss due to anthropogenic activities, reductions in abundances of burrowing mammals, and contaminants.

Currently, the Western Burrowing Owl is listed by the USFWS as a Bird of Conservation Concern-2002 in most of the BCR's in which it occurs, in every USFWS Region where it occurs, and on the National list (U.S. Fish & Wildlife Service 2002). This designation is intended to stimulate collaborative, proactive conservation actions among public and private land managers and others. Recommended conservation measures include efforts to monitor their demographics and trends more precisely, and to understand the factors affecting their populations during migration and winter. Conservation efforts should focus on protection of suitable habitats in desert, grassland, and shrub-steppe environments. Additional conservation efforts should focus on determining the status of Burrowing Owls in Mexico and on reversing the declines and local extirpations in the Great Plains and Canada. The conservation of burrowing mammals is essential to improve the status of Burrowing Owls, and the listing of the black-tailed prairie dog as a Candidate species should assist in the conservation of both species.

The Migratory Bird Management program of the USFWS recommends retaining the Western Burrowing Owl on the BCC lists on which it currently appears. The listing of the Burrowing Owl as a Bird of Conservation Concern highlights its potential vulnerability and need for increased monitoring and conservation attention by multiple Federal and State agencies and private organizations. The success of these efforts will be reviewed as the Birds of Conservation Concern list is revised.

Management and Conservation

Habitat

Habitat Features—Large, contiguous areas of treeless, native grasslands should be maintained (Warnock 1997, Warnock and James 1997, Clayton and Schmutz 1999). However, because Burrowing Owls forage over tall grass and nest and roost in short grass, a mosaic of grassland habitats are important and a patchwork of reserves with sustainable land uses in nesting and buffer areas is recommended (Clayton and Schmutz 1999). Standardized mitigation protocols to minimize impacts from developments and disturbances should be developed (Holroyd et al. 2001). Government programs and policies that impact Burrowing Owl habitat should be reviewed to ensure that land-use changes have positive effects on Burrowing Owl populations and habitats. Furthermore, management plans for public lands should include issues relative to the conservation of Burrowing Owls, fossorial mammals, and their associated habitats (Holroyd et al. 2001).

The following management recommendations are from the Columbia Basin in Oregon (Green and Anthony 1997): (1) Provide elevated perches near potential nest burrows in grassland areas if the average vegetation height is 5-15 cm; (2) Provide fresh cattle dung near nesting areas if dung is not available and mammalian predators, especially badgers, occur in the area. Burrowing Owls use shredded manure to line their nests and burrow entrances, possibly to mask nest odors as a predator-avoidance strategy (Haug et al. 1993, Dechant et al. 1999). In nc. Oregon, 72% of 32 successful nests were lined with manure, whereas only 13% (n = 15) of depredated nests were lined with manure; (3) Place artificial nest boxes no closer together than 110 m; (4) Construct boxes with width and length dimensions of at least 36 cm and place soil around the inside wall; or construct boxes with only three walls, with a funnel-shaped tunnel entrance; and (5) Select sites for establishing or increasing nest sites that have approximately 55% (40-70%) bare ground and average shrub coverage of <15%.

Fire—Fire may create suitable habitat by reducing vegetation around potential nest sites (Green and Anthony 1989). Post-settlement fire suppression may be responsible for the development of a taller, denser, and woodier plant community than previously existed in North Dakota (Murphy 1993).

Mowing—To encourage Burrowing Owl use in areas where black-tailed prairie dogs and other grazers have been eliminated, mowing may be used to control growth of grasses and woody vegetation. Abandoned black-tailed prairie dog colonies that were not mowed were not used by owls (Plumpton 1992). Mowing also may enhance the attractiveness of nest sites for Burrowing Owls returning from the wintering grounds (Plumpton and Lutz 1993). Mowing throughout the breeding season in mid- to late summer apparently does not adversely affect nesting Burrowing Owls (T. Wellicome, pers. commun.). Mowing can maintain abandoned prairie dog colonies at an early successional stage, with short (<8 cm) vegetation (Plumpton 1992, Plumpton and Lutz 1993). Mowing abandoned colonies may be effective in the short term; however, burrows may require maintenance by prairie dogs to remain suitable for Burrowing Owls (MacCracken et al. 1985, Desmond and Savidge 1999).

Grazing—Livestock grazing may be used to maintain abandoned prairie dog colonies where native burrowing mammals have been eliminated. Heavy grazing on saline, gravelly, stony, or sandy areas and moderate to intense grazing on fertile soils could create suitable habitat that otherwise would support tall vegetation (Wedgwood 1976). However, the effect of grazing on Burrowing Owl habitat and populations is unknown.

Burrowing Mammals

Conservation of those species of burrowing mammals that form Burrowing Owl nest sites is essential for maintaining populations of Burrowing Owls. Some populations of black-tailed prairie dogs are in danger of local extirpation, and their colonies may have become so isolated that re-population through natural dispersal and colonization is unlikely (Benedict et al. 1996). Fragmentation and isolation of habitat patches are potentially important factors in the decline of black-tailed prairie dog populations (Dechant et al. 1999). Burrows may require maintenance by prairie dogs in order to ensure their long-term suitability for owls and it may be necessary to release prairie dogs into inactive colonies (MacCracken et al. 1985, Desmond et al. 2000). Holroyd et al. (2001) suggested the expansion of prairie dog colonies on public lands, and the development of economic incentives to make it profitable to maintain prairie dog populations on private lands.

Regulation of poisoning and shooting of prairie dogs, particularly on public lands, may be necessary (Benedict et al. 1996, Toombs 1997). If lethal control of burrowing mammals is necessary, restricting the timing of control activities to avoid the period when Burrowing Owls choose nest sites or are nesting is recommended (Butts 1973). Traps, poisoned meat, or poisoned grain should not be used for rodent control, but rather burrows unoccupied by owls should be fumigated (Butts 1973, Thomson 1988). However, fumigation may have negative impacts on other burrow dependent species. The area of prairie dog colonies should be increased, possibly by reintroducing prairie dogs where they have been eliminated or by releasing additional prairie dogs into active colonies to promote colony expansion (Pezzolesi 1994, Toombs 1997). It is particularly important to protect colonies ≥ 35 ha in area, which provide adequate space for nesting Burrowing Owls (Desmond et al. 1995, Dechant et al. 1999).

Reintroduction and Relocation

Reintroduction—Reintroduction programs have been attempted in British Columbia, Manitoba, Minnesota, and Oklahoma with no success. In British Columbia, an ongoing captive breeding program reared and released over 140 Burrowing Owls between 1992 and 1998. Released birds have raised broods, overwintered at release sites, and migrated south in winter, but few have returned to the release site in spring (Leupin and Low 2001, Munro et al. 1984). In Manitoba, reintroductions between 1986 and 1996 used a variety of methods, including the aid of aviaries and artificial burrows, but resulted in low reproduction and poor return rates and reintroductions were discontinued (De Smet 1997). In Minnesota, 105 juveniles were released in a reintroduction program over four years, but no successful breeding occurred and the program was discontinued (Haug et al. 1993, Martell et al. 2001). Holroyd et al. (2001) recommended a review of Burrowing Owl reintroduction techniques and development of new techniques due to failure of previously used methods.

Relocations and Artificial Burrows—Relocations are those in which Burrowing Owls are evicted from their occupied burrows and artificial burrows are constructed as near to the eviction burrows as possible to provide acceptable unoccupied burrows for their use. Ninety percent (n = 6) of artificial burrows in California were immediately occupied and these burrows supported successfully breeding birds for three consecutive years (Trulio 1995). Artificial burrows were used when they were approximately 50-100 m from the burrow (Thomsen 1971, Haug and Oliphant 1990). Artificial burrows more than 100 m from the eviction burrow may greatly reduce the chances that new burrows will be used.

The rates of survival and reproduction of Burrowing Owls relocated to artificial burrows as well as the long-term use of artificial burrows and the ability of these burrows to maintain populations are unknown. The design and installation of artificial nest burrows should be summarized and the conservation value of this practice determined (Holroyd et al. 2001). Follow-up research needs to be conducted to determine the breeding success of relocated Burrowing Owls (Holroyd et al. 2001).

Pesticide Use

If insect control is necessary, insecticides with the lowest toxicity to nontarget organisms should be used (James and Fox 1987, Fox et al. 1989). Municipal governments and agricultural representatives should be encouraged to reduce or restrict the use of pesticides, and to use pesticides of low toxicity to nontarget species (Thomson 1988). Pesticides should not be sprayed within 400-600 m of Burrowing Owl nest burrows during the breeding season (Haug 1985, Haug and Oliphant 1990, James and Fox 1987). The possible negative effects of pesticides on Burrowing Owl populations should be considered on breeding and wintering grounds (Holroyd et al. 2001).

Monitoring

A standardized, range-wide survey for Burrowing Owls should be developed and implemented. Potential survey protocols should be tested to ensure the quantitative validity of the methodology (Holroyd et al. 2001). Most current monitoring programs have problems due to limited coverage or sample size (see Monitoring Activities, above). A standardized range-wide roadside survey using call playback has been recommended. This method was 80% effective at detecting Burrowing Owls using a 15 minute period (five minutes listening, five minutes call playback, five minutes listening periods), in early morning and in the early breeding season (Duxbury and Holroyd 1998). The use of recorded calls can significantly increase Burrowing Owl detections, particularly males (Haug and Didiuk 1993). Both historical sites and areas previously unoccupied by owls should be monitored. Because of low nest reoccupancy rates for Burrowing Owls, long-term monitoring of abundance should not be based solely on surveys of historical breeding sites (Lehman et al. 1998).

Migration

Little information is available. Research projects conducted by Saskatchewan Environment and Resource Management and the Canadian Wildlife Service have attempted to relocate radio-transmittered Burrowing Owl on their wintering grounds. Burrowing Owls marked during the breeding season in Canada (Saskatchewan and Alberta) have been relocated in s. Texas and c. Mexico (Veracruz and Michoacan states). Tagged Burrowing Owls were capable of migrating 200 km per night, taking at least 2-3 weeks to move from breeding to wintering grounds. It is estimated that Burrowing Owls take 6-8 weeks to move from wintering to breeding grounds (http://www.serm.gov.sk.ca/ecosystem/speciesatrisk/burrowingowl.htm, http://members.aol.com/joemoell/owl2.html, G. Holroyd, pers. commun.).

Wintering Areas

Very little information is available. Although the general wintering range of Burrowing Owls is known, very little is known about habitats used during the winter (Holroyd et al. 2001). Conservation of Burrowing Owls may depend on acquiring knowledge about the wintering areas and about movement patterns, timing, and ecology during migration and winter. Very few studies have been carried out in Mexico, Central America, or South America. The rapid population decline in Canadian provinces, despite apparent availability of suitable habitat, suggests unknown factors in winter and migration may be affecting survival or return rates (Schmutz 1997).

Education

Private landowners and the general public should be educated about the status of Burrowing Owls, the benefits of protecting habitat for the species and for burrowing mammals, and the negative effects of insecticides (Butts 1973, James and Fox 1987, Thomson 1988, Hjertaas 1993, Dechant et al. 1999, Holroyd et al. 2001). Stewardship of Burrowing Owls and their habitat should be encouraged on public land in the United States, Canada, and Mexico (Holroyd et al. 2001). An educational program should be developed for schools and outdoor education programs, and the media should be included in these activities (Thomson 1988, Holroyd et al. 2001). A project to improve the public image of prairie dogs should be undertaken (Benedict et al. 1996, Holroyd et al. 2001). Operation Burrowing Owl (a private stewardship program in Canada) has been extremely successful at obtaining landowner cooperation in conservation efforts, and has provided valuable population trend data for Burrowing Owls in Canada (Hjertaas 1997*b*). RMBO and Hawks Aloft, Inc. have also developed successful education and public participation programs.

Current Activities and Programs

United States—In California, the Burrowing Owl Consortium, an *ad hoc* group of biologists and advocates, meets two times a year. The Consortium members inform each other and the public of important issues related to the species, and subcommittees of the Consortium undertake projects designed to help the species (L. Trulio, pers. commun.). The California Burrowing Owl Consortium prepared the *Burrowing Owl Survey Protocol and Mitigation Guidelines* in 1993 to provide more consistent treatment of impacts to Burrowing Owls during development projects. This document was submitted to the California Department of Fish and Game and became the basis of their 1995 *Staff Report on Burrowing Owl Mitigation* (California Department of Fish and Game, unpubl. report).

RMBO manages "Prairie Partners", a program that requests voluntary cooperation from private landowners to conserve shortgrass prairie birds and their habitat through effective stewardship (Hutchings et al. 1999). In 1999, "Prairie Partners" documented 468 Burrowing Owl locations (79.3% on public land). Information is provided to landowners about shortgrass prairie conservation and Burrowing Owl natural history. The program also provides information about landowner attitudes toward Burrowing Owls and prairie dogs.

RMBO also published "Sharing Your Land with Shortgrass Prairie Birds" (Gillihan et al. 2001) which includes a section on Burrowing Owl identification, natural history, and habitat requirements and a booklet focusing on grasslands and grassland birds for elementary and secondary classroom use (Hutchings et al. 1999). These materials are being distributed to landowners, managers, and schools.

The New Mexico Burrowing Owl Working Group (NMBOWG) was formed in response to population declines at some sites in New Mexico (Hawks Aloft, Inc. 2002). The NMBOWG is an volunteer, collaborative effort of non-profit organizations, government agencies, private enterprises and individuals. The working group attempts to encourage communication, support research, and facilitate improved Burrowing Owl sighting accuracy and reporting. The NMBOWG currently supports on-going research projects at four sites: Holloman and Kirtland Air Force Bases, New Mexico State University, and the Turner Ranch. The NMBOWG has initiated a volunteer monitoring system to collect data on Burrowing Owl populations in the state (C. Finley, pers. commun., Hawks Aloft, Inc. 2002).

Canada—Operation Burrowing Owl is a program designed to address declines of Burrowing Owls in Saskatchewan and Alberta. Activities include increasing public awareness, placing nest boxes, encouraging voluntary land protection, and providing monetary incentives to landowners to protect nesting habitat and avoid pesticide use around nest sites (Hjertaas 1997*b*). As of 1993, several hundred landowners were enrolled in the project and were protecting over 20,000 ha of breeding habitat, which supported several hundred breeding pairs (Dundas and Jensen 1994/95).

Through the Critical Wildlife Habitat Program, Threatened Grassland Birds Project in Manitoba, nearly 3,500 ha of critical habitat have been leased or voluntarily protected for Burrowing Owls and other grassland species, and over 300 artificial nest burrows have been installed (Dundas and Jensen 1994/95).

The Canadian Burrowing Owl Recovery Team was formed in 1989 to coordinate and promote research and conservation activities to prevent the decline of this species in Canada. This team meets annually to review information and to develop and implement recovery plans. The British Columbia recovery team has attempted to reintroduce Burrowing Owls into that province for over a decade. In Alberta, a provincial recovery team was formed in 2001 to develop and implement a provincial action plan. Several organizations conduct public education programs to increase awareness of Burrowing Owl conservation issues. The Saskatchewan Burrowing Owl Interpretive Centre in Moose Jaw was specifically established to promote awareness of Burrowing Owl conservation both to visitors and through extensive school extension programs. The Alberta Fish and Game Association through their Operation Grassland Community delivers similar programs in the province. The Canadian Species at Risk Habitat Stewardship Program funds non-government partners to deliver habitat stewardship projects in all four western provinces which benefit Burrowing Owls, their habitats and other prairie wildlife. (G. Holroyd, pers. commun.).

Research Needs

Coordinated, range-wide research on population demographics needs to be conducted to determine causes of populations declines (Holroyd and Wellicome 1997, Holroyd et al. 2001). Metapopulation dynamics, influence of landscape patterns, and the effects of fragmentation and isolation on populations are not well understood. Basic distribution data and factors affecting survival during migration and on wintering grounds are poorly known and may be important in determining causes of population declines (Holroyd et al. 2001). A standardized survey to monitor population trends in Canada, the U.S., and Mexico is recommended as many population estimates are simply based on "best guesses" and current large-scale monitoring programs are largely inadequate (Holroyd et al. 2001).

Management strategies currently in use need to be evaluated for their effectiveness and the resulting information made easily available to managers. Further investigations also are needed on land use impacts, prescribed fire, grazing, mowing, habitat enhancements (e.g., artificial burrows and perches), relocation and reintroduction, and impact of predators on nest success (Millsap et al. 1997, Sheffield 1997*a*, Holroyd et al. 2001). Rates of habitat conversion and degradation (e.g., agricultural conversion or decline in burrowing mammal colonies) are rarely reported and more work is needed to determine rate and extent of habitat loss (James and Espie 1997). Modeling of Burrowing Owl habitat selection has been suggested to better understand the role of anthropogenic factors in population declines (Holroyd et al. 2001).

Although some research exists on carbofuran, studies of many other pesticides are also needed (James and Espie 1997, Holroyd et al. 2001). Indirect and sublethal effects of pesticides are largely unknown. The extent of mortality and vulnerability to shooting, particularly during prairie dog and ground squirrel control, is generally unknown.

Some education programs have already been successfully developed and implemented. However, additional research is needed to determine landowner and land manager attitudes to Burrowing Owls and burrowing mammals and to determine best methods for improving attitudes and conservation efforts on private and public lands.

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Appendix A: State Summaries of Burrowing Owl Status

Arizona

Summary: Combining historical and recent records, Burrowing Owls have been documented (breeding and/or wintering) in 14 of 15 counties (all except Greenlee County, Fig. A-1) (Brown 2001). A family group was observed in the San Rafael Valley, Santa Cruz County in 2002 (J. Ruth, pers. commun.). Although not present in the early 1900's along the lower Colorado River, Burrowing Owls are now common there, suggesting that agriculture may have benefitted the species in that region (Rosenberg et al. 1991, Brown 2001). However, the vegetation maintenance regime of farming and water districts may cause these populations to remain unstable due to unreliable and temporary habitats (Brown 2001). Main concentrations in the Tucson area are located at Davis-Monthan Air Force Base (DMAFB) and along the west branch of the Santa Cruz River (Estabrook and Mannan 1998).

Statewide Burrowing Owls populations appear to be relatively stable to slightly decreasing (T. Corman, pers. commun.); however, no quantitative information has been gathered on Burrowing Owls since Phillips et al. (1964; Brown 2001). Some local populations are decreasing, especially in urban and agricultural areas, and some populations have been extirpated (Brown 2001).

Status determination in the sw. United States in 1979 and 1988 was precluded by insufficient information (Johnson et al. 1979, Johnson-Duncan et al. 1988). A preliminary review of Burrowing Owls in Arizona was conducted in 1998, through extensive literature reviews, questionnaires, requests for observations, and personal observations (Brown 2001). A formal status could not be given due to the lack of quantitative information on this species in Arizona. Through survey responses, state biologists estimated 100 to 1,000 pairs in 1992 (James and Espie 1997).

BBS: No significant trends were detected over any survey periods (Sauer et al. 2002).

CBC: No significant trend was detected over the survey period (Sauer et al. 1996).

Atlas: Based on preliminary information collected by the Arizona Breeding Bird Atlas (Arizona Breeding Bird Atlas, Unpubl. data, 1993-2001, C. Wise, pers. commun.), the overall breeding range in Arizona has not changed substantially in the 1990's. Burrowing Owls were reported in 78 (4%) of 1825 BBA blocks (Fig A-1, T. Corman, pers. commun).

Research/Monitoring: The Urban Raptor Nest Watch Program of the Arizona Game and Fish Department (c. Arizona) recorded six nests for the Phoenix Metro Area in 1994, three in 1995, and five or six in 1996 (F. Esparza, pers. commun.). Estabrook and Mannan's (1998) urban study found 77 active breeding burrows in the Tucson area in 1997; 28 of these were on DMAFB and the majority of the others were on the west branch of the Santa Cruz River. The number of active burrows appeared to remain stable year-round on DMAFB and fairly stable in the Santa Cruz River flood plain; the vegetation maintenance regime along the flood plain often destroys active burrows (Estabrook and Mannan 1998).

Conservation Activities: Artificial burrows have been placed in some urban areas of the greater Phoenix area (T. Corman, pers. commun.). Artificial burrows have also been constructed at Cibola National Wildlife Refuge along the Lower Colorado River.

Major Populations: A major population occurs at the Davis-Monthan Air Force Base and west branch Santa Cruz River flood plain near Tucson. Unconfirmed high numbers of Burrowing Owls have been reported along the irrigation canals around the Yuma area. Burrowing Owls have been reported from a variety of other areas throughout Arizona; however, no quantitative information has been documented other than in the Tucson region (Estabrook and Mannan 1998).

State Status: None

Natural Heritage Rank: G4/S3 (rare and uncommon in the state)

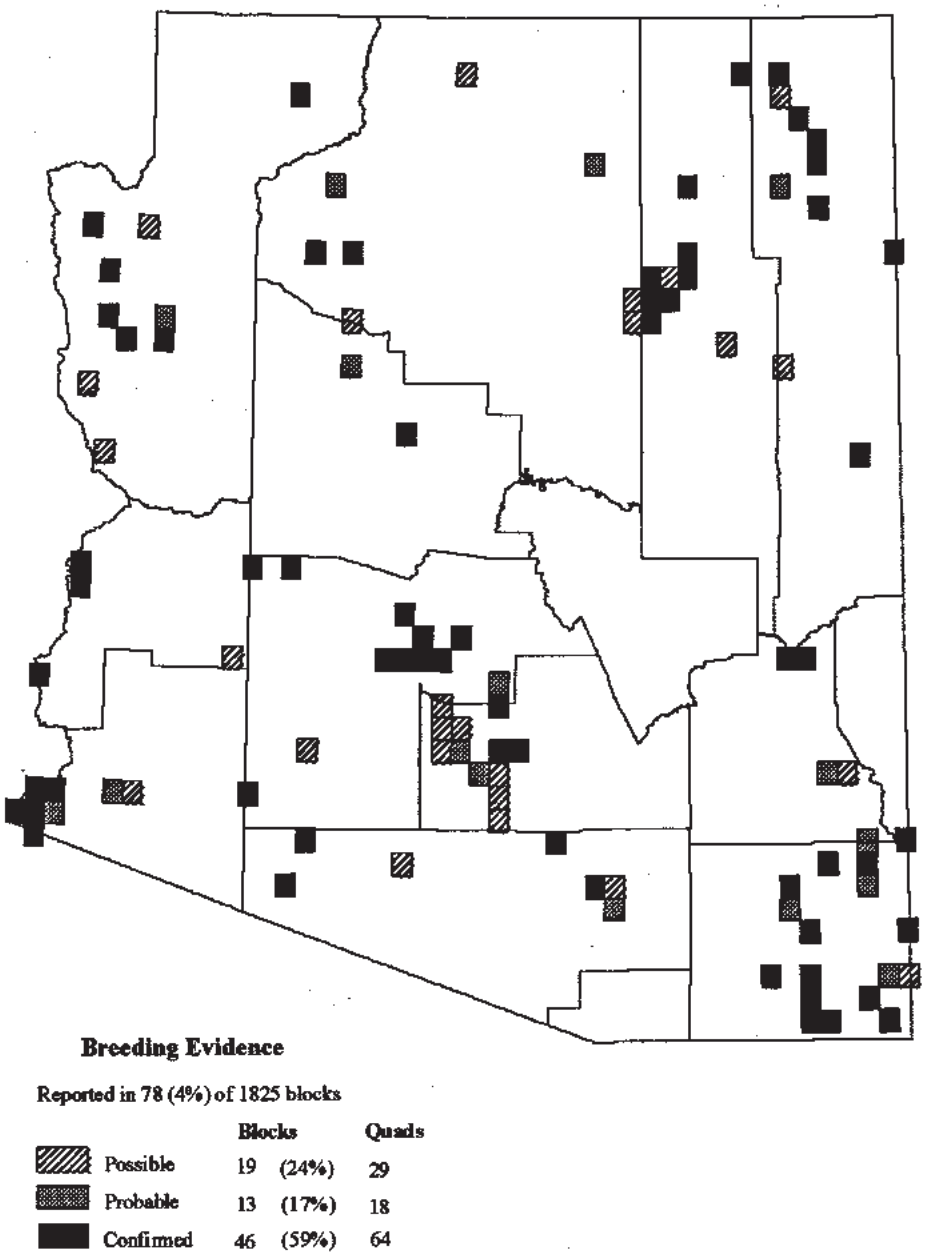

Fig. A-1. Distribution of the Burrowing Owl in Arizona from the Arizona Breeding Bird Atlas project (Arizona Breeding Bird Atlas, Unpubl. data (1993-2001), C. Wise, pers. commun.)

Habitat Condition: Arizona BBA activities located Burrowing Owls in the following habitat types: semi-desert grassland, plains grassland, cropland, Great Basin desert-scrub, lower Colorado River biome of the Sonoran Desert-scrub, barren ground, Great Basin grassland, Arizona upland biome of Sonoran Desert-scrub, Mojave Desert-scrub, rural, and residential (Brown 2001). From survey data, Brown (2001) indicated they also use parks (golf courses, cemeteries), cultivated woodlands (orchards, tree farms) and airports (including Air Force bases).

Burrowing Owls inhabit grass, forb, and open shrub stages of pinyon pine and ponderosa pine habitats (Carothers et al. 1973, Karlaus and Eckert 1974, Zenier et al. 1990). Other areas in Arizona where the owls might be found include washes, irrigation canals, near water tanks or corrals on rangelands, and in vacant lots, and other disturbed sites in urban and rural areas (Rosenberg et al. 1991, Witzeman 1997, deVos 1998, Brown 2001). Occasionally they are found in sandy, sparsely vegetated riparian woodlands in the Lower Colorado River Valley (Rosenberg et al. 1991).

Burrowing Owls are predominately associated with prairie dog towns and round-tailed ground squirrel populations (deVos 1998, Latta et al. 1999, Brown 2001). Both of these burrowing mammals usually inhabit open environments and provide burrows and short vegetation (Hoffmeister 1986, deVos 1998).

Shrub encroachment by mesquite in se. Arizona has eliminated extensive tracts of grassland habitat for the Burrowing Owl (Brandt 1951). In n. Arizona, Burrowing Owls formerly inhabited Anita and Pasture Washes in the Grand Canyon region, but the habitat is now unsuitable due to shrub encroachment (Brown 2001). Such habitat change has been due to grazing practices and prairie dog control programs (Brandt 1951, Brown 2001).

Threats: The Arizona Partners in Flight Bird Conservation Plan (Latta et. al 1999) lists the following threats: 1) Reduction of prairie dogs and ground squirrels through control programs and plague events indirectly limit habitats available to Burrowing Owls; 2) Urban and agricultural development directly reduces available habitat; 3) Urbanization also increases the risk of contraction of Trichomoniasis from doves (Estabrook and Mannan 1998); and 4) increased mortality from vehicles, humans, and domestic and feral animals.

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California

Summary: California supports one of the largest year-round (resident) and winter (migrant) populations of Burrowing Owls within the United States. The distribution of Burrowing Owls has changed considerably since introduction of industrial agriculture and increased urbanization, reflecting both losses and gains in local populations. Surveys conducted during 1991-93 reported >9,000 breeding pairs. Most Burrowing Owls occurred within the Central (24%) and Imperial Valleys (71%), primarily in agricultural areas. Burrowing Owls have disappeared or declined in several southern California and San Francisco Bay counties and in coastal areas. Without increased regulatory protection of habitat, Burrowing Owls will likely be extirpated in some areas. However, the large and widespread current population and the Burrowing Owl's high reproductive performance in disturbed environments suggests that the California population is not under immediate or foreseeable threat. Changes in agricultural practices, particularly regarding water conveyance, and urbanization have the potential to quickly affect California's Burrowing Owl population. Evaluation of the ability of large publicly managed lands to support Burrowing Owl populations is important to assess the Burrowing Owl's viability in California.

BBS: Significant increases in relative abundance in California over the 1966-2001 survey period (Trend = 5.5, $P < 0.01$, n = 32) and the 1980-2001 subinterval (Trend = 5.0, $P < 0.05$, n = 24). Data credibility is good indicating adequate sample size, moderate precision, and moderate abundance on routes (Sauer et al. 2002).

CBC: Significant decreasing trends in Burrowing Owl relative abundance were detected from 1959-88 (Trend = –1.2, $P < 0.05$, n = 97) (Sauer et al. 1996).

Atlas: Several counties have atlases, but no single state atlas is available.

Research/Monitoring: Historical accounts indicated that the Burrowing Owl was widely distributed and relatively common in California grasslands (Canfield 1869, Dawson 1923, Grinnell and Miller 1944). Numbers during winters were reported to have declined between 1954-1986 (James and Ethier 1989). Additional declines were reported from the San Francisco Bay area, where development has reduced the amount of Burrowing Owl habitat (DeSante et al. unpubl. ms, Trulio 1997). Johnson (1997) reported a rapid decline in numbers of nesting Burrowing Owls on a 370-acre study site on the University of California Davis campus (Yolo Co.).

The Institute for Bird Populations conducted a volunteer-based survey in 1991-1993 within most of the range of Burrowing Owls in California (DeSante et al. 1997, DeSante et al. unpubl. ms.). They estimated over 9,000 breeding pairs of Burrowing Owls in California (Fig. A-1). Most Burrowing Owls found during the survey were in agricultural areas although it was likely that higher numbers exist in large grasslands than revealed through the surveys (DeSante et al. *In press*). Based on comparisons of survey results and observations made during the early 1980s, DeSante et al. (unpubl. ms.) reported that Burrowing Owls were extirpated during the last 10-15 years from several areas in California, including Napa, Marin, San Francisco, Santa Cruz, and Ventura counties, and coastal San Luis Obispo county and Coachella Valley. Few individuals were observed in Sonoma, Santa Barbara, Orange, coastal Monterey, and San Mateo counties. Most of these areas maintained few Burrowing Owls prior to reported declines; occasional observations of Burrowing Owls nesting in some of these counties have been reported recently (D. DeSante, pers. commun.). The most apparent decline of Burrowing Owls was reported from the Bay area, where DeSante et al. (1997) estimated an approximately 50% decline in Burrowing Owl numbers from the 1980s to the early 1990s.

A multi-site demographic study was initiated in 1997 and coordinated through The Institute for Bird Populations, Oregon State University, and San Jose State University. The study included four sites by 1998, representing the primary habitats in which most of California's Burrowing Owl populations exist. This included South San Francisco Bay ("Bay Area") representing urban environments, Naval Air Station Lemoore ("Lemoore") representing small grassland patches surrounded by agriculture, Carrizo Plain National Monument ("Carrizo"), representing large grasslands, and the Imperial Valley, representing intensive agriculture with nests restricted to field borders. Preliminary results from this study (Rosenberg et al., unpubl. data) demonstrate variability in density and demographic performance among sites (Table A-1).

The number of pairs/ha within the entire study area was similar among sites except for Imperial Valley, which had densities approx. 8 times that of all other sites (Table A-1). By contrast, the number of pairs/ha of potential nest habitat, varied dramatically. Survival rates of Burrowing Owls captured as adults were similar among sites, with Imperial Valley having the highest rates (Table A-1), although there was high temporal variation that was site-specific (Rosenberg et al., unpubl. data). Mortality was high at Carrizo, with predation by other raptors identified as the single largest cause (Rosier et al., unpubl. ms). Reproductive rates, estimated as the number of 21-28 day-old young (Gorman et al., unpubl. ms.), varied among sites (Table A-1), but temporal variation within sites was greater. Temporal variation was apparently related to the abundance of vertebrate prey (Haley 2002, Gervais 2002, Ronan 2002). Reproductive rates were highest in the two agricultural sites, Lemoore and Imperial Valley. Nest failure was largely responsible for differences among the four sites.

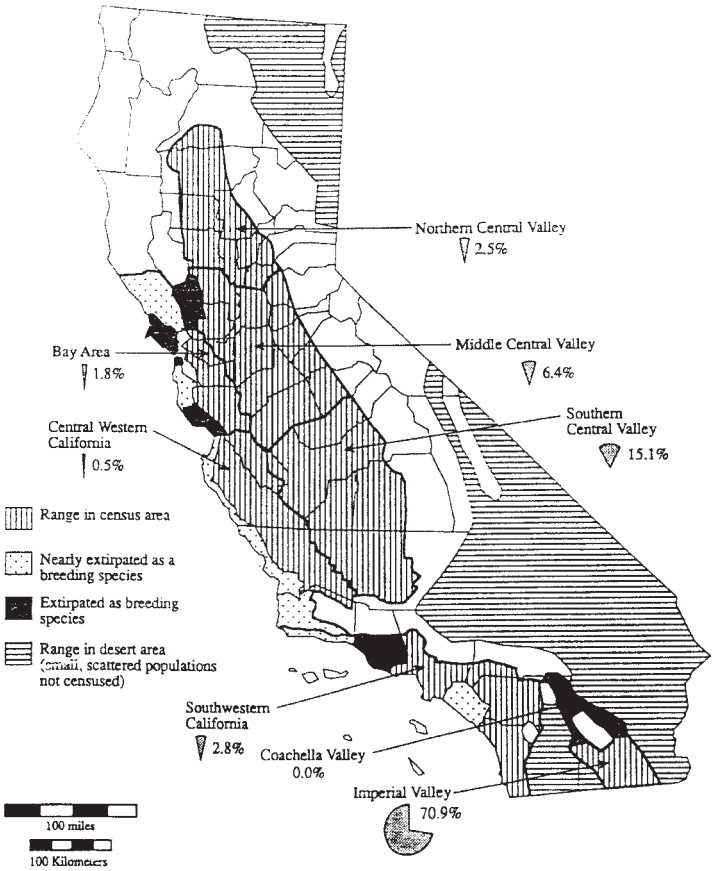

Fig. A-2. Distribution of Burrowing Owl Populations in California, 1991-1993 (9,266 breeding pairs, estimate) (DeSante et al. unpubl. ms.).

For Burrowing Owls, estimates of juvenile survival rates have rarely been reported (but see Gervais 2002), due in part to the difficulty of separating survival from emigration. If one assumes that survival is lower for juveniles than adults (i.e., <0.5, Table A-1), then stability is most likely to occur only when reproductive rates are >2 young/nest (Table A-2). This reproductive rate was achieved or exceeded at each site in some years.

Densities, survival rates, and reproductive rates of Burrowing Owls were high in a wide range of modified habitat conditions. These demographic characteristics were highest in agricultural areas (Lemoore and Imperial Valley) and similar between the urban area of southern San Francisco Bay and the grasslands of Carrizo. If we assume that Carrizo's population growth rate over the long-term is close to stable, then the modified environments of agriculture and urban landscapes (given the conditions at the time of the study) seem likely to provide habitat for stable populations of Burrowing Owls based on the preliminary results from the demographic study. The documented long-term decline in the San Francisco Bay Area is due to nest habitat loss. Further work determining densities of Burrowing Owls in large grasslands, survival rates of juvenile Burrowing Owls, and dispersal patterns of both juveniles and adults will be required for a better understanding of the long-term viability of Burrowing Owls in California. These analyses are now underway for the California demographic studies reported here.

Conservation Activities: The Burrowing Owl Consortium, an ad hoc group of Burrowing Owl biologists and advocates in the San Francisco Bay prepared the *"Burrowing Owl Survey Protocol and Mitigation Guidelines"* in 1993 (California Burrowing Owl Consortium 1997), the basis of California Department of Fish and Game's (1995) *"Staff Report on Burrowing Owl Mitigation."* Repeated conflicts between Burrowing Owls and development projects have lead some municipalities and larger-scale planning boards to consider preparing Burrowing Owl habitat conservation programs for their respective jurisdictions.

In an effort to better inform the public, a brochure and two videos on the Burrowing Owl in California were prepared by The Institute for Bird Populations and Oregon State University. These have been distributed at no charge to federal and state natural resource agencies, visitor centers at locations with Burrowing Owls, and to elementary and high schools.

Table A-1. Comparison of mean density, survival, and reproductive rates of Burrowing Owls at four sites in California.

Site	Years of Study	Area (km^2)	Pairs observed	Crude Density[a]	Ecological Density[b]	Survival[c]	No. Young[d]
Bay Area	98-01	60 (estimate)	64	1.1	5.2	0.55	1.6/3.1
Lemoore	97-00	76.1	67	0.9	15.2	0.44	2.8/3.8
Carrizo	97-00	183.5	38.9	1.0	1.0	0.23/0.61	1.9/4.0
Imperial Valley	98-01	11.8	99	8.3	145.6	0.60	2.1/2.9

[a] Number of estimated pairs/km^2.

[b] Number of estimated pairs/km^2 of potential nest habitat. A width of 20 m was used along canals and drains to estimate the area of nest habitat within the Imperial Valley.

[c] Apparent annual survival rates are based on the single best average estimate with years and sex pooled. At Carrizo, survival rate was estimated as an annual interval from mark-recapture data (0.23) and from radio-telemetry data (0.61) over a 3 month interval during the breeding season. The mark-recapture estimate from Carrizo is negatively biased due to high breeding dispersal (Rosier et al., umpubl. ms.). Apparent survival is an estimate of survival under the assumption that emigration from the study area does not exist.

[d] Number of young reported are, first, the average number for all nests assessed, and, second, the number at successful nests. Estimates are based on counts during 5, 30-min observation (Gorman et al, unpubl. ms.; Rosenberg and Haley *In press*).

Table A-2. Estimates of juvenile survival rates necessary for population stability under different adult reproductive and survival rates.

Adult Survival	Reproductive Rate	Necessary Juvenile Survival
0.5	1.5	0.67
0.5	2.0	0.50
0.5	2.5	0.40
0.6	1.5	0.54
0.6	2.0	0.40
0.6	2.5	0.32

Major Populations: Genetic analyses of Burrowing Owls from three of the demographic study sites (Lemoore, Carrizo, Imperial Valley) failed to identify population differentiation (Korfanta 2001). This was likely due to the continuous habitat relative to the long-distance dispersal of juveniles and some adults (Rosier et al., unpubl. ms). Owls are most abundant within the Central and Imperial Valleys (Fig. A-1). Based on the survey of DeSante et al. (unpubl. ms), most (91%) Burrowing Owls occur on private lands. However, the difficulty of detecting Burrowing Owls nesting within large grasslands (Ronan 2002, Rosenberg et al., unpubl. data) coupled with the densities estimated for Carrizo (Table A-1) suggests that large publicly managed grasslands within public lands may have large numbers of Burrowing Owls.

State Status: Species of Special Concern—declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction.

Natural Heritage Rank: G4/S2—imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state.

Habitat Use and Condition: Burrowing Owl nesting habitat is similar to the characteristics of land preferred for agricultural, residential, and commercial development. Because California's human population growth will continue, grassland and desert habitat can be expected to be further reduced. The primary regions of grasslands and deserts supporting Burrowing Owl populations are those managed by public agencies such as Bureau of Land Mangament and Department of Defense, although quantitative estimates of potential habitat have not yet been computed. Presumably, large areas of undeveloped deserts have sparse but stable (over the long-term) Burrowing Owl populations. Areas undergoing rapid urbanization, such as the San Francisco Bay area and many parts of southern California, have lost and will continue to lose habitats that once supported Burrowing Owl populations. The Central Valley and Imperial Valley have lost most of their native vegetation to large-scale agriculture, but Burrowing Owls are abundant (DeSante et al. *In press*; Rosenberg and Haley *In press*).

In California, Burrowing Owls have shown incredible tolerance for human encroachment and degradation of native habitats. In urban areas, they are often found nesting within landfills, golf courses, airports, and vacant lots within highly developed areas (Haug et al. 1993, Trulio 1997). The primary criterion for Burrowing Owl occurrence is a nest burrow. Because of this, habitat quality is spatially variable and highly dynamic. In modified ecosystems, habitat quality is often dependent on individual landholders and sensitive to a wide variety of land uses, such as farming practices.

Threats: Valley-bottoms in or near population centers are highly valued for residential and commercial development. Rapid development within the San Francisco Bay Area and other municipalities is responsible for declines in Burrowing Owl numbers in these areas. Further loss of Burrowing Owls on private lands within urban areas is expected under current land-use regulations. Because of the large numbers of Burrowing Owls that reside within the agricultural matrix of the Central and Imperial Valleys, change in methods of farming practices, particularly water conveyance, is likely to impact Burrowing Owl numbers (Rosenberg and Haley *In press*). Because Burrowing Owls in agricultural systems spend a large proportion of their time foraging in fields (Rosenberg and Haley *In press*), pesticide use will remain a threat to these populations. Some populations maintain substantial body burdens of persistent pesticides that may inhibit reproduction (Gervais et al. 2000), although these levels appear to fluctuate through time, making their impact difficult to predict (Gervais 2002). Throughout California, ground-squirrel control programs may affect Burrowing Owl numbers and persistence in local areas because most nest burrows are constructed by these species.

Burrowing Owls and their nests are protected by California Fish and Game Code and the U. S. Migratory Bird Treaty Act. Avoiding violation of these regulations usually requires that disturbance at occupied nest territories be reduced or eliminated during the nesting season. The California Environmental Quality Act offers some protection by stipulating that significant impacts to the species be mitigated. Although outright killing of the birds and active nests is addressed by California Fish and Game Code and the Migratory Bird Treaty Act, the loss of habitat is not. Existing regulatory mechanisms have not been effective at preventing or discouraging intentional destruction of Burrowing Owl habitat, including nest sites.

Vehicle collisions have been cited as a potentially significant source of mortality (Haug et al. 1993; Clayton and Schmutz 1997, Rosenberg et al., unpubl. data). The risk of vehicle collisions is likely greater in developed areas with dense human populations or along areas where Burrowing Owls nest predominately near roads.

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Colorado

Summary: Burrowing Owls are a breeding species across the plains of e. Colorado, with scattered occurrences in the Grand Valley (wc. Colorado), the San Luis Valley (sc. Colorado), and South Park (c. Colorado; Jones 1998). During mild winters, rarely an individual will winter in Colorado. Based on survey results of state biologists, James and Espie (1997) estimated 1,000-10,000 pairs of Burrowing Owls in Colorado in 1992. Rocky Mountain Bird Observatory estimated the total Burrowing Owl population of e. Colorado to be 20,408 individuals based on driving line transects and 15,796 individuals based on road-based point counts (Hanni 2001). Some Colorado counties no longer have Burrowing Owls where they did occur within recent years (Andrews and Righter 1992, J. Slater, pers. commun.).

BBS: No significant trends were detected over any survey period (Sauer et al. 2002).

CBC: N/A

Atlas: According to the 1998 Colorado Breeding Bird Atlas, breeding was confirmed for the species in 18 latilong blocks and four of the ten west slope latilong blocks in which Burrowing Owls have occurred historically (Fig. A-3, Jones 1998). They were found in 40% of the priority blocks in the eastern plains and the number of blocks with Burrowing Owls gradually decreased from east to west and south to north. The distribution of blocks with Burrowing Owls approximated that found in 1999 surveys by the Rocky Mountain Bird Observatory (RMBO, formerly Colorado Bird Observatory) (Hutchings et al. 1999). Jones (1998) documented breeding in the Grand Valley from Grand Junction to the Utah border, but not in nw. Colorado or South and Middle Parks. Burrowing Owls were recorded in only three blocks in sw. Colorado and four in the San Luis Valley (Jones 1998). Level of breeding evidence for priority blocks with Burrowing Owls was 152 confirmed (59%), 54 probable (21%) and 53 possible (20%).

Research/Monitoring Biddle (1996) stated that burrows which are vacated by prairie dogs soon become unsuitable to Burrowing Owls as they fall into disrepair, but also suggested additional associations between prairie dogs and Burrowing Owls may decrease the suitability of sites for breeding in the absence of prairie dogs. From anecdotal evidence, she found that towns recently vacated by prairie dogs, yet with available burrows, did not contain breeding Burrowing Owls. She noted one town in Logan County, Colorado, had no prairie dogs or Burrowing Owls in 1994, and breeding Burrowing Owls were present in 1995 after prairie dogs recolonized the site. Ongoing research is continuing at the Rocky Mountain Arsenal National Wildlife Refuge investigating relationships between prairie dog populations affected by epizootic plagues and Burrowing Owl populations (M. Hetrick, pers. commun.).

Lutz and Plumpton (1999) banded 60% of the known population on the Rocky Mountain Arsenal as either adults or as nestlings from 1990-94. Most (n = 513; 92%) were never reencountered after the year they were banded. Of adults banded in 1990, 39% returned in 1991 while only 5% of chicks banded in 1990 returned (Plumpton and Lutz 1993). Overall, 42 banded Burrowing Owls (8%) returned to the area in one year and used the area for two-four years (Lutz and Plumpton 1999). Adult males and females returned at similar rates (19% and 14%, respectively). Adult males and females nested in formerly used sites at similar rates (75% and 63%, respectively). They found no difference in productivity between philopatric adults and presumed new adults; however, past brood size was greater for females that returned to former nest sites (mean = 4.9 ± 0.69 young) than for females that changed nest sites in subsequent years (mean = 2.2 ± 0.79 young; Lutz and Plumpton 1999). Females banded as nestlings returned as adults after a year absence from the study area. Males banded as nestlings returned in the year following hatch, with one exception. Fledging rate ranged from 0-9 young per nest (mean = 3.62 ± 0.19 young/nest, n = 167). The majority of returning adults (66%) reused the same prairie dog town as the prior year and 90% of prairie dog towns and 20% of nesting burrows were reused (Plumpton and Lutz 1993).

Plumpton (1992) found nesting Burrowing Owls occupied burrows with a shorter distance to the nearest road, and shorter grass and forb height than generally available, while using black-tailed prairie dog towns with greater burrow density and percentage of bare ground than available. VerCauteren et al. (*In review*) found Burrowing Owl density was inversely related to the area of prairie dog towns, but total number of Burrowing Owls was positively related to town size. In concordance with Plumpton (1992), VerCauteren et al. (*In review*) found the number of Burrowing Owls in e. Colorado was significantly correlated with number of prairie dogs and number of burrows. Biddle (1996) found the number of shortgrass patches within 1000 m of prairie dog towns could be used to predict the presence of Burrowing Owls in Logan County, Colorado, with the probability increasing as the number of patches increased. Plumpton (1992) found that periodic mowing could maintain vegetation structure for Burrowing Owls when prairie dogs were eliminated by epizootics or chemical extirpation.

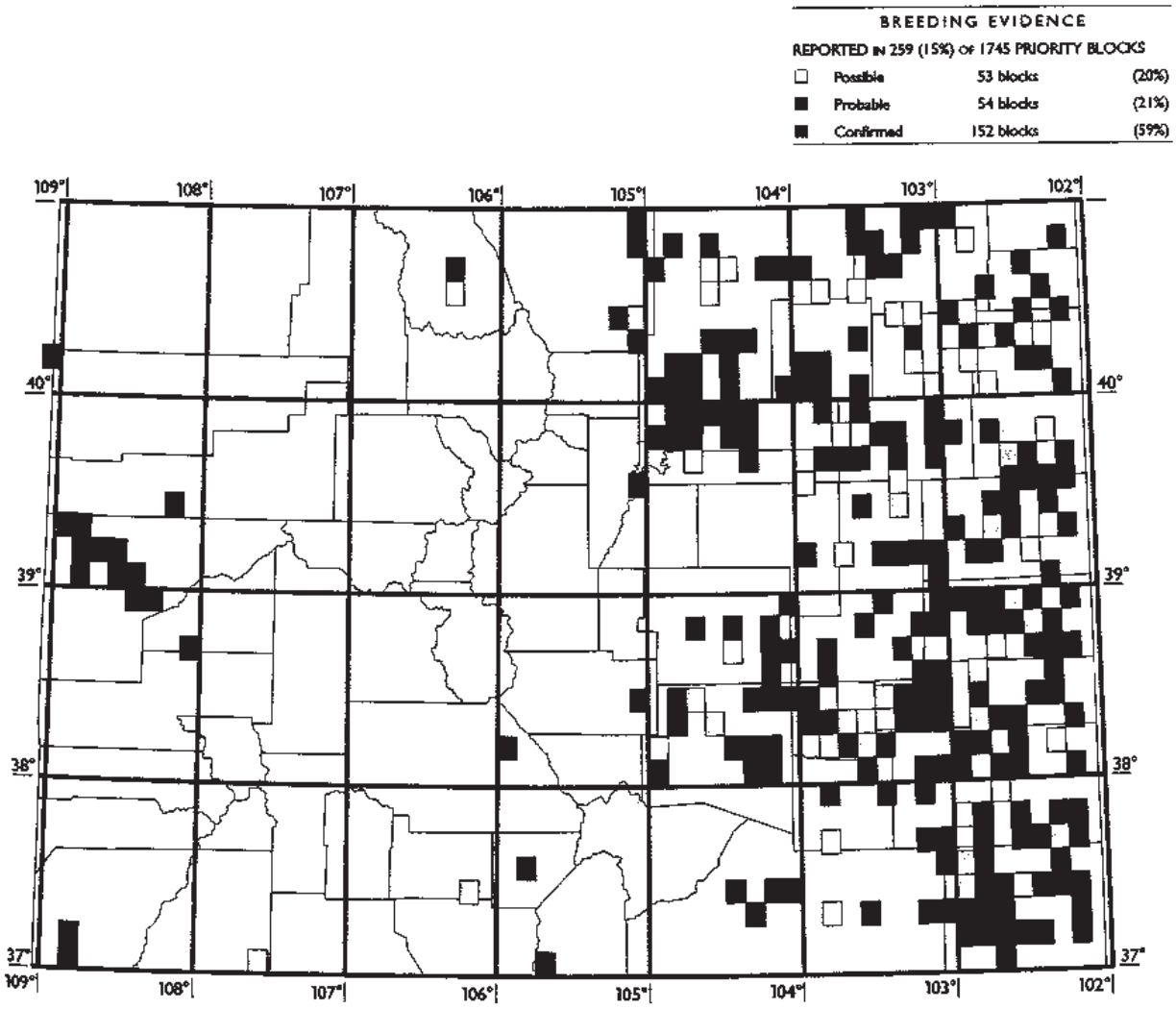

Fig. A-3. Distribution of Burrowing Owls in Colorado from the Colorado Breeding Bird Atlas project (Jones 1998).

Conservation Activities: Management efforts directed toward retention of active prairie dog towns (Plumpton 1992, Biddle 1996) and cropped vegetation (<8 cm) by either sciurids or mowing would be beneficial to nesting Burrowing Owls. The Colorado Division of Wildlife is planning to implement black-tailed prairie dog conservation efforts (J. Slater, pers. commun.).

The RMBO manages "Prairie Partners", a program that asks for voluntary cooperation from private landowners to conserve shortgrass prairie birds and their habitat through effective stewardship (Hutchings et al. 1999). In 1999, "Prairie Partners" documented 468 Burrowing Owl locations (79.3% on public land). Information is provided to landowners on shortgrass prairie conservation and Burrowing Owl natural history. The program also provided information about landowner attitudes toward Burrowing Owls and prairie dogs.

RMBO published "Sharing Your Land with Shortgrass Prairie Birds" (Gillihan et al. 2001) which includes a section on Burrowing Owl identification, natural history, and habitat requirements and a booklet focusing on grasslands and grassland birds for elementary and secondary classroom use (Hutchings et al. 1999). These materials are being distributed to landowners, managers, and schools.

Major Populations: Major populations are found at Rocky Mountain Arsenal in sc. Adams County and the following counties in Colorado according to VerCauteren et al. (2001): Baca, Bent, Cheyenne, Crowley, Kit Carson, Kiowa, Prowers, Pueblo, and Weld.

State Status: Threatened

Natural Heritage Rank: G4/S4B (S4—widespread, abundance, and apparently secure in state, with many occurrences during the breeding season, but of long-term concern).

Habitat Use and Condition: Habitat on the eastern plains is generally in good condition, but along the Front Range it is being rapidly converted to urban development. With the exception of Comanche and Pawnee National Grasslands (on the eastern plains), and a few other state and federal lands, Burrowing Owl habitat is found mostly on private lands (88% of eastern Colorado is in private ownership) (J. Slater, pers. commun.). Habitat loss is responsible for complete or near extirpation of Burrowing Owls in some areas; however, some areas have suitable habitat with no Burrowing Owls, thereby indicating other factors may be influencing Burrowing Owl populations in Colorado (Andrews and Righter 1992).

Threats: Rapid urban/suburban/exurban development along the Front Range of Colorado (Pueblo to Fort Collins) is reducing Burrowing Owl habitat by reduction of black-tailed prairie dogs and their habitat. Furthermore, direct eradication of prairie dogs is eliminating available burrows and short vegetation preferred by Burrowing Owls. Sylvatic plague events in prairie dogs are causing at least temporary reductions in habitat (J. Slater, pers. commun.). Increased use of desert areas in the Grand and Uncompahgre Valleys in w. Colorado has increase disturbance at many historical sites (R. Levad, pers. commun.).

The Burrowing Owl is a Colorado Threatened Species with an increased fine for killing them, but there are no legal implications for habitat destruction. The Colorado Division of Wildlife recommends Burrowing Owl surveys before any land development occurs and recommends avoidance measures, but there is no legal requirement to follow these recommendations (J. Slater, pers. commun.).

Research in Colorado indicated that radiotelemetry transmitter packages have a significant impact on Burrowing Owl behavior. Telemetered adults spent significantly less time resting and alert, and more time out-of-sight of nest burrows (Plumpton 1992). Telemetered Burrowing Owls also had significantly lower productivity than non-telemetered Burrowing Owls (D. Plumpton, unpubl. data).

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Although a separate subspecies from the Western Burrowing Owl (A. c. hypugaea), a state summary for the Florida Burrowing Owl (A. c. floridana) is included in this document to provide complete information on the species in the United States. This state summary is an update of information included in Millsap (1996).

Florida

Summary: Burrowing Owls are a mostly resident species primarily from c. Florida southward, though many northerly breeding birds apparently retreat to s. Florida during winter. Some breeding occurs regularly as far north as Duval County (as of 1975) and as far west as Okaloosa County (Eglin Air Force Base, as of 1993) in the western part of the Florida Panhandle. During 1995, a pair of Burrowing Owls summered but did not successfully breed in Decatur County, Georgia, near the Florida border, representing the furthest north breeding season occurrence, presumably of the Florida subspecies.

The Florida and Bahamas breeding populations have been named a separate subspecies (*A. c. floridana*) from populations in w. North America and populations elsewhere in the West Indies and South America (Ridgway 1914, Clark 1997). However, questions have been raised regarding the validity of morphological criteria used to determine subspecies within Burrowing Owls (Millsap 1996), as well as the identification of some Florida specimens collected during winter as representative of *A. c. hypugaea*, which have been found throughout the state (Stevenson and Anderson 1994). One female examined by Millsap from the breeding population in Okaloosa County exhibited characteristics of populations from western North America (Stevenson and Anderson 1994). Millsap (1996) recommends reevaluation of Burrowing Owl subspecies based on modern systematic methods, and some preliminary work in this regard is underway (Denton et al. *In review*).

The earliest treatments of Burrowing Owls in Florida indicated that most were located in the central Peninsular counties where dry prairies were most prevalent (Osceola, Okeechobee and DeSoto counties) and in the Gulf coastal lowlands, with the Tampa Bay area near the center (Rhodes 1892, Howell 1932, Bent 1938, Millsap 1996). Burrowing Owls have declined precipitously in these "natural" habitats with the loss of Florida prairies since the late 1800's (Bent 1938, Nicholson 1954, Owre 1978, Abrahamsom and Hartnett 1990, Cox et al. 1994, Stevenson and Anderson 1994, Millsap 1996). However, the species appears to have expanded since the 1940's through to at least the 1970's by taking advantage of human altered situations (airports, some agricultural situations with dirt canal banks and road berms, and early stages of development).

BBS: No significant trends detected for Florida (Sauer et al. 2002). However, for the few routes where Burrowing Owls were consistently detected (10 out of 81 statewide; 7 out of 34 in Peninsular Florida and 2 out of 10 in Subtropical Florida), the tendency was for fewer detections over time, but this may not be reflective of true population trends. High numbers of Burrowing Owls in Florida are concentrated in developing areas which are not generally well represented on BBS routes.

CBC: Insufficient data is available for determining clear trends from Christmas Bird Count (CBC) data. Over a three-year period (1993-1996, as a sample), Burrowing Owls were detected in two years on 11 Counts and in one year on eight Counts, out of a statewide total of 53 each year. The vast majority of CBCs each year detected fewer than 15 Burrowing Owls (8 of 11, 9 of 11, and 6 of 8, respectively). Many well-known breeding sites consistently fail to detect any Burrowing Owls during winter indicating either seasonal movements or an inherent decrease of detectability from breeding to non-breeding seasons. This species becomes mostly nocturnal during winter (Stevenson and Anderson 1994).

Atlas: The Florida Breeding Bird Atlas is unpublished, but data collected from 1987 – 1991 provide relative recent distributional data statewide. Atlas data show the Florida Burrowing Owl occurring over a relatively wide area of the state, from Madison and Duval counties south to the middle Keys. Within this broad range, the species can best be considered local and spotty in distribution and dependent on the availability of suitable habitat. During the BBA period, Burrowing Owls were conspicuously absent from the extensive wetlands of the Everglades and Big Cypress areas of South Florida, from the Panhandle, and from much of the northeastern Atlantic Coast (since then they have been observed nesting on Eglin AFB in the Panhandle).

Research/Monitoring There is no statewide monitoring program for Florida Burrowing Owls. Several local monitoring efforts have been undertaken in suburban and ruderal areas where Burrowing Owls have recently become established. Through these local monitoring efforts, we know that populations in many such areas collapse soon after densely packed housing or other development dominates the landscape (Courser 1976, Consiglio and Reynolds 1987, Millsap 1996).

A long-term research project has been underway in Cape Coral in sw. Florida to better document the reasons Burrowing Owl populations become established in some developing areas and then collapse at some threshold of development. This research has been undertaken with the goal of establishing management recommendations for communities interested in the conservation of this species (Millsap and Bear 1997, 2000, Millsap 2002). Burrowing Owls prefer "neighborhoods" when over

25% of the area is in developed lots but start to collapse when development exceeds 60%, possibly irretrievably so when over 70% of the area is in developed lots. Millsap (2002), presents data that adult males, adult females, and juveniles respond differently to landscape features in terms of survival and emigration. This complex situation requires more study, but it appears that some desirable level of development through zoning may allow for reasonably large and stable Burrowing Owl populations to persist within urban-suburban landscapes.

Conservation Activities: Active education programs appear to be working in Cape Coral to reduce harassment, and resulting nest failure, of Burrowing Owls. Most documented harassment is linked to school-aged children. The implementation of a formal "mandatory" Burrowing Owl education program in Cape Coral public schools has coincided with increasing local nesting success (Millsap and Bear 2000; similar results in Broward County have been reported, Consiglio and Reynolds 1987). Millsap and Bear (2000) also suggested buffer zones be established by the City of Cape Coral or developers, which can be useful in shielding owls from disturbance where construction is underway during the nesting season. They suggested a minimum of a 10-m buffer may be effective, but larger buffers are likely better. Finally, they suggested the most important conservation actions municipalities may undertake is to develop conservation agreements with the managers of public facilities such as schools, athletic fields, churches, parks, libraries, and office building complexes that provide open grounds necessary for Burrowing Owl habitat.

Although Burrowing Owl populations using urban-suburban environments have received much recent attention, it is still necessary to conserve populations persisting in natural habitats, especially Florida's dry prairies. Cox et al. (1994) used a combination of Breeding Bird Atlas (Kale et al. 1992) information and overlay of existing dry prairie acreage to address the site protection needs for this and other dry prairie associated species. They concluded that the greatest opportunities to conserve natural habitat for Burrowing Owl specifically on already identified conservation areas included the Kissimmee Prairie region, with Avon Park Air Force Range, Audubon Kissimmee Prairie Preserve, Arbuckle State Forest, and Three Lakes State Wildlife Management Area. This region supports key sites maintaining a large viable population of Burrowing Owls within historically important habitats. Outside existing conservation lands, there are patches of native dry prairie that could also be important for linking all the region's potentially isolated subpopulations together if these sites receive long-term protection from conversion. The priority sites include patches between Avon Park Air Force Range and Lake Kissimmee and between Avon Park Air Force Range and Three Lakes State Wildlife Management Area. With these connections in place, this entire region could constitute one large Florida Burrowing Owl population (Cox et al. 1994).

Two other concentration areas exist, worthy of conservation attention (Cox et al. 1994). The Miami Ridge presently supports sizeable population of Burrowing Owls in se. Florida, but these largely agricultural lands are quickly progressing towards urban-suburban development. Experiences in other similarly developing areas like Cape Coral may be useful for conserving these populations into the future. The last large concentration area considered here is along the western shore of Lake Okeechobee, which includes patches of remnant dry prairie and expansive agricultural lands, both which can provide suitable habitat for Burrowing Owls (Abrahamson and Hartlett 1990). Working in cooperation with private landowners is essential to conserve these isolated prairie remnants and the species dependent upon them, including Florida Burrowing Owls (see also Cox et al. 1994).

Major Populations: Bowen (2000) conducted a metapopulation analysis of Florida Burrowing Owls, which identified eight major subpopulations and 59 metapopulations in Florida (Table A-3). All major subpopulations were in south Florida, but the population on Eglin Air Force Base in the Panhandle is probably large enough to warrant inclusion here. Other central and north Florida metapopulations were present in 26 counties, but these were generally small in size, probably isolated, and had high predicted probabilities of extirpation.

State Status: Species of Special Concern (Millsap 1996; ranked by Millsap et al. 1990, with a Biological Score of 24). Burrowing Owls and their nests are protected by Commission rules (Chapter 39, Florida Administrative Code) and federal rules promulgated under the Migratory Bird Treaty Act (16 U.S.C. 703-712). The Florida Fish and Wildlife Conservation Commission requires that a permit be obtained from the agency before a Florida Burrowing Owl nest burrow can be destroyed.

Natural Heritage Rank: G4/S3 (Rare and uncommon in the state, Florida Natural Areas Inventory 2001)

Habitat Use and Condition: Habitat is best defined as very open well-drained treeless country, with short grassy or herbaceous vegetation maintained by regular and frequent grazing, mowing, or burning. Soil needs to be of a quality for Burrowing Owls to easily dig and maintain burrows. Although burrows of gopher tortoises or large fossorial mammals are used occasionally, in Florida most burrows used are dug by Burrowing Owls themselves.

These requirements were met historically in Florida on the dry prairies of the central peninsula in the vicinity of burns and along the edges of wetlands during dry periods (Howell 1932, Bent 1938, Millsap 1996). Land clearing and extensive drainage of

Table A-3. Distribution and abundance of Florida Burrowing Owls by major subpopulation and county.

Subpopulation	County	Est. population size (no. adults)	Source
Wellington Aerofield and golf course	Palm Beach	63	Bowen (2000)
Boynton Beach subdivisions	Palm Beach	64	Bowen (2000)
Pompano Beach Airport	Broward	69	Bowen (2000)
Ft. Lauderdale Executive Airport	Broward	77	Bowen (2000)
Cooper City, Penbrooke Pines, Davie	Broward	189	Bowen (2000)
Punta Gorda	Charlotte	37	Bowen (2000)
Cape Coral	Lee	756	Bowen (2000)
Marco Island	Collier	47	Bowen (2000)
Eglin Air Force Base	Santa Rosa and Okaloosa	25	Millsap (pers. obs.)

wetlands have led to expansion of habitat especially since the 1940's. Burrowing Owls still occur in remnant patches of dry prairie, but even here they are more often than not associated with canal banks and road berms even in otherwise "natural" habitat. The above habitat conditions are also featured in pastures converted to non-native grasses, airports, golf courses, athletic fields, and partially developed residential and industrial areas where expanses of mowed lawn and ruderal grassland are maintained (Millsap 1996).

Threats: Continued loss of native dry prairie habitat is a serious threat to many endemic taxa in Florida, but cumulative loss of this habitat is mitigated for Florida Burrowing Owls to a degree as they make use of a variety of altered situations. However, these altered habitats may be exposed to increased use of harmful chemicals, increased presence of predators (including domestic as well as feral and native), human harassment, and in some areas fire ants. In developed areas, most documented mortality is associated with vehicular collisions (Mealey 1997, Millsap 2002).

Although there is good evidence that a moderate degree of development in some areas can support large Florida Burrowing Owl populations, too much development leads eventually to population collapse. Habitat set aside programs will be needed to ensure long-term persistence for most of these populations (Millsap 1996).

Millsap (1996) concluded that Florida Burrowing Owls did not appear to warrant further legal protection at that time, but recommended continued or expanded monitoring of local populations, especially in urban-suburban environments. The Florida Fish and Wildlife Conservation Commission will be collecting data to determine if current management actions are maintaining population numbers in Cape Coral, perhaps the most significant subpopulation.

Recommendation on Current Status for the Florida Burrowing Owl: Population trend data are lacking or insufficient for Burrowing Owls in Florida. Limited data indicate that it is decreasing in some areas, but also has stable or increasing populations in others. The Florida Burrowing Owl continues to occupy the majority of its historical range and may have expanded into new areas. However, historical and continuing loss and reduction of dry prairies and an unclear future of urban/suburban population centers are the primary threats to this subspecies in Florida.

Currently, the Burrowing Owl is listed by the USFWS as a Bird of Conservation Concern-2002 (U.S. Fish & Wildlife Service 2002) in the Peninsular Florida and Southeastern Coastal Plain Bird Conservation Regions and in the USFWS Region 4 (Southeast Region). This designation is intended to stimulate collaborative, proactive conservation actions among public and private land managers and other partners. Recommended conservation measures include efforts to more accurately monitor population demographics and trends, and to better understand factors affecting populations now concentrated in urban/suburban areas of Peninsular Florida.

The Migratory Bird Management program of the USFWS recommends retaining the Florida Burrowing Owl on the BCC lists on which it currently appears. The listing of the Florida Burrowing Owl as a Bird of Conservation Concern highlights its potential vulnerability and need for increased monitoring and conservation attention by multiple Federal and State agencies and private organizations. The success of these efforts will be reviewed every five years as the Birds of Conservation Concern list is revised (U.S. Fish & Wildlife Service 2002).

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Idaho

Summary: Burrowing Owls are a locally common summer resident in s. Idaho. The only evidence that the species ever occurred in n. Idaho is a statement by Merriam in 1891 that it was reported by Bendire as nesting at Fort Lapwai (Nez Perce County) (Burleigh 1972). Birds arrive in s. Idaho in early March and young have been observed near natal burrows as early as 10 June and as late as 17 September (Rich 1986). Populations are believed to be generally increasing (K. Steenhof, pers. commun.) Current distribution and relative abundance information has been well documented for several small scale study areas on the Snake River Plain and vicinity. James and Espie (1997) estimated 1,000 to 10,000 pairs in Idaho based on a survey of state wildlife agencies in 1992. Habitat loss and possible impacts to local populations from agricultural activities have been noted (Rich 1986, James and Espie 1997). However, the extent to which agriculture and other habitat disturbances have impacted Burrowing Owl populations is unknown as the species nests in close proximity to cultivated fields in the Snake River Plain, roadsides (Belthoff and King 1997), firing ranges (Lehman et al. 1999), and other disturbed areas in and around sagebrush-steppe habitat (Rich 1986).

BBS: Significantly increasing trends were detected for all survey periods: 1966-2001 (Trend = 19.1, P <0.07, n = 9); 1966-1979 (Trend = 39.2, P <0.03, n = 3), and 1980-2001 (Trend = 28.4, P <0.06, n = 9). Data credibility is low due to small sample sizes and high variance (Sauer et al. 2002).

CBC: N/A

Atlas: Historical and current records of Burrowing Owls in Idaho documented confirmed breeding in 12 out of 29 latilong blocks, predominantly in s. Idaho (Stevens and Struts 1991). Circumstantial evidence of breeding Burrowing Owls is recorded for two additional latilong blocks including the single historical account of a nesting pair in n. Idaho on Fort Lapwai, Nez Perce County as reported in Burleigh (1972).

Research/Monitoring Rich (1986) investigated vegetative and topographical characteristics around 80 occupied Burrowing Owl nest sites in the sagebrush-steppe of sc. Idaho. Burrowing Owls used burrows provided by badgers in open soil. In small lava outcrops, Burrowing Owls exhibited a preference for burrows excavated by yellow-bellied marmots. Cover within a 50-m radius of 80 occupied burrows was mainly bare earth, cheatgrass, rock, and annual forbs. In comparison to randomly chosen sites, occupied sites had a greater cover of cheatgrass, greater habitat diversity, were lower in elevation, and were more frequently located on southerly aspects. Occupied sites had less acreage of farmland and big sagebrush compared to unoccupied sites. Burrow security and prey availability, especially the proximity to populations of montane voles on farmland, may explain some of the habitat selection observed (Rich 1986).

Gleason and Johnson (1985) found that 75% of the nesting pairs used burrows excavated by badgers and the remainder occupied natural cavities in lava flows. Density was 1 pair/58 km^2. Average productivity was 3.6 young/nesting pair. Weather and diet influenced productivity with average productivity in a normal precipitation year (1976) and low productivity during drought (1977). Of 22 mortalities (two nestlings, 15 juveniles, and five adults), six (27%) were from vehicle collisions. Badger predation was presumed to be significant prior to emergence of young from nest burrows, but most mortality occurred after fledging when young were most likely vulnerable to starvation. Gleason and Johnson (1985) also found large portions of the study area lacked Burrowing Owls apparently due to factors other than the availability of nest sites.

Lehman et al. (1998, 1999) studied 235 Burrowing Owl nesting attempts between 1991-1994 on the Snake River Birds of Prey National Conservation Area (SRBPNCA), in sw. Idaho. Nest success was studied in relationship to disturbance caused by military training activities in the Orchard Training Area (OTA) in the SRBPNCA. There were no significant differences in nest success between nests located within versus outside of the OTA. Since most military activity occurred after Burrowing Owls established nesting areas and laid eggs, Lehman et al. (1999) suggested that military activity did not play an important direct role in the distribution of raptor nests in the OTA. Furthermore, direct impact to nests was restricted to a relatively small proportion of nesting pairs each year. If confirmation of nesting is made when young emerge from burrows, Mayfield estimates of nest success are likely to be inflated as they were in this study (100%, as all nests found at this stage were successful). Other methods of estimating nest success yielded lower estimates (64-71%, Lehman et al. 1998). Rate of nest reoccupancy in this study was 11% from 1991 to 1992, and 42% from 1993 to 1994.

In sw. and sc. Idaho, Belthoff and King (1997) reported nest success was 94.4% with 4.6 ± 1.8 young/nest in the Kuna Butte area (Ada County) and 92.9% with 5.1 ± 2.4 young/nest the Grand View area (Elmore County). Radio-tagged Burrowing Owls dispersed an average of 1.4 km from natal burrows during the post-fledging period (Belthoff et al. 1995).

Turnover of individuals in the Kuna Butte area appeared to be relatively high based on low rates of return by both adults and young. Of 52 nestling Burrowing Owls banded in the Kuna Butte study area in 1995, two (one male, one female) were detected in the area in 1996. These owls bred 1.8 and 4.8 km from their natal burrows. Of five adult males banded as breeders during 1995, two returned in 1996 and used the same burrows but acquired

different mates. Of 14 adult females banded in 1995, two returned to breed in 1996 and used burrows 106 m and 503 m from their 1995 burrows. Mate retention was uncertain with these females. Belthoff and King (1997) felt the difference in return rates between adults was a result of greater female dispersal rather than increased mortality.

Individual burrows were frequently reoccupied in multiple years (Belthoff and King 1997). Of 30 known nest burrows in 1994-95, 50% were reused in a subsequent year. Five burrows were used for nesting in all three years of study and nine others were used for at least two years. Of 10 burrows that fledged young in 1994, 70% were reused at least once. Conversely, burrows tended to remain unoccupied in years following nest failures; six nests remained unused in 1995-96 after failing in 1994 (Belthoff and King 1997).

In another study of nest reoccupancy, Rich (1984) found that 69.4% of previously documented nest burrows were reoccupied. Burrows in rock outcrops were reused 57.5% of the time compared to 31.4% for nests in soil mounds. Outcrop sites also were used more often in consecutive years; 23 were used for two years, and 12 were used for three consecutive years. Fifteen mound nests were used for two years, five were used for three years, and one was used four consecutive years. Greater reuse of outcrop sites was likely related to security; no burrows in outcrops were destroyed while 26 old badger burrows containing nests were filled in by plowing, cattle trampling, drifting sand, dredging, and other unknown causes (Rich 1984). It was unclear why some burrows were not used more regularly, as the changing of burrows could not be attributed to burrow characteristics or to changes in the surrounding habitat. Regardless of an abundance of burrows in suitable habitat, some Burrowing Owls apparently relocate from year to year.

Major Populations: Rich (1986) documented 242 occupied Burrowing Owl nests between 1976-83 in sc. Idaho. Lehman et al. (1999) documented 235 Burrowing Owl nest attempts between 1991-94 on and near the OTA, also on the SRBPNCA. In sw. Idaho (Ada and Elmore counties), Belthoff and King (1997) located 30 Burrowing Owl burrows in 1994-1995. In se. Idaho, Gleason and Johnson (1985) found average densities of 1 pair/58 km^2.

State Status: Protected Nongame Species. No person shall take or possess protected nongame species including nests and eggs at any time or in any manner, subject to fine and possible imprisonment (Idaho Statutes 36-1102 & 36-1402). Habitat protection is not included in State protection law.

Natural Heritage Rank: G4/S3S4 (S3—rare and uncommon in the state, S4—widespread, abundant, and apparently secure in state, with many occurrences, but of long-term concern).

Habitat Use and Condition: On the SRBNCA, 77% of Burrowing Owl nest sites had farmland within a 693 m radius (Rich 1986). Hay was a common crop and variation in cutting dates made rodents readily available throughout the Burrowing Owl breeding season.

Sagebrush is an important habitat type on occupied sites along the Snake River; however, continuous stands of dense sagebrush (10-35% canopy cover) were not occupied by Burrowing Owls (Rich 1986). Also in s. Idaho, 30 of 36 occupied Burrowing Owl nests were located within l00 m of sagebrush (Rich 1986).

Belthoff and King (1997) found that fires did not adversely affect Burrowing Owls in their study area. All nest sites which burned in 1995 were reoccupied in 1996. Several additional burrows within burned areas (but with unknown histories) were occupied by Burrowing Owls in 1996. The fires did not cause direct mortality of adult or juvenile Burrowing Owls (already of fledging age). These owls were repeatedly observed at burned sites for several weeks after fires. Also, juvenile owls from other families dispersed into burned areas immediately following fires in 1995 (Belthoff and King 1997).

Burrowing Owls in sw. Idaho nested in sites close to roads and agricultural fields, and in areas containing exotic plant species such as cheatgrass, tumble mustard, and annual wheatgrass (Belthoff and King 1997). Rich (1986) found that cover within 50 m of the burrows indicated that sites had been disturbed by fire and grazing. However, the dominant plants were not indicative of the highest degree of disturbance possible in sagebrush-steppe habitats (Rich 1986).

Threats: Invasion of shrubby species may contribute to population declines (Rich 1986). Belthoff and King (1997) noted nest burrows destroyed by agriculture and fire rehabilitation. Natural habitat has decreased due to increasing use of irrigation and the growing importance of agriculture in the state (Burleigh 1972). Soil mound nests were destroyed by plowing, cattle trampling, drifting sand, dredging, and other unknown causes (Rich 1984).

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Iowa

Summary: Northwest Iowa is on the eastern edge of the Burrowing Owl range. There is little to suggest that this species was ever common; the pattern of occurrence suggests periods of range expansion and regression. Some birds nested in the 1960s and 1980s (Dinsmore et al. 1984). Tallgrass prairie in the pre-settlement era was likely too dense for Burrowing Owls. To date, most records have been in pasturelands (J. Dinsmore, pers. commun.).

BBS: N/A

CBC: N/A

Atlas: Only a single record for the Burrowing Owl was reported (J. Dinsmore, pers. commun.).

Research/Monitoring Monitoring is restricted to reports from birdwatchers and incidental observations by biologists. No database for records is known. Not actively monitored by Iowa Department of Fish and Wildlife personnel (D. Howell, pers. commun.).

Conservation Activities: None reported.

Major Populations: None.

State Status: Placed in original Threatened list in 1977 due to low abundance; removed and designated Accidental Breeder in 1994 (D. Howell, pers. commun.).

Natural Heritage Rank: G4/SAB (Accidental breeder)

Habitat Use and Condition: Burrowing Owls are found in grasslands and pastures (Dinsmore et al. 1984). Pasturelands are preferred over ungrazed tallgrass prairie due to excessive cover on the latter. Most native prairie is under intense rowcrop agriculture, and is unsuitable, but no records exist to indicate the species was ever common.

Threats: Remnant tallgrass prairies provide unsuitable habitat due to excessive cover. Potential Burrowing Owl habitat has been lost to rowcrop agriculture (J. Dinsmore, pers. commun.).

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Dinsmore, J. J., and T. H. Kent, D. Koenig, P. C. Peterson, and D. M. Roosa. 1984. Iowa Birds. Iowa State University Press, Ames, Iowa.

Kansas

Summary: Little data regarding Burrowing Owls in Kansas is available. Reports indicate it was "abundant" and "common" in the late 1800s in c. and w. Kansas. Burrowing Owls are currently considered uncommon summer residents in w. Kansas, but may be common in local areas. Prairie dogs have been nearly extirpated from many counties in c. Kansas, and sightings of Burrowing Owls are very localized. State agencies in 1992 reported the Burrowing Owl populations as between 100 and 1000 pairs, but decreasing due to reduced burrow availability (James and Espie 1997); however, this population estimate is disputed and believed to be in the 1,000 to 10,000 pair category (W. Busby, pers. commun.).

BBS: No significant trends were detected over any survey period (Sauer et al. 2002).

CBC: N/A

Atlas: Burrowing Owls were confirmed in 46 blocks, with probable and possible breeding occurring in 29 and 25 blocks, respectively (Fig. A-4). Burrowing Owls were observed only in the western half of the state where occurrences generally coincided with remaining areas of shortgrass prairie (Busby and Zimmerman 2001).

Research/Monitoring Burrowing Owl research and monitoring in Kansas is limited to natural history accounts and the Breeding Bird Survey which is too imprecise to detect population trends in this state.

Conservation Activities: None documented.

Major Populations: Burrowing Owl populations are highest in the shortgrass prairie region of Kansas. One of the state's largest populations is at Cimarron National Grassland in southwestern Kansas (W. Busby, pers. commun.).

State Status: No special status designated.

Natural Heritage Rank: G4/S3B, SZN (rare and uncommon breeding populations in the state, no non-breeding occurrences).

Habitat Use and Condition: Not reported.

Threats: Prairie dog populations and associated Burrowing Owl habitat appear stable although at levels far below historic levels. In the long term, increases in prairie dog populations are needed to create more Burrowing Owl habitat (W. Busby, pers. commun.).

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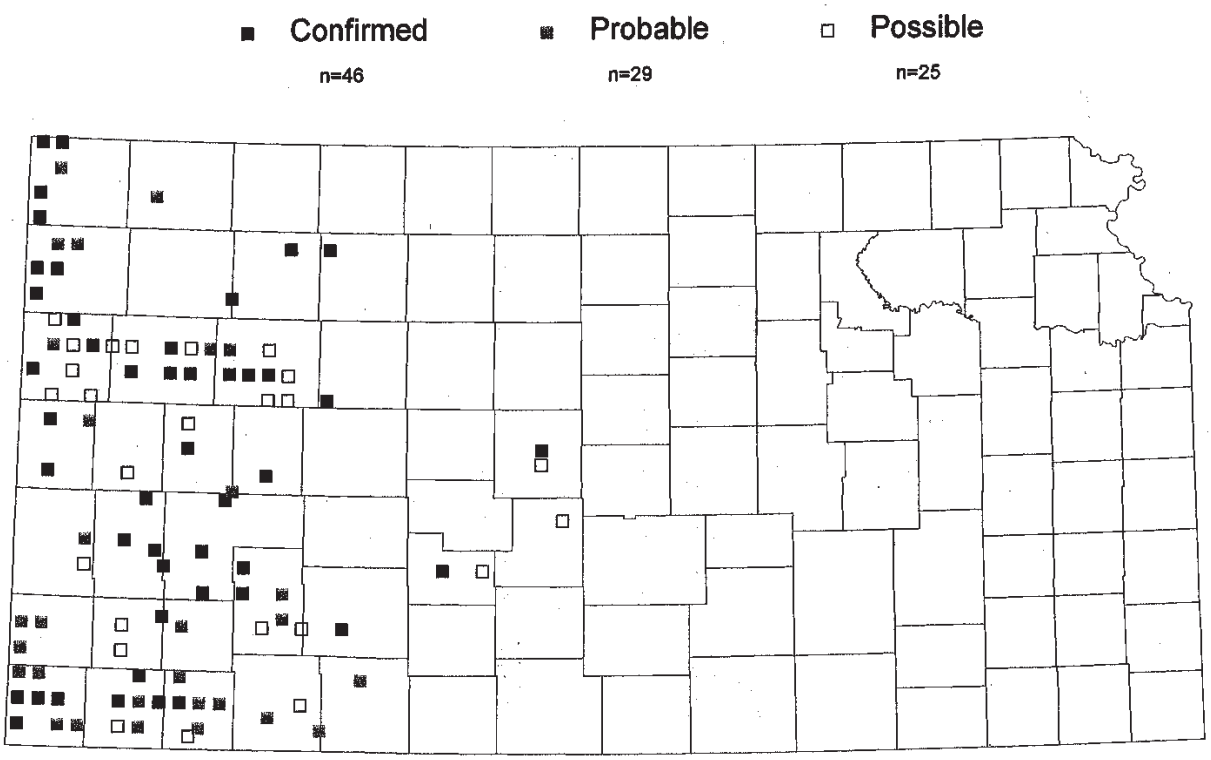

Fig. A-4. Distribution of Burrowing Owls in Kansas from the Kansas Breeding Bird Atlas project (Busby and Zimmerman 2001).

Minnesota

Summary: The Burrowing Owl was a regular to common breeding bird in the prairies of w. Minnesota in the first half of the century, but began to decline between approximately 1940 and 1960. The Burrowing Owl is now considered a very rare or casual resident in the sw. and wc. regions. Only ten documented breeding records exist from 1965-1985 (Janssen 1987, Martell et al. 2001). Reintroduction attempts from 1986-90 were unsuccessful; no returning Burrowing Owls were found in the years subsequent to release. Also, no successful natural nests were documented in 1992-98, despite significant efforts to locate the species (Martell et al. 2001).

BBS: N/A

CBC: N/A

Atlas: Unknown

Research/Monitoring Martell et al. (2001) located 13 natural nests at eight sites in Rock, Pipestone, Travers, and Yellow Medicine Counties, Minnesota during 1986-1990. Mean reproductive success was 3.54 young/pair. Nesting habitats included alfalfa fields (37.5%), pasture, (37.5%), roadside ditch (12.5%), and fenceline (12.5%).

During 1986-1990, 105 pre-flight juvenile Burrowing Owls were released (9 in 1986, 18 in 1987, 21 in 1988, 27 in 1989, and 30 in 1990). Eight fledgling mortalities were documented in the release area. No individuals were relocated after leaving the hack site and no successful nesting attempts were documented 1991-1998 (Martell et al. 2001).

Conservation Activities: Reintroduction of Burrowing Owls was attempted within the historic range in w. Minnesota from 1986-90 (Martell et al. 2001) but discontinued since no owls returned to breed in subsequent years. Land management reported in Martell et al. (2001) focused on protection and enhancement of nesting sites. Landowners were encouraged to maintain fields used by nesting Burrowing Owls in current rotations (e.g., alfalfa) or to enroll those fields in federal agricultural set-aside programs. In 1989, 24 artificial nest burrows were installed near natural burrows to provide alternate nest sites for returning pairs of owls or their offspring. One pair of owls nested and fledged seven young from an artificial burrow the year after their natural burrow collapsed. The artificial structure was located in the same field, approximately 40 m from the original burrow (Henderson 1984, Martell et al. 2001).

No management or research is currently planned beyond protection under current state and federal legislation (e.g., Migratory Bird Treaty Act, Minnesota Endangered Species Act). Should this situation change, habitat protection, management, and public education and cooperation will remain important. Selective use of reintroductions may also be useful in enhancing these efforts (Martell et al. 2001).

Major Populations: None. The Burrowing Owl is considered a very rare or casual resident in the sw. and wc. regions of Minnesota.

State Status: Endangered

Natural Heritage Rank: G4/S1 (Critically imperiled because of extreme rarity or other factor making it especially vulnerable to extirpation)

Habitat Use and Condition: In Minnesota, Burrowing Owls typically select heavily grazed pasture or mixed-grass prairie with colonies of Richardson's ground squirrels (Coffin and Pfannmuller 1988). Martell et al. (2001) reported nesting Burrowing Owls in alfalfa fields, suggesting some potential adaptability to agricultural habitats. Loss of pastures and prairies in western Minnesota has been a factor in the decline of Burrowing Owls in the state. However, some seemingly suitable habitat remains unused.

Threats: Loss of prairie and pasture habitats represent the primary threat to Burrowing Owls in Minnesota (Grant 1965, Martell et al. 2001).

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Montana

Summary: The Burrowing Owl is a rare breeder in Montana. The majority of confirmed Burrowing Owl breeding records are east of the continental divide in association with black-tailed prairie dog and Richardson's ground squirrel colonies. Breeding west of the continental divide is probably associated with badger-enlarged Columbian ground squirrel burrows.

Marti and Marks (1989) reported the Burrowing Owl as common in Montana with a stable population trend from 1977-86. However, no records for number of nesting pairs or number of nest sites were reported. Based on a survey of state wildlife agencies, James and Espie (1997) estimated 100 to 1,000 pairs of Burrowing Owls in Montana in 1992 with a stable population trend. Atkinson (2000) estimated 644 ± 114 Burrowing Owl pairs in known prairie dog colonies in Montana.

BBS: No significant trends were detected over any survey period (Sauer et al. 2002).

CBC: N/A

Atlas: No atlas available. The Montana Bird Distribution shows evidence of breeding in 25 latilongs and indirect evidence in an additional 13 latilongs between 1991-95 (Fig. A-5). Nonbreeding observations encompass another 7 latilongs and there were no records of Burrowing Owls in 2 latilongs (Montana Bird Distribution Committee 1996).

Research/Monitoring Atkinson (2000) derived an estimate of Burrowing Owl population size through analyses of the one-stage stratified random sample obtained from surveys in 1999. Surveyors detected 474 owls with at least 123 pairs; occupancy rate was 38.2% (78 of 204 colonies). Atkinson (2000) estimated the Burrowing Owl population size at 644 ± 114 pairs in known prairie dog colonies in Montana. As supporting evidence, Atkinson (2000) estimated 819 pairs by direct extrapolation of the pair density (123 pairs / 10,079 acres) from surveyed colonies to the known colony acreage statewide (67,080 acres). In identical fashion, he estimated 787 pairs by extrapolating 123 pairs / 209 colonies to 1,337 known colonies. Atkinson (2000) stated that c. Montana, the Charles M. Russell National Wildlife Refuge (NWR), the Custer area in Custer and Prairie counties, s. Chouteau County, and Phillips County were adequately sampled. Parts of Wheatland County, the Northern Cheyenne and Fort Belknap reservations, and Rosebud and s. Custer counties were not adequately sampled in 1999.

A population estimate of 864 Burrowing Owl pairs was derived for four study areas in eastern Montana (Fort Belknap Reservation, South Phillips County, Custer Creek, and Northern Cheyenne Reservation. Restani et al. (2001) documented one Burrowing Owl pair/110 ha of prairie dog town habitat in southeastern Montana in 1998. Prairie dog towns occupied by Burrowing Owls were similar in size to unoccupied towns and no selection was demonstrated for or against towns subjected to recreational shooting or grazing. Occupied nests were closer to active prairie dog burrows than random locations; otherwise Burrowing Owl nest sites were not different than random sites in numerous habitat characteristics (Atkinson 2000, Restani et al. 2001).

Mean Burrowing Owl productivity was 2.6 ± 0.4 young/pair (n = 13) and was not correlated with number of active or inactive burrows, total number of burrows, or town size (Restani et al. 2001). Productivity was not influenced by recreational prairie dog shooting (2.3 young/pair on shot towns; 2.9 young/pair elsewhere).

Prairie dog towns were similar in size and mean burrow density in 1991 and 1998; however, total acreage of prairie dog habitat increased slightly (Restani et al. 2001). Burrowing Owls were present at 16% of prairie dog towns surveyed in 1998 compared to 4% in 1996 (Wittenhagen and Tribby 1996), 14%, in 1991 (Richardson and Tribby 1991), and 27 % in 1978-79 (Restani et al. 2001, Knowles *In review*). Restani et al. (2001) felt the low density of breeding owls, high nearest neighbor distances, and abundant unoccupied habitat suggested the Burrowing Owl population was well below carrying capacity on their study site in southeastern Montana.

Conservation Activities: Indicator colonies will be selected and surveyed on a yearly basis for long-term trends and distribution in addition to randomly selected sites (Atkinson 2000).

Major Populations: Montana's largest prairie dog complex occurs in Phillips and Blaine counties and appears to contain Montana's largest Burrowing Owl complex (currently ~11,336 ha (28,000 ac). Prairie dog colony acreage in this complex appeared to peak in the early 1990s (~21,457 ha (53,000 ac)) (Knowles *In review*).

State Status: Species of Special Concern

Natural Heritage Rank: G4/S3B, SZN (rare and uncommon breeding populations in the state, no non-breeding occurrences).

Habitat Use and Condition: Black-tailed prairie dogs and Richardson's ground squirrel colonies comprise the primary and secondary habitats of Burrowing Owls in Montana. These species are found exclusively east of the Continental Divide and therefore most confirmed Burrowing Owl breeding records are also east of the Divide (Knowles *In review*). Most Burrowing Owls records from west of the Continental Divide are probably associated with badger-enlarged holes in Columbian ground squirrel colonies (Knowles *In review*).

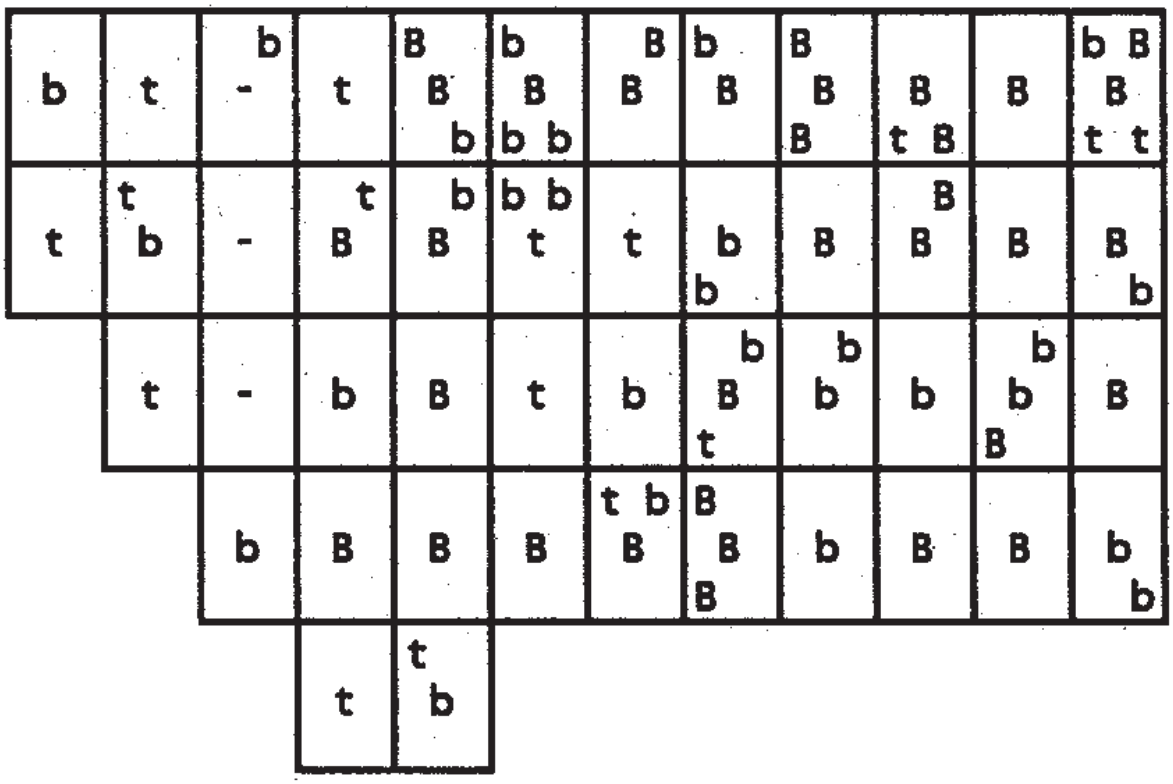

Fig. A-5. Latilong distribution of Burrowing Owls in Montana. B = direct evidence of breeding, b = indirect evidence of breeding, t = species observed, but no evidence of breeding (Montana Bird Distribution Committee 1996).

Most occupied prairie dog habitat in Custer and Harris Creek watersheds (southeast Montana) was on private land (65%), followed by federal (30%) and state lands (5%) (Restani et al 2001). Average town size was 11.0 ± 1.9 ha and 17.3 ± 5.3 ha on private and public lands, respectively. Fifty-four percent of breeding Burrowing Owls were on private land, 23% on state, and the remaining 23% on federal lands.

On the Charles M. Russell NWR in e. Montana, prairie dogs were limited to 283 ha (700 acres) in 1964 (the end of intensive eradication efforts; B. Haglan, pers. commun.). In 1974 prairie dog acreage was 1,807 ha (4,464 acres) and in 1979 acreage had increased to 2,504 ha (6,185 acres). Prairie dog surveys were conducted on the Refuge in 1983, 1988, 1993, and 1997, but data were not reported (Knowles *In review*).

Montana's prairie dog population has declined by 90% or more the 20th century (Flath and Clark 1986). The loss of prairie dogs due to systematic control resulted in a corresponding decline in Burrowing Owls up through at least 1972 when poisoning by the U.S. Fish and Wildlife Service's Animal Damage Control ended on private and public lands (Knowles *In review*). Approximately half of Montana's remaining prairie dog acreage has been lost during the past decade primarily due to plague (Knowles *In review*). Additional impacts identified for this period included recreational shooting, poisoning, and agricultural land conversions (Knowles *In review*).

Threats: Rodent poisoning, plague, and habitat conversion to cropland have reduced and fragmented prairie dog town habitat in Montana (Flath and Clark 1986). Montana's state agricultural agencies consider prairie dogs vertebrate pests and require systematic suppression (Restani et al. 2001), thereby reducing Burrowing Owl habitat.

Recreational shooting on Montana's prairie dog colonies has the potential to cause direct illegal mortality of Burrowing Owl. Anecdotal data suggests that owls are being shot but the significance of this problem remains undocumented (Knowles *In review*). Restani et al. (2001) found no evidence of Burrowing Owl mortality related to recreational shooting; however, they felt it may disrupted daytime foraging activity of adults. Prairie dog shooting may leave prairie dog carcasses on the surface with significant concentrations of lead, which may be ingested by Burrowing Owls (Knowles *In review*).

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Nebraska

Summary: Burrowing Owls regularly nest in the western two-thirds of Nebraska. Loss of prairie habitat and prairie dog declines have reduced available nesting areas, especially in the eastern part of the state (Ducey 1988). James and Espie (1997) estimated 100 to 1,000 pairs of Burrowing Owls in Nebraska in 1992. The population trend was thought to be decreasing due to habitat loss and pesticide use (James and Espie 1997).

BBS: No significant trends were detected for any survey period (Sauer et al. 2002).

CBC: N/A

Atlas: The Burrowing Owl was previously a common breeder throughout Nebraska; however, breeding is now restricted to the western two-thirds of the state where it is most abundant in the Panhandle (Fig. A-6). Rare observations occur in e. Nebraska, primarily during fall migration (Sharpe et al. 2001).

Research/Monitoring In w. Nebraska, breeding Burrowing Owl pairs declined 63% (91 to 34) from 1990-96 (Desmond et al. 2000). Owl numbers and density of active and inactive prairie dog burrows declined linearly between 1990-96. There was a time-lag in Burrowing Owl response to changes in burrow densities on several prairie dog colonies (Desmond et al. 2000).

Productivity from 1989-93 was low with 1.9 ± 0.1 fledglings/nest (Desmond et al. 2000). Few within-colony variables related to fledging success and a significant colony effect in all five years of productivity study indicated that factors influencing fledging success were at the colony scale. Predation by badgers was significantly lower in high density prairie dog colonies in three of seven years. In one of two years examined, successful nests had an average of 96 active prairie dog burrows within 75 m and unsuccessful nests had only 26 active burrows. This disparity in nesting success may be from enhanced detection of predators by prairie dogs, a dilution effect with abundant alternate prey, reduced vegetation height allowing increased visibility of predators, or presence of alternate burrows for brood dispersal (Desmond et al. 2000).

In w. Nebraska (Banner, Box Butte, Morrill, Scotts Bluff and Sioux counties) Desmond and Savidge (1996) found 85 Burrowing Owl nests in 1989, 109 in 1990, and 103 in 1991. More Burrowing Owls were found in prairie dog communities than in areas with only badger burrows for nesting. Burrowing Owl densities declined between 1989-91 in small prairie dog colonies (<35 ha), but were relatively constant in large colonies (≥ 35 ha). As an indication of density and distribution, nearest-neighbor distance averaged 125 ± 5 m (n = 105, range 46–229 m) for Burrowing Owl nest clusters in large prairie dog colonies. Mean nearest-neighbor distance in small colonies was 105 ± 7 m (n = 118, range 11–434 m) and 240 ± 39 m (n = 20, range 58–588 m) for Burrowing Owls nesting in badger burrows.

Desmond and Savidge (1996) found that Burrowing Owl densities were inversely related to prairie dog town size, active burrow density, inactive burrow density, and total burrow density for at least one of the three years of study. This suggested that burrow availability was not a limiting factor for Burrowing Owls on prairie dog colonies, but they did note that nest sites may be limiting in pastures with only badger burrows. Total Burrowing Owl numbers were positively related to prairie dog town size, but were not related to active, inactive, or total prairie dog burrow densities (Desmond and Savidge 1996). Thus, prairie dog town size, rather than numbers of burrows, was important in determining owl densities and numbers in western Nebraska.

Desmond et al. (1995) hypothesized that if gregarious nesting by Burrowing Owls in prairie dog towns was a response to limited habitat, owl nests should be randomly or regularly distributed throughout the towns with nearest neighbor distance positively related to town size. Alternatively, given sufficient space and burrows, they felt that Burrowing Owls should exhibit a nonrandom spatial nesting pattern. Desmond et al. (1995) found random distributions for Burrowing Owl nests at densities of ≥ 0.22 nests/ha which related to prairie dog towns <35 ha in size. Conversely, Burrowing Owls at densities ≤ 0.20 nests/ha had clumped distributions (with only one exception) and were related to prairie dog towns ≥ 35 ha in size. Within small towns, the nearest neighbor distance between Burrowing Owl nests was positively related to town size; however, this relationship did not occur in large towns. Clumping did not appear to be related to prey abundance or precipitation rates since the spatial patterns of Burrowing Owl nests were similar across the years of study while environmental factors changed. These findings suggest that habitat was limiting on small prairie dog towns and the random distribution was a function of minimum space requirements by Burrowing Owls. Habitat did not appear to be limiting on prairie dog towns ≥ 35 ha, as evidenced by lower Burrowing Owl density, clumped distributions, and unoccupied areas of apparently suitable burrows (Desmond et al. 1995). This research further suggested that additional limiting factors, beyond burrow availability, are influencing Burrowing Owl populations in Nebraska, and perhaps elsewhere.

In w. Nebraska, Burrowing Owl chicks preferred to use active versus inactive prairie-dog burrows for satellite burrows (Desmond et al. 1995). The authors cited burrow maintenance by prairie dogs as the primary benefit; inactive burrows degraded quickly (1-3 yrs) and were unsuitable for Burrowing Owls. Family groups used 10 ± 1 (range 0-36) satellite burrows within 75 m of the nest. Twenty-nine broods preferred active satellite burrows, two broods used active burrows less than expected (both were in

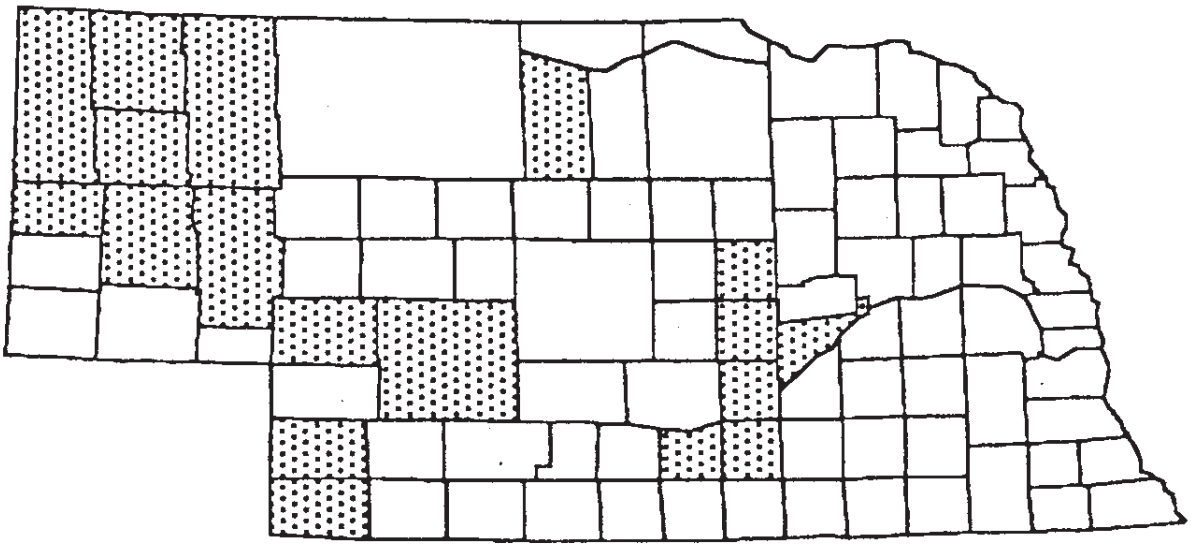

Fig. A-6. Distribution of Burrowing Owls in Nebraska, based on breeding evidence post-1960 (Ducey 1988).

areas with few active burrows due to poisoning), and 11 broods used active burrows in proportion to their availability. Furthermore, seven of the later category had nearly 100% of satellite burrows in active prairie dog burrows. Nine nest burrows had no active prairie-dog burrows within 75 m of the nest (Desmond et al. 1995).

Desmond et al. (1995) found that prairie dog activity in the vicinity of Burrowing Owl nests strongly influenced nest success and attributed this to predator avoidance through prairie dog alarm calls and the "dilution effect" where predators were more likely to target prairie dogs versus the owls. Successful Burrowing Owl nests had more active prairie-dog burrows within a 75-m radius of the nest burrow (Mean = 96 ± 5 m; n = 60) than unsuccessful nests (Mean = 26 ± 4 m; n = 104; Desmond et al. 1995).

Conservation Activities: None identified.

Major Populations: Desmond and Savidge (1996) found 85 Burrowing Owl nests in 1989, 109 in 1990, and 103 in 1991 in 21 prairie dog towns and 17 grassland pastures in Banner, Box Butte, Morrill, Scotts Bluff, and Sioux counties (western Nebraska).

Burrowing Owl surveys were conducted in Banner, Box Butte, Kimball, Morrill, Scotts Bluff and Sioux counties in nw. Nebraska. Of the 92 sites surveyed for prairie dog associates in May/June 2001, 67 contained Burrowing Owls (242 adult Burrowing Owls). Of the 67 Burrowing Owl locations, nine were off-colony sightings and generally only included one or two individuals. In only three of these cases were possible nest burrows observed (all appeared to be old badger or fox dens). The other Burrowing Owls may have been foraging individuals that had ventured far from their nest sites, though three were located in dense sagebrush habitat where ground burrows were difficult to detect (T. VerCauteren, pers. commun.). Sixty-one additional sites (171 individuals) were observed in Cheyenne, Garden, Keith, and Perkins counties by Z. Roehrs, University of Nebraska (T. VerCauteren, pers. commun.). The majority of these sightings were based on road-side counts and do not represent total populations.

State Status: None.

Natural Heritage Rank: G4/S3 (rare and uncommon in the state).

Habitat Use and Condition: Virtually no information was available on habitat condition. A small amount of habitat related research was conducted in western Nebraska by Desmond (1991); however, this thesis focused primarily on spatial relationships within prairie dog towns and badger burrow areas. The author found Burrowing Owls near both agricultural and range habitats. More nests were located in agricultural areas; however, there was no significant difference in numbers or density of Burrowing Owl pairs between the two habitat types.

Threats: Destruction of black-tailed prairie dogs is the primary threat to Burrowing Owls in Nebraska. Black-tailed prairie dog control in Nebraska in 1990-91 accounted for 50% of the reported prairie dog control activity nationwide, and Nebraska state law required prairie dog eradication on public and private lands until 1995 (Roemer and Forrest 1996, Desmond et al. 2000). Desmond and Savidge (1999) documented reduced burrow availability and increased predation rates in prairie dog town subjected to prairie dog control efforts.

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Nevada

Summary: Burrowing Owls breed throughout Nevada in salt desert scrub, Mojave shrub, and some sagebrush habitat, as well as in agricultural landscapes. It winters most frequently in the southern half of Nevada, but has been recorded throughout the state during all months (Herron et al. 1985). Local declines are noted where habitat is lost to development at the suburban fringe. For example observations suggest a decline of up to 50% in the Lahontan Valley since 1946 (Alcorn 1988). The statewide population was roughly estimated at 1,000 to 10,000 pairs in 1992, based on a survey of state wildlife agencies in 1992 (James and Espie 1997).

BBS: No significant trends were detected for any survey period (Sauer et al. 2002).

CBC: N/A. This species rarely winters in n. Nevada and sparingly in the s. part of the state.

Atlas: Confirmed or suspected breeding in nearly every county (Fig. A-7, Nevada Breeding Bird Atlas, unpublished data, T. Floyd, pers. commun.). No Atlas records for Mineral, Esmeralda, Douglas, Carson City, or Storey counties.

Research/Monitoring Burrowing Owls were intensively monitored on the Nevada Test Site (NTS) in sc. Nevada from 1996-2001 (Hall et al. *In review*, Steen et al. 1997). Three main ecoregions are recognized on the NTS: Great Basin Desert (Great Basin), Mojave Desert (Mojave), and a transitional ecoregion between the two deserts (transition). A total of 114 Burrowing Owl locations, including 84 burrowing sites and 30 sighting locations, were documented on the NTS for a density of 2.4 Burrowing Owls burrows/100 km^2. Sixty-two locations (54%) occurred in the transition, 37 (33%) occurred in the Mojave, nine (8%) occurred in the Great Basin, and six (5%) were at historic, unspecified locations. Most of the locations occurred in areas with disturbances containing partially buried metal culverts and pipes, relatively deep washes with defined banks, mounds of dirt or excavations, or roadcuts.

A total of 19 nest burrows were documented using camera systems from 1999-2001. Breeding was detected during at least one of the three years at 15 sites (10 in transition, 3 in Mojave, two in Great Basin). Breeding during two of the three years occurred at three sites (two in transition, one in Great Basin), and at one site (transition) breeding occurred during all three years. Nest burrows were predominately in metal culverts or metal or plastic pipes. Two nest burrows were in washbanks, two in man-made dirt mounds, two in roadcuts, and one in a desert tortoise burrow (Hall et al. *In review*, Steen et al. 1997).

A total of 26 breeding pairs and 122 young were detected over the three-year period. Seven, eight, and 11 breeding pairs and 24, 43, and 55 young were detected during 1999, 2000, and 2001, respectively. The average number of young per breeding pairs during the entire period was 4.7 (s.d. = 2.0, n = 26). The average number of young per breeding pair by year was 3.4 (s.d = 1.6, n = 7), 5.6 (s.d. = 1.6, n = 8), and 5.0 (s.d. = 2.1, n = 11) during 1999, 2000, and 2001, respectively. The average number of young per breeding pair by ecoregion was 5.0 (s.d. = 1.8, n = 19), 4.5 (s.d. = 3.1, n = 4), and 3.0 (s.d. = 0, n = 3) in the transition, Great Basin, and Mojave, respectively. Twelve (42%) nesting burrows produced young during two or more years between 1999 and 2001. There appeared to be a relationship between the number of young per breeding pair and the amount of precipitation received during the previous October to March. Young were detected between mid-May and early-September. The local population trend appears to be stable. The increase in number of breeding pairs is due to finding new burrows over the three years and does not necessarily reflect a true increase in the population (Steen et al. 1997, Hall et al. *In review*).

Most of the known Burrowing Owls were monitored at least monthly November 1997–July 1998 and November 1998–December 2001. Burrowing Owls were found on the NTS year-round. Generally, Burrowing Owls wintered on the NTS in low numbers with a large influx around mid-March. Owl numbers fluctuated slightly during the spring and summer, increased slightly during September-October, and then steadily declined through late fall and early winter until they reached their lowest point, usually in January (Steen et al. 1997, Hall et al. *In review*).

Burrowing Owls on the NTS appeared to be quite tolerant of disturbance as measured by traffic counters and flushing distance to observers on foot and in a vehicle. Burrowing Owls successfully produced young with few to many vehicles (<1 to 488 per day) passing withing 10 to 269 m of a nest burrow. No apparent relationship was evident between the number of vehicles per day or distance to road and the number of young. Average flushing distance was approximately 31 m (n = 130) to an observer on foot and approximately 29 m (n = 79) to a vehicle (Steen et al. 1997, Hall et al. *In review*).

The Las Vegas Field Station of the U.S. Geological Survey, Biological Resources Division, in cooperation with the National Park Service will initiate a research study on Burrowing Owls at the Lake Mead National Recreation Area (NRA) in s. Nevada, scheduled to begin in 2002. The objective of the study is to determine distribution and abundance of Burrowing Owls inhabiting the Lake Mead NRA, to relate population abundance to environmental variables on a landscape scale to determine area of high to low Burrowing Owl densities, and evaluate reproductive success in relation to habitat and environmental variables (R. Williams, pers. commun.).

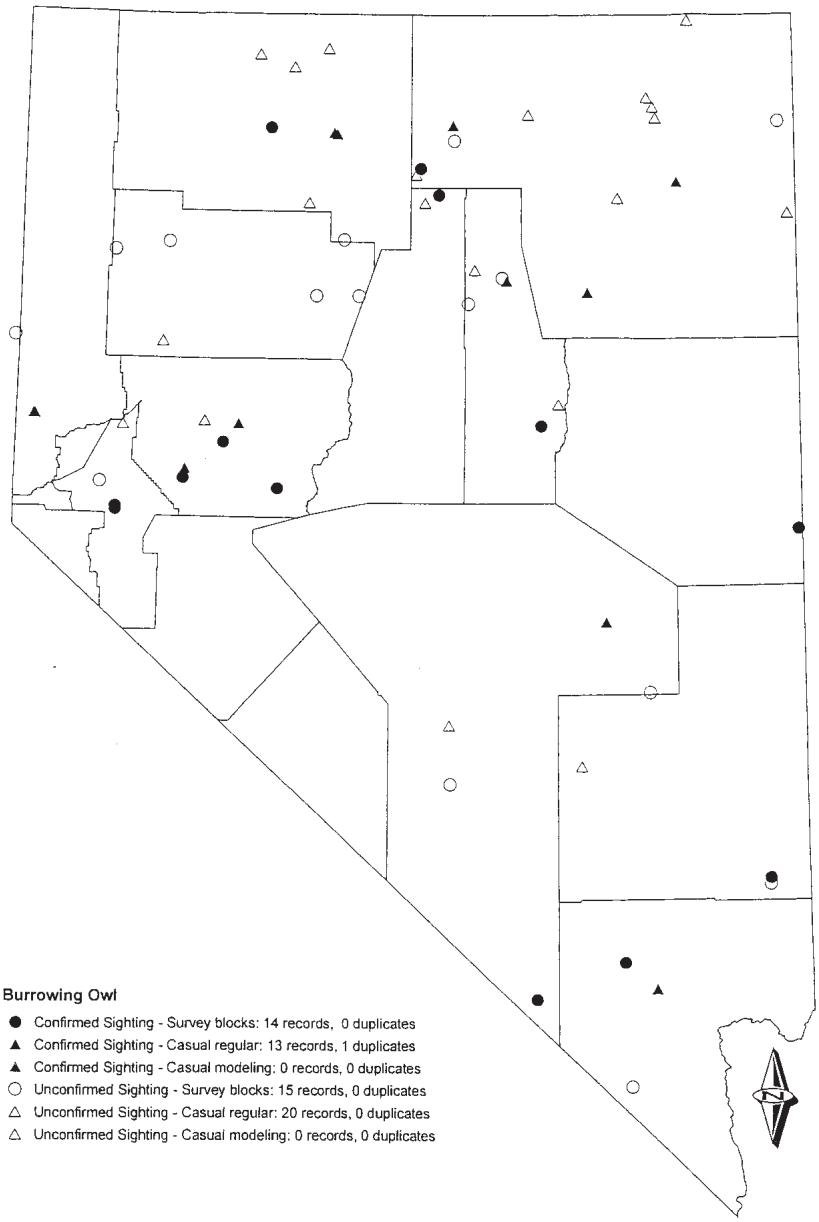

Fig. A-7. Distribution of Burrowing Owls in Nevada from the Nevada Breeding Bird Atlas project (Unpubl. data).

Conservation Activities: The Nevada Partners in Flight Bird Conservation Plan (Neel 1999) outlines conservation measures to improve conditions for Burrowing Owls in the State, and establishes a population objective, to stabilize Burrowing Owl populations by 2004, in each of the 3 habitat types used by Burrowing Owls in Nevada: Agricultural Landscapes, Mojave Scrub, and Salt Scrub.

The Nevada Breeding Bird Atlas proposes to predict the range and breeding locations of Burrowing Owls based on currently known breeding locations and on the distributions of vegetation types within the State. These projections may be used for conservation planning and, with ground-truthing, lead to further investigations of specific habitat conditions favorable for owls.

Major Populations: A total of 114 Burrowing Owl locations, including 19 nest burrows occurred on the NTS in sc. Nevada.

State Status: Species protected under Nevada Revised Statutes 501 and Nevada Administrative Code 503.

Natural Heritage Rank: G4/S3B (rare and uncommon breeding populations in the state).

Habitat Use and Condition: In Nevada, sparsely-vegetated habitats preferred by Burrowing Owls are predominantly found in the salt desert scrub habitat type, which occupies roughly 8.9 million hectares of valley bottoms within the Great Basin physiographic region. Sagebrush habitat was also occupied when artificial burrows were placed in moderately dense sagebrush communities. Burrowing Owls often breed around the fringes of agricultural lands and use crop and pasture lands for foraging during the breeding season. General habitat condition in many of the known nesting territories is poor. Excessive grazing by large ungulates does not seem to decrease nest site suitability, and may be preferred because of increased visibility. Burrowing Owls also nest in open urban areas with open space (e.g., golf courses, airport runways, and industrial areas) if burrows are available. Concrete slabs and other debris left at the old Stead Air Force Base north of Reno, inhabited by California ground squirrels, provided high density nesting habitat for over 40 years (Neel 1999).

Habitat condition of salt desert scrub varies with grazing and fire history. Indian ricegrass was likely much more prevalent historically in this habitat than it is today, and is an important plant for kangaroo rats, a key component in the ecology of this habitat and a prey item for Burrowing Owls. Indiscriminate livestock grazing over the 100-year period following European settlement has tipped the balance toward more durable shrubs, unpalatable forbs, and exotic annual grasses on vast tracts of salt desert scrub. Invasion of exotic plants such as cheatgrass, halogeton, Russian thistle, and in certain places, tamarisk has compromised native communities (Neel 1999). The effect of this type of habitat conversion on Burrowing Owls has not been measured.

Threats: In general, habitat loss is occurring due to agricultural cultivation and development. Development has placed nesting Burrowing Owls under increasing pressure near Reno, Carson City, and Minden-Gardnerville in particular (Neel 1999). Loss of native components and invasion of exotics in Nevada's shrub habitats may have negative implications for Burrowing Owls (see Habitat Use and Condition).

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New Mexico

Summary: Burrowing Owls are found in Great Basin shrub-steppe with open to dense stands of shrubs and low trees, including big sagebrush, saltbush, greasewood, or creosote bush. They are also found in Chihuahuan Desert scrub with open stands of creosote bush and large succulents, Mojave Desert scrub, annual grassland, and farms (New Mexico Dept. Game and Fish 2000). Numerous anecdotal accounts of distribution and relative abundance exist for New Mexico, but no quantitative data are available other than on small study sites. Based on a survey of biologists, James and Espie (1997) estimated 1,000 to 10,000 pairs in New Mexico in 1992 with a stable population trend.

BBS: A significant decline (Trend = –3.8, P <0.03, n = 6) was detected for the 1966-1979 subinterval. No other significant trends were detected. Moderate data deficiencies were noted (sample sizes <14, sub-interval trends significantly different from each other) (Sauer et al. 2002).

CBC: Detected on only three CBCs with regularity, with the largest numbers recorded at Las Cruces, the primary wintering area in the state. No detectable trend (Sauer et al. 1996), although local declines have been noted on the Roswell CBC, due probably to the elimination of a sizeable prairie dog town in that area.

Atlas: Commenced in 2000. Data not yet available.

Research/Monitoring: Botelho and Arrowood (1996) found Burrowing Owl pairs nesting in human-altered areas had significantly more nestlings and fledged significantly more young than pairs nesting in natural areas. They speculated that lower reproductive rates of natural-area pairs was due to increased inter-owl disturbance and/or to increased predation (Botelho and Arrowood 1996).

In 1996-97, Johnson et al. (1997) also found a predominance of nests in areas of heavy human activity on Holloman Air Force Base. Owls were attracted to these areas for a variety of reasons, including soil disturbance and insect-attracting lighting. They found 18 nest burrows in 1996 and 19 in 1997, for a total of 37 nests; 21 in areas of high disturbance and 11 in areas of low disturbance (five nests were not included in the analyses due to reoccupancy). The mean number of young fledged from all successful nests was 2.1 (range 1-4) in 1996 and 2.7 (range 1-5) in 1997. Nest success was 64% (n = 11) for 1996 and 77% (n = 13) for 1997. Nests in high disturbance areas were closer to high perches, closer to roads, further from shrubs, and had lower shrub cover than nests in low disturbance areas. Despite a preference to breed in these areas, and contrary to the findings of Botelho and Arrowood (1996), high rates of abandonment were noted in disturbed areas. Sixty-four percent of nests disturbed by human activity or natural events were abandoned. Of 11 nests disturbed by human activity alone, 55% (6) were abandoned (Johnson et al. 1997). Forty-five artificial burrows were installed on Holloman Air Force Base in 2000-2001 to replace natural burrows that had collapsed (C. Finley, pers. commun.).

Martin (1973) studied 15 breeding pairs of Burrowing Owls three miles south of Albuquerque, NM, in the Tijeras Arroyo and a railway cut in desert grassland. Burrowing Owls exclusively used rock squirrel burrows since no prairie dogs were present in the study area. Mean reproductive success was 4.9 young per pair. The lowest possible mean clutch size was 5.2 eggs based on 78 young seen.

Martin (1973) banded nine breeding males and nine females in 1970. Six males and two females returned in 1971. All returning males selected the same burrow they had inhabited in 1970, unless the burrow had been destroyed. Of banded birds, no pair combinations were retained in 1971, suggesting low intra-pair fidelity. It was unknown whether low female return rates were due to higher mortality or to lower site fidelity. Martin (1973) determined that few Burrowing Owls remained resident on the study area during winter. Fall departure was from August through September and earliest spring arrival was mid-March. Pair formation in some Burrowing Owls apparently occurred before arrival.

Hawks Aloft, Inc. has been monitoring breeding success in nests on Kirtland Air Force Base in Albuquerque since the late 1990's. Numbers declined significantly in 2000 and 2001 for unknown reasons (C. Finley, pers. commun.). Monitoring is continuing.

On Holloman Air Force Base, six of 18 (33%) nesting burrows were occupied by Burrowing Owls during the winter, in addition to two newly occupied winter burrows (Johnson et al. 1997). Similarly, most males and a few female Burrowing Owls overwinter at burrows they used for breeding on the campus of New Mexico State University in Las Cruces (Arrowood et al. 2000), while all fledglings leave the area. Few banded owls ever return to the study area. However, some owls return after several years of absence.

Arrowood et al. (2000) found that resident male Burrowing Owls produced more nestlings (mean = 3.5 ± 2.6) than migrant males (mean = 2.5 ± 1.9). Area-experienced females produced more nestlings than area-inexperienced females (mean = 2.2 ± 2.3). More nestlings were produced by resident males paired with area-experienced females than were produced by other pair types. Most females were migratory, although it is unknown what factors influence females to overwinter or to migrate.

Arrowood et al. (2001) reported that in some areas of New Mexico, Burrowing Owl populations were stable or increasing, although decreasing populations were reported in other areas. Stable and increasing populations were associated with the presence of suitable habitat and increased precipitation and food availability. Decreasing populations were associated with loss of suitable habitat, due to declining prairie dog populations and urban sprawl.

Conservation Activities: The New Mexico Burrowing Owl Working Group (NMBOWG) was formed in response to population declines at some sites in New Mexico (Hawks Aloft, Inc. 2002). The NWBOWG is a collaborative effort of non-profit organizations, government agencies, private enterprises and individuals. The goals of the working group are to (1) facilitate communication, (2) establish a statewide monitoring effort, (3) maintain a web page to educate the public, promote the NMBOWG, and provide on-line data forms, (4) promote the NMBOWG through public outreach, (5) develop a review committee to determine sighting accuracy, (6) enter sightings into a database and share the database with contributing organizations, (7) create a map showing general locations in New Mexico, (8) over time, determine the population trends of Burrowing Owls in New Mexico, and (9) develop conservation recommendations based on monitoring results. The NMBOWG currently supports on-going research projects at four sites: Holloman and Kirtland Air Force Bases, New Mexico State University, and the Turner Ranch. The NMBOWG has initiated a volunteer monitoring system to collect data on Burrowing Owl populations in the state (C. Finley, pers. commun., Hawks Aloft, Inc. 2002).

Major Populations: Burrowing Owls have been documented as permanent residents at the White Sands National Monument in Dona Ana and Otero counties (White Sands National Monument 1993), Grulla National Wildlife Refuge (USFWS 1994), Holloman Air Force Base (Mesilla Valley Audubon Society 1996), Gray Ranch in Hidalgo County (Black 1997), and the Las Cruces/New Mexico State University area (W. Howe, pers. commun.). Burrowing Owls are uncommon spring and fall migrants and common breeders at the El Malpais National Monument and National Conservation Area (Hvenegaard 1989), Sevilleta National Wildlife Refuge (USFWS 1992), and Fort Bliss (Fort Bliss Directorate of Environment 1995) (New Mexico Dept. Game and Fish 2000). A minimum of 475 Burrowing Owls were detected in sc. Quay county, Curry county, and n. Roosevelt County in 2002, where 63% of surveyed prairie dog colonies were occupied by Burrowing Owls (L. Sager and C. Rustay, pers. commun.). Kirtland AFB in Albuquerque has one of the largest populations of Burrowing Owls in New Mexico with 40-50 pairs present in some years.

State Status: No special designation.

Natural Heritage Rank: G4/S4B, S4N (widespread, abundant, and secure in the state, but of long-term concern during breeding and non-breeding seasons).

Habitat Use and Condition: The grasslands of southern New Mexico have been invaded by mesquite and creosote bush (Gardner 1951, York and Dick-Peddie 1960), reducing habitat suitability in much of this region.

Best (1969) studied Burrowing Owls in Dona Ana and Luna counties of south-central New Mexico from 1964-67, including nine colonies ranging from 9-19 birds. Burrowing Owls used a broad range of macro and micro-habitats. Single breeding pairs were found in small isolated areas of open habitat, and colonies were restricted to yucca grassland with burrows of banner-tailed kangaroo rats. The largest colonies found during the study were in areas occupied by cattle.

Fire affects Burrowing Owls by altering vegetation and prey base. Frequent fire can maintain or improve Burrowing Owl habitats by reducing plant height and cover around burrows and by controlling woody plant invasion. Periodic fire in grasslands probably increases prey diversity for Burrowing Owls, and may increase overall prey density (New Mexico Dept. Game and Fish 2000).

Threats: Prairie dog eradication, increased urbanization and human disturbance during the breeding season represent primary threats to Burrowing Owls in New Mexico (Arrowood et al. 2001).

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North Dakota

Summary: Burrowing Owl nesting was documented throughout North Dakota from the 1800s until the 1950s. From approximately 1950 to 1970, the range contracted and the species was no longer found in the eastern one-third to one-fifth of the state. From 1970 to 1999, the range further contracted and Burrowing Owls are currently rare north and east of the Missouri River. Literature reviews indicate no breeding records for e. North Dakota since the 1980s. James and Espie (1997) estimated 100 to 1,000 Burrowing Owl pairs in North Dakota with a stable population trend.

Extensive Burrowing Owl surveys from 1994-99 found very low occupancy rates at historically abundant sites (Murphy et al. 2001). Data sources are very current and reliable for trend information east and north of the Missouri River. West of the Missouri River the population trend is less clear, but is tied to the status of the black-tailed prairie dog, which has decreased significantly in recent decades.

BBS: A significant decline in Burrowing Owl relative abundance was noted for 1980-99 (Trend = –15.8, P <0.00, n = 9). No additional significant trends were detected. Data credibility is low due to small sample sizes and high variance (Sauer et al. 2002).

CBC: N/A.

Atlas: No breeding bird atlas is published for North Dakota. Stewart (1975) stated that Burrowing Owls were fairly common on the Northwestern Drift Plain; uncommon on the Missouri Coteau, Southwestern Slope, and Southern Drift Plain; and rare in the Agassiz Lake Plain and the Northeastern Drift Plain (Fig. A-8).

Research/Monitoring: Igl et al. (1999) compared Burrowing Owl abundance on 128 randomly selected plots (quarter-sections) from 1967 (Stewart and Kantrud 1972) and 1992-93 (Igl and Johnson 1997). Burrowing Owl frequency of occurrence on survey plots (% of plots with owls) did not change over the survey period; frequency was 1.6% in 1976 compared to 2.3% and 1.6% in 1992 and 1993, respectively. The statewide population estimate was 7,000 breeding pairs in 1967 compared to 7,000 and 5,000 pairs in 1992 and 1993, respectively.

Murphy et al. (2001) conducted three different Burrowing Owl surveys throughout much of w. and c. North Dakota between 1994-99. They (1) randomly sampled 20% of two intensive study areas in Divide and Kidder counties, (2) searched for Burrowing Owls within 500 m of 35 historic (1976-87) nesting areas in northwestern North Dakota, and (3) surveyed for Burrowing Owls in prairie dog towns on the Little Missouri National Grassland (LMNG; Billings, Slope, Golden Valley, and McKenzie counties of southwestern North Dakota). They found very few Burrowing Owls in random surveys of Divide County; the maximum density was 3.2 pairs/100 km^2 in 1998. The maximum density based on suitable habitat was 7.2 pairs/100 km^2. Also, no Burrowing Owls were detected during surveys of historic breeding areas throughout nw. North Dakota. They felt the decline in Burrowing Owl abundance in Divide County may be from loss of burrowing animals and grassland habitat. Due to the presence of what appeared to be unoccupied suitable habitat, Murphy et al. (2001) felt that additional factors may also be influencing Burrowing Owl populations in nw. North Dakota. Murphy et al. (2001) failed to locate Burrowing Owls during intensive random surveys of Kidder County in 1998, where the species was fairly common until the 1970s. Area resource staff noted declines in number of breeding Burrowing Owls since the mid-1980s. Burrowing Owls also have disappeared from Ward County in nc. North Dakota.

In 1991, De Smet et al. (1992) found Burrowing Owls at 45% of prairie dog towns surveyed on the LMNG, but felt the occupancy rate was underestimated due to poor survey conditions. Murphy et al. (2001) found Burrowing Owls at 39% of the same towns which were still active in 1996. Additionally, Burrowing Owls were detected on <50% of prairie dog towns during other spring and summer surveys (1998) reported in Murphy et al. (2001), despite anticipated higher detection rates for summer surveys

Murphy et al. (2001) also selected 10 prairie dog towns which had been documented as occupied by Burrowing Owls in 1991 (De Smet et al. 1992) for reoccupancy surveys in 1995-98. They found 5-7 of these were used by Burrowing Owls annually, and all but one town were occupied for more than one year. Higher occupancy rates of recently used prairie dog towns (<5 yr) indicate short-term site fidelity for the species. Non-use of available habitat within years may suggest the Burrowing Owl is below carrying capacity in North Dakota.

Conservation Activities: A program under the North American Waterfowl Management Plan and Ducks Unlimited exists to permanently protect native prairie through perpetual easements. This has some positive ramifications for Burrowing Owl habitat conservation but overlooks some important, historical owl habitats (R. Murphy, pers. commun.).

The U.S. Forest Service expects to implement a proposed Land and Resource Management Plan in the near future. The preferred alternative currently includes objectives to double prairie dog town acreage and protective measures for Burrowing Owl nest sites (D. Freed, pers. commun.).

North Dakota Game and Fish Department has solicited funding for compiling Burrowing Owl nesting records and provided financial assistance for the research conducted in Murphy et al. (2001) and to the Canadian Wildlife Service for a Burrowing Owl migration telemetry project (R. Murphy, pers. commun.).

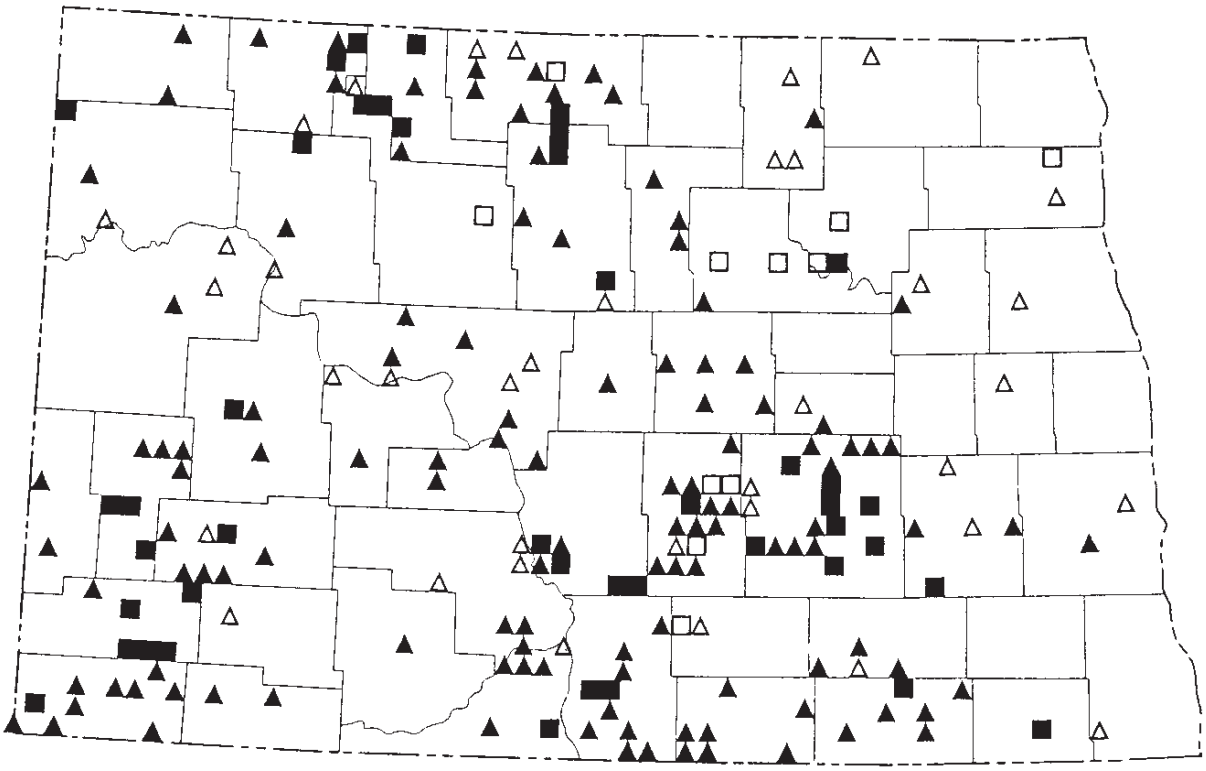

Fig. A-8. Distribution of Burrowing Owls in North Dakota, prior to 1972. Filled squares = nest or dependent young recorded from 1950 to 1972. Empty squares = nests or dependent young recorded prior to 1950. Filled triangles = territorial males or pairs recorded from 1950 to 1972. Empty triangles = territorial males or pairs recorded prior to 1950 (Stewart 1975).

Major Populations: Population estimate on the LMNG was 82 breeding pairs in 1999 (D. Freed, unpubl. data). Major populations also occur on tribal lands in Sioux County (Murphy et al. 2001).

State Status: No official state list for North Dakota.

Natural Heritage Rank: G4/SU (unrankable, possibly in peril in the state, but status not certain).

Habitat Use and Condition: Overall, about 75% of North Dakota mixed-grass prairie has been lost, primarily to agricultural cropland, with decreases being particularly great in the Drift Plain, the largest physiographic subregion in North Dakota (Samson and Knopf 1994, Murphy et al. 2001). Conversion of native prairie continues along with invasion of introduced and woody vegetation (Samson and Knopf 1994, Murphy et al. 2001). Burrowing Owls no longer occur on National Wildlife Refuges in North Dakota (Murphy et al. 2001) due to refuge management practices favoring tall, dense vegetation (Murphy 1993).

Burrowing Owls are closely associated with tracts of mixed-grass prairie that are heavily grazed by both livestock and prairie dogs. Burrowing Owls concentrate in grasslands with colonies of burrowing mammals, particularly colonies of black-tailed prairie dogs west of the Missouri River and colonies of Richardson's ground squirrels elsewhere (Stewart 1975). Murphy et al. (2001) felt the decline in Burrowing Owl abundance in w. North Dakota may be from loss of burrowing animals and grassland habitat. Native prairie around historic Burrowing Owl nest sites declined 33% in Divide County since the 1960s, from 15.5 ± 2.5 (SE) ha within 500 m of nests in 1969 to 9.5 ± 2.2 ha in 1998. Loss of breeding Burrowing Owls in c. North Dakota may be linked to declines in Richardson's ground squirrels, the primary burrow provider in this region. Murphy et al. (2001) seldom observed Richardson's ground squirrels, burrows, or heavily grazed native prairie in and near Kidder County. They felt ground squirrel abundance was negatively influenced by increased vegetation height in recent years (1993-99).

In sw. North Dakota, the black-tailed prairie dog is largely restricted to the LMNG and tribal lands in Sioux County. The remaining area is dominated by agriculture with few active towns. Acreage of prairie dog towns decreased 93% from 1939-72 in and near the LMNG (from 5,512 ha to 403 ha; Bishop and Culbertson 1976); and currently occupies only 0.2% of LMNG (Murphy et al. 2001). Acreage of prairie dog towns on the LMNG is believed to be stable to increasing slightly, while the status of prairie dog habitat outside the LMNG is unknown (D. Freed, pers. commun.). Prairie dogs are, however, considered a noxious pest in North Dakota and private landowners are required to eradicate them (North Dakota Century Code 63-01.1-02, subsec. 12; Murphy et al. 2001).

Threats: Loss of habitat is the primary threat to Burrowing Owls in North Dakota. Recent declines in Richardson's ground squirrels in c. and e. North Dakota may be influencing Burrowing Owls populations. Murphy et al. (2001) noted decreases in ground squirrel abundance coinciding with increased vegetation height in Kidder County (c. North Dakota). Livestock ranching, especially sheep grazing, has decreased in some east river counties in recent years. Burrowing Owl habitat quality is probably declining in part due to these changes. Large-scale plague events in prairie dog populations may result in long-term habitat loss for Burrowing Owls (D. Freed, unpubl. data).

Predation on Burrowing Owls has been exacerbated by increases in numbers of Red-tailed Hawks and Great Horned Owls due to increases in trees because of succession, shelter-belt planting, and fire suppression (Clayton and Schmutz 1999, Murphy 1993). Mammalian predation pressure likely has increased due to fragmentation of habitat and major change in composition and distribution of predator communities (Sargeant et al. 1993, Murphy et al. 2001).

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Oklahoma

Summary: Burrowing Owls in Oklahoma occur primarily in association with prairie dog towns in short- and mixed-grass prairies and mesquite savannahs in the w. third of the state and are primarily restricted to the panhandle (Sheffield and Howery 2001). During the breeding season some owls are found away from prairie dog towns in shortgrass prairie. Burrowing Owls occasionally winter in w. and c. Oklahoma in the vicinity of prairie dog towns, airports, and areas with short grass (Sheffield and Howery 2001). Based on a survey of biologists, James and Espie (1997) estimated 100 to 1,000 pairs in Oklahoma with a stable population trend. Sheffield and Howery (2001) estimated a breeding population of 800-1000 individuals in the state.

BBS: A significant negative trend was noted for 1966-2001 (Trend = –11.5, P <0.00, n = 10). No other significant trends were detected. Data credibility is low due to small sample sizes and high variance (Sauer et al. 2002).

CBC: N/A; <1% of the summer population remains resident during the winter in Oklahoma.

Atlas: Unknown

Research/Monitoring: In Beaver and Texas counties on the Oklahoma panhandle, Butts and Lewis (1982) found 66% (n = 359) of adult owls were associated with prairie dog colonies even though this habitat comprised only 0.16% of the study area. This was equivalent to a density of 0.52 Burrowing Owls/ha or 1 pair/1.9 ha. The estimated population outside 1.6 km from prairie dog colonies was 92 pairs (34%; 0.0002 Burrowing Owls/ha or 1 pair/4,604 ha). The average brood size was 4.7 (range 2-9, n = 54) and nest success was 79%. Survival of young owls from the fledgling stage through July was 89% (n = 38) (Butts 1971). Most of this population migrated from Oklahoma in October; about 0.05% of the total population remained resident (Butts and Lewis 1982). In a survey of prairie dog colonies and their associated vertebrates in Oklahoma, Shackford and Tyler (1991) recorded at least one Burrowing Owl on at least one prairie dog colony in every county with ≥ 7 prairie dog colonies (n = 11), but no Burrowing Owls in any county with ≤ 2 prairie dog colonies (n = 10).

Currently there are no on-going research projects in Oklahoma which specifically target Burrowing Owls. A project is underway to monitor prairie dog town numbers, acreage, and distribution and could potentially also address Burrowing Owls (M. Howery, pers. commun.).

Conservation Activities: The USFWS attempted reintroduction of Burrowing Owls to a prairie dog town on the Wichita Mountains National Wildlife Refuge. The reintroduction effort failed to establish a breeding population. An Oklahoma state management plan is currently being developed for the black-tailed prairie dog. The plan could have indirect benefits for the Burrowing Owl (M. Howery, pers. commun.).

Major Populations: Based on BBS data, other breeding records, and personal observations, Sheffield and Howery (2001) estimated the total breeding population in Oklahoma as 800-1,000 individuals. The majority of the breeding individuals are limited to the panhandle counties of Cimmaron, Texas, and Beaver. The wintering range of the Burrowing Owl in Oklahoma is limited primarily to the western half of the state, with periodic extra-limital records further east (Sheffield and Howery 2001).

State Status: Species of Special Concern, Category II (native species identified by technical experts as possibly threatened or vulnerable to extirpation but for which little, if any, evidence exists to document the population level, range, or other factors pertinent to its status).

Natural Heritage Rank: G4/S2 (imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state).

Habitat Use and Condition: Beaver and e. Texas counties in the panhandle of Oklahoma had 50-60% of the area cultivated with the remainder used primarily for cattle grazing. Most prairie dog towns were located in linear strips of remaining habitat along drainages (Butts 1971). Butts and Lewis (1982) found 66% (n = 359) of adult owls were associated with these prairie dog colonies even though this habitat comprised only 0.16% of the study area. Within colonies, Burrowing Owl nests were distributed randomly, concentrated along the edges of colonies, and clumped. Nests outside dog towns were in badger dens but never in the more numerous burrows of thirteen-lined ground squirrels, spotted ground squirrels, or Ord's kangaroo rats. Of approximately 300 nests, all but six were in heavily grazed, short grass; the exceptions were five nests on field edges with vegetation clipped short by prairie dogs and one nest in a mowed pasture. Burrowing Owls did not exhibit any preference for soil type. Eradication of prairie dogs resulted in rapid declines in numbers of burrows available (<3 yr), and consequently Burrowing Owls rarely used inactive towns. Burrowing Owls did not nest in areas where prairie dogs were eradicated. Areas with light cattle grazing were used occasionally for feeding and escape. The use of satellite burrows by the male and broods indicated a requirement met only in prairie dog towns (Butts and Lewis 1982). They believed non-prairie dog habitat in Oklahoma was marginal breeding habitat for Burrowing Owls. Prairie dog populations should be maintained if conservation of Burrowing Owls is desired (Butts and Lewis 1982).

Oklahoma historically had millions of hectares of prairie dog towns, but by 1968 this had declined to 3,856 ha (Tyler 1968). Butts (1973) documented a decrease of 7% in acreage and 12% in numbers of active prairie dog towns in his study area (Oklahoma panhandle) from 1967 through 1970. Formation of four new dog towns and a 9.5 % increase in acreage

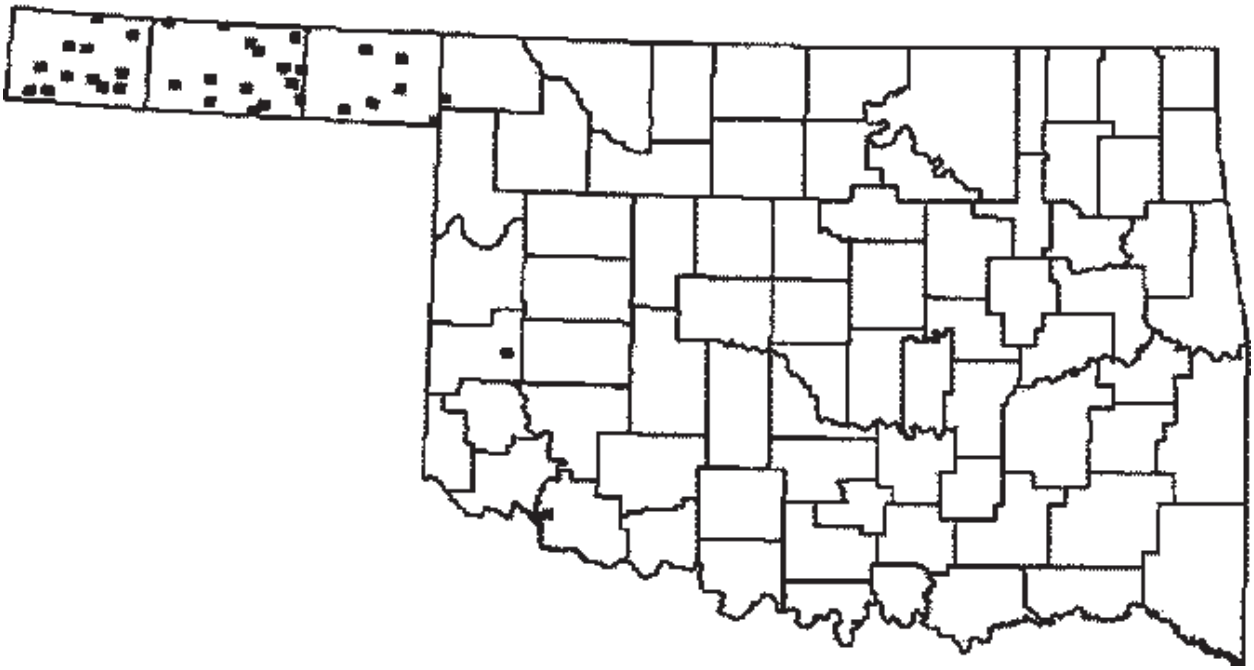

Fig. A-9. Distribution of Burrowing Owls in Oklahoma (Oklahoma Breeding Bird Atlas Project, D. Reinking, pers. commun.).

of existing towns tempered the net loss. Prairie dog eradication generally eliminated or reduced to a few individuals distinct colonies or colony segments (Butts 1973). Conversion of grassland to cropland (especially irrigated cropland) also caused a decrease in the availability and persistence of suitable nest burrows that could have adversely affected owl populations (Butts 1973). Tyler (1968) surveyed prairie dog colonies and associated vertebrates, and approximately 20 years later Shackford and Tyler (1991) repeated the survey. Comparison of the two studies showed a drastic decrease in both prairie dog colonies and Burrowing Owl numbers in the majority of the state (excluding the panhandle).

Threats: Conversion of grassland to cropland (especially irrigated cropland) has caused a decrease in the availability and persistence of suitable nest burrows that could adversely affect owl populations (Butts 1973). Continued habitat loss and loss of prairie dog to plague and direct eradication are also detrimental to Burrowing Owls.

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Oregon

Summary: East of the Cascades, the Burrowing Owl breeds in all or nearly all counties. As it was historically, it is now most common in Wasco, Morrow, Umatilla, Malheur, Harney, and Lake counties (Gabrielson and Jewett 1940, Adamus et al. 2001). West of the Cascades it bred in the Rogue River Valley (Jackson County) until the late-1970's or early 1980's (C. Cwiklinski, pers. commun). It is a rare winter visitor in the Rogue and Willamette valleys, along the coast, and occasionally in e. Oregon (Marshall et al. 1996). The population was estimated to be between 1,000 and 10,000 pairs in 1992 (James and Espie 1997). Burrowing Owl populations are generally thought to be stable in se. Oregon, possibly increasing with conversion of shrub-steppe to annual grasses in Malheur County, but significant trend data is lacking. Habitat loss has been greatest in the Columbia Basin (ne. Oregon) due to cultivation (Marshall et al. 1996).

BBS: No significant trends were detected over any survey period. Data credibility is low due to small sample size and high variance (Sauer et al. 2002).

CBC: Limited data available; rare winter records are from west of the Cascades, mostly interior valleys; some records from the coast.

Atlas: The Oregon Breeding Bird Atlas (Adamus et al. 2001) shows Burrowing Owls breeding throughout three se. counties: Malheur, Harney, and Lake (Fig. A-10). Additionally Burrowing Owls were reported in se. Deschutes and s. Crook counties, between the Wallowa and Blue Mountains in Baker and Union counties and east of the Columbia River Gorge in Wasco, Sherman, Gilliam, Morrow, and Umatilla counties. Breeding has been confirmed in s. Klamath County west of the Cascades, and Linn County. At this site, a pair was seen entering a burrow over the course of several weeks, but neither eggs nor chicks were observed and the birds did not return in subsequent years (P. Adamus, pers. commun.). Another summer sighting of a single individual on a culvert in this county suggests that Burrowing Owls might be re-established west of the Cascades if proper habitat conditions existed.

Research/Monitoring: In nc. Oregon (Gilliam, Morrow, and Umatilla counties) Burrowing Owl nest success was 57% for 63 nests in 1980 and 50% for 76 nests in 1981. Desertion was the major cause (32%; 45/139 nesting attempts) of nest failures and was related to the proximity of other nesting pairs (see below). Predation was the next most frequent cause of nest failure (14%; 20/139 attempts), and 90% (18/20) of depredation events were caused by badgers (Green and Anthony 1989).

Green and Anthony (1989) found a significant difference in nearest-neighbor distances for successful and deserted Burrowing Owl nests. In all cases where inter-nest distance was <110 m, at least one of the two nests was deserted in mid-nesting cycle (both nests abandoned when <60 m apart, n = 3). Only three of 21 (14%) pairs with inter-nest distances >110 m abandoned one or both nests. Many desertions occurred after hatching (Green and Anthony 1989). Apparently, clumped distributions of badger burrows and limited burrow availability in preferred habitat forced pairs close together; inter-pair competition for food presumably intensified as chick demand grew, available prey switched from small rodents to insects, and foraging bouts were conducted increasingly close to the nest (Green and Anthony 1989).

Green and Anthony (1989) also documented that 72% (23/32) of successful nests were lined with cow dung, while only 13% (2/15) of unsuccessful nests were lined. Presumably, dung masks the scent of the birds and thus lining nests with dung appears to be an adaptation to escape detection by predators.

Of five habitat types surveyed for Burrowing Owls, sites dominated by snakeweed, cheatgrass, and antelope bitterbrush were used by owls. Sites dominated by grasses (primarily needlegrass, Sandberg bluegrass, and bluebunch wheatgrass), or rabbitbrush were not used, despite having nearly twice the number of available badger burrows. Over-grazed snakeweed habitat was preferred, where burrows were surrounded with little grass cover conveying greater horizontal visibility than at less grazed sites. The success of Burrowing Owls nesting in the Columbia Basin appears to be dependent on a combination of the availability of properly-spaced badger burrows in preferred habitat, shifting prey resources during the nesting season, and on predation pressure by badgers (Green and Anthony 1989).

In the Malheur Resource Area, BLM personnel conducted Burrowing Owl surveys two to three times per year for 10 years along three to four survey routes. These data have not been analyzed, however the observers believe no major changes have occurred over the past 10 years (A. Bamman, pers. commun.).

Conservation Activities: In 1982, 13 Burrowing Owls were reintroduced by "hacking" at four artificial burrows in the Agate Desert of Jackson County, Oregon. Birds were obtained for reintroduction from nests in the Klamath Valley. The young were fed for about two months before full release. No reintroduced Burrowing Owls were detected in subsequent years (C. Cwiklinski, pers. commun.). Artificial nest burrows are being installed in areas of historic nesting by Burrowing Owls in Jackson County at the Rogue Valley International Airport and on private land with the goal of providing wintering habitat and stimulating summer use as well (C. Cwiklinski, pers. commun.). Twenty artificial burrows were installed in e. Oregon (Umatilla and Morrow counties) in the spring and summer of 1979

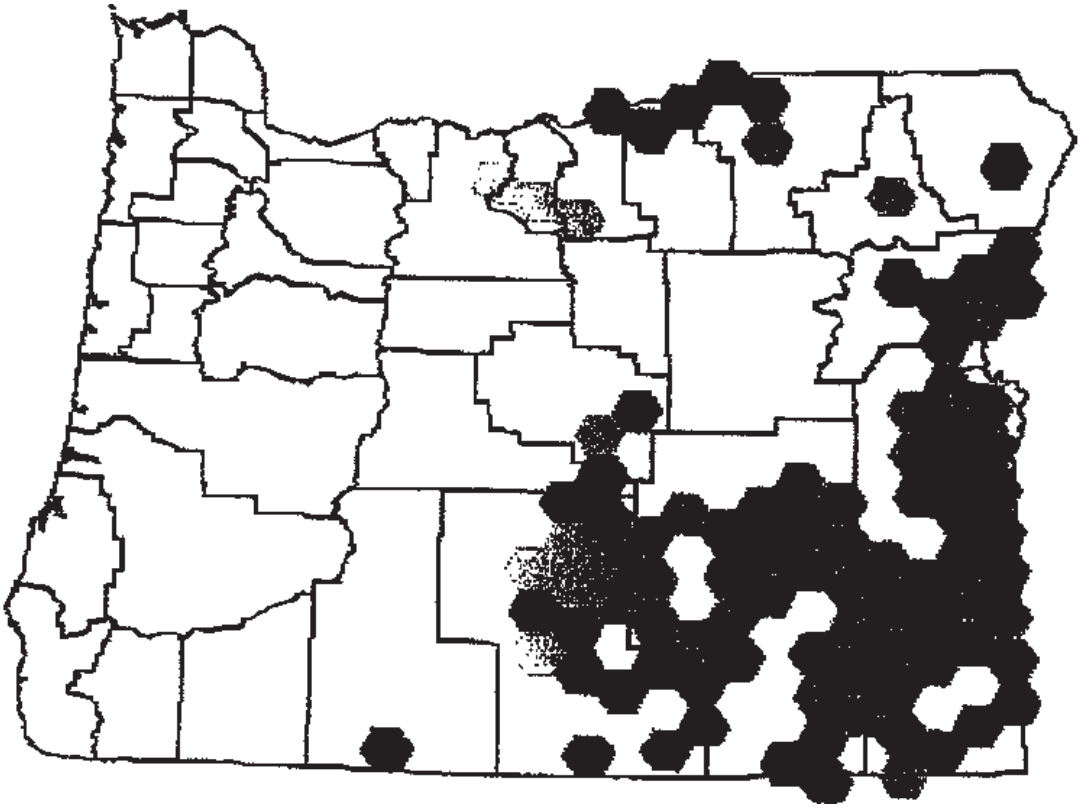

Fig. A-10. Distribution of confirmed (n = 49), probable (n = 9), and possible (n = 37) breeding activity of Burrowing Owls in Oregon from the Oregon Breeding Bird Atlas project (Adamus et al. 2001).

to facilitate research of the species (Henny and Blus 1981). No information was available on the continuation of this project.

In burned shrub-steppe, BLM is now to trying to replant with seed mixes that include sagebrush and other shrubs, and to rehabilitate cheatgrass dominated sites by a combination of prescribed fire, herbicide application and re-seeding with a mix of bunch grasses and shrubs. These efforts to restore the natural vegetation of the area may decrease the quality of habitat preferred by Burrowing Owls. However, BLM is also engaged in land exchanges to consolidate and expand contiguous parcels of Federal land; this probably has a beneficial effect on Burrowing Owls and other wildlife by securing the future ownership of larger blocks of habitat, reducing the chance of future habitat conversion (A. Bamman, pers. commun.).

Major Populations: The Oregon Breeding Bird Atlas (Adamus et al. 2001) shows the bulk of the state's Burrowing Owl population in se. Oregon counties, where they historically occurred (Gabrielson and Jewett 1940); however current and historic densities and numbers of breeding Burrowing Owls are unknown.

State Status: Critical (T&E status pending, or possible if conservation measures are not taken), in the Willamette Valley and Klamath Mountains, High Plains, Columbia Basin, and Blue Mountain physiographic provinces (ODFW 1997).

Natural Heritage Rank: G4/S2?B (imperiled during breeding season because of rarity or other factors making the species very vulnerable to extirpation; (?) indicates uncertainty about rank).

Habitat Use and Condition: Found in sagebrush-steppe, grasslands, pastures, roadsides, and even airports where vegetation is sparse and terrain is level. Also found where soil and/or vegetation has been disturbed through overgrazing, fire, construction, or farming; or at sites where vegetation has been heavily clipped or grazed by ground squirrels (Marshall et al. 1996). Burrows, such as those left by ground squirrels and badgers, are a necessity for breeding.

The areas of high Burrowing Owl populations are lower elevation flat to gently rolling hills with fine grain, deep soils. These areas are at the edge of farmlands where past range fires have repeatedly burned off the sagebrush and heavy grazing

apparently resulted in exotic annual grasses and forbs becoming the dominant plant species. This habitat contains moderate to high rodent numbers and suitable burrows, and is grazed most years. These conditions occur on both private and public lands. Individual Burrowing Owl breeding sites occasionally are found in sagebrush covered areas (A. Bamman, pers. commun.).

Threats: Extirpation of Burrowing Owls through loss of habitat to urbanization and irrigated agriculture has been documented in the Rogue River Valley (Marshall et al. 1996). Habitat conversions of this type are probably more of a threat in n. Oregon than se. Oregon.

Green and Anthony (1989) found predation accounted for 20% of nest failures in n. Oregon (see Research/Monitoring above). Occasional shooting by the public probably has a only a small, local impact.

USDA/APHIS/Wildlife Services poisons ground squirrels and gophers, and traps badgers; these activities could affect burrow availability. USDA/APHIS/Plant Protection and Quarantine conducts grasshopper control operations on a local basis during years when grasshopper populations are exceptionally high. Although direct poisoning is highly unlikely given the pesticides used and methods of application, loss of prey base might affect some pairs of birds some years. The effects of farmer-applied pesticides on birds nesting near and foraging in agricultural fields has not been documented.

Additional threats listed by Altman and Holmes (2000) include: domestic predators (cats and dogs); destruction of burrows through livestock trampling in sandy soils and human disturbance (e.g., ATV use) near nest burrows.

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South Dakota

Summary: Burrowing Owls were previously considered a locally common summer resident in South Dakota west of the Missouri River (except rare in the Black Hills), uncommon to the east, and casual in the winter (South Dakota Ornithologist Union 1991). Based on a survey of biologists, James and Espie (1997) estimated 100 to 1,000 pairs in South Dakota in 1992 with a stable population trend

BBS: A significant negative trend in relative abundance was detected from 1980-2001 (Trend = –11.4, P <0.08, n = 10). No significant trends were noted for other survey periods. Deficiencies in data quality were moderate (sample sizes <14, sub-interval trends significantly different from each other) (Sauer et al. 2002).

CBC: N/A.

Atlas: According to results of the South Dakota Breeding Bird Atlas (Peterson 1995), the Burrowing Owl is now "uncommon and scattered." Concentrations were noted in and near Buffalo Gap National Grassland, Badlands National Park, and the following counties: River Falls, Custer, Pennington, Meade, and Shannon in sw. South Dakota, and McPherson, Edmunds, Faulk, and Hand in nc. South Dakota (Fig. A-11). During field work for the South Dakota Breeding Bird Atlas, Burrowing Owls were found in 12.1% of random bocks with totals of 1 bird observed in each of 10 random blocks and 2-10 birds detected in each of five blocks (Peterson 1995). Of reported Burrowing Owl locations, 87 were from prairie dog towns and 42 from were from upland grassland sites (Peterson 1995).

Research/Monitoring: In 1991, Martell et al. (1993) documented a density of 1 pair/68 ha (0.015 pairs/ha) on prairie dog towns in Badlands National Park (Pennington and Jackson counties) in sw. South Dakota. In 1992, density on the same five towns was 1 pair/41 ha (0.024 pairs/ha) and density on three additional towns was 1 pair/48.5 ha. (0.021 pair/ha). The increase in Burrowing Owls detected from 1991-92 was partially due to increases in the area surveyed (from 819 ha to 1506 ha); however, for towns surveyed both years, increases were noted in the number of pairs (from 14 to 20 pairs), young (29 to 62 young), and average brood size (2.07 young/pair to 3.10 young/pair) indicating actual population increases between years.

Martell et al. (1993) applied the area-occupied technique of relative abundance estimation (Iverson and Fuller 1989) to Burrowing Owls on prairie dog towns in Badlands National Park. They determined the proportion of the area surveyed that was occupied by Burrowing Owls was 0.34 (SE = 0.07) in 1991. In 1992 the proportion of the area occupied increased to 0.57 (SE = 0.07). The probability of detection was 0.486 (SE = 0.056) for all study areas combined.

In the Conata Basin of Buffalo Gap National Grassland (Pennington and Jackson counties), Martell et al. (1993) documented 14 Burrowing Owl broods in 1991 and 11 Burrowing Owl broods in 1992, but did not provide a description of study area boundaries or density estimates. MacCracken et al. (1985) found that Burrowing Owls in the Conata Basin used burrows in early stages of plant succession (high forb and buffalograss cover, and reduced blue grama and perennial plant cover) where vegetation height was lower than the surrounding prairie.

Conservation Activities: Burrowing Owls are monitored as a sensitive species by the South Dakota Natural Heritage Program. Known information about nesting sites is included in environmental review comments on projects submitted for comment to the Heritage Program.

The Crow Creek Sioux Tribe plans to maintain the current number of prairie dogs and prairie dog towns through a Candidate Conservation Agreement with the U.S. Fish & Wildlife Service (L. Fredrickson, pers. commun.).

Major Populations: Concentrations of Burrowing Owl observations were noted in and near Buffalo Gap National Grassland, Badlands National Park, and the following counties: River Falls, Custer, Pennington, Meade, and Shannon in sw. South Dakota, and McPherson, Edmunds, Faulk, and Hand in nc. South Dakota (Peterson 1995).

State Status: None

Natural Heritage Rank: G4/S3S4B, SZN (S3—rare and uncommon breeding populations in the state, S4—widespread, abundant, and apparently secure in state, with many occurrences, but of long-term concern, no non-breeding occurrences).

Habitat Use and Condition: Results from the South Dakota Breeding Bird Atlas supported the importance of prairie dog towns to nesting Burrowing Owls. The majority of black-tailed prairie dogs presently occur on federal or tribal lands, although smaller colonies on private lands are undoubtedly important Burrowing Owl nesting areas as well. Prairie dog numbers and acreage are stable on the Lower Brule Sioux Tribal lands (S. Grassel, pers. commun.).

Threats: Any threats to black-tailed prairie dogs will impact Burrowing Owls in South Dakota. At present, the prairie dog population appears stable, although no systematic surveys are conducted on nesting Burrowing Owls (E. Dowd-Stukel and D. Backlund, pers. commun.). Rapid reductions in Richardson's ground squirrel abundance on private lands are also causing loss of potential Burrowing Owl habitat (R. Peterson, per. commun.)

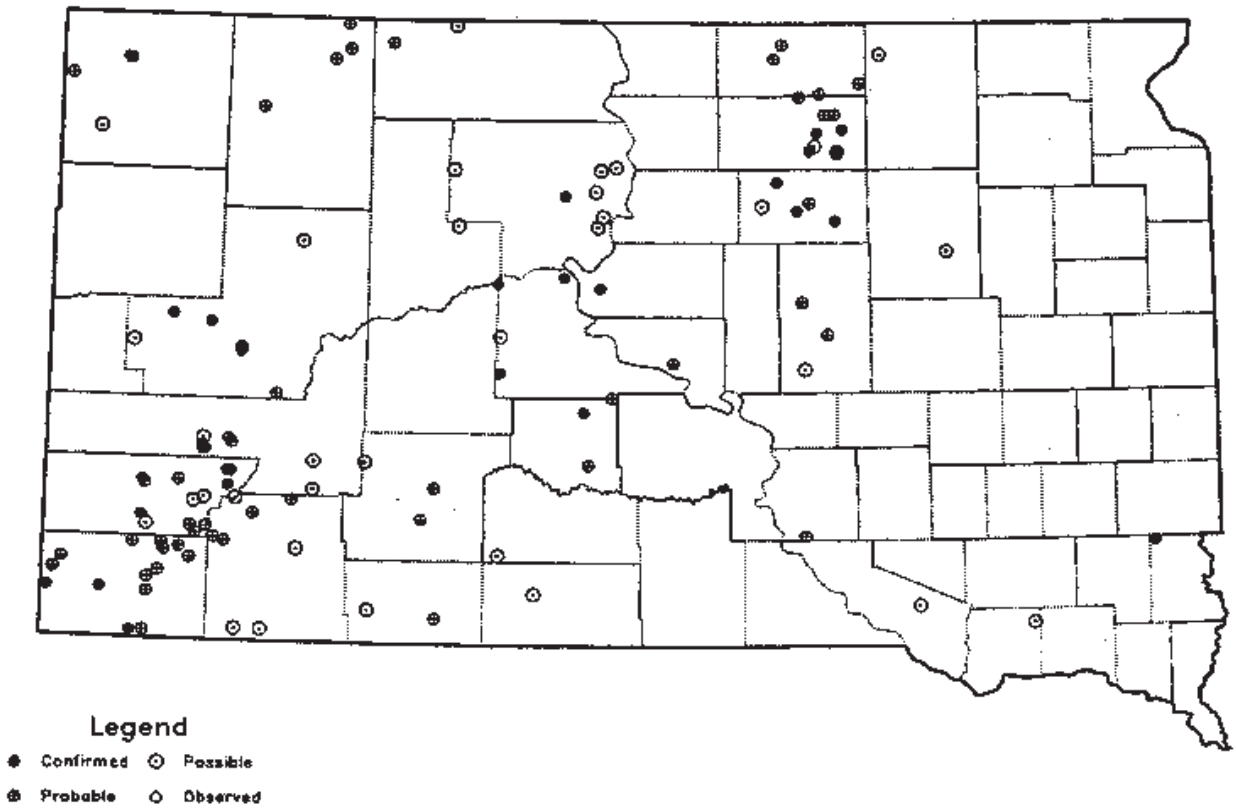

Fig. A-11. Distribution of Burrowing Owl breeding activity and observation in South Dakota from the South Dakota Breeding Bird Atlas project (Peterson 1995).

Literature Cited:

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MacCracken, J. G., D. W. Uresk, and R. M. Hansen. 1985. Vegetation and soils of Burrowing Owl nest sites in Conata Basin, South Dakota. Condor 87:152-154.

Martell, M. S., P. T. Redig, and J. Nibe. 1993. Demography of the Burrowing Owl in Badlands National Park: Final Report. The Raptor Center, Univ. of Minnesota, St. Paul, Minnesota.

Peterson, R. A. 1995. South Dakota Breeding Bird Atlas. South Dakota Ornithologists' Union, Aberdeen, South Dakota.

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South Dakota Ornithologists' Union. 1991. The Birds of South Dakota, Second Edition Aberdeen, South Dakota.

Texas

Summary: Burrowing Owls are an uncommon to common resident on the open prairies of the western half of the state, east to Wilbarger County. It is a rare migrant and winter visitor east to coastal Texas (Texas Ornithological Society 1995). In winter, Burrowing Owls are locally fairly common to uncommon in the c. and s. Panhandle, but usually withdraw from the n. Panhandle. Based on a survey of biologists in 1992, James and Espie (1997) estimated more than 10,000 pairs in Texas.

BBS: No significant trends were detected over any survey period (Sauer et al. 2002).

CBC: No significant trend detected over the survey period (1959-88) (Sauer et al. 1996).

Atlas: Unknown.

Research/Monitoring: In s. Texas (primarily the Corpus Christi area) a monitoring effort sponsored by the Canadian Wildlife Service, U.S. Geological Survey-Texas Gulf Coast Field Research Station, and the Texas A&M University-Corpus Christi was begun in the winter of 1998-99 and continues to the present. This cooperative project currently is focused on documenting range, numbers, and habitat use throughout agricultural areas of s. Texas and to determine the response to installation of artificial burrows. Plans are underway to trap, band, and place radio transmitters on Burrowing Owls to monitor over-winter movements and survival. Ongoing collection of pellets and feathers in Texas will continue for diet and isotope studies. (C. Shackelford, pers. commun.).

Conservation Activities: None documented.

Conservation Recommendations: None documented.

Major Populations: Mackenzie State Park in Lubbock. This population is currently threatened by the city of Lubbock's plan to eradicate prairie dogs from the area. No other major populations documented.

State Status: None

Natural Heritage Rank: G4/S3B (rare and uncommon breeding populations in the state).

Habitat Use and Condition: Habitat includes culverts along roads adjacent to plowed fields or cleared pastures. Areas immediately around occupied culverts have short and/or sparse vegetation. Most of these habitats occur on private lands. County roads allow visual sightings of many of the birds; however, numbers of Burrowing Owls wintering on large private ranches are unknown (C. Shackelford, pers. commun.).

Threats: Loss of traditional grassland habitats and associated natural burrows to agriculture and development are a primary threat. Vehicle collisions due to use of roadside culverts for burrows and ingestion of pesticides from prey associated with agricultural fields are also threats (C. Shackelford, pers. commun.).

Literature Cited:

James, P. C., and R. H. M. Espie. 1997. Current status of the Burrowing Owl in North America: an agency survey. Pages 3-5 *in* J. Lincer and K. Steenhof, editors. The Burrowing Owl, its biology and management including the Proceedings of the First International Burrowing Owl Symposium. Raptor Research Report Number 9.

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Texas Ornithological Society. 1995. Checklist of the birds of Texas 3rd edition. Capital Printing, Inc. Austin, Texas.

Utah

Summary: The Burrowing Owl is an uncommon permanent resident with localized occurrence (Behle and Perry 1975). Populations appear to have declined across the range; its distribution has been localized in many areas of Utah (Utah Division of Wildlife Resources 1998). Based on a survey of state biologists, James and Espie (1997) estimated 1,000 to 10,000 pairs in Utah in 1992 with a decreasing population trend.

BBS: No significant trends were detected for any survey period (Sauer et al. 2002).

CBC: The Burrowing Owl is a casual wintering resident in s. Utah.

Atlas: Unknown.

Research/Monitoring: Little published research was identified for Utah.

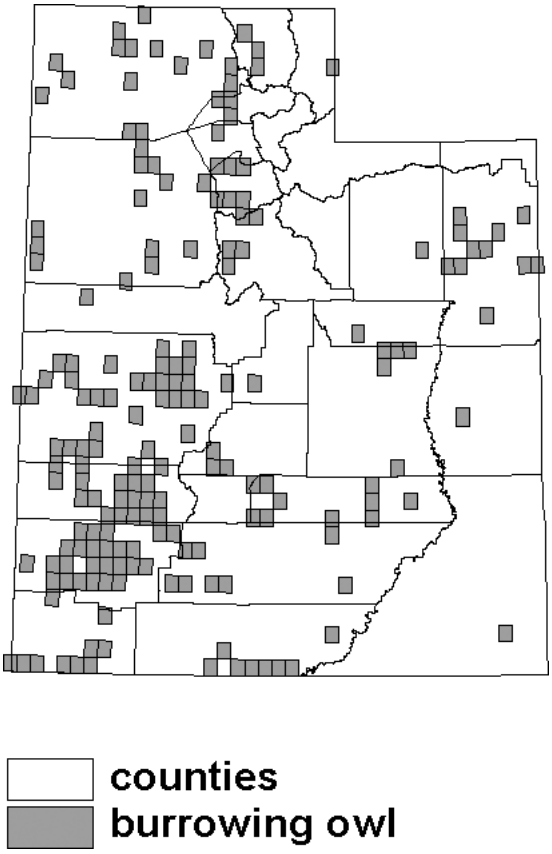

Fig. A-12. Distribution of Burrowing Owl observations in Utah (Utah Natural Heritage Program, A. Axel, pers. commun.).

Conservation Activities: None identified.

Major Populations: None identified.

State Status: Species of Special Concern.

Natural Heritage Rank: G4/S3B (rare and uncommon breeding populations in the state).

Habitat Use and Condition: Not documented.

Threats: None documented

Literature Cited:

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Utah Division of Wildlife Resources. 1998. Utah Sensitive Species List. Utah Division of Wildlife Resources homepage (http://www.nr.state.ut.us/dwr/sensppl.htm#bird). October, 2000.

Washington

Summary: Burrowing Owls are local and uncommon in shrub-steppe and grassland habitats east of the Cascades. It is widespread in the southern part of this region, but numbers fluctuate and breeders are limited to areas with suitable burrow sites. West of the Cascades, the Burrowing Owl was historically a rare migrant and winter resident of the n. Puget Sound region. It perhaps once nested in the vicinity of Bellingham, south of Tacoma, and Grays Harbor (Jewett et al. 1953). Smith et al. (1997) stated that in most areas numbers are seriously declining, and that losses are especially pronounced in the channeled scablands, Okanogan Valley, and se. Washington. This statement is supported by nest site occupancy analyses by Washington Department of Fish and Wildlife (WDFW), Wildlife Resources Data System (unpubl. data).

BBS: No significant trends were detected over any survey period (Sauer et al. 2002).

CBC: N/A.

Atlas: No breeding bird atlas is available for Washington; information regarding distribution is from the Washington Wildlife Resources Data System (Fig. A-13). Confirmed breeding records are concentrated in sc. Washington (east of the Cascades), in sw. Adams, extreme w. Walla Walla, Franklin, Grant, Benton, e. Yakima, and s. and e. Klickitat counties. Also in w. Whitman, c. Lincoln, sw. and n. Douglas, and s. Okanogan counties. There are no recent breeding records or suitable habitat west of the Cascades (Smith et al. 1997).

Research/Monitoring: WDFW surveys in 1987, 1999, and 2000 and occasional incidental observations of nest locations since 1960 show that the most significant change in distribution from pre-1987 to post-1987 is the apparent loss of owls from c. Okanogan County along the Okanogan River plain. GAP analysis also shows no remaining potential habitat for owls in this region (Smith et al. 1987). Other range changes are not as striking but involve the loss of burrow sites in se. Yakima County and s. Lincoln County (WDFW, Wildlife Resources Data System, unpubl. data).

The 1987 WDFW study was originally conducted to assess the status of the Washington State population, and its ability to absorb losses from a transplant program designed to re-establish Burrowing Owls in British Columbia. Additional nest information was collected, however, and follows (Radke 1987). The study was concentrated in a relatively small area of Grant (south of Ephrata), w. Adams, and nw. Franklin counties. Of the 117 nests found, 39% (46/117) were on county roadside rights-of-way (≤ 10 feet to the road). These data may be biased as they were predominantly conducted while driving roads. Only 13% (15/117) of the nests were in areas considered 'natural'. The remaining 45% (52/117) were roughly equally divided between pasture, canal and ditch banks, and vacant lots. Of all nests, 74% were within 50 feet of roads. By far the greatest disturbance to nests was vehicles or recreational uses (100 nests), followed by disturbance from agricultural operations (from cattle operations, 17 nests; grain crop activities, 10 nests; truck crop activities, 9 nests). Disturbance from development, industrial, and residential activities affected 16 nests altogether. Natural burrows accounted for 72% (84/117) of the nests; the rest were in culverts or irrigation pipes (21%, 25/117) or in artificial nest burrows (7%, 8/117).

In 1999 and 2000 WDFW surveyed approximately 80% of all previously documented Burrowing Owl nesting sites in Washington. All nest sites visited were classified as either occupied, unoccupied, destroyed, or not found (Table A-4, WDFW, Wildlife Resources Data System, unpubl. data).

Conservation Activities: Prairies and steppe, and shrub-steppe habitats are listed as "Priority Habitats" by WDFW under the Priority Habitat and Species (PHS) Program. This designation facilitates consideration of conservation needs and measures during state and local land use planning. WDFW is currently developing management guidelines to promote the conservation of all priority habitats and species identified under the PHS Program. This will include conservation guidelines for prairies and steppe, and shrub-steppe habitats and species management guidelines for the conservation of Burrowing Owls. WDFW also plan to conduct a state status assessment for Burrowing Owls and searches for Burrowing Owls will be intensified in se. Washington (E. Cummings, pers. commun.).

Radke (1987) and Smith et al. (1997) mentioned that artificial nest burrows have been placed by conservation groups. No concerted or systematic nest box programs are known, however.

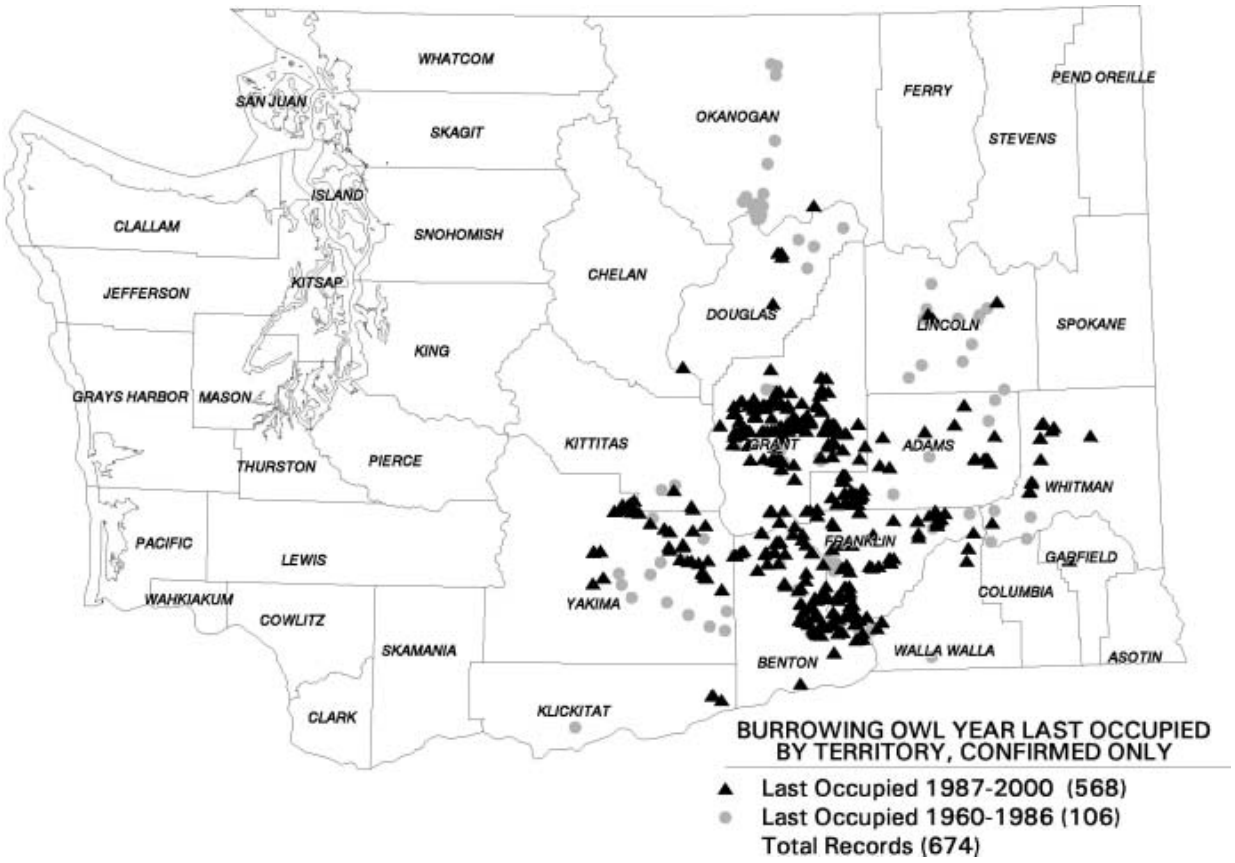

Fig. A-13. Distribution of Burrowing Owls burrows in Washington (Washington Department of Fish and Wildlife, Wildlife Resources Data System, J. Brookshier, pers. commun.).

Table A-4. Number of occupied, unoccupied, destroyed, and not found Burrowing Owl nests located in Washington during Washington Department of Fish and Wildlife surveys in 1999 and 2000.

Year	Occupied	Unoccupied	Destroyed	Not Found	Total # Sites Visited
1999	170	100	44	141	455
2000	195	220	54	130	599

Major Populations: Grant and Franklin counties hold over half (55%) of nest sites in the State, occupied or historical (WDFW, Wildlife Resources Data System, unpubl. data 2001).

State Status: Candidate for listing as State Endangered, Threatened, or Sensitive.

Natural Heritage Rank: G4/S3B (rare and uncommon breeding populations in the state)

Habitat Use and Condition: Most nest sites located by Radke (1987) were near agricultural areas, and 21% were in artificial burrows of some sort, such as culverts and irrigation pipes. About 75% of nests found were within 50 feet of roads. Thus, disturbed, artificial situations are often used by these birds in Washington.

Threats: Loss of historic nest sites to agricultural conversion has been documented in Walla Walla County (Smith et al. 1997). However, agriculture has provided habitat in some areas (E. Cummings, pers. commun.).

The Burrowing Owl is currently a candidate for listing as Threatened, Endangered, or Sensitive in Washington. This designation serves to facilitate consultation with WDFW regarding state and local land use planning but no specific regulatory protection is afforded beyond that of other native wildlife species in Washington

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Radke, M. 1987. Burrowing Owls in the Columbia Basin, Washington, 1987. British Columbia Conservation Foundation Report. June 28, 1987.

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Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding birds of Washington State. Volume 4 *in:* K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich, editors. Washington State Gap Analysis—Final Report. Seattle Audubon Society Publications in Zoology No. 1, Seattle, Washington.

Wyoming

Summary: Burrowing Owls occur statewide in grasslands and open areas of shrub-steppe regions. Burrowing Owls have been documented in all latilong blocks in the state but are considered uncommon (Wyoming Game and Fish Dept. 1997). Marti and Marks (1989) listed Burrowing Owls as common in Wyoming with an unknown population trend. They listed more than 200 nesting pairs and more than 200 nest sites from 1977-86, based on a National Wildlife Federation survey of state wildlife agencies in 1987. Based on a survey of state biologists, James and Espie (1997) estimated 1,000 to 10,000 pairs in Wyoming in 1992 with a stable population trend.

BBS: Significant negative declines were detected 1966-2001 (Trend = –23.7, P <0.04, n = 11). No significant trends were detected for other survey periods. Deficiencies in data quality were moderate (sample sizes <14, sub-interval trends significantly different from each other) (Sauer et al. 2002).

CBC: N/A

Atlas: No breeding bird atlas is available for Wyoming. Burrowing Owls were recorded as breeding in 24 of 28 latilongs and observed in all latilongs (Wyoming Game and Fish Dept. 1997). The Wyoming Natural Diversity Database (WYNDD) maintains a database of historic and current Burrowing Owl observations throughout Wyoming. Records are from various sources such as the Wyoming Game and Fish Dept. Wildlife Observation System (WOS), agency surveys, university research projects, and personal observations; all of which are scrutinized for credibility (D. Keinath pers. commun.).

Research/Monitoring: Martin (1983) recorded Burrowing Owl observations while conducting day and night searches for black-footed ferrets in sc. and sw. Wyoming from June through September of 1978-82. He found 86 Burrowing Owls on 34 of 426 (8.0%) white-tailed prairie dog colonies. This included 14,349 ha searched on 16 colonies in Sweetwater, 14 in Carbon, three in Uinta, and one in Lincoln counties. Nest burrows with young were documented on 10 (2.4%) colonies (2.7 ± 0.5 young / nest, range 1-5). Burrowing Owl density on white-tailed prairie dog colonies was one adult/172.5 ha. Low Burrowing Owl density was attributed to taller vegetation and less open habitat on white-tailed versus black-tailed prairie dog colonies (Martin 1983). Colonies occupied by Burrowing Owls averaged 72.8 ± 13.2 ha (n = 33; range 0.8-325.1) with 31.6 ± 6.9 burrows / ha (n = 25; range 4.7-167.2). Colonies with owl nests averaged 74.0 ± 12.8 ha (n = 10; range 27.5-147.8) with 20.0 ± 2.7 burrows / ha (n = 9; range 7.2-34.3; Martin 1983).

The WYNDD (June 2000) has documented 43 Burrowing Owl occurrences in the state. An "occurrence" is a locality where multiple Burrowing Owls or confirmed breeding/nesting behavior have been documented. An occurrence generally represents an established prairie dog town that reliably contains several nesting pairs of owls each year (Keinath pers. commun.).

In 1999 and 2000, the Rocky Mountain Bird Observatory (RMBO) conducted roadside surveys of potential Burrowing Owl habitat in se. Wyoming including most of Platte, Goshen, and Laramie counties, and extreme s. Niobrara County. In 1999, RMBO located 71 colonies of Burrowing Owls, totaling 180 individuals (Hutchings et al. 1999). In 2000, they located 107 sites with 575 Burrowing Owls; site reoccupancy was 66% between 1999 and 2000 (T. VerCauteren pers. commun.).

In 1998, the U.S. Forest Service conducted surveys for Burrowing Owls on black-tailed prairie dog towns within the Great Plains National Grasslands (Sidle et al. 2001). In the n. Great Plains (including Wyoming), 196 (59%) of 330 active towns were occupied by Burrowing Owls, and 12 (25%) of 48 inactive towns had owls. However, only 16% of prairie dog towns on Thunder Basin National Grassland in northeastern Wyoming had owls. Furthermore, Sidle et al. (2001) noted that surveys in 1995 failed to locate Burrowing Owls on Thunder Basin, but did not provide information on the extent or conditions of surveys.

Korfanta et al. (2001) examined Burrowing Owl sightings in the WOS. Burrowing Owl sightings were broadly distributed throughout Wyoming, with the highest concentrations occurring in the southern half of the state (Fig. A-14). Two trends were evident from the WOS data (Figure A-15): numbers of records generally increased between 1974-80, while record numbers decreased between 1981-97. There was a significant, negative linear relationship ($P = 0.002$, $r^2 = 0.64$) between numbers of Burrowing Owl sightings and time for the 1986-97 subset of the WOS data (Fig. A-15). However, there may be potential reporting bias in the WOS, which might obscure real population trends.

Korfanta et al. (2001) surveyed 103 historic sites and 85 random sites selected on the basis of vegetation in eastern Wyoming in 1999. A total of 37 Burrowing Owls were seen at 16 sites; 36 on WOS historical sites (n = 103), one on a "high probability" site (n = 55), and none on "low probability" sites (n = 30). High probability sites were comprised of northern mixed- or short-grass prairie while low probability sites contained sub-optimal Burrowing Owl habitat such as sagebrush or open ground. A total of 43% of occupied sites (n = 16) and 10% of unoccupied sites (n = 168) were also occupied by black- or white-tailed prairie dogs. Twenty-percent of the occupied sites were currently or recently (within the previous year) grazed by cattle, sheep, or buffalo.

Conservation Activities: Burrowing Owls are monitored and managed within the vicinity of surface mines as mandated by the federal Surface

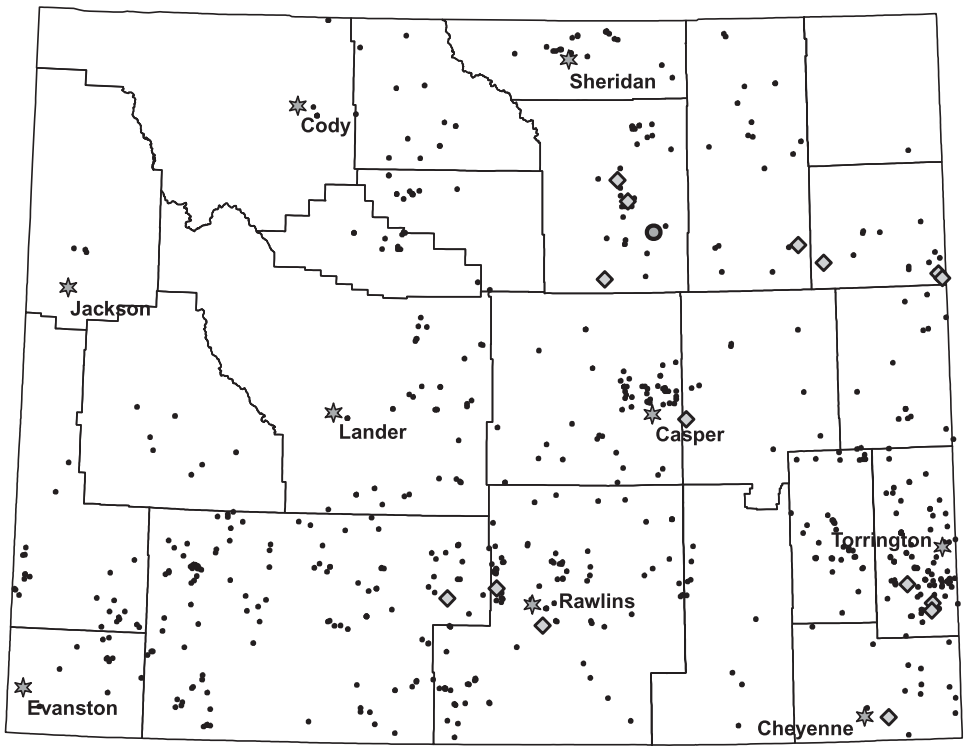

Fig. A-14. Historic Burrowing Owl records (dots) from the Wyoming Game and Fish Department Wildlife Observation System and reoccupancy survey sites with Burrowing Owls (diamonds) in 1999 (from Korfanta et al. 2001).

Fig. A-15. Numbers of Burrowing Owl records per year in the Wyoming Game and Fish Department Wildlife Observation System. The trend line for the 1986 – 1997 period represents a period of presumed consistent search effort (from Korfanta et al. 2001).

Mining Control and Reclamation Act of 1977 (30 U.S.C. 1201).

Major Populations: Burrowing Owl sightings are distributed primarily in e. and s. Wyoming with higher concentrations around Torrington, Sheridan, and Rawlins (Fig. A-14) although this may reflect a reporting bias in WOS data whereby owls are more readily detected near population centers (Korfanta et al. 2001). Hutchings et al. (1999) found 107 sites with Burrowing Owls in Platte, Goshen, Laramie, and s. Niobrara counties in 2000. Significant potential habitat exists on Thunder Basin National Grassland; however, few Burrowing Owls were documented during 1995 and 1998 surveys of prairie dog towns within the Grassland (Sidle et al. 2001).

State Status: Species of Special Concern (Category 4)

Natural Heritage Rank: G4/S3B, SZN (rare and uncommon breeding populations in the state, no non-breeding occurrences)

Habitat Use and Condition: During re-occupancy surveys of historic nest sites in e. Wyoming, Korfanta et al. (2001) found 43% of Burrowing Owls observed in 1999 were associated with prairie dog colonies. Only one Burrowing Owl was located during surveys of 85 random sites in the same region, which included 55 high probability sites in northern mixed- or short-grass prairie and 30 low probability sites with sagebrush, irrigated croplands, or desert shrub as the dominant cover type.

Only 1.9% of the Great Plains National Grasslands deemed suitable for prairie dogs was inhabited by the species (Sidle et al. 2001). The U.S. Forest Service estimated Thunder Basin National Grassland contains 1,013 ha of active prairie dog towns at approximately 121 burrows/ha. National Grasslands in general are fragmented, making active prairie dog management difficult, and there is no concerted effort to restore prairie dog towns. Despite this, Great Plains National Grasslands offer abundant potential habitat for prairie dogs and therefore, Burrowing Owls (Sidle et al. 2001).

Threats: Destruction of prairie dog habitat and rodent control are believed to have reduced Burrowing Owl numbers in the state (Wyoming Game and Fish 1977, Martin 1983, Sidle et al. 2001). Sylvatic plague outbreaks in prairie-dog populations have also reduced available Burrowing Owl habitat in Wyoming (USFWS 2000). Recreational shooting of prairie dogs may also significantly influence population size and therefore, available Burrowing Owl habitat in portions of Wyoming.

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Korfanta, N. M., L. W. Ayers, S. H. Anderson, and D. B. McDonald. 2001. A preliminary assessment of Burrowing Owl population status in Wyoming. Journal of Raptor Research 35:337-343.

James, P. C., and R. H. M. Espie. 1997. Current status of the Burrowing Owl in North America: An agency survey. Pages 3-5 *in* J. Lincer and K. Steenhof, editors. The Burrowing Owl, its biology and management including the Proceedings of the First International Burrowing Owl Symposium. Raptor Research Report Number 9.

Marti, C. D., and J. S. Marks. 1989. Medium-sized owls. Pp. 124-133 *In:* B. A. Giron Pendleton, editor. Proceedings of the Western Raptor Management Symposium and Workshop, National Wildlife Federation, Washington, DC

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Sauer, J. R., J. E. Hines, and J. Fallon. 2002. The North American Breeding Bird Survey, Results and Analysis 1966-2001. Version 2002.1, U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland. http://www.mbr-pwrc.usgs.gov/bbs/bbs2001.html

Sidle, J. G., M. Ball, D. Weber, J. Chynoweth, G. Foli, R. Hodorff, G. Moravek, and R. Peterson, D. Svingen. 2001. Occurrence of Burrowing Owls in prairie dog towns on Great Plains. Journal of Raptor Research 35:316-321.

U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants: 12-month finding for a petition to list the black-tailed prairie dog as Threatened. Proposed Rules. Federal Register 65:5476-5488 (Feb. 4, 2000).

Wyoming Game and Fish Dept. 1997. Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming. Wyoming Game and Fish Dept., Wildlife Division, Biological Services Section, Lander, Wyoming.

Arkansas, Illinois, Missouri, Wisconsin

Summary: IL, MO, WI: Vagrant; AR: Irregular migrant and winter resident

BBS: N/A

CBC: N/A

Atlas: N/A

Research/Monitoring: No research identified.

Conservation Activities: No conservation activities reported.

Major Populations: None.

State Status:

AR: State—None. There are a few scattered, records in the 1960's in Lonoke County. Single birds have been reported in Arkansas, Craighead, Cross, Crittenden, Jefferson, Mississippi, Pope, and Prairie counties (James and Neal 1986)

IL: Status—Nongame Protected. The Burrowing Owl is a very rare spring vagrant in n. and c. Illinois (Illinois Natural Resources Information Network 2000). No breeding records exist.

MO: Status—None. The Burrowing Owl is transient in w. Missouri and accidental in eastern Missouri during migration. It is an accidental summer and winter resident with one confirmed breeding record.

WI: State—None. The Burrowing Owl is a vagrant in Wisconsin. Undocumented historic observations suggest potential isolated breeding. There were 12 accepted state records between 1939 and 1992 (R. Domagalski, pers. commun.).

Natural Heritage Rank: AR: Unknown; IL: SA (Accidental in State); MO, WI: S? (Unranked in State).

Habitat Use and Condition: Unknown

Threats: Unknown

Literature Cited:

Illinois Natural History Information Network. 2000. Illinois Birds: Burrowing Owl (*Athene cunicularia*). Illinois Natural History Survey webpage (http://www.inhs.uiuc.edu/chf/pub/ifwis/birds/index.html) version August, 2000.

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Appendix B: Summary of Conservation Recommendations for Burrowing Owls

Below is a summary of conservation recommendations from western states gleaned from the literature, State wildlife agencies, Partners in Flight Bird Conservation Plans, and researchers in the field. Sources of the summarized conservation recommendations for each state are listed at the end of this section. Discussion of on-going conservation activities in each state can be found in Appendix A. There is considerable variability in the recommendations, but they are generally organized into six categories (Table B-1). No recommendations were found for Arizona, New Mexico, Oklahoma, Texas, or Utah.

Statewide Management Strategies

A statewide management strategy was suggested for Burrowing Owls in California, addressing ground squirrel control policies, fire management and agricultural practices, and land management on golf courses, airports, and private lands. Additionally, it was recommended the State relocate Burrowing Owls threatened by development, while striving to maintain populations encircled by development.

Recommendations in Nevada included development of Best Management Practices for rangeland pesticides and minimizing use, particularly in areas of high Burrowing Owl density. The impacts of off-road vehicles could be mitigated by adjustment of sanctioned event routes and closure of casual use in Burrowing Owl breeding centers, presumably regulated by State and Federal agencies.

Artificial Burrows

Artificial Burrows as a means of maintaining current populations or encouraging populations to immigrate to new sites was recommended in California, Idaho, and Nevada. Care was suggested in Nevada to place artificial burrows, whether used as mitigation or not, in protected areas suitable to support owls. The suggestion of a "Burrowing Owl trail," as with bluebirds, was made in Minnesota.

Relocation

Relocation of colonies away from impending development was suggested in California, where development pressure in several areas of the state is especially great, although most relocations were unsuccessful.

Surveys and Research

Surveys were recommended in California, Minnesota, Nebraska, Nevada (Mojave Desert region), North Dakota, and South Dakota, either to locate new nest sites, monitor known sites, or both. Survey recommendations in North Dakota included the development of a database of incidental sightings in the State. Research recommendations in North Dakota included detailed studies of Burrowing Owl reproductive success and survival (particularly on prairie dog colonies). In Nevada, research on the impacts of rangeland pesticides and off-road vehicles on Burrowing Owls, and on the degree to which populations are reliant on agriculture was recommended.

Education

Education of people who shoot ground squirrels and prairie dogs was recommended in Colorado, Minnesota, and Montana. Farmers and off-road vehicle enthusiasts are suggested targets of education in Nevada. In Nevada, it was suggested that USDA Natural Resource Conservation Service (NRCS) extension services could help to educate the farming community regarding the benefits of field margins as wildlife habitat, the effects of the indiscriminate use of insecticides and rodenticides, and the advantages of maintaining high raptor populations to control pests on crop and pasture lands.

Table B-1: General categories of conservation recommendations for Burrowing Owls from states for which recommendations were found[1].

	CA	ID	MN	MT	NE	NV	ND	OR	SD	WA	WY
Statewide Management Strategy	◆					◆					
Artificial Burrows	◆	◆	◆			◆					
Relocate Owls	◆										
Surveys & Research	◆		◆		◆	◆	◆		◆		
Education			◆	◆		◆					
Habitat Protection & Management, & Burrowing Animal Management		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

[1]–No recommendations were found for Arizona, Colorado, New Mexico, Oklahoma, Texas, or Utah.

Habitat Protection

Habitat protection and management, and protection and management of burrowing mammals was suggested in several states. Recommendations included the following: introduce fire in shrub-steppe to increase grassland near cropland, reduce the conversion of grasslands and pasture to cultivation, and maintain pesticide- and herbicide-free zones of 600-m radius around burrows (Idaho); leave drain ditches unburned and ditch banks and turnrows undisturbed (Nevada); protect burrow sites (Colorado, Idaho, and Nevada); establish conservation easements with private landowners to secure good owl habitats (Nevada); maintain open ground cover >40%, and native grass cover <40% and <40 cm tall on average, and maintain a 200-m buffer around nest burrows where human activities are prohibited (Oregon and Washington); maintain 100-300 m buffers around nest burrows (Colorado); preserve shortgrass habitat and manage for ground squirrels and badgers (Minnesota); preserve salt desert scrub habitat and its burrowing mammal community (Nevada); manage plague in prairie dog towns and change regulations regarding shooting of prairie dogs and ground squirrels (Montana); survey prairie dog colonies for burrowing owls and reevaluate hunting of prairie dogs (Nebraska and South Dakota); manage habitats for prairie dogs (North Dakota) and restore former prairie dog colonies on National Grasslands (Wyoming); preserve habitat for burrow providers (Oregon and Washington); and work with developers in urban and suburban areas to preserve open space within developments for Burrowing Owls (Nevada).

Sources of Conservation Recommendations

California

California Burrowing Owl Consortium
http://www2.ucsc.edu/scpbrg/owls.htm

J. Barclay, pers. commun.

Colorado

Coloardo Partners in Flight Bird Conservation Plan. 2000. http://rmb.wantjava.com/bcp/index.htm

Idaho

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Minnesota

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Martell, M. S., J. Schladweiler, and F. Cuthbert. 2001. Status and attempted reintroduction of Burrowing Owls in Minnesota. Journal of Raptor Research 35:331-336.

Montana
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Restani, M., L. R. Rau, and D. L. Flath. 2001. Nesting ecology Of Burrowing Owls occupying prairie dog towns in southeastern Montana. Journal of Raptor Research 35:296-303.

Nebraska
Desmond, M. J., and J. A. Savidge. 1999. Satellite burrow use by Burrowing Owl chicks and its influence on nest fate. Pages 128-130 *in* P. D. Vickery and J. R. Herkert, editors. Ecology and conservation of grassland birds of the western hemisphere. Studies in Avian Biology 19.

Nevada
Neel, L. 1999. Nevada Partners in Flight Bird Conservation Plan. Nevada Partners in Flight. http://www.blm.gov/wildlife/plan/pl-nv-10.pdf

North Dakota
R. Murphy, pers. commun.

Oregon
Altman, B., and A. Holmes. 2000. Conservation strategy for landbirds in the Columbia Plateau of eastern Oregon and Washington, version 1.0. Oregon-Washington Partners in Flight.

South Dakota
E. Dowd Stukel and D. Backlund, pers. commun.

Washington
Altman, B., and A. Holmes. 2000. Conservation strategy for landbirds in the Columbia Plateau of eastern Oregon and Washington, version 1.0. Oregon-Washington Partners in Flight.

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Appendix C: Distribution List for the Burrowing Owl Status Assessment and Conservation Plan

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Appendix D: Scientific and Common Names of Animals and Plants Mentioned in the Burrowing Owl Status Assessment and Conservation Plan

Table D-1: Scientific and common names of animals mentioned in the "Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States".

Scientific Name	Common Name
Accipiter cooperii	Cooper's Hawk
Athene cunicularia floridana	Florida Burrowing Owl
Athene cunicularia hypugaea	Western Burrowing Owl
Bubo virginianus	Great-horned Owl
Buteo jaimaicensis	Red-tailed Hawk
Buteo regalis	Ferruginous Hawk
Buteo swainsoni	Swainson's Hawk
Canis familiaris	Domestic dog
Canis latrans	Coyote
Circus cyaneus	Northern Harrier
Corvus brachyrhynchos	American Crow
Cynomys ludovicianus	Black-tailed prairie dog
Cynomys gunnisoni	Gunnison's prairie dog
Cynomys leucurus	White-tailed prairie dog
Dasypus novemcinctus	Nine-banded armadillo
Dipodomys ordii	Ord kangaroo rat
Dipodomys spectabilis	Banner-tailed kangaroo rat
Dipodomys spp.	Kangaroo rat
Eremophila alpestris	Horned Lark
Falco columbarius	Merlin
Falco mexicanus	Prairie Falcon
Falco peregrinus	Peregrine Falcon
Falco sparverius	American Kestrel
Felis catus	Domestic cat
Gopherus agassizii	Desert tortoise
Gopherus polyphemus	Gopher tortoise
Haliaeetus leucocephalus	Bald Eagle
Lynx rufus	Bobcat
Marmota flaviventris	Yellow-bellied marmot
Marmota monax	Woodchuck
Mephitis spp.	Skunk
Microtus californicus	Meadow vole
Microtus montanus	Montane vole

Table D-1: Continued

Scientific Name	Common Name
Mustela nigripes	Black-footed ferret
Mustela spp.	Weasel
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Deer mouse
Reithrodontomys megalotis	Western harvest mouse
Solenopsis wagneri	Fire ant
Spermophilus columbianus	Columbian ground squirrel
Spermophilus douglasii	Douglas's ground squirrel
Spermophilus richardsonii	Richardson's ground squirrel
Spermophilus spilosoma	Spotted ground squirrel
Spermophilus tereticaudus	Round-tailed ground squirrel
Spermophilus tridecemlineatus	Thirteen-lined ground squirrel
Spermophilus variegatus	Rock squirrel
Taxidea taxus	Badger
Thomomys spp.	Pocket gophers
Tyto alba	Barn Owl
Vulpes spp., *Urocyon cineroargenteus*	Foxes

Table D-2: Scientific and common names of plants mentioned in the "Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States".

Scientific Name	Common Name
Agropyron spicatum	Bluebunch wheatgrass
Artemisia tridentata	Big sagebrush
Atriplex polycarpa	Saltbush
Bouteloua gracilis	Blue grama
Bromus tectorum	Downy brome, Cheatgrass
Buchloe dactyloides	Buffalograss
Chrysothamnus nauseosus	Rabbit brush
Gutierrezia sarothrae	Snakeweed
Halogeton glomeratus	Halogeton
Larrea divaricata	Creosote bush
Oryzopsis contracta	Indian ricegrass
Pinus edulis	Pinyon pine
Pinus ponderosa	Ponderosa pine
Poa sandbergii	Sandberg bluegrass
Prosopis spp.	Mesquite
Purshia tridentata	Antelope bitterbrush
Sarcobatus vermiculatus	Greasewood
Salsola tragus	Russian thistle
Stipa comata	Needle and thread
Tamarix ramosissima	Tamarisk

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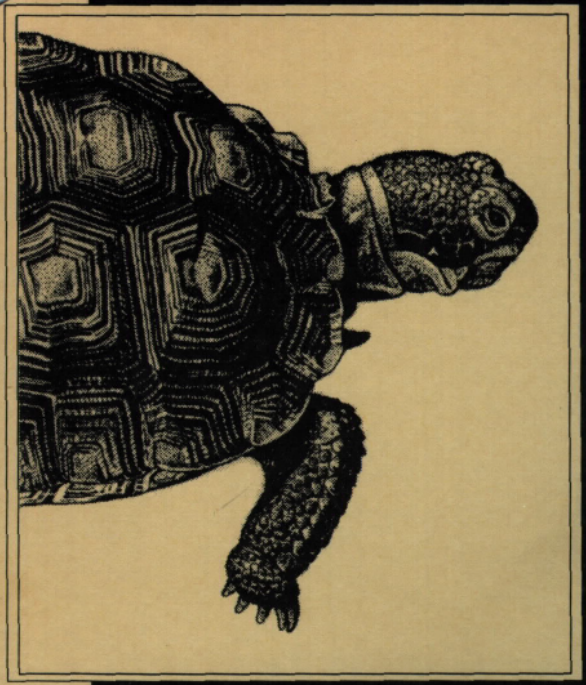
June 2003

EXHIBIT 647

Desert Tortoise

(Mojave Population)



Recovery Plan

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island Territories under U.S. administration.

Desert Tortoise

(Mojave Population)

Recovery Plan

June 1994

Prepared for Regions 1, 2, and 6 of the U.S. Fish and Wildlife Service
Region 1 - Lead Region, Portland, Oregon.

DESERT TORTOISE (MOJAVE POPULATION)

RECOVERY PLAN

Prepared by
the Desert Tortoise Recovery Team

For

Regions 1, 2, and 6
U.S. Fish and Wildlife Service
Region 1 - Lead Region, Portland, Oregon

Approved _____
Regional Director, U.S. Fish and Wildlife Service

Concurred _____
Chairman, Desert Tortoise Management Oversight Group

Date Approved June 28, 1994

DISCLAIMER PAGE

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than the Fish and Wildlife Service, and only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in special status, and the completion of recovery tasks.

LITERATURE CITATION SHOULD READ AS FOLLOWS:

Fish and Wildlife Service. 1994. Desert tortoise (Mojave population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 73 pages plus appendices.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
Telephone: (301) 492 6403 or
1-(800) 582 3421

The fees for plans vary depending on the number of pages.

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EXECUTIVE SUMMARY

Current Status:

The range of the desert tortoise, *Gopherus agassizii*, includes the Mojave and Sonoran deserts in southern California, southern Nevada, Arizona, the southwestern tip of Utah, and Sonora and northern Sinaloa, Mexico. The Mojave population of the desert tortoise (an administrative designation for animals living north and west of the Colorado River) was listed as threatened on April 2, 1990. Critical habitat for the Mojave population was designated on February 8, 1994.

Habitat Requirements and Limiting Factors:

The Mojave population of the desert tortoise occurs primarily on flats and bajadas characterized by scattered shrubs and abundant inter-space for growth of herbaceous plants, with soils ranging from sand to sandy-gravel. Desert tortoises are also found on rocky terrain and slopes, and there is significant geographic variation in the way desert tortoises use available resources.

The Mojave population was listed because desert tortoise numbers are declining precipitously in many areas. These declines are mainly attributed to direct and indirect human-caused mortality coupled with the inadequacy of existing regulatory mechanisms to protect desert tortoises and their habitat. Impacts such as the destruction, degradation, and fragmentation of desert tortoise habitat result from urbanization, agricultural development, livestock grazing, mining, and roads. Human "predation" is also a major factor in the decline of desert tortoise populations. Predation is used here in its broadest sense, meaning the taking of desert tortoises out of their populations either by death (accidental or intentional) or removal from native habitat. An upper respiratory tract disease (URTD) is an additional major cause of desert tortoise mortality and population decline, particularly in the western Mojave Desert.

Recovery Objective:

Delisting through recovery.

Delisting Criteria:

Genetics, morphology, behavior, ecology, and habitat use define six distinct population segments or recovery units[1] within the range of the Mojave population: northern Colorado, eastern Colorado, upper Virgin River, eastern Mojave, northeastern Mojave, and western Mojave. The

---

[1] For the purpose of this document, the following definitions should be used:

Recovery unit - a geographic area harboring an evolutionarily distinct population of the desert tortoise (Mojave population);
Desert Wildlife Management Area (DWMA) - administrative area within the recovery unit which is managed such that reserve-level protection is afforded desert tortoise populations while maintaining and protecting other sensitive species and ecosystem functions (e.g., watersheds).

population within a recovery unit may be considered for delisting when the following criteria are met:

(1) As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation);

(2) enough habitat must be protected within a recovery unit, or the habitat and desert tortoise populations must be managed intensively enough to ensure long-term viability;

(3) provisions must be made for population management within each recovery unit so that discrete population growth rates (lambdas) are maintained at or above 1.0.

(4) regulatory mechanisms or land management commitments must be implemented that provide for long-term protection of desert tortoises and their habitat; and

(5) the population in the recovery unit is unlikely to need protection under the Endangered Species Act in the foreseeable future.

Actions Needed:

This Recovery Plan describes a strategy for recovery and delisting. Key to this strategy is

- the establishment of at least one Desert Wildlife Management Area

- implementation of reserve level protection within each DWMA

so as to maintain at least one viable population at a minimum density of 10 adult tortoises per square mile within each of the six recovery units. Based on genetic and demographic considerations outlined in the Plan it is recommended that each DWMA within a recovery unit be at least 1,000 square miles in extent so as to contain a viable population of desert tortoises that is relatively resistant to extinction processes. To insure population persistence the Plan proposes multiple DWMAs connected by protected functional habitat within recovery units wherever enough extant desert tortoise habitat exists. Multiple, smaller, and more intensively managed DWMAs with a combined area of 1,000 square miles may be necessary in recovery units where individual DWMAs of 1,000 square miles are not possible to contain a viable population. In all, 14 DWMAs are proposed.

The Recovery Plan recommends general areas where DWMAs should be established within recovery units. DWMA selection and boundary delineation, however, should be accomplished by land management agencies in close coordination with the Fish and Wildlife Service and State wildlife agencies, after soliciting input from other interested parties. The design of DWMAs should follow accepted concepts of reserve design. Action Need 1 is recommended to establish the DWMAs:

1. Develop and implement recovery unit management plans. This task includes (a) selection and delineation of DWMAs, (b) securing of habitat in DWMAs, (c) development of management within DWMAs necessary to reduce or eliminate factors which have caused declines in desert tortoise populations, (d) implementation of DWMA management, and (e) monitoring of the recovery effort.

Additional actions needed to accomplish recovery are:

2. Environmental education to inform the public about the status of the desert tortoise and regulations within DWMAs.

3. Research activities necessary to monitor and guide the recovery effort.

Costs:

(in $1,000s) Costs of specific management actions in DWMAs will be determined after recovery unit management plans are developed and are shown as "to be determined" (TBD).

Year	Need 1	Need 2	Need 3	Total
1994	860	950	1760	3570
1995	2055	0	1817	3872
1996	0	0	1750	1750
1997	0	0	1225	1225
1998	1135	0	1205	2340
1999	0	0	325	325
2000	0	0	305	305
2001	1135	0	285	1420
2002	0	0	285	285
2003	0	0	300	300
2004	1135	0	90	1225
2005	0	0	50	50
2006	0	0	70	70
Recovery Costs:	6,320	950	9,432	16,702

Date of Recovery: Delisting could be initiated in year 2019 if recovery criteria have been met.

CONTENTS

	Page
Executive Summary	i
Contents	iv
List of Figures	v
List of Tables	vi
I. INTRODUCTION	1
A. Status of the Mojave Population of the Desert Tortoise	2
1. Listing of the Mojave population	2
2. Critical habitat designation	2
3. Current population trends	3
B. Reasons for Decline	3
1. Human contact and direct mortality	6
2. Predation	6
3. Disease	7
4. Habitat destruction, degradation, and fragmentation	8
C. Current Management	10
1. Endangered Species Act protection	10
2. BLM management	13
3. Management by other agencies	14
4. State laws protecting desert tortoises	14
D. Desert Tortoise Habitat	15
1. Desert regions and vegetational communities	15
2. Habitat requirements	15
E. Natural History of the Desert Tortoise	15
1. Nomenclature and description	15
2. Paleontology and distribution	16
3. Genetics and morphology	17
4. Ecology and natural history	17
F. Distinct Population Segments of the Desert Tortoise	19
1. Background	19
2. Evolutionarily significant units of the desert tortoise within the Mojave region	20
G. Desert Tortoise Life History, Population Dynamics, and Other Factors Which Dictate a Slow and Uncertain Recovery	27

II. RECOVERY 31

A. Principles Followed in Developing Recovery Goals 31

1. Maintenance of distinct population segments 31
2. Genetic considerations in population viability 31
3. Demographic considerations in population viability 32
4. Comprehensive considerations in population viability 33
5. Reserve Architecture 34
6. Ecosystem protection 36

B. Recovery Strategy 36

1. Size and Number of Reserves 36
2. Experimental Management Zones 36
3. Modification of the Recovery Plan 37

C. Recovery Objective and Delisting Criteria 43

1. Recovery objective 43
2. Recovery criteria 43

D. Narrative Outline Plan for Recovery Actions Addressing Threats 45

1. Establish DWMAs and implement management plans for each of the 6 recovery units 46
2. Establish environmental education programs 52
3. Initiate research necessary to monitor and guide recovery efforts 53

E. Desert Wildlife Management Areas: Management Recommendations 55

1. Recommended regulations in DWMAs 56
2. Recommended management actions 58

III. IMPLEMENTATION SCHEDULE 63

IV. APPENDICES

Appendix A. Estimation of Regional Densities A-1
Appendix B. Guidelines for Translocation B-1
Appendix C. Desert Tortoise Population Viability C-1
Appendix D. Human Activities which Directly or Indirectly Threaten Naturally-Occurring Populations of Desert Tortoises and Their Habitats in the 1990's D-1
Appendix E. Vegetation and Climate of the Mojave Region E-1
Appendix F. Summary Descriptions of Desert Wildlife Management Areas F-1
Appendix G. Environmental Determinants of Population Size G-1
Appendix H. Critical Habitat Maps H-1
Appendix I. Summary of Comments I-1

V. ACRONYMS USED IN THE DOCUMENT ACR-1

VI. LITERATURE CITED LIT-1

LIST OF FIGURES

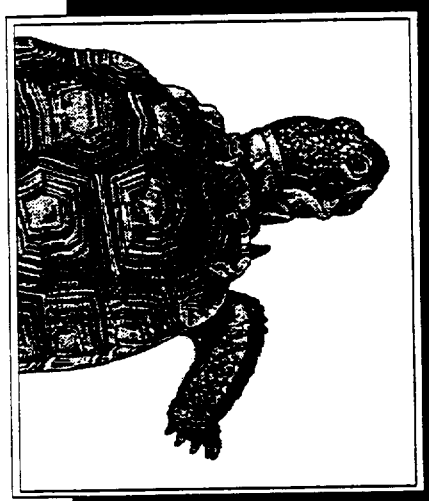
Figure	Page
1. Population trends on ten long-term study plots with a high incidence of human-caused mortality	4
2. Annual home range sizes for desert tortoises as a function of the amount of food resources (spring annual plants)	9
3. Approximate boundaries of recovery units of the desert tortoise in the Mojave region	23
4. Simulated population growth rate of desert tortoises assuming various rates of mortality and maturation	29
5. Adult and juvenile survivorship necessary for a net reproductive rate of (population neither growing nor declining) when females produce an average of 5 to 6 eggs per year	30
6. Schematic representation of wildlife reserves within recovery units	35
7. Proposed DWMAs in the northern Colorado and eastern Colorado recovery units	39
8. Proposed Upper Virgin River DWMA in the Upper Virgin River recovery unit	40
9. Proposed DWMAs in the eastern and northeastern Mojave recovery units	41
10. Proposed DWMAs in the western Mojave recovery unit	42

LIST OF TABLES

	Table	Page
1.	Partial summary of references relating effects of human activities on the desert tortoise	5
2.	Vegetation communities and typical foods used by the desert tortoise (*Gopherus agassizii*) within recovery units	24
3.	Topography, substrate, winter burrow site preference, and denning behavior of the desrt tortoise (*Gopherus agassizii)* in each recovery unit	25
4.	Distribution of recovery units of the desert tortoise (*Gopherus agassizii*) by genetic unit (mtdna) and phenotype	26
5.	Numbers of freezing days and amounts and timing of precipitation within recovery units	26
6.	Adult desert tortoise densities, and degree of threat for desert tortoise populations in the 14 proposed Desert Wildlife Management Areas	38
7.	Actions needed immediately in proposed Desert Wildlife Management Areas	60

I. Introduction

Desert Tortoise
(Mojave Population)



Recovery
Plan

proposed Desert Wildlife Management Areas; Appendix G proposes a means to analyze the environmental determinants of population size; Appendix H contains designated desert tortoise critical habitat maps which were based upon DWMA boundaries proposed in the Draft Plan; and Appendix I provides a summary of the comments received on the Draft Plan.

A. Status of the Mojave Population of the Desert Tortoise.

1. Listing of the Mojave Population.

In the early 1970's, biologists began to recognize that desert tortoise populations were declining through much of their range in the United States. In 1980, the Fish and Wildlife Service listed the desert tortoise on the Beaver Dam Slope in Utah as a federally threatened species and designated critical habitat. In 1984, the Defenders of Wildlife, Natural Resources Defense Council, and Environmental Defense Fund petitioned the Fish and Wildlife Service to list the desert tortoise as endangered (Fish and Wildlife Service 1985). In 1985, the Fish and Wildlife Service made a determination that the listing was warranted, but action was precluded because of other pending higher priorities. New information on mortality rates resulted in the emergency listing of desert tortoises north and west of the Colorado River (excluding the Beaver Dam Slope population) as endangered, on August 4, 1989 (Fish and Wildlife Service 1989a). The entire Mojave population* was subsequently listed as threatened on April 2, 1990 (Fish and Wildlife Service 1990a). The primary reasons for listing this population included deterioration and loss of habitat, collection for pets or other purposes, elevated levels of predation, loss of desert tortoises from disease, and the inadequacy of existing regulatory mechanisms to protect desert tortoises and their habitat (Fish and Wildlife Service 1990a).

2. Critical habitat designation.

In 1993 several environmental groups sued the Department of the Interior to compel designation of critical habitat for the Mojave population of the desert tortoise, alleging that the Secretary had failed to meet the designation deadline under section 4(b)(6)(C)(ii) of the Endangered Species Act. Final critical habitat designation for the Mojave population was published in the Federal Register in February 1994 (59 FR 5820). Designated critical habitat for the desert tortoise encompasses portions of the Mojave and Colorado deserts that contain the primary constituent elements and focuses on areas that are essential to the species' recovery. The critical habitat

* "Mojave population" as used here is a regulatory designation for those desert tortoises occurring north and west of the Colorado River. Elsewhere in this document "population" adheres to the biological definition: a group of individuals in a given area at a given time (Ehrlich et al. 1974).

unit boundaries were based on proposed DWMAs in the Draft Recovery Plan for the Desert Tortoise (Mojave Population) (Fish and Wildlife Service 1993) (Appendix H). Further discussion of critical habitat and its relevance to recovery of the species can be found in Section II.E.

3. *Current population trends.*

It is estimated that many desert tortoise populations have declined at rates ranging between 3 and 59 % per year (Berry 1990, as amended). These declines have been attributed to direct take by humans (e.g., collection for pets or food, shooting, killing and injuring with motor vehicles); habitat loss, degradation, and fragmentation (e.g., due to roads, agriculture, residential development, military training); diseases; and recent drought (Sievers et al. 1988, Luckenbach 1982, Coombs 1977a and b, Appendix D). Populations in areas with a high incidence of known human-caused mortality exhibit the greatest declines (Figure 1).

B. *Reasons for Decline.*

The following account draws upon a large body of literature detailing the major causes of desert tortoise population decline (Table 1). This information is reviewed in Appendix D and in Jacobson (1994), except where otherwise cited.

The most serious problem facing the remaining desert tortoise populations in the Mojave region (the area occupied by the Mojave population of the desert tortoise) is the cumulative load of human and disease-related mortality accompanied by habitat destruction, degradation, and fragmentation. Virtually every extant desert tortoise population has been affected by one or more of these factors. While the recent drought undoubtedly exacerbated already difficult conditions for desert tortoises, current population declines are not simply the result of drought. Drought is a natural occurrence which desert tortoises have experienced and survived for thousands of years (VanDevender et al. 1987).

As a result of cumulative impacts, desert tortoise populations have been extirpated or almost extirpated from large portions of the western and northern parts of their geographic range in California (e.g., Antelope, Indian Wells, and Searles valleys) (Appendix D). Population declines or extirpations attributable to cumulative impacts have occurred in and near the California communities of Mojave, Boron, Kramer Junction, Barstow, Victorville, Apple Valley, Lucerne Valley, and Twentynine Palms. Similar patterns are evident near Las Vegas, Laughlin, and Mesquite, Nevada; and St. George, Utah. Future extirpations can be expected in the vicinity of all cities, towns, and settlements.

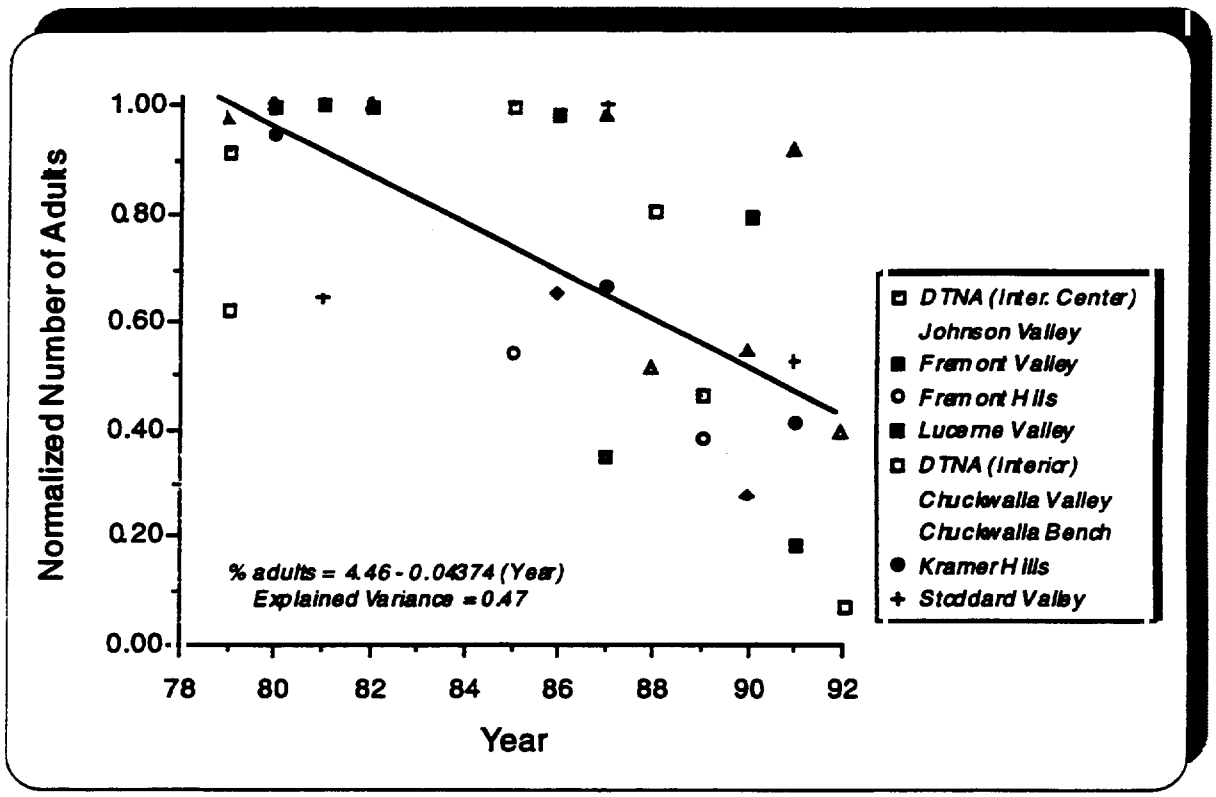


Figure 1. The number of adult desert tortoises found on desert tortoise trend plots located in California (Berry 1990, as amended) The study plots shown occur in areas with a high incidence of known human-caused mortality. All data are normalized to the highest population size recorded within the years populations were monitored. The downward trend in population density is highly significant ($F_{1,14} = 28.4$, $p < 0.0001$).

Table 1. Partial summary of references relating the effects (direct and indirect) of human activities, off highway vehicles (OHVs), and grazing of domestic cattle and sheep on desert tortoise habitat and on the desert tortoise (*Gopherus agassizii*).

HUMAN ACTIVITIES

Effects of Human Population Growth and Urbanization
- Biosystems 1992
- Berry 1984b
- Berry and Burge 1984
- Berry and Nicholson 1984b
- Klemens 1989
- Lamb 1991
- Swingland and Klemens 1989
- Tierra Madre 1991

Effects of Freeways, Highways, Paved and Dirt Roads, and Railroads
- Berry et al. 1986a
- Berry and Turner 1984
- Boarman et al. 1992
- Dames and Moore 1991
- Goodlett and Goodlett 1991, 1992
- Marlow and Hoff 1992
- Mount 1986
- Nicholson 1978a, 1978b
- U.S. Ecology 1989

Effects of Military Operations
- Berry and Nicholson 1984b
- Krzysik 1985
- Krzysik and Woodman 1991
- Prose 1985, 1986
- Prose and Metzger 1985
- Prose et al. 1987

Effects of Energy (transmission and pipelines), and Mineral Development
- Berry 1984b
- Berry and Nicholson 1984b
- Biosystems 1992
- Brum et al. 1983
- Riedy 1989
- Robinette 1973
- Woodman et al. 1983

Human Vandalism
- Berry 1984b, 1986a, 1990, as amended
- Berry and Nicholson 1984b
- Berry et al. 1986a
- Bury and Marlow 1973
- Campbell 1981
- Ginn 1990
- Jaeger 1950
- Jennings 1991

Human Predation for Food
- Ditzler 1991
- Swingland and Klemens 1989
- Schneider and Everson 1989

Collection and Commercial Trade
- Berry 1990, as amended
- Berry and Burge 1984
- Berry and Nicholson 1984b
- Ginn 1990
- Howland 1989
- Jennings 1991
- St. Amant 1984
- Stewart 1991

USE OF OHVs

Immediate Effects

Loss of Soil
- Wilshire 1977a, 1977b, 1979
- Wilshire et al. 1977

Loss of Annual Plants, Grasses
- BLM 1975
- Wilshire et al. 1977

Loss of Perennial Plants
- Wilshire 1979
- Wilshire et al. 1977

Loss of Desert Tortoise Burrows
- Burge 1983
- Bury 1978
- Bury and Luckenbach 1986
- Bury and Marlow 1973

Crushing Desert Tortoises
- Bury and Luckenbach 1986
- Luckenbach 1975

Delayed and Cumulative Effects

Loss of Soil
- Baldwin and Stoddard 1973
- Gilette and Adams 1983
- Hinckley et al. 1983
- Nakata 1983
- Sheridan 1979
- Stull et al. 1979
- Wilshire 1980
- Wilshire et al. 1977

Soil Compaction
- Adams et al. 1982a
- Bodman and Constantin 1965
- Dickey et al. 1973
- Webb 1983
- Webb et al. 1978
- Wilshire 1977a, b
- Wilshire and Nakata 1976
- Wilshire et al. 1977

Effect on Annual Plants
- Adams et al. 1982a, 1982b
- Rowlands et al. 1980

Effect on Perennial Plants
- Biosystems 1992
- Bury and Luckenbach 1983, 1986
- Bury et al. 1977
- Davidson and Fox 1974
- Keefe and Berry 1973
- Lathrop 1983a, b
- Vollmer et al. 1976

Effects on Live Desert Tortoises
- Bury 1987
- Bury and Luckenbach 1986
- Bury et al. 1977

Effects on Other Vertebrates
- Berry 1973
- Bondello 1976
- Brattstrom and Bondello 1983
- Bury and Luckenbach 1983
- Bury et al. 1977
- Busack and Bury 1974
- U.S. BLM 1975

GRAZING OF DOMESTIC SHEEP AND CATTLE

Changes in Habitat

Soil
- Arndt 1966
- Avery et al. 1992
- Ellison 1960
- Gifford and Hawkins 1978
- Klemmedson 1956
- Sharp et al. 1964

Vegetation
- Bentley 1898
- Clements 1934
- Coombs 1977a, b
- Corbett 1952
- Ellison 1960
- Frenkel 1970
- Gardner 1951
- Hardy 1945
- Humphrey 1958, 1987
- Janzen 1986
- Kay et al. 1988
- Mack 1981
- Nicholson and Humphreys 1981
- Orians 1984
- Reynolds 1958
- Rowlands et al. 1980
- BLM 1980a
- Webb and Stielstra 1979
- Wester 1981

Competition Between Tortoises and Livestock
- Berry 1978
- Biosystems 1992
- Coombs 1979
- Medica et al. 1982
- Nicholson and Humphreys 1981
- Sheppard 1981

Trampling
- Berry 1978
- Berry and Shields et al. 1986
- Knowles 1987
- Marlow 1974
- Nicholson and Humphreys 1981
- Rauzi and Smith 1973
- Webb and Wilshire 1980

Consequences of Altered Habitat
- Coe et al. 1976, 1979
- Congdon and Gibbons 1985
- Gibbons and Patterson 1982
- Gibbons et al. 1983
- Jarchow and May 1989
- Jones 1987
- Mitchell 1985
- Swingland and Coe 1979
- Tracy 1992
- Turner et al. 1984, 1987
- Wingfield 1983

Population Declines in the Tortoise and Other Native Herbivores
- Busack and Bury 1974
- Karl 1980, 1982
- Medin and Cleary 1989
- Phillips 1936
- Turner et al. 1981

1. Human contact and direct mortality.

Human "predation" is a major factor in the decline of the desert tortoise. Here predation is used in its broadest sense, meaning the taking of desert tortoises out of their natural populations either by death (accidental or intentional) or by removal. People illegally collect desert tortoises for pets, food, and commercial trade. Some new immigrants to the United States collect desert tortoises for medicinal or other cultural purposes (Section 4.1 of Appendix D). Stewart (1991) reported that from 12.5 to 43.7% of desert tortoises with radio transmitters were poached or suspected of being poached from his research site in the western Mojave Desert between 1987 and 1991. Berry (1990, as amended) presented similar evidence of illegal collections at a study plot near Stewart's site during the 1980's. Even in remote areas, desert tortoises on permanent study plots have been collected and later have appeared in cities or towns dozens of miles away from the plots.

Desert tortoises are often struck and killed by vehicles on roads and highways, and mortality of desert tortoises due to gunshot and off-highway vehicles is common in parts of the Mojave region, particularly near cities and towns where people and desert tortoises most frequently come in contact. For example, between 1981 and 1987, 40% of the desert tortoises found dead on a study plot in the Fremont Valley, California, were killed by gunshot or vehicles traveling cross-country or on trails (Berry 1990, as amended). Berry (1986a) reported that nearly 15% of 635 desert tortoise carcasses that were examined from several California study sites showed signs of gunshot.

2. Predation.

Desert tortoises, particularly hatchlings and juveniles, are preyed upon by several native species of mammals, reptiles, and birds. Domestic and feral dogs are a new, and probably significant, source of mortality (Causey and Cude 1978, Berry 1979). Predation by the common raven (*Corvus corax*) is intense on younger age classes of the desert tortoise, and the Fish and Wildlife Service's Breeding Bird Survey Program provided data to show a 15-fold increase in raven populations in the Mojave Desert and a 4.7-fold increase in raven populations in the Colorado and Sonoran deserts from 1968 and 1988 (Bureau of Land Management et al. 1989, Table 1). Raven population increases seem to be due to increased food supplies, (e.g., roadkills, landfills, trash, garbage dumps, agricultural developments), as well as new sites for perches and nests (e.g., fence posts, power poles and towers, signs, buildings, bridges, and freeway access-ramps).

The contribution of mammalian or avian predation to overall desert tortoise mortality is not well understood. The best-documented predator is the raven. Berry (1990, as amended) believes that

predation pressure from ravens probably has resulted in such high losses of juveniles in some portions of the Mojave region that recruitment of immature desert tortoises into the adult population has been halted. Increased mortality of young desert tortoises combined with drastically lowered survivorship of adults is likely responsible for observed catastrophic population declines (Berry 1990, as amended).

3. *Disease.*

Disease has contributed to high mortality rates in the western Mojave Desert in the last four years (Berry 1990, as amended, Avery and Berry 1990, Jacobson 1994). Disease is also suspected of contributing to declines in desert tortoise populations in the Chuckwalla Bench area of the eastern Colorado Desert and at some sites on the Beaver Dam Slope in the northeastern Mojave Desert (Berry 1992, Jacobson et al. 1994).

An upper respiratory tract disease (URTD) is prevalent in captive desert tortoises and has been identified in wild desert tortoises in many localities in the Mojave region. The disease is currently a major cause of mortality in the western Mojave Desert and perhaps elsewhere. Recent studies have demonstrated *Mycoplasma agassizii* sp. nov. as the causative agent of URTD. A serological test has been developed to determine exposure status of desert tortoises to URTD (Schumacher et al. 1993). Predisposing factors such as habitat degradation, poor nutrition, and drought are also likely involved (Jacobson et al. 1991). Drought and concomitant poor nutrition have the potential to compromise desert tortoises immunologically and, therefore, make them more susceptible to URTD. However, in recent experimental studies, URTD was induced in apparently healthy desert tortoises when challenged with an isolate of *M. agassizii* obtained from an ill desert tortoise (M.B. Brown, University of Florida, pers. comm. 1993). Under certain conditions, even healthy desert tortoises may become infected with the causative organism and develop signs of URTD. Controlling human-related spread of URTD (Jacobson 1994), improving habitat conditions, and monitoring health status of desert tortoise populations are some of the more important management tools which can be used in controlling URTD in wild populations of the desert tortoise.

URTD appears to be spreading, and may have been introduced to wild populations through illegal releases of captive desert tortoises that were ill (Jacobson 1994). Wild desert tortoises with signs of URTD are commonly found near cities and towns with concentrations of captive desert tortoises (Marlow and Brussard 1992).

A shell disease, characterized by lesions, is correlated with desert tortoise decline in the Chuckwalla Bench population in the eastern Colorado Desert (Jacobson et al. 1994, Berry 1992). Lesions

typically appear at seams between adjacent scutes and then spread toward the middle of each scute in an irregular pattern. A variety of mineral and metal deficiencies, as well as various toxicants, are known to cause integumentary pathology in mammals, suggesting a disease or toxicosis may be responsible for these observed shell abnormalities (Appendix D).

4. *Habitat destruction, degradation, and fragmentation.*

Changes in vegetation accumulating over almost a century and a half in the Mojave region have been substantial. In general, these changes are characterized by decreases in perennial grasses and native annuals and an increase in exotic ephemerals such as red brome (*Bromus rubens*). Continuous stands of exotic ephemerals provide fuel which can carry fire over large areas. Historically, fires were small or infrequent over vast areas of the Mojave region, and because native desert plants have not evolved with fire and are not adapted to it, they generally are killed by high-intensity fire. The increasing incidence and severity of fires in the Mojave region are already converting desert shrublands into ephemeral grasslands. The effects of invading exotic grasses on several ecosystems have recently been reviewed by D'Antonio and Vitousek (1992).

These vegetational changes can be detrimental to desert tortoises for a number of reasons. First, these animals require perennial shrubs for cover from the intense solar radiation in the desert. Second, perennial grasses are important secondary food sources for the desert tortoise in many areas. Third, recurrent fires and competition from exotic ephemerals may reduce the abundance and diversity of native forbs which are the major food source of the desert tortoise. Finally, major fires fragment desert tortoise habitat; fires can also kill desert tortoises (Appendix D).

Habitat fragmentation is a major contributor to population declines (Berry 1984b, Berry and Burge 1984, Berry and Nicholson 1984b, and Berry 1984c). Desert tortoises require a great deal of space to survive (Figure 2; see also Appendix C). Over its lifetime, each desert tortoise may require more than 1.5 square miles of habitat and may make forays of more than 7 miles at a time (Berry 1986b; Esque et al. in prep; K.H. Berry, pers. comm. 1993). In drought years, desert tortoises forage over larger areas (Figure 2) and thus have a greater probability of encountering potential sources of mortality. Roads and urban areas form barriers to movement and tend to create small, local populations which are much more susceptible to extinction than large, connected ones (Wilcox and Murphy 1985).

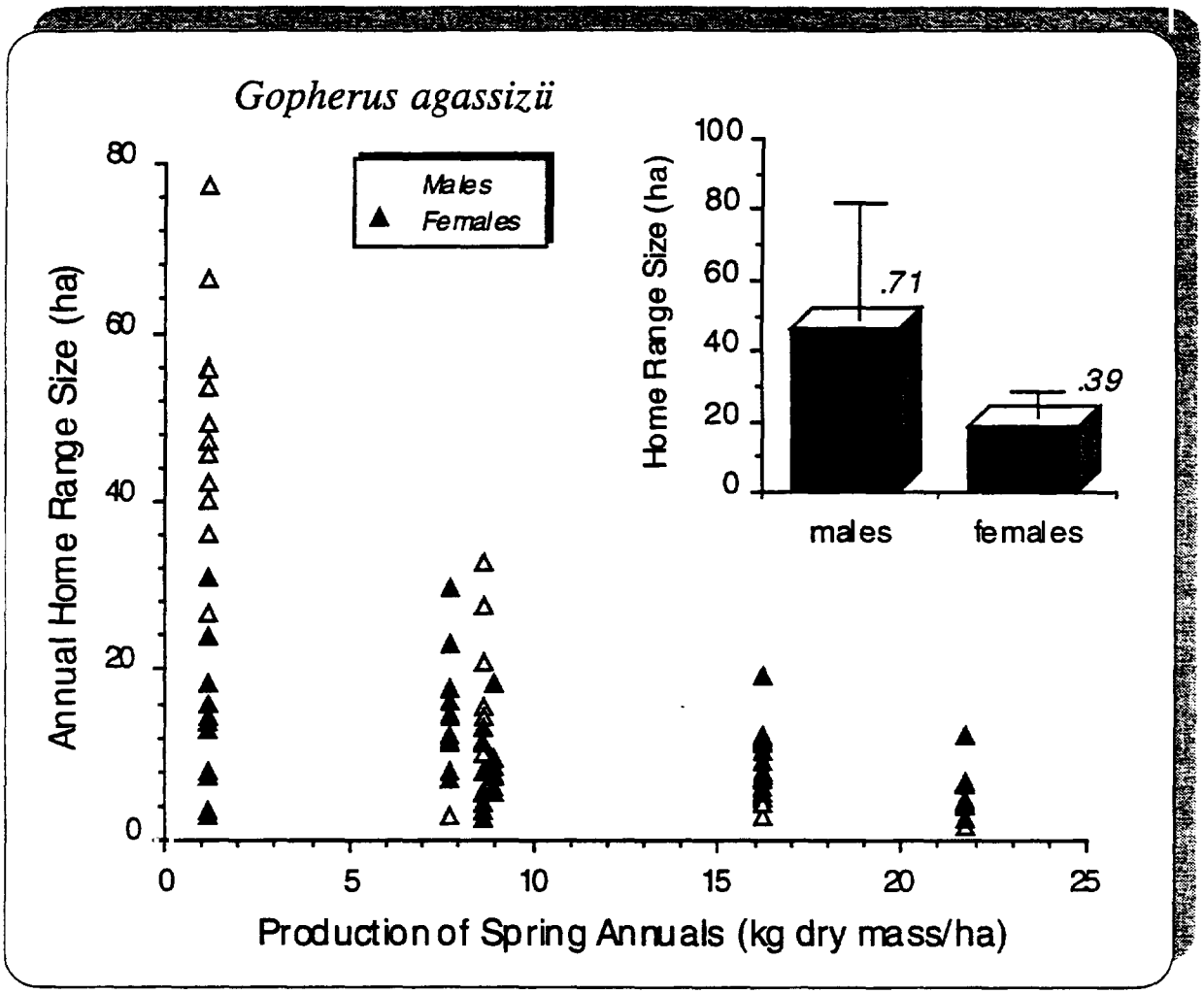


Figure 2. Annual home range sizes of desert tortoises as a function of the amount of food resources (spring annual plants) (from Esque et al., in prep.)

Grazing by cattle, domestic sheep, and feral equids can also affect desert tortoises and their habitats negatively. Livestock can kill desert tortoises and eggs directly by trampling. Grazing can also damage soil crusts, reduce water infiltration, promote erosion, inhibit nitrogen fixation in desert plants, and provide a favorable seed bed for exotic annual vegetation. Habitat destruction and degradation is especially evident in the vicinity of livestock water sources. Off-road vehicle (ORV) use also destroys, degrades, and fragments considerable areas of desert tortoise habitat; and disturbances from both grazing and ORVs facilitate the invasion of exotic plants and increased incidence of fire (Table 1, Appendix D).

A variety of other human uses have caused significant quantitative and qualitative losses of desert tortoise habitat. Urbanization; agricultural development; construction and use of transportation routes and corridors; development of utility corridors; exploration for and development of hard rock minerals, sand and gravel pits, oil and gas, and other mineral resources; and concentrated visitor use are all important causes of widespread habitat destruction. In some portions of the desert, military activities such as maneuvers, bombings, and explosions also contribute to the degradation and loss of desert tortoise habitat (Kryzik and Woodman 1991, Fish and Wildlife Service 1992). The combined effects of these various activities have resulted in extirpations and population declines of desert tortoises throughout the Mojave region. The relative contributions of these factors are well documented in some areas, but not in others (Table 1, Appendix D).

C. *Current Management*

1. *Endangered Species Act protection.*

Section 9 of the Endangered Species Act prohibits the take of any listed wildlife species, including the desert tortoise. The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. "Harm", in the definition of "take", includes significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Sections 7 and 10 of the Endangered Species Act provide regulatory mechanisms for actions affecting desert tortoises on public and private lands, respectively. Section 7(a)(1) directs Federal agencies to use their authorities to carry out programs for the conservation of endangered and threatened species. Through the section 7(a)(2) process, all Federal agencies are required to ensure that any action they authorize, fund, or carry out in the United States or upon the high seas is not likely to jeopardize the continued existence of any listed species [50 CFR 402.01(a)]. Section 10(a)(1)(B) of the Endangered Species Act gives the Fish and Wildlife Service the authority to issue permits to non-Federal and private entities for the

take of listed wildlife species, as long as such taking is incidental to, and not the purpose of, carrying out otherwise lawful activities (16 U.S.C. 1539). A section 10(a)(1)(B) permit is granted only if the applicant institutes appropriate conservation measures for habitat maintenance, enhancement, and protection, coincident with the action.

Since the emergency listing of the desert tortoise in August 1989, the Fish and Wildlife Service has reviewed hundreds of proposals for activities that could adversely affect the desert tortoise. Over this time, the Fish and Wildlife Service, other Federal agencies, and State wildlife agencies, have developed and implemented measures to minimize harm and mortality to desert tortoises resulting from human activities. These measures include the following provisions for avoiding impacts to desert tortoises found in project areas: moving animals from harm's way to adjacent undisturbed habitat where their probability of survival is increased; land acquisition and protection as compensation for destruction of desert tortoise habitat; increased law enforcement; improved management; public education; and research. The Fish and Wildlife Service has specified that all handling of desert tortoises would be in accordance with procedures approved by them.

The section 7 process can influence the planning activities of Federal agencies to reduce impacts to desert tortoises and, in some cases, benefit desert tortoises. For example, through informal consultation with the Fish and Wildlife Service, the Marine Corps developed an alternative location for a new airfield that avoided impacts to the largest concentration of desert tortoises at the Marine Corps Air Ground Combat Center at Twentynine Palms, California. In another example, through the section 7 consultation process the Fish and Wildlife Service and the Navy developed a programmatic approach for desert tortoise management and routine operations at the Naval Air Weapons Station at China Lake, California. This consultation specified standard mitigation measures for Navy staff to implement whenever desert tortoises are encountered during an action. The Navy has established an area of approximately 200,000 acres in which it will attempt to avoid siting any new facilities that would result in the disturbance of greater than 2.5 acres of desert tortoise habitat at any one time. The Navy also committed to continue its ongoing efforts to remove feral burros from desert tortoise habitat and to fence its boundary to prevent livestock grazing on its lands. In Nevada, programmatic consultations directed urban development and ORV use in the Las Vegas Valley to areas of degraded or poor habitat, thereby reducing conflicts in areas necessary for desert tortoise recovery.

Other important section 7 consultations have resulted in time and space restrictions on domestic sheep and cattle grazing and reduced impacts to desert tortoises and their habitat resulting from ORV activities, right-of-way development, mining operations, military

actions, and many other activities authorized, funded, or carried out by Federal agencies.

In 1991, the Fish and Wildlife Service issued a 3-year section 10(a)(1)(B) incidental take permit to Clark County and the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City in Nevada. As a condition of the permit, the permittees are implementing a habitat conservation plan (HCP) which provides for conservation and management of at least 400,000 acres in Clark County for the benefit of the desert tortoise (RECON 1991). Three types of mitigation measures are required by the terms of the permit: (1) conservation and management of desert tortoise habitat, (2) initiation of a desert tortoise research and relocation program, and (3) imposition of a $550-per-acre mitigation fee on projects in the permit area. Key management actions to be implemented on the 400,000 or more acres of conservation lands include: acquisition and retirement of grazing privileges; designation of roads and trails and elimination of off-highway vehicle events over most of the conservation lands; no new landfills or intensive recreation sites; and adequate enforcement, biological monitoring, and maintenance actions needed to implement these actions. The $550-per-acre mitigation fees are to be used to fund the conservation and mitigation measures. The permittees are pursuing a long-term incidental take permit which will address all of Clark County for a period of 20 years or more.

The Fish and Wildlife Service is also involved in preparation of HCPs for Washington County, Utah, and Nye County, Nevada, and several other section 10(a)(1)(B) permits have been issued or are pending for smaller projects.. Washington County, Utah is in the process of applying for a 20-year incidental take permit for desert tortoise. On May 4, 1994, the Fish and Wildlife Service received a proposed Washington County HCP (Washington County Commission 1994), as part of a permit for incidental take of desert tortoise and its habitat. The major mitigation proposed for take of desert tortoise is increased protection of the remainder of desert tortoise habitat in the area through establishment of a desert habitat reserve, or desert wildlife management area. Land ownership within the reserve will be Federal, and land exchanges and acquisition are required to consolidate habitat and management efforts. Management of the desert habitat reserve is proposed to be by BLM through eventual establishment of a National Conservation Area. The proposed reserve extends from the eastern boundary of the Paiute Indian Reservation on the west, to the City of Hurricane on the east. Within the reserve, land uses will be carefully controlled and all management actions will place the desert tortoise/habitat conservation as the highest priority. Acquisition of habitat, fencing, enforcement, education, and removal of competing uses comprise the majority of mitigation measures for proposed take. The Washington County HCP also includes proposed conservation measures for other listed and candidate species. Funding for administration, implementation, and monitoring of the

Washington County HCP includes collection of county-wide fees: 0.2% of all new construction costs, plus $250 per acre for plotted housing developments. The Fish and Wildlife Service is currently reviewing the Washington County HCP.

The Bureau of Land Management's (BLM) California Desert District, in cooperation with the Fish and Wildlife Service, California Department of Fish and Game, and local governments, is currently developing the West Mojave Coordinated Management Plan. This multi-species management strategy for 8.6 million acres will provide for long-term conservation of the desert tortoise and other rare or sensitive species, such as the Mohave ground squirrel. The plan will be the basis for a programmatic section 7 consultation for BLM activities in the planning area and serve as an HCP for local governments to obtain section 10(a)(1)(B) permits. This plan is expected to be the first of several regional conservation planning efforts in California, which would implement the guidance provided in this Recovery Plan.

2. *BLM management.*

The BLM manages most desert tortoise habitat in the Mojave region and initiated management actions to conserve this species. In 1988, the BLM issued a habitat management plan for conservation of the desert tortoise on public lands throughout its range in the United States (Spang et al. 1988). The plan groups desert tortoise habitat into three goal-oriented categories:

> Category I—Maintain stable, viable populations and protect existing tortoise habitat values; increase populations, where possible.
>
> Category II—Maintain stable, viable populations and halt further declines in tortoise values.
>
> Category III—Limit tortoise habitat and population declines to the extent possible by mitigating impacts.

Habitat areas are categorized according to four criteria: (1) importance of the habitat to maintaining viable populations, (2) resolvability of conflicts, (3) desert tortoise density, and (4) population status (stable, increasing, or decreasing). BLM's goal is to maintain viable desert tortoise populations in category 1 and 2 habitats and to limit population declines to the extent possible in category 3 habitats. The plan identifies management actions needed to implement these goals, which address environmental education, ORV use, energy and mineral development, livestock use, lands and realty actions, and other activities which may affect desert tortoises. Included is a provision to compensate for residual impacts to desert tortoises after other mitigation measures are incorporated into proposed actions. A compensation formula was

developed and adopted to implement this provision (Desert Tortoise Compensation Team 1991).

The Federal Land Policy Management Act of 1976 (public law 94-579) directed the BLM to manage public lands for multiple use and sustained yield. Wildlife is identified as one of the major uses of public lands. The Sikes Act (public laws 93-452 and 95-420) authorizes the BLM to develop and implement plans in cooperation with State wildlife agencies for the development and protection of wildlife habitat. In response to these authorizations, the BLM has developed numerous habitat management plans which address the management and conservation of the desert tortoise. The California Desert Conservation Area Plan, 1980 (BLM 1980a), a management strategy for 12.1 million acres of public land, identified five areas where habitat management plans were to be developed to conserve desert tortoise habitat. This plan also designated eight crucial desert tortoise habitat areas with specific management actions to protect desert tortoises. In addition, the BLM carries out land exchanges and uses Land and Water Conservation funds to acquire desert tortoise habitat. Special land use designations such as Areas of Critical Environmental Concern and Research Natural Areas have also been established by the BLM for the desert tortoise in the Mojave region.

3. Management by other agencies.

The BLM is the primary land manager, but a number of other Federal, State, and local entities also manage desert tortoise habitat in the Mojave region. The National Park Service provides protection for desert tortoise habitat at Joshua Tree National Monument and at Death Valley National Monument in California, and Lake Mead National Recreation Area in Nevada. The Department of Defense manages large parcels of land, particularly in California at the Fort Irwin National Training Center, the Naval Air Weapons Station at China Lake, Edwards Air Force Base, the Marine Corps Air Ground Combat Center at Twentynine Palms, and the Chocolate Mountains Gunnery Range, and in Nevada at the Nellis Air Force Base. Desert tortoise management plans have been or are being prepared for some of these military lands. The Fish and Wildlife Service's Desert National Wildlife Refuge provides protection for a portion of the desert tortoise habitat in the Coyote Spring area of Nevada. Other lands are managed by State parks and wildlife agencies, Bureau of Indian Affairs, Bureau of Reclamation, and other government agencies.

4. State laws protecting desert tortoises.

All four states in which the Mojave desert tortoise occurs have laws that provide some protection for this species; for instance, the collection of desert tortoises is prohibited in all four states. In Nevada, section 501.110.1 (d) of the Nevada Revised Statutes prohibits transportation of desert tortoises within Nevada or across

State lines. The desert tortoise is also listed as a threatened species under the California Endangered Species Act of 1984. Similar to the Federal Act, this legislation requires State agencies to consult with the California Department of Fish and Game on activities which may affect a listed species. Compensation is required by California Department of Fish and Game for projects which result in loss of desert tortoise habitat.

D. Desert Tortoise Habitat.

1. Desert regions and vegetational communities.

The Mojave region includes portions of both the Mojave and Sonoran deserts. Within the Mojave region, the Mojave Desert is represented in parts of Inyo, Kern, Los Angeles, San Bernardino, and Riverside Counties in California; the northwestern part of Mohave County in Arizona; Clark County, and the southern parts of Esmeralda, Nye, and Lincoln Counties in Nevada; and part of Washington County, Utah. The Colorado Desert, a division of the Sonoran Desert, is located south of the Mojave Desert, and includes Imperial County and parts of San Bernardino, and Riverside Counties, California. The climatic, geological, and ecological features of those portions of the Mojave and Colorado deserts inhabited by the desert tortoise are described in Appendix E.

2. Habitat requirements.

Within the varied vegetational communities of the Mojave region, desert tortoises can potentially survive and reproduce where their basic habitat requirements are met. These requirements include sufficient suitable plants for forage and cover, and suitable substrates for burrow and nest sites. Throughout most of the Mojave region, desert tortoises occur primarily on flats and bajadas with soils ranging from sand to sandy-gravel, characterized vegetationally by scattered shrubs and abundant inter-shrub space for growth of herbaceous plants. Desert tortoises are also found on rocky terrain and slopes in parts of the Mojave region, and there is significant geographic variation in the way desert tortoises use available resources (see Section I.F. for further details).

E. Natural History of the Desert Tortoise.

1. Nomenclature and description.

The generic assignment of the desert tortoise has gone through a series of changes since its original description by Cooper (1863) as *Xerobates agassizii*. Until the status of the genus is further clarified, this Recovery Plan will use the more familiar *Gopherus agassizii*. Morafka and Brussard (in prep.) detail the history of this nomenclature.

The genus *Gopherus* contains between 15 and 19 fossil, and four living, species (Auffenberg 1976, Crumly 1984). Generally, these species are divided into two groups based on morphological and genetic evidence (Auffenberg 1976, Crumly 1984, Lamb et al. 1989). One group includes the living *G. agassizii* and the Texas tortoise (*G. berlandieri*). The extant Mexican bolson tortoise (*G. flavomarginatus*) and gopher tortoise of the southeastern United States (*G. polyphemus*) are included in the second group. The recently described peninsular Baja Californian *Xerobates lepidocephalus* would have added a fifth extant species to the genus, but this taxon is most probably based on individuals of Sonoran Desert *G. agassizii* which were released into the Cape region of Baja California (Crumly 1994).

The desert tortoise is the only naturally occurring tortoise in the Mojave region. It is distinguished from the other three species of the genus *Gopherus* by a combination of characters, including a rounded front head, interhumeral seam longer than integular seam, single triangular axillary scale, and distance from base of first claw to fourth claw equal for forefoot and hindfoot (Brame and Peerson 1969). In comparison to the Mojave *G. agassizii*, *G. berlandieri* exhibits a wedge-shaped head, relatively small adult size, a bifurcate and upturned gular projection in males, and a high-domed carapace (Bogert and Oliver 1945, Behler and King 1979). *G. polyphemus* has a rounded head and is similar in maximum size to *G. agassizii*, but its carapace is more elongate and tends to be widest at midbody, whereas in *G. agassizii* the carapace is widest at about the fourth costal scute (Grant 1960, Behler and King 1979). *G. flavomarginatus* attains the largest size of any of the four species. It is distinguished from *G. agassizii* by a broad head and the presence of a pale yellow lateral border on its carapace laminae (Morafka 1982). Escaped or released captive tortoises other than *G. agassizii* (particularly *G. berlandieri*) are occasionally encountered in the Mojave region.

2. *Paleontology and distribution.*

The earliest fossils of *G. agassizii* come from Pleistocene deposits (Brattstrom 1961). During the Holocene, *G. agassizii* ranged as far west as California's San Joaquin Valley (Miller 1942, VanDevender and Moodie 1977). Prior to European settlement of the Mojave region, its range included the Mojave and Sonoran deserts in southern California, southern Nevada, western Arizona, the southwestern tip of Utah, and Sonora and Sinaloa, Mexico (Stebbins 1954, 1966). This species is also found on Tiburon Island in the Sea of Cortez (Linsdale 1940). The desert tortoise is now considerably reduced in numbers throughout much of this area and has been extirpated from parts of its historic range (Spang et al. 1988, Berry 1978).

3. *Genetics and morphology.*

Jennings (1985) used starch-gel electrophoresis of allozymes encoded by about 20 loci to explore genetic variation in *G. agassizii*. Although he found no fixed genetic differences among samples, phenograms generated from genetic distance values suggest two major population groupings that correspond roughly with the Mojave region and Sonoran Desert in Arizona. In addition, a plasma protein was polymorphic in samples from the Mojave Desert, but monomorphic in samples from the Sonoran Desert (Glenn et al. 1990).

Based on mitochondrial DNA (mtDNA) restriction-fragment polymorphisms, Lamb et al. (1989) described three major genetic units within *G. agassizii*. One unit is found in the Colorado and Mojave deserts and a second in the Sonoran Desert from west-central Arizona to central Sonora. The Colorado River appears to have been a sufficient barrier for these two assemblages to have evolved independently since the Pliocene. The third major unit is found in southern Sonora and Sinaloa, south of the Yaqui River.

Morphological variation coincides reasonably well with the mtDNA genotypes found north of Mexico. There are three distinct shell phenotypes in the United States: (1) the California phenotype from California and southwestern Nevada; (2) the Sonoran Desert phenotype from Arizona south and east of the Colorado River, and (3) the Beaver Dam Slope phenotype from extreme southwestern Utah and Arizona north of the Grand Canyon (Weinstein and Berry 1987). The California and Sonoran Desert phenotypes correspond to the Mojave region and Sonoran Desert mtDNA genotypes, respectively.

Thus, based on genetic and morphological criteria, *G. agassizii* is divided into at least two well-differentiated entities, one in the Sonoran Desert in Arizona and one in the Mojave region. A third may exist in Sonora and Sinaloa, Mexico.

4. *Ecology and natural history.*

The most complete account of the biology, ecology, and natural history of the desert tortoise is that of Woodbury and Hardy (1948). These authors studied a population of desert tortoises on the Beaver Dam Slope in extreme southwestern Utah for more than 10 years. Their study presented details of reproduction, growth and development, longevity, food habits, behavior, movement patterns, and general adaptations to desert conditions. Although no other single study of *G. agassizii* covers as many topics as Woodbury and Hardy's, a reasonably large body of literature exists on most aspects of desert tortoise biology. Berry (1986c) lists over 30 papers

published between 1976 and 1985 on topics such as distribution, abundance, habitat use, size-age class distributions, sex ratios, mortality rates, time and energy budgets, thermal relations, metabolism, and the effects of land use on population dynamics. The following general account is based upon information contained in these papers except where otherwise referenced.

Desert tortoises spend much of their lives in burrows, emerging to feed and mate during late winter and early spring. They typically remain active through the spring, and sometimes emerge again after summer storms. During these activity periods, desert tortoises eat a wide variety of herbaceous vegetation, particularly grasses and the flowers of annual plants (Berry 1974, Luckenbach 1982). Desert tortoises are essentially "K-strategists" (MacArthur and Wilson 1967), with delayed maturity and long life. Eggs and hatchlings are quite vulnerable, and pre-reproductive adult mortality averages 98% (Wilbur and Morin 1988, Turner et al. 1987, Morafka in press). Adults, however, are well protected against most predators (other than humans) and other environmental hazards and consequently are long-lived (Germano 1992, Turner et al. 1987). Their longevity helps compensate for their variable annual reproductive success, which is correlated with environmental conditions.

Desert tortoises are well adapted to living in a highly variable and often harsh environment. In adverse conditions they retreat to burrows or caves, at which time they reduce their metabolism and loss of water and consume very little food. Adult desert tortoises lose water at such a slow rate that they can survive for more than a year without access to free water of any kind. During a recent drought, desert tortoises at a study site in eastern California not only survived with very little food or water, but they produced an average of three eggs per female per year (B. Henen, UCLA, pers. comm.). Desert tortoises apparently tolerate large imbalances in their water and energy budgets (Nagy and Medica 1986). This ability enables them to survive lean years and exploit resources that are only periodically available. During years of average or better than average precipitation and forage production, desert tortoises can balance their water budgets and have a positive energy balance, providing opportunity for growth and reproduction (Nagy and Medica 1986). All the mechanisms by which desert tortoises maintain their energy and water balance in the face of stochastic availability of resources are still not clear, but desert tortoises seem to be flexible in their mechanisms of energy and water gain and in their expenditures of these resources (Wallis et al., 1992).

F. Distinct Population Segments of the Desert Tortoise

1. Background.

As a general rule, most widespread species show substantial geographic variation in genetic, morphological, ecological, physiological, and behavioral traits. This is largely attributed to natural selection favoring different character states in different climates and biotic communities (Darwin 1859), or genetic drift (Wright 1931). Such divergence, which may arise from past or present barriers to dispersal or from mere distance (Williams 1992), requires at least the partial isolation of gene pools within a species .

The desert tortoise is no exception to this generalization, because groups of populations within the Mojave region exhibit different habitat preferences, food habits, periods of activity, selection of sites for burrowing and egg-laying, and social behavior (see Section I.F.2. below). This is not surprising, since this region encompasses two major North American deserts, eight vegetational provinces, and numerous vegetation types (Appendix E).

Sections 2(b and c) and 3(15) of the Endangered Species Act provide protection to "any distinct population segment of any [listed] species of vertebrate fish or wildlife which interbreeds when mature." Waples (1991) states that, "[a] vertebrate population will be considered distinct . . . for purposes of protection under the Act if the population represents an evolutionarily significant unit (ESU) of the biological species." An ESU is a population, or group of populations, that represents significant adaptive variation within a species (Ryder 1986). Evidence of current or past reproductive isolation is not, by itself, sufficient evidence for ESU designation. Rather, the identification of ESUs requires evidence that population units have undergone significant evolutionary differentiation. Thus the identification of ESUs requires data on range and distribution, natural history, morphometrics, and genetics; concordance among two or more of these data sets strengthens the case for ESU designation (Ryder 1986). The following questions are relevant (Waples 1991):

(1) Is the population genetically distinct?

(2) Does the population occupy unusual or distinct habitat?

(3) Does the population show evidence of unusual or distinct adaptation to its environment?

2. *Evolutionarily significant units of the desert tortoise within the Mojave region.*

Data from a variety of sources indicate that there are at least six ESUs of the desert tortoise within the Mojave region. These ESUs consist of populations or groups of populations that show significant differentiation in genetics, morphology, ecology, or behavior (Tables 2, 3, 4, and 5) and thus are important components of the evolutionary legacy of *Gopherus agassizii*. The conservation of all these ESUs will help to ensure that "the dynamic process of evolution [in this species] will not be unduly constrained in the future" (Waples 1991). Hereafter these ESUs are referred to as "recovery units" (Figure 3).

In the following accounts, information on the ecology and distribution of desert tortoises comes primarily from unpublished data and field notes of the Recovery Team.

Northern Colorado Recovery Unit.

This recovery unit is located completely in California. Here desert tortoises are found in the valleys, on bajadas and desert pavements, and to a lesser extent in the broad, well-developed washes. They feed on both summer and winter annuals and den singly in burrows under shrubs, in intershrub spaces, and rarely in washes. The climate is somewhat warmer than in other recovery units, with only 2 to 12 freezing days per year. The tortoises have the California mtDNA haplotype and phenotype. Allozyme frequencies differ significantly between this recovery unit and the Western Mojave, indicating some degree of reproductive isolation between the two.

Eastern Colorado Recovery Unit.

Desert tortoises in the eastern Colorado recovery unit, also located completely in California, occupy well-developed washes, desert pavements, piedmonts, and rocky slopes characterized by relatively species-rich Succulent Scrub, Creosote Bush Scrub, and Blue Palo Verde-Ironwood-Smoke Tree communities. Winter burrows are generally shorter in length, and activity periods are longer than elsewhere due to mild winters and substantial summer precipitation. The tortoises feed on summer and winter annuals and some cacti; they den singly. They also have the California mtDNA haplotype and shell type.

Upper Virgin River Recovery Unit.

This recovery unit encompasses all desert tortoise habitat in Washington County, Utah, except the Beaver Dam Slope, Utah population. The desert tortoise population in the area of St. George, Utah, is at the extreme northeastern edge of the species' range and experiences long, cold winters (about 100 freezing days) and mild summers, during which the tortoises are continually active. Here

the animals live in a complex topography consisting of canyons, mesas, sand dunes, and sandstone outcrops where the vegetation is a transitional mixture of Sagebrush Scrub, Creosote Bush Scrub, Blackbush Scrub, and a psammophytic community. Desert tortoises use sandstone and lava caves instead of burrows, travel to sand dunes for egg laying, and use still other habitats for foraging. Two or more desert tortoises often use the same burrow. Shell morphology and mtDNA have not been studied in this recovery unit, but allozyme variation is similar to that found in the northeastern Mojave recovery unit.

Eastern Mojave Recovery Unit.

Primarily in California, this recovery unit also extends into Nevada in the Amargosa, Pahrump, and Piute valleys. In the eastern Mojave recovery unit, desert tortoises are often active in late summer and early autumn in addition to spring because this region receives both winter and summer rains and supports two distinct annual floras on which they can feed. These desert tortoises occupy a variety of vegetation types and feed on summer and winter annuals, cacti, perennial grasses, and herbaceous perennials. They den singly in caliche caves, bajadas, and washes. This recovery unit is isolated from the western Mojave by the Baker Sink, a low-elevation, extremely hot and arid strip that extends from Death Valley to Bristol Dry Lake. This area is generally not suitable for desert tortoises. Desert tortoises have both the California and the southern Nevada mtDNA haplotype and the California shell type. They are also differentiated from desert tortoises in the northeastern Mojave recovery unit at several allozyme loci.

Northeastern Mojave Recovery Unit.

This recovery unit is found primarily in Nevada, extending into California along the Ivanpah Valley and into extreme southwestern Utah and northwestern Arizona. Desert tortoises here are generally found in Creosote Bush Scrub communities of flats, valley bottoms, alluvial fans, and bajadas, but they occasionally use other habitats such as rocky slopes and Blackbush Scrub. Two or more desert tortoises often den together in caliche caves in bajadas and washes, and they typically eat summer and winter annuals, cacti, and perennial grasses. Three mtDNA haplotypes are found in this recovery unit, but they exhibit low allozyme variability with relatively little local differentiation. A distinct shell phenotype occurs in the Beaver Dam Slope region.

Western Mojave Recovery Unit.

The Western Mojave recovery unit is completely in California and is exceptionally heterogeneous and large. It is composed of the Western Mojave, Southern Mojave, and Central Mojave regions, each of which has distinct climatic and vegetational characteristics. The most pronounced difference between the Western Mojave and

other recovery units is in timing of rainfall and the resulting vegetation. Most rainfall occurs in fall and winter and produces winter annuals, which are the primary food source of tortoises. Above ground activity occurs primarily in spring, associated with winter annual production. Thus, tortoises are adapted to a regime of winter rains and rare summer storms. Here, desert tortoises occur primarily in valleys, on alluvial fans, bajadas, and rolling hills in saltbrush, creosote bush, and scrub steppe communities. Tortoises dig deep burrows (usually located under shrubs on bajadas) for winter hibernation and summer estivation. These desert tortoises generally den singly. They have a California mtDNA haplotype and a California shell type.

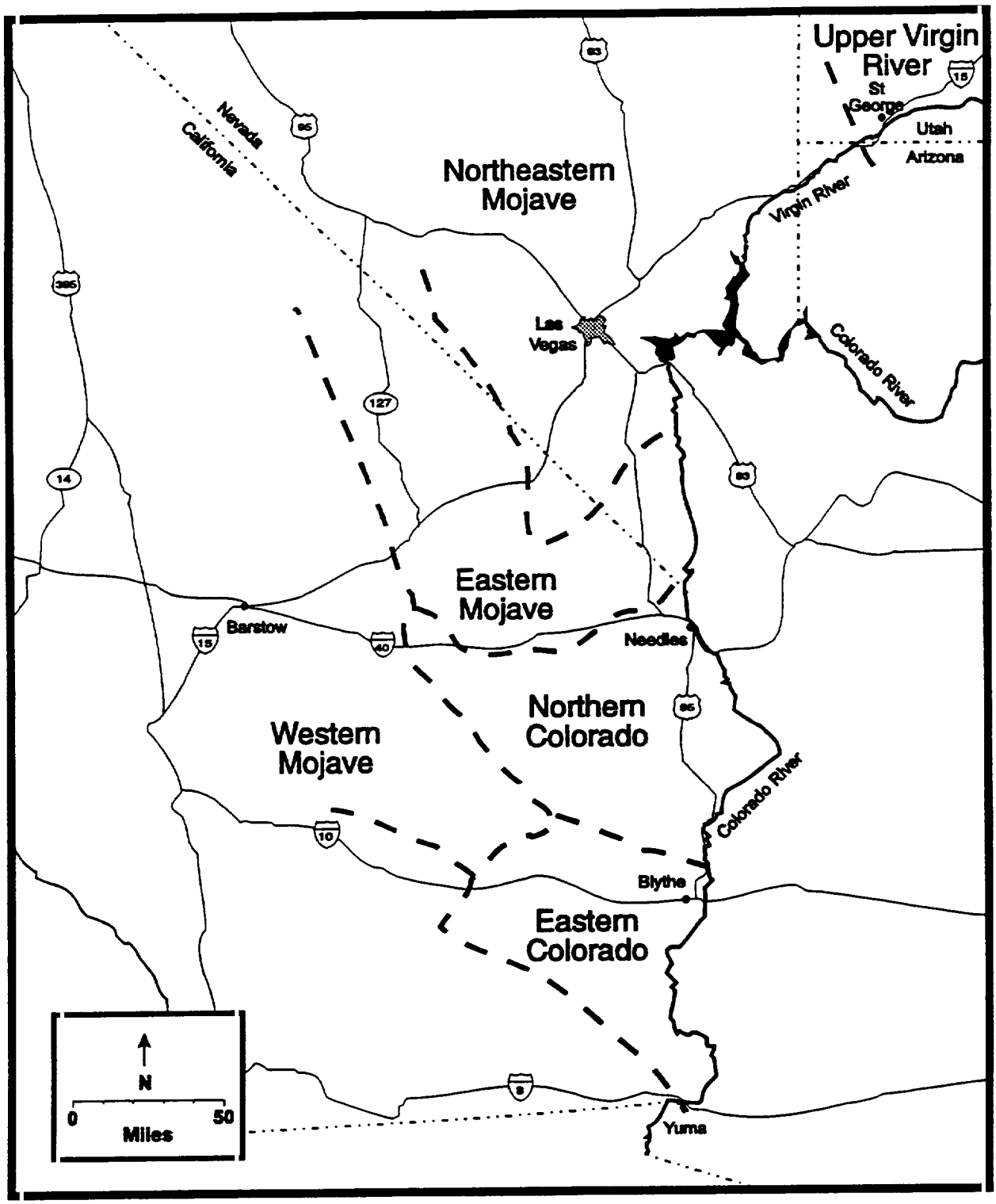


Figure 3. Approximate boundaries of recovery units of the desert tortoise in the Mojave region

Table 2. Vegetation communities and typical foods used by the desert tortoise (*Gopherus agassizii*) within recovery units.

Recovery Units	Vegetation Communities[1]	Plant Foods
Northern Colorado	(1) Succulent Scrub (*Fouquieria, Opuntia, Yucca*), (2) Blue Palo Verde-Smoke Tree Woodland, (3) Creosote Bush Scrub (lava flows)	Summer and winter annuals
Eastern Colorado	(1) Succulent Scrub (*Fouqueria, Opuntia, Yucca*), (2) Blue Palo Verde-Ironwood-Smoke Tree Woodland, (3) Creosote Bush Scrub (rocky slopes)	Summer and winter annuals, cacti
Upper Virgin River	Transitional Vegetation: (1) Sagebrush Scrub, (2) Psammophytes, Great Basin (sand sage), (3) Blackbush Scrub	Summer and winter annuals, perennial grasses, cacti (< 5%)
Northeastern Mojave	(1) Creosote Bush Scrub, (2) Big Galleta Scrub-Steppe, (3) Desert Needlegrass Scrub-Steppe, (4) Blackbush Scrub	Summer and winter annuals, cacti, perennial grasses
Eastern Mojave	(1) Big Galleta-Scrub Steppe, (2) Succulent Scrub (*Yucca, Opuntia* species), (3) Creosote Bush Scrub, (4) Cheesebush Scrub (east Mojave type), (5) Indian Rice Grass Scrub-Steppe	Summer and winter annuals, cacti, perennial grasses, herbaceous perennials
Western Mojave	(1) Creosote Bush Scrub, (2) Mojave Saltbush- Allscale Scrub (endemic), (3) Indian Rice Grass Scrub-Steppe, (4) Hopsage Scrub, (5) Big Galleta Scrub Steppe, (6) Cheesebush Scrub (west Mojave type), (7) Desert Psammophytes, (8) Blackbush Scrub	Winter annuals, few herbaceous perennials, cacti

[1]From Appendix E

Table 3. Topography, substrate, winter burrow site preference, and denning behavior of the desert tortoise (*Gopherus agassizii*) in each recovery unit.

Recovery Unit	Physical Attributes of Habitat	Burrow Sites	Denning Behavior
Northern Colorado	Flats, valleys, bajadas, rocky slopes, small washes	Under shrubs, in intershrub spaces, few in washes	Single
Eastern Colorado	Flats, valleys, fans, small washes, deeply dissected washes, rocky slopes	Shallow burrows, bajadas, more use of shrubs	Single
Upper Virgin River	Rock caves, sandstone crevices	Burrows in sand, and in sandstone crevices; (Do not use habitat like NE Mojave, even if available)	Multiple
Eastern Mojave	Flats, valleys, fans, bajadas, rocky slopes	Some caliche caves, bajadas, washes	Single
Northeastern Mojave	Flats, valleys, fans, bajadas, rocky slopes	Caliche caves, bajadas, washes	Multiple
Western Mojave	Flats, valleys, fans, rolling hills, mountainous slopes, rock outcrops, badlands, sand dunes, lava flows	Under shrubs, in bajadas, few in washes	Single

Table 4. Distribution of recovery units of the desert tortoise by genetic unit (mtDNA) and phenotype.

Recovery Unit	Genetic	Phenotype
Northern Colorado	California	California
Eastern Colorado	California	California
Upper Virgin River	Eastern Nevada/Utah	Unknown
Eastern Mojave	California, Southern Nevada	California
Northeastern Mojave	Western Nevada, Central Nevada, Eastern Nevada/ Utah	Beaver Dam Slope, Unknown
Western Mojave	California	California

Table 5. Numbers of freezing days and amounts and timing of precipitation within desert tortoise recovery units.

Recovery Unit	Mean number of freezing days annually	Precipitation	
		Mean annual precip. (mm)	%precip. July-Sept.
Northern Colorado	2-12	112-129	33-34
Eastern Colorado	12-16	96-100	32-37
Upper Virgin River	96	210	24-29
Eastern Mojave	24-46	112-208	28-38
Northeastern Mojave	46-127	100-210	24-31
Western Mojave (totals)	33-104	90-150	6-27
Fremont-Kramer DWMA	33-84	90-150	6-10
Ord-Rodman DWMA	57-104	108	18-27
Superior-Crones DWMA	57+	109	27

G. Desert Tortoise Life History, Population Dynamics, and Other Factors Which Dictate a Slow and Uncertain Recovery.

The life history strategy of the desert tortoise depends on longevity and iteroparity (reproduction many times per lifetime). Under natural conditions, this strategy allows the species to persist in spite of the stresses of extremely harsh and variable environments. Because adults normally live long enough to have multiple opportunities to reproduce, populations can grow or at least remain stationary (neither growing or declining) if long periods with unsuccessful reproduction are punctuated occasionally with a few successful years. These factors also make recovery of the desert tortoise more difficult, and one or two good years of reproductive success do not signal a trend toward recovery any more than several poor ones signal inevitable extirpation.

This life history strategy is advantageous where availability of resources is unpredictable and juvenile survival rates are highly variable, but even moderate downward fluctuations in adult survival rates can result in rapid population declines (Stearns 1976). Thus, maintaining high survivorship of adult desert tortoises is the key factor in the recovery of this species.

Even when adult survivorship is "normal" (approximately 98% per year), desert tortoise populations are not capable of rapid growth. For example, the 7-year average egg production at a study site near Goffs, California, was 5.8 eggs per female per year (Turner et al. 1986, B. Henen, UCLA, pers. comm.). At this rate of egg production and assuming "normal" adult survivorship, population growth would be less than 0.5% per year (Figure 4). At this growth rate, more than 140 years would be required for the population to double in size.

Under reasonably favorable conditions, a desert tortoise population might be able to grow at an average rate of 1% per year. At that rate of growth, its doubling time would be 70 years. This means that a population that has decreased to 10 adults per square mile would require three doublings, or 210 years, to reach a density of 80 per square mile.

No population with rates of growth as low as these can stand loss rates of breeding adults as high as those reported in the populations shown in Figure 1 without serious threat of extinction. Desert tortoise populations can withstand high rates of natural juvenile mortality as long as the probability of adults surviving each year does not drop below approximately 98% (Figure 5; Appendix C). Thus, the desert tortoise is extremely vulnerable to extinction in

areas in which the probability of adult survival has been significantly reduced. Other species with similar life history strategies (e.g., California condor, black rhinoceros, blue whale) have been caught in altered environments in which the probability of adult survival has decreased dramatically. These species are all in danger of extinction.

Other factors also affect recoverability of this species. For example desert tortoises have complex social behaviors and intimate familiarity with their home ranges, which are quite large. This means that translocating desert tortoises is not likely to be very successful (Berry 1986b) until research projects determine if translocation can be a successful means of recovery (Appendix B).

Desert tortoise recovery is further complicated by the large area involved. The Mojave region spans four states (each with different laws and regulations), two different deserts (Mojave and Colorado), and several hundred thousand square miles. There is considerable genetic and ecological variability within the desert tortoise throughout the Mojave region. Maintaining this variability is necessary for desert tortoises to adapt to these varied environmental conditions and possible future changes in the environment. In addition, the threats facing the desert tortoise differ in degree, although not necessarily in kind, in different parts of the Mojave region. Consequently management actions needed to promote recovery will have to be tailored to the needs of specific areas. If recovery is to be achieved, the cooperative efforts of a myriad of State, Federal, and local agencies will be necessary to abate these threats and implement the recovery strategy outlined in this Recovery Plan.

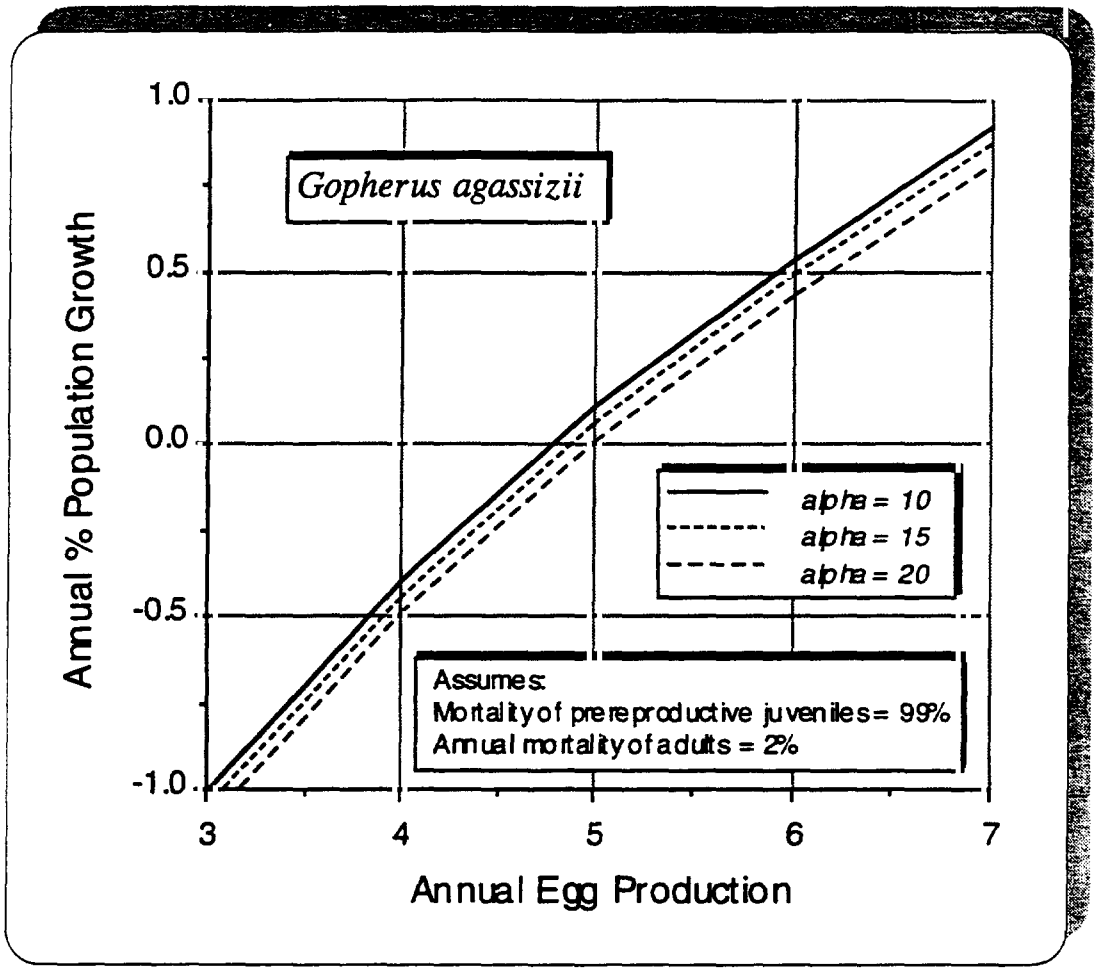


Figure 4. Simulated population growth rate of desert tortoises assuming various rates of mortality and maturation. Alpha is the age of first reproduction.

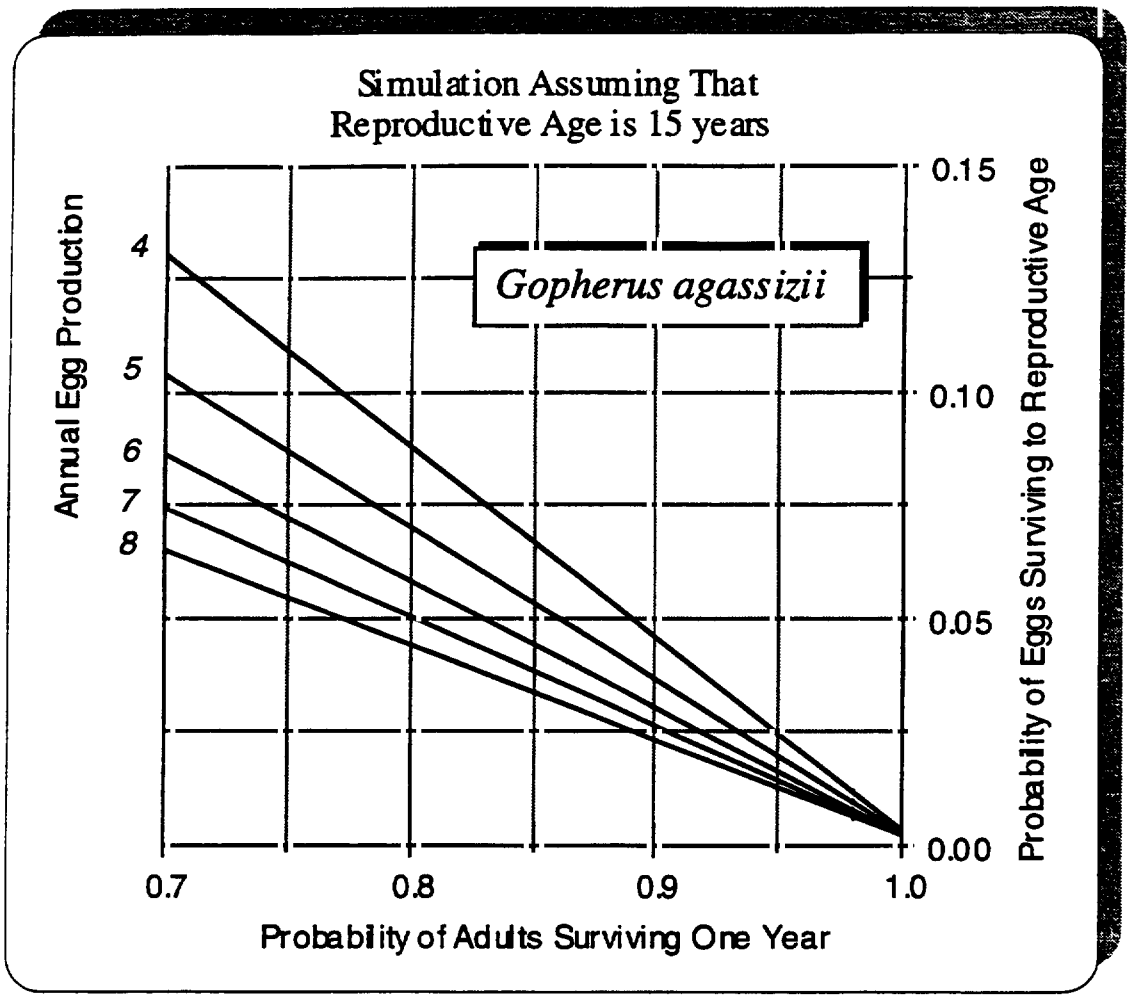
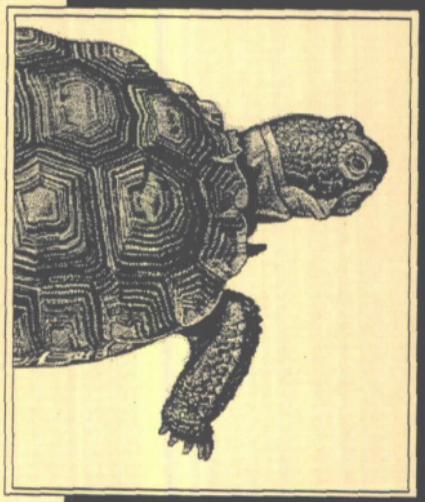


Figure 5. Adult and juvenile survivorship necessary to have a net reproductive rate of 1 (viz., a population neither growing nor declining) when females produce an average of 5 to 6 eggs per year.

Appendices

Desert Tortoise
(Mojave Population)



Recovery Plan

II. RECOVERY

A. Principles Followed in Developing Recovery Goals.

The following biological principles provide the framework for development of delisting criteria and the recovery strategy for the Mojave population of the desert tortoise.

1. Maintenance of distinct population segments.

Data on habitat use, general ecology, genetics, and behavior reviewed in section I.F. define six distinct population segments or recovery units of the desert tortoise within the Mojave region: the northern Colorado, the eastern Colorado, the Upper Virgin River, the eastern Mojave, the northeastern Mojave, and the western Mojave recovery units (Tables 2, 3, 4, and 5, Figure 3). Preserving viable populations of desert tortoises within each of these units is essential to the long-term recovery, viability, and genetic diversity of the species. Identification of these recovery units also facilitates the tailoring of recovery strategies to the varying biological requirements and management needs of each recovery unit. Within recovery units, Desert Wildlife Management Areas (DWMAs) need to be identified in which recovery actions will be implemented to provide for the long-term persistence of viable desert tortoise populations and the ecosystems upon which they depend.

2. Genetic considerations in population viability.

In small populations, short-term genetic deterioration occurs from inbreeding and loss of genetic heterozygosity (Frankel and Soulé 1981, Ralls and Ballou 1983). This genetic deterioration can cause problems in individual fitness and in the population's ability to increase. In the longer-term, inbreeding depression and loss of heterozygosity can limit the ability of the population to respond adaptively to changes in environment. Both of these problems can contribute to the probability of population extinction.

The extent to which genetic deterioration can affect populations is related to the genetically effective size (N_e) of the population (loosely defined as the number of individuals actually passing on their genes to the next generation). In vertebrates, N_e is usually between 0.1 and 0.5 of the total population size, N (Ryman et al. 1981, Shull and Tipton 1987). There are no data on N_e/N ratios in desert tortoises, but the age structure and mating strategies of this species indicate that its N_e/N ratio will be at the lower end of that range. The long-term evolutionary potential of populations requires an N_e of about 500 individuals, although this number is not very precise and might be off by an order of magnitude (Lande and Barrowclough 1987). Thus, if the N_e/N ratio for a desert tortoise

population is 0.1, and an N_e of about 500 to 5,000 individuals is required to maintain the long-term evolutionary potential of the species, then a population size (N) of 5,000 to 50,000 would be required for a genetically healthy population. Desert tortoise population age structures indicate that the percentage of adults in the population range between 4 and 40% (see Appendix C); thus, a population of 5,000 total individuals could have between 200 and 2,000 adult animals; a population of 50,000 total individuals could have between 2,000 and 20,000 adults. While estimates that vary over two orders of magnitude are not very satisfying, they indicate a need for caution in assessing the conditions under which a population will remain viable. Thus, a minimally viable population of desert tortoises from genetic considerations should probably contain at least 2,000 to 5,000 adult animals.

3. *Demographic considerations in population viability.*

In addition to genetic deterioration that can occur at very small population sizes, numerous negative demographic effects can occur when population sizes are small or when their densities are low. When population densities are very low, random variations in sex ratios, age distributions, and birth and death rates among individuals (called demographic stochasticity) can cause the population to fluctuate widely and potentially go extinct (Richter-Dyn and Goel 1972). In very sparse populations, males and females may have problems finding mates. This phenomenon is called the Allee effect, and it also can result in population declines or extinction (Ehrlich and Roughgarden 1987). In desert tortoises, the population densities below which demographic stochasticity and the Allee effect become a matter of concern are estimated to be approximately 10 adults per square mile (See Appendix C). Below this density extinction becomes increasingly possible.

Even at much larger sizes, populations can go extinct from a variety of random (stochastic) events, although large populations have a much lower probability of extinction than small ones. Recovery targets should be set at population levels that have comfortable extinction probabilities. To determine the likelihood of stochastic extinctions for desert tortoise populations of various sizes, three population viability analyses (PVAs) were performed (Appendix C). A PVA provides an estimate of how large a population has to be to have a given probability of persistence over a certain period of time.

The first PVA modeled population persistence as a function of the discrete population growth rate (lambda) and its variance. Using data from 13 study plots (see Appendix C), the average lambda was calculated to be 0.985 and its variance 0.08. Using these figures, the model predicted that 50% of the populations starting with 20,000 adult animals would go extinct within about 500 years, or 20 tortoise generations. This prediction was based upon observed variability in population growth rates during 1979-89, relatively equitable years for desert tortoises, at least with respect to food

production. Even so, the average lambda of 0.985 shows that populations declined during these years, although not drastically. However, during 1990 and 1991, population growth rates declined substantially because of the cumulative effects of drought and disease. Thus, an additional analysis was conducted which incorporated greater variability in population growth rates on the assumption that droughts and epizootics are likely to recur during the next few centuries. Increasing the variation in the 1979-89 growth rates by 50% resulted in the model predicting that a minimum population size of approximately 40,000 to 60,000 adult desert tortoises would be required in order for the population to persist for a 500-year median extinction time.

A second PVA was based on detailed demographic data from the Goffs study site in California and samples from 19 populations in California and Nevada which have been monitored for a number of years (Berry 1990, as amended). The mean lambda for this more extensive sample was determined to be 0.975 with a standard deviation of 0.019 (due entirely to random variation around population trends; the other sources of variation had been partitioned out). This model predicted that a population with this mean lambda (0.975) could never persist for more than about 390 years, or approximately 15 tortoise generations, regardless of initial population size. Running the model with lambdas of 1.0 and a standard deviation of 0.019 gave quite long times to extinction. A third PVA also emphasized the importance of lambdas near 1.0 for population persistence.

4. *Comprehensive considerations in population viability.*

These analyses of minimal viable populations and population persistence probabilities suggest several things. First, tortoise populations at minimum densities (10 adults per square miles) require at least 200 to 500 square miles to be genetically viable (see Sections II.A.2 and II.A3). Second, if lambdas are slightly below 1.0 but vary over a range of approximately 25%, extremely large reserves (5,000 square miles to support 50,000 adults at minimal density) are necessary to support populations that are relatively resistant to extinction within the next half century. Third, if lambdas are below 0.975 on average, no population size is large enough for persistence to 500 years.

These findings indicate that suitable DWMAs could be somewhere between 200 to 5,000 square miles, a fairly wide range of choices. In view of this uncertainty, at least 1,000 square miles is recommended as the target size. Reserves of this size will likely provide sufficient buffering from demographic stochasticity and genetic problems at low population densities, and they are large enough to support recovered populations that have reasonable probabilities of persistence into the future. The utility of large reserves in preventing extinction is one of the best established tenets

of conservation biology (e.g., Terborgh and Winter 1980; Soulé and Simberloff 1986). And, all else being equal, large reserves will conserve more species than small ones (Wilcox 1980; Simberloff and Abele 1982; Wilcove et al. 1986).

Large reserves will also facilitate managing desert tortoise populations within the DWMAs to maintain average lambdas of 1.0 or more during the recovery process. Large reserves are more likely to have sufficient internal environmental heterogeneity and enough isolated areas in their interiors to ensure that some subpopulations will be growing even if others are declining. In summary, genetic, demographic, and other considerations point to the inescapable conclusion that small reserves in a highly fragmented habitat are a recipe for extinction of the desert tortoise.

A preliminary analysis suggests that there may be a mechanistic link between mean annual production of grasses and forbs and maximum tortoise densities (see Appendix G). However, additional research is necessary to ascertain what properties of the environment determine the maximum number of tortoises that can be supported in particular regions of the desert. Information from this kind of research is critical to a proper evaluation process of the efficacy of management schemes.

5. *Reserve architecture.*

DWMA size is not the only important consideration in determining the probability of success in preserving desert tortoise populations. Principles of reserve design dictate that the shape of DWMAs is also very important (see Section II.D.1.d). Population persistence will be maximized in a recovery unit if the unit has several large DWMAs (each of which is at least 1,000 square miles; see Section II.A.3). Furthermore, these DWMAs should be designed to minimize perimeter relative to area. The optimal shape for such a DWMA is circular, but this configuration may not be feasible (see Figure 6A). Fewer large DWMAs per recovery units diminish persistence probabilities; a minimally acceptable condition is one large DWMA with a minimum perimeter/area ratio (Figure 6B). When no other choice is available, it may be necessary to create smaller DWMAs. These must be connected with very wide strips of suitable tortoise habitat (Figure 6C). In extreme cases, it may be necessary to create DWMAs that are smaller than the recommended size and unconnected to other DWMAs by functional habitat. Such DWMAs must be intensely managed to control extrinsic sources of mortality (Figure 6D). More details on reserve design are found in Section D.1.b.

RECOVERY UNITS

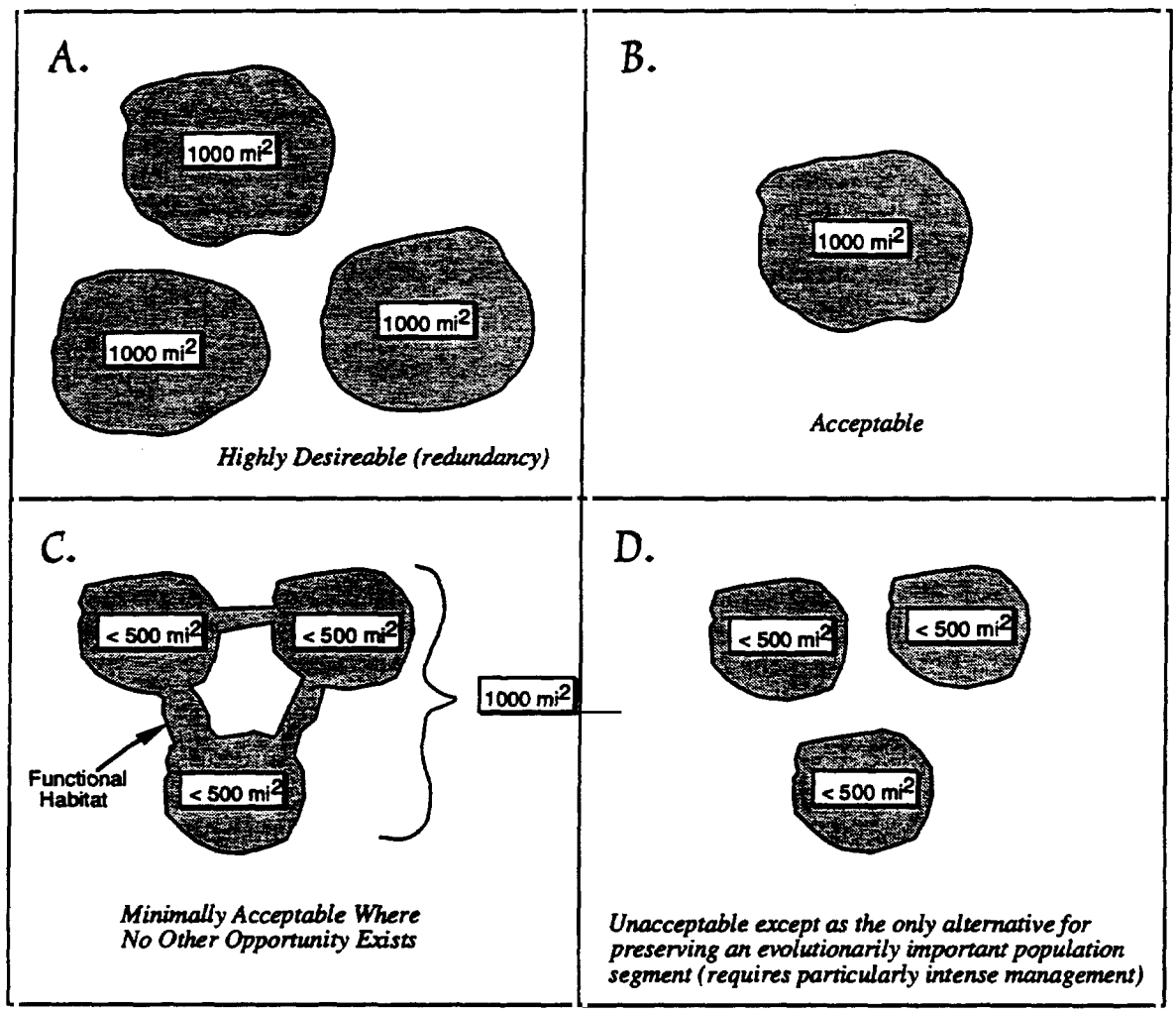


Figure 6. Schematic representation of possible wildlife reserves within recovery units; (A) The recommended arrangement in which several DWMAs will be located in each recovery unit; (B) The minimally acceptable arrangement in which there is no redundancy in DWMAs, (C) The minimally acceptable arrangement in situations in which it is not possible for a round DWMA - corridors of suitable habitat need to connect smaller units of a DWMA; (D) The generally unacceptable alternative of small, unconnected DWMAs. Such reserves must be intensely managed in perpetuity to ensure population persistence.

6. Ecosystem protection.

Section 2(b) of the Endangered Species Act provides for protection of the ecosystems on which threatened or endangered species depend. Thus, survival and recovery of the desert tortoise should occur in its natural habitat, not in zoological gardens or other artificial situations, and DWMAs should protect the environments in which the desert tortoise lives. In preserving these environments, other species will benefit, including many rare and/or sensitive species. Land managers are strongly encouraged to take a multi-species approach to reserve design and include habitat of other rare or declining species into DWMAs. Such an approach would reduce the need to list other species of plants and animals in the Mojave region.

B. Recovery Strategy

This Recovery Plan describes a strategy for the recovery and delisting of the Mojave population of the desert tortoise. This strategy includes: (1) identification of six recovery units within the Mojave region, (2) establishment of a system of DWMAs within recovery units, and (3) development and implementation of specific recovery actions within DWMAs. This recovery strategy will be revised as recovery actions are implemented and new information becomes available from research and monitoring.

1. Size and number of reserves.

The key to this recovery strategy is timely establishment of at least one DWMA in each recovery unit and prompt implementation of reserve-level protection within them. DWMAs must be located in areas with good desert tortoise habitat currently supporting a minimum of several hundred adult animals at a density of no fewer than 10 per square mile (See Section II.A). More than one DWMA within each recovery unit will increase the probability that a population within a recovery unit will recover. The Recovery Plan identifies 14 proposed DWMAs (Table 6, Figures 7, 8, 9, 10, Apendix F), some of which occur in more than one recovery unit. Summary descriptions of the 14 proposed DWMAs are presented in Appendix F and Brussard et al. (1994).

2. Experimental management zones.

All DWMAs should restrict human activities that negatively impact desert tortoises (Section II.E.1., Appendix F, Brussard et al. 1994). However, a maximum of 10% of tortoise habitat within a DWMA may be designated as an experimental management zone (EMZ) where certain prohibited activities (e.g., intrusive research on desert tortoises) may be permitted on an experimental basis during the recovery period. EMZs should be located toward a DWMA's periphery.

3. Modification of the Recovery Plan.

Conservation biology works with the best available knowledge for any given species in its current situation as the basis for hypotheses or models that will best effect the recovery of the species. These models originate, and are debated, on the scientific side of conservation biology. They evolve quite slowly, and are usually stable throughout the planning process. However, new data can become available at any time, and such new data should be able to influence management practices. Thus, this Recovery Plan should be reassessed every three to five years or at any time it becomes apparent that the plan is not fulfilling its function to guide recovery. Reassessment should be based on recent and ongoing research, on population and habitat trends, and on the results of any restoration efforts both inside and outside of the DWMAs. The reassessment team should consist of representatives from all affected Federal, state, and local wildlife and land management agencies, and experts in the field from other agencies, the private sector, and academia. The Desert Tortoise Management Oversight Group should facilitate this review process.

Table 6. List of Desert Wildlife Management Areas, their current estimated densities (adults per square mile), and degree of threat (1=low, 5=extremely high).

Recovery Unit	DWMA	Estimated Density (adults/mi^2)	Degree of Threat
Northern Colorado			
	Chemehuevi	10-275	1
Eastern Colorado			
	Chuckwalla	5-175	4
Upper Virgin River			
	Upper Virgin River	up to 250	5
Eastern Mojave			
	Fenner[1]	10-350	3
	Ivanpah[2]	5-250	3
	Piute-Eldorado[2]	40-90	2
Northeastern Mojave			
	Beaver Dam Slope	5-60	5
	Coyote Spring	up to 90	2
	Gold Butte-Pakoon	5-60	2
	Mormon Mesa	40-90	3
Western Mojave			
	Fremont-Kramer	5-100	5
	Ord-Rodman	5-150	4
	Superior-Cronese	20-250	5
	Joshua Tree[3]	up to 200	1

1 Located in both the eastern and northern Colorado recovery units.
2 Located in both the eastern and northeastern Mojave recovery units.
3 Southeastern corner of this DWMA is located in the eastern Colorado recovery unit.

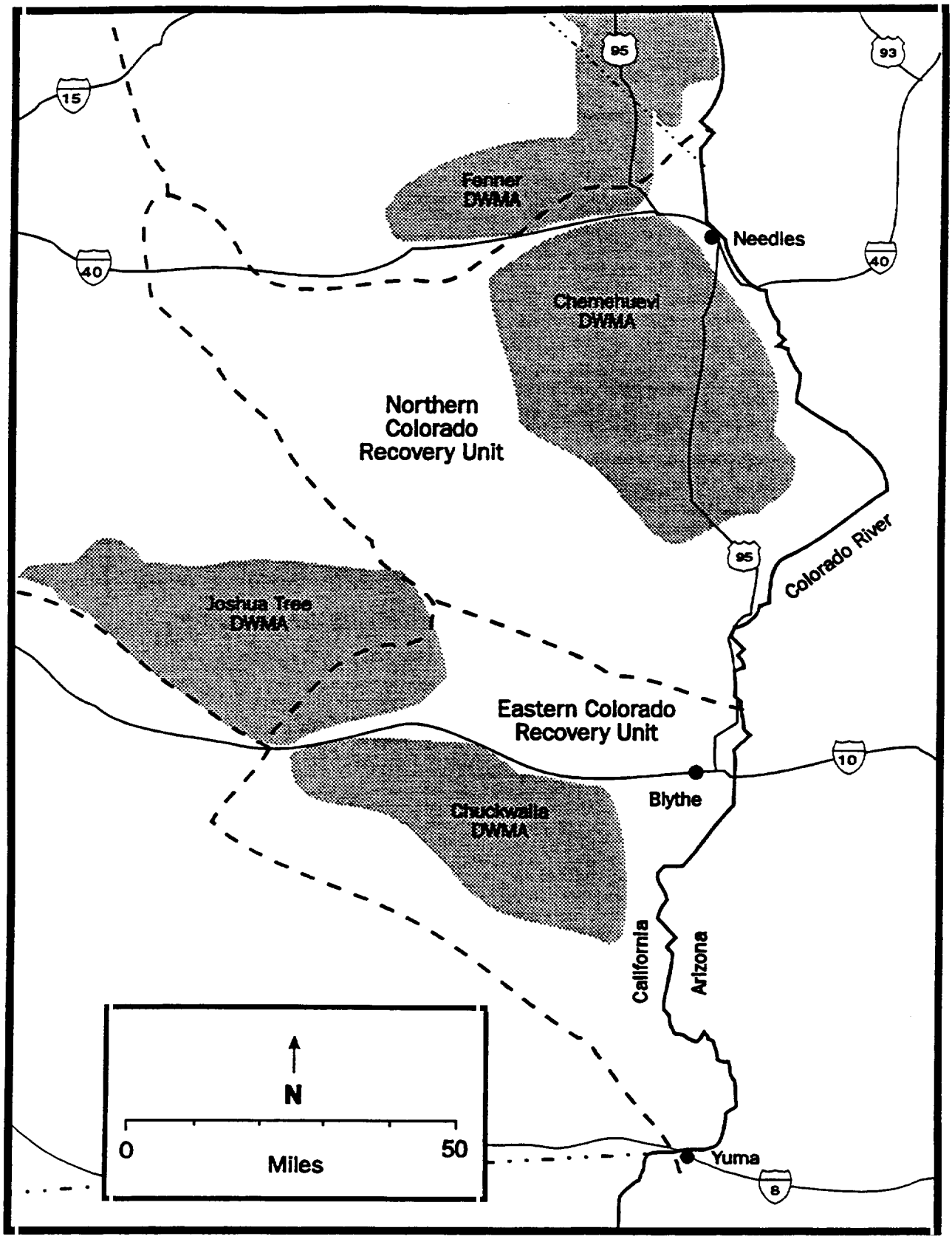


Figure 7. Proposed DWMAs in the northern Colorado and eastern Colorado recovery units.

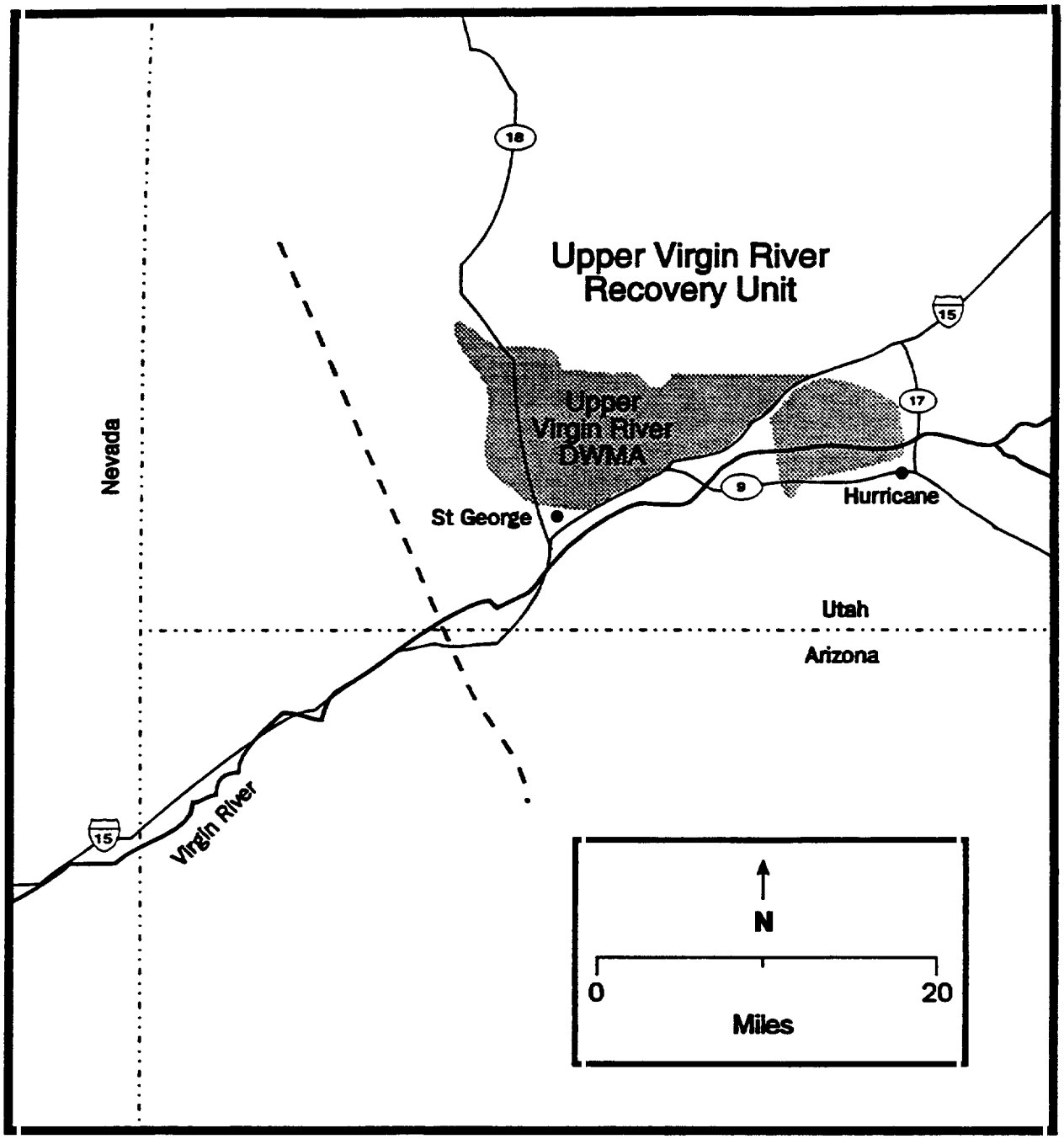


Figure 8. Proposed Upper Virgin River DWMA in the Upper Virgin River recovery unit.

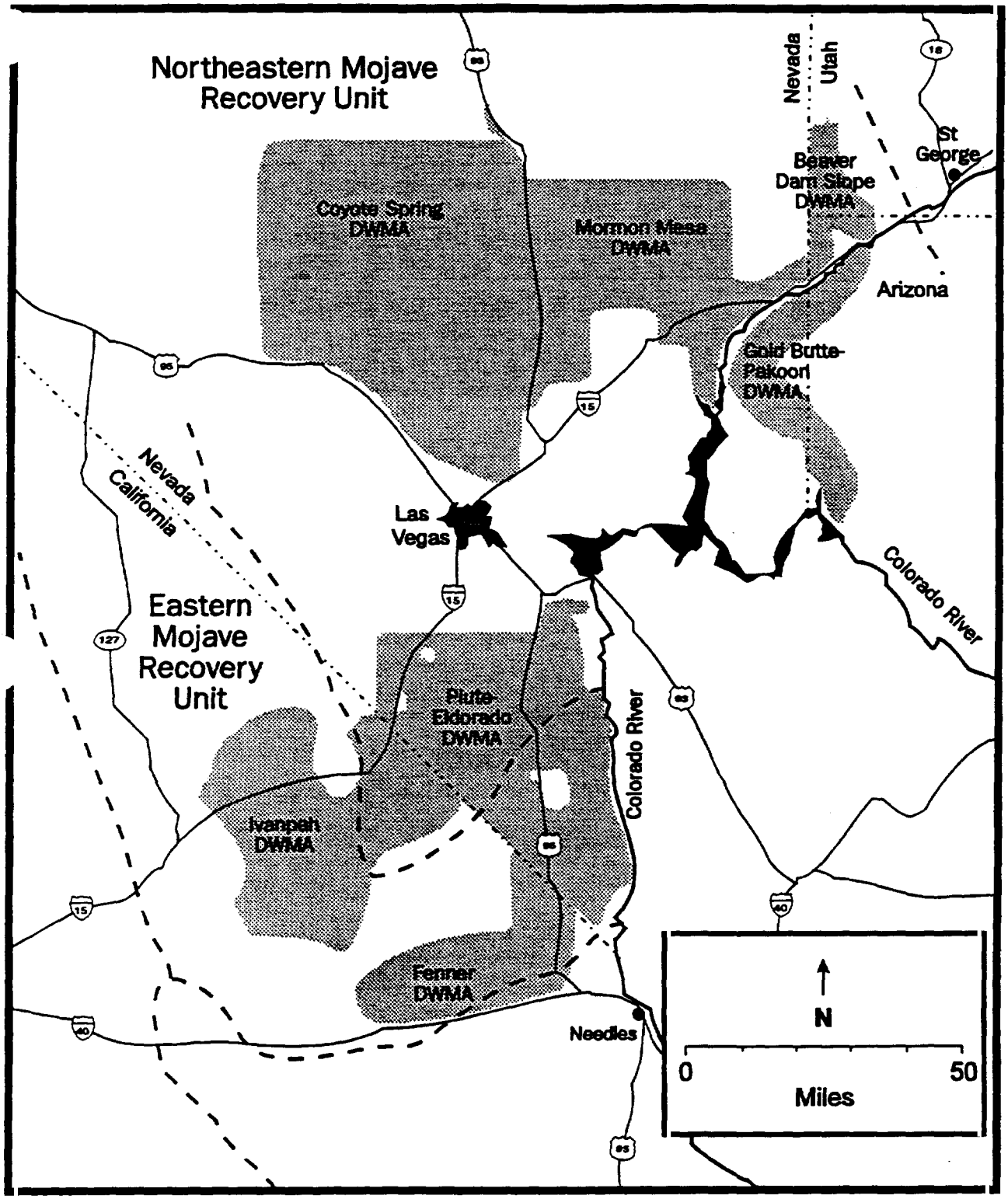


Figure 9. Proposed DWMAs in the eastern and northeastern Mojave recovery units.

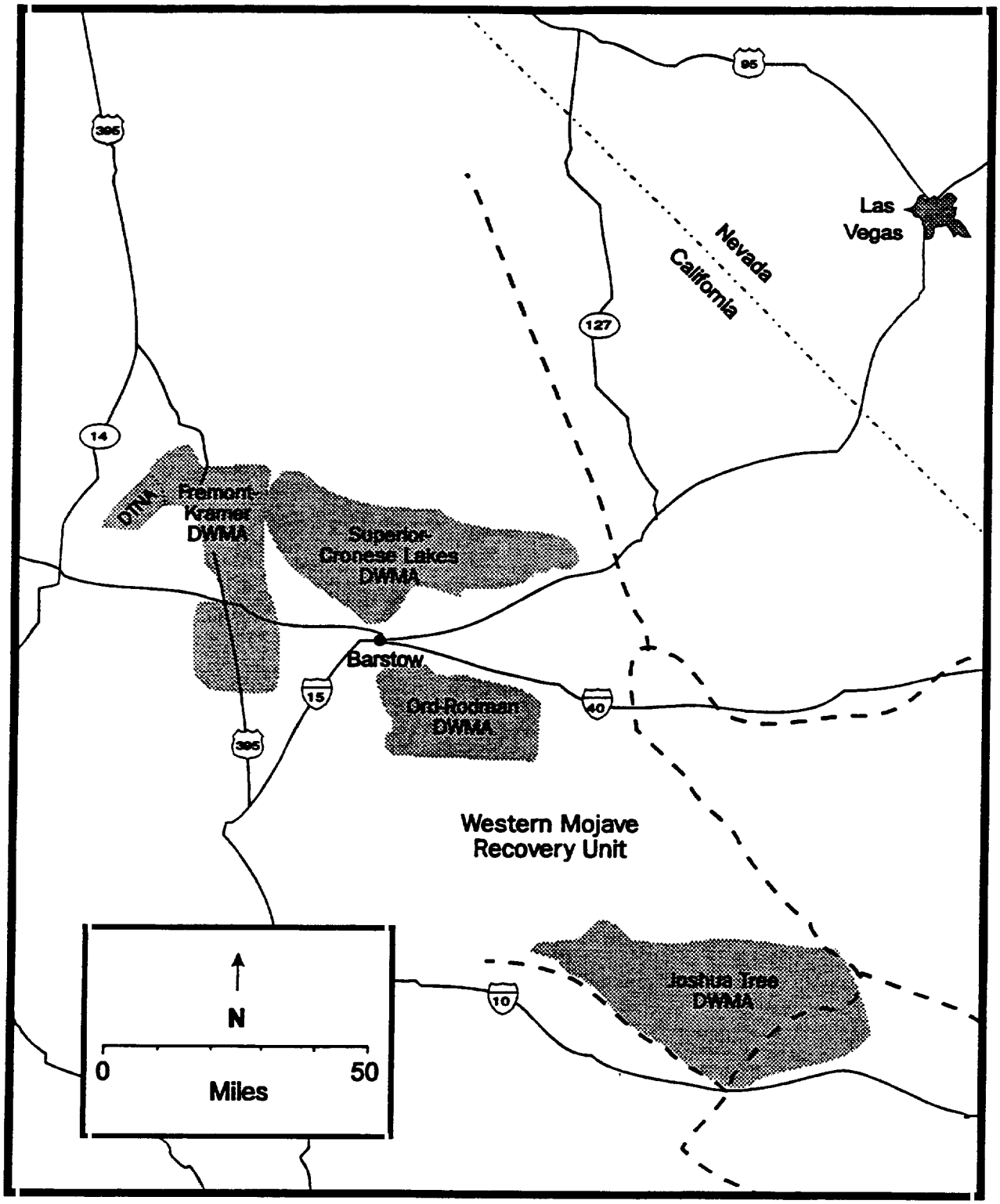


Figure 10. Proposed DWMAs in the western Mojave recovery unit.

C. Recovery Objective and Delisting Criteria.

1. Recovery objective.

The objective of this Recovery Plan is the recovery and delisting of the Mojave population of the desert tortoise. Management actions and research necessary to effect recovery are described, supported, and scheduled.

2. Recovery criteria.

Desert tortoise populations, which are only capable of very slow growth, have declined substantially throughout much of the Mojave region in the last two decades. Therefore, desired improvement in the status of these populations will necessarily be a very long process, measured in decades or centuries. Nevertheless, delisting may be considered if population size is stationary or increasing (long-term trends in lambda are equal to or less than 1.0), sufficient habitat is protected or managed for recovery and long-term persistence, regulatory mechanisms are in place, and the population is unlikely to become threatened again in the foreseeable future.

Recovery units are considered distinct population segments and may be individually delisted if they meet the recovery criteria. Specifically, the population within a recovery unit may be considered for delisting when **all** of the following criteria are met:

Delisting Criterion 1:

As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation). Consistent with Appendix A, a sampling plan should be instituted in each recovery unit to monitor the progress of recovery. Appendix A calls for a population estimation every 5 years; thus data from at least five estimates need to be considered in evaluating population trends. Monitoring should continue following delisting to ensure population stability.

Delisting Criterion 2:

Enough habitat must be protected within a recovery unit, or the habitat and the desert tortoise populations must be managed intensively enough, to ensure long-term population viability. Consistent with section II.A., at least one DWMA must be established in each recovery unit that is, except under unusual circumstances, at least 1,000 square miles in area.

Delisting Criterion 3:

Provisions must be made for population management at each DWMA so that populational lambdas are maintained at or above 1.0 into the future.

Delisting Criterion 4:

Regulatory mechanisms or land management commitments have been implemented that provide for adequate long-term protection of desert tortoises and their habitat, such as those described in Sections II.D. and E. Delisting would be followed by a loss of protection under the Endangered Species Act; therefore adequate protection through alternative means is essential before delisting can occur. For example, management plans for Federal lands should provide adequate assurances of habitat protection prior to consideration of delisting. The form of these regulations, commitments, and their implementation should be determined during future land management planning efforts and will likely vary throughout the Mojave region and by agency, reflecting the differing management needs of different areas. Reasonable assurance must exist, on a case by case basis, that conditions which brought about population stability will be maintained, or as necessary, improved during the foreseeable future.

Delisting Criterion 5:

The population in the recovery unit is unlikely to need protection under the Endangered Species Act in the foreseeable future. Detailed analyses of the likelihood that a population will remain stable or increase must be carried out before determining whether it is recovered. These analyses should include observed and anticipated effects of: (a) fluctuations in abundance, fecundity, and survivorship; (b) movements of desert tortoises within the area and to or from surrounding areas; (c) changes in habitat, including catastrophic events; (d) loss of genetic diversity; and (e) any other threats to the population which might be significant.

When the population within a recovery unit meets all of these five criteria it may be considered recovered and eligible for delisting. When all recovery units are considered recovered, the Mojave population of the desert tortoise could be considered for delisting. These recovery criteria were designed to provide a basis for consideration of delisting, but not for automatic delisting. Before delisting may occur, the Fish and Wildlife Service must determine that the following five listing factors are no longer present or continue to adversely affect the listed species: (1) the present or threatened destruction, modification, or curtailment of the species' habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease and predation; (4) inadequacy of existing regulatory mechanisms; and (5) other human-made or natural factors affecting the continued existence of

the species (50 CFR 424.11). The final decision regarding delisting would be made only after a thorough review of all relevant information by the Fish and Wildlife Service.

The five recovery criteria and the methods to determine densities will be revised as appropriate as new information pertinent to these topics becomes available. Revisions must be based on the best data available and must be approved by the Fish and Wildlife Service.

D. *Narrative Outline Plan for Recovery Actions Addressing Threats*

The desert tortoise was listed as threatened primarily because of a variety of human impacts which cumulatively have resulted in widespread and severe desert tortoise population decline and habitat loss. The destruction, degradation, and fragmentation of desert tortoise habitat and loss of individual desert tortoises from human contact, predation, and disease are all important factors in the decline of the Mojave population (section I.B.). If the desert tortoise is to be recovered within its native range, the causes of the decline must stop, at least within the DWMAs. Some factors are likely more important than others; for instance, urbanization has probably caused more habitat loss than light cattle grazing. However, eliminating all factors that are deleterious to desert tortoise populations will certainly result in faster recovery than will selective elimination of a few.

Because of the many political jurisdictions in the Mojave region, implementation of recovery actions will require unprecedented interagency cooperation. Delays in implementing this Recovery Plan caused by political constraints would increase the costs of recovery and decrease the likelihood that recovery efforts will successfully avert extinction of the desert tortoise. Interagency cooperation could be facilitated by the Desert Tortoise Management Oversight Group. All agencies with management responsibilities for the desert tortoise need to participate in the implementation of the recovery strategy.

Desert tortoises outside of DWMAs will still be protected by section 9 of the Endangered Species Act. Take of desert tortoises is prohibited unless specifically authorized by the Fish and Wildlife Service pursuant to sections 7 or 10 of the Endangered Species Act. These desert tortoises may be important in recovery of the Mojave population by providing a source of adult desert tortoises for repopulating extirpated populations in DWMAs once translocation techniques have been perfected. Habitat outside DWMAs may provide corridors for genetic exchange and dispersal of desert tortoises among DWMAs.

In addition, isolated populations of healthy desert tortoises found outside of DWMAs should be noted, but no active management is

recommended for these populations unless it is needed to ensure their viability. These isolated populations may have a better chance of surviving the potentially catastrophic effects of URTD or other diseases than large, contiguous populations.

Accomplishment of the recovery actions described in this section is needed to reduce or eliminate human-caused impacts in the recovery units and to implement the recovery strategy described in section II.C. Recovery actions are listed in a stepdown form in which broad categories of recovery actions are stepped down to specific tasks. Tasks listed here also appear in the Implementation Schedule (Section III), in which costs and scheduling are estimated and lead Federal agencies are identified for specific actions. DWMA-specific tasks and costs, which will be crucial to implementation of management plans, are not detailed here or in the Implementation Schedule because they will vary depending on the number, location, and size of DWMAs selected and the management needs of specific areas. The contributions of state agencies will come into play when specific management plans are written for each recovery unit.

Although DWMA-specific management actions cannot yet be precisely defined, the reduction and elimination of threats necessary to recover the desert tortoise broadly define the range of actions necessary within DWMAs. Actions which will likely be needed in all DWMAs to address these threats are listed in Section II.E. The summary descriptions for each DWMA in Appendix F include recommendations to address site-specific management needs of the 14 proposed DWMAs. These recommendations are presented to aid land managers in the development of management plans. These plans should implement the guidance provided in this Recovery Plan. The costs associated with the following recommended tasks are provided in the Implementation Schedule (Section III). The Implementation Schedule will be amended and expanded as management plans are developed and DWMA-specific management actions are identified. In addition, as new information becomes available and recovery actions are implemented, ongoing recovery actions may be modified to speed recovery.

1. Establish DWMAs and implement management plans for each of the six recovery units.

Management plans should be developed and implemented for each of the six recovery units. Such management plans should determine the number, size, location, and boundaries of DWMAs; determine how habitat within DWMAs will be secured and managed, and describe how monitoring of the recovery effort will be accomplished. Plans should be developed by land management agencies in close coordination with the Fish and Wildlife Service, State wildlife agencies, local governments, and the public. Splitting recovery units by political or other boundaries and developing more than one management plan to address a single recovery unit should be discouraged. Nevertheless, additional site-specific plans to address

management of individual DWMAs may be appropriate to implement guidance provided in the recovery unit management plans.

DWMAs have great potential to serve as multi-species reserves which could conserve habitat for a variety of species. Land managers should be strongly encouraged to consider this multi-species approach in development of recovery unit management plans, as it could preclude the need for Federal listing of other sensitive species of the Mojave region. The Western Mojave Coordinated Management Plan, currently being developed by the BLM, California Department of Fish and Game, Fish and Wildlife Service, and local governments, could be the first of these recovery unit management plans.

1.a. Select DWMAs.

General requisites for determining number and size of DWMAs in a recovery unit are described in the Recovery Strategy (Section II.B.). Generally, reserves should be established within each recovery unit which are at least 1,000 square miles in extent, or if this is not possible, particularly intensive habitat and desert tortoise population management should be implemented to ensure long-term viability of the population. In many areas of the Mojave Desert, it is possible to establish DWMAs large enough to provide a high probability of recovery. However, some population segments will have to be recovered in smaller DWMAs. These will have to be particularly well managed to prevent extinctions because of the higher probabilities of extinction ascribed to small populations (see Appendix C). Many population segments within most recovery units are currently declining, and human-caused mortality, habitat loss, and the possible catastrophic effects of URTD or other diseases further endanger these populations. Thus, simply setting aside the minimum land area necessary to support a viable population will not be adequate to effect recovery.

The task of selecting DWMAs is listed in the Implementation Schedule in a stepdown fashion by recovery unit. Table 6 lists the Recovery Team's recommendations for DWMAs in the six recovery units. Proposed DWMAs are described in Table 6, Figures 7, 8, 9, 10, Appendix F, and in Brussard et al. (1994).

1.a.1. Northern Colorado Recovery Unit

1.a.2. Eastern Colorado Recovery Unit

1.a.3. Upper Virgin River Recovery Unit

1.a.4. Eastern Mojave Recovery Unit

1.a.5. Northeastern Mojave Recovery Unit

1.a.6. Western Mojave Recovery Unit

1.b. Delineate DWMA boundaries.

Whenever possible, DWMA boundaries should be drawn to include the best examples of desert tortoise habitat in specific vegetation regions. In addition, heterogeneous terrain, soil types, and vegetation within DWMAs will best provide protection for the entire ecosystems upon which healthy desert tortoise populations depend.

Boundary delineations for DWMAs (and contained EMZs) should be consistent with current theory and practice of reserve design (Thomas et al. 1990, Noss 1991). Land-management agencies should follow these guidelines when establishing boundaries for DWMAs and EMZs. These guidelines should also be followed in prescribing management goals.

(a) Reserves that are well-distributed across a species' native range will be more successful in preventing extinction than reserves confined to small portions of a species' range. Preservation of one or more viable populations within each of the six recovery units will ensure that the full range of variation within the species is maintained, enhancing the desert tortoise's ability to adapt or adjust to future environmental changes.

(b) Large blocks of habitat, containing large populations of the target species, are superior to small blocks of habitat containing small populations. While the persistence of all desert tortoise populations is subject to the effects of environmental stochasticity and catastrophes, the persistence of small populations is additionally threatened by demographic and genetic stochasticity (see Section II.A. and Appendix C). This means that the largest possible blocks of good desert tortoise habitat in an area, containing the most dense desert tortoise populations, should be included within DWMA boundaries.

(c) Blocks of habitat that are close together are better than blocks far apart. This arrangement facilitates dispersal of desert tortoises among habitat patches. Connecting habitat segments should be of medium to high quality and be wide enough to accommodate several desert tortoise home-range widths (several miles), but narrow enough to discontinue contact between DWMAs by double fencing, if necessary to impede the spread of disease (Figure 6). Such linkages are necessary both for a demographic "rescue effect" (Brown and Kodrik-Brown 1977) and for continued genetic interchange.

(d) Habitat that occurs in less fragmented, contiguous blocks is preferable to habitat that is fragmented. The desert tortoise does best in undisturbed environments where the presence of edge species, such as ravens, is minimized. Highly fragmented habitat is mostly edge (because small patches maximize the ratio of edge to interior area) and should be avoided to the extent possible within DWMAs.

(e) Habitat patches that minimize edge to area ratios are superior to those that do not. This means that round or square patches of habitat are more likely to retain desert tortoise populations than elliptical or rectangular ones. Long, linear strips are the least desirable.

(f) Interconnected blocks of habitat are better than isolated blocks, and linkages function better when the habitat within them is represented by protected, preferred habitat for the target species. Interpopulation dispersal, as mentioned above, is important for population persistence. One possible negative effect of interpopulation dispersal on the desert tortoise is the potential for spreading disease from infected to non-infected populations. Inclusion of isolated but healthy populations into DWMAs could be valuable in avoiding the possible catastrophic effects of this disease. However, aside from the problems of disease transmission, the advantages of dispersal often outweigh the disadvantages. Thus, maintaining linkages among habitat patches within DWMAs and among the DWMAs themselves is considered here to be important. This will require maintaining connecting segments of habitat that are at least marginally acceptable to the desert tortoise.

(g) Blocks of habitat that are roadless or otherwise inaccessible to humans are better than blocks containing roads and habitat blocks easily accessible to humans. Because declines in desert tortoise populations are associated with high densities of access routes, vehicular traffic, and human access (Appendix D, Schoenwald-Cox and Buechner 1992), the access must be limited in the DWMAs. Populations within DWMAs that are inaccessible to motorized recreation or similar activities will have a much better chance of recovery than those in DWMAs where human access is prevalent.

Delineation of DWMA boundaries should be guided by the above concepts and will be integral to development of recovery unit management plans.

1.b.1. Northern Colorado Recovery Unit

1.b.2. Eastern Colorado Recovery Unit

1.b.3. Upper Virgin River Recovery Unit

1.b.4. Eastern Mojave Recovery Unit

1.b.5. Northeastern Mojave Recovery Unit

1.b.6. Western Mojave Recovery Unit

1.c. Secure habitat within DWMAs.

To ensure manageability, private and State lands in DWMAs (exclusive of State parks or other lands managed for the benefit of the desert tortoise) should be acquired or conservation agreements developed to protect desert tortoise habitat. Land acquisitions should include surface and subsurface mineral rights whenever possible. Habitat conservation plans, or similar efforts, should consider this as appropriate mitigation for the take of desert tortoises and/or habitat.

1.c.1. Northern Colorado recovery unit

1.c.2. Eastern Colorado recovery unit

1.c.3. Upper Virgin River recovery unit

1.c.4. Eastern Mojave recovery unit

1.c.5. Northeastern Mojave recovery unit

1.c.6. Western Mojave recovery unit

1.d. Develop reserve-level management within DWMAs.

Because the factors causing the decline of the desert tortoise are primarily human-related (see Section I.B.), many human activities within DWMAs will need to be strictly regulated or eliminated. Because the kinds and levels of human uses vary among recovery units and proposed DWMAs, defining specific management actions needed for recovery must be preceded by DWMA selection and boundary delineation. DWMA management needs could be identified in recovery unit management plans or in specific DWMA plans. Section II.E. describes recommended recovery actions in DWMAs which should become part of recovery unit management plans if DWMAs are selected and delineated as described here. Recommended management actions should be tailored to the needs of specific DWMAs and include activities such as eliminating burro, horse, and domestic livestock grazing; limiting vehicular access, including prohibiting new vehicular access and reducing existing access; and prohibiting new surface disturbances, except to improve the quality of wildlife habitat, watershed protection, or improve opportunities for non-motorized recreation; among others (see Section II.E.).

1.d.1. Northern Colorado recovery unit

1.d.2. Eastern Colorado recovery unit

1.d.3. Upper Virgin River recovery unit

1.d.4. Eastern Mojave recovery unit

1.d.5. Northeastern Mojave recovery unit

1.d.6. Western Mojave recovery unit

1.e. Implement reserve-level management within DWMAs.

Once habitat is secured, management necessary to remove threats to the desert tortoise and its habitat must be implemented. Specific actions are recommended in Section II.E. and include activities such as partial fencing of DWMA boundaries to control livestock, burros, and horses; increased law enforcement; closure of vehicle routes and designation of vehicle ways; and construction of barrier fencing and highway underpasses that can be used by desert tortoises, thus reducing mortality of animals on and near roads and railroad tracks.

DWMAs will serve as recovery sites for the desert tortoise, but they will also be important as ecosystem reserves and as habitat for other rare and/or sensitive species or communities. DWMAs also can play a secondary role in providing watershed protection and some forms of recreation which are compatible with desert tortoise recovery. Management actions should be tailored to meet these other needs whenever possible. These concepts helped shape the management recommendations in Section II.E., Appendix F, and Brussard et al. (1994).

Although specific tasks are difficult to define at this time, implementation of recovery unit plans will be a crucial step in recovering the desert tortoise. As a result, implementation is included in the Implementation Schedule. Most costs and scheduling are listed as "to be determined", as they are contingent upon size and location of DWMAs.

1.e.1. Northern Colorado recovery unit

1.e.2. Eastern Colorado recovery unit

1.e.3. Upper Virgin River recovery unit

1.e.4. Eastern Mojave recovery unit

1.e.5. Northeastern Mojave recovery unit

1.e.6. Western Mojave recovery unit

1.f. Monitor desert tortoise populations within recovery units.

Monitoring of desert tortoise populations will be crucial to determining if desert tortoise populations are stationary, declining, or increasing (recovery criterion 1). Currently, monitoring of trends in population densities, such as described in Appendix A, is the only defensible way to evaluate recovery of desert tortoise populations. The advantages of this method include: (1) it assesses population trends over large areas, not just in single plots; (2) sample areas are selected randomly, allowing comparisons with standard statistical techniques; and (3) it violates no known assumptions of the underlying model.

Population trend monitoring should be funded by the appropriate land management agency, conducted by qualified biologists, and reviewed by the Fish and Wildlife Service and other appropriate agencies. If monitoring indicates that the desert tortoise population within a DWMA or recovery unit is not progressing towards recovery, management within DWMAs will need to be modified to ensure positive population growth or stability.

In addition to the population trend monitoring described in Appendix A, intensive, long-term study plots should also be maintained throughout the Mojave region, because the data they produce are critical for a thorough understanding of desert tortoise population biology and are necessary for delisting criterion #4.

1.f.1. Develop monitoring plan

A monitoring plan has been completed (Appendix A) and a workshop will be held in 1994 to further refine the techniques to be used for the desert tortoise.

1.f.2. Implement monitoring plan

Apply the monitoring plan developed in task 1.f.1. to each of the six recovery units.

1.f.2.a. Northern Colorado recovery unit

1.f.2.b. Eastern Colorado recovery unit

1.f.2.c. Upper Virgin River recovery unit

1.f.2.d. Eastern Mojave recovery unit

1.f.2.e. Northeastern Mojave recovery unit

1.f.2.f. Western Mojave recovery unit

2. Establish environmental education programs.

Start an aggressive and widespread effort in schools, museums, hunting clubs, and in BLM and National Park Service visitor centers and interpretive sites, etc. to inform the public about the status of the desert tortoise and its recovery needs. Develop interpretive kiosks or visitor centers near DWMAs to disseminate information about the desert tortoise and the need for regulated access and use of habitat. Education programs should include such subjects as: husbandry and adoption programs for captive tortoises, the illegality of releasing captive tortoises to wild lands, the illegality of translocating wild tortoises from one site to another, and the role of euthanasia in managing captive and wild populations where disease is a serious threat to survival of the species. Education efforts should be focused

on groups that use the desert on a regular basis, such as rockhounders. A permit system would offer one way to do this.

2.a. Develop environmental education programs.

Recovery unit management plans should include an environmental education feature, but such programs could also be developed by land management or other entities to educate contracted or in-house construction crews and other personnel who might encounter desert tortoises, or for educating the public in urban centers outside of recovery units.

2.b. Implement environmental education programs.

Implement the environmental education program developed in task 2.a.

3. *Initiate research necessary to monitor and guide recovery efforts.*

Unlike the situation with many threatened or endangered species, considerable data exist on many aspects of the biology of the desert tortoise. Unfortunately, few of these data are useful in recovery planning. The magnitude and scope of new research data essential for recovery planning requires an unprecedented level of coordination and cooperation within and among agencies. Biologists and research scientists in the Department of the Interior (BLM, NPS, Bureau of Reclamation, and National Biological Survey), Department of Defense, and other Federal agencies must work closely with their colleagues in state agencies to achieve this goal. No one agency can handle all the essential research, and monitoring. Employing talents of academic researchers will be essential. During the next two decades, research priorities on the desert tortoise should focus on the following areas:

3.a. Obtain baseline data on desert tortoise densities both inside and outside of DWMAs.

In addition to the population monitoring within DWMAs described in task 1.e., population density and distribution data are needed in some areas. The methodology recommended to determine densities is described in Appendix A. This methodology should be tested for replicability and accuracy in a variety of habitats.

3.b. Develop a comprehensive model of desert tortoise demography throughout the Mojave region and within each DWMA.

Such a model should be based on at least 25 years of data. This time span represents one desert tortoise generation and is necessary to capture the effects of normal environmental variability on desert tortoise survival and reproduction. Research should be done in both high- and low-density areas.

Research to develop documents for this model should include the following actions:

3.b.1. Initiate epidemiological studies of URTD and other diseases.

3.b.2. Research sources of mortality, and their representation of the total mortality, including human, natural predation, diminishment of required resources, etc.

3.b.3. Research recruitment and survivorship of younger age classes.

3.b.4. Research population structure, including the spatial scale of both genetic and demographic processes and the extent to which DWMAs and recovery units conform to natural population subdivisions.

3.c. Conduct appropriately designed, long-term research on the impacts of grazing, road density, barriers, human-use levels, restoration, augmentation, and translocation on desert tortoise population dynamics.

3.d. Assess the effectiveness of protective measures (e.g., DWMAs) in reducing anthropogenic causes of adult desert tortoise mortality and increasing recruitment.

3.e. Collect data on spatial variability of climate and productivity of vegetation throughout the Mojave region and correlate this information with population parameters (e.g., maximum sustainable population size, see Appendix G).

3.f. Conduct long-term research on the nutritional and physiological ecology of various age-size classes of desert tortoises throughout the Mojave region.

3.g. Conduct research on reproductive behavior and physiology, focusing on requisites for successful reproduction.

E. Desert Wildlife Management Areas: Management Recommendations

General requisites for siting DWMAs are found in Section II.B.; concepts of reserve design needed to guide delineation of DWMA boundaries and needed management actions are listed in the narrative outline of recovery actions (Section II.D.). The narrative outline contains only those actions which at this time can be identified. After DWMAs are selected and their boundaries delineated, DWMA-specific management actions must be defined to address specific threats and management problems in each DWMA. This chapter provides recommendations for management in the 14 proposed DWMAs (see Table 7). Although in some recovery units proposed DWMAs may be larger than 1,000 square miles (Appendix F and Brussard et al. 1994), declining populations and continuing threats from human-caused mortality and disease suggest that protecting only the minimum area necessary to support a viable population probably will not be adequate to achieve recovery. If DWMAs are selected and established as described in this Recovery Plan, and if DWMA-specific management actions recommended herein are implemented to protect habitat and to reverse current declines in desert tortoise populations, recovery should be an achievable goal.

Appendix F provides a broad range of information on each proposed DWMA including: (1) summary description, (2) current densities and population size, (3) land ownership, and (4) threats specific to individual DWMAs. Brussard et al. (1994) details further site-specific information which will be needed by land managers to delineate boundaries and assemble management plans for DWMAs. General boundaries are described in Figures 7, 8, 9, 10 and in Appendix F for each DWMA; however, these boundaries can be somewhat flexible.

Only one DWMA is proposed for the Upper Virgin River recovery unit. With intensive and careful management this recovery unit can support a viable population. Similarly, apart from a small portion of the Fenner DWMA, the Chemehuevi DWMA is the only proposed DWMA identified in the northern Colorado recovery unit and thus is a key area. The Chuckwalla DWMA is also very important because it is the only DWMA entirely contained within the eastern Colorado recovery unit. The Joshua Tree DWMA is partially in the eastern Colorado recovery unit, but most of the desert tortoises and most of the land area in this DWMA are in the western Mojave recovery unit.

The 1994 designation of critical habitat for the desert tortoise (59 FR 5823) was based on recommendations of the Draft Plan (Fish and Wildlife Service 1993), and is consistent with the recommendations of this final Plan (Appendix H). Areas not included in critical habitat, but recommended as DWMAs in the Draft Plan, were

considered to have current management policies which provided adequate protection against potential habitat-altering activities because they are primarily managed as natural ecosystems. The regulation of activities within critical habitat through section 7 (of the Endangered Species Act) consultation will be based on recommendations in this Plan (Section II C.1.). Critical habitat does not accomplish the same goals or have as dramatic an effect upon tortoise conservation as does a recovery plan because critical habitat does not apply a management prescription to designated areas. However, designation of critical habitat does provide protection of desert tortoise habitat until such time as the Desert Tortoise Recovery Plan is implemented and DWMA management is employed.

The management needs of DWMAs will likely be influenced by some important regulatory decisions in the near future. For instance, the California Desert Protection Bill (S.21, H.R. 518), currently before Congress, may affect proposed DWMA management needs. If passed into law, proposed DWMAs in the California portion of the eastern Mojave recovery unit could be managed wholly or in part by the National Park Service, and they may contain significant land area designated as wilderness.

The following actions are recommended for each DWMA. However, until DWMA boundaries are established, cost estimates cannot be derived. The Implementation Schedule (Section III) will be updated as these costs become available.

1. Recommended regulations in DWMAs.

For reasons given in Section I.B., if DWMAs are to function well as desert tortoise reserves, some human activities must be restricted. Extensive, rigorously obtained data which unambiguously define activities that are incompatible with desert tortoise recovery are largely unavailable. However, extensive anecdotal as well as other data do exist and they suggest strongly that the following activities should be prohibited throughout all DWMAs if population trends are to be reversed and recovery is to occur within a reasonable period of time. Implementation of these regulations will require intensive enforcement and willing cooperation.

The following activities should be prohibited throughout all DWMAs because they are generally incompatible with desert tortoise recovery and other purposes of DWMAs:

• all vehicle activity off of designated roads; all competitive and organized events on designated roads;

• habitat-destructive military maneuvers, clearing for agriculture, landfills, and any other surface disturbance that diminishes the capacity of the land to support desert tortoises, other wildlife, and native vegetation;

- domestic livestock grazing;
- grazing by feral ("wild") burros and horses;
- vegetation harvest, except by permit;
- collection of biological specimens, except by permit;
- dumping and littering;
- deposition of captive or displaced desert tortoises or other animals, except under authorized translocation research projects (see Appendix B.);
- uncontrolled dogs out of vehicles;
- discharge of firearms, except for hunting of big game or upland game birds from September through February; and

The following activities are compatible with tortoise recovery and may be allowed in DWMAs:

- non-intrusive monitoring of desert tortoise population dynamics and habitat;
- limited speed travel on designated, signed roads and maintenance of these roads;
- non-consumptive recreation (e.g., hiking, birdwatching, casual horseback riding, and photography);
- parking and camping in designated areas;
- fire suppression that minimizes surface disturbance;
- permitted or otherwise controlled maintenance of existing utilities;
- surface disturbances that enhance the quality of habitat for wildlife, enhance watershed protection, or improve opportunities for non-motorized recreation. This includes the construction of visitor centers, wildlife guzzlers, camping facilities, etc. where appropriate;
- population enhancement of native wildlife species such as desert bighorn, Gambel's quail, etc;
- mining on a case-by-case basis, provided that the cumulative impacts of these activities do not significantly impact desert tortoise habitats or populations, that any potential effects on desert tortoise populations are carefully mitigated during the operation, and that the land is restored to its pre-disturbance condition; and
- non-manipulative and non-intrusive biological or geological research, by permit.

DWMAs are intended to provide suitable habitat for the desert tortoise and effect recovery. They will also serve as ecosystem reserves, refuges for other plants and animals, and play secondary roles in watershed protection and in furnishing non-motorized recreational opportunities. Permit requirements (on some activities listed above) provide an opportunity for the land-management agency to instruct users on these goals. Manipulative or intrusive biological or geological research should generally be discouraged in DWMAs except under unusual circumstances, and none should be allowed except by permit.

Whether or not livestock grazing should be allowed in DWMAs is extremely controversial. At this time, there are no data showing that continued livestock grazing is compatible with recovery of the desert tortoise, although it appears that cattle grazing under certain circumstances can be compatible with desert tortoise survival (Tracy et al., in prep.). Because tortoise recovery is the goal of management within DWMAs, until such data are forthcoming, no grazing should be permitted within the DWMAs. Data required to show that cattle grazing can be compatible with recovery include a demonstration that adult tortoise densities are stationary or increasing and that regular recruitment is occurring into the adult age classes in areas where cattle are grazed. Such studies must be adequately controlled, replicated, and statistically robust.

2. *Recommended management actions.*

Actions recommended for immediate implementation inside DWMA boundaries to effect recovery of the desert tortoise are shown in Table 6. These and other necessary actions are discussed below:

2a. Control vehicular access in DWMAs.

Paved highways, unpaved and paved roads, trails, and tracks have profound impacts on desert tortoise populations and habitat. In addition to providing many opportunities for accidental mortality, they also provide access to remote areas for collectors, vandals, poachers, and people who do not follow vehicle-use regulations. Substantial numbers of desert tortoises are killed on roads. Thus, desert tortoises thrive best where the density of access routes is low, traffic on them is low, and human access is limited. The following actions should be implemented in all DWMAs to control vehicular access:

1. Restrict establishment of new roads in DWMAs.

2. Implement closure to vehicular access with the exception of designated routes, including Federal, State, and County maintained vehicle routes.

3. Implement emergency closures of dirt roads and routes as needed to reduce human access and disturbance in areas where human-caused mortality of desert tortoises is a problem.

4. Fence or otherwise establish effective barriers to tortoises along heavily-traveled roads; install culverts that allow underpass of tortoises to alleviate habitat fragmentation.

2b. Enforce regulations.

Several DWMAs have serious problems with vandalism, collecting of desert tortoises, release of captives, and unauthorized vehicle use, all of which contribute to abnormally high desert tortoise mortality rates. Therefore, regular and frequent patrols of such DWMAs by law enforcement personnel will be essential.

2c. Restore disturbed areas.

Surface disturbance in DWMAs should be restored to pre-disturbance conditions (defined as the topography, soils, and native vegetation that exist in adjacent undisturbed or relatively undisturbed areas). This includes such actions as closing access to non-designated roads and restoring non-designated roadbeds to their pre-disturbance state.

2d. Sign and fence DWMAs as needed.

The periphery of some DWMAs (on a case-by-case basis) should be fenced with material such as raised hog wire in areas where conflicts with adjacent land uses exist and where access cannot otherwise be controlled. In any event, it is essential that the boundaries of the DWMAs be clearly marked to regulate authorized use and to discourage unauthorized use. Boundaries of EMZs also should be clearly marked.

2e. Implement appropriate administration.

For the DWMAs to function effectively as reserves, local residents should understand and support them, as some traditional uses will be eliminated. Each DWMA may require a reserve manager, additional staff, and law enforcement personnel. In some cases, adjacent DWMAs could be managed by the same staff. DWMA personnel should be hired locally whenever possible. The relevant agencies and the DWMA employees should meet with various user groups to discuss implementation of land use restrictions in the DWMAs. The formation of local advisory committees to assist with this task is strongly recommended. Certain incentives may be necessary to encourage local people to respect DWMA boundaries; these might be paid for from funds collected through regional habitat conservation plans. As funds become available, each DWMA or group of DWMAs managed as a unit should have an associated visitor center or set of interpretive sites and panels and perhaps other amenities such as campgrounds or provisions for guided tours. These amenities would attract tourists and needed revenue to the local area. However, increased tourist traffic will need to be prevented from coming into conflict with the biological needs of the desert tortoise.

Table 7. Actions recommended for immediate implementation in proposed Desert Wildlife Management Areas to effect recovery of the desert tortoise.

Desert Wildlife Management Areas (DWMAs)	UV RV	BDS	FK	SC	CHU	OR	MM	IV	FE	PE	CS	GBP	CHE	JT
Level of Threats to DWMAs (1 = low; 5 = high)	5	5	5	5	4	4	3	3	3	2	2	2	1	1
ISSUES														
Modify Planned and Ongoing actions			X	X		X		X	X		X			X
Withdraw Grazing		X	X	X	X	X	X	X	X					
Withdraw Mining			X		X			X						
Develop DWMA Management Plans	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop Education Program	X	X	X	X			X			X		X		
Secure Habitat	X		X	X	X						X			
Modify/Control Landfills			X	X	X	X		X						
Sign and Fence Boundaries	X		X	X		X	X			X				
Halt Unauthorized ORV Use			X	X		X								
Halt Vandalism of Desert Tortoises		X	X	X	X	X	X			X				
Halt Collecting of Desert Tortoises			X	X	X	X	X	X	X	X				
Halt Releases of Captive Tortoises			X	X		X	X	X	X	X				
Control Vehicle Access			X	X	X	X		X	X					

UVRV = Upper Virgin River Valley; BDS = Beaver Dam Slope; FK = Fremont-Kramer; Superior-Cronese; CHU = Chuckwalla; OR = Ord-Rodman; MM = Mormon Mesa; IV = Ivanpah; FE = Fenner; PE = Piute-Eldorado; CS = Coyote Spring; GBP = Gold Butte-Pakoon; CHE = Chemehuevi; JT = Joshua Tree

2f. Modify ongoing and planned activities.

Ongoing and planned activities should be modified so they are consistent with the recovery objective and recommendations of this Recovery Plan.

2g. Control use of landfills and sewage ponds by desert tortoise predators.

Identify and clean up unauthorized dumps in DWMAs. Reduce or eliminate use of authorized landfills and sewage ponds in and near DWMAs by predators of desert tortoise (e.g., ravens & coyotes). Allow no new landfills or sewage ponds within DWMAs.

2h. Establish environmental education programs and facilities.

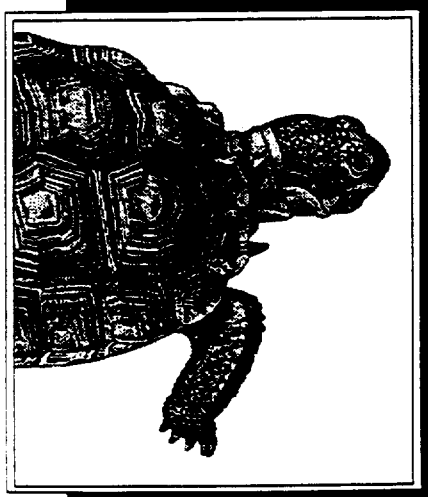
As described in Task 6, visitor centers, interpretive sites, guided tours, and campgrounds are all appropriate in towns near DWMAs to educate the public about the status and management needs of the desert tortoise and its habitat. In addition, desert tortoise programs should be developed for use in schools, museums, clubs, the media, etc. Education efforts should be focused on groups using the desert regularly, such as rockhounders.

These actions are recommended to increase manageability, establish an enforcement presence, effect an immediate reduction in the threats to extant desert tortoise populations in DWMAs, and build local support for the reserve concept. In addition to these actions, emergency closures of cattle and domestic sheep allotments, or placement of allotments and licenses into nonuse categories will be needed in many DWMAs. Mineral withdrawals will likely be needed in some DWMAs to prevent impacts to desert tortoises and their habitat. Other actions critical to recovery in DWMAs have been defined in Section II.D. and the Implementation Schedule (Section III), including research necessary to guide recovery efforts, and monitoring. In addition, land managers are encouraged to implement management actions which promote the conservation of other species and biotic communities.

If extinction occurs in any DWMA, efforts to recolonize the DWMA with wild desert tortoises from the same recovery unit should be undertaken. Long-term research and monitoring would be necessary to ensure the success of any such recolonization effort. All translocations should be done in accordance with the guidelines in Appendix B.

III. Implementation Schedule

Desert Tortoise
(Mojave Population)



Recovery Plan

III. IMPLEMENTATION SCHEDULE

The table that follows is a summary of scheduled actions and costs for this recovery program. It is a guide to meet the recovery objective. This table indicates the scheduling priority for each task, which agencies are responsible for performing these tasks, and the estimated costs to perform them. Implementation of all tasks listed in the Implementation Schedule will lead to recovery. Initiation of these actions is subject to availability of funds.

Priorities in column two of the implementation schedule are assigned as follows:

1. **Priority 1:** An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. **Priority 2:** An action that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

3. **Priority 3:** All other actions necessary to meet the recovery objective.

ACRONYMS USED IN THE IMPLEMENTATION SCHEDULE

*	= Lead Agency
AGFD	= Arizona Game and Fish Department
BLM	= Bureau of Land Management
CC	= Clark County
CDSP	= California Department of State Parks
CDFG	= California Department of Fish and Game
CEC	= California Energy Commission
DOD	= Department of Defense
DOE	= Department of Energy
DWMA	= Desert Wildlife Management Area
ECRU	= Eastern Colorado recovery unit
EMRU	= Eastern Mojave recovery unit
FWS	= Fish and Wildlife Service
FHWA	= Federal Highway Administration
NCRU	= Northern Colorado recovery unit
NDOW	= Nevada Division of Wildlife
NEMRU	= Northeastern Mojave recovery unit
NPS	= National Park Service
TBD	= To be determined
UDWR	= Utah Division of Wildlife Resources
UNR	= University of Nevada, Reno
USP	= Utah State Parks
UVRRU	= Upper Virgin River recovery unit
URTD	= Upper respiratory tract disease

Clearly, managers must be able to alleviate detrimental impacts on a population so that the expected growth is at least zero. At zero the population will stay constant in total size. However, even with such management, there will still be random forces that impel a population both up and down. These are the stochastic factors discussed in Section 3 of this appendix. There is often a threshold in total population size, density, or spatial arrangement below which these stochastic factors can result in a high probability of extinction within a given time period. A PVA may be able to predict this threshold--the minimum viable population.

Catastrophes. - A catastrophe is an extreme event which, by itself, can result in population extinction. Fires, floods, and epizootics are commonly cited catastrophes. In general, catastrophes are rare events whose probabilities are hard to estimate, and because of the difficulty they are typically handled in ad hoc fashion outside of a formal PVA. The Upper Respiratory Tract Disease (URTD) is a possible catastrophe threatening desert tortoises. However, its rate of spread and potential ultimate impact have not yet been estimated by epidemiological models.

The only protection against catastrophes is to have redundancy built into the management system--several widely-spaced populations would not likely be struck by the same catastrophic event at the same time. For threats such as drought or flooding, local populations would have to be distributed over a region that is large compared to the total spatial scale of catastrophes. Since the epidemiology of URTD is not yet understood, managing this epizootic is extremely problematic.

Desert Tortoise Genetics.

A comprehensive PVA requires considering population genetics--including loss of heterozygosity, inbreeding depression, outbreeding depression, long-term loss of adaptability, pedigrees, paternities, population structure, etc. However, most PVAs involve much smaller total populations (Table C1) than currently exist for the desert tortoise (although population density must be considered vis-a-vis short-term genetic deterioration as well).

Table C1. The number of individuals modeled in PVAs for endangered species.

Species	Number of Individuals
Blackfooted Ferrets	6
California Condors	28
Whooping Cranes	50
Yellowstone Grizzlies	200
Northern Spotted Owls	2000

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.a.6	Select DWMAs in Western Mojave Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				NPS	10		10			
				DOD	10		10			
				CDFG	10		10			
1	1.b.1	Delineate DWMA boundaries in Northern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				CDFG	10		10			
1	1.b.2	Delineate DWMA boundaries in Eastern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				CDFG	10		10			
				DOD	10		10			
1	1.b.3	Delineate DWMA boundaries in Upper Virgin River Recovery Unit	1	FWS*	20	20				
				BLM	20	20				
				UDWR	20	20				
				USP	10	10				
1	1.b.4	Delineate DWMA boundaries in Eastern Mojave Recovery Unit	1	FWS*	20	10	10			
				BLM	20	10	10			
				NPS	10	5	5			
				NDOW	10	5	5			
				CDFG	10		10			
				CDSP	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.b.5	Delineate DWMA Boundaries in Northeastern Mojave Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				DOD	10		10			
				NPS	10		10			
				AGFD	10		10			
				NDOW	10		10			
				UDWR	10		10			
1	1.b.6	Delineate DWMA boundaries in Western Mojave Recovery Unit	1	FWS*	50		50			
				BLM	100		100			
				NPS	20		20			
				DOD	20		20			
				CDFG	20		20			
1	1.c.1	Secure DWMAs in Northern Colorado Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				CDFG	TBD					
1	1.c.2	Secure DWMAs in Eastern Colorado Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				CDFG	TBD					
				DOD	TBD					
1	1.c.3	Secure DWMAs in Upper Virgin River Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				UDWR	TBD					
				USP	TBD					

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.c.4	Secure DWMAs in Eastern Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				NPS	TBD					
				NDOW	TBD					
				CDFG	TBD					
				CDSP	TBD					
1	1.c.5	Secure DWMAs in Northeastern Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				DOD	TBD					
				NPS	TBD					
				AGFD	TBD					
				NDOW	TBD					
				UDWR	TBD					
1	1.c.6	Secure DWMAs in Western Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				NPS	TBD					
				DOD	TBD					
				CDFG	TBD					
1	1.d.1	Develop DWMA Management Plan in Northern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				CDFG	10		10			
1	1.d.2	Develop DWMA Management Plan in Eastern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				CDFG	10		10			
				DOD	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.d.3	Develop DWMA Management Plan in Upper Virgin River Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				UDWR	20		20			
				USP	10		10			
1	1.d.4	Develop DWMA Management Plan in Eastern Mojave Recovery Unit	1	FWS*	40		40			
				BLM	40		40			
				NPS	20		20			
				NDOW	10		10			
				CDFG	10		10			
				CDSP	10		10			
1	1.d.5	Develop DWMA Management Plan in Northeastern Mojave Recovery Unit	1	FWS*	50		50			
				BLM	40		40			
				DOD	10		10			
				NPS	10		10			
				AGFD	10		10			
				NDOW	10		10			
				UDWR	10		10			
1	1.d.6	Develop DWMA Management Plan in Western Mojave Recovery Unit	1	FWS*	50		50			
				BLM	250		250			
				NPS	50		50			
				DOD	50		50			
				CDFG	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.e.1	Implement DWMA Management Plans in Northern Colorado Recovery Unit	Cont.	BLM*	TBD					
1	1.e.2	Implement DWMA Management Plans in Eastern Colorado Recovery Unit	Cont.	BLM*	TBD					
				DOD	TBD					
1	1.e.3	Implement DWMA Management Plans in Upper Virgin River Recovery Unit	Cont.	BLM*	TBD					
				USP	TBD					
1	1.e.4	Implement DWMA Management Plans in Eastern Mojave Recovery Unit	Cont.	BLM*	TBD					
				NPS	TBD					
1	1.e.5	Implement DWMA Management Plans in Northeastern Mojave Recovery Unit	Cont.	BLM*	TBD					
				DOD	TBD					
				NPS	TBD					
				FWS	TBD					
1	1.e.6	Implement DWMA Management Plans in Western Mojave Recovery Unit	Cont.	BLM*	TBD					
				DOD	TBD					
				NPS	TBD					
2	1.f.1	Develop Monitoring Plan	1	FWS*	10	10				
				UNR	10	10				
				CC	30	30				

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
2	1.f.2.a	Implement Monitoring Plan in Northern Colorado Recovery Unit	Cont.	BLM*	400		100			100
2	1.f.2.b	Implement Monitoring Plan in Eastern Colorado Recovery Unit	Cont.	BLM*	300		75			75
				DOD	100		25			25
				NPS	100		25			25
2	1.f.2.c	Implement Monitoring Plan in Upper Virgin River Recovery Unit	Cont.	BLM*	140		35			35
				USP	60		15			15
2	1.f.2.d	Implement Monitoring Plan in Eastern Mojave Recovery Unit	Cont.	BLM*	960		240			240
				NPS	200		50			50
				CDSP	40		10			10
2	1.f.2.e	Implement Monitoring Plan in Northeastern Mojave Recovery Unit	Cont.	BLM*	800		200			200
				NPS	80		20			20
				FWS	160		40			40
2	1.f.2.f	Implement Monitoring Plan in Western Mojave Recovery Unit	Cont.	BLM*	600		150			150
				DOD	200		50			50
				NPS	400		100			100
		Subtotal costs needs 1			6320	200	2715	0	0	1135

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
		Needs 2: Establish Environmental Education Program								
2	2.a	Develop Environmental Education Programs	1	FWS*	200	200				
				BLM	200	200				
				DOD	50	50				
				NPS	200	200				
				CDGF	50	50				
				AGFD	50	50				
				NDOW	50	50				
				UDWR	50	50				
				CDSP	50	50				
				USP	50	50				
2	2.b	Implement Environmental Education Programs	Cont.	FWS*	TBD					
				BLM	TBD					
				DOD	TBD					
				NPS	TBD					
				CDGF	TBD					
				AGFD	TBD					
				NDOW	TBD					
				UDWR	TBD					
				CDSP	TBD					
				USP	TBD					
		Subtotal costs needs 2			950	950	0	0	0	0

Desert Tortoise (Mojave Population) Implementation Schedule

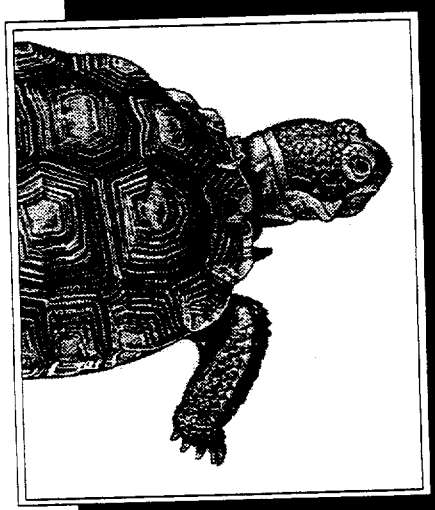
Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
		Needs 3: Conduct Tortoise Research								
2	3.a	Research on Tortoise Densities	5	FWS*	25	5	5	5	5	5
				BLM	250	50	50	50	50	50
				DOD	100	20	20	20	20	20
				NPS	100	20	20	20	20	20
				CDSP	25	5	5	5	5	5
				USP	25	5	5	5	5	5
				UDWR	25	5	5	5	5	5
2	3.b.1	Research on Upper Respiratory Tract Disease and other Diseases	3	BLM*	1000	350	350	300		
				AGFD	3	3				
				UDWR	10	10				
				FWS	25	25				
2	3.b.2	Research on Mortality	10	BLM*	400	40	40	40	40	40
				CC	200	100	100			
2	3.b.3	Research on Recruitment and Survival	10	BLM*	440	20	20	50	50	50
				DOE	100	50	50			
				DOD	20	10	10			
				UDWR	45	5	5	5	5	5
2	3.b.4	Research on Population Structure	10	BLM*	1000	100	100	100	100	100
				NPS	400	40	40	40	40	40
				DOE	60	20				
				FWS	60	20				

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
2	3.c	Research on Human-use Impacts	5	BLM*	2940	420	420	700	700	700
				DOD	80		20	20	20	20
				NPS	80		20	20	20	20
				CC	225	105	120			
				CEC	40	20	20			
				FHWA	250	40	140	70		
				CDFG	4	2	2			
3	3.d	Research on Effectiveness of Protection	cont.	FWS*	550			50	50	50
3	3.e	Research on Climate and Vegetation	cont.	NPS	100	20			20	
3	3.f	Research on Nutrition and Physiology	5	BLM*	260	100	100	60		
				NPS	100	20	20	20	20	20
				UDWR	100	20	20	20	20	20
				CC	240	80	80	80		
3	3.g	Research on Reproductive Behavior	5	BLM*	150	30	30	30	30	30
				UDWR	45	5	5	5	5	5
		Subtotal costs needs 3			9432	1760	1817	1715	1225	1205
		Total costs			16702	2910	4532	1715	1225	2340

Appendices

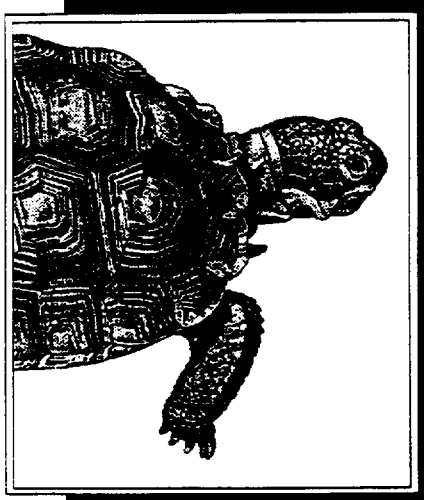
Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix A

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix A: Estimation of Regional Densities

I. Introduction

Accurate determination of desert tortoise densities is a critical component of this recovery plan. Densities should be monitored both inside and outside of Desert Wildlife Management Areas (DWMAs) to determine whether or not protection from human activities within DWMAs is effective in reversing current population declines. Comparisons of population growth rates between experimental management zones (EMZs) and other reserve areas will be necessary to assess the impact of activities permitted in the former and not in the latter and to adjust management actions accordingly.

The method described herein is to be used for estimating desert tortoise densities throughout a recovery unit. It should not be confused with the widely-used strip transect and study plot techniques (Berry 1984a; Berry and Nicholson 1984a, 1984b; Karl 1983). Strip transects provide data to map desert tortoise distribution and may allow estimation of relative densities if properly calibrated on nearby study plots in similar habitats. Intensive surveys of study plots produce detailed data on habitat condition, human uses, and such population attributes as densities, size-age class structure, sex ratios, recruitment, causes of death, and mortality rates in localized areas. However, neither of these techniques is suitable for economical and reliable estimates of desert tortoise densities on a regional scale.

II. Hypothesis to be tested

Most desert tortoise populations in the Mojave region have experienced rapid declines, and recovery depends on reversing these trends. Because most population declines appear to be directly or indirectly caused by various human activities, the establishment of a network of DWMAs where such activities are curtailed or carefully managed should result in positive population growth rates and the eventual achievement of recovery goals. Thus, monitoring of desert tortoise density should be performed to test the following hypothesis:

H_1. If protection afforded by DWMAs has no effect on desert tortoise population dynamics, there will be no significant differences between the densities of populations inside and outside of the DWMAs.

III. Methods

A. Number and Location of Sample Plots Within Each DWMA.

Each sample plot should be 1 square kilometer in area. The number of sample plots per DWMA will depend upon its size, but at least 5% of the total area of the DWMA must be sampled in each sampling cycle (e.g., 10 square miles [25.9 square kilometers]), or 26 sample plots, would be the minimum acceptable area to sample within a DWMA of 200 square miles). No fewer than three control plots must be sampled outside of each DWMA. These plots must be located no closer than 2 miles and no farther than 10 miles from the DWMA boundary. Adjacent DWMAs may share one or more control plots that fit these criteria.

The DWMAs should be divided into plots 1 square kilometer in area using Universal Transverse Mercator coordinates, and each plot should receive a unique number. Plots to be sampled should be chosen from a random number table. If a randomly chosen plot is in an area that is very unlikely to contain desert tortoises, it should be excluded and another plot chosen. Such exclusions include (1) plots with average elevations over 4000 feet, (2) plots transected by paved highways, (3) plots largely consisting of playas or other areas with no natural vegetation, and (4) plots with large areas of human-caused surface disturbance (e.g., agricultural field, gravel pit). Control plots should be chosen using the same criteria as plots within the DWMAs. New plots should be chosen each time the DWMA and the control areas are sampled.

B. Data Collection - Scheduling.

Initial population estimates to establish baseline densities must be accomplished as soon as DWMA boundaries are established. Resampling must occur every 3 years. Because population estimations must coincide with periods of high desert tortoise activity, all surveys must be completed during the months of February through May. This 16-18 week period is sufficient for a team of properly trained biologists to survey at least 10 sample plots, allowing for periods of inclement weather and other complications.

Each square kilometer plot may require up to 7 days of complete sampling by a team of four experienced desert tortoise biologists. If ten DWMAs required 26 plots plus three outside controls each, this would mean a total of 290 plots to sample. However, it is unlikely that all DWMAs will be established simultaneously, and with a 3-year resampling schedule, approximately one-third of this number, or 97, would have to be sampled every year. Thus, nine teams, starting in areas with early greenup and moving into regions with later phenologies, could accomplish these sampling goals.

C. *Data Collection - Methods.*

The removal method (Southwood 1978; Zippin 1956, 1958) should be used to estimate densities of large immature and adult desert tortoises (carapace length > 140 mm) in the square-kilometer plots. The principle behind this method is that if a known number of animals is "removed" (in this case, marked and released in situ) on each sampling occasion, the rate at which new captures fall off will be directly related to the size of the total population and the total number "removed." Thus, the removal method, unlike capture-mark-release methods, requires that animals be handled only once during a survey. The assumptions of this method are that (1) the catching procedure does not lower the probability of other animals being caught, (2) the population remains stationary during the sample period, (3) the population is not so large that the capture of one individual interferes with the capture of another, and (4) the chance of capture is equal for all animals. By restricting the sample to adult and large immature animals and by analyzing males and females separately, none of these assumptions is violated.

All samples should be made by a four-person team of experienced desert tortoise biologists. The biologists should proceed to a previously selected, randomly chosen plot and use a global positioning device to locate its four corners. Temporary flags, to be removed after the sample period, should be used to mark plot boundaries. The plot should be searched thoroughly for desert tortoises each day of the sample by all four biologists, concentrating on times of high activity. Each biologist should search one quarter of the plot to achieve complete coverage each day. Desert tortoises are to be sampled only on the surface, except when they can be coaxed out of their burrows by thumping. No desert tortoises will be pulled from their burrows with hooks or other devices.

Upon capture, adult desert tortoises should be sexed and measured, in millimeters, along the midline of the carapace. Those with midline carapace length of 140 mm or greater will be included in the sample. These animals should be marked with a small dot of acrylic paint placed on the dorsal surface of both the anterior and posterior marginals; the paint marks will enable the survey team to recognize previously handled ("removed") desert tortoises.

Even if no desert tortoises are encountered, each plot should be sampled for a minimum of 3 days in weather suitable for the animals to be above ground. If desert tortoises are found, sampling should continue for 7 days or until no unmarked desert tortoises have been encountered for 2 consecutive days.

D. *Data analysis.*

Zippin's (1956, 1958) maximum likelihood method, as described in Southwood (1978, pp. 232-236), should be used to estimate desert tortoise densities and their standard errors in each square-kilometer

plot. Because plots were randomly selected, these estimates will provide an accurate picture of desert tortoise densities and spatial variation within the DWMA and surrounding areas.

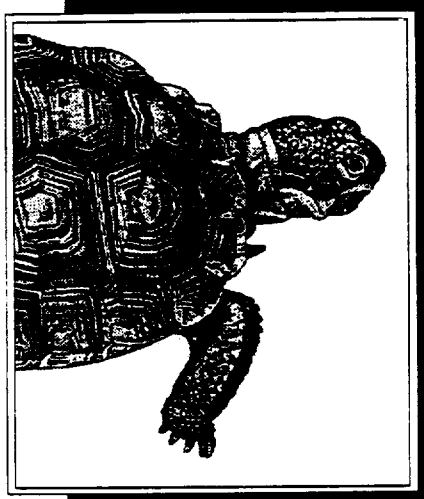
IV. Interpretation of results.

The immediate goal of these samples is to obtain reliable estimates of desert tortoise densities in the DWMAs and adjacent, non-protected areas. The long-term goals are to assess the success of the recovery strategy developed in this plan, adjust management goals as appropriate, and determine when recovery has been achieved. Sufficient data to accomplish the long-term goals will require many sampling periods. Estimated densities and their standard errors accumulated over at least 12 years, or five samples, will be necessary to adequately falsify the hypotheses posed above and to consider delisting a recovery unit.

If it appears that desert tortoise densities are still declining after the second sample, these data should trigger a reassessment of management practices and suggest additional research. For example, examining the effectiveness of management efforts directed at curtailing human activities within the DWMA would be appropriate under these circumstances. On the other hand, research may show that desert tortoise habitat has been so degraded by previous management practices that it will take several more years of freedom from disturbance before conditions for desert tortoises will improve within the DWMA.

Appendix B

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix B: Guidelines for Translocation of Desert Tortoises

(1) Experimental translocations should be done outside experimental management zones. No desert tortoises should be introduced into DWMAs—at least until relocation is much better understood.

(2) All translocations should occur in good habitat where the desert tortoise population is known to be substantially depleted from its former level of abundance. Translocation of reproductively competent adults into depopulated areas can have beneficial effects on population growth. Before population growth can occur, however, individuals must establish home ranges and enter into any existing social structure. Desert tortoises should be periodically evaluated against a defined health profile (proportional weight/size, fecal scans, and blood panels).

(3) Areas into which desert tortoises are to be relocated should be surrounded by a desert tortoise-proof fence or similar barrier. The fence will contain the desert tortoises while they are establishing home ranges and a social structure. If the area is not fenced, past experience suggests that most animals will simply wander away from the introduction site and eventually die. (Fencing is not cheap; estimates range from $2.50 to $5.00 per linear foot). Once animals are established some or all of the fencing can be removed and probably reused.

(4) The best translocations into empty habitat involve desert tortoises in all age classes, in the proportions in which they occur in a stable population. Such translocations may not always be possible, since young desert tortoises are chronically underrepresented in samples, often due to observer sampling error, and may now actually be underrepresented in most populations due to poor recruitment and juvenile survivorship during the last several years. Desert tortoises smaller than the 7-year age-size class are particularly vulnerable to predation and may be a poor investment for translocation, unless predator exclusion (fencing, for example) is incorporated into such endeavors. Mature females would probably be the best sex/age class to introduce into below carrying capacity extant populations because of their high reproductive value (low potential mortality, high potential fecundity for many years).

(5) The number of desert tortoises introduced should not exceed the pre-decline density (if known). If the pre-decline density is not known, introductions should not exceed 100 adults or 200 animals of all age classes per square mile in category 1 habitat (Bureau of Land Management designation for management of desert tortoise habitat) unless there is good reason to believe that the habitat is capable of supporting higher densities. Post-introduction mortalities

might be compensated by subsequent introductions if ecological circumstances warrant this action.

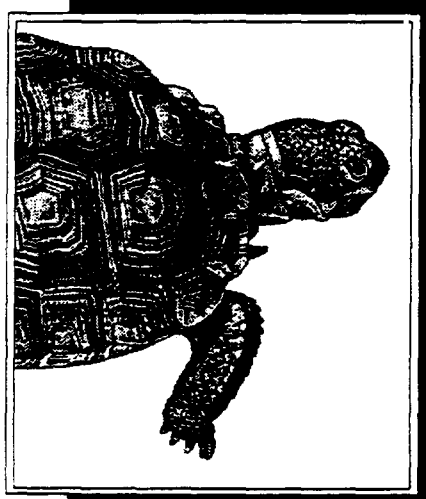
(6) All potential translocatees should be medically evaluated in terms of general health and indications of disease, using the latest available technology, before they are moved. All translocatees should be genotyped unless the desert tortoises are to be moved only very short distances or between populations that are clearly genetically homogeneous. All translocated animals should be permanently marked, and most should be fitted with radio transmitters so that their subsequent movements can be closely tracked.

(7) If desert tortoises are to be moved into an area that already supports a population--even one that is well below carrying capacity--the recipient population should be monitored for at least 2 years prior to the introduction. Necessary data include the density and age structure of the recipient population, home ranges of resident desert tortoises, and general ecological conditions of the habitat.

Areas along paved highways can serve as good translocation sites, if properly fenced. Many such areas support good habitats, but vehicle-caused mortalities and/or collecting have substantially reduced or totally extirpated adjacent desert tortoise populations. Any translocation sites should be isolated by a desert tortoise barrier fence or similar barrier next to the highway or road. The purpose of fencing the highway is obvious--to keep translocated animals from being crushed by vehicles on the road. However, fencing the other sides of the translocation area is critical for establishment. If a fenced area or strip of habitat approximately 0.125 to 0.25 mile wide is established along highways, some translocatees should establish home ranges and a social structure within this strip. When the inside fence is removed, the translocated desert tortoises and those from the extant population farther away from the road will eventually expand their home ranges into the remaining low-density areas. A second reason for inside fencing is to prevent any diseased, but asymptomatic, desert tortoises from infecting nearby, healthy populations. In the event that disease is an issue and a resident population is present nearby, double inside fencing should be considered.

Appendix C

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix C: Desert Tortoise Population Viability

I. Introduction

Because desert tortoises live to such great age, are found in very sparse populations, and are very difficult to study, we know very little about the tortoise population dynamics. Thus, computer modeling has been used as a means of supplementing our knowledge in this area. We present here a life history analysis of the consequences of demographic characteristics in tortoise populations, an analysis of trends in these populations, and, finally, an analysis of the population viability of desert tortoises in the Mojave. These exercises have all supported the necessity for large reserves (DWMAs) for the recovery of the species.

II. Life history analysis

Understanding the life-history consequences of modifications to mortality and/or fecundity to population persistence is crucial to management decisions on desert tortoise populations. Nevertheless, the quality of data for such an analysis are understandably poor for this extremely long-lived species that may undergo huge natural temporal and spatial swings in population density in response to a stochastically varying environment. Mertz (1971) developed an approach to investigate life-history consequences to changing environments of a long-lived species. We have used this approach to estimate the relative contributions of juvenile and adult mortality, as well as fecundity, to the ability of desert tortoise populations to maintain themselves at stable population densities. The basis of the analysis is a model of the demography of the desert tortoise. This model purposely does not contain great demographic detail, since the questions asked do not require great detail. Mertz used a similar low-resolution model to ask "broad-brush" questions about California Condors.

The basis of the model comes from the work of Leslie (1966). The model is based upon transition matrices containing age-specific mortality and fecundity. The following simplifying assumptions were made:

1. Mortality for eggs and juveniles were lumped into a probability of surviving to reproductive age, β.

2. Mortality of reproductive adults was taken to be the same regardless of age and was represented as the probability of surviving one year, ρ.

The model predicting net reproductive rate is:

$$R_o = (\beta * f * C * (1 - F) * (1 - \rho^{(\omega - \alpha)}) / (1 - \rho^{T})$$

where:

R_o = The net reproductive rate or the proportional change in population size per generation.

β = The probability of surviving to reproductive age.

ρ = The probability of an adult surviving one year.

f = The proportion of females in the population.

C = The clutch size.

F = The proportion of females failing to breed.

ω = The age at which reproduction ends.

α = The age at which reproduction begins.

T = The time interval at which reproduction occurs.

Simulations illustrated the conditions that produced a net reproductive rate, R_o, of zero (or stable population size). These simulations included the following additional assumptions for the purpose of the analysis:

1. Sex ratio was assumed to be 0.5.

2. All reproductive-aged females were assumed to reproduce.

3. Reproduction was assumed to continue to age 100 (this assumption was checked separately and found not to affect the results greatly).

4. The age of first reproduction was taken to be 15 years (this assumption has no effect on simulations confined to $R_o = 1.0$).

5. Egg laying, multiple clutching, and years without reproduction were all condensed to an average number of eggs produced per year (thus, separate mortality probabilities for different clutches, and clutches in bad years were not considered).

Three variables were considered:

1. ρ, differences in which can be taken as reflecting elevated adult mortality.

2. β, differences in which can be taken as elevated mortality of eggs or juveniles.

3. C, differences in which can be taken as reflecting conditions more or less optimal for reproduction.

Figures C1 and C2 present simulations showing the combinations of r, b, and C necessary to have $R_O = 1.0$. Clearly, if a population is healthy, and relatively free from sources of adult mortality, and thus having a r of > 0.95 and a fecundity > 9 eggs/year, then very few juveniles need survive to adulthood. Indeed, somewhere in the order of only 1% of all eggs need survive to reproductive age. On the other hand, a 10% increase in adult mortality can require a 300% increase in juvenile survivorship. Furthermore, any reduction in fecundity of adults exacerbates this still further. These results illustrate the requirements of desert tortoises in their natural environments, particularly the premium placed upon adult survival. The life-history strategy of desert tortoises may have evolved in an environment in which 99% of all juveniles die before reaching reproductive age. However, this life-history strategy may not work for desert tortoises faced with increased mortality on adults. Desert tortoises may very well have been able to handle high juvenile mortality in the past, but in populations suffering high mortality from URTD, off-road vehicles, and pet collection, juvenile survivorship becomes increasingly important.

The simulations also point to the necessity of considering all sources of age-specific mortality in management plans, not just mortality in a particular age group. Finally, the simulations point to the extremely potent effect that climate change could have if new conditions resulted in abandoning reproduction altogether in numerous bad years interspersed among somewhat better years for production of food resources.

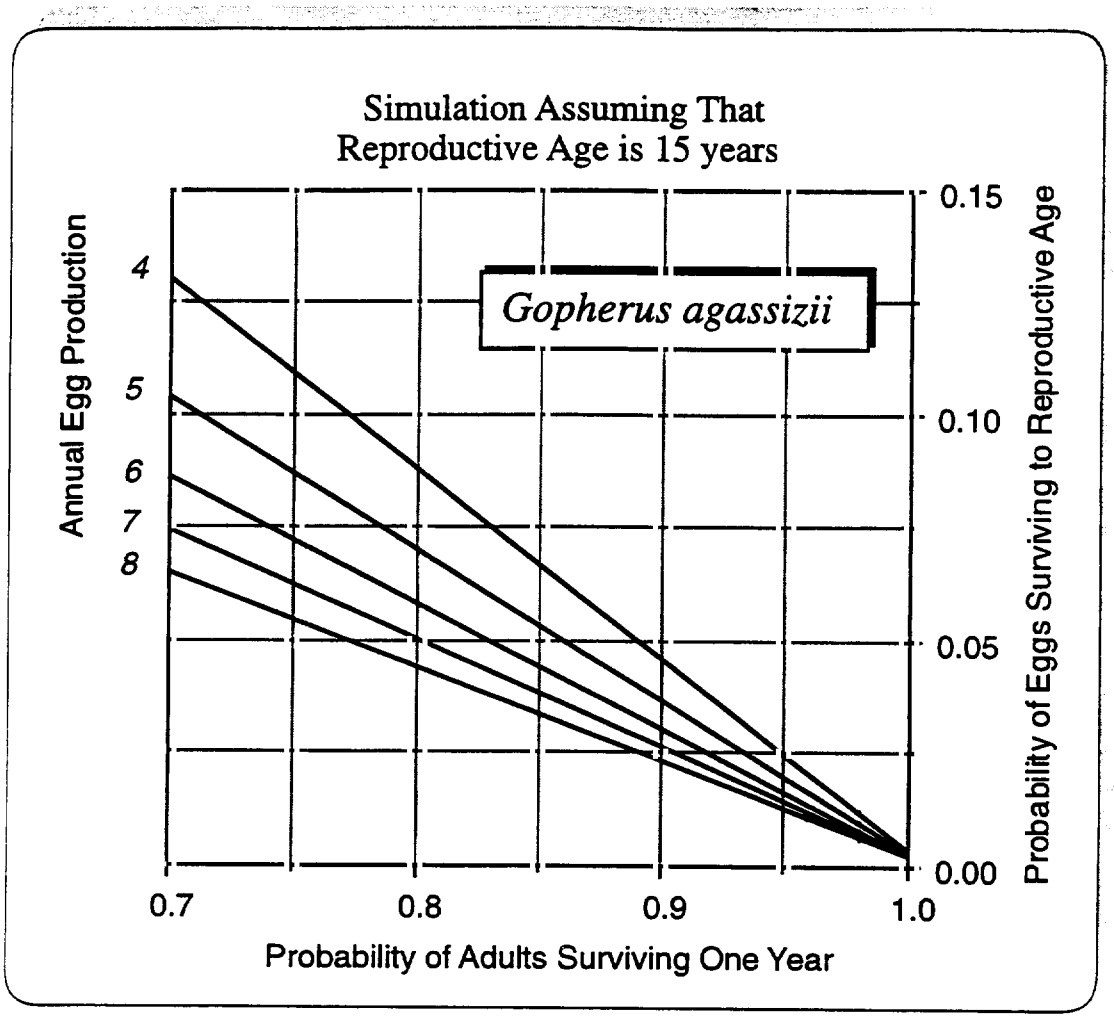


Figure C1. Calculated requirements for adult and juvenile survivorship in order to have a net reproductive rate of 1 (viz., a population neither growing nor declining) as a function of the average number of eggs produced per year.

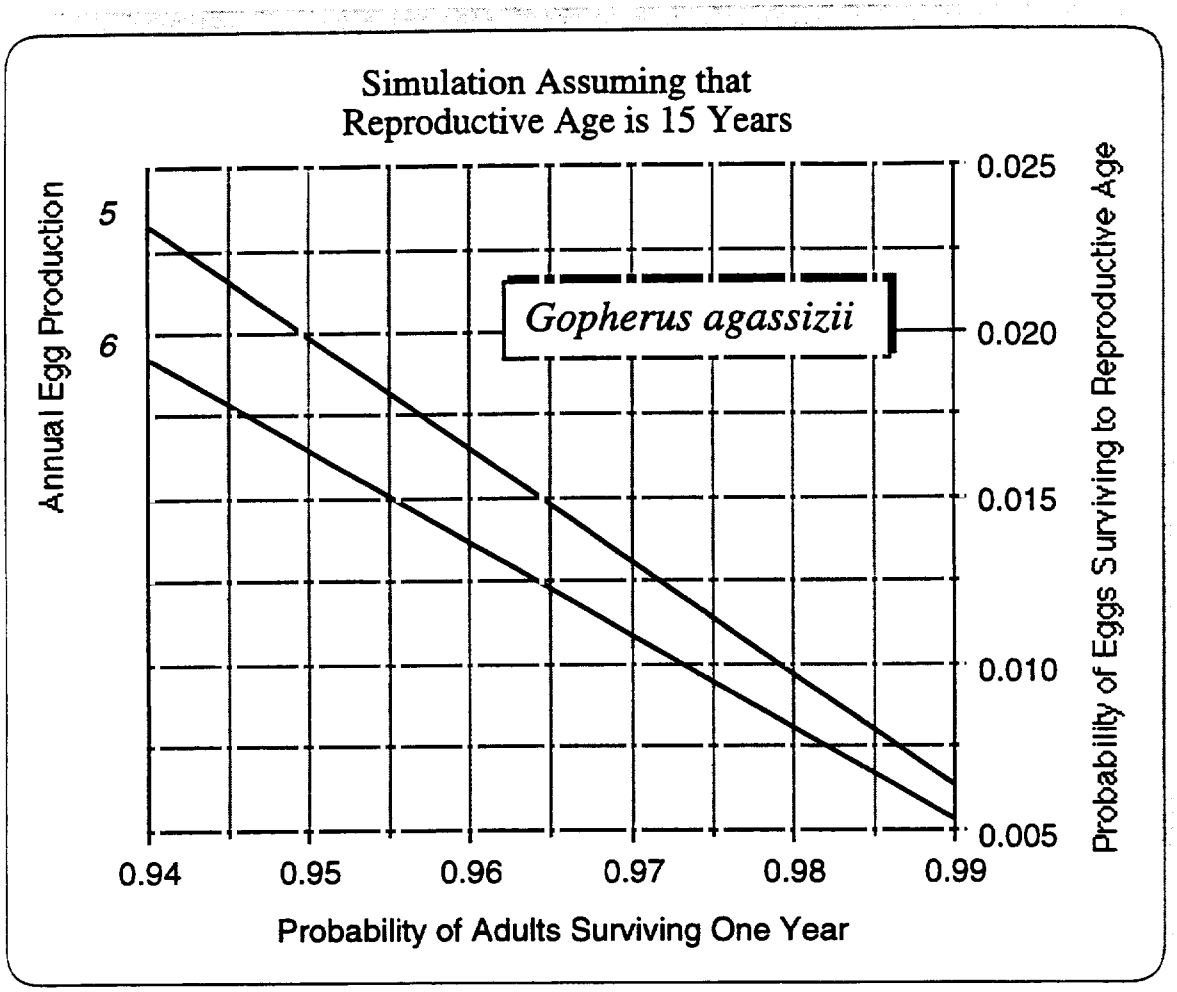


Figure C2. Calculated requirements for adult and juvenile survivorship in order to have a net reproductive rate of 1 (viz., a population neither growing nor declining) when females produce an average of 5 to 6 eggs per female per year.

III. Population Trends in the Mojave Desert Tortoise in Different Parts of the Mojave Desert

The desert tortoise has been listed as a threatened species because of disturbing downward trends in population sizes in many portions of the species range. Some desert tortoise populations have reached such low numbers that extirpation is highly probable. Furthermore, the population dynamics of this species are so ponderous that recovery from major reductions in population size is problematic. Nevertheless, desert tortoises have persisted in the Mojave Desert for thousands of years even though there have almost certainly been random local extinctions and subsequent reinvasions (Hanski 1991). Today, many desert tortoise populations are so fragmented that they have little ability to recover from major population declines. Thus, it is very important to distinguish between the forces causing "normal" fluctuations in population sizes and those that threaten population persistence.

There are two kinds of population change: stochastic fluctuations and trends. Population trends are monotonic changes in population size caused by some persistent demographic change in the population (Figure C3). For example, persistently reduced fecundity or increased rates of mortality will cause changes in the "equilibrium" population size as well as changes in the ability of populations to grow. In the desert tortoise, such changes could be caused by increased predation by animals or humans, reduction in the forage base due to changes in climate or competition with domestic grazers, etc. Clearly, downward population trends must be halted in order for a population to persist.

Stochastic fluctuations (Figure C3) occur when some random event causes a downturn from which the population begins immediate recovery. These events can be caused by such things as drought, fire, and disease. Recovery from stochastic fluctuations will depend upon their frequency and severity. Thus, a large population which is infrequently influenced by random events will have a high probability of persistence; alternatively, small populations repeatedly assaulted by stochastic increases in mortality or decreases in fecundity will have a lower probability of persistence.

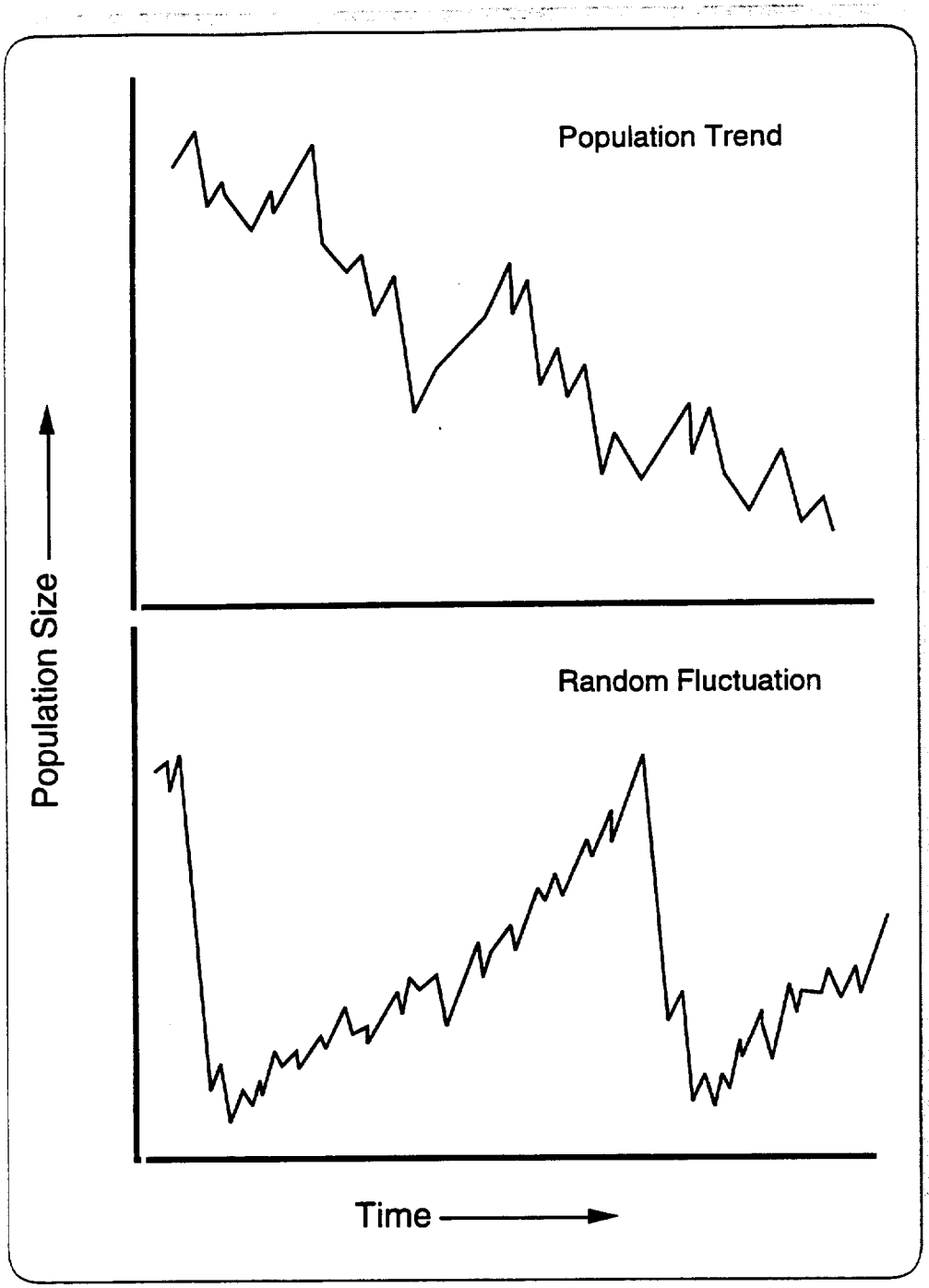


Figure C3. Hypothetical population dynamics over time for a population undergoing a trend in numbers and a population undergoing stochastic declines followed by recovery in numbers.

Populations undergoing steady downward trends will go extinct. The likely time to extinction is easily calculated. However, extinctions can also occur in populations that, on average, are stochastically fluctuating around some long-term mean. Thus, it is critical that existing data on the population dynamics of desert tortoises can be classified as trends or as stochastic fluctuations. Clearly, the severe droughts in 1989 and 1990 contributed to severe crashes in population sizes for many tortoise populations (Berry 1990, as amended). Droughts are stochastic events that will, of course, occur in the desert, and desert tortoise populations have a long history of recovering from the effects droughts. However, populations that have been fragmented into smaller units or with densities reduced by the effects of increased predation, human vandalism, or competition with grazers will have a lower probability of persistence in the face of these stochastic events.

Because of the difficulty of obtaining accurate population size estimates on these cryptic, semi-fossorial, and sparse animals, most data collected over the last 15 years on the dynamics of desert tortoise populations are insufficient to determine whether a population is stationary, fluctuating stochastically, or undergoing a population trend. However, the data from many samples may be statistically "blocked" according to similarities among sites in order to sort out possible trends and their causes.

Data collected by the Bureau of Land Management (Berry 1990, as amended) has been sorted into two categories: the Western Mojave, which includes areas that both do not normally receive summer rains and also have heavy human-induced mortality of tortoises, and the Eastern and Northeastern Mojave and Eastern and Northern Colorado areas which receive summer as well as winter rains and where relatively little mortality is directly attributable to humans. Our analysis indicates that areas receiving summer rains and are relatively free from human-induced mortality show no statistically significant population trend (Figure C4), whereas areas in the Western Mojave clearly show a downward trend in population size during the same time period (Figure C5).

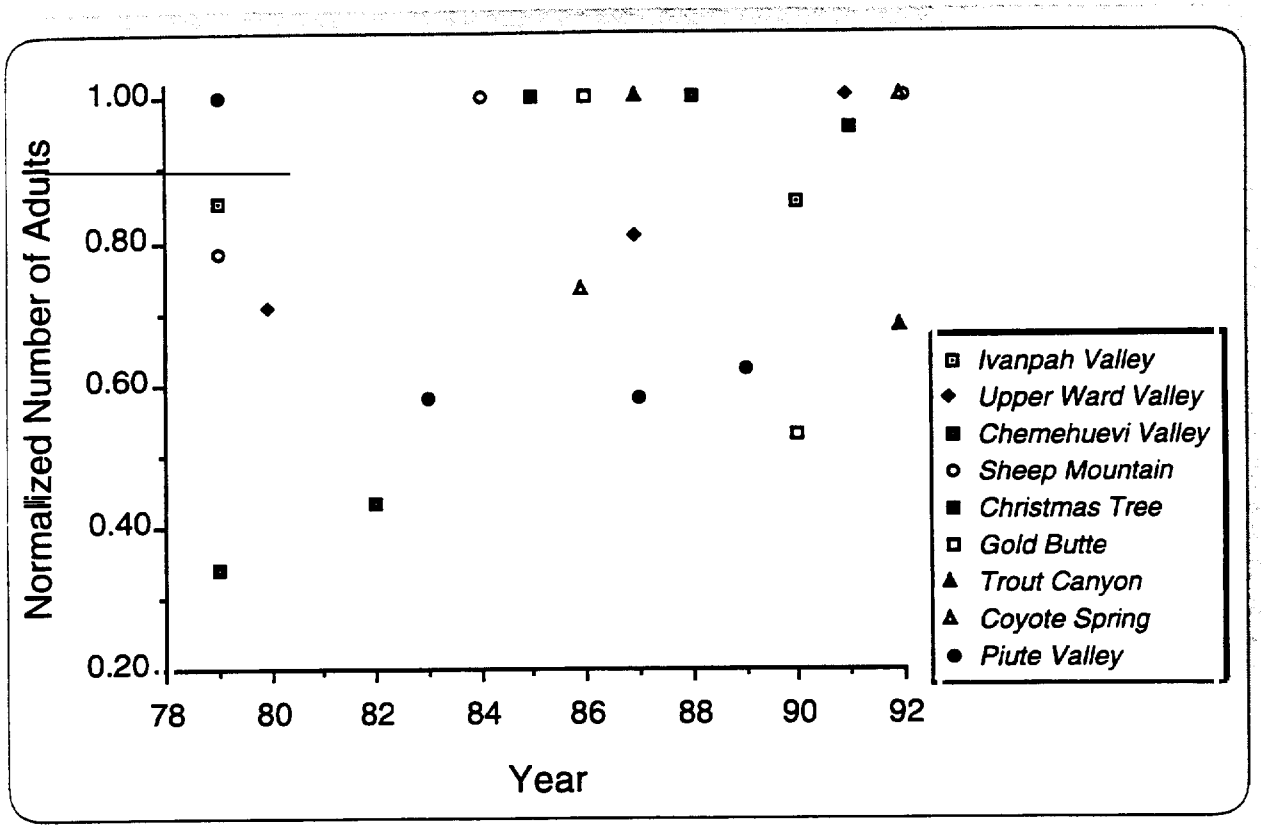


Figure C4. The number of adult desert tortoises found on BLM trend plots located in areas receiving summer rains and relative freedom from human-induced tortoise mortality. Only those trend plots sampled at least twice are included in the analysis. All data are normalized to the highest population size recorded within the years populations were monitored.

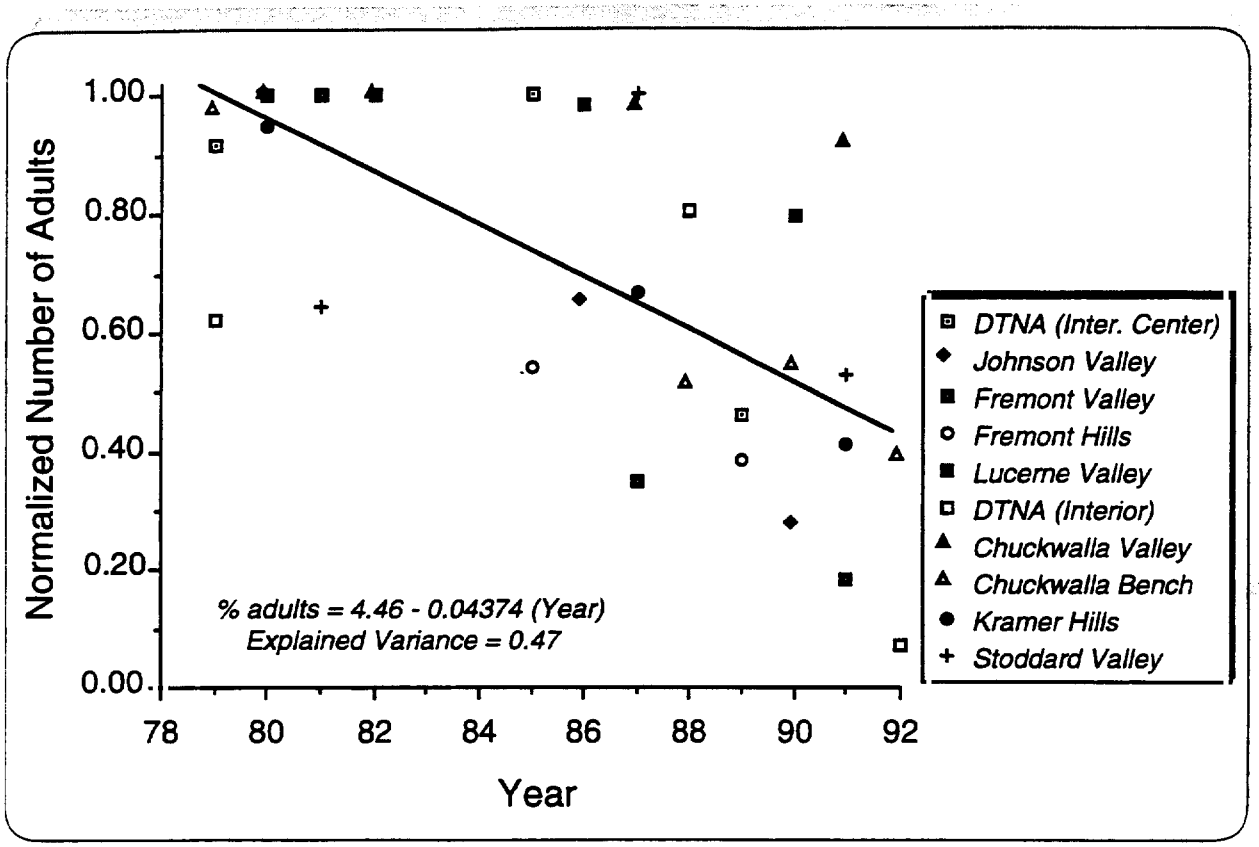


Figure C5. The number of adult desert tortoises found on BLM trend plots located in the Western Mojave. All data are normalized to the highest population size recorded within the years populations were monitored. The downward trend in population density is highly significant ($F_{1,14} = 28.4$, $p < 0.0001$).

This analysis emphasizes that management of tortoise populations requires recognition of two separate types of population change: population trends and stochastic fluctuations. Uncorrected downward trends are disastrous and must be corrected or else the population will go extinct. Stochastic fluctuations can be disastrous for small populations or populations that are frequently victims of stochastic increases in mortality. However, large, "healthy" desert tortoise populations should be able to withstand normal stochastic fluctuations with a reasonable probability of persistence.

This analysis also shows that several areas within the Mojave region are seriously impacted by human-induced mortality. Specifically, all of the sampled sites located close to BLM designated Off-Highway Vehicle Areas and/or towns have high levels of known direct human-induced tortoise mortality. These areas have significant downward trends in population sizes; thus, these trends can only result in extinction of desert tortoises unless their causes are mitigated. The actual mechanisms of these downward trends cannot be determined from this analysis, but in all the sampled areas there is evidence of high mortality caused by off-highway vehicles and guns. Additionally, it is likely that tortoises from these areas are taken as pets, and it is also likely that diseased tortoise pets are released into these areas. Thus, the ultimate cause of downward trends in desert tortoise populations is uncontrolled human disturbance.

Finally, this analysis leads to the conclusion that the Desert Wildlife Management Area concept is the logical means by which human activity can be controlled in desert tortoise habitat, and it is perhaps the only way to reverse downward population trends in desert tortoise populations.

IV. Population Viability Analysis

Background

Earlier reviews have discussed the reasons why populations become extinct (Shaffer 1981, Soulé 1980, Simberloff 1986, Gilpin and Soulé 1986). Four explanations are generally implicated in **conditions for extinction** (CFE). Three of the CFEs are can act very quickly within a generation or two, and the fourth can take many generations.

One of the proximate conditions of extinction is **Demographic Stochasticity**, problems caused by random demographic imbalances which can occur in small populations (Richter-Dyn and Goel 1972). These events include imbalances in sex ratios, birth or death rates, or age distributions. In very small populations males or females may have difficulty finding mates, most of the population

may be post- or pre-reproductive, etc. These "accidental" demographic imbalances can occur when a population becomes very small or very sparsely distributed, and all of them can result in extinction. Demographic stochasticity certainly could be a force in highly fragmented and diminished desert tortoise populations such as can be found in the Western Mojave and Beaver Dam Slope.

A second condition of extinction is **Social Dysfunction**. This can occur by many mechanisms, and it also occurs in very small populations. In some populations, mating only occurs when it is socially facilitated. This is especially true in some birds and mammals that form leks, colonies, or herds. The selective forces leading to vulnerability through social dysfunction has been discussed by Simberloff (1986). This CFE is not likely to be important for desert tortoises because this species is widely distributed and mating does not occur in groups. However, no data exist on the extent to which breeding behavior is socially facilitated in this species.

A third CFE comes from any of several possible **Extrinsic Forces**. Extrinsic forces generally occur when there exists temporal variation in abiotic, habitat, or biotic conditions with which the population cannot contend. These can include random abiotic catastrophes such as floods, droughts, and fires. They could include epizootics (such as URTD), or shifts in prey base of predators (such as ravens switching from road-killed jackrabbits to hatchling or yearling tortoises). Other forces could include anthropogenic changes in habitat such as urbanization, mining, road development, or livestock grazing. This CFE can affect populations that are large or dense, particularly when the frequency of "damaging" extrinsic forces increase to levels never encountered by a species during its evolutionary history. This CFE is probably the most important one with which desert tortoises must contend today.

The fourth CFE is **Genetic Deterioration**. Short-term genetic deterioration results from inbreeding depression and loss of genetic heterozygosity (Frankel and Soulé 1981, Rall and Ballou 1983). These factors can cause problems in individual fitness and in a population's ability to increase. A longer-term problem resulting from loss of genetic heterogeneity is that a population may be unable to adapt to a changing environment. Generally, genetic problems occur only in very small populations. Thus, they may be a problem for the highly diminished populations of desert tortoise in the Western Mojave and Beaver Dam Slope areas.

Prescriptions for abating loss of genetic diversity has led to the "50/500 rule" (Franklin 1980) which suggests that a **genetically effective population size** of at least 50 is needed to avoid the problems of inbreeding depression in the short term and that a **genetically effective population size** of at least 500 is needed to retain enough genetic heterogeneity for long-term evolution. However, the 50/500 rule has been criticized for a variety of reasons, and Dawson et al. (1986) have speculated that a genetic

population size of at least 1500 is needed for long-term persistence of vertebrate populations such as the northern spotted owl.

Characteristics Important in Defining Minimum Population Sizes

To ensure persistence of the desert tortoise in the Mojave region it is necessary to determine the conditions under which a population will remain viable. This is called a Population Viability Analysis (PVA). Population viability is very difficult to determine (Dawson et al. 1986) largely because a PVA requires data that are often not collected for rare and difficult-to-study species. Determining population viability for the desert tortoise is especially difficult since the species has a long generation time, a complex demography, and it is being assaulted by ecological factors to which it may not have been previously exposed during its evolutionary history.

Conservation biologists and managers must understand a number of terms, definitions, and standards before the implications of a PVA can be clearly understood (Gilpin and Soulé 1986). These are:

Time Frame .- Population viability must be defined for a specific time horizon; i.e., the probability of being extant T years from now. Time spans, T, of 100 or 200 years are commonly used. However, desert tortoises may live 80 years or more, and generation time is around 25 years. Thus, for this species, a time horizon of 500 years (or approximately 20 generations) into the future is a reasonable time frame for evaluating population persistence probabilities.

Population Size .- Early work on Population Viability (Franklin 1980, Shaffer 1981) postulated that extinction probabilities were a function of population size alone. Shaffer (1981), working with data from the Yellowstone National Park grizzly bear population, looked solely to demographic and environmental factors that influenced population fluctuations. On the other hand, Franklin (1980) focused on loss of genetic variation through genetic drift, a process whose rate is inversely proportional to population size. Even though both of these early efforts at population viability determination were monofactorial, both processes can be important and should be considered in a PVA.

Population Density .- Under some circumstances, population dynamics may depend upon density of individuals per unit area rather than the total population number remaining in the region. For example, finding a mate becomes problematical in very sparse populations because few animals of the right sex are encountered.

Spatial Fragmentation .- In situations where a population is divided into a set of loosely-coupled spatial units exchanging a few animals per year, the configuration of these units in two-dimensional space may be more important than total population size. Thus, a system of small local populations, each of which is nonviable by itself, can nonetheless form a viable system if connectivity is

sufficient so that local populations that go extinct can be recolonized from other local populations in the system.

Deterministic vs. Stochastic Factors. - A population that has, on average, negative population growth is doomed to extinction. The time to extinction is straightforwardly calculated from the exponential growth equation, $dN/dt = rN$. If r is the negative per-year population change, then the time to extinction, T_{ext}, is

$$T_{ext} = \log(N/2)/r,$$

where N is the current (i.e., initial) population size. Suppose, for example, that a population of 25,000 is decreasing at 10% per year, as is the case for several local populations of the desert tortoise. The expected time to extinction is easily calculated--95 years. A doubling of N produces only a small increase in time to extinction. If N were 50,000, then the time to extinction is only increased to 102 years, hardly any gain at all. The following graph shows T_{ext} for some other negative growth rates:

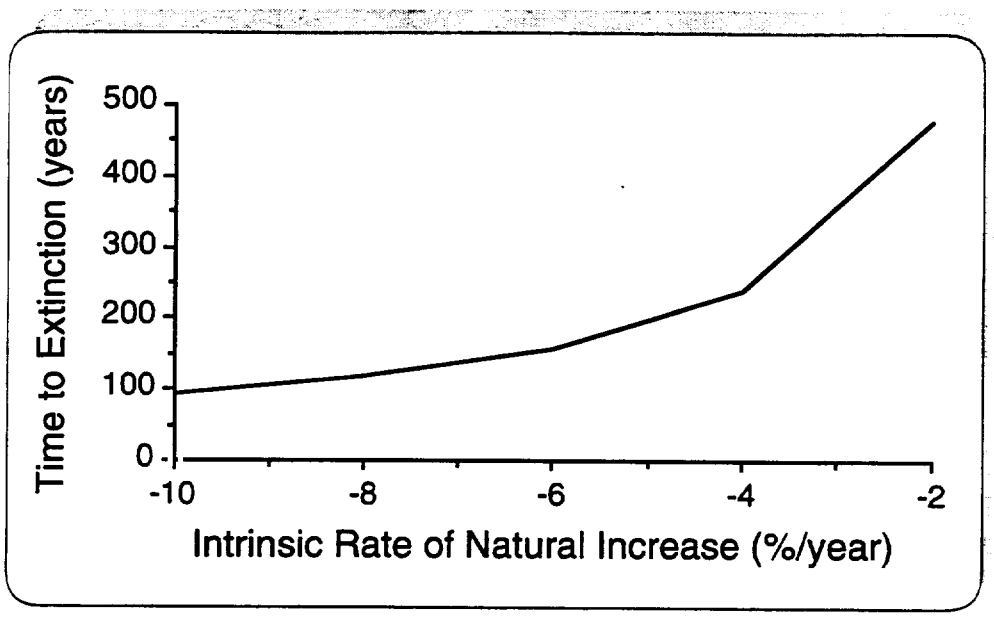


Figure C6. Time to extinctions for a population of 25,000 animals as a function of the intrinsic rate of natural increase expressed as percent decline per year.

Clearly, managers must be able to alleviate detrimental impacts on a population so that the expected growth is at least zero. At zero the population will stay constant in total size. However, even with such management, there will still be random forces that impel a population both up and down. These are the stochastic factors discussed in Section 3 of this appendix. There is often a threshold in total population size, density, or spatial arrangement below which these stochastic factors can result in a high probability of extinction within a given time period. A PVA may be able to predict this threshold--the minimum viable population.

Catastrophes. - A catastrophe is an extreme event which, by itself, can result in population extinction. Fires, floods, and epizootics are commonly cited catastrophes. In general, catastrophes are rare events whose probabilities are hard to estimate, and because of the difficulty they are typically handled in ad hoc fashion outside of a formal PVA. The Upper Respiratory Tract Disease (URTD) is a possible catastrophe threatening desert tortoises. However, its rate of spread and potential ultimate impact have not yet been estimated by epidemiological models.

The only protection against catastrophes is to have redundancy built into the management system--several widely-spaced populations would not likely be struck by the same catastrophic event at the same time. For threats such as drought or flooding, local populations would have to be distributed over a region that is large compared to the total spatial scale of catastrophes. Since the epidemiology of URTD is not yet understood, managing this epizootic is extremely problematic.

Desert Tortoise Genetics.

A comprehensive PVA requires considering population genetics--including loss of heterozygosity, inbreeding depression, outbreeding depression, long-term loss of adaptability, pedigrees, paternities, population structure, etc. However, most PVAs involve much smaller total populations (Table C1) than currently exist for the desert tortoise (although population density must be considered vis-a-vis short-term genetic deterioration as well).

Table C1. The number of individuals modeled in PVAs for endangered species.

Species	Number of Individuals
Blackfooted Ferrets	6
California Condors	28
Whooping Cranes	50
Yellowstone Grizzlies	200
Northern Spotted Owls	2000

Most desert tortoise populations are probably still larger than even the largest of these above-cited cases (although some populations may have become this small by the time the recovery plan is implemented). Furthermore, the generation time of the desert tortoise is long, at least 25 years, which slows genetic deterioration in calendar time. Beyond this, the current information about the genetics of the desert tortoise is extremely scant. All of these facts suggest that genetic considerations will be secondary to other problems threatening the desert tortoise with extinction--at least for the time being.

Nevertheless, genetical considerations are important in reserve design. DWMAs must support a tortoise population with a large enough genetically effective population size to maintain sufficient genetic diversity for long-term persistence. Genetically effective population, N_e, is usually between 0.1 and 0.5 of the total adult population size, N, in vertebrates (Ryman et al. 1981, Shull and Tipton 1987). Details of desert tortoise life history suggests that the N_e/N ratio will be at the low end of this range--certainly no larger than 0.1, particularly in populations of low densities. If we assume that a genetic population size of at least 500 is necessary to maintain the genetic diversity required for long-term evolutionary potential, DWMAs should contain no fewer than 5,000 adult tortoises.

V. *Home Range and Movements*

If we know the amount of area that a tortoise occupies, we can determine the probability that individuals will encounter one another for mating. If there is a diminished probability of encounter between males and females, then population growth will be impeded by stochastic demographic forces discussed in Section IV of this appendix. Thus, knowledge of home range size is critical for determining a minimum viable population *density* for desert tortoises.

Estimates of the home range sizes of desert tortoises are necessarily constrained by inadequate data. In particular, desert tortoises may live in excess of 50 years, and thus, data on the normal lifetime movements of desert tortoises simply do not exist for logistic reasons. Indeed, the difficulty of working with desert tortoises has resulted in estimates of home range size that are seriously in error. Although estimated home range sizes of desert tortoises have been summarized recently (Berry 1986b), most of these estimates are based upon very small sample sizes or questionable methods (Table C2). Small sample sizes tend to produce estimates that underestimate actual habitat use. On the other hand, many of the statistical estimates of home range size assume that tortoises use their habitat as "central-place foragers" resulting in a distribution of habitat use that is spatially Gaussian (see Turner et al. 1981). This

assumption of spatial normality tends to inflate estimates of home range size.

In spite of these problems, these data can produce insights into home range size in desert tortoises. First, some of these estimates can be used as an index of habitat use without claiming that these estimates are seasonal, annual, or lifetime home ranges of tortoises. If this is done, females seem to have habitat-use indices that are approximately 58 % (ranging from 40 to 73 %) of the indices of males. Thus, it would appear that habitat requirements of male tortoises are different from those of females. Data on habitat use by two populations of desert tortoises have been collected by Esque et al. (in prep.) who have monitored populations from sites in Utah and Arizona for three years. Their preliminary data show that estimates of home range size increase continually with the number of relocations of tortoises over time (Figure C7).

Table C2. Home range estimates (ha) for desert tortoises from six sites (after Berry 1986)

Location	Males	Females	All	Source
Argus, California	53 (39 -77)	21 (4 - 46)		Berry 1974
Ivanpah Valley, California			22 (3 -89)	Turner et al. 1981
			19 (2 - 73)	Medica et al 1982
Arden, Nevada	26 (20 - 38)	19 (11 - 27)		Burge 1977
Picacho, Arizona			-- (0.3 - 268)	J. Schwartzmann unpublished data
	26 (4 - 33)	15 (2 - 34)		Vaughan 1984
Beaver Dam Slope, Arizona	23 (5 - 59)	15 (2 - 34)		Hohman and Ohmart 1980
Beaver Dam Slope, Utah			-- (4 - 40)	Woodbury and Hardy 1948

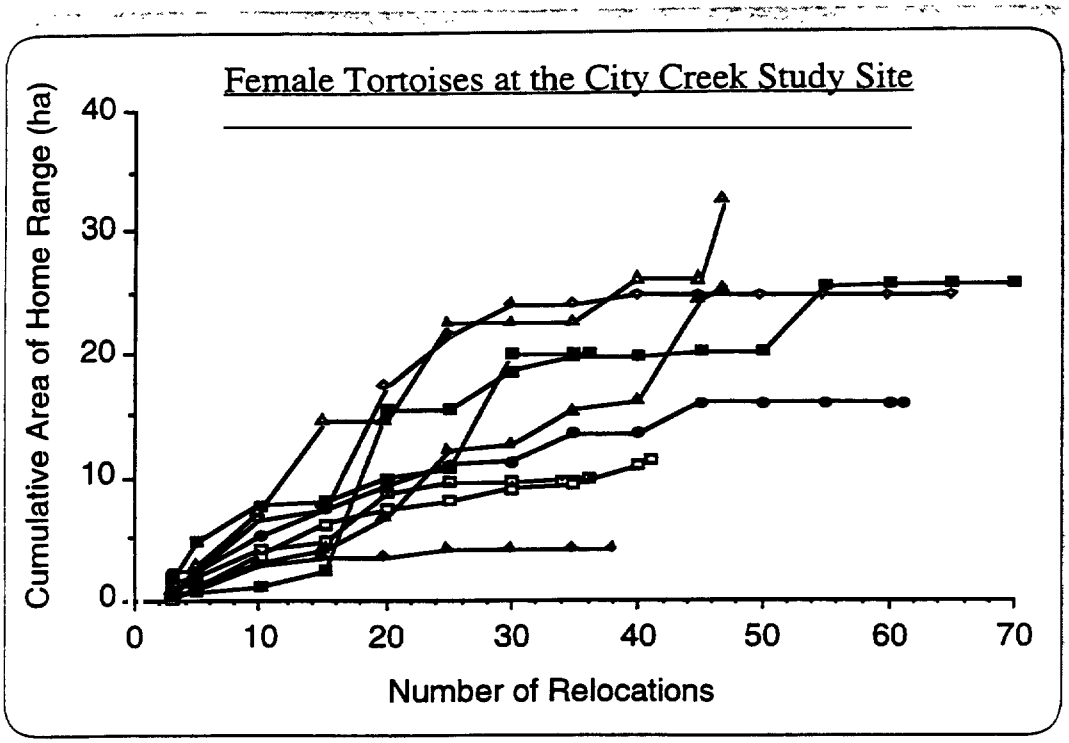


Figure C7. Cumulative estimate of home range size of adult female desert tortoises as a function of the number of relocations of each tortoise (Esque et al. in prep.). Relocations were separated in time by at least two days, and most relocations were spaced evenly over the activity season of the tortoises over a period of three years. Home range sizes were determined by the minimum convex polygon method.

This occurs for two reasons. First, the estimate depends upon the amount of data comprising the estimate. Too few data points will lead to an underestimation of the actual use of the habitat. Second, tortoises never occupy the same exact area of habitat from year to year, so that as more and more data are collected, the resulting estimate of home range size becomes larger and larger (Figure C8). It follows that to determine the lifetime home range size of desert tortoises, data would be needed on movements of tortoises over a period of at least 50 years. Clearly, this is not yet feasible, but the preliminary data may allow a reasonable estimate. Home range sizes appear to vary with site and among different years. However, in a data set covering four sites across most of the Mojave, and covering three years, the effect of site on home range size disappears ($F_{1,68}$ = 0.005, p = .94) when the effect of food availability (measured as production of spring annual plants, $F_{1,68}$ = 15.3, p = .0002) is entered into a statistical model (Figure C8). Furthermore, when both sexes of tortoises are considered at all sites, it is clear that home

range size is strongly predicted by food availability (Figure C9). When food becomes scarce, home range sizes become larger. However, when annual plant production exceeds approximately 30 kg dry mass/ha, home range sizes for both sexes appear to remain constant at a relatively small size. When each gender of tortoise is considered separately, it appears that female tortoises maintain approximately the same size home range regardless of site or food production at that site (Figure C10). However, male tortoises greatly increase their home range sizes in response to low food availability (Figure C10).

Many tortoises appear "to anchor" their annual movements to an overwintering site that may be used repeatedly in many seasons (Figure C11). This fidelity to an overwintering cave or burrow has also been seen by C. C. Peterson (unpublished data) at The Desert Tortoise Natural Area in the eastern Mojave and at Ivanpah Valley in the western Mojave of California. This does not mean that all tortoises invariably return to the same winter cave or burrow, but rather that fidelity to a well-developed cave or burrow appears to be fairly common. If a tortoise does indeed anchor its use of the habitat to an overwintering cave or burrow to which it remains faithful for many years, then it can be assumed that over its lifetime a tortoise would range in all directions from the overwintering site at distances similar to those seen in any one year. Thus, a circle can be drawn with the overwintering burrow as the center and the radius being the furthest point from the overwintering burrow. The resulting area is the estimated lifetime home range of the tortoise (Figure C12). From this analysis, the estimated lifetime home range for the City Creek tortoise ranging furthest in the three year study (female # 11.0 in Figure C11) is 180 hectares or about 0.7 square mile. The average estimate for all tortoises at City Creek is 97 ha (ranging from 38 to 180 ha).

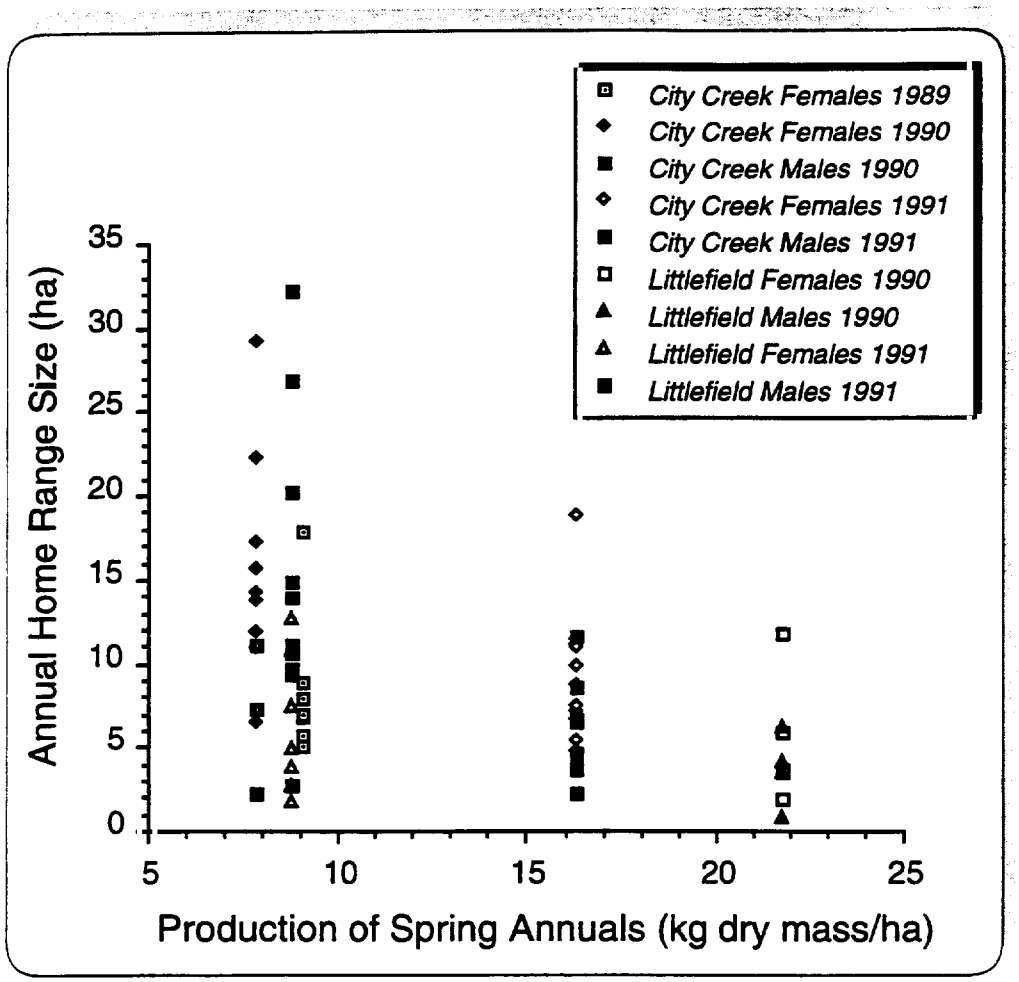


Figure C8. Annual home range sizes of tortoises at the City Creek and Littlefield Study Sites.

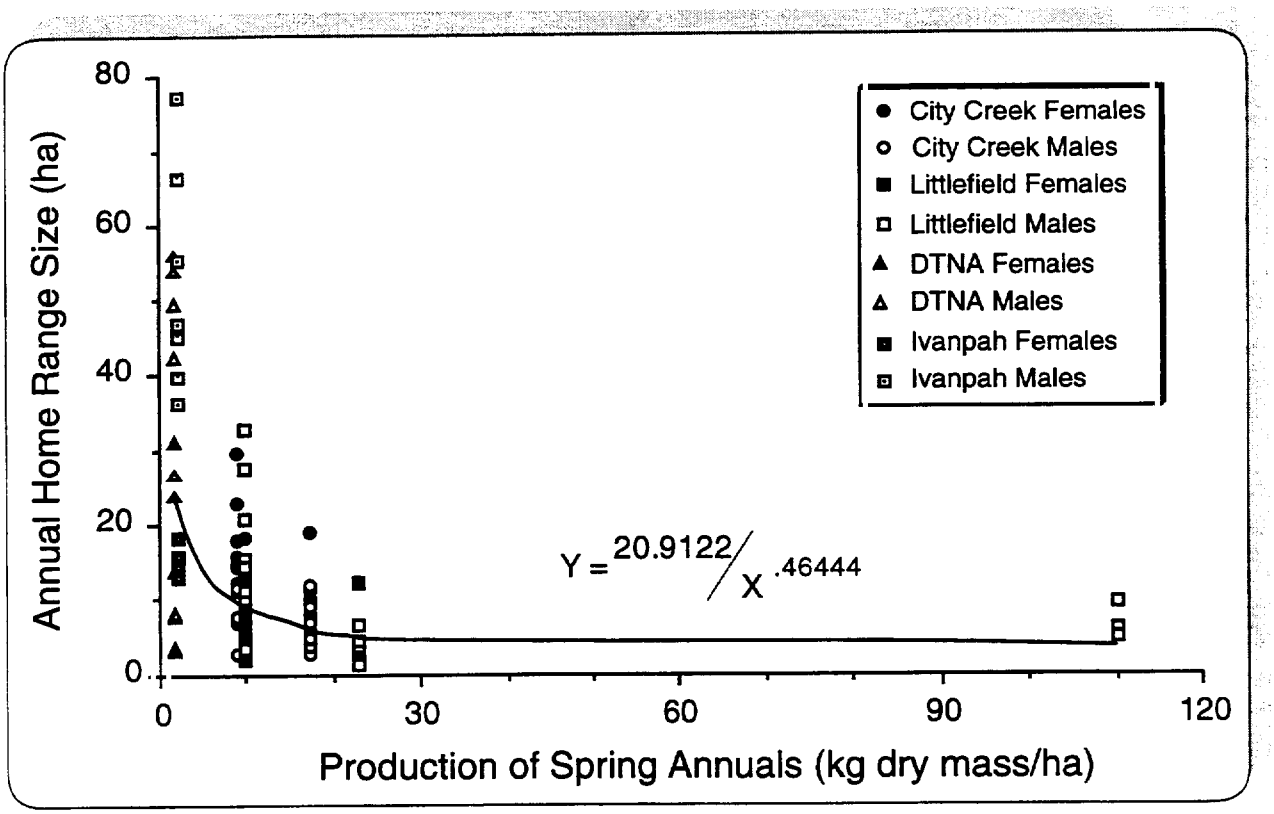


Figure C9. Annual home range sizes of desert tortoises at four sites in the Mojave Desert during the period of 1988 to 1991.

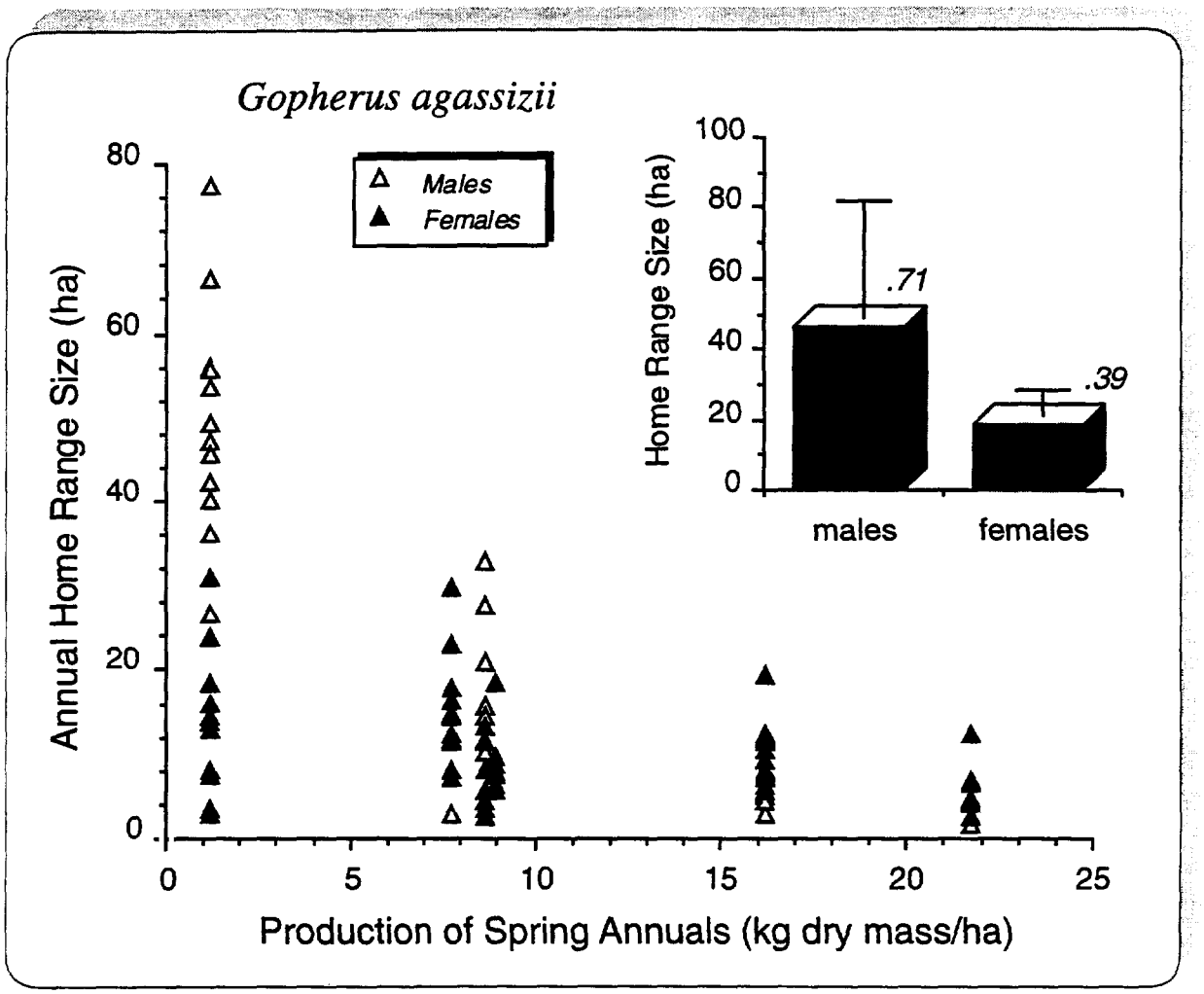


Figure C10. Annual home range sizes of desert tortoises at four sites in the Mojave Desert.

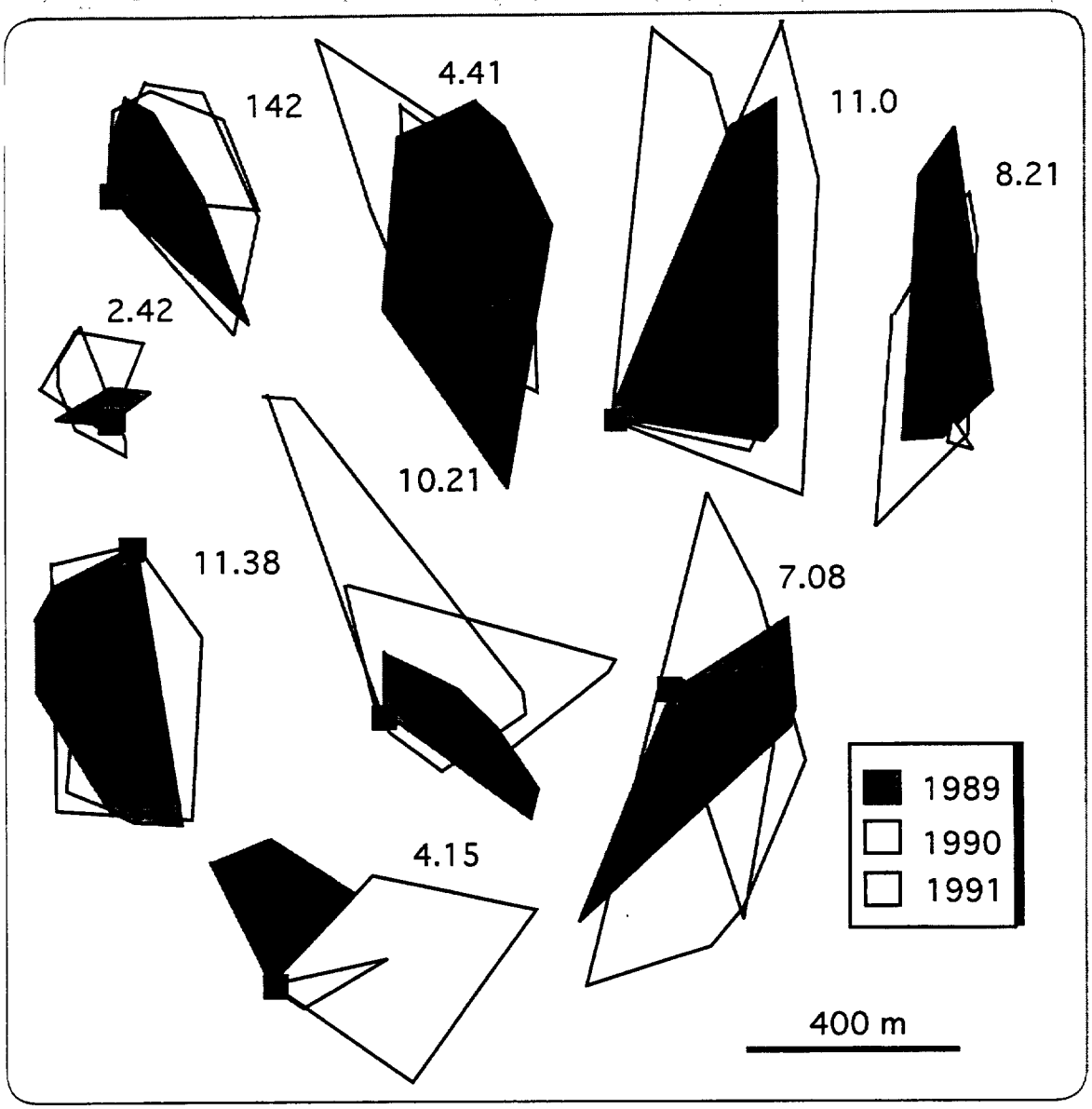


Figure C11. Home ranges estimated from the minimum convex polygons of relocations of nine adult female tortoises from the City Creek Study Site, St. George, Utah. Polygons were generated from 38-70 relocations (see Fig. 7) over a three-year period from 1989 to 1991. Relocations were evenly spaced over the activity seasons of each year. In most cases an overwintering cave was identified (black square), and in all of these cases, the overwintering cave was used repeatedly over the three-year period.

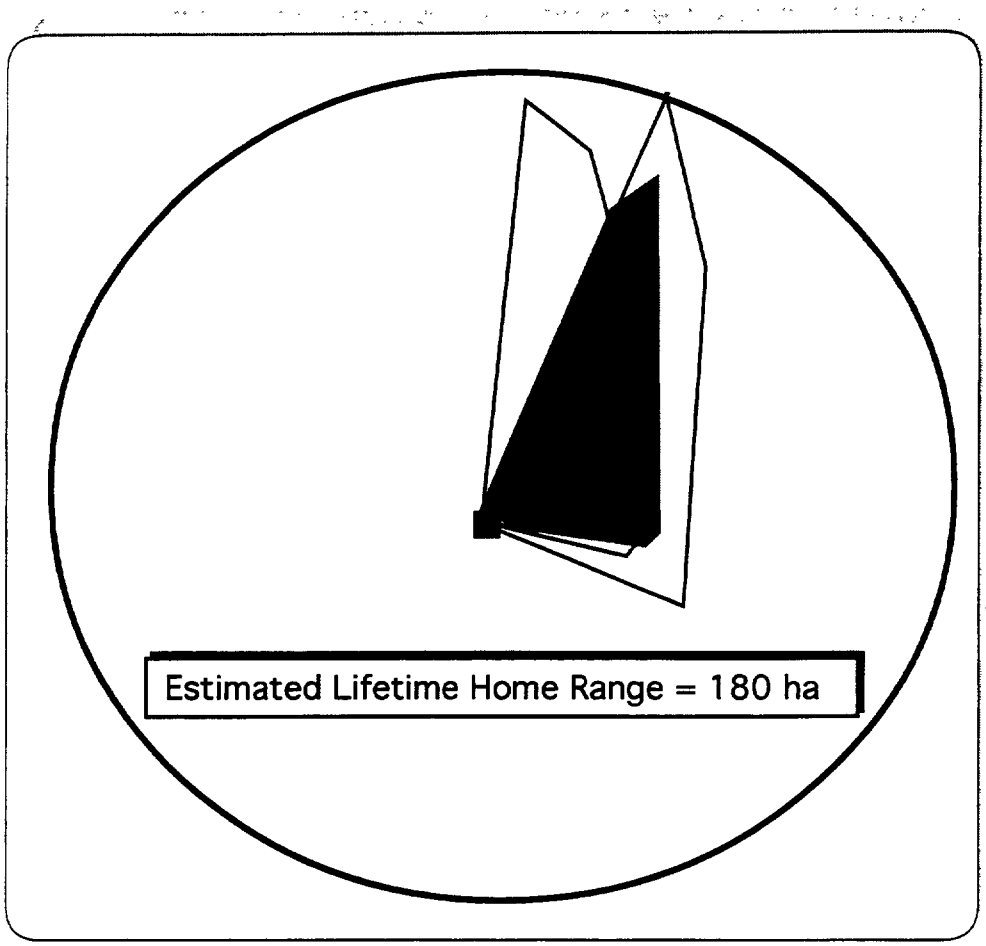


Figure C12. Estimated maximum lifetime home range of adult female tortoises at the City Creek Study Site, St. George, Utah.

Because these estimates are for females, and because females have home ranges that are about half that of males, it can be assumed that the lifetime home range of adult males may be twice these sizes, or about 194 ha (ranging up to 360 ha or about 1.5 square miles).

Even these estimates of lifetime home range size could substantially underestimate the habitat use of a tortoise that lives to a very old age. For example, tortoises are known to take lengthy forays from their home ranges and then return. Both male and female tortoises have been observed to make very long-distance forays (Figure C13). For example, at the DTNA Site, one female tortoise moved more than 8 km from its hibernation burrow over a period of between 11 and 58 days (the telemetry signal from the tortoise could not be found

during a sample 11 days after a previous sample, and the tortoise was not relocated until 58 days after its previous relocation). Two of four tortoises known to make long forays were found dead within three months of the initiation of the foray. One of those two tortoises was the first desert tortoise in nature to be observed with Upper Respiratory Tract Disease. Of the two tortoises that lived after having made a long-distance foray, one moved from a small area of activity (less than 10 ha) to another similar-sized area more than 2 km distant. This tortoise never returned to the area in which it was originally observed. The other tortoise was repeatedly relocated in an area totaling 38 ha before it made a foray of approximately 4km.

From these estimates of home range sizes of adult tortoises, we can estimate the minimum viable density of tortoise populations. Because we have very few data on mate-finding strategies in this species, this estimate is necessarily crude. Refinements, however, require considerable additional data.

Male and female tortoises have home ranges that are dynamic from year to year and from place to place. During years in which food resources are sparse, male tortoises expand their home ranges considerably, and female tortoises somewhat less (Figure C10). Averaging across several studies, male home ranges have been shown to expand to approximately 50 hectares, with considerable variability around the average, when food resources are scarce. Thus, in years when average home ranges are very large, approximately 5 male tortoises can "fit" into a square mile with no overlap of their annual home ranges. (This assumes that tortoises are "overdispersed," which may or may not be true.) At this density, males moving about as they have been seen to do in years when home ranges are very large, would theoretically patrol all of their habitat. Fewer than five males would result in some parts of this theoretical square mile not being patrolled, and females in the unpatrolled parts would not come into contact with males every year. Assuming that the population is 50% females, then the "minimum contact density" which would guarantee that all females would be mated every year is 10 adult animals per square mile, or higher if the population had more females than males.

This reasoning suggests that the minimum viable density of tortoise populations--the density below which the potential for population growth is diminished due to stochastic demographic forces--is about 10 adults per square mile. Thus, a DWMA has to be large enough to hold some predetermined number of tortoises at a density of no less than this.

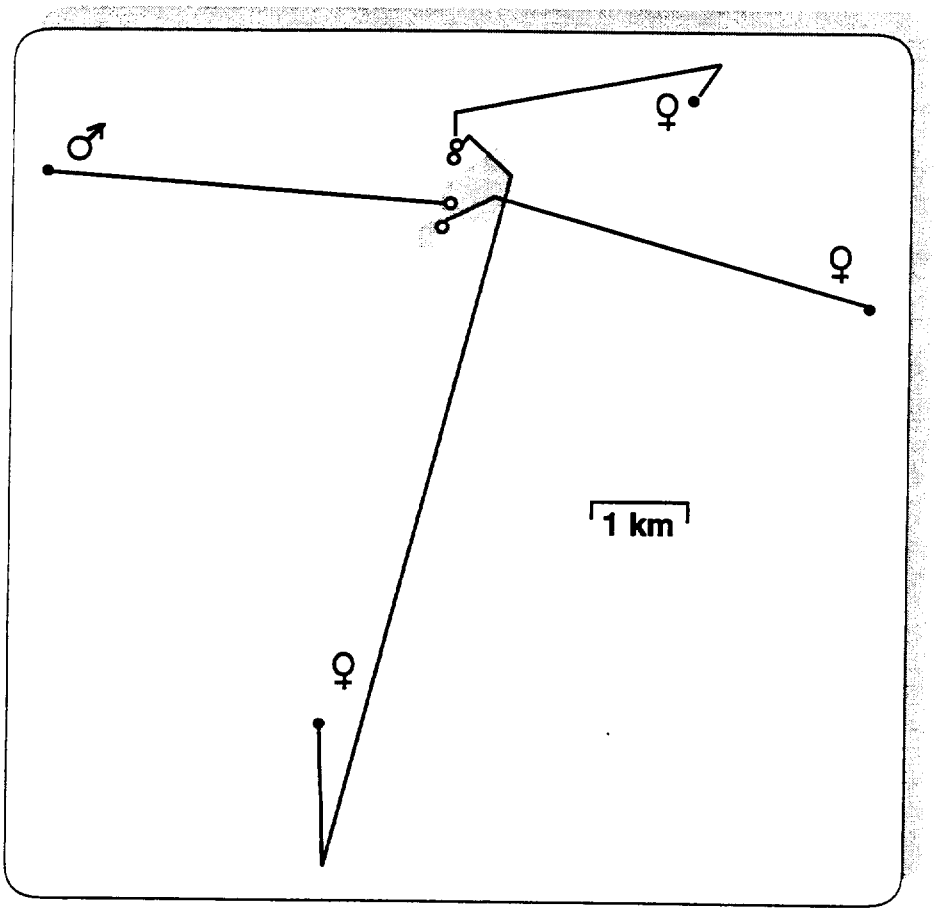


Figure C13. Long-range movements of tortoises at the DTNA site.

VI. Desert Tortoise Demography

Tortoise demography is complex but the overall features are well known. There is a long prereproductive period and females first reproduce at ages between 12 and 25 years (Turner et al. 1984) with animal size bing more important than age in determining vital rates. As a general rule-of-thumb, 185 mm is the carapace length for first reproduction. There seems to be no senescence; adults die off at a slow rate and may live for more than 80 years. Adults continue to reproduce throughout their lives. In general, females reproduce in most years and may have two clutches per year. The survival of juveniles is very low and probably varies from year to year.

Because of limited data on the demographic processes and parameters for desert tortoise, modeling of desert tortoise population dynamics is difficult and not independent of modeling assumptions. Thus, three separate modeling exercises were conducted to assess extinction probabilities in desert tortoises. These three exercises were conducted at different times during the production of the Recovery Plan. Thus, some had the benefit of more recent data. The first of the analyses, the Gilpin analysis, is the richest with respect to the diversity of questions asked of the models. The second, the Tracy analysis, partitioned the variance in the empirical data upon which the modeling is based into its different components. The third, the Peacock model, was done as a check on both of the previous modeling exercises by using a commercially available demographic program.

A. The Gilpin Model

A Projection Model. The data for this analysis come from the work of Turner et al. (1987) on a population near Goffs, California. From these data, it is straightforward to construct an age or stage projection matrix (Biehl and Gilpin 1990). A stage-structured matrix was constructed by collapsing Turner et al.'s (1987) more finely resolved data:

Stage 1 = hatchlings
Stage 2 = 1-5 years old
Stage 3 = 6-10 years old
Stage 4 = Subadults
Stage 5 = Adults

These correspond to a five element column vector. The output from one run of the program is:

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
.000	.000	.000	.000	6.200
.620	.706	.000	.000	.000
.000	.093	.802	.000	.000
.000	.000	.031	.719	.000
.000	.000	.000	.111	.937

Stage 1 had 23.4485% of the individuals.
Stage 2 had 48.3691% of the individuals.
Stage 3 had 21.9897% of the individuals.
Stage 4 had 2.38581% of the individuals.
Stage 5 had 3.80685% of the individuals.

Stage 1 Reproductive value = 1
Stage 2 Reproductive value = 1.62349
Stage 3 Reproductive value = 5.24694
Stage 4 Reproductive value = 34.402
Stage 5 Reproductive value = 89.1427

This output is for a single run of the model. Each of the parameters in the transition matrix has some uncertainties associated with it; thus, a sensitivity analysis was done on the matrix before any conclusions were drawn from the model. These conclusions are given in the following sections.

The per year growth rate of desert tortoises is low. The Turner et al. (1987) study found only 2% per year. If this rate is a maximum that is generally true for all populations, desert tortoises have low resistance to negative deterministic impacts (harvesting by humans, predation, disease, kills by motor vehicles, competitive interactions from livestock, etc.) to the population. Figure C14 illustrates this schematically.

Because of the extremely long prereproductive period (to an age as great as 25 years), the reproductive values of desert tortoises vary greatly. Figure C15 shows the reproductive values versus age for the Turner et al. (1987) desert tortoise data.

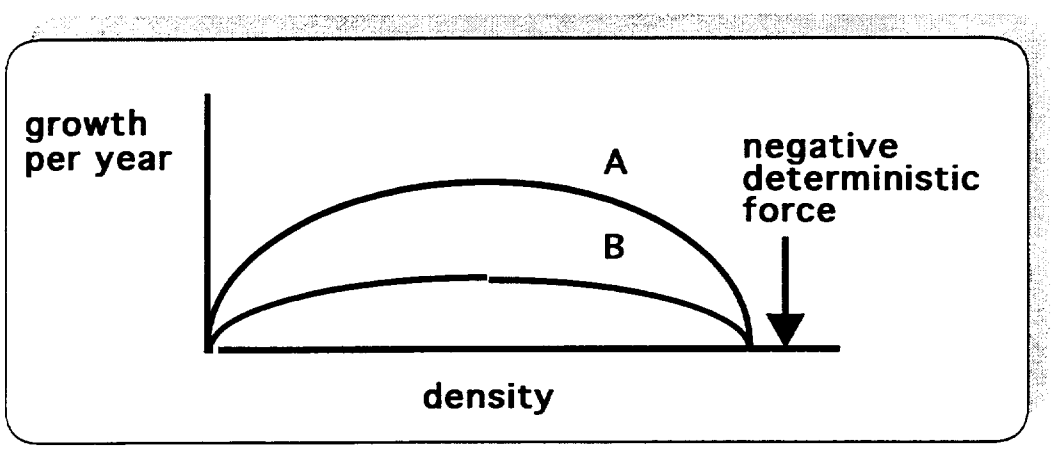


Figure C14. Two population growth curves. Both A and B have the same carrying capacity (the rightmost point on the abscissa where the growth curves intersect). Curve A has a higher intrinsic rate of increase. If a deterministic force indicated by the downward arrow at the right of the figure impacts the population, the population following curve A could adjust to a lower equilibrium density and could persist. Curve B, however, has too low a rate of increase and would be overwhelmed by the negative deterministic force and the population would go extinct.

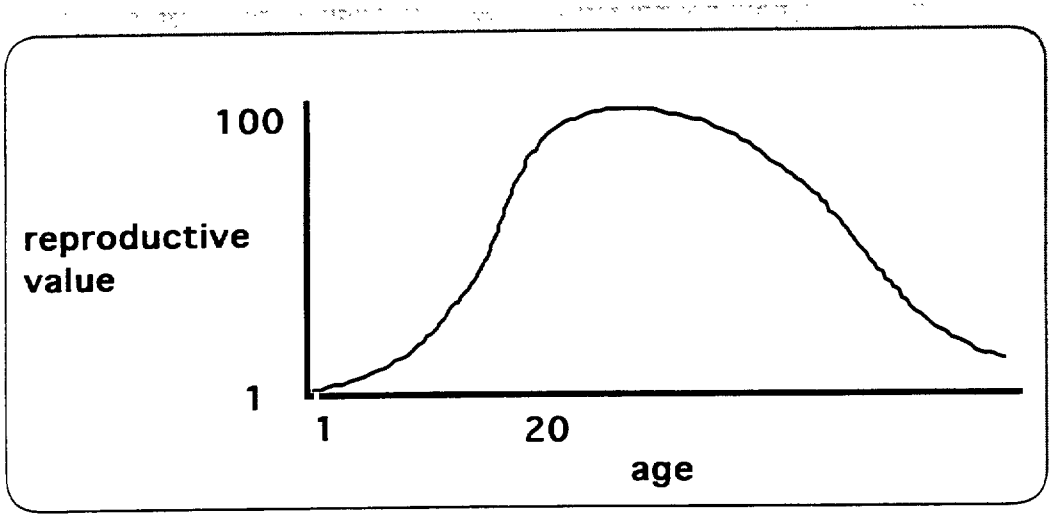


Figure C15. Reproductive values.

One consequence of this is that introductions of desert tortoises to empty habitat should best be accomplished with the addition of high reproductive value individuals; i.e., young adults. Of course, this mathematical result is consistent with common sense.

The age and size structure of a population of desert tortoises is very slow to return to the stable distribution following a perturbation. This is much like the human population, where, for example, in the United States the consequences of the baby boom will be felt for a century. An out-of-equilibrium age/size distribution could have implications for desert tortoise social structure. Figure C16 shows one simulation of age-structured growth that begins from a disturbed (non-steady) state. Note that the initial oscillations have a period of about 14 years. This implies that any trend analysis for less than 14 years could give very misleading projections.

Density dependence.- Nothing is known about the mechanism of density dependent population regulation in the desert tortoise. That is, what sets a carrying capacity, K? Is K ever reached? If so, what determines K - food resources, soil available for burrows? There is some suggestion that maximum densities of desert tortoises are set by levels of primary productivity (See Appendix G). Other relevant questions include: Are tortoise densities held down by predation? Is there social regulation of population density?

Demography and deterministic population regulation is an area that needs further research and study. These processes may vary over the range of the desert tortoise, and applications of details from the Goffs study to desert tortoise populations in the far western Mojave or to northern populations in

Nevada and Utah, may be inappropriate. However, the general character of desert tortoise demography as revealed by the Goffs study is probably valid throughout the range.

Variable Growth Rates of Desert Tortoises (Environmental Stochasticity). Growth rates for desert tortoise populations are variable from time period to time period and from one local population to the next local population. With variable growth rates comes the possibility of stochastic extinction: the population will have a run of bad luck and its density will drop below the threshold of extinction. This is environmental stochasticity.

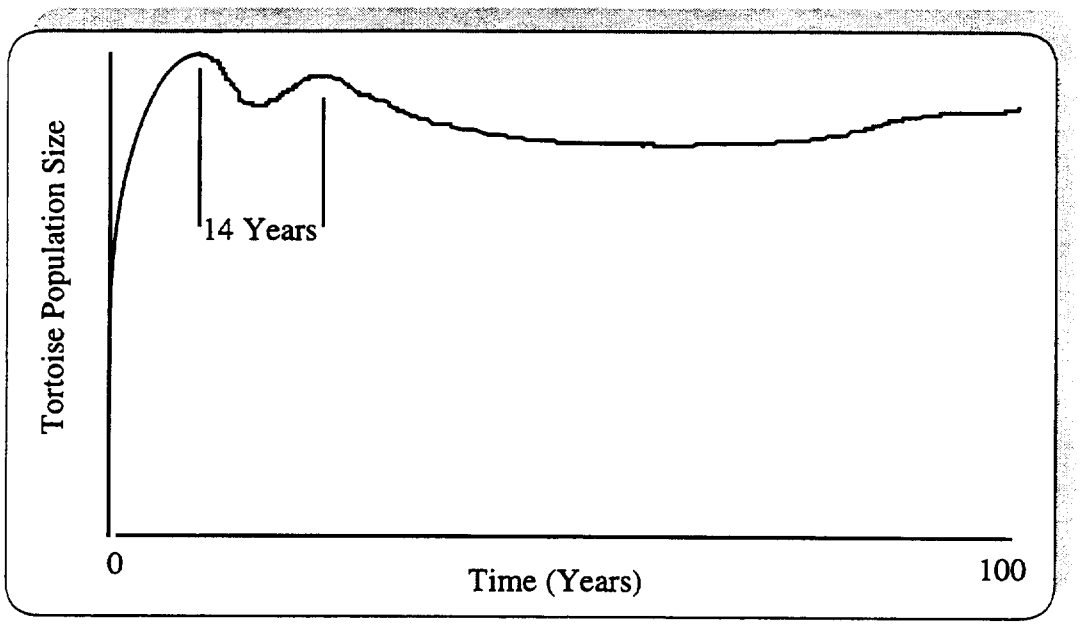


Figure C16. A projection of age structured growth for a desert tortoise population.

A simple discrete equation for stochastic growth is:

$$N_{t+1} = \{\text{lambda}\}\, N_t \qquad \text{if} \qquad N <= K$$
$$N_{t+1} = 1 \qquad \text{if} \qquad N > K$$

where N_t is the current population size and where N_{t+1} is the size of the next time period, and where {lambda} represents a random variable for discrete growth described below. If the current population is above K, the carrying capacity, the population size drops to K the next year. But if the population is below K, the new population size is determined by drawing a discrete growth rate, lambda, from a probability distribution with a known mean and variance. In most explorations of this model, it is assumed that the mean lambda is greater than 1, which corresponds to an r of greater than 0. The relationship between r and lambda is:

$$\rho = \log_e (\text{lambda}).$$

In more sophisticated models (e. g., Goodman 1987), the mean and variance of the distribution of lambda values may change with the size of the population; that is they may be functions of N. For populations in natural environments, it is almost impossible to determine the relationship of mean and variance of lambda to N, if for no other reason than the problem of obtaining a sufficiently large sample size. Thus, it will not always be the case that the variation of population growth will be modeled as independent of N.

Data for this model came from desert tortoise populations that had been sampled at 13 locations throughout the Mojave desert (Berry 1990, as amended, Nevada Department of Wildlife 1990; SWCA, Inc. 1990):

California:	Chemehuevi
	Chuckwalla Bench
	Goffs
	Ivanpah valley
	Upper Ward Valley
	Desert Tortoise Natural Area
	Fremont Valley
	Johnson Valley
	Kramer Hills
	Lucerne Valley
	Stoddard Valley
Nevada:	Piute Valley
Arizona:	Littlefield

Samples of adult desert tortoises were taken at these study locations at various years. From these samples, the discrete growth rate

lambdas can be computed. These lambdas are based on per year growth intervals. For samples on two successive years, the lambda is given by:

lambda = final_sample/initial_sample.

If the period is more than 1 year, the relationship is

lambda=(final_sample/initial_sample)^(1/no_of_years).

where the "^" sign indicates exponentiation. From these study locations, some of which had more than two samples, 27 different values of lambda can be determined, which define a probability distribution. The mean lambda is .985, with a standard deviation of 0.08. The probability distribution of lambdas is shown in Figure C17.

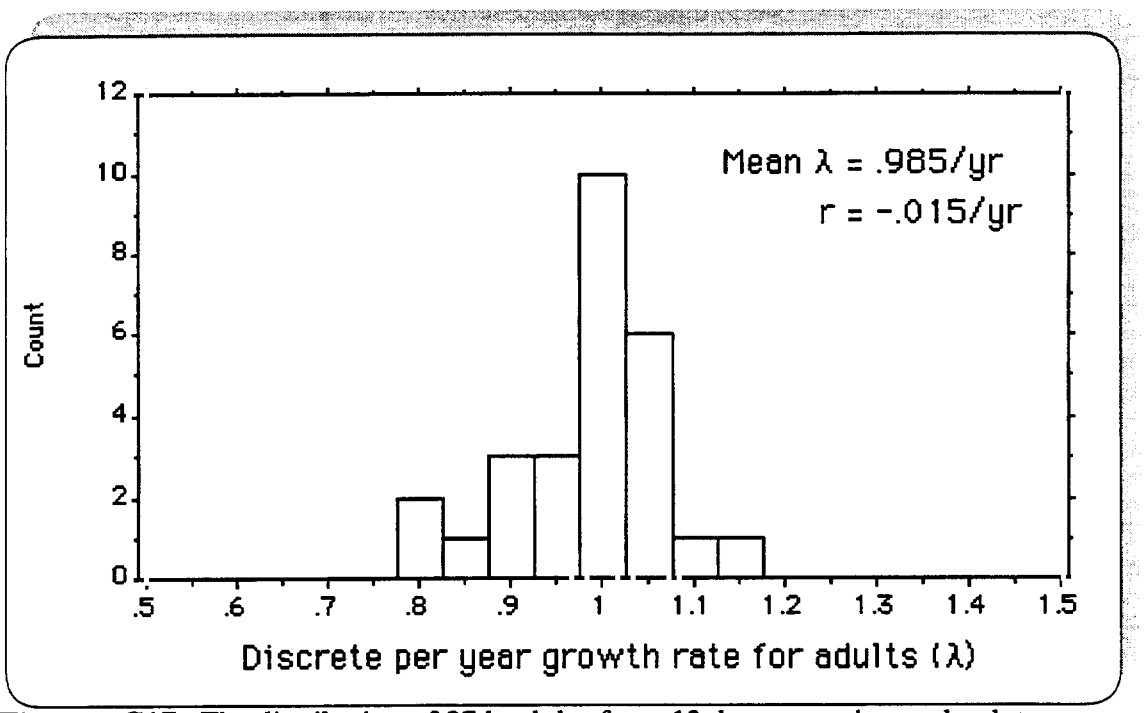


Figure C17. The distribution of 27 lambdas from 13 desert tortoise study plots.

The lowest lambda is 0.8 and the highest is 1.15. These correspond to per year changes of roughly -20% and +15%, with a mean of -1.5%/year. That the average growth rate from these sites is -1.5% does not mean that the entire desert tortoise population is only shrinking at this rate, for these study populations represent for the most part local populations in the centers of good habitat. The entire species population of desert tortoises could simultaneously be shrinking in its spatial extent, and this would not be represented in these figures. Furthermore, these are pre-URTD studies. Adult dieoff accelerates by as much as an order of magnitude not long after URTD is first identified in these populations. Also, the extreme growth rates of -20% and +15% probably correspond to cases where the age structure of the population is badly out of stable age distribution (see below), or where there is some form of animal movement into or out of the local population.

Nonetheless, the variance in lambda values possibly represents the variance that would be present in reserve systems with protected boundaries and which were free of URTD. Thus, these are good numbers to use in a first-pass simulation study of local extinction of desert tortoise populations on reserves. They may set one kind of lower limit to the scale of reserve units, suggesting that anything smaller is certain to be inadequate. They may also be a best-case scenario insofar as the consequences of disease are not reflected in the data.

To model time to extinction, N_{t+1} is calculated using the empirical distribution of lambdas in Figure C18. The first simulation assumed an initial N of 20,000 adult desert tortoises at equilibrium (i.e., K is the same value). An extinction threshold is taken as 2 individuals. The distribution of times (in years) to extinction is given in Figure C18.

From Table C3 it can be seen that, among other things, 90% of the populations will survive at least 350 years, and that the mean time to extinction is 505 years, with a standard deviation of 115 years.

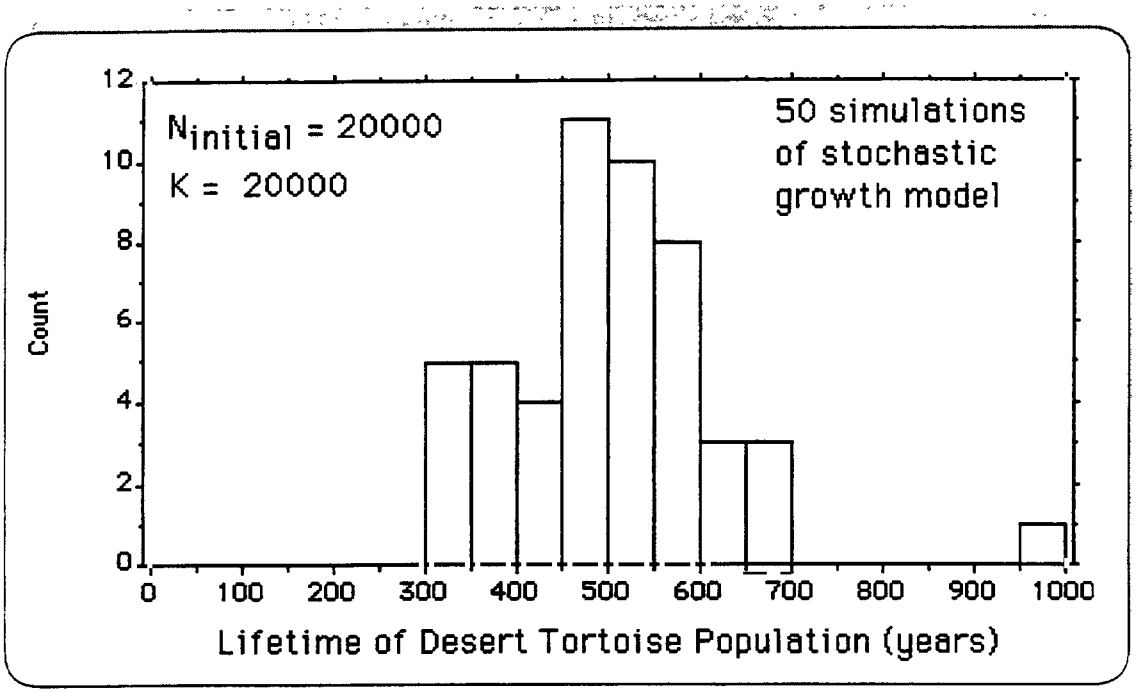


Figure C18. Time to extinction based on current best estimates of stochastic growth.

Table C3. Descriptive statistics for the distribution of times to extinction (Fig. C18).

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
504.8	115.427	16.324	13323.429	22.866	50
Minimum:	Maximum:	Range:	Sum:	Sum Squared:	# Missing:
332	987	655	25240	13394000	0
# < 10th %:	10th %:	25th %:	50th %:	75th %:	90th %:
5	350	423	499.5	562	633.5
# > 90th %:					
5					

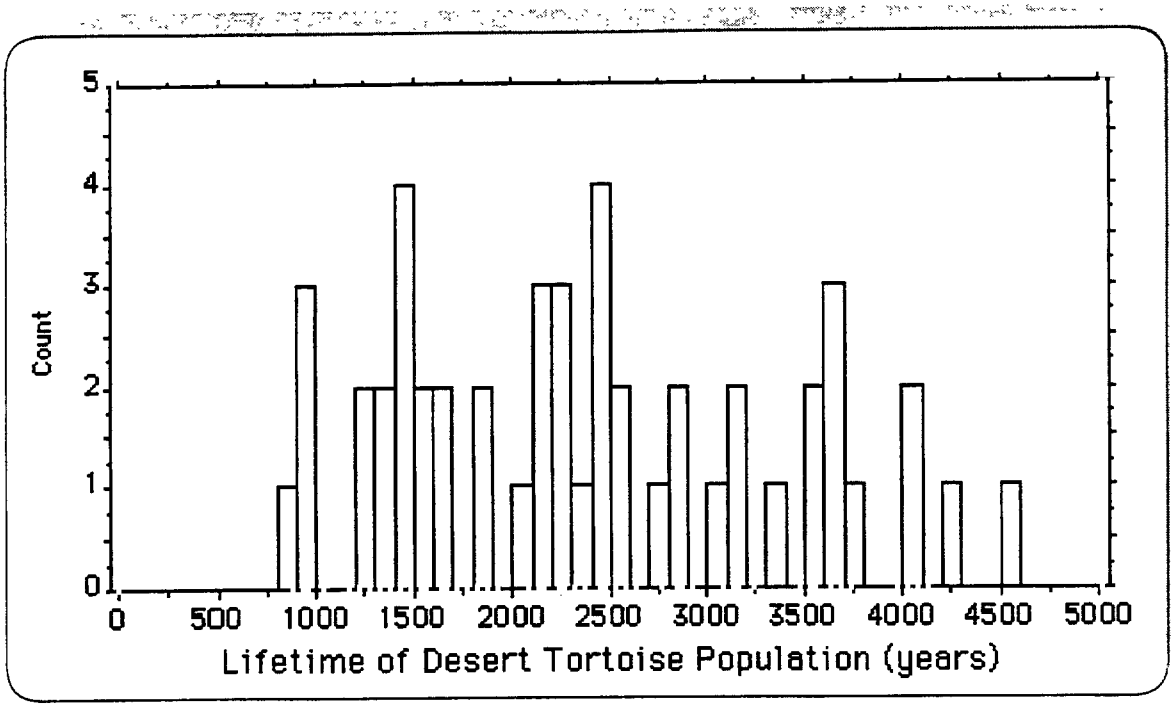


Figure C19. Extinction time under hypothesized management (see text).

These projections are based on a relatively simple model and on relatively limited data. One way to get a feeling for the reasonableness of "stability" of such projections is to change the model slightly. If the mean lambda is raised from 0.985 to 1.000 (a growth rate for maintaining stable population size), but the variance in growth remains the same; that is, that the histogram in Figure C18 is shifted rightwards by an amount 0.015, the mean tendency is for the population to remain stationary in size. However, it cannot increase above its K, while at the same time it has no lower bound other than extinction. If the model is now run with the slight increase in mean lambda, the growth distributions are as shown in Figure C19.

The mean time to extinction has now increased five fold to 2,474 years, with a standard deviation of 1,150 years. That is, given the hypothetical situation for growth now assumed for a desert tortoise population, a 1.5% elevation of the growth rate leads to a 500% increase in time to extinction. This suggests that a little management of tortoise habitat may go a long way to help local populations.

A second manipulation is also instructive. If the mean lambda is kept at 1.000, but the local population is made ten times smaller (i.e., $N_{initial} = 2000$ and $K = 200$), the mean time to extinction is

361 years(Figure C20). Thus, the size of the population (and hence the reserve) matters greatly given the observed fluctuation in growth rates. Thus, even with improved management, a reserve with a maximum population of 2,000 desert tortoises is too small to achieve a reasonable predicted time to extinction.

Even though tortoise populations declined (mean lambda = 0.985), the years 1979-1989 were relatively good ones for the desert tortoise compared to the next two. During 1990 and 1991 marked declines in numbers occurred. If the data from 1990-91 are added to the 1979-89 data, the mean lambda (i. e., the per year discrete growth rate) is so reduced that the model populations promptly go extinct. However, recovered populations, or populations on their way to recovery, should have the ability to rebound from bad years, once most of the extrinsic sources of mortality have been removed. Clearly, these years are not the first drought or disease episode experienced by desert tortoises over their long history of occupation of this region. In addition to bad years, there will also be some years of extraordinarily high lambdas associated with very good conditions. This implies that the average lambda from the 1979-89 data set will still be obtained--only its variance (or standard deviation) will be increased. The amount of the increase in the standard deviation will depend on the frequency of very good years and very bad years, whatever that may be.

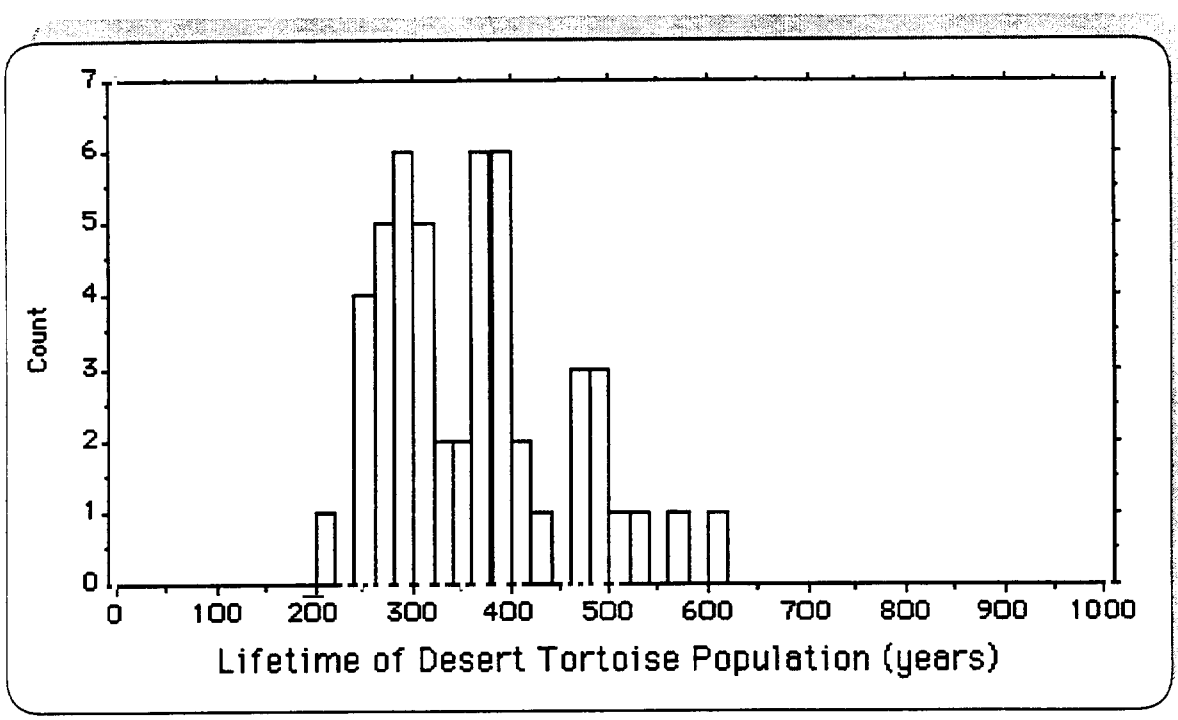


Figure C20. Extinction times in a small managed reserve.

This model can also be used to examine the time to extinction for various modifications to variation in lambdas. Population ceilings of 200, 2000 and 20,000 adult desert tortoise were used, and the variation in lambdas is increased by certain percentage amount while all else was kept constant. Fifty trials were performed for each case, and the median number of years of persistence is used as the estimator of time to extinction. The results are shown in Figure C21. Time to extinction increases linearly with the logarithm of population size, as is expected from standard theory. The highest line is for the 1979-1989 data. The 500 year time to extinction is reached with a population ceiling (K) of 20,000 adult desert tortoises. The three lower lines on the figure, based upon simulations using ceilings of 200, 2000 and 20,000 adult animals, show the effect of increasing the variance in lambda to 120%, 150% and 200% of its value in the 1979-1989 data set.

This experiment shows that the higher the variability of population growth, the larger the population size required for viability. For example, about 50,000 adult tortoises would be required for a median time to extinction of 500 years if the actual variance in lambda is 120% of the 1979-89 value. Since population size is a function of reserve size, a reserve large enough to support this number of adult tortoises would be necessary. That is, this model suggests that reserves large enough to support 50,000 adult desert tortoises would be advisable building blocks to achieve a median time to extinction of 500 years for recovered populations.

This model does not incorporate three important features. First, it ignores catastrophes. Second, it extrapolates from the last decade of desert tortoise history hundreds of years into the future. Many things, such as climate change, could invalidate these data considerably. Third, it does not account for spatial structure and the possible interactions of local populations. Nonetheless, this analysis does show that a reasonable reserve size for long-term protection of desert tortoises should be large enough to accommodate roughly 50,000 adult animals.

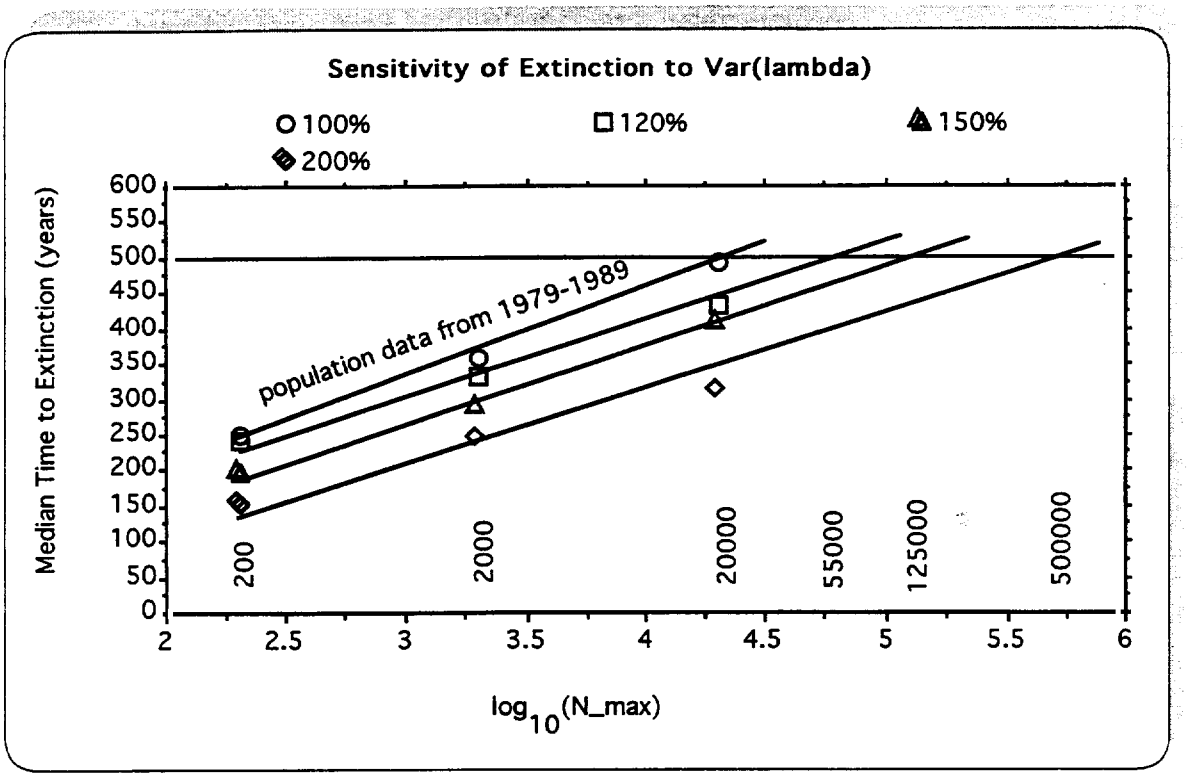


Figure C21. Median time to extinction as a function of population carrying capacity (denoted N_max) and of the variance of the discrete growth rate, lambda. The standard deviation of lambda is increased by 20%, 50% and 100% above the value used in the original report. The horizontal line is at 500 years, which is taken as the minimally acceptable time for a single reserve.

B. The Tracy Analysis

Matrix Population Model. - The only compilation of detailed demographic data for the desert tortoise comes from studies at the Goffs Site in California (Turner et al. 1987, Burnham et al. 1987). From these data it is straightforward to construct a stage-transition matrix (Caswell 1989). All tortoises were placed into five stage categories (Table C4), and these stages were incorporated into a five-stage demographic model (Figure C22).

The demographic flows modeled in Figure C22 are placed into a transition matrix:

$$\mathbf{A} = \begin{pmatrix} P_1 & F_2 & F_3 & F_4 & F_5 \\ G_1 & P_2 & 0 & 0 & 0 \\ 0 & G_2 & P_3 & 0 & 0 \\ 0 & 0 & G_3 & P_4 & 0 \\ 0 & 0 & 0 & G_4 & P_5 \end{pmatrix}$$

The G and P elements of this matrix model were estimated from the simulated survivorship curve (Figure C23) for the Goffs Site (Turner et al. 1987, Burnham et al. 1987). The F element (only "adults" produce eggs) was taken as a variable based upon population growth rates to be modeled.

Table C4. Description of the ages of desert tortoises included in the five stages for the stage-based demographic model of desert tortoise population growth.

Stage	Ages
1	hatchlings
2	1 to 5 years old
3	6 to 10 years old
4	subadults
5	adults

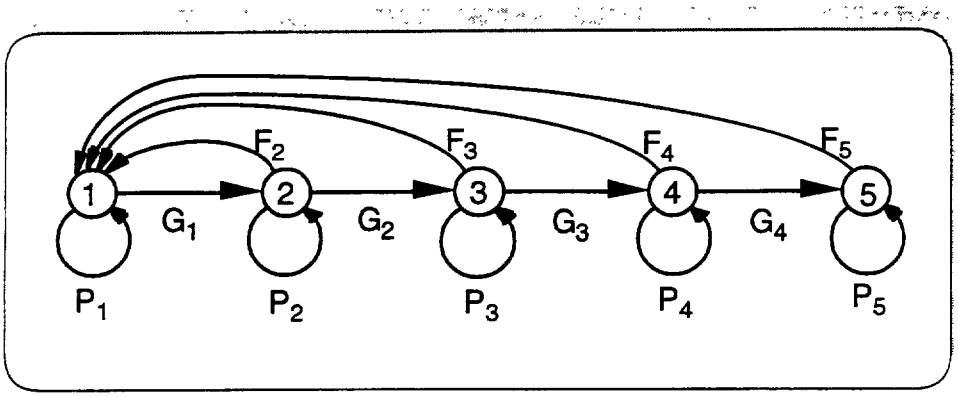


Figure C22. Conceptual model of the life cycle of desert tortoises in which individuals move among the five stages within the life cycle according to two probabilities of movement: P_X is the probability of an individual remaining in a particular stage x, G_X is the probability of an individual moving to the next older stage x, and F_X is the number of hatchlings produced by individuals surviving to the adult stage.

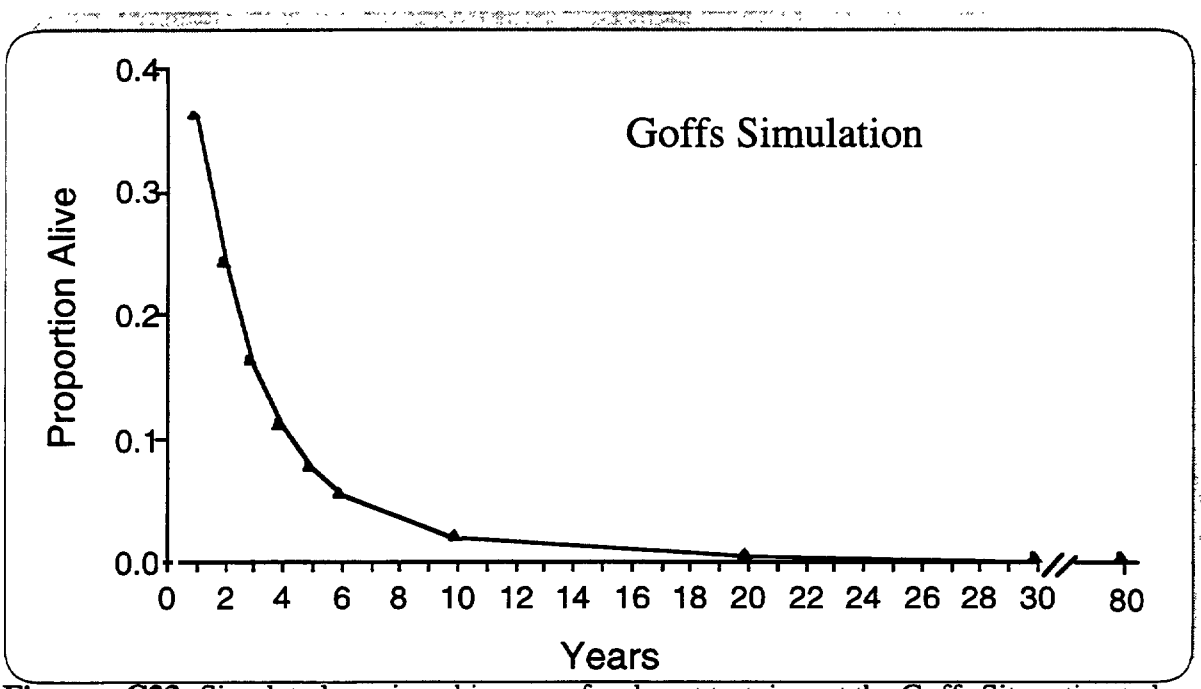


Figure C23. Simulated survivorship curve for desert tortoises at the Goffs Site estimated from data presented in Turner et al. (1984) and Burnham et al. (1987). Survivors are presented as proportion of the population still alive as a function of tortoise age.

Growth of Mojave Populations

Nineteen sites in California and Nevada have been monitored for desert tortoise population sizes since 1979 (Table C5). At all of these sites populations have been sampled more than once over a period of 13 years yielding a total of 39 estimates of the discrete growth rate (lambda, l) calculated as,

$$l = (N^*/N)^{(1/(t^*-t))}$$

where:

N^* = Population size at time = t^*

N = Population size at time = t

t^* = time of the initial sample

t = time of the second sample

The mean lambda for all monitoring sites was 0.975 (Figure C24A) with a standard deviation of 0.091. However, this standard deviation for the mean lambda includes variation attributable to several sources: (1) differences in lambda among sites, (2) differences in lambda due to temporal trends in population size, (3) year-to-year variation around the temporal trends, and (4) errors in the estimation of population sizes. An analysis of covariance was performed to partition these sources of variation around the mean lambda (Figure C25). The standard deviation for the mean lambda due only to year-to-year variation around the temporal trends, plus the estimation errors, was only 0.019 (Figure C24B). Until an analysis is performed to determine the errors in population estimation, it is not possible to sort out the year-to-year variation around the mean lambda completely.

Using the transition matrix from Goffs and the mean Lambda for the 39 sites in California and Nevada, the unknown F_x in the model can be solved for. This results in the transition matrix for the "average" population in the Mojave to be,

$$\mathbf{A} = \begin{pmatrix} .000 & .000 & .000 & .000 & .500 \\ .360 & .614 & .000 & .000 & .000 \\ .000 & .076 & .715 & .000 & .000 \\ .000 & .000 & .171 & .840 & .000 \\ .000 & .000 & .000 & .174 & .940 \end{pmatrix}$$

Table C5. Long-term monitoring sites at which population sizes of desert tortoises have been estimated between 1979 and 1992.

Sites Receiving Winter and Summer Rains

Chemehuevi Valley, California
Chuckwalla Bench, California
Chuckwalla Valley, California
Ivanpah Valley, California
Upper Ward Valley, California
Christmas Tree, Nevada
Coyote Springs, Nevada
Gold Butte, Nevada
Piute Valley, Nevada
Sheep Mountain, Nevada
Trout Mountain, Nevada

Sites Receiving Winter Rains Only

Desert Tortoise Natural Area (Interior), California
Desert Tortoise Natural Area (Visitors Center), California
Fremont Valley, California
Fremont Peak, California
Johnson Valley, California
Kramer Mountains, California
Lucerne Valley, California
Stoddard Valley, California

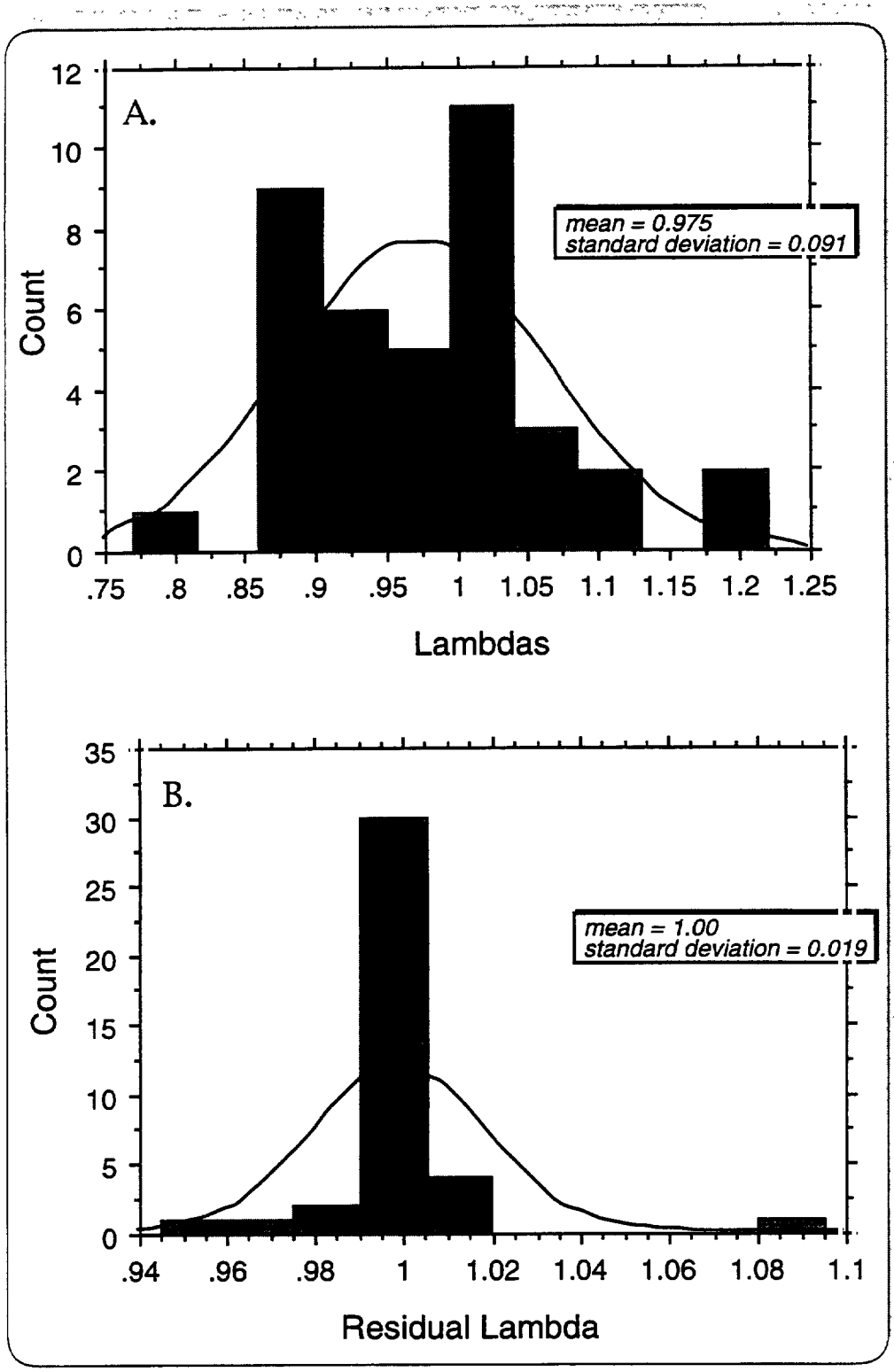


Figure C24. Frequency distribution of Lambdas for (A) all 39 Lambda estimations, and (B) for the residuals after variation due to site, time, and site * time interaction are removed.

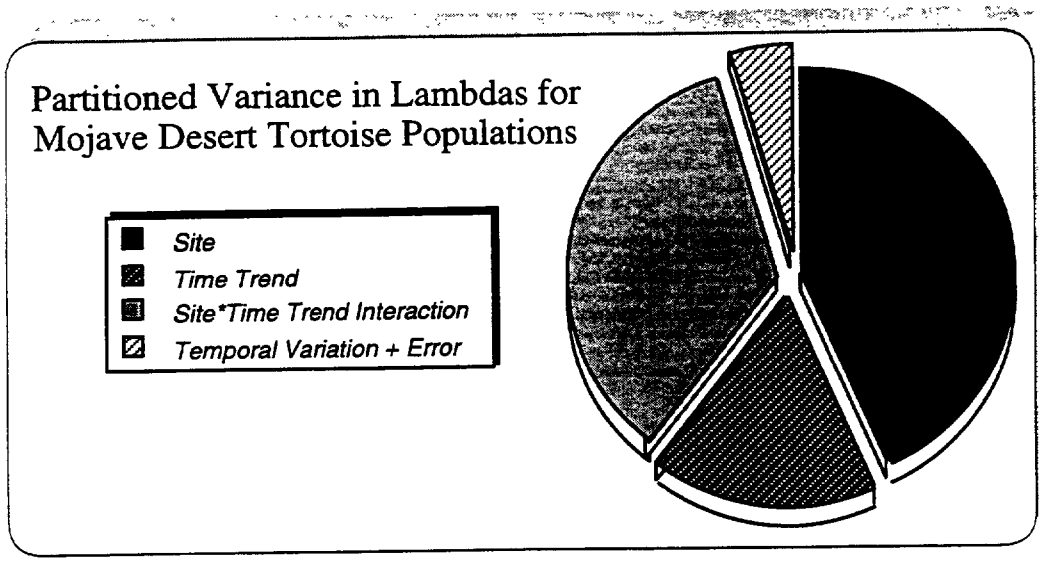


Figure C25. Proportions of variance around the mean lambda for 39 sites in California and Nevada.

When the "A" matrix (the transition matrix) is multiplied times a vector containing the number of tortoises in each of the five stages, the result is a new vector containing the numbers of tortoises in each stage one time step (one year) into the future. After many repeated time steps, the relative proportions of tortoises in each stage remains a constant, and the population is said to have reached a stable-age distribution. The stable-age distribution for an idealized population with the growth and survival characteristics of the Goffs population and the Lambda of the average population from the monitored sites is given in Figure C26. This stable-age distribution is similar to a collective size distribution assembled from data at several study sites in the Mojave and Sonoran desert tortoise populations (Figure C27). Moreover, when the data in Figure C27 are collapsed to a stage distribution and compared to the stage-based distribution assembled for the Goffs population (Turner et al. 1987, Burnham et al. 1987), it would appear that the Goffs population is typical of other desert tortoise populations (Figure C28).

The principal difference between the stage distributions in Figure C26 (simulated) and Figure C28 (observed in the field) is that the modeled distribution has a greater proportion of individuals in the hatchling and 1-5 year age classes than do the distributions from Goffs and the multi-site aggregate. While it is true that there are high levels of mortality at the younger ages (with only approximately 7% of all hatchlings surviving to the age of six years), the low proportions of young tortoises in the empirical distributions (Figure C28) more likely reflect the difficulties with locating very small tortoises in the field. Regardless, the proportion of individuals that are adults is very high: 42% in the simulated population and 60% in the empirical data sets.

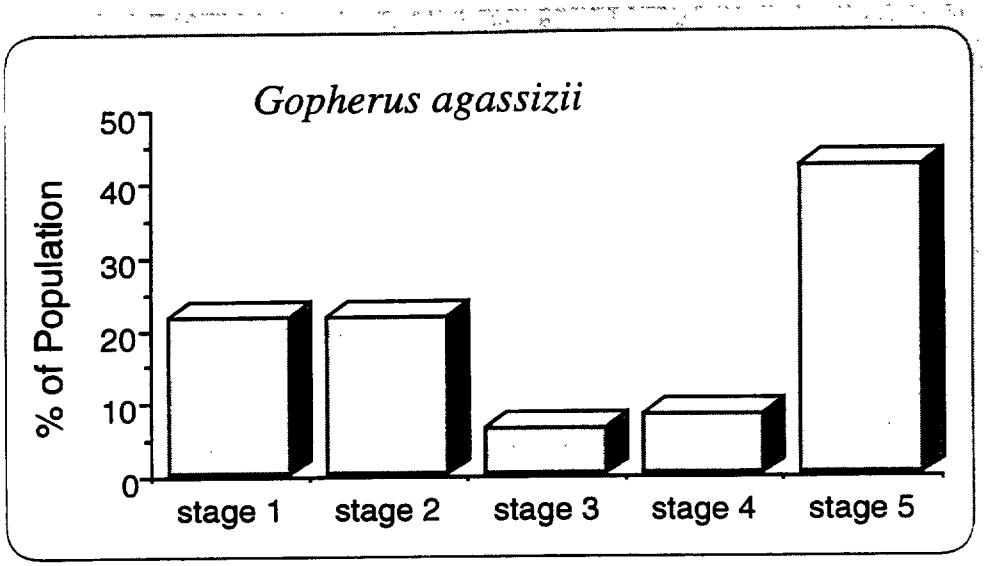


Figure C26. The proportion of individuals in each age stage of the modeled population when the population is in stable-age distribution.

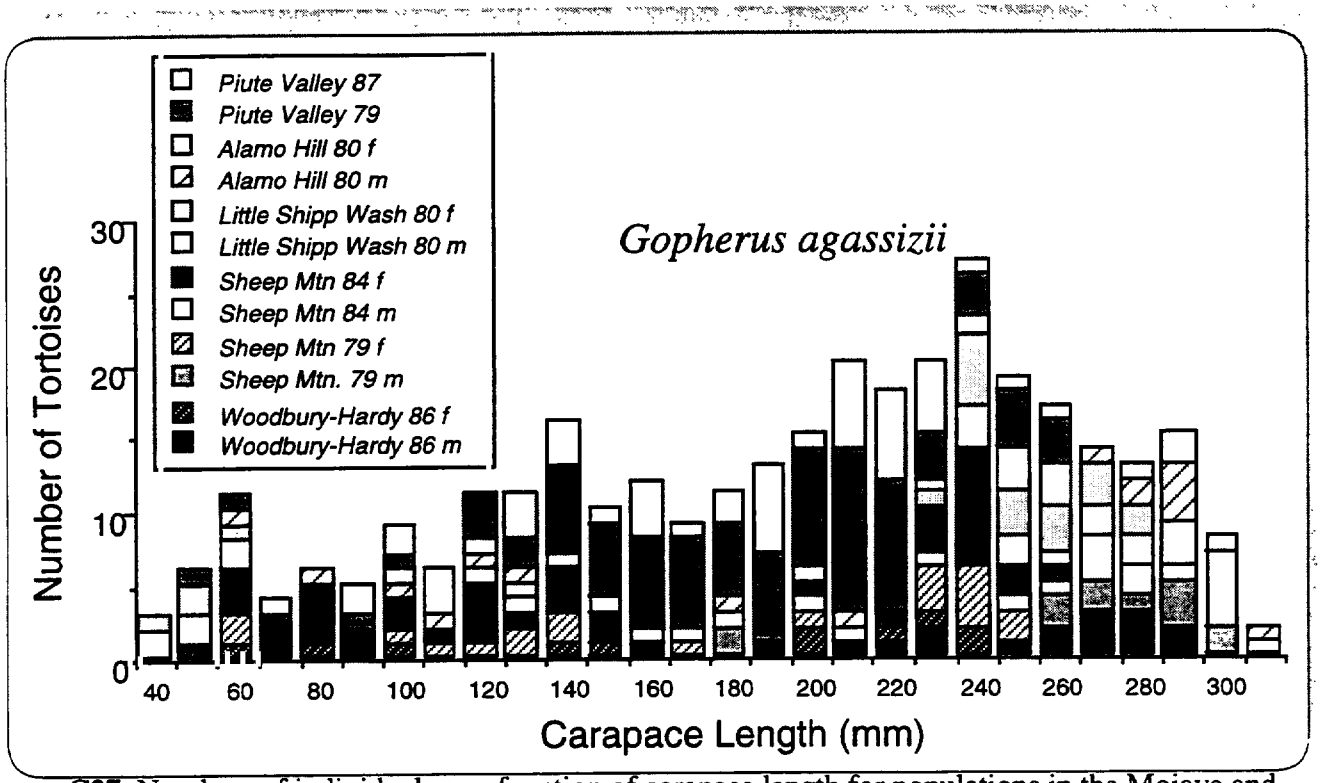


Figure C27. Numbers of individuals as a function of carapace length for populations in the Mojave and Sonoran deserts.

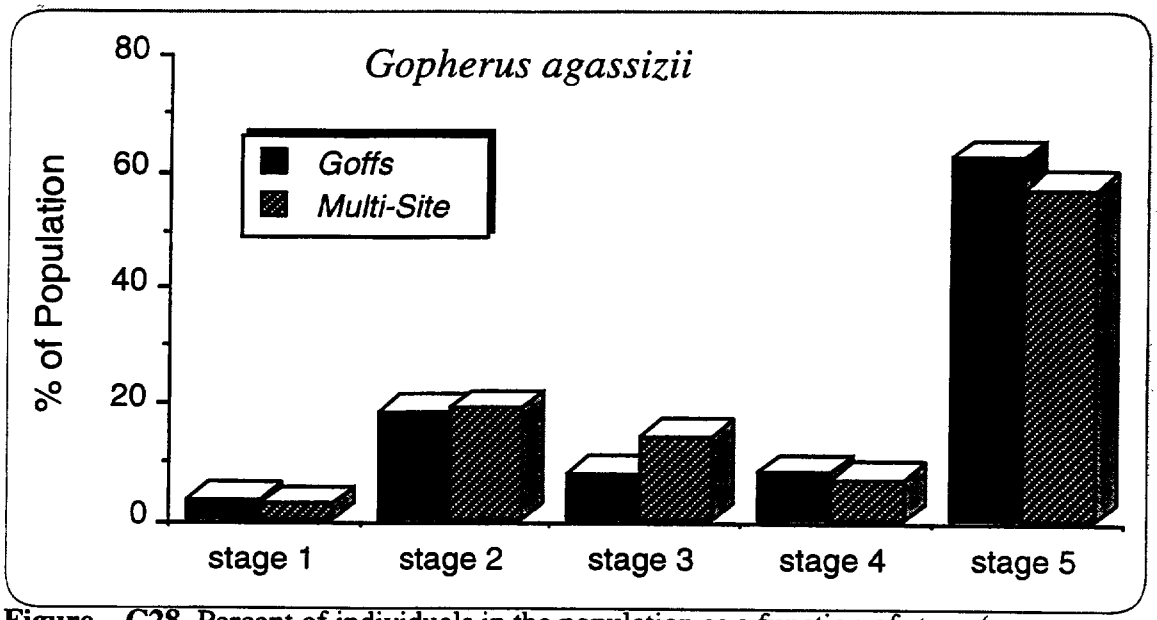


Figure C28. Percent of individuals in the population as a function of stage (age categories) for (a) the Goffs population (Turner et al. 1987, Burnham 1987), and (b) an aggregate of populations in the Mojave and Sonoran deserts.

Effects of Environmental Stochasticity. - Environmental stochasticity can cause population growth rates to vary from time to time and from locality to locality, and variable population growth rates can increase the probability of extinction. For example, a population could have a run of years with stochastic drops in population size until its density drops below a recovery threshold and it subsequently goes extinct.

Stochastic population growth was simulated with a "Monte Carlo" simulation, with lambda being drawn from a probability distribution with different means (all below 1.0 and including the observed mean of 0.975), and a standard deviation of 0.19 (the standard deviation due to random variation around population trends calculated from sampled populations; see Figure C24). An additional simulation was performed holding the mean lambda at 0.975 and using two different standard deviations around lambda (0.019 and 0.038). All simulated populations were started with different numbers of tortoises to assess the effect of mean lambda, standard deviation of lambda, and starting population size on the computed time to extinction (extinction was assumed to occur when the population reached two individuals).

Of course, all simulations with lambdas below 1.0 eventually go extinct. The time required to reach extinction theoretically is affected by both lambda and the stochastic variation around lambda (Figure

C29). However, the effect of the mean lambda was considerably greater than was the standard deviation around those means. The model's prediction that a population with a mean lambda of 0.975 (the observed mean of sampled populations in California and Nevada) could never persist for more than approximately 390 years (approximately 15 tortoise generations), regardless of the initial population size, was particularly disturbing.

Partitioning the variance in lambdas into its components was also instructive. The importance of within-population environmental stochasticity is trivial unless lambdas are close to 1.0. Even then, such populations are predicted to persist for a long time.

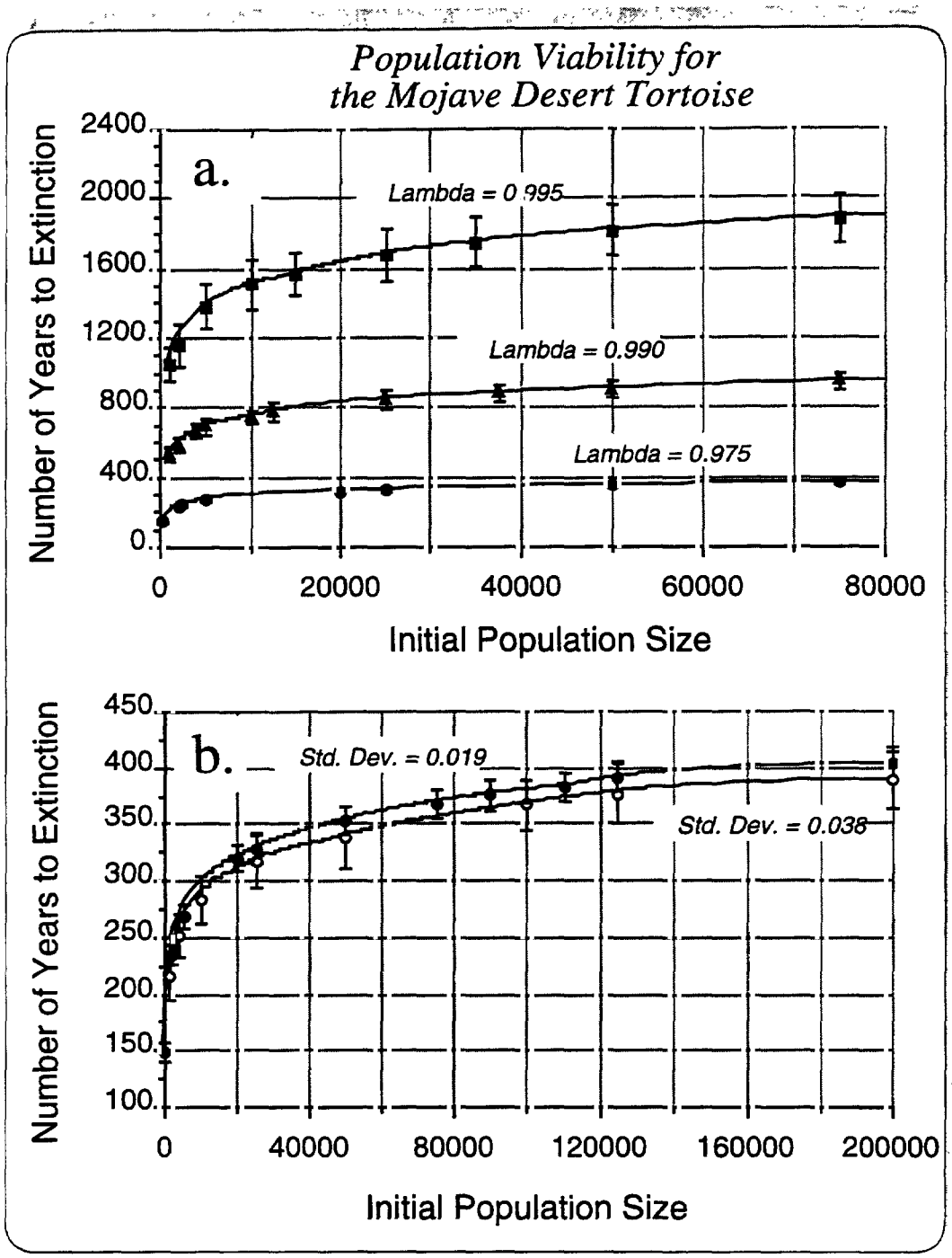


Figure C29. Results of a Monte Carlo simulation of the mean time to extinction for desert tortoise populations (a) as a function of lambda all with a standard deviation of 0.019, and (b) as a function of two different standard deviations at a lambda of 0.975 for populations starting at different initial sizes.

C. The Peacock Model

Projection Model. - Demographic data for the desert tortoise was entered into RAMAS/Stage, a single-species, stage-based model developed by Applied Biomathematics (Ferson, 1990). RAMAS simulates discrete-time stage-structured population dynamics. This model is used to predict the behavior of population trajectories (probability of extinction or population explosion) as influenced by demographic parameters and stochastic environmental variables. RAMAS is a modeling environment which allows the user to build a species-specific model using mathematical expressions based upon stage modeling theory (Lefkovitch 1965).

The effect of environmental variability on demographic processes was not measured independently for the desert tortoise; thus, the effect of stochastic environmental variation on population dynamics could not be modeled separately from demographic variation. Five life history stages were defined as in the Gilpin Analysis (see above) and the Tracy Analysis (see above): 1) hatchlings, 2) 1-5 year olds, 3) 6-10 year olds, 4) subadults, 5) adults or 17-100 year olds. Transition matrix variables: P_X (probability of remaining in a stage), G_X (probability of moving to the next older stage) and F_X (number of hatchlings produced by individuals surviving to the adult stage) were then used to simulate population growth over a 600-year period,

$$\mathbf{A} = \begin{pmatrix} P_1 & F_2 & F_3 & F_4 & F_5 \\ G_1 & P_2 & 0 & 0 & 0 \\ 0 & G_2 & P_3 & 0 & 0 \\ 0 & 0 & G_3 & P_4 & 0 \\ 0 & 0 & 0 & G_4 & P_5 \end{pmatrix}$$

Survival probabilities estimated from demographic data (Turner et al. 1987) were used to construct a transition matrix (Table C6). Because data on survivorship from the egg to hatchling stage are unavailable, F_5 was defined as the average number of eggs produced per adult female per year. (More properly, F_5 should be the number of hatchlings--which will always be lower than the number of eggs because not all eggs live to become hatchlings--but reliable data were not available.) Initial population size was modeled as 20,000 individuals; additional simulations were also conducted using starting populations of 40,000, 60,000, and 100,000 individuals. The initial stage distribution used for all simulations was based upon stable-age distribution generation by The Tracy Analysis (Figure C26).

Simulation Results. - The simulation of population dynamics over a 600-year period predicts a steady decline in the population

(Figure C30). With a starting population of 20,000, the total declines to 100 individuals by 327 years, 24 individuals by 400 years, and goes extinct (at one individual) at 553 years. Lambda averaged over the first 400 years of the simulation was 0.979. Abundances in each stage at 200, 400, and 600 years show a preponderance of individuals in stages 1 and 2 (Figure C31) with very low recruitment from stage 2 to 3 (although this result is likely due to the overestimation of recruitment of hatchlings into the population). A stable-stage distribution generated at the end of 200 years indicates that the adult breeding population would be reduced to 100 individuals. Although the total population was still relatively high (N=1400) after 200 years, a small breeding population (based upon the number of adults present) due to primarily to the low recruitment of individuals from stage 2 to 3, results in a potentially unstable population.

Population projections using starting populations of 40,000, 60,000, and 100,000 individuals show that after 200 years populations would be 200, 300, and 400 individuals respectively. By 400 years, all simulations, regardless of starting population size, produced populations of less than 100 total individuals and breeding adult populations of less than 10 individuals (Table C7). Given the current survival probabilities, desert tortoises would be extinct (fewer than one individual) in less than 600 years (Figure C32).

Table C6. The transition matrix used in population simulations, calculated using survival probabilities from Turner et al. 1987.

	Hatchlings	1-5	6-10	11-16	Adults
Hatchlings	0	0	0	0	5.8
1-5-year olds	0.36	0.619	0	0	0
6-10-year olds	0	0.057	0.6	0	0
11-16-year olds	0	0	0.085	0.806	0
Adults	0	0	0	0.126	0.925

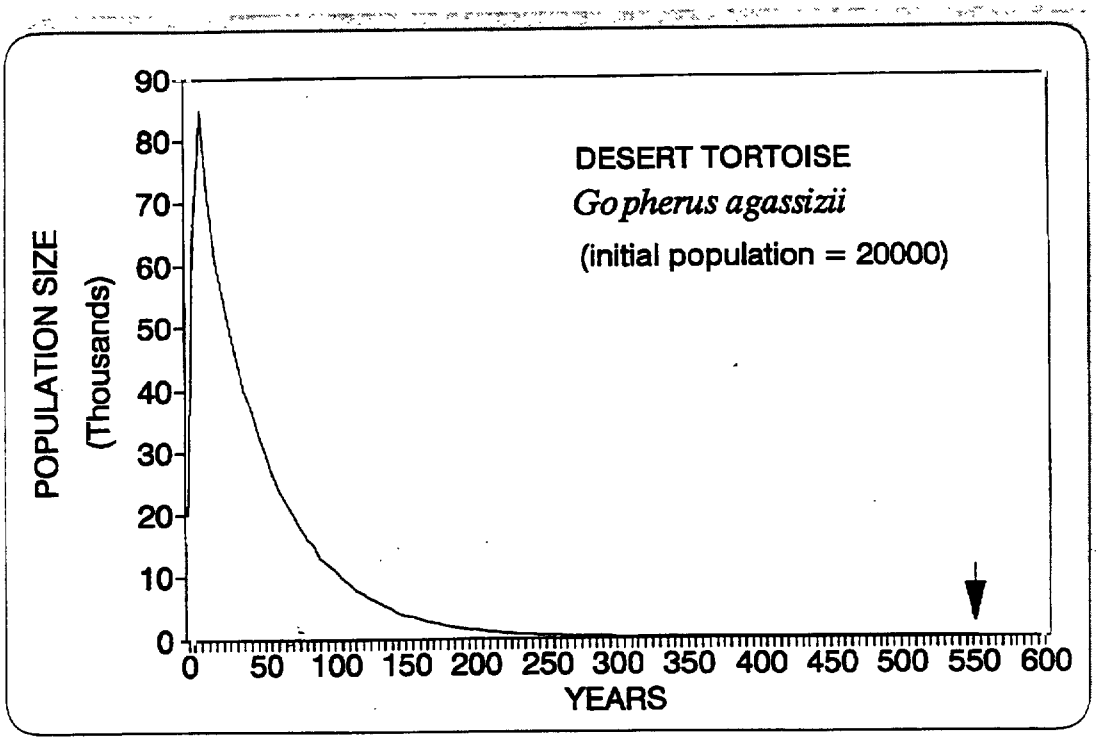


Figure C30. Population projection based upon survival probabilities for each stage (Turner et al. 1987). The starting population size was 20,000 individuals. The population goes extinct (at 1 individual) at 553 years.

Table C7. The total number of individuals remaining in the population given current survival probabilities after 200, 400, and 600 years of simulation. Simulations were conducted for populations with initial sizes of 20,000, 40,000, and 60,000, and 100,000 individuals.

Initial Size	200 y	400 y	600 y
20,000	1,400	24	0
40,000	2,900	48	0
60,000	4,300	72	1
100,000	5,700	96	1

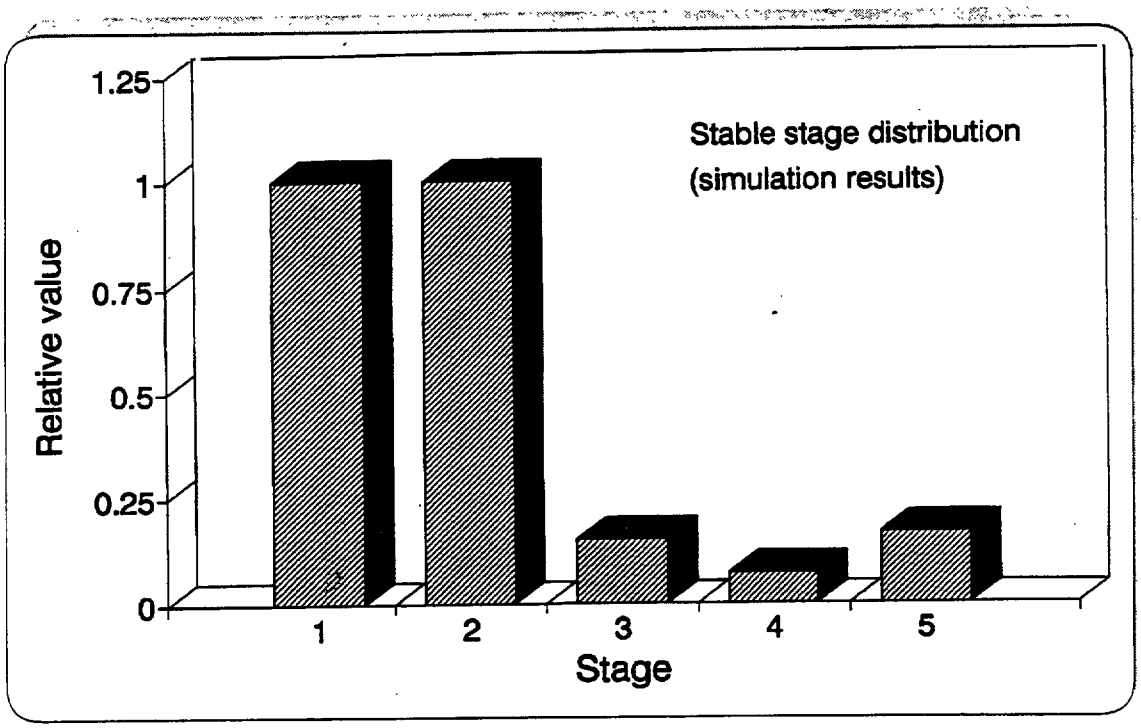


Figure C31. The stable stage distribution generated by the simulations.

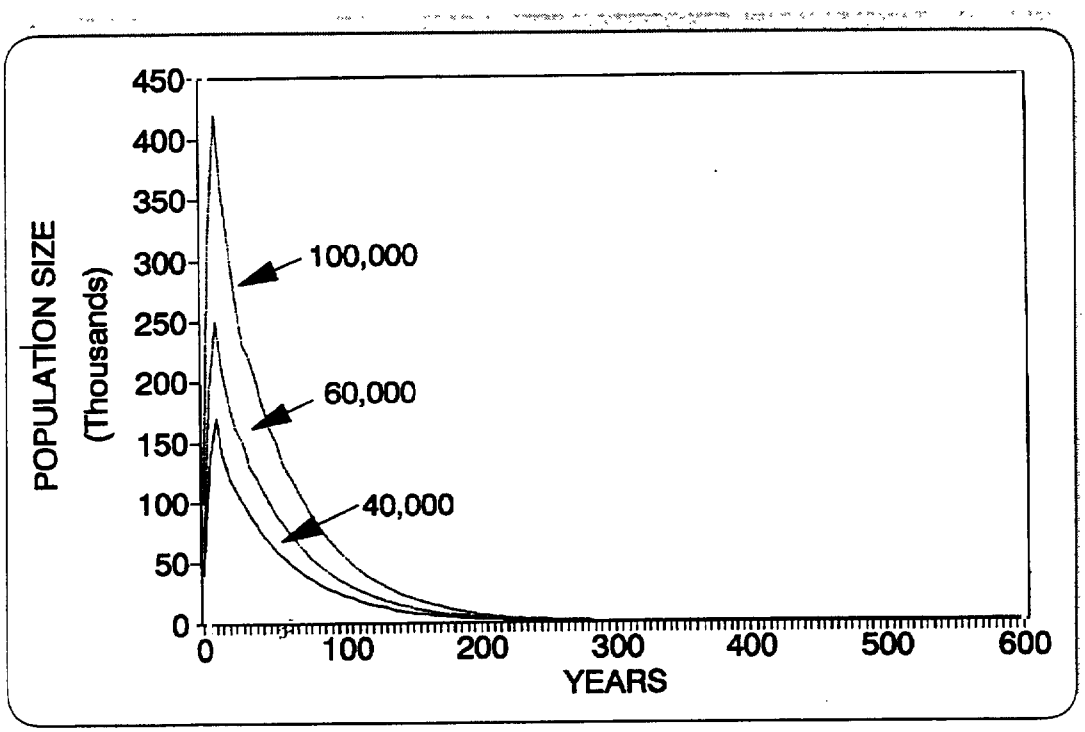


Figure C32. Population projections with starting populations of 40,000, 60,000, and 100,000 individuals. Regardless of starting size, all populations go extinct at the same time.

VII. Viability of the Mojave Desert Tortoise Population

Several criteria important to recovery and long-term persistence for the desert tortoise have been reviewed in this appendix. These include avoiding conditions for extinction (CFE) which are (1) demographic stochasticity, (2) social dysfunction, and (3) genetic deterioration. These CFEs are closely related to population density and population size. Therefore, the vulnerability of a population to these CFEs can be directly affected by two conditions: (1) extrinsic sources of mortality, and (2) the area occupied by the population. Any plan to recover the desert tortoise through the establishment of reserves must consider both the sizes of the reserves and controlling levels of mortality on the reserves.

Population Density and Size of Reserves

In Section 5 of this appendix it was shown that a minimum population density for desert tortoises is approximately 10 adults per square mile. Below this density there will be a high probability of demographic stochasticity, social dysfunction, and genetic deterioration. Section 4 of this appendix shows that a population of at least 5,000 tortoises (all age classes) is necessary to maintain sufficient genetic diversity for long-term evolutionary potential. Taken together, these two analyses indicate that an area of at least 500 square miles is necessary to maintain evolutionary potential at minimum density (Figure C32). In practice, reserves should be larger than this because acceptable tortoise habitat is patchy and not all areas are occupied. Thus, 1,000 square miles should be taken as the minimum size for a viable reserve based on these criteria.

Population Numbers and Size of Reserves

In Section VI. of this appendix it was shown that desert tortoise populations are extremely vulnerable when lambda decreases to low levels. For example, a population with a lambda of 0.975 will decrease to half its starting size in only 25 years. However, the time it takes a population with a lambda of 0.975 to decline to extinction depends most upon the size of the population before it begins its decline. For all populations with lambdas less than 1.0 there is a curvilinear relationship between mean time to extinction and initial population size (Figure C29). At population sizes exceeding 10,000 to 20,000 individuals, any further increases in population size do not greatly increase the time to extinction. That is, if variances in lambda due to year-to-year variation in population trends are small, very large populations do not have a much lower risk of extinction than do populations of approximately 10,000 to 20,000 individuals. However, the time to extinction for very small populations is strongly related to population size. If desert tortoise populations become smaller than 10,000 to 20,000 individuals, strict

management of extrinsic sources of mortality is required to prevent the populational lambda from falling much below 1.0. If this management is ineffective, the population will rapidly progress to extinction.

Taken together, these characteristics of desert tortoise population dynamics indicate two themes of major importance for recovery: (1) Reserves should be large enough to contain at least 20,000 individuals to buffer the population adequately from extinction vulnerability due to small size. (2) Populations must be managed to prevent lambdas from falling below 1.0 on average; otherwise the populations become extremely vulnerable to extinction. These themes translate directly to two management prescriptions: (1) Assuming that most current population declines will not be reversed until minimal viable density is reached (10 adults per square mile, Figure C33), reserves should be no smaller than 1000 square miles. (2) Sources of extrinsic mortality, i.e., the threats listed in Appendix D, should be reduced to the point that lambdas can reach at least 1.0. The precise means by which this can be achieved are given in the Recovery Plan section called, "Desert Wildlife Management Areas: Descriptions and Specific Management Recommendations."

Reserve Sizes in Relation to both Population Density and Size

Considerations of both minimum population densities and minimum population numbers indicate that reserves, or DWMAs, should be at least 1,000 square miles. When populations are well above minimum viable density (e.g., 30 or more adult tortoises per square mile) and lambdas can be maintained, on average, at 1.0 or greater through elimination of extrinsic sources of mortality, smaller reserves that provide high-quality, secure habitat for 10,000 to 20,000 tortoises should provide comfortable persistence probabilities for the species well into the future.

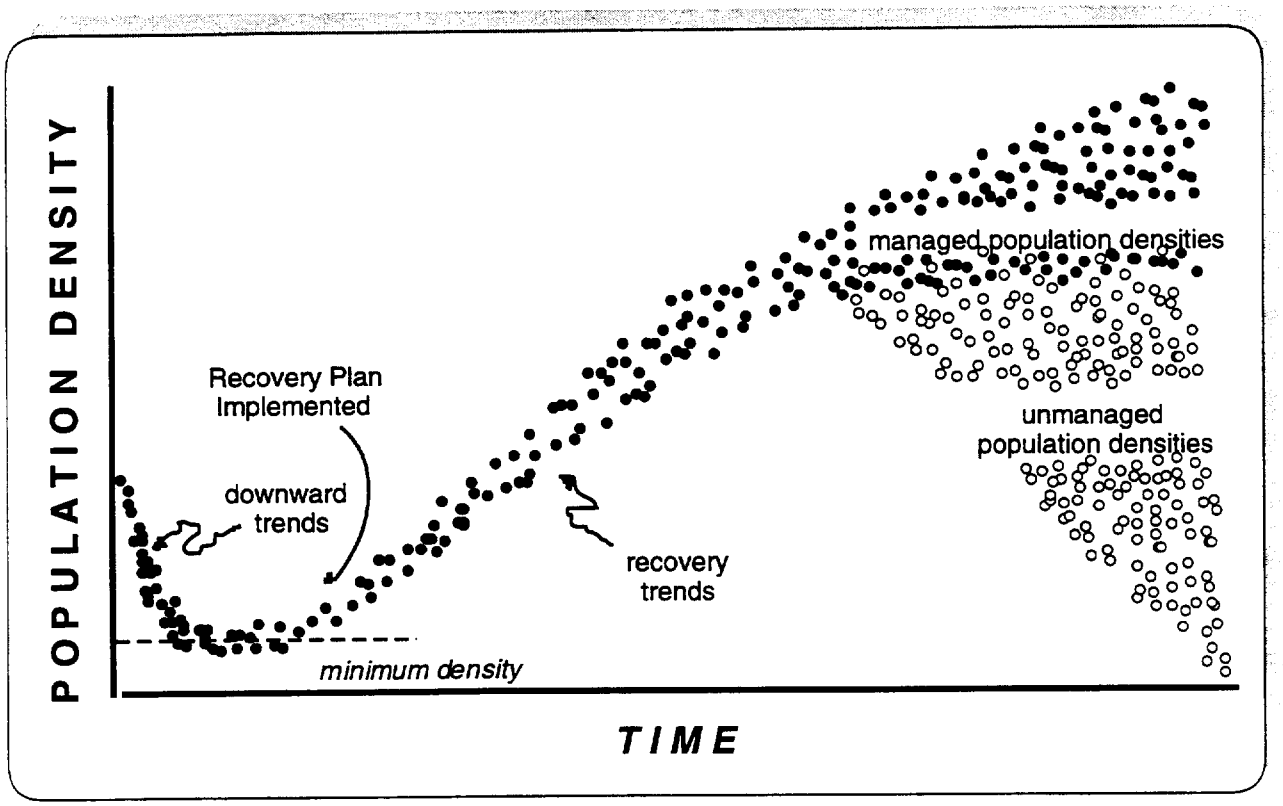
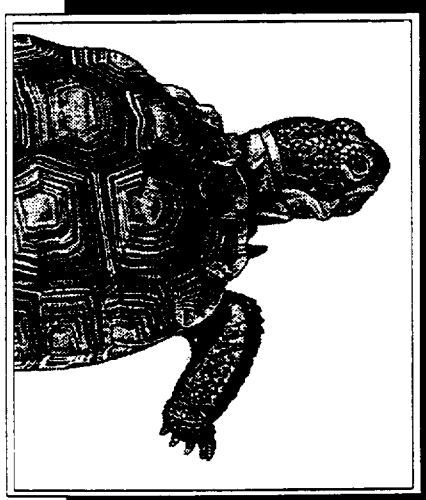


Figure C33. Idealized population densities as a function of time shown before, during, and after recovery. Downward trends are reversed at or near minimum viable density. Subsequently, the population "recovers" by growing significantly for 25 years. At that time, the population could continue to grow in response to good conditions created by proper management until (or if) the population reaches a "carrying capacity". After the population has become dense, the population might continue to grow, fluctuate around a high density, or, if management is relaxed, it may again decrease slowly.

Appendix D

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix D: Human Activities Which Directly or Indirectly Threaten Naturally-Occurring Populations of Desert Tortoises and Their Habitats in the 1990's

I. Introduction

The purpose of this appendix is to review, update, document, and summarize human-induced pressures operating on naturally occurring populations of desert tortoises in the Mojave and Colorado deserts. The appendix begins with a brief overview of prehistoric and historic trends in human-desert tortoise interactions both globally--relative to the entire tortoise family (Testudinidae), and regionally--relative to desert tortoises. This document focuses on demonstrated and probable threats to desert tortoise recovery areas. Where appropriate, records of specific threats to other chelonians are incorporated to establish their potential impact to desert tortoises. The collective, synergistic, and cumulative nature of threats is illustrated with a case study of progressive extirpation of desert tortoises in the Antelope Valley, California of the western Mojave recovery unit.

II. Methods and Sources of Data

The following resources were used, in descending order of confidence: (1) peer-reviewed journal articles; (2) published symposia and professional texts; (3) government agency reports and data; (4) environmental impact statements and related documents; (5) reports and commentaries of private consultants; and (6) properly attributed personal communications of qualified professionals and lay people.

We have drawn particularly on the following published or released surveys of human threats to desert tortoises: (1) California Statewide Desert Tortoise Management Policy (BLM and California Department of Fish and Game 1990); (2) Chapters 3, 4, 6, 8, and 10 of Berry (1984); (3) (Final) Cumulative Impacts Study on the Desert Tortoise in the Western Mojave Desert (Chambers Group, Inc. 1990b); and (4) "Assessment of Biological Information for Listing the Desert Tortoise as an Endangered Species in the Mojave Desert, A Predecision Document" (Fish and Wildlife Service

1990b). Also of interest were locally focused supplemental reports, e.g., Desert Tortoise Impacts Analysis (Lamb 1991) and the Short-Term Habitat Conservation Plan for the Desert Tortoise in Las Vegas, Clark County, Nevada (RECON 1991).

III. History of Human-Desert Tortoise Interactions

A. Prehistoric Accounts.

Prehistoric human predation on desert tortoises in California and Nevada was vigorous and widespread (Schneider and Everson 1989). Aboriginal groups that used desert tortoises included the Chemehuevi, California; Owens Valley Paiute and Mono, Tubatulabal, and Panamint Shoshoni, California; the Cahuilla in California; and Southern Paiute of Ash Meadows and Shoshoni of Beatty, Nevada. However, some aboriginal groups such as the Mohave had a "great aversion to eating desert tortoise and spoke in a derogatory manner about groups that did eat the animal" (Schneider and Everson 1989).

Human predation often involved well-developed techniques for hunting (Schneider and Everson 1989). For example, in Mexico, Seri Indians used dogs to locate desert tortoises, water to induce them to emerge from their burrows, and hooked probes for extracting them from their burrows. Papago Indians even developed protocols for roasting desert tortoise flesh (removing the plastron and inserting hot rocks). Hunting practices varied with both the location and chronology of the site.

Morafka (1988) reviewed the Late Quaternary prehistory of human-desert tortoise interactions globally, emphasizing data on the progressive extirpation of the bolson tortoise, *Gopherus flavomarginatus*. Human predation, which is still ongoing, appears to have had a pivotal role in reducing bolson tortoise distribution over the last 20,000 years.

B. Human-Tortoise Interactions and Human Cultures.

Globally, tortoises are preyed upon for a variety of reasons (Swingland and Klemens 1989). Swingland (1989) stated:

> In economic terms, the tortoise is an important part of rural dynamics, being used for food in most parts of the world, as a musical instrument (maracas and banjo), as a scoop or water bail in boats, and canned as meat in parts of the Mediterranean. The adults are often kept in village pens for food and as a source of hatchlings, which are becoming a new economic product of this traditional habit.

The traditions of developing countries may seem tangential to a review of threats to desert tortoises posed by human actions in the southwestern United States, but in fact many former residents of these areas are bringing their traditional practices with them as they immigrate to the pluralistic societies of Los Angeles, Las Vegas, and elsewhere in the West.

Highway mortalities and habitat modification and fragmentation have critical negative impacts on terrestrial turtles in the more industrial societies (Swingland and Klemens 1989). Most authors of species accounts in Swingland and Klemens' book described similar threats. For example, Klemens (1989) described problems faced by emydid turtles in New England, a region subject to the kinds of development which now increasingly characterize Mojave Desert landscapes.

Nowhere are the correlations with human influences more pronounced than in the history of the insular tortoises of Madagascar and the adjacent western Indian Ocean. More than a dozen putative taxa of giant tortoises once occurred in this region (Arnold 1979). Of these, all but a single population of the species *Geochelone gigantea* were apparently driven to extinction by the direct or indirect impact of abrupt human colonization. The chronology of these human colonizations and resulting tortoise extinctions were strikingly correlated. Interestingly, similar extinctions were not observed on the adjacent African mainland where more than half a dozen tortoise taxa of varying sizes have occurred sympatrically with hominoids for tens of millions of years. Perhaps the continued existence of the mainland tortoise species can be explained by long-term associations with hunter-gatherers in complex and relatively stable relationships. In contrast, the sudden appearance of humans, especially in the simplified and isolated ecosystems of oceanic islands, had a much more catastrophic impact on tortoises and their habitats.

IV. Human-Induced Threats to Desert Tortoises

A. Deliberate Removal of Desert Tortoises by Humans.

1. Predation for food. The use of tortoises for food was historically the primary motive for collections on a global scale (Swingland and Klemens 1989) and regionally for desert tortoises in the Great Basin and southwestern deserts (Schneider and Everson 1989). Many cultures have engaged in both individual and commercial exploitation of desert tortoises as food items (Berry and Nicholson 1984b). Commercial exploitation has included export of desert tortoises from the Mojave Desert to restaurants in Los Angeles, the Central Valley, and elsewhere in the West. Such practices continue today. Meat markets which offer live aquatic turtles still exist in some areas of metropolitan Los Angeles--Monterey Park for example. Asian nationals were arrested in two separate incidents for taking over one dozen desert tortoises from the Western Mojave Desert for food and ceremonial purposes in 1991 and 1993 (Ditzler 1991, BLM files).

2. Collection and commercial trade for pets. This threat is similar to, and may not be clearly separable from, collecting desert tortoises for food or other purposes. Collections for pets and the commercial trade were undoubtedly of importance in the past (Berry and Nicholson 1984b). Commercial collecting of desert tortoises continued to be significant into the 1970's, even though full legal protection was extended to the species in California by 1961 (St. Amant 1984). Intense collecting of desert tortoises occurred well into the 1960's in the Jawbone Canyon region of Kern County, California (David J. Morafka, pers. comm.). Dr. A. D. Stock (University of Nevada, pers. comm. to D.J. Morafka) similarly recalled fairly intense commercial collecting of desert tortoises and Gila monsters (*Heloderma suspectum*) in the Beaver Dam Slope region of southwestern Utah. Two instances of commercial collecting in Nevada were documented in 1982 and 1983 (Berry and Burge 1984). In one case, more than 30 wild desert tortoises were taken to Alabama.

In spite of Federal and State listings, commercial collecting still occurs. Felicia Probert, a BLM District Ranger in Riverside, California, described an ongoing case involving the attempted sale of desert tortoises in 1990, at a Barstow gas station. An arrest warrant was issued, but the suspect apparently fled the country to avoid prosecution. Other cases provide circumstantial evidence of large-scale take. For example, a substantial decline in subadult and adult desert tortoises occurred between 1982 and 1987 at the Kramer Hills study site in California, without any evidence of mortality (Berry 1990, as amended). Within the same time frame, signs of human excavation of desert tortoises burrows were observed near the study site (A.P. Woodman pers. comm.), and a sheepherder reported to a BLM employee that he saw a truck containing over a

dozen desert tortoises at nearby Kramer Junction (Berry 1990, as amended).

Families and individuals still collect desert tortoises for personal pets, especially when they are found on roads. This threat is serious in areas with high visitor use and is, surprisingly, even operative in remote desert areas. Three examples of desert tortoises taken from research sites (and, in some cases later recovered) provide an indication of the extent of the threat. During studies conducted from 1987 to 1991 near Kramer Junction in the western Mojave Desert, two of 16 desert tortoises with radio transmitters were lost to poaching; five others may have also been poached (Stewart 1991). This area experiences human traffic of more than 500 visitors/mi^2 per year. In another example, one of a few dozen desert tortoises with transmitters was removed from a study site in the Ward Valley, California in summer of 1990 (A. Karl pers. comm.). The site is in an area with fewer than 100 visitor-use days/mi^2 per year. The transmittered desert tortoise was recovered at a motel parking lot in Bullhead City, Arizona. In Nevada, one of 78 desert tortoises (1.3%) marked in 1986 at the BLM's Coyote Spring Valley study site was found as a captive in the Las Vegas Valley a few years later (Betty L. Burge, per. comm.). This site is in a relatively remote part of Nevada and has few human visitors.

Naturalists at the Desert Tortoise Natural Area in eastern Kern County, California described probable illegal take during spring (Howland 1989, Ginn 1990, Jennings 1991). Additional information is also available from personal discussions between agency biologists and the public by phone, at meetings, or in government offices. Each year, Berry (pers. comm.) receives several accounts from individuals who describe "saving" desert tortoises from traffic on highways. Most such desert tortoises are either inappropriately released or retained in captivity.

The threat of collections should not be underestimated and will continue to remain high for three reasons. First, most new arrivals to the Southwest are unaware that desert tortoises are protected. Second, the presence of law enforcement officers in open desert lands is inadequate. And third, commercial poaching of rare, threatened, and endangered species is well documented, and in some cases, a lucrative business (Reisner 1991, Poten 1991). Reisner (1991), who presented a powerful documentary of the effects of poaching on alligators, pointed out that many wildlife biologists tend to attribute population declines to habitat loss, when illegal collections are a major factor.

B. Vandalism.

Shooting and vandalism play a major role in losses of desert tortoises in many areas, particularly where human visitation is high (measured in visitor-use days/unit area per year). Deliberate

shooting of desert tortoises or crushing them with vehicles has been documented (Berry 1986a, Berry and Nicholson 1984b; Michael Coffeen, BLM, Glenallen, Alaska, pers. comm.). Acts of vandalism have also included beheading, severing of body parts, and overturning. At the BLM's western Mojave Desert study plots, 14.6% to 28.9% of all desert tortoise carcasses bore evidence of gunshots, whereas carcasses from the less-visited eastern Mojave Desert yielded gunshot frequencies of 0% to 3.1% (Berry 1986a). Fencing the Desert Tortoise Natural Area did not effectively reduce the frequency with which carcasses bearing gunshot holes were encountered, at least in the vicinity of the interpretive center (Berry and Shields et al. 1986). The highest rate of vandalism was recorded in the Fremont Valley, where 40.7% of desert tortoises found dead between 1981 and 1987 showed signs of gunshots and other vandalism (Berry 1990, as amended).

In 1991, local residents of Mesquite, Nevada, and St. George, Utah, threatened to undertake "reprisal" killings of desert tortoises in response to the recent Federal listing, economic hardships, and perceived loss of local self-government (Tim Duck, BLM, St. George, Utah; pers. comm. to David J. Morafka). Residents threatened to shoot desert tortoises or flip them over to immobilize them.

Desert visitors also harass desert tortoises. Three incidents of harassment occurred at the Desert Tortoise Natural Area in the spring of 1990 when visitors handled wild desert tortoises (Ginn 1990). In one case, a group of adults from France poked a desert tortoise with a stick. Jennings (1991) described the trampling of a burrow by a visitor.

People who vandalize desert tortoises are difficult to identify and classify, thus increasing the problem of apprehending and educating them. Some who are suspected of shooting desert tortoises claim to be hunting rabbits, but such "hunters" are regarded as "plinkers" by legitimate hunters. In general, "...illegal hunters face little threat of arrest from the thinly spread force of ... federal and state wildlife enforcement officers" (Satchell 1990). While no law enforcement officer has caught a person in an act of vandalism to desert tortoises since the species was federally listed in August of 1989, the threats and actual mortalities from such acts remain high in many areas.

C. Deliberate Manipulation of Desert Tortoises by Humans.

1. Relocation and translocation. Relocation can be defined as "... moving an animal or population of animals away from an area where they are immediately threatened...to an area where they would be less prone to habitat loss..." (Dodd and Siegel 1991). Past relocations of desert tortoises were frequently motivated by sincere attempts at conservation, but their results have been both

varied and disappointing, so much so that poorly planned and executed relocations should be treated as a threat.

Several factors are likely to contribute to low success rates of relocations: (1) the tendency of the released desert tortoises to travel or wander from the site or attempt to return home; (2) increased vulnerability to predators; and (3) the potential for agonistic responses from resident or host desert tortoises (Berry 1986b, Stewart 1991). Significantly higher mortality rates were recorded for relocated desert tortoises than in the host or control population in a 1990-1991 relocation project (Weinstein 1992). The higher mortality rates did not appear to be associated with higher rates of predation or availability of food and water.

The potential for introducing or spreading diseases must not be overlooked. Diseases such as URTD pose a grave threat to wild populations, especially because such a significant proportion of ill desert tortoises are asymptomatic (Brown et al. 1992, Jacobson 1994). Diseases such as URTD may be passed from mother to offspring through the eggs and from male to female through seminal fluid.

Illegal relocations by local desert residents and visitors occur frequently and must be treated as an ongoing threat. Such activities have been best documented at the Desert Tortoise Natural Area in eastern Kern County, California (Howland 1989, Ginn 1990, and Jennings 1991), but are by no means limited to that site. For example, illegal releases or attempted releases of six wild desert tortoises were recorded in 1990 elsewhere in California (Ginn 1990, Gilbert Goodlett, BLM files).

2. Release of captive desert tortoises. Captive releases pose numerous problems to their wild host populations, not to mention the inhumanity of placing animals which have been provided with water, food, and shelter on a regular basis into a hostile environment. Examples of areas of concern include genetic pollution, the potential for introducing or spreading disease, and disturbance to the social structure of the host population. In terms of genetics, the most potentially disruptive releases into the Mojave region would be the introduction of Sonoran Desert tortoises or Texas tortoises (Gopherus berlandieri), which are reported to hybridize with desert tortoises in captivity.

Release of captives has been, and continues to be, a problem (Jacobson 1993). The California Department of Fish and Game released thousands of captives and has formal records for over 800 releases undertaken in the 1960's and 1970's (Berry and Nicholson 1984a). In the 1970's, California Department of Fish and Game also set up a program to rehabilitate captive desert tortoises and prepare them for return to the wild through quarter-way and half-way house projects. Of more than 200 individuals exposed to the desert transitional pens, only 15% survived more than a few years. About 30 of the survivors, some of which were apparently ill with

URTD, were subsequently released in Antelope Valley (Cook 1983).

Information on the prevalence of released or former captive desert tortoises in wild populations can be derived from several sources. For example, a single captive release was found among 45 wild desert tortoises registered during a formal survey in the Black Mountains, Mojave County, Arizona (Hall 1991). In the Las Vegas Valley in 1990, 13 (1.5%) captive desert tortoises were found among a sample of 842 wild desert tortoises collected from private parcels of land (Hardenbrook and Tomlinson 1991). Ten of the 13 captives were found in close proximity to urban development. Naturalists at the Desert Tortoise Natural Area in California intercepted people in the process of releasing captives and discovered recently released captives (Howland 1989, Ginn 1990, and Jennings 1991). Howland (1989) reported illegal releases and an attempted release of five desert tortoises, three of which showed signs of URTD. Jennings (1991) recorded two such instances. Released captives may introduce infectious diseases, including URTD, to wild populations (e.g., see Berry and Slone 1989, Jacobson 1993). In the Mojave population, the outbreak and incidence of URTD appears to be closely correlated with known and suspected release sites for captives, as well as with the proximity to urban development and degree of human access (e.g., Hardenbrook and Tomlinson 1991, Jacobson 1993, and Tomlinson and Hardenbrook 1992).

V. Human-Induced Habitat Alterations Coupled with Losses of Desert Tortoises

A. Urbanization.

Many terrestrial chelonians are affected by habitat destruction and fragmentation resulting from urbanization (Swingland and Klemens 1989, Klemens 1989). In addition, populations of chelonians are often depressed in the vicinity of roads as a result of animals killed by vehicles or collected by visitors.

The portions of the desert Southwest occupied by desert tortoises have experienced episodic human settlements since the mid to late 1800's. A checkerboard or braided pattern of public and private lands has encouraged patchy development. Current areas of rapid development include, but are not limited to, the Antelope, Peerless, Fremont, Indian Wells, Lucerne, Yucca and Victor valleys of the western Mojave Desert; the Mojave River Valley of the western and central Mojave; Las Vegas and Virgin River valleys, and the towns of Mesquite, St. George, and Searchlight in the eastern Mojave Desert; Laughlin, Bullhead City, Lake Havasu City, Parker, and

Blythe along the Colorado River; and parts of the Chuckwalla Valley (Berry 1984a).

Tierra Madre (1991) provided careful documentation for the current status of desert tortoises for about 225 square miles in the City of Lancaster and surrounding areas. Surveyors walked transects and recorded desert tortoise sign on 90 square miles of undeveloped, nonagricultural lands. Three desert tortoise carcasses and a single live desert tortoise (observed in 1983) were the only remaining records of the presence of this once common species. Within the City limits and the general planning area, evidence of sheep grazing, shotgun shells and rifle cartridges, trash, litter, ORV tracks, domestic canines, unimproved roads, and ravens were recorded in over 50% of the transects. The lack of desert tortoise sign was attributed in part to these disturbances. Roughly a third of the area was found to be no longer suitable for desert tortoises (Tierra Madre 1991).

Desert tortoise populations have virtually been extirpated to the south of the City of Lancaster (Judy Hohman, Fish and Wildlife Service, Ventura, California, pers. comm.). Occasional desert tortoise sign is still observed east of Palmdale, but not in Palmdale west of Hwy 14 (Palmdale Freeway) or south of Hwy 138 (Pearblossom Highway). No signs of desert tortoises were found in a survey of 68 square miles of northeastern Palmdale and at Saddleback Butte State Park (Feldmuth and Clements 1990).

Las Vegas illustrates regional trends for future growth in the eastern Mojave Desert. The City is projected to increase in population by more than 100%, from 674,000 in 1988 to 1,400,000 in 2030 (Clement Associates, Inc. 1990). Numbers of visitors are expected to similarly increase. The City of St. George, Utah, may increase in population by as much as 1000% in the next 35 years. In addition, the Southern California megalopolis is spreading north and east from metropolitan Los Angeles into the deserts of Kern, Los Angeles, San Bernardino, and Riverside counties. The desert portion of San Bernardino County, with a 1984 population of 192,100, is projected to reach 441,800 (a 230% increase) by the year 2010.

In the Colorado Desert, the Coachella and Imperial valleys are centers for continuing urban and agricultural growth, a process which dates back to the turn of the century (Berry and Nicholson 1984b). Here, most development does not impinge directly on important desert tortoise habitats. However, the proposed transfer of urban-generated wastes to desert landfills via rail through the Chuckwalla Bench Area of Critical Environmental Concern (RECON 1991) and the new prison in the Chuckwalla Valley bring urban threats to portions of the Colorado Desert.

Urban environments have indirect impacts on desert tortoise populations and habitat at their interface with the desert (Berry and Nicholson 1984b, Berry and Burge 1984, Lamb 1991). Dogs range

into the desert, often for several miles (see Predators: Non-natives). Unauthorized collecting of desert tortoises, dumping of trash, and removal of vegetation are common near urban development. Children and adults shoot firearms and use ORVs indiscriminately adjacent to towns. For example, Lamb (1991), in discussing ORV/off-highway-vehicle use in the eastern Mojave, reported that the "...greatest amount of unauthorized off-highway vehicle use occurs around urbanized areas such as Beaver Dam, Windy Acres, and Mesquite, Nevada."

B. Agriculture.

Agricultural development yields disturbance patterns similar in distribution and extent to urban development. However, no future projections for agricultural growth can rival the rates for urban centers. As of 1980, about 3,000 square miles of desert tortoise habitat had been developed for agricultural use in California, especially in the Antelope, Victor, Lucerne, Coachella and Imperial valleys, and around the Cantil-Koehn Dry Lake region (Berry and Nicholson 1984b). Other areas that have experienced additional development since 1980 include the Cadiz and Chuckwalla valleys and parts of the Colorado River Valley near Blythe in California (Berry and Nicholson 1984b); and Mesquite and the Virgin River Valley in Nevada, Arizona, and Utah (Lamb 1991).

Most agricultural developments, such as alfalfa farming, draw water from local or regional ground water aquifers and require clearing of native vegetation, plowing of previously undisturbed soils, and applications of pesticides and/or fertilizers. All such activities either kill desert tortoises directly, obliterate their habitats, lower primary productivity, or otherwise negatively impact wildlands. Even fields long fallow contain pesticides and fertilizers, along with compacted and disturbed soils. Old fields are often invaded by Mediterranean and Asian weeds and become sources of seeds. For example, Russian thistles blow from adjacent agricultural fields at Cantil into the Desert Tortoise Natural Area in eastern Kern County, California, where they are becoming established (BLM and California Department of Fish and Game 1988).

Desert tortoise deaths occurred as a result of jackrabbit poisoning in the Cantil, California, farming area in 1952 and 1953 (Berry and Nicholson 1984b). Populations of the marginate tortoise (*Testudo marginata*) are adversely affected in agricultural areas in Greece, where they are killed by machinery and herbicides (Stubbs 1989a). The Egyptian tortoise (*T. kleinmanni*) is also threatened by agriculture, related human settlements, dogs, and corvids (Mendelssohn 1990).

Pumping of ground water for agricultural and urban developments has caused local and widespread depression of the water table in numerous valleys and basins within desert tortoise habitat (see Berry

and Nicholson 1984b). For example, in the western Mojave Desert, depressions in the water table at Koehn Dry Lake and adjacent Fremont Valley were evident from the 1950's to the 1970's due to pumping of ground water from deep-water wells for cotton and alfalfa farming (Koehler 1977). Depression of the water table resulted in the death of mesquite trees along the edge of Koehn dry lake. By 1983, large fissures, which can function as giant pit-fall traps, formed in the earth. One such fissure was a mile-long, 15- to 20-feet deep, and varied from 6 inches to 50 feet in width. Similar fissures occurred at Rogers Dry Lake on Edwards Air Force Base in 1990-1991.

C. Garbage, Trash, and Balloons.

Turtles and tortoises are known to eat foreign objects, such as rocks, balloons, plastic, and other garbage (John Behler, Chairman of the Freshwater Turtle and Tortoise Group, Species Survival Commission, International Union for the Conservation of Nature, and New York Zoological Society, pers. comm; Karen Bjorndahl, pers. comm.). Such objects can become lodged in the gastrointestinal tract or entangle heads and legs, causing death. A desert tortoise was observed consuming trash from an abandoned campsite and fire ring adjacent to the Desert Tortoise Natural Area in 1991 (BLM files for Site 4, Desert Tortoise Natural Area Interpretive Center). Burge (1989) has found metal foil and glass chips in scat of wild desert tortoises. She also discovered a desert tortoise entangled by a rubber band caught in the mouth and around the forelegs. In still another case, string, which was caught around a desert tortoise's leg, resulted in the eventual amputation of the limb.

Unauthorized deposition of refuse occurs close to towns, cities, and settlements in remote, inaccessible areas. Remnants of 130 balloons were found on a square-mile study plot in the Lucerne Valley in 1990 (southern Mojave Desert, California), which is about 9 miles from the nearest town. Only one of the 130 balloons was a weather balloon; four were message balloons; and the remaining 125 were individual balloons, possibly released by children at schools during fairs or other celebrations. Balloons are found on study plots in remote parts of the eastern Mojave and Sonoran deserts also. Burge (1989) described how she answered letters and notes attached to balloons and learned that some balloons were released 100 to 200 miles from landing sites. Refuse such as bicycle tires, chains, lawn clippings, sheet rock, and more recently, plastic bottles with toxic wastes are not unusual sights. On the Ward Valley study plot in the northern Colorado Desert, California, bags of garbage apparently dropped from an airplane were found (Burge - BLM field notes).

D. Mortality and Collections Associated with Freeways, Highways, Paved and Dirt Roads, and Railroads.

Impacts of roads on desert tortoise populations are well documented in California and can be assumed to similarly affect desert tortoises elsewhere. Desert tortoises are frequently killed or collected on freeways, paved highways and roads, and dirt roads, resulting in depletion of adjacent populations (e.g., Boarman et al. 1992). A significant and parallel pattern of loss in terrestrial wood turtles (*Clemmys insculpta*) and box turtles (*Terrepene carolina*) was noted in southwest New England where a growing number of roads and highways have fragmented wood turtle habitat (Klemens 1989).

Desert tortoise populations are depleted up to a mile or more on either side of roads when average daily traffic is greater than 180 vehicles (Nicholson 1978a, 1978b). Numbers of juvenile desert tortoises on permanent study plots in California were significantly lower adjacent to well-used dirt and paved roads (Berry and Turner 1984). Significant differences in desert tortoise densities were also documented adjacent to Highway 58 in San Bernardino County, California (Boarman et al. 1992). Based on desert tortoise sign, a similar situation occurs along Highway 395 (LaRue 1992). The breeding cohort of desert tortoises was severely depressed on a U.S. Ecology study plot about 2 miles from Interstate 40 in eastern San Bernardino County, California (Karl 1989, and in Dames and Moore 1991). Even dirt roads with relatively low vehicle use can contribute to depressions in local desert tortoise densities (Berry et al. 1986a).

Railroads are similar sources of mortality for desert tortoises and other chelonians (U.S. Ecology 1989, Dames and Moore 1991, Mount 1986). Desert tortoises can get caught between the tracks, overheat, and die or be crushed on the tracks by trains. Railroad workers have reported finding dead desert tortoises between the tracks (U.S. Ecology 1989). Desert tortoise populations adjacent to railroads are probably depleted in the same way that desert tortoise populations are diminished adjacent to well-used dirt or paved roads. The effects of railroads on desert tortoises was examined at the U.S. Ecology study plot; however, the effects of the railroad could not be separated from the effects of the adjacent Goffs Road (Dames and Moore 1991).

E. Mining, Minerals, and Energy Development.

Exploration and extraction of locatable minerals, fossil fuels, geothermal resources, and other types of mineral resources occur in most desert tortoise habitats. The potential for fragmenting DWMAs with small and large disturbances from mining and mineral exploration and extraction is high for some areas and moderate to low for others. The types of impacts are numerous, including: (1)

cross-country travel by vehicles during the exploration phase; (2) construction of roads; (3) disturbance of the soil surface and vegetation for access to the mineral resources (shafts, mill sites, open pits, placer diggings, tailings, leach pits, etc.); (4) production of toxic products or byproducts; (5) development of small towns and settlements to support large mines; and (6) temporary (short- or long-term oil and gas leases) or permanent transfer of title of public lands to the private sector, and (7) refuse of stakes and wire from seismic testing.

Examples of the above-listed problems, including large-scale destruction of desert tortoise habitat, are obvious in the western Mojave Desert with the mining of gold, tungsten, and borax in the Rand Mountains, Atolia, and Boron, respectively. The new cyanide heap-leach process for obtaining gold has initiated a new era in surface disturbance throughout the Mojave region.

As of 1991, leasing for oil and natural gas exploration and development was less common in the Mojave region than development of hard-rock minerals. However, it is nonetheless a substantial threat. Major exploration in the 1970's in the Ivanpah Valley left behind an uncapped well, peripheral unmitigated damage to the habitat, and an unauthorized road (Berry and Nicholson 1984b). During the 1980's, several areas of 0.5 to a few acres were cleared and/or damaged by exploratory oil and gas wells in the proposed Fremont-Kramer DWMA. At one site, an ORV trail was established, mud was dumped from the well over several hundred square feet, and additional surface area was cleared and compacted to construct temporary living quarters (BLM files).

F. Utility and Energy Facilities and Corridors.

Most proposed DWMAs have one or more pole or power lines, natural gas pipelines, fiberoptic cables, and/or communication sites. In some States, the localities for utility and energy corridors are specified in land-use plans (e.g., BLM 1980). Construction, operation, and maintenance of facilities usually involves clearing of land, creation of access routes, and generally large-scale disturbances. Vegetation is removed or degraded, soils are disturbed, and trenches are dug. Disturbances are usually linear in nature and are similar to those described above for urbanization, agricultural uses, and roads.

The zone of disturbance in utility corridors can gradually increase from 50 to 100 feet to several hundred yards as the number of transmission lines increases. Natural gas pipelines are similar: the area of disturbed soils devoid of vegetation can be 125 feet or more in width.

The potential for utility lines and energy corridors to fragment habitat is obvious; less obvious are impacts that occur during

construction and from long-term maintenance. For example, the temporary opening of deep trenches for pipelines can form significant "pit traps" into which desert tortoises may fall (Olson et al. 1992, S. Hale, pers. comm.). Towers supporting transmission lines also provide predatory birds with new perching and nesting sites which are otherwise scarce in the generally treeless habitat of the Mojave region (see Predators: Native, below).

G. Military Operations.

Impacts to desert tortoises and their habitats caused by military activities fall into at least four categories: (1) construction, operation, and maintenance of bases and support facilities (air strips, roads, etc.); (2) development of local support communities, including urban, industrial, and commercial facilities; (3) field maneuvers; including tank traffic, air to ground bombing, static testing of explosives, littering with unexploded ordnance, shell casings, and ration cans; and (4) distribution of chemicals. The several military bases and test ranges in the Mojave Desert include Edwards, and George Air Force bases, Twentynine Palms Marine Air-Ground Combat Center, Fort Irwin National Training Center, China Lake Naval Air Weapons Station, the Mojave B and Randsburg Wash Test Ranges, and Cuddeback Aerial Gunnery Range. The Chocolate Mountains Aerial Gunnery Range is the primary base affecting desert tortoise habitat in the Colorado Desert.

Some military activities occurred outside the above designated bases during World War II and later. General Patton conducted extensive maneuvers using tanks in Nevada, California, and Arizona to prepare troops for the North African campaigns in the 1940's (e.g., see Berry and Nicholson 1984b, Prose 1986). Additional maneuvers occurred in 1964 in California as part of Desert Strike (Berry and Nicholson 1984b). Even today some military activities overflow base boundaries, damaging or destroying adjacent habitats.

Hundreds of square miles of the Ivanpah, Fenner, Chemehuevi, and Chuckwalla DWMAs were affected by tank maneuvers during the early 1940's. Desert tortoise populations and habitat are still recovering from these impacts that occurred almost 50 years ago. The effects of tank maneuvers on soil compaction are significant, as are changes in composition, abundance, and distribution of perennial plants (Prose 1985, Prose and Metzger 1985, Prose et al. 1987). In general, areas with intense disturbance (camps, roads, and parking lots) probably will require additional decades or centuries for recovery.

The construction of military bases, test facilities, and supporting civilian communities have substantially affected desert tortoise populations and habitat in entire valleys since about 1940. For example, with development of the Naval Ordnance Test Station

(presently the Naval Air Weapons Station) at China Lake in the 1940's and 1950's, human populations rapidly grew to about 20,000 people in Indian Wells Valley. Desert tortoise populations correspondingly declined to low levels by the late 1970's (Berry and Nicholson 1984a). Similar patterns were observed at Edwards Air Force Base and Twentynine Palms. At Edwards Air Force Base, the civilian population of about 13,000 people affected desert tortoise populations for more than 30 miles in any direction. Large numbers of desert tortoises were collected on the base, especially on runways, and relocated north of base boundaries (Berry and Nicholson 1984b).

Detailed reports on impacts to tortoises from military maneuvers are available primarily for the National Training Center at Fort Irwin (Krzysik 1985, Krzysik and Woodman 1991, Woodman et al. 1986) and to a lesser extent the Naval Air Warfare Center at China Lake (Kiva Biological Consulting and McClenahan and Hopkins Assoc. 1991).

Dramatic reductions in shrubs (especially cover of creosote), pulverization of soils, and high frequencies of weedy annuals were observed at Fort Irwin in areas heavily used by tanks (Krzysik 1985, Krzysik and Woodman 1991, Woodman et al. 1986). The most recent assessment of tank traffic and the impact of ordnance directly on desert tortoises was summarized by Krzysik and Woodman (1991):

> In 1983, desert tortoise density was low in the two main valleys used for training exercises, but by 1989 tortoise density decreased by an additional 62%. Training scenarios have increased dramatically in the northwest portion of the fort since 1985, and in this area tortoises have declined by 81%.

Military ORV use results in some habitat damage. However, little habitat damage from ORVs was reported on the Naval Air Weapons Station except during retrieval of ordnance with ORVs (Kiva Biological Consulting and McClenahan and Hopkins Associates 1991).

Military maneuvers, installations, and camps can encourage congregations of desert tortoise predators such as the common raven (see Predator: Natives, below). Stubbs (1989b), in describing threats to Egyptian tortoise populations in Israel and North Africa, stated that the brown-necked raven (Corvus ruficollis) was a predator of concern and that: "Army camps in the desert also serve to increase the raven population."

Explosions of ordnance, static tests, and air-to-ground bombing on or adjacent to military installations may affect desert tortoise habitat and populations. For example, a new bomb crater, phosphorus flares, and parachutes were discovered on the Chuckwalla Bench study plot in California during 1988 (Berry 1990, as amended).

Military activities associated with the Chocolate Mountains Aerial Gunnery Range were probably responsible. Nearby, two student pilots released twelve 500-pound bombs near a campsite with 10 civilians (Bernstein 1989, Coleman 1989, Hurst and Healy 1989, Katoaka 1989). The bombs left foot-deep craters 10- to 12-feet wide and set fire to yuccas, palo verdes, and creosotebushes.

Damage is also incurred by collectors of scrap metal from military operations and utility lines. On the Chuckwalla Bench, Milpitas Wash drainage, and on the Chocolate Mountains Aerial Gunnery Range, California, scrap collectors illegally travel off-road in search of metal to sell. In 1989, unauthorized travel caused so much habitat damage that the BLM closed some areas of the Chuckwalla Bench (BLM 1989b).

H. Off-Highway (OHV) or ORV - Recreation.

ORV use takes many forms: organized events such as the Fast Camel Cruise in the southeastern Colorado Desert, California; large- or small-scale competitive races involving up to thousands of motorcycles (e.g., the Barstow to Las Vegas motorcycle competition); and casual family activities. ORV activities are among the most destructive, widespread, and best documented of threats to the survival of desert tortoises and other vertebrates, and to the integrity of their habitats (Adams et al. 1982ga and b, 1984; Berry and Nicholson 1984b; Brattstrom and Bondello 1983; Bury 1987, Bury and Luckenbach 1983, 1986; Bury et al. 1977; Busack and Bury 1974; Luckenbach 1975; Sheridan 1979; Stebbins 1974, 1975; Webb and Wilshire 1983).

The list of impacts from ORV use is extensive, including: mortality of desert tortoises on the surface and below ground; collapsing of desert tortoise burrows; damage or destruction of plants used for food, water, and thermoregulation; damage or destruction of the mosaic of cover provided by vegetation; adverse effects to the general well-being of desert tortoises through water balance, thermoregulation, and energy requirements; noise pollution; impact, damage or destruction of soil crusts; soil erosion; proliferation of weeds; and increases in numbers and locations of wild fires.

ORV use in the desert has increased and proliferated since the 1960's (Adams et al. 1982a, Stebbins 1974). As of 1980, ORV activities affected approximately 25% of all desert tortoise habitat in California and 67% of habitat which supported densities estimated at more than 100 individuals/mi^2 (Berry and Nicholson 1984b). Substantial portions of desert tortoise habitat in southern Nevada are also affected (Berry and Burge 1984, Burge 1986).

Government documents provide ample evidence of severe declines in biomass of plants and vertebrates as well as desert tortoise densities in the western and southern Mojave deserts due to

OHV/ORV-related activities (Busack and Bury 1974, Bury et al. 1977, Berry and Nicholson 1984b, Berry 1990, as amended). Bury (1987) demonstrated that desert tortoise densities and health (measured by length-scaled body weight) also deteriorated as a result of ORV activities when contrasted to values from appropriate control areas.

In the Southwest, the BLM and some other governmental agencies have been (and continue to be) ineffective in preventing ORV competitive events and casual use from causing more habitat damage and loss in important desert tortoise habitats (Burge 1983, 1986, Woodman 1983, BLM 1989a, 1990a, Fish and Wildlife Service 1989a, 1989b, 1989c). For example, when competitive events are held, old routes are widened, new routes are formed, race participants and observers camp and park in unauthorized areas, race monitors are unable to prevent unauthorized activities, and garbage is not appropriately handled. In general, more habitat is damaged or destroyed with each new event. In 1989, the BLM and Fish and Wildlife Service monitored the annual Barstow-to-Vegas race and reported that motorcycles and other vehicles strayed beyond the designated course by an average of 30 feet, causing damage or loss of hundreds of acres of desert tortoise habitat in the eastern Mojave Desert (BLM 1989a, 1990a).

The BLM has been unable to protect important habitats in the Rand Mountains and Fremont Valley of eastern Kern County, California from damage by casual recreational vehicle users (Goodlett and Goodlett 1991, 1992). This area, which is part of the proposed Fremont-Kramer DWMA and adjacent to the Desert Tortoise Natural Area, has experienced intensive ORV-oriented recreation since 1973, and has the highest rate (40.7%) of vandalism to desert tortoises (Berry 1990, as amended). Between 1989 and 1990, BLM closed much of the area to recreational use on an emergency basis to protect desert tortoises, but then reopened a network of "designated routes" in November of 1990. After route designation, vehicle-oriented recreationists traveled on closed routes and vandalized signs marking closed routes. Motorcyclists illegally traveled parallel to designated routes, creating new tracks and trails and widening existing routes. Just prior to, during, and after the Thanksgiving holiday in 1991, the level of unauthorized use was extremely high (Goodlett and Goodlett 1992). For example, of 65 vehicles observed in a 4-hour period, only 38% were following regulations and traveling on authorized routes, whereas 62% traveled cross-county or were on closed routes. In a second experiment, 39 transects (each of which was 500 feet long) were established perpendicular to designated, open routes, and data were recorded on numbers of trails and tracks crossing the transects. Eighty-five trails and 553 recent, unauthorized tracks were recorded. An average of 16 unauthorized trails or tracks crossed each transect, or one track every 31 feet. In a third experiment, 17 trails signed as "closed" were raked to remove tracks before Thanksgiving and then re-visited a week later. There were 195 new tracks or 11.5 unauthorized tracks per closed route.

I. Livestock Grazing.

Negative interactions between grazing and desert tortoises are not restricted to the American Southwest. In the habitat of *Testudo kleinmanni* in North Africa and Israel, livestock grazing changes the composition of desert vegetation and the altered vegetation is less favorable to rodents (Stubbs 1989b). Rodent burrows are vital to the survival of the species during summer. Livestock grazing has also contributed to declines in *Chelonoidis chilensis* (Waller et al. 1989, pers. comm.). In reference to a proposed nature preserve in Israel, Mendelssohn (1990) stated that "...areas were badly affected or even destroyed by overgrazing." Mendelssohn (1983) adds:

> The...Egyptian tortoise...is endangered by much of its habitats being turned into agricultural land, and, in the remaining areas, by overgrazing by Bedouin herds which destroys the protective vegetation and exposes the turtles to predation by ravens.

Sheep, cattle, burros, and horses can affect desert tortoises and their habitats directly and indirectly. The degree of impact depends on a number of factors including, but not limited to: resiliency of soil and vegetation types, type of stock, stocking rates, season of use, and years of use with and without rest. Other factors which interact with livestock grazing and can affect the degree and extent of impacts include: introduction and spread of weeds, previous grazing-induced changes in vegetation, fire, drought, and other land uses.

Livestock can trample, injure, or kill desert tortoises either above ground or while in burrows. Trampling of live desert tortoises by cattle has been observed in the eastern Mojave Desert (M. Coffeen pers. comm., T. Duck pers. comm) and juvenile desert tortoises have been trampled in the western Mojave Desert (Berry 1978a, Berry and Shields et al. 1986, Nicholson and Humphreys 1981; Craig Knowles, BLM field notes for Stoddard Valley). Livestock can also trample desert tortoise nests. Feral burros damaged nests of giant tortoises in the Galapagos, thereby reducing nesting success (Fowler de Neira and Roe 1984).

Livestock can also trample burrows and other cover sites. BLM study plot files (journal notes, 35-mm slides) for desert tortoises contain numerous examples of burrows trampled by cattle and sheep. For example, sheep damaged 10% and destroyed 4% of 164 freshly-used desert tortoise burrows on a study plot in the western Mojave Desert during less than 2 weeks of grazing (Nicholson and Humphreys 1981). Juvenile desert tortoise burrows are particularly vulnerable to trampling because of their locations and the shallow soil covering protecting the tunnels.

Livestock also trample shrubs (e.g., creosote) used as sites for desert tortoise burrows and pallets, and which provide protection from predators and temperature extremes. Cattle and sheep have been observed breaking apart large creosote bushes while feeding on annual plants in coppice mounds and when seeking shade and bedding sites (Berry 1978, Jeff Aardahl, pers. comm.). Cattle have also been observed swinging their heads/horns back and forth in creosote bushes, breaking apart the branches (Harold Avery, BLM, Riverside, pers. comm.). Once the branches were broken, the cattle then ate the annual plants in coppice mounds at the base of the creosote. The overall result was a loss of shrub biomass and canopy cover and reduction in shade-giving properties, etc. Burge (1977) and Berry and Turner (1984, 1986) described the importance of shrubs in providing cover for burrows and shade for desert tortoises. For example, most juvenile burrows (80%) were sheltered by shrubs, particularly creosote and burro bush, (*Ambrosia dumosa*).

Grazing can cause soil erosion and soil compaction similar to vehicle-induced compaction (Arndt 1966, Ellison 1960, Klemmedson 1956). Data from 25 grazing studies showed that filtration rates decrease by about 25% in areas of light to moderate grazing, and about 50% in areas of heavy grazing (Gifford and Hawkins 1978). Runoff of precipitation in heavily grazed areas was 150% greater than in areas of moderate grazing and 1000% greater than in areas of light grazing (Sharp et al. 1964). When grasses were continually grazed, their root systems shrink, and their capacity to hold soil from erosion was reduced (Johnson 1983). Livestock grazing also has negative impacts on soil crusts and cryptogams (e.g., Avery et al. 1992).

Livestock grazing can and has altered perennial vegetation in a number of ways. Livestock grazing has caused, or contributed substantially to, the reduction and loss of native perennial grasses (e.g., members of the genera *Bouteloua*, *Hilaria*, *Stipa*, *Oryzopsis*, *Poa*, *Muhlenbergia*, *Sporobolus*) in the desert as well as in other parts of the western United States (e.g., Bentley 1898; Frenkel 1970; Humphrey 1958, 1987; Rowlands, unpubl.; BLM 1980). Perennial grasses in many areas have been replaced by woody shrubs, often with an understory of non-native annual grasses introduced from Europe and Asia. Livestock play an important role in proliferation of non-native weeds such as *Erodium cicutarium*, *Schismus barbatus*, *S. arabicus*, *Bromus*, and *Salsola iberica* (Kay, Meyers, and Webb 1988). This profound change in structure of vegetation has contributed to invasion of weeds and an increase in fire (see below).

Livestock grazing has affected composition of shrubs used for cover by desert tortoises. For example, sheep reduced some perennial shrubs by 65 to 68% in volume and by 16 to 29% in cover (Webb and Stielstra 1979). In areas consistently and heavily grazed by sheep, cover of many species of shrubs was substantially reduced and creosote and weeds were often the predominant vegetation

(Webb and Stielstra 1979). The following shrubs can be reduced in numbers and vigor in such grazed sites: burro bush, goldenhead (*Acamptopappus sphaerocephalus*), Anderson thornbush (*Lycium andersoni*), spiny hop sage (*Grayia spinosa*), winter fat (*Ceratoides lanata*), and Mojave aster (*Machaeranthera tortifolia*).

Livestock grazing can affect quality and quantity of plant foods available to desert tortoises, and thereby affect nutritional intake. Data gathered through spring of 1992 indicate that desert tortoises are generally quite selective in their choices of foods (Burge 1977, Nagy and Medica 1986, Turner et al. 1987, Avery 1992, Esque 1992, 1994, Henen 1992, Jennings 1992, 1993). Desert tortoises may have individual preferences and seek out particular species to eat. In some areas, the preferences are clearly for native plants over the weedy non-natives. Food preferences may vary by age, sex, and locality.

The relation between food availability and growth, reproduction, and general well-being of desert tortoises has been the discussion of many published papers (e.g., Tracy 1992). For example, juvenile desert tortoises exhibit increased growth in years when rainfall and forage are abundant (Medica et al. 1975). Desert tortoises also produce more eggs when more food and water are available than when these resources are scarce (due to drought or grazing pressure) (Turner et al. 1986, 1987, Henen 1992).

Juvenile desert tortoises may be at greatest risk in grazed areas, because they are likely to be too small to reach remaining food items concealed within shrubs after livestock have used an area. Juveniles are less likely to travel the distances necessary to locate remaining patches of forage. If soils have been churned by trampling, juveniles may not be able to travel easily across the landscape. In addition, juveniles may require diets with more protein than adults (see Adest et al. 1989 for the bolson tortoise, also Troyer 1984).

The most substantial impacts to vegetation, soils, and desert tortoises likely occur at and in the vicinity of heavy-use sites where livestock are watered, bedded down, or trailed. The loss of cover and changes in vegetation are often evident for many acres around each cattle watering trough or tank. Biologists have observed trails leading to stock-watering sites miles from the actual waters. Sheep bedding and watering areas also receive substantial impacts (Nicholson and Humphreys 1981). Loss of cover can increase vulnerability of desert tortoises to predation (see below).

J. Invasion and Establishment of Weedy and Non-Native Plants.

The relationships among livestock grazing, invasion of non-native plants, and fire are complex. From a global perspective, invasions by non-native grasses are most severe in the arid and semi-arid western United States (D'Antonio and Vitousek 1992). Cheatgrass

(*Bromus tectorum*) for example, spread throughout the Great Basin in conjunction with the introduction of sheep and cattle.

Many species of non-native plants from Europe and Asia have invaded desert tortoise habitats in the Mojave and Colorado deserts and have become common to abundant in some areas, particularly where disturbance has occurred and is ongoing. Some of the more common non-native or native weedy species found within the Mojave region include: bassia (*Bassia hyssopifolia*), sand bur (*Ambrosia acanthicarpa*), western ragweed (*Ambrosia psilostachya var. californica*), common spikeweed (*Hemizonia pungens*), pineapple weed (*Matricaria matricarioides*), fiddleneck (*Amsinckia intermedia, A. tessellata*), flixweed (*Descurania sophia*), tumble mustard (*Sisymbrium altissimum*), London rocket (*Sisymbrium irio*), Russian thistle (*Salsola iberica*), redstem filaree (*Erodium cicutarium*), turkey mullein (*Eremocarpus setigerus*), and horehound (*Marrabium vulgare*) (in part from Tierra Madre 1991, and BLM files). Several species of annual grasses are also important, including: foxtail chess or red brome (*Bromus rubens*), cheat grass or downy brome (*Bromus tectorum*), barley (*Hordeum glaucum, H. jubatum, H. leporinum*), Mediterranean or split grass (*Schismus barbatus*), and Arab grass (*S. arabicus*).

The above weeds--particularly filaree, foxtail chess, and cheat grass--thrive in many open deserts which have been or are (1) grazed by livestock, particularly sheep; (2) disturbed by OHV/ORVs and cross-country travel; (3) used for military maneuvers; and (4) used for settlements, townsites, or air-strips. Weedy species, which lack adaptations for germinating in thickly crusted desert soils, gain entry when crusts are broken. Certain soil types, such as aeolian sands, are particularly vulnerable to such invasions.

As non-native plant species become established in some areas, some native perennial and annual plant species decrease, diminish, or die out (D'Antonio and Vitousek 1992). For example, under pressure from livestock grazing, many native perennial bunch grasses have declined, died out, and been replaced with such species as foxtail chess (Robbins et al. 1951). The native bunch grasses include, but are not limited to: desert needle grass (*Stipa speciosa*), Indian rice grass (*Oryzopsis hymenoides*), bush muhly (*Muhlenbergia porteri*), the grama grasses (*Bouteloua sp.*), fluffgrass (*Erioneuron pulchellum*), and members of the genera Poa and Sporobolus. Many areas formerly occupied by the native grasses have been filled by annual grasses and weeds from Europe and Asia.

Some botanists view non-native species as aggressive competitors capable of replacing native species (Frank Vasek, pers. comm., Webb and Stielstra 1979, D'Antonio and Vitousek 1992). Loss of native plants and replacement by weedy, non-native plants has resulted in what some call disclimax vegetation (Vasek, pers. comm.). Native plant populations in disturbed habitats have been in a weakened condition for decades, and are more vulnerable to competition than at any other time in the historic past (Vasek, pers.

comm.). Drought conditions in the last few years have placed additional pressures on native plant populations.

Few quantitative data are available to document patterns of successful invasion of non-native plants in the northern Mojave; however, vegetation samples from Rock Valley, Nevada, clearly show a remarkable increase in abundance of foxtail chess (Figure D1). Furthermore, expansion of foxtail chess does not correlate with population sizes of native plants (Figure D2), suggesting that foxtail chess is successfully invading the Mojave, but may not be competitively displacing native plants. In some areas, the bromes have become so abundant that they are capable of fueling fires that threaten the very structure of the desert as a shrubland (see Section 5.K. below). A prime example is the Pakoon Basin in northern Arizona (Lamb 1991).

K. Fire.

Fire has the potential to be an important force governing habitat quality and persistence of desert tortoises. Impacts of fire on desert tortoises have not been well documented; however, a few accounts provide some evidence that animals are injured or killed by fire (e.g., Woodbury and Hardy 1948, Richard Franklin pers. comm.). Remains of 14 desert tortoises thought to have been killed by a fire 2 years earlier were found near Bunkerville, Nevada, in December 1942 (Woodbury and Hardy 1948). Stubbs (1981a, 1981b, 1984) provided substantial evidence of the serious impacts of fire on a population of *Testudo hermanni* in Greece in alyki heaths, which is similar in appearance to the saltbush or alkali sink communities in California deserts. Fires maim or kill tortoises in Greece as surely as they do in the United States if the tortoises are above ground or exposed in shallow burrows.

With the help of Richard Franklin (BLM, Riverside, California), data were assembled from BLM files in areas where desert tortoises occur in Utah, Arizona, Nevada, and California. In excess of 5,000 fires occurred in the four-state region, burning more than 1 million acres (Table D1).

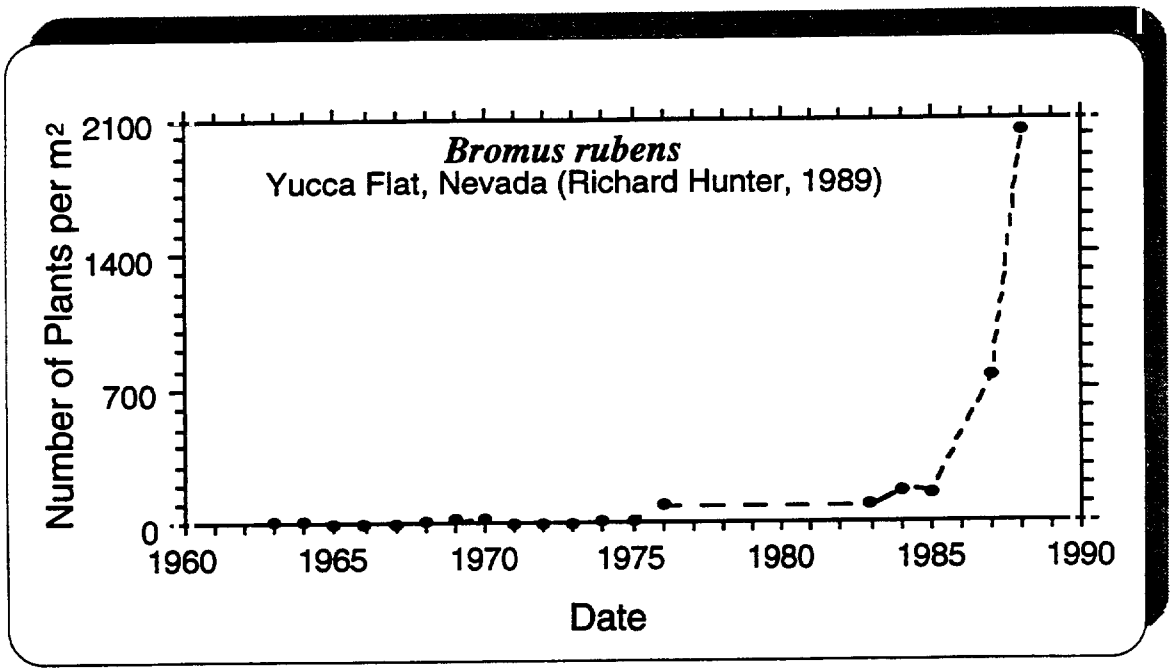


Figure D1. Historical increase in Bromus rubens in Yucca Flat, Nevada as a function of time (Hunter 1989).

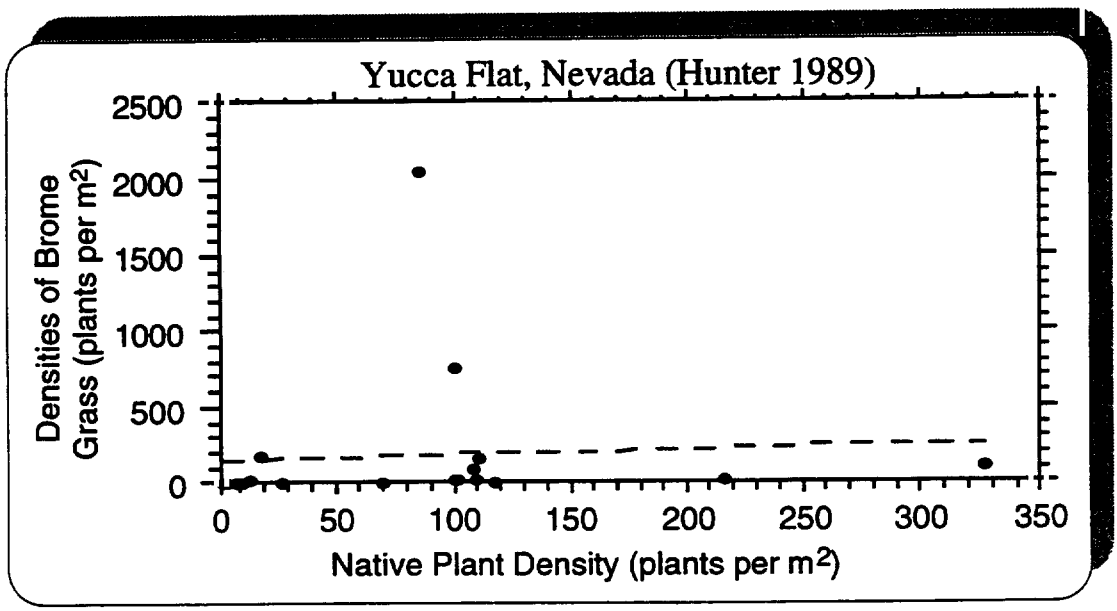


Figure D2. Relationship of densities of brome grass to native plant densities at Yucca Flat, Nevada.

Table D1. Number of fires and areas burned from 1980 to 1990 in the Mojave Desert.

State	No. of fires	No. of acres
Utah	830	49,944.6
Arizona	745	102,031.8
Nevada	2,114	159,275.8
California	1,437	243,316.9
Total	5,126	554,569.1

Most fires during the 1980's occurred in Nevada, but more habitat was burned in California (Figure D3). During the 1980's, the trend was towards an increasing number of fires in California, compared with a downward trend in the number of fires in Nevada (Figure D3, Tables D2 and D3). These trends were not due to lightning, and there was no significant trend in the number of fires caused by lightning in California or Nevada (Figures D3 and D4). Thus, fires directly caused by humans explain trends in both California and Nevada. The frequency of fires in California is significantly related to winter rainfall (Table D3). In years when winter rainfall exceeded eight centimeters, more fires occurred in the subsequent spring and summer seasons (Figure D5, Table D4). Rainfall is responsible for increased plant production, which in turn can produce more fuel for fire (Figure D5, see section on invasion of non-native weeds, above). Fires are more prevalent in areas where European and Asian weeds are successfully established. Ironically, in years with high rainfall that could produce greater amounts of potential food for desert tortoises, more fires occur which directly endanger desert tortoises and destroy shrub cover necessary for suitable desert tortoise habitat. Fires are associated with changes in annual and perennial desert vegetation not necessarily associated with changes in climate (Brown and Minnich 1986; Humphrey 1963, 1974; O'Leary and Minnich 1981, Reynolds and Bohning 1956). The relations among fire, disturbance, and changes in annual plant composition are complex. Biomass of weedy species has increased remarkably in deserts and desert tortoise habitat due to disturbance from vehicles, grazing, agriculture, and urbanization, etc. (Figure 5, see transect data in Berry 1990 as amended). Weedy, non-native grasses such as red brome, cheat grass, and split grass; and forbs increasingly blanket the desert floor, resist decomposition, and provide flammable fuel for fires. Once fires occur, they may improve opportunities for invasion and increases in the weeds. For example, Brown and Minnich (1986) reported that "...postfire herb cover was 23% greater in burned than unburned stands ...[and]...most cover was of exotic European annuals..."

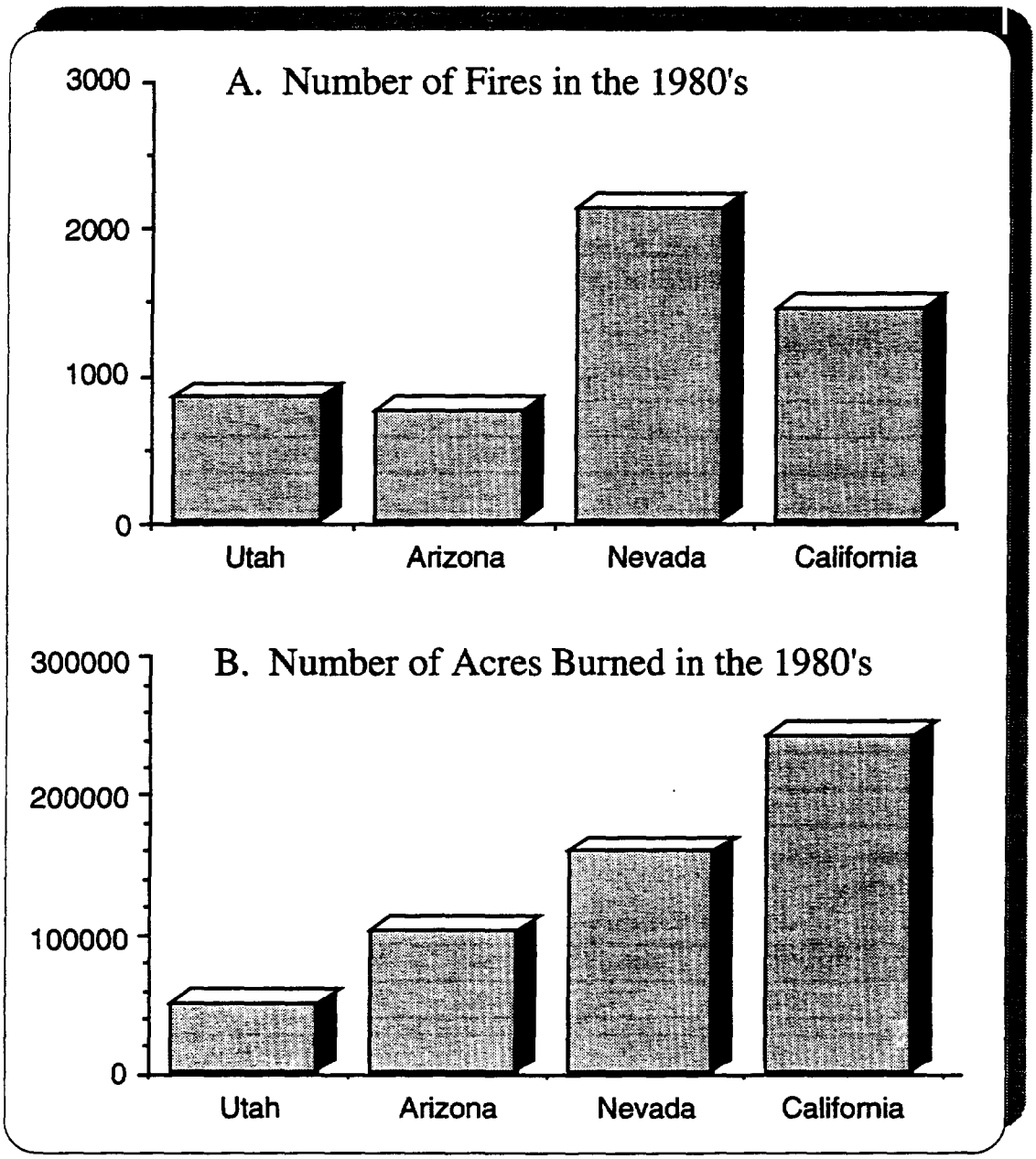


Figure D3. Number of fires and acres burned in the Mojave Desert between 1980 and 1990.

Table D2. Results of a regression analysis of the number of fires occurring in the Las Vegas District as a function of time (year in which the fire occurred).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Intercept	1	34285.461	34285.461		
year	1	23476.809	23476.809	9.356	.0136
Residual	9	22584.100	2509.344		

Dependent: no. of fires

Model Summary
Dependent: no. of fires

R-Squared	.510	Adj. R-Squared	.455	RMS Residual	50.093

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	1	23476.809	23476.809	9.356	.0136
Error	9	22584.100	2509.344		
Total	10	46060.909			

Model Coefficient Table
Dependent: fires

	Beta	Std. Error	t-Test	P-Value
Intercept	1501.682	406.259	3.696	.0049
year	-14.609	4.776	-3.059	.0136

Table D3. Results of a regression analysis of the number of fires occurring in the California Desert District as a function of time (year in which the fire occurred) and whether or not winter rainfall was above or below eight centimeters (rainfall category).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
year	1	20384.861	20384.861	14.561	.0051
rain category	1	8055.276	8055.276	5.754	.0433
Residual	8	11199.806	1399.976		

Dependent: No. of Fires

Model Summary
Dependent: No. of Fires

R-Squared	.649	Adj. R-Squared	.562	RMS Residual	37.416

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	2	20734.921	10367.461	7.405	.0151
Error	8	11199.806	1399.976		
Total	10	31934.727			

Model Coefficient Table
Dependent: No. of Fires

		Beta	Std. Error	t-Test	P-Value
Intercept		-1201.322	350.189	-3.430	.0089
year		15.897	4.166	3.816	.0051
rain category	below 8	-70.955	29.580	-2.399	.0433
	above 8	0.000	•	•	•

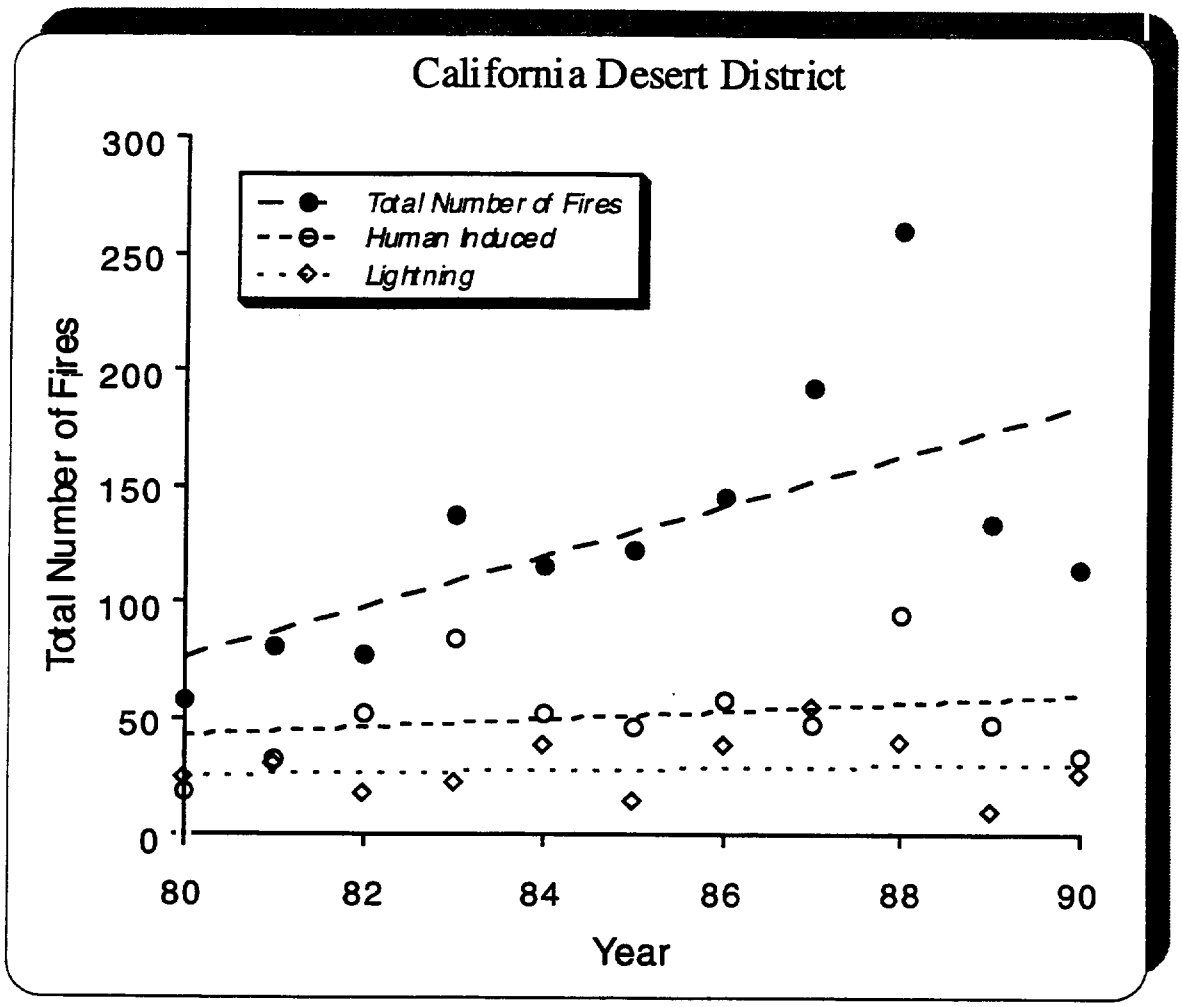


Figure D4. Number of fires occurring between 1980 and 1990 in the California Desert District of the BLM. Fires are presented as those produced by lightning, humans, and the total of lightning and human-induced fires.

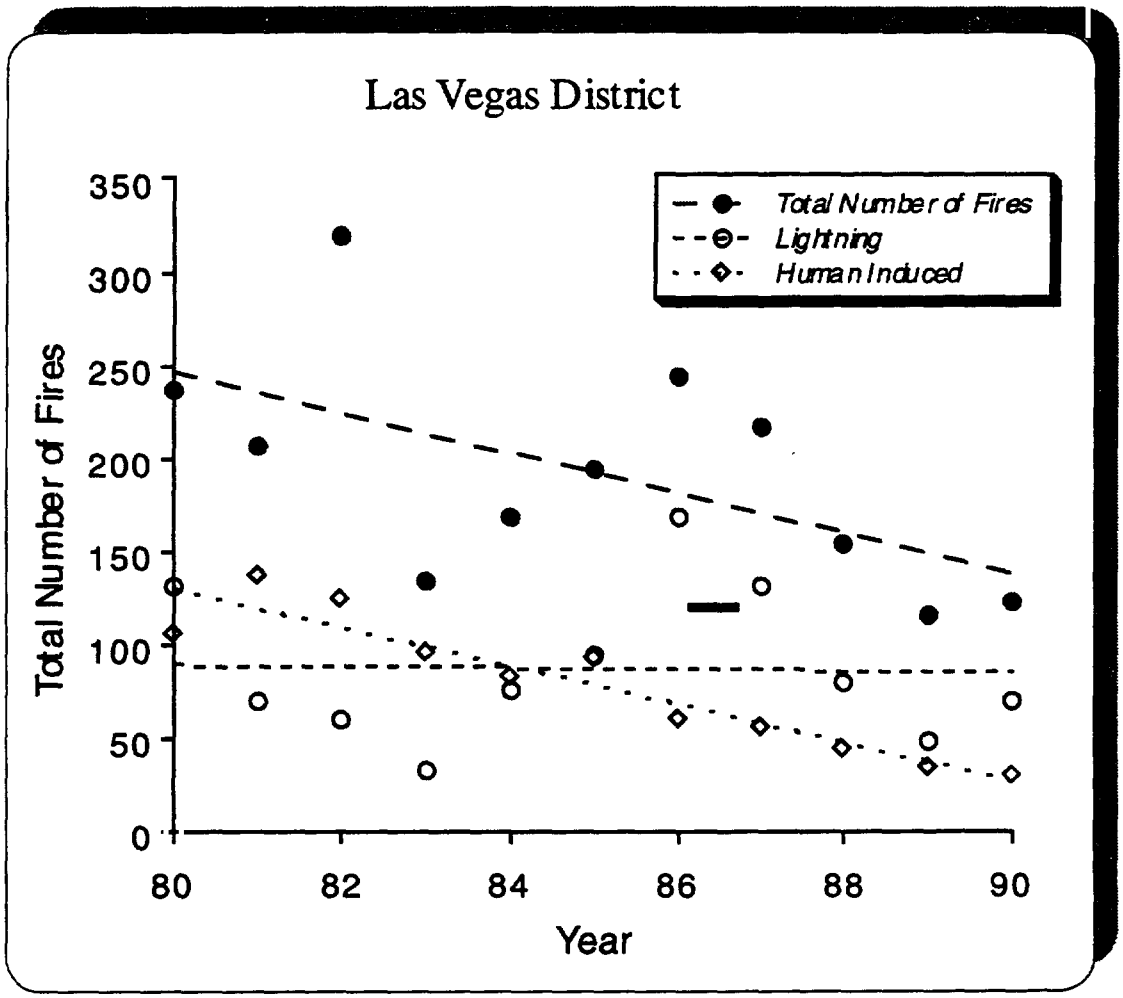


Figure D5. Number of fires occurring between 1980 and 1990 in the Las Vegas District of the BLM. Fires are presented as those produced by lightning, humans, and the total of lightning and human-induced fires.

Table D4. Results of a regression analysis of the number of fires occurring in the Las Vegas District as a function of time (year in which the fire occurred).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
year	1	20384.861	20384.861	14.561	.0051
rain category	1	8055.276	8055.276	5.754	.0433
Residual	8	11199.806	1399.976		

Dependent: No. of Fires

Model Summary
Dependent: No. of Fires

R-Squared	.649	Adj. R-Squared	.562	RMS Residual	37.416

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	2	20734.921	10367.461	7.405	.0151
Error	8	11199.806	1399.976		
Total	10	31934.727			

Model Coefficient Table
Dependent: No. of Fires

		Beta	Std. Error	t-Test	P-Value
Intercept		-1201.322	350.189	-3.430	.0089
year		15.897	4.166	3.816	.0051
rain category	below 8	-70.955	29.580	-2.399	.0433
	above 8	0.000	•	•	•

Desert perennials are poorly adapted to burning and are poor colonizers (Tratz and Vogl 1977, Tratz 1978). Creosote, for example, can require hundreds of years to recolonize and recover (Vasek 1980, 1983). Fuel loads provided by canopies of split grass and brome make it more likely for fire to become hot enough to damage shrubs. Ultimately, fire can change the character of desert shrublands into Mediterranean grass and weedlands. Some shrublands have already been converted to annual grasslands in parts of the Apple, Stoddard, and Victor valleys in the southern Mojave Desert (R. Franklin, pers. comm.) and in the Pakoon Basin of northwestern Arizona (Lamb 1991). In the latter area, 88,152 acres of habitat burned from 1980 to 1990. Conversion of shrublands to annual grasslands can be devastating for desert tortoises, which depend upon shrubs for cover.

Relations among fire, rain, domestic grazing, proliferation of weeds, and destruction of desert tortoise habitats are complex; but understanding these relations is essential to promoting long-term habitat recovery. Grazing can promote invasion of weeds, which can enhance the destructive forces of fires. For example, grazing of sheep in California deserts is authorized by the BLM when winter rains produce sufficient poundage of winter annuals. Thus, rainfall simultaneously provides opportunities for sheep grazing, which in turn encourages proliferation of weeds and provides fuel for fires. Rainfall, especially when above the norm, virtually always encourages fires in disturbed habitats. Many desert fires are ignited by humans, thereby turning a "bounty" of potential desert tortoise foods into a season with higher potential for fires and habitat destruction.

L. Harvest and Vandalism of Vegetation.

Cacti and tree yuccas (*Yucca brevifolia, Y. schidigera*) are the primary targets of both legal and illegal harvesters. Harvesting operations impose much the same negative impacts as ORV activities: crushing of desert tortoises and their burrows, removal of vegetative cover, compaction of soils, and inhibition of annual and grass germination (Berry and Nicholson 1984b). Harvesting of yuccas can be viewed as a form of desertification because of the loss of cover and structure in the plant communities and the long period required for recovery.

Berry and Nicholson (1984b) summarized the data on yucca harvesting in California through the early 1980's. In recent years, San Bernardino County has modified the permitting process to enhance protection of the environment, but has continued to issue permits for yucca harvests on private lands in the eastern Mojave and northern Colorado deserts; notably in the Fenner, northern Ward, and Chemehuevi valleys. Several dozen square miles of private lands have recently been harvested both legally and illegally, and some illegal harvests occurred on public lands (U.S. Ecology 1989).

Vandalism of vegetation is common in some parts of the desert. Tree yuccas and cacti are frequent targets and are shot or set on fire, sometimes setting off wild fires (R. Franklin, pers. comm.). For example, use of semi-automatic and automatic weapons to vandalize vegetation is increasingly frequent in the southern parts of the Needles Resource Area (Chemehuevi DWMA) and "a...pipe bombing was associated with more shooting of structures and cactus in the Turtle Mountain area" (BLM 1991b).

M. Predation.

1. Native predators. Many species of predators prey on desert tortoises at different stages of their life cycle, including predation on eggs by Gila monsters (Beck 1990), destruction (and probably consumption of eggs) by kit foxes and coyotes (Turner et al. 1987), predation of juvenile and immature desert tortoise by ravens (Berry 1985, Woodman and Juarez 1988, Farrell 1989), and predation of immature and adult desert tortoises by golden eagles (Berry 1985). Many authors have reported predation by ophidians, felids, canids, and mustelids.

Natural predation in undisturbed, healthy ecosystems is generally not an issue of concern. Under certain situations, however, the level and type of predation becomes a management issue, and action must be taken to control the predator(s). The most obvious example is when numbers of desert tortoises become precariously low in local areas or regions, and any loss of individuals is likely to threaten that population. Predation rates may be altered when natural habitats are disturbed or modified. For example, densities of predators may increase, food habits of predators may be altered so that desert tortoises become more frequent components in the diets, and predators may be able to prey upon desert tortoises more easily when cover has been reduced.

The most important predators of desert tortoises at this time are the common raven (*Corvus corax*) and the coyote (*Canis latrans*). Based on data from over 1,000 remains, ravens generally kill juvenile desert tortoises with a carapace length of less than 110 mm (Campbell 1983, Berry 1985, Woodman and Juarez 1988). The evidence that ravens are preying upon and not scavenging juvenile desert tortoises is three-fold. First, ravens have been observed killing juvenile desert tortoises (Tom Campbell, Jim Farrell, Ted Rado, and others, pers. comm.). In contrast, scavenging of juveniles has not been observed (although scavenging of larger road-killed desert tortoises has been documented).

Second, large numbers of young desert tortoise remains show signs consistent with raven predation. Many remains show puncture wounds made by ravens' beaks or have entry wounds on the carapaces or plastrons where ravens pecked through the shells and

withdrew the organs (Berry 1985). The patterns of damage to the shell and removal of heads, legs, and girdles are consistent from one geographic region to another and from one species of tortoise to another (see Geffen 1990, for *Testudo kleinmanni*). The puncture wounds and openings in the shell must have been made when the tortoise was alive or within minutes of death, when the shell was soft and pliable and could be opened without fracturing it. Third, large numbers of young desert tortoise remains are found in and at the base of raven nests, as well as near perches. Concentrations of shells have been discovered along fence posts (Campbell 1983), at the bases of known raven perches and nests (Woodman and Juarez 1988), and along transmission line towers (Farrell 1989). For example, between 1987 and 1990, 564 shells of carapace length less than 110 mm were collected in California from 1987 to 1990 on study plots, along powerlines, and at raven nests and perch sites. Of this total, 215 (38%) were found on study plots and 349 (62%) were found associated with raven perch or nest sites, most of which were along powerlines.

In spring 1991, a case of probable raven predation occurred at a research site on the National Training Center, Ft. Irwin, California (D. Morafka, pers. comm.). In early 1990, two contiguous predator-proof enclosures were established for neonate desert tortoises. One enclosure had a roof of chicken-wire screen to prevent avian predation, and the other did not. In late summer and autumn 1990, approximately 30 juveniles hatched inside the roofed enclosure, 18 in the outside enclosure, and another 12 were free ranging. During a 2-week period in spring 1991 (29 April to 9 May), an avian predator, presumably a raven, preyed upon and killed the 18 desert tortoises in the open enclosure. Of the 12 free-roaming desert tortoises (each with a radio transmitter) outside the enclosures, 8 were found dead. All shells had punctures either through the carapace or plastron or both in patterns consistent with raven predation (Campbell 1983, Berry 1985, and others). The shells were within a few hundred feet of the sites where desert tortoises were last seen alive.

Raven predation on juveniles can be a threat to the long-term persistence of desert tortoise populations. In California, desert tortoise study sites that show high percentages of raven-killed juveniles also show significant changes in size-age class structure of populations from the 1970's to the 1980's (Berry et al. 1986a and b). The data show significant declines in percentages of live juveniles desert tortoises as well as declines in recruitment of juvenile and immature desert tortoises into the young adult size-age classes. Ray et al. (1992) developed a simple model to evaluate spatially structured raven predation on juvenile tortoises. This model predicts that ravens must increase mortality of juveniles 5 years old by 25% before a discrete reduction in population growth from 1.02 to 1.00 can occur.

The extent of raven predation varies regionally and appears to be correlated with densities of raven populations. Berry (1985)

demonstrated that the proportion of juvenile shells showing evidence of raven predation was significantly higher in the western Mojave than the eastern Mojave and southern Colorado deserts. This pattern is consistent with raven surveys in which large numbers of raven sightings were recorded in the western Mojave, intermediate numbers in the eastern Mojave, and relatively few in the southern Colorado deserts (Knowles et al. 1989a, 1989b). Considerable predation also occurs in the eastern Mojave Desert. For instance, most of the 248 desert tortoise remains collected in 1988 at or near three active raven nests and one foraging site in the eastern Mojave were estimated to have died that year (Farrell 1989).

Populations of common ravens apparently have been increasing for many decades. Numbers of ravens observed during Fish and Wildlife Service breeding bird surveys in the Mojave Desert increased by 1528% between 1968 (the year the surveys were initiated) and 1988 (Fish and Wildlife Service, Laurel, MD; cited in BLM 1989). Increases of 474% were also documented for the Colorado Desert during the same time period. Probable causes for population increases are increased availability of foods (e.g., landfills, sewage ponds, dumpsters, highways, cities) and water (e.g., sewage ponds, agricultural fields, golf courses). Artificial sources of food and water help sustain more individuals during times of low natural resource availability, such as winter and summer. Such artificial food sources also probably facilitate larger clutch sizes or increased frequencies of clutches and greater fledgling success for the common raven. In addition, human-made structures have increased numbers and distribution of perches and nest sites (power and telephone poles, bridges, bill boards, freeway overpasses, etc.). The presence of human refuse in almost a quarter of 226 raven pellets collected from the eastern Mojave Desert in May 1991 demonstrates the close relationship between humans and ravens (Camp et al. 1992). In another example, ravens spent 51% of non-flight time along transmission towers, railroads, telephone poles, and non-native tamarisk shrubs in the eastern Mojave (Sherman and Knight 1992).

A parallel issue involves Egyptian tortoises, which are preyed upon by the hooded crow (*Corvus corone sardonius*) and the brown-necked raven (*C. corax ruficollis*) in Israel, Egypt, and elsewhere in North Africa (Geffen and Mendelssohn 1989, Mendelssohn 1990, Stubbs 1989b):

> When I came to Palestine in 1933 the brown-necked raven was not a rare, but neither was it a common, desert bird. Each pair has a territory of about 100 kilometers^2 and there were small nomadic flocks of immatures and non-breeding adults. After the foundation of the State of Israel, when large scale immigration, agricultural, and settlement development began, the brown-necked raven became synanthropic and started a population explosion.

> Formerly a cliff-nesting species, it now began to nest on trees, on power line pylons, and on and in large buildings (hangars, etc.). ...The hooded crow has recently been removed from the list of protected species because of its population explosion and damage to agriculture. Brown-necked ravens are still on the list of protected species but in case of damage are controlled by rangers of the Nature Reserves Authority.
>
> [The hooded crow] was formerly distributed only in areas close to the Mediterranean, where human settlements were quite dense and high trees for nesting were available. Predation on young *Testudo graeca floweri* (a semi-desert subspecies) has been observed several times. Following human settlements they advanced eastwards penetrating into the area of *T. kleinmanni* and recently reaching Beer Sheva, 50 kilometers from their former distribution area. This synanthropic species can reach very high densities, notwithstanding that breeding pairs are territorial, but feed also outside their territory, as do the flocks of immatures and non-breeding adults. Recent research carried out not far from Tel Aviv, has shown that there can be up to 17 breeding pairs in 1 kilometer^2!
>
> [The brown-necked raven]...became also synanthropic and invaded the areas of *T. kleinmanni* from the east, so that now both species are sympatric there. Lack of trees so far prevents these corvids from exploiting much of the area, but I have seen even the hooded crow, not such a good flyer as the brown-necked raven, flying several kilometers from the next settlement over the *T. kleinmanni* habitat, apparently foraging (Mendelssohn 1990).
>
> Shells of young tortoises of both species, some still bloody from predation, are often reported. The disappearance of *T. graeca floweri* from some areas is likely due to crow predation, and there is increased concern about the impact of brown-necked ravens on Egyptian tortoises (Mendelssohn 1990).

The above documentation is sufficient to demonstrate that corvids in general are extremely efficient and demanding predators on young or small tortoises throughout the world. Their impact, relative to other predators and to tortoise population growth and general survivorship, is likely to vary from site to site.

Coyotes have been implicated in heavy levels of predation on desert tortoises at the Desert Tortoise Natural Area, Rand Mountains, and

Fremont Valley since 1988. Coyotes dug up and ate several adult desert tortoises which were fitted with radio transmitters (Charles Peterson, UCLA, pers. comm.). However, desert tortoises may have been ill (with URTD) or dead and then scavenged by coyotes, or coyotes may have been attracted to the area by large numbers of dying and dead desert tortoises. Feral dogs may have also been responsible for some of the predation.

2. Domestic and feral predators. Domestic and feral dogs are documented threats to captive and wild tortoises alike, not only for desert tortoises but for other species as well (Swingland and Klemens 1989). With the growing number and sizes of cities, towns, and settlements in the desert, this type of threat is increasing and will be difficult to control. Dogs singly, and in packs, often roam miles from home, dig up desert tortoises and injure them beyond recovery. For example, in 1971 and 1972, many burrows destroyed or damaged by dogs and two severely injured desert tortoises were found near scattered homes along Highway 58 in Kern County, California (K. Berry pers. comm.). Dog tracks and scats were unambiguously identified (size and shape of print; size and composition of scat).

Dogs have also attacked desert tortoises on BLM's permanent study plots in California. Judging from gnawed and chewed scutes and bones, a large proportion of desert tortoises observed at the Lucerne Valley study plot in 1986 and 1990 appeared to have been attacked by dogs. Numerous dog packs were observed at the same time (BLM files, Riverside, California).

At the Desert Tortoise Natural Area in California, two dogs were observed harassing a desert tortoise (Jennings 1991). Also at the Desert Tortoise Natural Area, George Moncsko of the Desert Tortoise Preserve Committee (pers. comm. to Kristin Berry) chased a pack of dogs from a desert tortoise. In the adjacent Fremont Valley permanent study plot, dog packs were observed on three occasions in spring of 1991, and dogs had apparently excavated desert tortoise burrows and probably killed desert tortoises there (Craig Knowles and Paul Frank, pers. comm.). On one occasion, the dogs charged a fieldworker. In each case, the nearest human habitation was 2- to 3-miles away.

N. Diseases and Toxicosis.

In this section, diseases related to toxicosis are discussed. Information on other diseases may be found in Jacobson (1994).

Evidence is mounting that desert tortoises are experiencing toxic effects and higher rates of mortality from one or more elements or compounds, such as selenium, heavy metals, chlorinated hydrocarbons, organophosphates, as well as nitro compounds and alkaloids in plants. In some cases, such chemicals occur naturally

or result from distribution or concentration through human-induced activities. While research on the aforementioned subjects in desert tortoises is in preliminary stages, existing data are sufficient to suggest that these sources of mortality may be important, especially when coupled with drought.

Levels of mercury in the livers of desert tortoises ill with URTD at the Desert Tortoise Natural Area were significantly higher than in desert tortoises from the Ivanpah Valley (eastern Mojave Desert) (Jacobson et al. 1991). The mercury levels in livers of Desert Tortoise Natural Area desert tortoises could be higher for natural reasons, e.g., naturally higher levels in soils and plants, or perhaps higher levels as a result of mining:

Many attribute mercury levels to emissions from industrial activity in the area. However, most of the area is within an epithermal alteration area due to, and within acid volcanic rocks. These rocks, and the saprolites and soils mantling these rocks, contain anomalous levels of mercury. Many of the deposits currently being mined...were defined in part by using mercury geochemical tracing. There may be naturally high levels of mercury in plants, and those animals that graze these plants. In addition, considerable smelting of ores has occurred in the early part of this century that could have resulted in emissions and deposition of elemental mercury in the surrounding soils (e.g., Tropico Mill) (Robert Waiwood, BLM geologist, pers. comm.).

Jacobson et al. (1991), in summarizing the potential effects of mercury on desert tortoises, stated:

> ...several investigators have reported altered host resistance to pathogens...depressed antibody responses to mitogen stimulation..., and thymic cortex and splenic follicular atrophy with concomitant depression of ... antibody response to mitigen stimulation...

Between 1982 and 1988, desert tortoise populations on the Chuckwalla Bench permanent study plot (Riverside County, California) sustained about a 70% decline in numbers (Berry 1990, as amended). Dead desert tortoises and a high proportion of the remaining live animals showed signs of shell disease (Berry 1990 as amended). These animals had experienced dyskeratosis and metabolic disorders typical of toxicosis from such elements or compounds as selenium; mercury, lead, and other heavy metals; chlorinated hydrocarbons; and/or organophosphate (Jacobson et al. 1991). The exact cause(s) of the shell disease has not been determined, but it is widespread in the California deserts, and most common in the eastern Mojave, northern Colorado, and southern Colorado deserts (K. Berry, pers. comm.).

During spring 1991, two partially paralyzed, dying desert tortoises were discovered in the eastern Mojave Desert of California and

southern Nevada. A necropsy of one of these animals showed it had been suffering from lymphangiectasia of the gastrointestinal tract; focal ulceration and heterophilic inflammation of the nasal sinuses; marked denervation atrophy and edema of skeletal muscle; and myelomalacia, liquefaction necrosis, and degeneration of the spinal cord (etiology unknown) (James Klaassen, APL Veterinary Labs, Las Vegas, NV, pers. comm.). The paralysis and some other symptoms were typical of selenium toxicosis in swine (E.R. Jacobson pers. comm., Casteel et al. 1985). Sheep and cattle also experience similar symptoms, not only from selenium, but from poisoning by some species of locoweed (*Astragalus sp.*). Poisoning from locoweed can occur in four ways: as selenium converter plants; through poisoning by aliphatic nitro compounds; by locoine (the toxic principle is not yet known); and with congenital defects and abortion. Some locoweeds may also reduce cell-mediated immune responses. Selenium toxicosis can occur in ranges where the nonselenium accumulating forage is depleted by livestock and selenium-accumulating plants remain (Blood et al. 1989, Fuller and McClintock 1986). Desert tortoises in some parts of the Mojave region consume locoweed, including species known to have properties toxic to livestock (e.g., *A. layneae*; see Fuller and McClintock 1986).

Many other species of desert plants besides locoweed are toxic to livestock (Keeler et al. 1978) and could affect desert tortoises. The levels of lead in plants and soils should also be explored, especially along roadways and adjacent to mines (Robert Waiwood, pers. comm.).

O. Noise and Vibration.

Anthropogenic noise has several potential impacts on desert tortoises, including disruption of communication and damage to the auditory system. Background noise has been shown to mask vocal signals essential for individual survival and reproductive success in other animals (e.g., bushcrickets, Conocephalus brevipennis, Bailey and Morris 1986; green treefrogs, Hyla cinerea, Ehret and Gerhardt 1980). Desert tortoises are known to have hierarchical social interactions (Brattstrom 1974), are capable of hearing (Adrian et al. 1938; Patterson, 1971, 1976), and communicate vocally (Campbell and Evans 1967; Patterson, 1971, 1976). Desert tortoises use eleven different classes of vocalizations in a variety of social encounters (Patterson 1971, 1976). The signals are relatively low in amplitude, have fundamental frequencies as low as 0.2 kHz or lower, and harmonics as high as 4.5 kHz (Patterson 1976).

Many human-induced sources of noises, such as automobiles, jets, and trains, cover a wide frequency bandwidth. When such sounds propagate through the environment, the high frequencies rapidly attenuate, but the low frequencies may travel great distances (Lyon, 1973). The dominant frequencies that remain after propagation

correspond closely to the frequency bandwidth characteristic of desert tortoise vocalizations. The masking effect of these sounds may significantly alter an individual's ability to effectively communicate or respond in appropriate ways. The same holds true for incidental sounds made by approaching predators; masking of these sounds may reduce a desert tortoise's ability to avoid capture by a predator. The degree to which masking affects desert tortoise survival and reproduction probably depends on the physical characteristics (i.e., frequency, amplitude, and short- and long-term timing) of the noise and the animal signal, the propagation characteristics of the sounds in the particular environment, the auditory acuities of desert tortoises, and importance of the signal in mediating social or predator interactions.

Loud noises (and associated vibrations) may damage the hearing apparatus of desert tortoises. Sources of noise and vibration include, but are not limited to: cars, trucks, and other vehicles on paved highways, dirt roads, and test tracks; trains; recreation vehicles traveling on or off road; terrestrial military vehicles; commercial and military aircraft; equipment associated with exploration for and development of hard-rock minerals and saleable and leasable minerals; explosions from military ordnance; air to ground bombing or release of missiles; mining; road construction; and nuclear tests. Little research has been performed on desert tortoise ears, but it is clear that they are able to hear, and the relatively complex vocal repertoires demonstrated by desert tortoises suggests that their hearing acuity is similarly complex. Brattstrom and Bondello (1983) experimentally demonstrated that ORV noise can reduce hearing thresholds of Mojave fringe-toed lizards (Uma scoparia). Relatively short bursts (500 sec) of loud sounds (95 decibels at 5 meters) caused hearing damage to seven test lizards. Comparable results were obtained when desert iguanas (Dipsosaurus dorsalis) were exposed to 1 to 10 hours of motorcycle noise (Brattstrom and Bondello 1983). Repeated or continuous exposure to damaging noises is likely to cause an even greater reduction in auditory response of these lizards. It is not unreasonable to expect loud noises to similarly impact the auditory performance of desert tortoises.

Ground vibrations can cause desert tortoises to emerge from their burrows; slapping the ground several times within a few feet of a desert tortoise burrow entrance will often cause a desert tortoise to emerge (C. Peterson, pers. comm., and others). Research is needed to determine what kinds of vibrations and noise cause a desert tortoise to emerge from its burrow.

P. Other Potential Impacts.

Impacts to desert tortoise populations and their habitats described above are well documented or established. While chelonian experts and conservation biologists may not agree on the importance of each

particular impact or the degree of effect, they generally have concluded that such impacts should be substantially reduced or eliminated.

Another group of impacts which can be categorized as "potential impacts" includes air pollution, acid rain, acid precipitation, electromagnetic fields, electromagnetism, global warming, and greenhouse effects. The role of these factors in the status and recovery of desert tortoise populations should become apparent as more information becomes available.

VI. Cumulative and Synergistic Effects of Human Uses on Desert Tortoise Populations and Habitats

A. Interface between the Desert and Developed Areas.

Overall, desert tortoise habitats most susceptible to negative impacts are those at the interfaces between developed lands and open desert. At this interface, many, if not all, threats described above may be present. For example, deserts adjacent to urban and agricultural areas are exposed to deliberate take or removal of desert tortoises, vandalism, release of captives, translocation of wild desert tortoises, unauthorized or authorized deposition of trash, dumping of toxic or hazardous waste, vehicle kills on and off road, proliferation of trails and roads, clearing of land for utility lines and corridors, casual ORV use and general recreation, invasions of weedy and non-native plants, human-caused fires, harvest and vandalism of vegetation, predation by domestic animals, and noise. Even near small settlements, isolated tracts, and ranches, the same factors are present, and the cumulative impacts can spread in a radius of several miles from such areas. Dog packs, for example, can be found digging up and killing desert tortoises miles from home. Ravens can use resources available at human settlement, such as perches, nest sites, water, and food, as a springboard for preying on wild animals nearby. Examples of existing problem areas include but are not limited to the Antelope, Indian Wells, Fremont, Apple, Victor, Lucerne, Johnson, Chuckwalla, and northern Ivanpah valleys in California; Las Vegas, Laughlin, Piute and Mesquite in Nevada; and the Virgin River Valley and St. George in northern Arizona and Utah.

B. Human Access.

The density of paved and dirt roads, routes, trails, and ways in desert tortoise habitat has a direct effect on mortality rates and losses of desert tortoises. The status of desert tortoise populations is directly linked to access, because access allows people to penetrate

into remote parts of the desert, and people cause or contribute to mortality of desert tortoises and habitat loss (Nicholson 1978, Berry 1986, 1992, see discussion above). As mileage of roads, trails, and tracks increased on BLM study plots in California, desert tortoise population declines occurred at greater rates (Berry 1990, as amended, 1992).

The types of human activities recorded on or near access routes in remote parts of the desert include, but are not limited to: take or removal of desert tortoises (predation for food, collections for pets, and commercial trade), vandalism, translocation and release of captive desert tortoises, dumping of trash and other wastes, vehicle kills on and off roads, proliferation of roads and trails, invasion of weedy, non-native plants, fire, harvest of and vandalism to vegetation, and predation by dogs and ravens. Remote areas of the desert are also disturbed by mining, grazing, military use (past and current), and the access routes that permit such activities. The long list of threats to desert tortoises becomes a greater burden when each individual, vehicle, family, or event (e.g., vehicle race or tour) enters desert tortoise habitat. As numbers of visitor days increase, the potential for losses of desert tortoises and their habitats increases (e.g., Berry 1986a).

To ensure recovery of desert tortoises, mortality from human-related sources must be eliminated or reduced to very low levels. Because of the natural history characteristics of the species, losses of even a few adults can delay or prevent recovery (see Appendix C). Currently, acts of vandalism, collecting, release of captives, vehicle kills, etc. occur on all or nearly all desert tortoise study sites. Low rates of desert tortoise mortality from human causes have been documented for only a few relatively remote areas with low levels of human access, such as parts of Ivanpah, Ward, Fenner, Chemehuevi, and Piute valleys. Vandalism and vehicle kills occur at these sites but at relatively low rates. The level of human access in DWMAs, as measured in linear miles of access routes per square mile or township, should mirror road/route densities in areas where: (1) human-caused death rates are very low, and (2) stable or increasing desert tortoise populations exist. Route densities in DWMAs should be reduced where human-caused mortality of desert tortoises is a problem.

C. Recovery Rates of Habitat.

Natural recovery rates of soils and perennial vegetation in desert habitats from development of utility-line corridors, military activities, and human settlements may require decades, centuries, or even millennia (Lathrop 1983b, Lathrop and Archbold 1980, Vasek 1989, Vasek et al. 1975a, 1975b, Webb and Newman 1982, Webb et al. 1983). Recovery rates of native annual plants, a critical source of food for desert tortoises, has not been examined in depth and cannot be estimated. Potentially, recovery of native plant

communities could be hastened by revegetation. However, the science of restoration and revegetation of native ecosystems is in its infancy. In general, because of the uncertainties and costs associated with revegetation and the long periods required for natural recovery, the first priority in mitigation should be to minimize land disturbance (Kay et al. 1988).

VII. A Case Study in Extirpation of Desert Tortoise Populations: Antelope Valley in Los Angeles and Kern Counties, California

The Antelope Valley is currently the most broadly urbanized landscape within the Mojave region. Portions of this valley supported high densities of desert tortoises from 1920's to the 1950's (Berry 1984b), but a series of human activities gradually reduced desert tortoise populations and destroyed or damaged the habitat. Examples of causative factors include, but are not limited to: collection of desert tortoises for food, pets, and commercial purposes; agricultural and urban development; construction of roads, railroads, and utility corridors; mining and energy development; high native predator densities (ravens); and uncontrolled predation by domestic and feral pets (Berry 1984b, Luckenbach 1982). The Antelope Valley is now characterized by numerous cities and small towns, several major State highways, Edwards Air Force Base, several airports and airfields, light and heavy industry, and a burgeoning human population. Parts of the Valley have become suburbs of the greater Los Angeles area. The town of Rosamond was recently a toxic-waste disposal site and is now identified has having high rates of cancer in the human population. Alfalfa and other crops are supported with crop dusting, fertilizers, plowing, and irrigation. Skip development has left hundreds of acres of scattered lots covered by Asian and Mediterranean weeds (Tierra Madre Consultants, Inc. 1991), which fuel increasing numbers of wildfires.

The vast network of paved and dirt roads render most areas accessible to ORV-oriented recreationists and general recreationists. Power, communication, water, gas lines, and fiber-optic cables border many of these roads, creating broad corridors of disturbed and destroyed habitat. Telephone and power poles further contribute to pressures on desert tortoises because they have become perch sites for increasingly abundant raven populations.

As of 1991, extirpation of desert tortoises from the Antelope Valley was nearly complete. Desert tortoise sign is occasionally observed east of Palmdale but not in Palmdale west of Highway 14 (Palmdale Freeway) or south of Highway 138 (Pearblossom Highway) (J. Hohman, pers. comm.). For instance, desert tortoise sign was observed recently in the vicinity of Lake Los Angeles (G.M. Groenendaal, Tehachapi, California, pers. comm. 1991). Desert

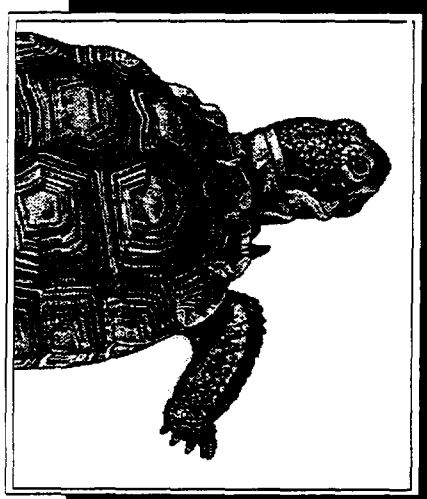
tortoise sign has also been reported in northeastern Palmdale (Feldmuth and Clements 1990), and desert tortoises have been observed recently at Saddleback Butte State Park by park naturalists.

Surveys for tortoises and habitat condition were conducted in a 225 square mile area, including the City of Lancaster and surrounding lands (Tierra Madre). Only 90 square miles of land were undeveloped, nonagricultural lands. The only remaining records of the presence of the once common desert tortoise were three desert tortoise carcasses and a single live desert tortoise (observed in 1983). An analysis of disturbance, which included types of impacts observed on each desert tortoise transect and from aerial photographs, was conducted in the same area (Tierra Madre 1991). Very high levels of disturbance were recorded in the city and surrounding lands, and lack of desert tortoise sign was attributed in part to this disturbance. Roughly a third of the area had been rendered unsuitable for desert tortoises.

Although we lack the data base and chronological history to resolve specific contributions to extirpation of desert tortoises, the Antelope Valley provides unambiguous evidence of the cumulative and synergistic effects of human activities on desert tortoises and how such trends have led to the demise of desert tortoise populations from a substantial portion of the historical range in the western Mojave Desert. Furthermore, these same patterns are operative nearby in the Indian Wells, Fremont, Victor, Mojave River, Apple, Lucerne, and Johnson valleys. Human activities are likely having the same impact in the Las Vegas, Colorado River, and Virgin River valleys.

Appendix E

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix E: Vegetation and Climate of the Mojave Region

I. Regional Setting

North America includes five desert regions (Jaeger, 1957): The Chihuahuan Desert of North Central Mexico and adjacent parts of Texas and New Mexico; the Sonoran Desert of northwest Mexico and parts of southern California and Arizona; the Mojave Desert in part of southeastern California, southern Nevada and adjacent parts of Utah and Arizona; the Great Basin Desert in the Great Basin region of Nevada, Utah, Oregon, Idaho, Wyoming and Colorado; and the Navahoan Desert of the four corners region of Utah, Colorado, Arizona and New Mexico.

The Desert Tortoise does not occur in the Great Basin or the Navahoan Deserts. It does occur in the other three deserts but our present interest is concerned with its range in the Mojave Desert and in that portion of the Sonoran Desert located west of the Colorado River, namely the Colorado Desert of California.

Mojave Desert

The Mojave Desert is located in southern California, southern Nevada, the northwest corner of Arizona, and the southwest corner of Utah. The Mojave Desert is bordered on the north by the Great Basin Desert, on the west by the Sierra Nevada, on the south by the San Gabriel and San Bernardino Mountains and by the Sonoran Desert, and on the east by the Hurricane Cliffs in Utah, and by Grand Wash Cliffs and the Peacock and Hualapai Mountains in Arizona.

The boundary between the Mojave Desert and the Great Basin Desert is basically defined, at low elevations, by a vegetational component, namely the creosote bush (*Larrea tridentata*) which occurs in the Mojave, but not in the Great Basin (Cronquist, et al., 1972). The boundary is thus an irregular line across southern Nevada extending roughly from Olancha (south of Bishop), in Inyo County, California to St. George, in the southwest corner of Washington County, Utah. The Mojave Desert includes all of Clark County as well as the southern parts of Esmeralda, Nye, and Lincoln Counties, Nevada.

Sonoran Desert

The greater Sonoran Desert includes seven geographical divisions (Shreve and Wiggins 1951). The lower Colorado Valley division of the Sonoran Desert occurs in western Arizona, in southeastern California, in northwestern Sonora, and in Baja California east of the Peninsular Ranges as far south as Bahia de Los Angeles. The other six divisions of the Sonoran Desert occur elsewhere in Arizona and in Mexico and do not concern us at present.

The Lower Colorado Valley Division was considered by Jaeger (1957) to consist of two parts: the Yuman desert in Arizona and Sonora; and the Colorado Desert in California, Baja California and a small part of Arizona near Needles, California. The Lower Colorado Valley Division in retained as a unit by Crosswhite and Crosswhite (1982) as the Lower Colorado-Gila Division, since it includes much of Arizona's Gila River drainage. Nevertheless, use of Colorado Desert for the California portion has gained widespread and consistent currency. We follow that custom and consider the Colorado Desert to be that part of the Colorado-Gila Division of the Sonoran Desert located west of the Colorado River.

The boundary between the Mojave Desert and the Colorado Desert has been subject to controversy. Toward the west, the Little San Bernardino and Cottonwood Mountains provide excellent boundary definition. Farther east, mountains seem less prominent and more widely spaced, and provide little definition. To the contrary, broad lowland areas provide north to south continuity, with Sonoran elements extending far to the north, and Mojavean elements extending far to the south. As a result, the boundary between the two deserts has variously been interpreted to be farther north or farther south (References in Vasek and Barbour, 1977) than the arbitrary line running from Indio to Needles as indicated by Crosswhite and Crosswhite (1982). Most interpretations extend the Colorado Desert northward along the Colorado River Valley to the vicinity of Needles, California.

A more northerly distribution of the Colorado Desert along the Colorado River Valley and also as far west as the Bristol Mountains, was proposed by Rowlands et al. (1982) after analysis of vegetation and climate. We basically adopt the definition of the Colorado Desert proposed by Rowlands with only minor modification. According, the boundary between the Mojave and Sonoran (Colorado) Deserts extends eastward along the Little San Bernardino and Cottonwood Mountains, then goes north from Cottonwood Pass along the eastern edge of the Hexie, Pinto, Sheephole and Bullion Mountains to Ludlow. It continues northward through Broadwell Lake and then loops around the northern end of the Bristol Mountains. The boundary returns southeast between the Granite and Old Dad Mountains, and then heads eastward along the northern edge of the Marble, Clipper, Piute and Dead Mountains before crossing the Colorado River about 20 miles north of Needles.

The boundary between the Mojave Desert and the Sonoran (Yuman) Desert extends eastward into Arizona, skirts around the southern end of the Black Mountains and proceeds eastward to the base of the Hualapai Mountains, approximately at the latitude of Yucca, Arizona.

The triangular portion of Mohave County, Arizona between Needles, Yucca and Parker Dam is included in the Colorado Desert on two maps by Jaeger (1957), but his discussion of the Yuman Desert clearly indicates its extension along the Colorado River to the north of Needles. We adopt the strict interpretation that the Colorado Desert occurs west of the Colorado River (and Gulf of California) in California and Baja California, and the Yuman Desert occurs east of the Colorado River and Gulf of California) in Arizona and Sonora.

The Mojave Desert includes most of San Bernardino County and parts of Inyo, Kern, Los Angeles and Riverside Counties, California, and the western part of Mohave County, Arizona. The Colorado Desert occurs west of the Colorado River in Imperial and parts of San Bernardino, Riverside, and San Diego Counties, California.

Subdivisions of the Mojave Desert

The Mojave Desert has been divided into five regions for the convenience of description (Rowland et al., 1982); namely the Northern, Eastern, Central, Southwestern and South Central regions. We agree that the five regions are defined on the basis of significant, large scale differences in soils and land forms, in climate, in plant ecology and vegetation, and in animal ecology. Accordingly, we accept the five Mojavean regions, but propose a slightly simpler nomenclature by shortening the last two regional names to the Western region and the Southern region respectively. We also propose some rather mind changes in the boundaries. Those boundaries are somewhat arbitrary and do not follow straight lines. Hence, the following descriptions of the five Mojavean regions must be considered approximate:

I - A Northern Mojave region has two sections: a California section roughly corresponding to the desert areas of Inyo County; and a Nevada section roughly corresponding to the desert portions of Esmeralda and Nye Counties.

II - An Eastern Mojave region has three sections: a Southern Nevada section in Clark County and the desert portion of Lincoln County; an Arizona section in western Mohave County, Arizona, and extending to St. George, Utah; and a California section from the Soda Lake Basin to the Nevada State Line.

III - A Southern Mojave region (the Southcentral region of the Rowlands, et al., 1982) occurs roughly from Victorville to Ludlow in San Bernardino County, California, and then southward to the Little San Bernardino and Cottonwood Mountains in Riverside County, California.

IV - A Central Mojave region includes the area around Barstow, and extends northward nearly to the Panamint Range, and eastward toward Baker and Ludlow, all in San Bernardino County, California.

V - A Western Mojave region (the Southwestern region of the Rowlands, et al., 1982) occurs in San Bernardino, Kern and Los Angeles Counties, California, roughly in the area from Trona to Victorville and west to the bordering mountains.

Subdivisions of the Colorado Desert

Subdivisions of the Colorado Desert. The Colorado Desert has informally been subdivided into eastern and western regions by Rowlands (unpubl.). Such subdivision is useful. However, we suggest three subdivisions of the Colorado Desert, based largely on general considerations of topography and vegetation.

I - The Northern Colorado Desert region includes the area from the Bristol Mountains to the Colorado River north of Needles, and southward to the Coxcomb Mountains and Vidal Wash.

II - An Eastern Colorado Desert region includes the area south from Pinto Basin and Vidal Wash between the Salton Trough and the Colorado River.

III - The Southwestern Colorado Desert region includes the Salton Trough and the desert to the south and west from the Little San Bernardino Mountains south into Baja California, Mexico (The peninsular strip of Colorado Desert along the Gulf of California coast may comprise a fourth subdivision.)

Boundaries between desert subdivisions

The boundary between Northern and Eastern Mojave regions comes southward from Emigrant Valley in Nye and Lincoln Counties, Nevada, to Indian Springs Valley and then around the western edge of the Spring Mountains where it crosses into California just east of the Resting Spring and Nopah Ranges. It skirts the west edge of Pahrump Valley and turns westward around the south edge of the Kingston Range. It then follows the north edge of Kingston wash to the north end of Silurian Valley, at the junction of Salt Creek with the Amargos River.

The boundary between the Northern and Central Mojave regions proceeds westward from Salt Creek through a low channel to Leach Lake and Pilot Knob Valley to the south end of the Slate Range. This boundary is south of the Owlshead and Quail Mountains, and north of the Avawatz and Granite Mountains.

The boundary between the Northern and Western Mojave regions goes north along the west edge of the Slate Range and turns westward at the north end of Searles Valley, passing just north of the Southern Argus Mountains and the Coso Basin, joining the Sierra Nevada just south of Little Lake.

The boundary between the Western and Central Mojave regions goes south from the south end of the Slate Range, skirting the west edge of Black Hills, to Fremont Peak, loops around Fremont Peak and cuts back to the south east, passing along the north edge of Harper Lake and then goes due south to Hinkley, joining the Mojave River near Hodge.

The boundary between the Western and Southern Mojave regions is the Mojave River, from Hodge southward through Victorville to the San Bernardino Mountains.

The boundary between the Central and Southern Mojave regions goes easterly from Hodge, passing south of Lenwood, to Daggett. It then follows Interstate Highway 40 to Ludlow.

The boundary between the Central Mojave and the Northern Colorado regions proceeds north from Ludlow through Broadwell Lake, and passes along the northwest edge of the Bristol Mountains to the northern tip of the Bristol Mountains.

The boundary between the Central and Eastern Mojave regions proceeds from the northern tip of the Bristol Mountains northward through Soda, Silver and Silurian Lakes to the junction of Salt Creek and the Amargosa River.

The boundary between the Eastern Mojave and the Northern Colorado regions proceeds southeast from the northern tip of the Bristol Mountains between the Old Dad Mountains and the Granite Mountains to the northern tip of the Marble Mountains. It proceeds eastward along the northern edge of the Clipper Mountains toward Goff and the northern end of the Dead Mountains. It crosses the southernmost couple of miles of Nevada before ending at the Colorado River.

The boundary between the Eastern Mojave region and the Yuman Desert of the Colorado-Gila Division of the Sonoran Desert goes from the Colorado River to the Black Mountains in Arizona and then around the southern end of the Black Mountains and proceeds eastward to the base of the Hualapai Mountains, approximately at the latitude of Yucca, Arizona.

The boundary between the Southern Mojave and the Northern Colorado regions goes south from Ludlow along the eastern edge of the Bullion Mountains and the eastern edge of the Sheephole Mountains to Clark's Pass.

The boundary between the Southern Mojave and the Eastern Colorado regions goes south from Clark's Pass in a sinuous path at the base of the Pinto and Hexie Mountains around Pinto Basin and Smoketree Wash to Cottonwood Pass at the eastern end of the Cottonwood Mountains. It continues westward to the southeast end of the Little San Bernardino Mountains near Cactus City.

The boundary between the Southern Mojave and the Southwest Colorado regions follows the scarp of the Little San Bernadino Mountains westward to Morongo Valley.

The boundary between the Eastern Colorado and the Southwest Colorado regions goes southwest from Cactus City around the Mecca Hills and then southeast along the edge of the Salton Trough to the Colorado River.

II. Major Topographic Features

The desert region under consideration varies extensively with regard to number, size and stature of mountains. Topographic diversity is greatest in the Northern Mojave Desert region with numerous high mountain ranges and large basins at low elevations. For example, the sink of the Amargosa River in Death Valley reaches 280 feet below sea level whereas Telescope Peak in the Panamint Range a few miles to the west reaches an altitude of 11,049 feet above sea level. Topographic diversity and the stature of mountains generally decreases southward. Concomitantly, the proportion of open desert consisting of broad plains and gentle alluvial fans also increases southward. Hence, each subdivision of the desert has its own characteristic array of landforms.

The Northern Mojave Desert region includes the Amargosa (8,738), Coso (8,160), Kingston (7,323), Last Chance (674), Nelson (7,701), Nopah (6,394), Panamint (11,049), Resting Springs (5,264), Saline (6,548), and northern Argus Ranges (8,839) as well as California, Chicago, Death, Eureka, Greenwater, Long, Panamint, and Saline Valleys in the California section. Features of the Nevada section include the Bare Mountains (6,316), Gold Mountain (7,565), the Sportted Range (6,254), and part of the Amargoas Range (8,738) as well as Sarcobatus Flat, the Amargosa Desert (Valley) and Ash Meadows.

The Eastern Mojave Desert region also has impressive mountains and Valleys. The Nevada section, including Arizona, includes the Black (5,456), Cerbat (6,900), Eldorado (5,060), Newberry

(5,639), Spring (11,919), and Virgin (8,056) Mountains and the Desert (6,540), Las Vegas (6,943), McCullough (7,026) and Pintwater (7,040) and Sheep (9,120) Ranges. It also includes Desert, Dry Lake, Eldorado, Hidden, Hualapai, Indian Spring, Las Vegas and parts of Ivanpah, Pahrump and Piute Valleys. The California section includes Table Mountain (6,176), and the Castle (5,120), Clark (7,929), Granite (6,786), Ivanpah (6,163), Mescal (6,493), Mesquite (5,160), New York (7,530, Old Dad (4,250), Pinto (6,144), Providence (7,040) Mountains or Ranges, as well as Clipper, Ivanpah, Lanfair, Mesquite, Pahrump, Piute, Silurian, and Valjean Valleys and the Soda Lake Basin and the Devil's Playground.

The Southern Mojave Desert region includes the Bullion (4,187), Cottonwood (4,375), Hexie (3,820), Little San Bernardino (5,814), Newberry (4,882), Ord (6,270), Pinto (3,963), Rodman (6,010), Sheephold (4,685), and Sidewinder (5,168) Mountains. It also includes Antelope, Apple, Johnson, Lucerne, Sidewinder, Stoddard, and Yucca Valleys as well as Dale, Emerson, Melville, Soggy, Rabbit and Lucerne Dry Lakes.

The Central Mojave Desert region includes the Avawatz Mountains (6,154), Calico Mountains (4,542), Eagle Crags (5,512), Granite Mountains (4,862), Pilot Knob (5,428), Slocum Mountains (5,124), Soda Mountains (3,617) and Tiefort Mountains (5,090). Important Basins are Goldstone, Harper, Coyote, Troy, Cronese, Soda and Superior Dry Lakes and the lower half of the Mojave River.

The Western Mojave Desert region includes the southern Argus Mountains (6,562), El Paso Mountains (5,244), Fremont Peak (4,584), Rand Mountains (4,755), Red Mountain (5,270), and numerous smaller mountains. Important Basins include Antelope, Fremont, Indian Wells, Searles and Victor (part) Valleys, as well as China, Cuddeback, Koehn, El Mirage, Rogers and Rosamond Dry Lakes.

The Northern Colorado Desert region includes the Bristol (3,422), Calumet (3,723), Chemehuevi (3,697), Clipper (4,604), Iron (3,296), Marble (3,842), Old Woman (6,326), Piute (4,165), Sacramento (3,308), Turtle (4,231), and Whipple Mountains (4,131). Important valleys are Cadiz, Chemuevi, Fenner, Vidal and Ward, together with Bristol and Cadiz Dry Lakes.

The Eastern Colorado Desert region includes the Arica (2,163), Big Maria (3,100), Cargo Muchacho (2,130), Chuckawalla (4,504), Chocolate (2,967), Coxcomb (4,416), Eagle (5,350), Granite (4,353), Little Chuckawalla (1,261), Little Maria (3,043), Little Mule (1,465), McCoy (2,835), Mule (1,801, Orocopia (3,815), Palen (2,443), Palo Verde (1,795), Riverside (2,252), and West Riverside (2,667) Mountains, and the Mecca Hills (1,642). It also includes Chuckawalla Valley, Ford Dry Lake, Hayfield Lake,

McCoy Wash, Milpitas Wash, Palen alley, Palo Verde Mesa, Palo Verde Valley, Pinto Basin and Rice Valley.

The Southwestern Colorado Desert includes the Algodones Dunes, Fish Creek Mountains (2,334), Indio Hills (1,739), and Superstition Mountains (759). Its main features are the Borrego, Coachella and Imperial Valleys and the Salton Sea.

Climate of the Mojave and Colorado Deserts

Weather recording stations are relatively few, especially in the mountainous Northern and Central Mojave regions and the remote lowland areas that experienced early agricultural development. The climatic data (Table E1) and the accompanying description are drawn largely from Rowlands (unpubl.), Huning (1978), and Rowlands et al. (1982). Temperatures are given in degrees Celsius; precipitation is given in mm rainfall.

The two major climatic factors, temperature and precipitation, are both extremely variable in both space and time. Temperature decreases with latitude and elevation, thus permitting a calculation of lapse rate. Temperature also shows extensive, but predictable seasonal variation and extreme, unpredictable yearly variation. Precipitation increases with elevation and also has marked seasonal variation and even more extreme yearly variation.

Temperature

The hottest places are in low elevation basins. Mean July maxima are nearly 47°C in Death Valley, 43 at Baker, 41 at Trona, 32 to 40 at other Mojave Desert stations and from 32 to 36 at neighboring Great Basin stations. Mean July maxima range from 41 to 43 over much of the Colorado Desert and from 39 to 43 in the Yuman Desert of Arizona, reflecting the slightly higher elevations of the latter.

The coldest places are at the higher elevations of the Northern and Eastern Mojave Desert. Mean January minima range from -6 to -10 C at Great Basin Stations, but -1 to +5 in the Northern Mojave, -6 to +3 in the Eastern Mojave, and -3 to +2 in the Western, Central and Southern Mojave. Mean January minima range from +2 to +5 in the Colorado Desert and from -1 to +5 in the Yuman Desert of Arizona, again reflecting slightly higher elevations of the latter.

The number of freezing days ranges above 144 at Great Basin stations, 3 to 127 in the Mojave Desert (plus 157 at Alamo on the Great Basin margin), 1 to 19 in the Colorado Desert, and 0 to 65 in the Yuman Desert.

Mean annual temperatures range roughly from 11 to 14 at neighboring Great Basin stations and 14 to 19 at Mojave Desert stations, except for two hotter stations in Death Valley at 22 and 25. Mean annual temperatures range from 21 to 23 in the Colorado Desert and 18 to 23 in the Yuman Desert.

Precipitation

Precipitation is delivered by storms which follow one of the three principal patterns: winter cyclonic storms; summer thunder storms; and erratic hurricanes (locally called "chubascos"). Winter storms bring moisture from the north Pacific. They are usually widespread, mostly of low intensity, and frequently deliver snow at the higher elevations. Their effects diminish toward the south and toward low elevations.

Summer thunder storms are usually intense, of fairly short duration and somewhat local. Chubascos are very large, violent, and may deliver very large amounts of rain, but they are quite sporadic. Both summer thunder storms and chubascos bring moist tropical air northward from the Gulf of California and up the Colorado River Valley into the Eastern Mojave Desert. These storms may diverge northwestward through the Salton Trough, or westward through Rice Valley, but their effects usually diminish award from the Colorado River Valley.

Total precipitation ranges from 90 to 203 mm at nearby Great Basin stations, 50 to 260 at stations in the Northern and Eastern Mojave Desert regions, and 80 to 170 mm in the Western, Central and Southern Mojave regions (plus recordings of 263 and 377 near mountains at the southern margin of the Western Mojave Desert). Total precipitation ranges from 49 to 139 mm in the Colorado Desert and from 77 to 281 in the Yuman Desert.

The percentage of summer precipitation ranges from 5 to 40 at Great Basin stations, 15 to 20 in the Northern Mojave, 20 to 40 in the Eastern Mojave, only 3 to 10 in the Western Majoave, but 6 to 36 in the Central and Southern Mojave. The percentage of summer precipitation ranges from 11 to 36 in the Colorado Desert and 35 to 59 in the Yuman Desert.

Precipitation during the spring is usually recorded on more than three days a year at stations in the Great Basin, the Eastern Mojave Desert, and Southern Mojave Desert, the Northern Colorado Desert, and the Yuman Desert, but on fewer than three days at Eastern Colorado and Southwest Colorado Deserts.

Vegetation of the Mojave and Colorado Deserts

Vegetation in the desert areas strongly reflects availability of water and evaporative demand for water. Consequently, vegetational biomass is very low at low elevations with their characteristic low precipitation and high temperatures. Vegetational biomass generally increases with elevation as precipitation increases and temperatures decrease. Vegetation structure follows a similar pattern with the predominant growth form being low shrubs at low elevations and in valley bottoms, larger shrubs at intermediate elevations, small trees at higher elevations and larger trees at high mountain elevations.

Vegetational species composition follows a similar elevational pattern and is further modified by regional climatic and other environmental factors.

Classification

The California desert vegetation has been described in detail and classified by Rowlands (unpubl.). We basically follow his classification with slight augmentation from included references (e.g. Thorne, 1982,1986, Vasek and Thorne, 1988). The entire desert area supports seven major vegetational complexes (Table E2). Each complex includes one to several subcomplexes, and each subcomplex includes one to several vegetation types. A vegetation type typically includes all the numerous, similar communities dominated by a given group of perennial plants.

Vegetation across the Mojave Desert is quite complicated,with much variation in species composition and much interdigitation between vegetation units. A range of variation in space and in time exists for each environmental parameter, and a range of variation in tolerance to each parameter exists in each species. Although exact correspondence between variation in species composition and variation in physical environmental factors does not exist, vegetational units must reflect good generalizations on species composition, biomass productivity, soils, climatic conditions and the water table.

Many of the common species may live in more than one vegetation type. Hence, Complex is an appropriate term for major vegetational units (Rowlands unpubl.). Furthermore, the occurrence of common species outside their primary vegetation unit leads to difficulty in delimitation and classification, and hence to differences of opinion regarding the correct classification of vegetation. In all probability, there is no such thing as a "correct classification" (Rowlands unpubl.). Any system of classification is only as good as its utilitarian value. We follow the system out lined by Rowlands based on the judgement that the vegetational units described are reasonable in terms of repetitive observation and useful in terms of management units.

Vegetation Types

I. Desert Scrub Complex

The Desert Scrub Complex includes three subcomplexes. This vegetation occurs on slopes, plains, and alluvial fans and in basins and valleys at low elevations over most of the desert area.

1. The Mojave-Colorado Desert Subcomplex is most common and widespread, occurring over more than 70% of the area of the Mojave and Colorado Deserts. Its three component vegetation types experience similar climatic conditions. This vegetation is limited by cold temperatures at

northern or upper elevational margins, and by high salt or extreme aridity at low elevations.

Creosote Bush Scrub is by far the most important and widespread desert vegetation type. It occurs on most terrain below about 1,500 meters, being common on alluvial fans and gentle slopes, becoming less common on steep, rocky slopes. It is dominated in various proportions by *Larrea tridentata* and *Ambrosia dumosa*, but a great many other species (see Table E3) also occur in various proportions at various places, and may even assume co-dominance.

The ratio of Potential Evaporation to Precipitation varies from 4 at upper elevations to 32 in Death Valley. Precipitation ranges from 40 to about 270 mm. Mean January minimum temperatures range from -6 to 6 degrees C, and mean July maxima range from 34 to 47 (Table E4).

Cheesebush Scrub occurs within the Creosote Bush Scrub zone on sandy, mobile substrate, usually in washes and drainage channels of the Mojave Desert which do not have an overstory microphyll woodland. Some components evidently play a role in secondary succession (Vasek 1975a, b). Plants in this vegetation seem to tolerate slightly lower winter temperatures than those in the Creosote Bush Scrub (Table E4).

Succulent Scrub occurs on upper slopes and bajadas within the Creosote Bush Scrub zone, thus experiencing the most favorableclimatic conditions of that zone. It is dominated by stem succulent species: mostly *Cactaceae*, but also *Yucca,* in the Mojave Desert; and mostly Agavaceae, but also Cactaceae and *Fouquieria*, in the Colorado Desert. Other species of the Creosote Bush Scrub also occur here, but the strong dominance of stem succulent plants, which undergo CAM metabolism, warrants recognition as a functional vegetation type.

2. The Saline-Alkali Scrub Subcomplex occupies mostly sinks and valley bottoms, and also some upland slopes with or without pronounced saline or alkaline conditions. The five vegetation types are dominated by chenopodiaceous shrubs and constitute what others have called `salt bush scrub'. The first three vegetation types are primarily xerophytic in nature and the last two types are halophytic.

Shadscale Scrub occurs on alkaline soils at low elevations in the Great Basin and the northern and eastern Mojave Desert. It also occurs on heavy soils on steep slopes in mountains of the Death Valley region. It tolerates both high salt levels and very arid conditions. Shadscale Scrub often occupies a position between Creosote bush Scrub and Sagebrush Scrub, similar to the position of Blackbush Scrub, and the climate is similar to that for Black bush Scrub (Table E4). Shadscale Scrub is dominated by *Atriplex confertifolia*, although several other species usually are also present (Table E3).

Desert Holly Scrub occupies extremely arid sites mostly in the northern and eastern Mojave Desert. In Death Valley, stands of Desert Holly occur at the foot of alluvial fans which contain a high percentage of carbonate rocks and a very salty substrate. Precipitation is very low but summer temperatures and the potential evaporation are very high (Table E4). *Atriplex hymenelytra* often occurs in pure, albeit sparse, stands, but sometimes *Atriplex polycarpa* or *Tidestromia oblongifolia* are also present.

Mojave Saltbush - Allscale Scrub occurs only in the southwest Mojave Desert near Kramer Junction and Fremont Peak. It occupies some upland areas and is rather similar to Shadscale Scrub. The dominant species are *Atriplex spinifera* and *A. polycarpa* but other components may also occur (Table E3).

Allscale - Alkali Scrub occurs in and around sinks and dry lakes where available ground water may contain up to 2.5% salts. This vegetation includes succulent or semi-succulent halophytes such as *Atriplex polycarpa* and several other species of *Atriplex*, *Kochia* spp., *Suaeda torreyana* and *Haplopappus acradenius*. The climate is hot and dry (Table E4), but the vegetation is mediated primarily by the salty water table.

Iodinebush - Alkali Scrub is similar to the preceding in habitat, climate and physiognomy, but occurs in sinks where available ground water may contain up to 6% salts. This vegetation is dominated by succulent halophytes, primarily *Allenrolfea occidentalis*. It may also include *Sarcobatus vermiculatus*, *Nitrophila occidentalis* and several others (Table E3).

3. The Great Basin Scrub Subcomplex occurs primarily in the Great Basin but is represented by significant occurrences of three vegetation types at upper elevations of the Desert Scrub Zone, in the eastern and northern Mojave Desert and to a lesser extent southward. It generally occurs at elevations below the Xeric Conifer Woodland (see below) and above the Creosote Bush Scrub and Succulent Scrub.

Sagebrush Scrub is the dominant scrub vegetation of the Great Basin region, but may be found at upland Mojave Desert sites, such as Round Valley north of the Providence Mountains. The climate is generally colder in winter and cooler in summer than for the two preceding subcomplexes, and the precipitation is a little higher (Table E4). Usually *Artemisia tridentata* dominates over extensive areas, but sometimes is replaced by *Artemisia nova*, especially on heavy, rocky soils. Many other species (Table E3) also occur in various combinations at different places. Sagebrush Scrub often forms an under story to Pinyon and Juniper Woodland types.

Blackbush Scrub occurs widely in the Mojave Desert on rocky, heavy soils at elevations of 1,000 to 2,000 meters. It occurs sparingly in the Colorado Desert. This vegetation is dominated by *Coleogyne ramosissima*. In addition, *Grayia spinosa*, *Ceratoideslanata*, *Thamnosma montana*, and species of *Ephedra*, *Yucca*, *Lycium*, *Haplopappus*, etc. (Table E3), may also occur but species diversity is usually low at any one locality. The climate is similar to that of Succulent Scrub, but a little cooler in summer (Table E4).

Hopsage Scrub is common in the eastern Mojave Desert, usually on sandy-loamy soils with only moderate rock content. Otherwise the habitat and climatic conditions are very similar to those of Blackbush scrub. *Grayia spinosa* is the usual dominant, often with any of several species of *Lycium* as a co-dominant. *Haplopappus cooperi* and several components of Creosote Bush Scrub may also be present.

Sometimes Joshua Trees (*Yucca brevifolia*) may occur in Hopsage Scrub, Blackbush Scrub, Shadscale Scrub, Creosote Bush Scrub, Succulent Scrub, and the Juniper - One-leaf Pinyon Woodlands. In these cases, Joshua Trees may appear as visual dominants, but they provide very minor fractions of ground cover or biomass. Hence, Joshua Trees are not dominant anywhere, despite

their conspicuity around the Mojave Desert, and do not provide consistent basis for recognizing a separate vegetation type (Rowlands 1978).

II. Desert Woodland Forest-Conifer Complex

A Conifer Woodland-Forest Complex, with two subcomplex components, occurs in mountains and high elevation desert areas.

1. The Xeric Conifer Woodland Subcomplex covers large areas between about 1,200 to 2,800 meters in elevation. It includes three vegetation types dominated by shrubs and small trees. This subcomplex is a highly productive and floristically diverse desert vegetation.

Utah Juniper - One-Leaf Pinyon Woodland is common in the Great Basin region and in the Northern and Eastern Mojave Desert. It occurs in the Providence Mountains and then has a major disjunction in the San Bernardino Mountains. The overstory trees are *Juniperus osteosperma* and *Pinus monophylla*, and sometimes a few Joshua Trees. Some arborescent shrubs are *Quercus turbinella* and *Cercocarpus ledifolius*. A rich assortment of other associated shrubs is partly listed in Table 3. The climate is similar to that of Sagebrush Scrub but is a little wetter and colder (Table E4).

California Juniper - One-Leaf Pinyon Woodland occurs on mountains bordering the Mojave Desert from just north of Walker Pass in Kern County, California southward to the mountains bordering the Colorado Desert in San Diego County, California. It also occurs on mountains of sufficient stature within the desert area such as the Granite Mountains and Granite Pass*, the Old Woman, Coxcomb, Eagle, Cottonwood and Little San Bernardino Mountains. This vegetation type is dominated by small trees (*Pinus monophylla*) and arborescent shrubs (*Juniperus californica*). Some of the other associated species are listed in Table E3. The more southern distribution makes for a warmer climate than for the preceding type (Table E4).

California Juniper - Four-Leaf Pinyon Woodland occurs in the peninsular ranges of California and Baja California at the western margin of the Colorado Desert. The dominant species are *Juniperus*

* The sudden change from a Utah Juniper Woodland in the Providence Mountains to a California Juniper Woodland in the Granite Mountains and Granite Pass may be strong biogeographical evidence in favor of including the Granite Mountains in the Colorado Desert rather than the Mojave Desert.

californica, *Pinus quadrifolia*, and *P. monophylla*. Some of the associated understory species (Table E3) include several found in Desert Chaparral and Redshanks Chaparral (Hanes, 1977). The climate is similar to that of the preceding (Table E4).

2. A Desert Mountain Forest Subcomplex occurs in the limited area at higher mountain elevations, and essentially represent sub-humid islands in an arid environment. Three vegetation types are included.

White Fir Forest elements occur in small pockets in the New York, Clark and Kingston Ranges. These small pockets of forest are essentially imbedded in the upper parts of Utah Juniper-Oneleaf Pinyon Woodland where local site characteristics mediate an evapotranspiration rate well below that expected for the region. Some of the associated species (Table E3) are found with White Fir in the Charleston (Spring) Mountains. These pockets represent the western most attenuation of the White fir-Douglas fir-Blue spruce zone of the Wasatch Series of the Great Basin vegetation (Vasek and Thorne, 1988). The dominant tree is *Abies concolor* .

Subalpine Woodland is found on upper slopes of high desert margin mountains from the Sweetwater Mountains to the Transverse and Peninsular Ranges of Southern California, and on the highest desert mountains, namely the Inyo, Panamint and White Mountains, at elevations of about 2,900 to 3,500 meters. The main trees are *Pinus flexilis* and sometimes *Acer glabrum* or *Juniperus occidentalis*. This woodland may overlap the upper Pinyon Woodland at its lower margin and may overlap the Bristlecone Pine Forest at the higher elevations. The trees are usually small and sparsely distributed. A few associated shrubs are listed in Table E3. The climate is characterized by low precipitation and cold winters.

Bristlecone Pine Forest is found on the highest mountains in the Mojave Desert and Great Basin From the Inyo, Panamint and White Mountains of California to Nevada and Utah. A few trees also occur in the Last Chance Mountains. The trees, primarily *Pinus longaeva*, are usually small and scattered. They sometimes form small forest-like stands in the Inyo and White Mountains, but more commonly are scattered in a `woodland'.

III. Desert Microphyll Woodland Complex

A Desert Microphyll Woodland Complex with two subcomplexes occurs in low desert areas with favorable, but often intermittent,soil moisture conditions.

1. A Paloverde Microphyll Woodland occurring in washes and on slopes with substantial regular summer rain (e.g. Whipple Mountains), includes two vegetation types.

Foothill Paloverde - Saguaro Woodland occurs in Sonoran Desert areas with substantial summer rain. It is sparsely represented in California, being found only near the Colorado River, primarily in the Whipple Mountains, but is far more important southward in Arizona. Similarly, the two most conspicuous components, *Cercidium microphyllum* and *Carnegiea gigantea*, are also rare in California.

Blue Paloverde - Ironwood - Smoketree Woodland is rather common in the Colorado Desert. It occurs throughout the Creosote Bush climatic zone, usually being concentrated in washes. The main components are *Cercidium floridum*, *Olneya tesota*, *Psorathamnus spinosa*, *Chilopsis linearis*, *Acacia greggii*, and a few others (Table E3). The understory is drawn from species also found in Creosote Bush Scrub and Cheesebush Scrub.

2. A Mesquite Microphyll Woodland with only one vegetation type is found in basins near and around seeps and sinks, or on sand sheets over a shallow, salty water table.

Mesquite Thicket is dominated by *Prosopis glandulosa* and *Prosopis pubescens*. The understory associates are commonly halophytic species found in the Allscale - Alkali Scrub and the Iodinebush - Alkali Scrub. The climate is hot and arid (Table E4). This vegetation type is controlled mostly by the occurrence of water near the surface.

IV. Streamside (Riparian) and Woodland Complex

A Riparian and Oasis Woodland Complex, with two subcomplexes, is found in areas near running water.

1. Streamside Woodland Subcomplex, with two vegetation types, is found along rivers and streams. This vegetation reflects azonal humid conditions within an arid zone, being dependent on water flow in or under a stream channel and therefore essentially inde pendent of the general climate.

Cottonwood - Willow - Mesquite Bottomland vegetation occurs intermittently in narrow strips on either side of major streams, such as the Colorado, Mojave and Virgin Rivers (near Parker, Victorville and Beaver Dam, respectively). It is dominated by *Populus macdougallii*, *P. fremontii*, *Salix exigua* and other willows, and *Prosopis glandulosa*. This vegetation has been suffering extensive degradation from the after-effects of dam construction, exhaustive recreational development and invasion of tamarisk trees.

Cottonwood - Willow Streamside Woodland occurs along small streams that flow into the desert. Some examples are the Amargosa Gorge near China Ranch, Andreas and Palm Canyons near Palm Springs, the Whitewater River and many canyons draining the Panamint Mountains and the eastern side of the Sierra Nevada. The dominant trees are *Populus Fremontii*, *Salix* spp., occasionally *Platanus racemosa*, and, in the Colorado Desert, *Washingtonia filifera*.

2. Desert Oasis Woodland Subcomplex has one vegetation type occurring primarily in the Colorado Desert, but also at Sonoran localities in Mexico and Arizona, and sparingly in the Mojave Desert as far north as southern Nevada and Death Valley National Monument.

Palm Oases occur around springs and seeps, being especially common along the San Andreas fault. *Washingtonia filifera* is the only species consistently found in all palm oases. The soil surface is often salt encrusted. Plants of the Saltgrass Meadow and Allscale- Alkali Scrub are frequent in the understory. The climate is similar to that of the Paloverde-Ironwood-Smoketree Woodland (Table E4).

V. Desert and Semidesert Grassland Complex

A Desert and Semidesert Grassland Complex, occurs in rather scattered locations, usually near the ecotone between scrub vegetation and woodland vegetation.

1. A Desert-Semidesert Scrub Steppe Subcomplex, in which perennial bunch grasses are at least co-dominant with shrubs, is widespread but scattered in the Mojave Desert. It includes four vegetation types (Table E2).

Indian Ricegrass Scrub-Steppe occurs in the Western and Southern Mojave where winter rainfall is the primary moisture source, or in mountains above 1,500 meters where winters are cold. The dominant grasses, *Oryzopsis hymenoides* and *Stipa speciosa*, have C3 metabolism. Shrub components within the grass matrix are usually *Larrea tridentata* and *Ambrosia dumosa*. A scattered overstory of *Yucca brevifolia* or *Juniperus californica* frequently occurs at higher elevations. The climate is somewhat like that of Blackbush Scrub, but a little hotter in summer (Table E4) and perhaps a little wetter.

Desert Needlegrass Scrub-Steppe also occurs in the Western and Southern Mojave, frequently at localities with significant summer rain. Extensive stands of *Stipa speciosa* often have a scattered overstory of *Yucca brevifolia* or *Juniperus californica*. Shrub associates are mostly those of the Blackbush Scrub (Table E3). The climate is slightly cooler than that of the Ricegrass Scrub Steppe (Table E4).

Big Galleta Scrub-Steppe is widely distributed through the Mojave Desert in areas where at least 20% of the precipitation falls in summer. It is dominated by *Hilaria rigida*, *Bouteloua eriopoda* and *Muhlenbergia porteri*, which are summer-active C4 grasses. The scattered overstory consists of *Juniperus osteosperma* and *Yucca brevifolia jaegeriana* in the Eastern Mojave and *Juniperus californica* and *Yucca brevifolia brevifolia* in the Western and Southern Mojave Desert. Associated scrub species are mostly those of the Hopsage Scrub and Blackbush Scrub (Table E3). Below 1,000 meters, where an overstory is not present, conditions approach those of Creosote Bush Scrub. Above 1,000 meters, an overstory is usually present and conditions are more like those of Hopsage Scrub or Blackbush Scrub (Table E4).

Galleta - Blue Grama Scrub-Steppe occurs mostly in the Eastern Mojave Desert at elevations above 1,400 meters where it replaces the preceding type. It is dominated by the summer active C4 grasses, *Hilaria jamesii* and *Bouteloua gracilis*. Shrub associates are usually those of Sagebrush Scrub and the overstory, when present, is usually *Juniperus osteosperma*. The climate is similar to that of Sagebrush Scrub (Table E4.)

2. A Desert Alkali Grassland Subcomplex with one vegetation type, occurs on highly saliferous substrates around springs and alkali seeps at low elevations.

Saltgrass Meadow occurs locally at Saratoga Springs, Tecopa Springs, and various places along the Amargosa River. It is dominated by *Distichlis spicata* and may also include *Sporobolus airoides*, *Anemopsis californica*, *Juncus cooperi* and several others (Table E4). Shrub cover and biomass are rather low. The few shrubs are mostly halophytes like *Allenrolfea*. The climate is very harsh with little precipitation and very high summer temperatures.

VI. Desert Saxicole Shrub Complex

A Desert Saxicole Scrub Complex, with two subcomplexes occurs on steep cliffs and rock faces, and therefore consists of highly localized and edaphically specialized azonal plant assemblages.

1. The Calciphyte Saxicole Subshrub Subcomplex has one vegetation type which grows on rock outcrops widely distributed in the Northern and Eastern Mojave Desert.

Calciphyte Saxicole Subscrub occurs in crevices and on rock faces of dolomite, dolomitic limestone and similar calciferous outcroppings. It includes two series: a dolomitic series on rocks high in calcium-magnesium carbonate; and, a gypsicolus series on rocks rich in calcium sulfate. The species composition is highly variable from one locality to another. Many are rare endemics. A partial list of such species for each series is given in Table E3.

2. The Non - Calciphyte Saxicole Subshrub Subcomplex also has one vegetation type which occurs on rock outcrops which are not or only slightly, calciferous.

Non - Calciphyte Saxicole Subscrub also occurs in the Northern and Eastern Mojave Desert but is more common to the south. The rock substrates are rather heterogeneous, and the species assemblages vary extensively from one locality to another. A partial list of species is given in Table E3.

VII. Desert Psammophyte Complex

A Desert Psammophyte Complex with only one subcomplex, the Desert Psammophyte Subcomplex, occurs on sand dunes.

1. The Desert Psammophyte Subcomplex occurs on sand dunes in both deserts. The largest dunes have the richest flora, and the most constant species, *Larrea tridentata* and *Coldenia plicata*, are not restricted to dunes and certainly are not obligate psammophytes. Many species are restricted to sand dunes or sandy substrates. Some of these obligate psammophytes apparently do not occur in northern dune systems and others do. Some rare endemics occur only on the Eureka Valley dune system (*Swallenia alexandre*, *Oenothera avita eurekensis*). Some rare species occur only in the Algodones Dunes (*Astragalus magdalenae peirsonii*, *Croton wigginsii*, *Helianthus niveus tephrodes*, *Pholisma sonorae*). The species composition varies from one locality to another. The vegetation is quite complex, consisting of local azonal assemblages. They are probably mediated largely by the fact of sand substrate, perhaps with associated water availability characteristics, rather than by climate *per se*.

Table E1. Climatic Summary for stations in several desert regions. (% J-S = percent of precipitation falling in summer; W and S = number of winter and spring days with 2.5 mm precipitation.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w/ 2.5 mm ppt W	S
Great Basin									
Sarcobatus	1225	13.5	-6.5	36.8	144	89.9	40.0	6	3
Bishop	1252	13.4	-6.2	34.9	147	157.5	4.7	9	0
Caliente	1342	11.7	-8.7	35.2	165	202.7	27.4	18	5
Deep Spr.	1593	11.3	-10.1	33.4	155	131.3	12.8	9	3
Goldfield	1733	----	-6.8	32.0	150	127.8	23.3	---	---
Northern Mojave									
Cow Creek	-38	25.1	4.9	46.7	3	49.5	17.4	4	0
Greenland	-51	22.4	3.1	46.6	8	41.4	18.4	4	0
Beatty	1010	15.3	-2.4	37.5	88	118.0	14.9	11	2
Wildrose RS	1250	----	-1.6	35.1	---	185.2	19.8	---	---
Eastern Mojave									
Baker	319	----	0.9	42.9	---	75.2	20.7	8	1
Littlefield	567	18.2	-1.1	40.3	74	157.5	23.8	15	3
Las Vegas WPAP	659	18.9	-0.1	40.1	46	99.1	40.0	8	3
Boulder City	770	19.4	3.3	38.4	13	137.2	33.4	11	3
St. George	823	15.6	-5.3	38.4	96	209.6	29.2	16	4
Desert Game R	890	16.8	-1.5	38.2	127	103.9	27.1	6	3
Kingman	1016	16.4	-0.7	36.6	59	276.9	33.1	15	7
Alamo	1049	13.7	-5.9	37.7	157	164.9	30.7	12	2
Searchlight	1070	17.5	1.7	36.1	34	208.7	37.3	11	5
Pierce Ferry	1177	----	-2.2	35.6	---	256.5	35.9	---	---
Yucca Grove	1204	----	-2.5	35.3	---	185.4	21.0	---	---
Mitchell's Cav	1320	----	-3.1	34.2	---	171.5	27.5	---	---
Mountain Pass	1442	----	-2.0	34.8	---	173.0	31.2	---	---

Table E1. Climatic Summary for stations in several desert regions. (Continued.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w /2.5 mm ppt W	S
Western Mojave									
Trona	517	18.9	-0.6	41.3	47	82.0	8.4	8	0
Lancaster	717	16.1	-1.9	37.4	80	124.2	2.9	11	0
Inyokern	744	17.6	-1.1	39.4	65	90.7	5.6	8	0
Palmdale AP	767	15.8	-1.6	36.7	81	139.2	3.2	12	0
Buckus Ranch	806	16.6	-1.2	37.0	67	162.9	5.5	12	1
Palmdale	809	16.5	-2.7	36.6	60	130.8	3.7	12	0
Mojave	846	----	-0.7	37.4	---	128.5	8.1	---	---
Victorville	871	15.3	-2.7	35.4	84	135.7	5.6	9	0
Fairmont	933	15.7	2.2	32.6	29	376.7	2.3	20	0
Randsberg	1076	17.2	1.6	36.7	33	149.6	9.9	11	1
Valyermo	1129	13.9	-2.5	40.3	103	263.3	7.6	13	1
Llano	1164	16.1	0.9	34.5	44	174.8	7.9	13	2
Haiwee	1166	15.5	-1.3	37.0	73	150.6	9.6	8	2
Central Mojave									
Barstow	653	17.7	-0.4	39.1	57	108.5	27.2	10	2
Southern Mojave									
Twentynine Palms	602	19.7	1.6	37.2	29	104.4	36.3	5	4
Joshua Tree	838	----	----	----	---	123.7	23.4	---	---
Lucerne Valley	919	15.8	-2.4	38.9	104	108.2	18.1	10	3
Hesperia	974	----	----	----	---	157.7	6.3	---	---
Kee Ranch	1318	----	----	----	----	167.6	9.2	7	2
Northern Colorado									
Parker Res	225	23.3	5.3	42.3	1	129.3	32.8	8	3
Needles	278	22.5	4.7	42.3	6	111.8	33.9	7	3
Iron Mtn	281	23.0	5.6	42.1	2	79.5	20.1	5	2

Table E1. Climatic Summary for stations in several desert regions. (Continued.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w/ 2.5 mm ppt W	S
Eastern Colorado									
Blythe	81	22.2	2.0	42.2	12	100.3	32.7	5	1
Eagle Mtn	297	23.0	5.6	41.0	1	82.8	36.5	5	1
Hayfield	418	21.1	3.4	40.5	16	95.6	31.9	6	1
Southwestern Colorado									
El Centro	-11	22.6	3.4	42.8	15	65.3	28.0	5	1
Imperial	-20	22.4	3.9	41.6	5	49.0	25.0	5	0
Brawley	-36	22.9	3.2	42.1	7	59.4	21.4	2	0
Thermal	-37	22.8	3.9	41.8	12	70.1	21.4	4	1
Mecca	-53	22.1	2.9	41.2	12	75.9	24.1	3	0
Indio	3	22.9	3.4	41.6	15	79.8	19.7	4	0
Palm Springs	128	22.3	4.4	42.2	12	138.9	11.2	9	2
Borrego Spr.	191	21.1	2.6	41.4	19	89.2	26.8	7	1
Yuman Desert									
Yuma	42	22.2	3.7	41.3	11	82.3	38.0	3	3
Wellton	79	21.4	1.1	41.6	38	105.7	41.6	4	4
Dateland	138	22.9	3.4	43.1	15	76.7	35.1	4	4
Gila Bend	225	22.3	3.0	42.7	13	142.5	39.9	7	5
Phoenix PO	330	21.5	4.0	39.8	6	194.1	39.0	8	10
Organ Pipe NM	507	20.7	2.8	39.2	19	207.8	47.6	8	10
Ajo	537	21.8	4.8	39.4	6	231.9	48.6	9	9
Kofa Mtns	541	23.1	8.0	39.9	0	140.7	58.8	8	6
Yucca	594	----	----	----	---	167.1	36.3	---	---
Wickenburg	631	18.2	-1.1	39.3	65	272.0	40.3	13	8
Wickieup	648	18.8	0.6	40.3	55	264.6	38.8	12	7
Aguila	665	18.8	0.2	39.7	58	236.1	37.0	12	7
Signal	762	----	----	----	----	281.2	40.7	---	---

Table E2. Classification of Desert Vegetation.

Complex

Subcomplex

Vegetation Type

Desert Scrub

Great Basin Scrub

Sagebrush Scrub

Blackbush Scrub

Hopsage Scrub

Saline Alkali Scrub

Shadscale Scrub

Desert Holly Scrub

MOjave Saltbush-Allscale Scrub

Allscale-Alkali Scrub

Iodinebush-Alkali Scrub

Mojave Colorado Desert Scrub

Creosote Bush Scrub

Cheesebush Scrub

Succulent Scrub

Desert Conifer Woodland-Forest

Xeric Conifer Woodland

Utah Juniper-Oneleaf Pinyon Woodland

California Juniper-Oneleaf Pinyon Woodland

California Juniper-Fourleaf Pinyon Woodland

Desert Montane Forest

White Fir Forest

Subalpine Woodland

Bristlecone Pine Forest

Table E2. Classification of Desert Vegetation. (Continued.)

Desert Microphyll Woodland

Paloverde Microphyll Woodland

Foothill Paloverde-Saguaro Woodland

Blue Paloverde-Ironwood-Smoketree Woodland

Mesquite Microphyll Woodland

Mesquite Thicket

Riparian and Oasis Woodlands

Riparian Woodland

Cottonwood-Willow Riparian Woodland

Cottonwood-Willow-Mesquite Bottomland

Oasis Woodland

Palm Oasis

Desert and Semidesert Grassland

Desert and Semidesert Scrub Steppe

Indian Ricegrass Scrub Steppe

Desert Needlegrass Scrub Steppe

Big Galleta Scrub Steppe

Galletta - Blue Grama Scrub Steppe

Desert Alkali Grassland

Saltgrass Meadow

Desert Saxicole Subscrub

Calciphyte Saxicole Subscrub

Calciphyte Saxicole Subscrub

Non-Calciphyte Saxicole Subscrub

Non-Calciphyte Saxicole Subscrub

Desert Sand Dune

Desert Psammophyte

Desert Psammophyte

Table E3. Some characteristic plants of desert vegetation.

Great Basin Scrub Subcomplex

Sagebrush Scrub	
Artemisia tridentata	*Artemisia nova*
Purshia glandulosa	*Chrysothamnus nauseosus*
Chrysothamnus viscidiflorus	*Coleogyne ramosissima*
Cowania mexicana	*Ceratoides lanata*
Tetradymia sp.	*Oryzopsis hymenoides*
Gutierrezia sarothrae	*Poa secunda*
Sitanion hystrix	*Ephedra viridis*
Blackbush Scrub	
Coleogyne ramosissima	*Yucca baccata*
Yucca brevifolia	*Thamnosma montana*
Grayia spinosa	*Ceratoides lanata*
Artemisia spinescens	*Agave utahensis*
Ephedra nevadensis	*Ephedra viridis*
Atriplex confertifolia	*Atriplex canescens*
Tetradymia spp.	*Eriogonum* spp.
Lycium spp.	*Haplopappus* spp.
Hopsage Scrub	
Grayia spinosa	*Lycium pallidum*
Lycium andersonii	*Lycium shockleyi*
Haplopappus cooperi	*Larrea tridentata*
Ambrosia dumosa	*Yucca brevifolia*

Saline - Alkali Scrub Subcomplex

Shadscale Scrub	
Atriplex confertifolia	*Atriplex canescens*
Ceratoides lanata	*Artemisia spinescens*
Grayia spinosa	*Menodora spinescens*
Gutierrezia spp.	*Coleogyne ramosissima*
Yucca brevifolia	
Desert Holly Scrub	
Atriplex hymenelytra	*Atriplex polycarpa*
Tidestromia oblongifolia	
Mojave saltbush - Allscale Scrub	
Atriplex spinifera	*Atriplex polycarpa*
Ceratoides lanata	*Larrea tridentata*
Tetradymia glabrata	*Yucca brevifolia*
Tetradymia stenolepis	
Allscale-alkali Scrub	
Atriplex polycarpa	*Atriplex confertifolia*
Atriplex torreyi	*Atriplex lentiformis*
Atriplex canescens	*Kochia* spp.
Suaeda torreyana	*Haplopappus acradenius*
Allenrolfea occidentalis	*Prosopis* spp.
Sarcobatus vermiculatus	*Nitrophila occidentalis*
Suaeda spp.	*Atriplex* spp.

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Saline - Alkali Scrub Subcomplex

Allscale-alkali Scrub (Continued.)

Salicornia utahensis	*Sporobolus airoides*
Phragmites australis	*Juncus cooperi*
Pluchea sericea	

Mojave-Colorado Desert Scrub Subcomplex

Creosote Bush Scrub

Larrea tridentata	*Ambrosia dumosa*
Hymenoclea salsola	*Atriplex* spp.
Encelia farinosa	*Acamptopappus sphaerocephalus*
Opuntia spp.	*Yucca* spp.
Lycium spp.	*Dalea* spp.
Hilaria rigida	*Stipa speciosa*
Oryzopsis hymenoides	

Cheesebush Scrub

Hymenoclea salsola	*Encelia farinosa*
Brickellia incana	*Brickellia oblongifolia*
Chrysothamnus paniculatus	*Baccharis* spp.
Ambrosia eriocentra	*Larrea tridentata*
Cassia armata	*Acacia greggii*
Chilopsis linearis	

Succulent Scrub

Agave spp.	*Nolina* spp.
Yucca spp.	*Opuntia* spp.
Ferocactus acanthodes	*Echinocereus* spp
Mammilaria spp.	*Coryphantha* spp.
Fouquieria splendens	*Larrea tridentata*
Ambrosia dumosa	*Encelia farinosa*

Xeric Conifer Woodland Subcomplex

Utah Juniper - Oneleaf Pinyon Woodland

Juniperus osteosperma	*Pinus monophylla*
Yucca brevifolia	*Artemisia tridentata*
Artemisia nova	*Ephedra viridis*
Coleogyne ramosissima	*Eriogonum wrightii*
Ceanothus greggii	*Cercocarpus ledifolius*
Fallugia paradoxa	*Chrysothamnus teretifolius*
Chrysothamnus viscidiflorus	*Rhus trilobata*
Quercus turbinella	*Cowania mexicana*
Purshia glandulosa	*Ribes velutinum*
Hilaria jamesii	*Stipa* spp.
Gutierrezia spp.	*Thamnosma montana*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Xeric Conifer Woodland Subcomplex (Continued.)

California Juniper - Oneleaf Pinyon Woodland

Juniperus californica	*Pinus monophylla*
Yucca brevifolia	*Quercus turbinella*
Quercus dunnii	*Arctostaphylos glauca*
Eriogonum spp.	*Ephedra* spp.
Crossosoma bibelovii	*Haplopappus* spp.
Purshia glandulosa	*Prunus fasciculata*
Nolina parryi	*Salvia dorii*
Opuntia basillaris	*Hilaria rigida*
Stipa speciosa	*Bouteloua gracilis*

California Juniper - Fourleaf Pinyon Woodland

Juniperus californica	*Pinus quadrifolia*
Arctostaphylos glauca	*Pinus monophylla*
Nolina parryi	*Yucca whipplei*
Yucca schidigera	*Rhus ovata*
Ceanothus greggii	*Opuntia* spp.
Adenostoma fasciculatum	*Adenostoma sparsifolium*

Desert Montane Forest Subcomplex

White Fir Forest

Abies concolor	*Pinus monophylla*
Juniperus osteosperma	*Acer glabrum diffusum*
Amelanchier utahensis	*Fraxinus anomala*
Holodiscus microphyllus	*Petrophytum caespitosum*
Philadelphus microphyllus	*Quercus chrysolepis*
Quercus turbinella	*Ribes cereum*
Ribes velutinum	

Subalpine Woodland

Pinus flexilis	*Pinus longaeva*
Acer glabrum diffusum	*Juniperus occidentalis*
Artemisia tridentata	*Ribes cereum*
Chamaebatiaria millefolium	*Chrysothamnus viscidiflorus*
Ribes montigenum	*Symphoricarpus longiflorus*

Bristlecone Pine F.

Pinus longaeva	*Pinus flexilis*
Antennaria rosea	*Arenaria kingii*
Astragalus kentrophyta	*Chrysothamnus viscidiflorus*
Cymopterus cinerarius	*Erigeron pygmaeus*
Haplopappus acaulis	*Muhlenbergia richardsonis*
Phlox covillei	

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Paloverde Microphyll Woodland Subcomplex

Foothill Paloverde -Saguaro Woodland

Cercidium microphyllum	*Carnegiea gigantea*
Larrea tridentata	*Encelia farinosa*
Opuntia bigelovii	

Blue Paloverde-Ironwood-Smoketree Woodland

Cercidium floridum	*Bebbia juncea*
Olneya tesota	*Prosopis spp.*
Psorathamnus spinosa	*Hymenoclea salsola*
Chilopsis linearis	*Ambrosia dumosa*
Castela emoryi	*Larrea tridentata*
Acacia greggii	*Chrysothamnus paniculatus*
Hyptis emoryi	*Hoffmannseggia microphylla*
Cassia armata	*Brickellia* spp.

Mesquite Microphyll Woodland Subcomplex

Mesquite Thicket

Prosopis glandulosa	*Prosopis pubescens*
Atriplex polycarpa	*Atriplex confertifolia*
Atriplex torreyi	*Atriplex lentiformis*
Atriplex canescens	*Kochia* spp.
Nitrophila occidentalis	*Suaeda torreyana*
Sarcobatus vermiculatus	*Salicornia utahensis*

Streamside Woodland Subcomplex

Cottonwood - Willow - Mesquite Bottomland

Populus fremontii	*Salix exigua*
Salix spp.	*Prosopis glandulosa*
Tamarix spp.	

Cottonwood - Willow - Streamside Woodland

Populus fremontii	*Salix* spp.
Platanus racemosa	*Prosopis* spp.
Washingtonia filifera	*Typha* spp.
Pluchea sericea	*Phragmites australis*
Baccharis spp.	

Desert Oasis Woodland Subcomplex

Palm Oasis

Washingtonia filifera	*Pluchea sericea*
Sporobolus airoides	*Distichlis spicata*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Desert-Semidesert Scrub Steppe Subcomplex

Indian Ricegrass Scrub Steppe

Oryzopsis hymenoides	*Stipa speciosa*
Larrea tridentata	*Ambrosia dumosa*

Desert Needlegrass Scrub Steppe

Stipa speciosa	*Juniperus californica*
Yucca brevifolia	*Coleogyne ramosissima*
Ephedra nevadensis	*Haplopappus linearifolius*
Purshia glandulosa	*Lycium andersonii*
Tetradymia spinosa	
Eriogonum fasciculatum var. polifolium	

Big Galleta Scrub Steppe

Hilaria rigida	*Bouteloua eriopoda*
Muhlenbergia porteri	*Stipa speciosa*
Oryzopsis hymenoides	*Yucca brevifolia*
Juniperus spp.	*Larrea tridentata*
Ambrosia dumosa	*Ephedra nevadensis*
Hymenoclea salsola	*Yucca schidigera*
Haplopappus spp.	*Salazaria mexicana*
Thamnosma montana	*Menodora spinescens*
Yucca baccata	*Opuntia* spp.

Galleta-Blue Grama Scrub Steppe

Hilaria jamesii	*Bouteloua gracilis*
Sitanion hystrix	*Oryzopsis hymenoides*
Juniperus osteosperma	*Artemisia tridentata*

Desert Alkali Grassland Subcomplex

Salt Grass Meadow

Distichlis spicata	*Sporobolus airoides*
Phragmites australis	*Allenrolfea occidentalis*
Anemopsis californica	*Juncus cooperi*
Pluchea sericea	

Saxicole Subscrub Subcomplexes

Calciphyte Saxicole Subscrub
-dolomitic-

Arctomecon merriami	*Arenaria kingii*
Astragalus funereus	*Astragalus panamintensis*
Buddleia utahensis	*Cymopterus gilmani*
Cowania mexicana	*Dedeckera utahensis*
Dudleya saxosa	*Eriogonum gilmani*
Eriogonum intrafactum	*Eriogonum heermannii floccosum*
Fendlerella utahensis	*Forsellesia pungens*
Forsellesia nevadensis	*Gilia ripleyi*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Saxicole Subscrub Subcomplexes

Calciphyte Saxicole Subscrub
-dolomitic- (Continued.)

Hecastocleis shockleyi	*Holmgrenanthe petrophile*
Hedeoma nana	*Mimulus rupicola*
Mortonia utahensis	*Phacelia mustelina*
Penstemon calcareus	*Penstemon stephensii*
Salvia funerea	*Scopulophila rixfordii*
Viola charlestonensis	*Cheilanthes feei*
Notholaena jonesii	*Notholaena sinuata*
Mentzelia pterosperma	*Phacelia pulchella*
Enceliopsis argophylla	*Enceliopsis nudicaulis*
Eriogonum insigne	*Petalonyx parryi*
Phacelia palmeri	*Psathyrotes pilifera*
Arctomecon californica	*Camissonia multijuga*

Non-Calciphyte - Saxicole Subscrub

Peucephyllum schottii	*Haplopappus cuneatus*
Perityle emoryi	*Brickellia desertorum*
Pleurocoronis pluriseta	*Heuchera rubescens*
Arabis spp.	*Mimulus* spp.
Dudleya spp.	*Cheilanthes* spp.
Notholaena spp.	
Pellaea spp.	

Desert Psammophyte Subcomplex

Desert Psammophyte

Larrea tridentata	*Hesperocallis undulata*
Coldenia plicata	*Ammobroma sonorae*
Psorothamnus emoryi	*Hilaria rigida*
Ephedra trifurca	*Prosopis glandulosa*
Palafoxia arida	*Atriplex polycarpa*
Atriplex canescens	*Helianthus niveus*
Petalonyx thurberi	*Swallenia alexandre*
Oryzopsis hymenoides	*Oenothera avita eurekensis*
Croton wigginsii	*Astragalus lentiginosus micans*
Haplopappus acradenius	*Astragalus magdalenae peirsonii*
Abronia villosa	

Table E4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit).

Vegetational Category	Mean Annual Precip (mm)		Temperature (°C) Mean Jan. Minima		Mean July Maxima		PotE/Ppt Range		Approx. Elev. (x100m)	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
I. Desert Scrub Complex										
A. Great Basin Scrub Subcomplex										
1. Sagebrush Scrub	175	325	-12	-4	25	36	2	5	12	26 (30)
2. Blackbush Scrub	150	240	-8	-4	29	37	3	7	10	20
3. Hopsage Scrub	150	240	-8	-4	29	37	3	7	10	20
B. Saline-Alkali Scrub Subcomplex										
1. Shadscale Scrub	130	225	-8	-4	31	37	3	7	10	18
2. Desert Holly Scrub	42	90	-8	-4	37	47	10	32	-0.8	8 (15)
3. Mojave Saltbush - Allscale Scrub	110	150	-1	1	37	40	6	8	6	10
4. Allscale - Alkali Scrub	82	170	-5	5	36	43	8	20	-0.8	12 (18)
5. Iodinebush - Alkali Scrub	42	275	-10	6	39	47	10	32	-0.8	7
C. Mojave - Colorado Desert Scrub Subcomplex										
1. Creosote bush Scrub	42	275	-6	6	30	47	4	32	-0.7	13
2. Cheesebush Scrub	42	275	-10	6	30	47	3	32	-0.7	20
3. Succulent Scrub	150	275	-8	-2	29	47	2	7	10	20
II. Xeric Conifer Woodland - Desert Montaine Forest Complex										
A. Xeric Conifer Woodland Complex										
1. Utah Juniper - One-leaf Pinyon Woodland	175	375	-13	-4	23	36	1	4	15	30
2. California Juniper - One-leaf Pinyon Woodland	175	400	-9	-2	34	38	1	4	12	18
3. California Juniper - Four-leaf Pinyon Woodland	225	400	-9	-1	35	39	1	4	11	17

Table E4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit). (Continued.)

Vegetational Category	Mean Annual Precip (mm)		Temperature (°C) Mean Jan. Minima		Mean July Maxima		PotE/Ppt Range		Approx. Elev. (x100m)	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
II. Xeric Conifer Woodland - Desert Montaine Forest Complex (Continued.)										
B. Desert Montaine Forest Subcomplex										
1. White Fir Forest Enclaves	250	325	-10	-7	26	30	1.5	3	19	24
III. Desert Microphyll Woodland Complex										
A. Paloverde Microphyll Woodland Subcomplex										
1. Foothil Paloverde - Saguaro Woodland	115	160	1	6	40	44	10	12	3	4
2. Blue Paloverde - Ironwood - Smoketree Woodland	80	160	1	6	40	44	10	20	0	8
B. Mesquite Microphyll Woodland Subcomplex										
1. Mesquite Thicket	42	160	-2	6	40	47	8	32	-0.8	8
IV. A. Streamside and Oasis Woodland Complex										
1. Cottonwood - Willow - Mesquite Bottomland	80	160	-4	6	35	42	5	17	0	10
2. Cottonwood - Willow - Streamside Woodland	125	250	-7	1	30	38	3	9	8	20
B. Desert Oasis Woodland Subcomplex										
1. Palm Oases	80	150	1	6	40	44	10	15	0	10

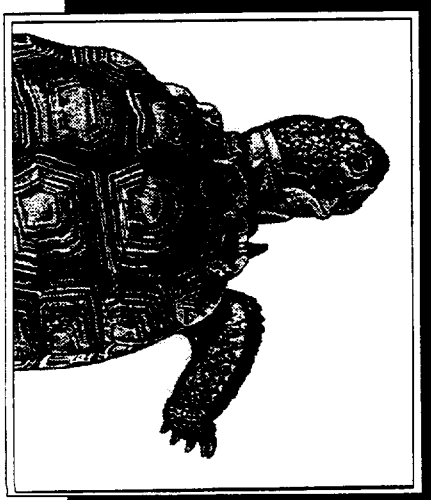
Table 4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit). (Continued.)

Vegetational Category	Mean Annual Precip (mm)		Temperature (°C) Mean Jan. Minima		Mean July Maxima		PotE/Ppt Range		Approx. Elev. (x100m)	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
V. Desert and Semidesert Grassland Complex										
A. Desert - Semidesert Scrub-Steppe Subcomplex										
1. Indian Ricegrass Scrub-Steppe	120	300	-9	0	28	40	2	8	6	23
2. Desert Needlegrass Scrub-Steppe	120	250	-9	-2	30	38	2	5	10	20
3. Big Galleta Scrub-Steppe	110(80)	250	-4	3	35	44	3	8(15)	3(0)	23
4. Galleta - Blue Grama Scrub-Steppe	175	300	-9	-3	28	36	2	4	12	23
B. Desert Alkali Grassland Subcomplex										
1. Saltgrass Meadow	42	120	-5	5	38	47	8	32	-0.8	10
VI. Desert Savicole Subscrub Complex										
A. Calciphyte Saxicole Subscrub Subcomplex										
1. Calciphyte Saxicole Subscrub[1]	100	300	-9	0	26	38	2	10	6	24
B. Non-Calciphyte Saxicole Subscrub Subcomplex										
1. Non-Calciphyte Saxicole Subscrub[1]	100	300	-9	0	26	38	2	10	6	24
VII. Desert Psammophyte (Sand Dune) Complex										
A. Desert Psammophyte Subcomplex										
1. Desert Psammophyte[1]	42	150	-4	6	37	47	7	32	0	10

[1]An adequate synecologoical analysis should result in substantial subdivision of these types.

Appendix F

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix F: Summary Descriptions of Proposed Desert Wildlife Management Areas

I. NORTHERN COLORADO RECOVERY UNIT

1. Chemehuevi DWMA

Current densities: 10 to 275 adult desert tortoises per square mile.

Location and Description:

The proposed Chemehuevi DWMA in San Bernardino County, California, lies approximately south of Interstate 40; north of Highway 62; west of Havasu National Wildlife Refuge and the Chemehuevi Indian Reservation; and east of the Old Woman Mountains and Essex (Figure 7). The Chemehuevi DWMA is varied, both vegetationally and topographically. It includes elements of both Colorado Desert and Mojave Desert floras, and elevations range from about 600 to 4,700 feet. A number of basins and ranges are represented. The BLM manages 67% of the lands in the proposed DWMA; remaining lands are in private (25%) or State (6%) ownership.

The desert tortoise population in this DWMA is relatively large, unfragmented, and little affected by human impacts. If this DWMA is made large, as proposed here, it could provide a relatively secure refuge for the species as populations in other areas are recovering.

Desert Tortoise Densities and Trends:

Currently the largest and most robust population of desert tortoises remaining within the geographic range is found in portions of the Ward and Chemehuevi valleys (Berry and Nicholson 1984a, Berry 1990, as amended). Between 1979 and 1988, densities in the Chemehuevi Valley increased from 145 to 224 tortoises per square mile, but had declined by 1992, at least among adults and subadults by 1992. The changes were not statistically significant. At the northern Ward Valley plot, total numbers of tortoises captured increased substantially between 1980 and 1991, and densities of the tortoises in the larger size classes increased markedly from 107 to 190 tortoises per square mile, but the changes were not statistically significant. Regional densities are probably depressed from military activities in the 1940s, livestock grazing, and other human uses (Berry and Nicholson 1984b). Densities along major highways,

such as Interstate 40 and Highways 62 and 95, are also depressed (Berry and Turner 1984, Karl 1989).

Threats:

In terms of current and planned human uses which may adversely affect desert tortoises, the Chemehuevi DWMA is one of the least threatened DWMAs. Major current human uses which impact desert tortoises include cattle grazing on the Lazy Daisy and Chemehuevi allotments; and fragmentation and mortality caused by highways, roads, and the Colorado River Aqueduct. Wild burros are also present in the DWMA and degrade desert tortoise habitat. Harvest of Mojave yucca is a problem in some areas.

As of 1991, no documented cases of URTD were known from the Chemehuevi DWMA, however, about 25% of desert tortoises are symptomatic for a shell disease, which appears different from that described for the Chuckwalla DWMA (K.H. Berry, pers. comm. 1993).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.2.), the following specific actions should be implemented in the Chemehuevi DWMA:

(1) Remove livestock grazing.

(2) Maintain feral burros within herd management areas at zero population levels, or as experimental populations. Remove feral burros outside of herd management areas.

(3) Construct desert tortoise barriers and underpasses along Interstate 40; Highways 95 and 62; the Atchison, Topeka, and Santa Fe Railroad; and frequently used roads. Evaluate the need for barrier fencing along the Colorado River Aqueduct and around communities such as Essex and Vidal, California.

(4) Establish a center, at or near Needles, where unwanted captive desert tortoises could be deposited. Develop programs to make unwanted desert tortoises available for research and educational purposes.

(5) Monitor health of desert tortoises, particularly URTD and shell disease.

Recommended Research:

The following research topic is especially suited to the management needs and opportunities presented in the Chemehuevi DWMA.

(1) The effects of feral burros, utility corridors, and barrier fencing on desert tortoises.

II. EASTERN COLORADO RECOVERY UNIT

1. Chuckwalla DWMA

Current densities:

5 to 175 desert tortoises per square mile.

Location and Description:

The proposed Chuckwalla DWMA is located in Riverside and Imperial Counties, California. Starting with the northwest corner, the proposed boundary would extend along the north facing slopes of the Orocopia Mountains, then run eastward along the southern edge of Interstate 10 to Wiley Well Road, then south to near Midway Well, and then north and west along the eastern portion of the Chocolate Mountains Aerial Gunnery Range to the south slopes of the Orocopia Mountains and the Southern Pacific Railroad (Figure 7). The DWMA contains several mountain ranges and valleys, ranging in elevation from 400 to 4,500 feet. Included is the Chuckwalla Bench, a bajada which has in the recent past supported the highest known densities of desert tortoises. Plant communities are typical of the Colorado Desert (Appendix E). Land ownership is a checkerboard of BLM, military, and private lands.

This DWMA is not large enough to support 50,000 adult desert tortoises at target density. Although the Joshua Tree DWMA is primarily in the western Mojave recovery unit, its southeast corner is in the eastern Colorado recovery unit. Protection of habitat there, as well as in the Chuckwalla DWMA, should be implemented to protect sufficient habitat for recovery.

Desert Tortoise Densities and Trends:

The Chuckwalla Bench DWMA has two study plots that provide density estimates and trend data: Chuckwalla Bench and Chuckwalla Valley (Berry 1990, as amended, Berry and Nicholson 1984a). In 1979-1982, estimated densities were 578 tortoises per square mile on the Chuckwalla Bench; by 1990 densities had declined to 160 tortoises per square mile. On the second plot, Chuckwalla Valley, densities were 163 tortoises per square mile in 1980 and subsequently declined to 73 tortoises per square mile in 1992. The density figures reflect the higher density portions of the DWMA (Berry and Nicholson 1984a). Declines are attributable to vandalism, vehicle kills, raven predation, and a shell disease (Berry 1990, as amended, BLM et al. 1989, Rosskopf 1989, Jacobson et al. 1994).

Threats:

Habitat in the Chuckwalla DWMA has been degraded or destroyed due to military activities in the 1940s, domestic sheep grazing, agricultural development, diversion dikes along Interstate 10, bombing associated with the Chocolate Mountains Aerial Gunnery Range, unauthorized ORV activity, and mining (Berry 1984b, Berry and Nicholson 1984b, Bernstein 1989, Hurst and Healy 1989, Kataoka 1989, Marquis 1989). A proposed landfill site in the Eagle Mountains is of concern because refuse would be transported via the old Southern Pacific railroad, which would contribute to fragmentation of desert tortoise habitat in the Chuckwalla Bench area.

The presence of URTD has not been confirmed in the proposed Chuckwalla DWMA; however, a substantial portion of desert tortoises on the Chuckwalla Bench experienced a shell disease that was associated with high mortality rates between 1982 and 1991 (Berry 1990, as amended, Jacobson et al. 1994).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.D.2), the following specific actions should be implemented in the Chuckwalla DWMA:

(1) Restrict train traffic to 1991 levels or construct barrier fencing and desert tortoise underpasses along the railroad tracks to reduce or eliminate mortality and population fragmentation.

(2) Construct barrier fences and underpasses for desert tortoises along well-used roads in the DWMA, including the south side of Interstate 10.

(3) Determine actual and potential raven use of palm trees and other roost and perch sites at the Chuckwalla Prison and the adjacent new prison site. Eliminate raven perch and nest sites.

(4) Work cooperatively with the Chocolate Mountains Aerial Gunnery Range to eliminate unauthorized bombing of public lands and mitigate habitat damage which has resulted from these activities.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Chuckwalla DWMA:

(1) The effects of dirt roads and mining on desert tortoise populations and habitat. Research habitat restoration, particularly of old agricultural fields and areas adversely affected by diversion dikes.

(2) Continue research on shell and other diseases to isolate causes of high mortality.

III. UPPER VIRGIN RIVER RECOVERY UNIT

1. Upper Virgin River DWMA

Current densities:

Small areas of the DWMA contain up to at least 250 adult desert tortoises per square mile; desert tortoises in this DWMA occur in a mosaic of high to low densities.

Location and Description:

The proposed Upper Virgin River DWMA in Washington County, Utah, lies approximately north of St. George and Hurricane, Utah, west of Highway 18, east of Snow Canyon, and south of Yant Flat and Cedar Bench (Figure 8). Desert tortoises of this proposed DWMA are notable among populations in the Mojave Region because they represent the northern-most population of the species and densities are currently very high in some areas. Desert tortoise habitat in this DWMA is characterized by rugged terrain of rocky outcrops and hills interspersed with sandy areas. Vegetation is diverse and includes creosote scrub, blackbush scrub, big galleta scrub steppe, desert psammophyte, and Utah juniper - one-leaf pinyon woodland (Appendix E). Land ownership is a patchwork of BLM, State, and private lands.

Because this recommended DWMA will not contain 1,000 square miles of contiguous desert tortoise habitat intensive management, even after recovery, will be necessary to ensure a reasonable probability of long-term population persistence (Figure 6D).

Desert Tortoise Densities and Trends:

On the City Creek study plot (1-mile square), 243 desert tortoises were marked in 1988, of which 163 were adults or subadults (Rick Fridell, Utah Division of Wildlife Resources, pers. comm. 1993). However, densities are much lower and patchy throughout most of the proposed Upper Virgin River DWMA. Data are insufficient to evaluate population trends; but, populations could decrease in the future as tcities in Washington County grow and human use of this area increases.

Threats:

Quantitative, rather than qualitative, loss of habitat is the primary threat to the desert tortoise population in this proposed DWMA. Although a variety of human uses occur, the condition of the habitat is generally good. ORV use occurs in Snow Canyon but is limited by topography. Cattle grazing occurs, but is limited by topography

and access to water. A popular shooting area is located in the western portion of the DWMA on BLM land. A turkey farm occupies a large tract of private land, and dumps and landfills occur in the DWMA and nearby. Desert tortoise populations are also affected by human activities in and around St. George, a growing community with a population of 35,600 in 1993, up from 28,500 in 1990. Interstate 15 and Highway 18 are the major transportation corridors in the area. No mining occurs in this DWMA.

URTD is not currently known to be a threat to desert tortoises in this DWMA.

Specific Management Actions:

This is the only DWMA proposed for the Upper Virgin River recovery unit. Because of the small size of this proposed DWMA, management will need to be intensive and promptly implemented if this desert tortoise population is to be given a reasonable chance of long-term persistence. Acquisition of private inholdings (or development of conservation easements *in perpetuity*)is imperative for recovery, particularly for non-Federal and private lands north and northeast of St. George, Paradise and Padre canyons, and north of Hurricane. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Upper Virgin River DWMA:

(1) Remove livestock grazing from the DWMA.

(2) Construct and maintain desert tortoise barrier fencing along Interstate 15, Highway 18, and the road to the turkey farm.

(3) Install underpasses for desert tortoises along Highway 18 between Paradise Canyon and Twist Hollow, and the road to the turkey farm.

(4) Close the debris dam road north of St. George or restrict access through installation of a locked gate.

(5) Establish a visitor center outside the DWMA which would educate the public about the desert tortoise and serve as a drop-off site for unwanted captive tortoises. Develop a program to make these animals available for educational and research purposes.

(6) Consolidate ownership and management of the entire DWMA, primarily for desert tortoise, under Federal management as a National Conservation Aea.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Upper Virgin River DWMA:

(1) Desert tortoise reproduction and growth rates.

(2) Desert tortoise nutritional ecology and physiology.

(3) Factors governing desert tortoise distribution in this DWMA.

IV. EASTERN MOJAVE RECOVERY UNIT

1. Fenner DWMA

Current densities:

10 to 350 desert tortoises per square mile.

Location and Description:

The proposed Fenner DWMA in San Bernardino County, California, would include the northeastern part of the Clipper Valley, north-central part of the Fenner Valley, and the southern Piute Valley. The DWMA would be bounded by the Providence Mountains on the west, Hackberry and Piute Mountains and the Nevada border on the north, the Dead Mountains on the east, and Interstate 40 and the Clipper Mountains on the south (Figure 9). This proposed DWMA is primarily in the eastern Mojave recovery unit, but as described here, the southeastern edge is in the northern Colorado recovery unit. The area is heterogeneous topographically with elevations from about 1,600 to 3,454 feet. Several plant communities are present, including Big Galleta Scrub Steppe, Succulent Scrub, a rich Creosotebush Scrub, Hop Sage Scrub and Blackbush Scrub (Appendix E). This proposed DWMA includes portions of the East Mojave National Scenic Area. Land ownership is about 67% public, 28% private, and 5% State.

Desert Tortoise Densities and Trends:

The highest densities of desert tortoises occur in only a few patches of a few square miles each (Berry et al. 1994), with the Goffs study plot supporting the highest levels. In the Goffs area, densities west of Lanfair Road range from 50 to 100 desert tortoises per square mile. To the east of the Lanfair Road, densities probably average about 50 per square mile. The desert tortoise population on the Goffs plot declined from 440 tortoises per square mile in 1980 to 362 in 1990 (Berry 1990, as amended). In less than 2 years of work on a health profile study in this DWMA, 7 of 20 desert tortoises either died or were presumed dead (Berry 1991, Nagy et al. 1990). Densities are probably depressed throughout the proposed DWMA as a result of a variety of human impacts (Berry 1984a).

Threats:

The Fenner, Clipper, and Piute valleys have experienced harvest of Mojave yuccas on Southern Pacific lands, with some unauthorized

harvest on BLM lands, and long-term cattle grazing. The valleys are the sites of major transportation and utility corridors, which undoubtedly have contributed to declines of adjacent desert tortoise populations. Settlements at Goffs, Essex, and the Providence Mountains State Park add to the cumulative impact load. As general recreation pressures increase in the East Mojave National Scenic Area, desert tortoise mortality rates from collecting, vandalism, and roadkills are likely to increase. Raven populations appear to be growing in the valley and nearby areas (Knowles et al. 1989a, 1989b).

Four ill desert tortoises were found on the Goffs study plot in 1990. The poor condition of these animals was attributed to below optimum water and nutrient uptake (Jacobson and Gaskin 1990), probably due to drought. *Mycoplasma sp.* and *Pasteurella testudinis* were found in a Goffs' desert tortoise in the summer of 1991. Both these organisms often appear together in desert tortoises with URTD (Jacobson et al. 1991).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Fenner DWMA:

(1) Remove livestock grazing.

(2) Implement a program to control raven predation on juvenile desert tortoises.

(3) Construct and maintain desert tortoise-proof fencing and underpasses along the Atchison, Topeka, and Santa Fe Railroad; Interstate 40; and well-used roads, such as the Goffs Road.

(4) Sign the DWMA boundary near the Goffs settlement.

(5) Establish a drop-off site for unwanted captive desert tortoises. Develop a program to make these animals available for research and educational purposes.

(6) Implement emergency action to halt harvest of yuccas and other vegetation.

(7) Closely monitor predation by ravens on desert tortoise populations. Where appropriate, ensure that excessive predation is controlled and that sufficient recruitment of juveniles into the subadult and adult cohorts occurs.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Fenner DWMA:

(1) Health profiles, disease, and reproduction in desert tortoises at established sites (continue ongoing studies until complete).

(2) Population demography, movements, and food preferences and availability.

(3) The effects of small settlements, road densities, and railroads on adjacent desert tortoise populations and habitat, and effectiveness of barriers and underpasses.

(4) Methods to protect desert tortoises from high density forms of general recreation.

2. *Ivanpah DWMA*

Current densities:

5 to 250 desert tortoises per square mile.

Location and Description:

The proposed Ivanpah DWMA in San Bernardino County, California, is horseshoe in shape and is composed of the Ivanpah, Kelso, and Shadow valleys and interconnecting corridors (Figure 9). Although most of this proposed DWMA lies in the eastern Mojave recovery unit, Ivanpah Valley is in the northeastern Mojave recovery unit. Elevations range from 2,500 to 4,764 feet and topography includes bajadas, rolling hills, lava flows, one playa lake, and a few major drainages. Vegetation is diverse and includes seven distinct communities (Appendix E). This proposed DWMA includes portions of the East Mojave National Scenic Area. This area is managed almost entirely by BLM.

Desert Tortoise Densities and Trends:

The highest known densities of desert tortoise occurred in southern Ivanpah Valley, where about 20 square miles support densities of 200 to 250 per square mile. Throughout much of the northern Ivanpah, Kelso, and Shadow valleys, densities were generally less than 50 per square mile. About half of these were adult or subadult animals (Berry 1990, as amended, Berry 1991). On the Ivanpah Valley plot, densities declined from 368 tortoises per square mile in 1970 to 249 in 1990, but this trend was not statistically significant (Berry 1990, as amended). Nine of 18 desert tortoises monitored in Ivanpah Valley from 1989 to 1991 succumbed to drought-related stress (Nagy et al. 1990, Berry 1992, Jacobson and Gaskin 1990). In addition, the proportion of juvenile desert tortoises declined from the 1970's to the 1990's at the Ivanpah Valley plot, apparently as a result of high predation rates by ravens (Berry et al. 1986b, Berry 1990, as amended, 1991, BLM et al. 1989).

Threats:

A variety of human uses have contributed to habitat loss and degradation in this DWMA. Military maneuvers during the mid 1960's impacted areas in the southern Ivanpah Valley, while motorcycle races, including the Barstow to Vegas race, affected habitat in the Shadow Valley and northern Ivanpah Valley. Cattle grazing occurs on portions of five allotments in this DWMA, and perennial grasses are heavily grazed in some areas. Other major human uses include recreation that contributes to habitat degradation, mining, powerline corridors. Urban development at

Stateline, Nevada; OHV use in northern Ivanpah Valley and around Roach Lake; and landfills, garbage dumps, and sewage ponds which attract ravens all contribute to desert tortoise mortality and habitat destruction.

A few desert tortoises in a health profile research program tested positive for URTD (*Mycoplasma*) during 1991 (Brown et al. 1993). Some animals also have shell disease (Berry pers. comm. 1993). An adult desert tortoise was found paralyzed in Shadow Valley in 1991. Possible causes of the paralysis included poisoning resulting from ingestion of locoweed (*Astragalus sp.*) or some other toxin (Klaasan 1991, Blood et al. 1989, Casteel et al. 1985, Fuller and McClintock 1986).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Ivanpah DWMA:

(1) Remove livestock grazing from the Crescent Peak, Clark Mountain, Kessler Springs, Valley Wells, and Valley View allotments.

(2) Construct and maintain desert tortoise-proof barriers and underpasses to protect tortoises and habitat from Interstate 15 and well-used roads, such as Nipton and Ivanpah Roads. Also, construct fencing to protect desert tortoises from recreational vehicle use on the Ivanpah Dry Lake and near Whiskey Pete's casino.

(3) Conduct intensive new surveys (using strip transects) in northern Ivanpah, Shadow, and Kelso valleys and Cima Dome to gather information on distribution and densities of desert tortoises.

(4) Implement a raven-control program to reduce predation on juvenile tortoises. Monitor desert tortoise populations to ensure that juveniles are recruited into subadult and adult cohorts in sufficient numbers to promote population recovery.

(5) Sign DWMA boundaries in the vicinity of Nipton, Kelso, and other similar settlements and areas with conflicting land uses.

(6) Promote return of perennial grasses and increases in cover values of native grasses and decreaser species.

(7) Construct desert tortoise barriers and underpasses along the Union Pacific Railroad.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in this DWMA:

(1) Disease, health, nutritional requirements and physiology, as well as effects of grazing on vegetation, soils, and desert tortoise behavior (continue ongoing intrusive research).

(2) The extent and potential causes of toxicosis (possibly selenium poisoning, locoweed poisoning, or some other form of toxicosis) in desert tortoises in the Shadow Valley and elsewhere in this DWMA. Identify sources of poison and distribution of potentially poisonous plants.

(3) Genotypes of desert tortoises in areas of potential linkages between this DWMA, and the Fenner and Piute-El Dorado DWMAs.

(4) The effects of utility towers on the desert tortoise and its habitat. Towers and similar structures may encourage an increase in avian predators.

3. *Piute-Eldorado DWMA*

Current densities:

40 to 90 adult desert tortoises per square mile

Location and Description:

The proposed Piute-Eldorado DWMA in Clark County, Nevada, lies approximately west of the Colorado River, north and east of the California State line, south of Boulder City, and southeast of Goodsprings and the north end of the McCullough Mountains (Figure 9). As described here, this proposed DWMA would include portions of both the eastern and northeastern Mojave recovery units. This DWMA is heterogeneous vegetationally and topographically, and includes several parallel mountain ranges divided by valleys, dry lakes, and bajadas. Several plant communities are represented, including Shadscale Scrub, Creosote Bush Scrub, Blackbush Scrub, and Utah Juniper - One-Leaf Pinyon Woodland (Appendix E). The proposed Piute-Eldorado DWMA has a common border with the Fenner and Ivanpah DWMAs in California. Land ownership is a mix of National Park Service, BLM, and private lands.

Desert Tortoise Densities and Trends:

The Piute Valley represents the largest area of high density desert tortoise habitat known in Nevada. The population is contiguous with a larger high-density area in California and represents a zone of contact between two genetic types (Brussard 1992). Data are insufficient to assess population trends; however, densities are likely declining due to human-related disturbances which adversely affect desert tortoises, such as recreation, mines, residential development, and livestock grazing (Appendix D, Nevada Department of Wildlife 1990).

Threats:

Desert tortoises have been adversely affected by a variety of human uses in the proposed DWMA. ORV activity, including organized races, is the principle recreational activity affecting desert tortoises. Transmission lines and associated access roads run southwest from Hoover Dam through the DWMA. Six cattle grazing allotments are also present. Interstate 15 and Highway 95 pass through the DWMA and act as formidable barriers to east-west movement. Road density in the area was estimated at 0.9 miles per section in 1984, but has probably increased since that time. Historic as well as current mining is evident in many portions of the proposed DWMA.

A habitat management plan for this area, prepared by the BLM in cooperation with the National Park Service, Nevada Department of Wildlife, and the Nature Conservancy, is currently in draft form. This plan will implement mitigation actions required in a 10(a)(1)(B) incidental take permit issued to Clark County and the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City. The habitat management plan proposes management plans and policies for about 430,000 acres in the Eldorado, Cottonwood, and Piute Valleys. It provides for land use controls including removal of livestock grazing, restriction of landfills and intensive recreation, elimination of most competitive off-highway vehicle events, and increased law enforcement (BLM 1983). To date four of the six grazing allotments have been purchased and are currently being held in non-use by The Nature Conservancy.

URTD has been observed in desert tortoises in this area. The occurrence of this disease is correlated with locations of releases of captive desert tortoises, particularly in and around urban areas and degraded habitats (Marlow and Brussard 1992).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the proposed Piute-Eldorado DWMA:

(1) Maintain feral equids within herd management areas at zero population levels. Remove feral equids outside herd management areas.

(2) Construct and maintain desert tortoise barrier fencing to protect desert tortoises and their habitat from vehicles and access provided by Highway 95, State Route 163, and the Nipton Highway. Install underpasses to allow for movements and gene flow within this DWMA.

(3) Establish a visitor center which would educate the public about the desert tortoise and its habitat and include a drop-off site for unwanted captive desert tortoises. Develop a program to make unwanted captives available for research and educational purposes.

(4) Sign DWMA boundaries around Searchlight, Laughlin and other settlements.

(5) Acquire Colorado River Commission lands or secure conservation easements for surface and subsurface management.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Piute-Eldorado DWMA:

(1) The effects of ORV use in the Eldorado Valley on the desert tortoise and its habitat.

(2) The impacts of various linear features, particularly Highway 95, which divides the proposed DWMA.

(3) Movements of desert tortoises through narrow passes (i.e., between Eldorado Valley and Jean Lake) compared with movement patterns in unstructured, unbounded areas (i.e., Piute Valley).

(4) Genetic relationships between desert tortoises in the northern and southern ends of the DWMA.

V. NORTHEASTERN MOJAVE RECOVERY UNIT

1. Beaver Dam Slope DWMA

Current densities:

5 to 56 desert tortoises per square mile.

Location and Description:

The proposed Beaver Dam Slope DWMA in extreme southwestern Washington County, Utah, and northwestern Mohave County, Arizona, lies approximately north of Interstate 15 and Littlefield, Arizona; west of the western slope of the Beaver Dam Mountains; south of Motoqua, Utah; and east of the Nevada State border (Figure 9). This proposed DWMA would include critical habitat designated for the desert tortoise in 1980 (Fish and Wildlife Service 1980). Desert tortoise habitat in this DWMA is typically eastern Mojave Desert Scrub, characterized primarily by Creosote Bush Scrub. Joshua trees (*Yucca brevifolia*) are well developed in this vegetation type, especially in the more northerly parts of the Beaver Dam Slope. Topography varies from the steep, lower slopes of the Beaver Dam Mountains to gently sloping creosote bush flats intersected by small to major washes, which often provide deep caliche-cave hibernacula for desert tortoises. Most lands within this proposed DWMA are in private ownership or managed by the BLM. About 22.4 square miles of this proposed DWMA were designated critical habitat for the desert tortoise in 1980 (Fish and Wildlife Service 1980).

The desert tortoise population in this DWMA is currently linked to the Mormon Mesa population across about 15 miles of fair to poor habitat north of the Virgin River. Because of its small target population, the probability of long-term persistence of desert tortoises on the Beaver Dam Slope DWMA would be enhanced if this corridor remains viable.

Desert Tortoise Densities and Trends:

Monitoring of desert tortoise numbers in this DWMA began with the Woodbury-Hardy study plot in the 1930s (Woodbury and Hardy 1948). Currently, desert tortoise numbers are monitored at 2 plots; one on the Beaver Dam Slope and one near Littlefield. Since the late 1970's, desert tortoise densities on the Beaver Dam Slope plot have declined; these declines have been drastic in some areas (Fridell and Coffeen 1993). Densities on the Littlefield plot have remained approximately constant at about 50 desert tortoises per square mile (Duck and Snider 1988), but more carcasses than expected have

been found over the last several years, suggesting increased mortality.

Threats:

The proposed Beaver Dam Slope DWMA is one of the most threatened DWMAs. Cattle grazing occurs over most of the area. Non-native annual plants comprise significant portions of the ephemeral cover, and perennial grasses are reduced or eliminated in some areas due, in part, to grazing. (Appendix D). Mining and agricultural development have eliminated desert tortoise habitat in Beaver Dam Wash. Access through the area is provided by Highway 91 and a network of ranch, mine, and graded dirt roads. ORV use is increasing in some areas.

Desert tortoises with signs of URTD have been found on the Beaver Dam Slope in Utah and extreme northern Arizona. A study of higher than expected mortality on the Beaver Dam Slope concluded that thinning of shell bone (osteopenia) had occurred in 16% of more than 200 desert tortoise carcasses examined and that the osteopenia may be related to poor nutrition (Jarchow and May 1989).

Specific Management Actions:

Current densities in this DWMA are at the minimum necessary to avoid demographic and stochastic effects that accelerate population declines (Section II.A.2). Immediate implementation of proposed management actions will be necessary to avoid extirpation of this population. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific management actions should be implemented in the Beaver Dam Slope DWMA:

(1) Remove livestock grazing or, if desired, establish terms for experimental livestock grazing in EMZs.

(2) Initiate a semi-wild breeding program (Appendix B) to rebuild and restore the population of desert tortoises in this DWMA.

(3) Sign DWMA boundaries adjacent to communities and settlements to reduce conflicting land uses.

(4) Construct desert tortoise barrier fencing along Interstate 15 and Highway 91 to protect desert tortoises from vehicle kills, collection, and vandalism.

(5) Construct underpasses along Highway 91 to allow movement of desert tortoises and exchange of genetic material within this DWMA.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in this DWMA:

(1) The impacts of ORV use on the desert tortoise and its habitat.

(2) The effects of small settlements on the desert tortoise and its habitat.

(3) Translocation of desert tortoises.

2. *Coyote Spring DWMA*

Current densities:

0 to 90 adult desert tortoises per square mile.

Location and Description:

The proposed Coyote Spring DWMA in Lincoln and Clark Counties, Nevada, would consist mostly of Fish and Wildlife Service refuge lands on the Desert National Wildlife Refuge (DNWR). This DWMA would be bounded approximately by the Nye County line on the west, the DNWR boundary on the north and south, and Highway 93 on the east (Figure 9). The flats and lower slopes within this DWMA are characterized by well-drained alluvial sands and gravels dominated floristically by creosote and bursage. Mojave yucca and Joshua trees are common at higher elevations, and a shadscale scrub community is present west of the Sheep Range (Schneider et al. 1982).

Desert Tortoise Densities and Trends:

1986 transect data estimated adult desert tortoise densities at 36 to 62 per square mile in the Coyote Spring Valley and Hidden Valley (Nevada Department of Wildlife 1990, BLM, Las Vegas District, Las Vegas files). In 1982, transects were conducted on the DNWR east of Alamo Road, including areas around Desert Dry Lake which revealed low to moderate densities (0 to 90 desert tortoises per square mile). The area east of Alamo Road remains unsurveyed, but desert tortoises there are thought to be patchily distributed in low densities. Data are insufficient to evaluate trends.

Threats:

Due to resource management by DNWR, human impacts have left a minimal imprint throughout much of this DWMA. Near Highway 93, habitat has been degraded by ORV use, dumping, utility construction, sand and gravel mining, and other impacts. Large herds of feral horses are currently present, and the recent drought has caused heavy use of the range by these animals. Grazing by livestock is absent or minimal as all allotments are currently inactive. Military activities on the Nellis Bombing Range have resulted in some localized habitat destruction.

Several cases of desert tortoises with URTD have been reported in this area (Nevada Department of Wildlife 1990, RECON 1991).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following actions should be implemented in the Coyote Spring DWMA:

(1) Maintain feral equid within herd management areas at zero populations. Remove feral equids outside herd management areas.

(2) Remove livestock grazing of, if desired, establish terms for experimental cattle grazing in EMZs.

(3) Construct and maintain desert tortoise barrier fencing to protect desert tortoises and habitat along Highways 93 and 95. Install desert tortoise underpasses along Highway 93 to allow for movements and gene flow between the Coyote Springs DWMA and the Mormon Mesa DWMA.

(4) Establish a visitor center which would include a drop-off site for unwanted captive desert tortoises. Develop a program to make these animals available for educational and research purposes.

(5) Modify existing management plans and policies at DNWR to be consistent with this Recovery Plan.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Coyote Spring DWMA:

(1) The effects of bombing activities on the desert tortoise and its habitat. This research should include a comparison of survivorship of desert tortoises both inside and outside bombing ranges. Withdraw areas from bombing in which research shows adverse effects on desert tortoises or their habitat.

(2) The impacts of all road types (e.g., highways, roads, tracks, ways, etc.) on the desert tortoise and its habitat, particularly in the Indian Springs Valley and Three Lakes Valley area of Nellis Air Force Base.

(3) Movement patterns of desert tortoises through managed corridors (i.e., underpasses) and along fences (i.e., railroads and highways). This research should examine desert tortoise behavior, establishment, gene flow, reproduction, etc.).

(4) Distribution and abundance of desert tortoises east of Alamo Road.

3. *Gold Butte-Pakoon DWMA*

Current densities:

5 to 56 desert tortoises per square mile.

Location and Description:

The proposed Gold Butte-Pakoon DWMA in Mohave County, Arizona, and Clark County, Nevada, would be approximately bounded on the north by the Virgin River, on the east by the Virgin Mountains and Grand Wash, on the west by the Virgin River and Gold Butte, and on the south by Lake Mead (Figure 9). A habitat corridor to promote genetic exchange between this Gold Butte-Pakoon area and the proposed Mormon Mesa DWMA is included on the southwestern corner of the this DWMA. Desert tortoises in this area inhabit rolling hills and sloping bajadas, but are also found in volcanic boulder fields of the Pakoon Basin. The vegetation is mostly creosote bush scrub with occasional stands of Joshua trees or Mojave yucca. Land ownership is a mix of BLM, National Park Service, and private lands.

Desert Tortoise Densities and Trends:

Density estimates are available from transect data and at the Gold Butte study plot (RECON 1991, SWCA 1990). Most of the DWMA has densities of about 20 adult desert tortoises per square mile. Data are insufficient to derive trends.

Threats:

The entire Gold Butte-Pakoon DWMA has been grazed by livestock over the past century. Native perennial grasses have been reduced or eliminated in some areas, and non-native annual weeds such as filaree and red brome are common. Fires, carried by stands of introduced annuals, have contributed to the loss of perennial grasses and shrubs in some areas. Historic and current mining activity is evident in parts of the DWMA, but the most intensive mining has historically occurred in less important desert tortoise habitat areas, such as Gold Butte. The ruggedness of the terrain and relatively few roads, especially in the Gold Butte and Pakoon Basin areas, tend to limit human impacts to desert tortoise habitat. Recently, however, there have been noticeable increases in ORV vehicle activity, especially both north and south of the Virgin River in Arizona and Nevada.

One desert tortoise with signs of URTD was found in 1991 in the Pakoon Basin, Arizona (T.A. Duck, pers. comm.). URTD has not been reported in the Gold Butte area in Nevada.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Gold Butte-Pakoon DWMA:

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Construct desert tortoise barrier fencing along Interstate 15 and Highway 91 to protect desert tortoises from vehicle kills, collection, and vandalism.

(3) Sign DWMA boundaries adjacent to communities and settlements (e.g. Littlefield, Arizona, Mesquite, Nevada, etc.) and other areas with conflicting land uses.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of this DWMA:

(1) The direct and indirect impacts (including, soils and vegetation) of grazing to the desert tortoise and its habitat.

(2) The impacts of ORV use on the desert tortoise and its habitat.

(3) Restoration of desert tortoise habitat converted to annual grasslands.

4. Mormon Mesa DWMA

Current density:

41 to 87 subadult and adult desert tortoises at the Mormon Mesa study plot.

Location and Description:

The Mormon Mesa DWMA in Clark and Lincoln Counties, Nevada, would lie east of Highway 93; south of the northern end of the Mormon Mountains; west of the east Mormon Mountains, Flat Top Mesa, and the Virgin River; north of the Moapa Valley; and northeast of Hidden Valley (Figure 9). The vegetation is predominantly creosote bush scrub. Mohave yucca, Joshua tree, and juniper increase in dominance with elevation (Appendix E). Major landowners include the BLM, Union Pacific Railroad, and other private parties.

Desert Tortoise Densities and Trends:

Estimated 1989 desert tortoise densities from the BLM permanent study plot at Mormon Mesa were 41-87 subadults and adults per square mile. Desert tortoise densities are patchy with the best habitat occurring in the northern portions of the DWMA. Data are insufficient to assess population trends.

Threats:

A variety of human, or human-associated, uses and impacts affect desert tortoises in the Mormon Mesa DWMA (Nevada Department of Wildlife 1990). A network of roads averaging about 1.3 linear miles per section crisscrosses the DWMA, including Interstate 15 which separates South Mormon Mesa from North Mormon Mesa. ORV use occurs in some BLM-designated "open" areas, as well. Domestic sheep grazing occurs on the eastern half of Mormon Mesa and cattle grazing occurs on the western side of the DWMA. Parts of 17 grazing allotments are contained within the Mormon Mesa DWMA. Mining and utility corridors have also adversely affected desert tortoises in this area.

Two cases of URTD were reported in 1989 in this proposed DWMA. Several animals with symptoms of nutritional deficiency were also noted at the same time (Nevada Department of Wildlife 1990).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Mormon Mesa DWMA.

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Maintain feral equids within herd management areas at zero population levels. Remove feral equids outside herd management areas.

(3) Construct desert tortoise barrier fencing and underpasses along Highway 93 and Interstate 15 to allow movement of desert tortoises between the Mormon Mesa DWMA and Coyote Spring DWMA, and to connect the northern and southern parts of the Mormon Mesa DWMA.

(4) Construct desert tortoise barrier fencing and underpasses along the Union Pacific Railroad.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Mormon Mesa DWMA:

(1) Movement patterns of desert tortoises through natural corridors to determine what constitutes a corridor or boundary edge (see Beaver Dam Slope DWMA description). Research should include the movement patterns of desert tortoises through managed corridors (i.e., underpasses) and along fences (i.e., railroads and highways), and examine desert tortoise behavior, establishment, gene flow, reproduction, etc.

(2) The impacts of all road types (highways, roads, tracks, ways, trails, etc.) on the desert tortoise and its habitat.

(3) Distribution and abundance of desert tortoises throughout the DWMA.

VI. WESTERN MOJAVE RECOVERY UNIT *

1. Fremont-Kramer DWMA

Current densities:

5 to 100 desert tortoises per square mile.

Location and Description:

The proposed Fremont-Kramer DWMA in Kern and San Bernardino Counties, California, includes the Desert Tortoise Natural Area on its northwestern boundary as well as other lands south and east of Koehn Lake to the Randsburg Wash test range of the China Lake Naval Air Weapons Station in the northeast, almost to Helendale in the southeast, and to Edwards Air Force Base in the southwest (Figure 10). Six plant communities are represented (Appendix E); and the terrain is characterized by rolling hills and mountains up to 5,270 feet and valleys as low as 1,900 feet. Land ownership is a mix of private, BLM, military, and State lands.

Desert Tortoise Densities and Trends:

Data on population densities and trends are available from five plots: two at the Desert Tortoise Natural Area, as well as in Fremont Valley, near Fremont Peak and at Kramer Hills (Berry 1990, as amended). For example, in 1979 densities at the Desert Tortoise Natural Area ranged from 339 to 387 tortoises per square mile; in 1981, the Fremont Valley plot had 278 tortoises per square mile, and Fremont Peak had 99 tortoises per square mile. By the early 1990's, densities had declined precipitously, e.g. 88% at the Desert Tortoise Natural Area, due to a number of human impacts, URTD, and raven predation.

* The Western Mojave recovery unit is the largest and most heterogenous of the recovery units in terms of climate, vegetation and topography. It includes three major vegetation types—the Western Mojave, Central Mojave, and Southern Mojave—each of which has significant and distinctive elements (Tables 4 and 5). Four DWMAs within the Western Mojave recovery unit represent this diversity. The Fremont-Kramer DWMA represents the Western Mojave region; the Superior-Cronese DWMA represents the Central Mojave region, and the Ord-Rodman DWMA represents the Southern Mojave region. The Joshua Tree DWMA, the fourth within this recovery unit, contains Southern Mojave and Eastern Colorado elements. The tortoises have responded to this habitat heterogeneity with different food habits and behavior in each of these areas. Thus, three DWMAs are essential in this recovery unit to preserve the heterogeneity. Secure, large reserves are especially critical because of the severe population declines and heavy human use in these areas.

Threats:

The Fremont-Kramer DWMA is one of the most threatened DWMAs. Collecting, vandalism, road kills, disease, raven predation, ORV activity, and other human-related impacts have contributed to significant population declines. Since the mid-1980's, numbers of adult desert tortoises have dropped 90% over large areas. The area has been grazed by cattle and domestic sheep, explored for hard-rock and leasable minerals, and has experienced human settlements since the 1860's. Since the 1960's, ORV recreationists have traveled cross-country over much of the region. Major transportation routes exist, including paved Highways 58 and 395, the Garlock Road, and Red-Rock Randsburg Road. The Fremont-Kramer DWMA has little, if any, habitat in pristine or climax condition (Berry and Nicholson 1984b, Chambers Group Inc. 1990 a and b). The Desert Tortoise Natural Area, which is fenced and intensively managed for desert tortoises, has some of the least disturbed habitat in the region.

URTD was first detected on the Fremont Valley plot in 1979 and is now present throughout the DWMA (Avery and Berry 1990, Berry 1990, as amended, Berry and Slone 1989). Recent high mortality rates are due in part to this disease (Berry 1990, as amended).

Specific Management Actions:

Current densities in this proposed DWMA are at the minimum necessary to avoid demographic and stochastic effects that accelerate population declines (Section II.A.2.). Immediate implementation of proposed management actions will be necessary to avoid extirpation of this population. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Fremont-Kramer DWMA.

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Implement emergency measures to control unleashed dogs and dog packs.

(3) Initiate a semi-wild breeding program to rebuild and restore the population. The Desert Tortoise Research Natural Area is an ideal place to begin such a program.

(4) Construct a visitor education center at the Desert Tortoise Natural Area which would include facilities for research as well as a drop-off site for unwanted captive desert tortoises. Develop programs to promote use of unwanted captives for research and educational purposes.

(5) Construct desert tortoise barrier fencing and underpasses along Highway 395; parts of Highway 58; the Randsburg-Mojave Road; the Red Rock-Randsburg Road; the Red Rock-Garlock Road; and the Atchison, Topeka, and Santa Fe Railroad north and adjacent to Highway 58 to protect desert tortoises from vehicle kills, collection, and vandalism; and to promote movement of desert tortoises within this DWMA.

(6) Sign or fence DWMA boundaries adjacent to communities and settlements such as Kramer Junction, California City, Cantil, Galileo Hill, Randsburg, Johannesburg, Atolia, and Helendale.

(7) Reduce populations of the common raven in the Fremont-Kramer DWMA to reduce predation on small desert tortoises to a point where recruitment of young into the adult cohort can occur at as rapid a rate as possible.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Fremont-Kramer DWMA:

(1) Desert tortoise diseases, including URTD; toxicosis; shell lesions; general health; nutritional status; food preferences and requirements; water balance and energy flow; predation by feral dogs and other mammalian predators; raven predation; habitat restoration; the effectiveness of desert tortoise-proof fencing and culverts in eliminating road kills; interactions of desert tortoises with urban barrier fencing; protective barriers between urban development and open desert; and effects of mining, domestic sheep and cattle grazing, noise/vibrations, and cumulative impacts on mortality and survivorship (ongoing research should be continued).

(2) Translocation. Desert tortoises from adjacent lands, such as the El Mirage Open Area, should be experimentally translocated into this DWMA to increase the density of desert tortoises and salvage breeding stock.

2. *Ord-Rodman DWMA*

Current densities:

5 to 150 desert tortoises per square mile.

Location and Description:

The proposed Ord-Rodman DWMA southeast of Barstow in San Bernardino County, California, would lie approximately south of Interstate 40, east of Highway 247, west of Argus Mountain, and north of the central portion of the Fry Mountains (Figure 10). Elevations range from about 2,500 feet in Stoddard Valley to over 6,000 feet in the Ord Mountains. Several plant communities are present: Creosotebush Scrub, Indian Rice Grass Scrub-Steppe, Blackbush Scrub, and Cheesebush Scrub (west Mojave type) (Appendix E). Land ownership is a checkerboard comprised of about 65% public and 35% private lands.

Desert Tortoise Densities and Trends:

Data on population densities and trends are available from three study plots in the DWMA: Stoddard Valley, Lucerne Valley, and Johnson Valley (Berry 1990, as amended). In 1991, the densities at the Stoddard Valley plot were 125 tortoises per square mile (Berry 1990, as amended). In 1990, density at the Lucerne Valley was estimated at 82, a decline of 53% from 1980. At Johnson Valley, the 1990 density estimate was 18 tortoises per square mile, a decline of 84% from 1980. Densities over most of the DWMA are generally much lower than at these plots. Densities were probably considerably higher between the 1930's and 1950's (Berry 1984a). Declines appear to be due to human-related activities, URTD, and raven predation (Berry 1984b, Berry 1992).

Threats:

Collecting, vandalism, road kills, disease, ORV activities, livestock grazing, mining, excessive raven predation and other human-related impacts have contributed to significant population declines. The Ord-Rodman DWMA has a long history of domestic grazing by cattle and domestic sheep. Vegetation has largely been altered by grazing, but pockets of substantially unaltered vegetation remain in northern Lucerne Valley, and perhaps elsewhere. Major transportation routes for recreationists occur along power line corridors and Camp Rock, Troy, and Ft. Cady Roads.

Desert tortoises with signs of URTD have consistently been observed in eastern Stoddard Valley and Lucerne Valley since 1988 (Berry and Slone 1989). This disease is now thought to be present

throughout the DWMA and contributing to the observed high levels of mortality (Berry 1990, as amended).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Ord-Rodman DWMA.

(1) Remove livestock grazing or, if desired, establish terms and conditions for experimental cattle grazing in EMZs.

(2) Implement emergency measures to control off-leash dogs.

(3) Construct and maintain desert tortoise barrier fencing and underpasses to protect desert tortoises and their habitat from traffic on well-used highways and roads such as Highway 247.

(4) Construct and maintain special fencing to protect desert tortoises from recreational-vehicle use in the Johnson Valley Open Area and surrounding lands.

(5) Sign DWMA boundaries in the vicinity of Barstow, Newberry Springs, Lucerne, Landers, Lucerne Valley, etc.

(6) Establish a drop-off site for unwanted captive desert tortoises at the BLM's Barstow Way Station. Develop programs to promote use of unwanted desert tortoises for research and educational purposes.

(7) Reduce populations of the common raven to lessen predation on juvenile desert tortoises and ensure recruitment of juveniles into the subadult and adult populations, thus allowing a rapid recovery of the desert tortoise.

(8) Designate the Ord-Rodman DWMA as an Ecological Reserve and Research Natural Area.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Ord-Rodman DWMA:

(1) Translocation of desert tortoises from adjacent lands, such as the Johnson and Stoddard Valley Open Areas, into the DWMA to augment low densities of desert tortoises and to salvage breeding stock.

(2) Disease epidemiology; the effects of ravens and other predators on desert tortoise populations; and the effects of hunting of upland birds, big game, and fur bearers on desert tortoises and their habitat.

3. Superior-Cronese DWMA

Current densities:

20 to 250 desert tortoises per square mile.

Location and Description:

The proposed Superior-Cronese DWMA in San Bernardino County, California, would be bordered on the west by the Fremont-Kramer DWMA and Cuddeback Dry Lake, on the north by the northern end of Superior Valley and NASA Road on the National Training Center, on the east by West Cronese Dry Lake, on the southeast by Interstate 15, and on the south and southwest by Rainbow Basin National Natural Landmark and the southern end of the Gravel Hills (Figure 10). This DWMA is diverse topographically and vegetationally. It includes numerous dry lakes and springs and parts of several mountain ranges. Land ownership is about 63% BLM, 22% private, and 15% Department of Defense.

Desert Tortoise Densities and Trends:

Part of the Superior-Cronese DWMA has been surveyed for desert tortoises with triangular transects (Berry and Nicholson 1984a; Chambers Group 1990; Kiva Biological Consulting and McClenahan and Hopkins Associates 1991; Woodman and Goodlett 1990; Woodman et al. 1984). These data indicate patchy concentrations of desert tortoises throughout the DWMA. D. Morafka and M. Joyner-Griffith (California State University, Northridge, pers. comm.) found a wide range of younger age-size classes represented throughout the eastern portion of the DWMA, indicating a high probability of successful reproduction and possible recruitment there. Densities are thought to be depressed as a result of a number of human impacts and disease.

Threats:

The Superior-Cronese DWMA is one of the more threatened DWMAs. Current activities include livestock grazing (mostly cattle, but some sheep), small local mining operations, power and other utility lines, civilian and military ORV activity, aerial ordnance testing on the northern periphery, construction and operation of space communications and experimental stations, small-scale horticulture and agriculture in the vicinity of Coyote Lake, and hunting. The Kern River natural gas pipeline was constructed through the DWMA in 1991. One herd management area for feral equids occurs in this area (BLM 1980a).

An adult desert tortoise symptomatic for URTD was discovered near Barstow on the Ft. Irwin Road in spring 1991; however, the proposed Superior-Cronese DWMA contains at least some areas where desert tortoises are apparently free of URTD, shell disease, and other diseases. The observed health of desert tortoises within the DWMA appeared to be excellent as of spring 1992.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Superior-Cronese DWMA.

(1) Remove livestock grazing or, if desired, establish terms and conditions for experimental grazing in EMZs.

(2) Establish a drop-off site for unwanted captive desert tortoises at BLM's Barstow Way Station (see Ord-Rodman DWMA summary). Develop programs to make unwanted captives available for research and educational purposes.

(3) Construct barrier fencing along Interstate 15, Ft. Irwin Road, Manix Trail, Superior Lake Road, and the northern border of the DWMA to protect desert tortoises from vehicles, collection, and habitat degradation.

(4) Sign DWMA boundaries adjacent to communities and settlements including Barstow, small settlements north of Barstow, and other areas with conflicting uses.

(5) Construct highway underpasses along the Ft. Irwin Road to allow desert tortoise movement and to facilitate genetic exchange throughout this DWMA.

(6) Reduce raven populations in the DWMA to lessen mortality of small desert tortoises to a point where recruitment into the adult cohort can occur at as rapid a rate as possible.

(7) Initiate cleanup of surface toxic chemicals and unexploded ordnance.

(8) Fence the periphery of the DWMA as needed to enforce regulations and protect desert tortoises from human impacts. Along the boundary with the Fremont-Kramer DWMA, a double row of desert tortoise barrier fencing may be necessary to prevent the spread of URTD into the Superior-Cronese DWMA.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented by the Superior-Cronese DWMA:

(1) The effects of domestic sheep grazing, wave/radiant energy, visitor use, military traffic, ORVs, and highways on the desert tortoise and its habitat.

(2) Epidemiology of URTD and other diseases; physiological, ecological, nutritional, and behavioral requirements of hatchling and juvenile desert tortoises; nutritional qualities of preferred food plants; habitat restoration; and characteristics of undisturbed desert tortoise habitat. Continue using the latest medical techniques to assess the health of desert tortoises. Conduct epidemiological surveys to determine the distribution and frequency of desert tortoises with URTD and other diseases. These surveys are critical to determine if fencing is necessary within the DWMA or between the Fremont-Kramer DWMA and the Superior-Cronese DWMA.

4. Joshua Tree DWMA

Current densities:

Up to 200 desert tortoises per square mile.

Location and Description:

The proposed Joshua Tree DWMA in Riverside and San Bernardino Counties, California, includes Joshua Tree National Monument (Monument) and adjacent lands in the Pinto Mountains, Eagle Mountains, and elsewhere on the perimeter of the Monument (Figure 10). It includes elements of both the Colorado and Mojave deserts, and it occurs partly in the eastern Colorado recovery unit and primarily in the western Mojave recovery unit. Elevations range from below 1,500 feet in Pinto Basin to 5,814 feet at Quail Mountain. Most of the proposed DWMA is managed by the National Park Service.

Desert Tortoise Densities and Trends:

Density data are available from two study plots in the Monument: the Panorama and Pinto Basin plots. In 1991, densities were estimated at 200 and 226 desert tortoises per square mile at the Pinto Basin and Panorama plots, respectively (Freilich and Moon 1991). Triangular transects have also been conducted in the Monument. These data show that distribution and densities of desert tortoises in the Monument are patchy, and densities are typically much lower than at the two study plots. Desert tortoises are frequently reported from between Smoke Tree Wash and Cottonwood Pass near the southern end of the Monument, and relatively high densities are thought to occur near the Coxcomb Mountains (Karl 1988, Dr. Jerry Freilich, Monument, pers. comm., 1992). Recent surveys in the Monument indicate few tortoises occur near the main road which dissects the Monument (J. Freilich, pers. comm., 1992).

Because of differing techniques used to calculate densities at different times, existing data are not appropriate to derive trends. Based on a large number of remains, Barrow (1979) believed densities were declining at the Pinto Basin plot; however higher densities were registered (using different techniques) in 1991 (Freilich and Moon 1991).

Threats:

Because of protective management by the National Park Service, this DWMA is one of the least threatened DWMAs. Within the Monument, vehicle access is restricted to 130 miles of roads, and no mining, ORV use, or grazing is permitted. Prior to establishment of

the Monument in the 1930's, the western half of the DWMA was intensively grazed, hard-rock mining occurred, and numerous settlements were present. Limited grazing continued into the 1950's (Hickman 1977). Areas of the proposed Joshua Tree DWMA which lie outside the Monument are primarily managed by BLM for multiple use. Evidence of mining can be seen in the Eagle and Pinto Mountains, east and north of the Monument, respectively. The proposed Eagle Mountain Landfill is located at the eastern end of the DWMA.

In 1991, two desert tortoises were found with signs of URTD at the western end of the Monument where releases of desert tortoises have occurred in the past. No other diseased animals have been reported.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Joshua Tree DWMA:

(1) Establish a portion of the visitor center for the purpose of educating visitors to the Monument on the status and plight of the desert tortoise and its recovery needs, and to serve as a drop-off site for unwanted captive desert tortoises. Develop programs to make these animals available for educational or research purposes.

(2) Construct desert tortoise barrier fencing to protect desert tortoises and their habitat from human activities along roads and in urban settings. This should include desert tortoise barrier fencing along the north side of the DWMA boundary and along the road from Cottonwood Pass through the Monument from Desert Center to the Eagle Mountain Mine. Desert tortoise underpasses should accompany fence construction along the Cottonwood Pass Road, as well. Chain-link fence may be needed in some areas as barbed wire does not prevent urban encroachment. If fencing is not permitted within the Monument, expand the boundary of the DWMA to the boundary of the Monument.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Joshua Tree DWMA:

(1) The genetic origin of existing desert tortoises in the Monument, focusing at the northwestern end of the Monument near the release locations.

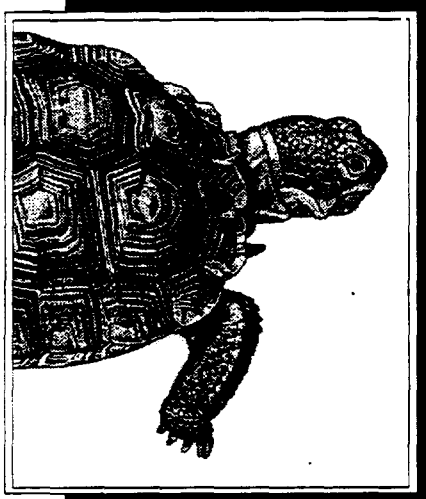
(2) Habitat restoration.

(3) Desert tortoise predation, including level of raven predation at the Monument and adjacent urban areas, and raven predation as a reflection of certain types of human uses.

(4) The effects of non-vehicular oriented recreation on desert tortoises and their habitat.

Appendix G

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix G: Environmental Determinants of Population Size

Census data and anecdotal accounts indicate that desert tortoise populations existed at quite different densities in various parts of the Mojave region prior to their recent decline. Thus, it is reasonable to expect that different DWMAs will support different tortoise densities after recovery, depending upon each reserve's particular ecological conditions and geographic location. Site-specific density might be equivalent to "carrying capacity," the density at which population growth is reduced as a result of competition among individual animals, although no data demonstrate such density-dependent feedback in desert tortoise populations. Another of the many possible factors that might determine site-specific density is the average amount of food available to tortoises during their active season. Food availability has the potential to control individual growth rates and, consequently, the age at which a tortoise reaches the size of reproductive competence. Food availability also influences fecundity. Both of these factors influence population growth rates and, hence, densities.

Some data do suggest that food availability is related to site-specific desert tortoise densities. Figure G1 shows the relationship between the highest recorded population density of adult and subadult tortoises at a study site and the mean production of annual forbs and grasses at the site, the latter being an index of long-term average food availability. Although highly significant, this correlation does not necessarily indicate causation. Many other factors, including those that might covary with food availability (e.g., variance in food availability), could actually be more important in determining population density. Nevertheless, this relationship might be used as a starting point to estimate a "target density" for each DWMA.

Before the concept of target density can be utilized effectively, research must be initiated to determine the strength and generality of the relationship indicated in Figure G1 and to identify the mechanisms underlying this relationship. Figure G1 represents only one hypothesis about factors which might determine desert tortoise population densities.

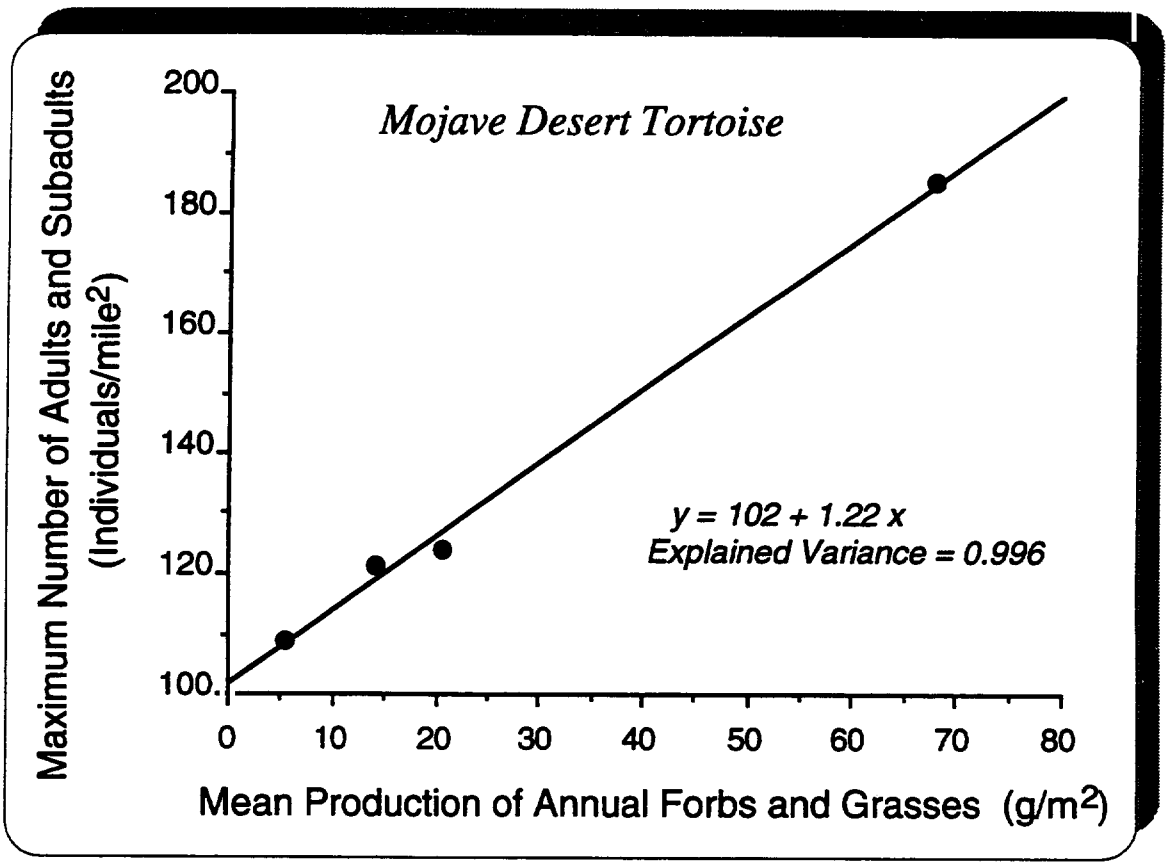
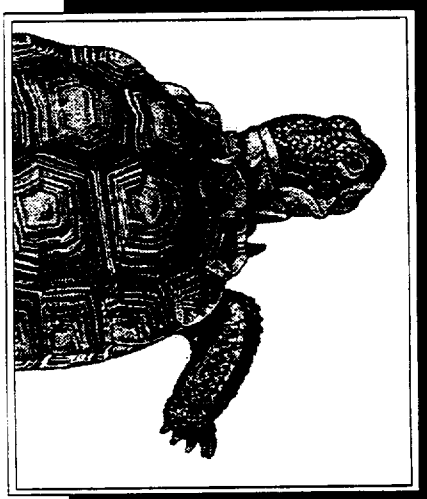


Figure G1. The highest estimated number of adult and subadult desert tortoises in a study site as a function of the long-term average production of spring annuals available in the same area. The sites represented are the Desert Tortoise Natural Area (Interior) Study Site, California; the Stoddard Valley Study Site, California; the Goffs Study Site, California; and the Woodbury/Hardy Study Site, Utah.

Appendix H

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix H: Critical Habitat for the Desert Tortoise (Mojave Population)

On February 8, 1994, the U.S. Fish and Wildlife Service published a final rule in the *Federal Register* (59 FR 5820) designating 6.4 million acres of critical habitat for the Mojave population of the desert tortoise (*G. agassizii*). This designation includes primarily Federal lands in southwestern Utah, northwestern Arizona, southern Nevada, and southern California.

In California, critical habitat designation totals 4,754,000 acres in Imperial, Kern, Los Angeles, Riverside, and San Bernardino counties. Of this, 3,327,400 acres are Bureau of Land Management land, and 242,200 acres are military land. The remainder includes 132,900 acres of state land and 1,051,500 acres that are privately owned.

In Nevada, four units totalling 1,224,400 acres are designated in Clark and Lincoln counties. Of this, 1,085,000 acres are Bureau of Land Management land, 103,600 acres are National Park Service land, and 35,800 acres are private.

In Utah, two units totalling 129,100 acres are designated in Washington County. This consists of 89,400 acres of Bureau of Land Management land, 27,600 acres of state land, 1,600 acres of Indian Tribal land, and 10,500 acres of private land.

In Arizona, two units totalling 338,700 acres are designated in Mohave County. This includes 288,800 acres of Bureau of Land Management land, 43,600 acres of National Park Service land, 5,700 acres of state land, and 600 acres of private land.

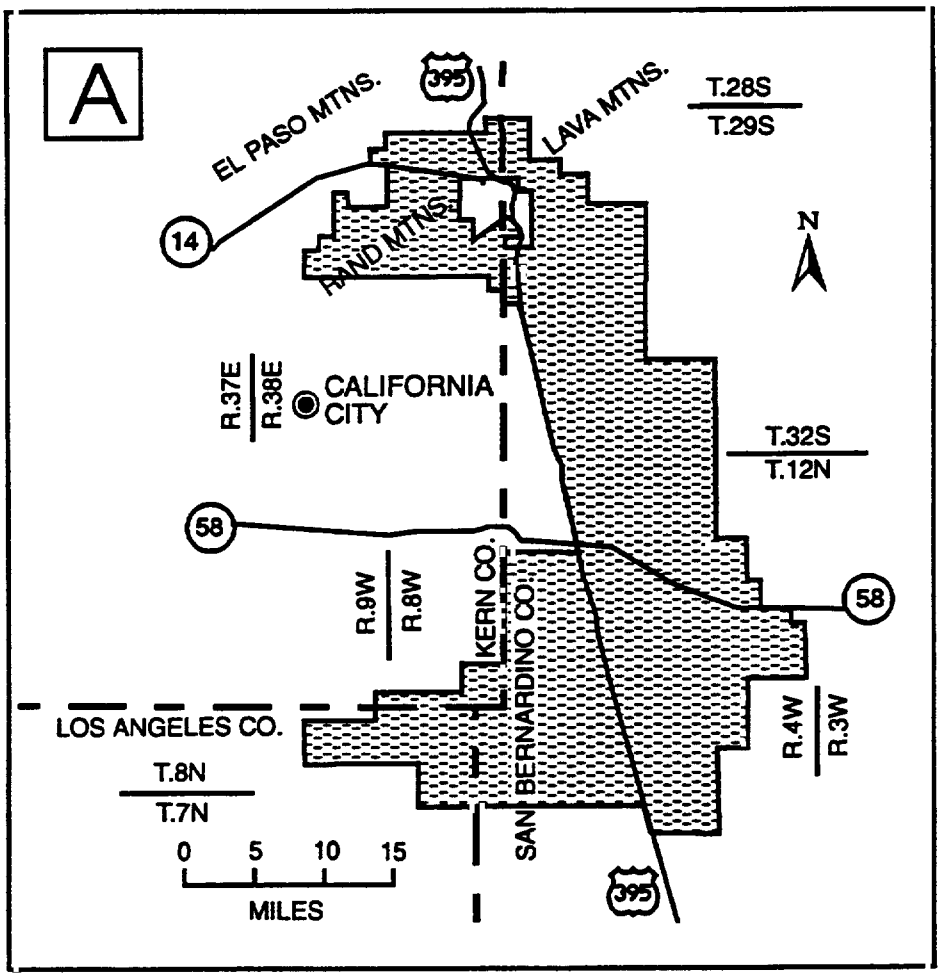
California. Areas of land as follows:

1. **Fremont-Kramer Unit.** Kern, Los Angeles, and San Bernardino Counties. From Bureau of Land Management Maps: Victorville 1978 and Cuddeback Lake 1978. (Index map location A).

Mt. Diablo Meridian: T. 29 S., R. 39 E., secs. 13, 14, 22-26, 35, and 36; T. 29 S., R. 40 E., secs. 12-33; T. 29 S., R. 41 E., secs. 7, 8, 17-20, 27-30, and 32-36; T. 30 S., R. 38 E., secs. 24-26, 35, and 36; T. 30 S., R. 39 E., secs. 1-36 except secs. 3-5; T. 30 S., R. 40 E., secs. 4-9, and 13-36, except that portion of secs. 13, 14, and 23 lying northwesterly of the Randsburg-Mojave Road; T. 30 S., R. 41 E., secs. 1-36, except secs. 5-8, and 20 and that portion of secs. 17 and 18 lying easterly of U.S. Highway 395; T. 30 S., R. 42 E., secs. 7-10, 15-22, and 27-34; T. 31 S., R. 40 E., secs. 1 and 6, except that portion of sec. 6 lying southeasterly of the Randsburg-Mojave Road; T. 31 S., R. 41 E., secs. 1-17, 20-29, and 32-36, except that portion of secs. 20, 29 and 32 lying westerly of U.S. Highway 395; T. 31 S., R. 42 E., secs. 3-10, 15-22, and 27-34; T. 32 S., R. 41 E., secs. 1-4, 9-16, 21-28, and 34-36, except that portion of secs. 4, 9, 16, 21, 27, 28, and 34 lying westerly of U.S. Highway 395; T. 32 S., R. 42 E., secs. 1-36; T. 32 S., R. 43 E., secs. 4-9, 16-21, and 28-33.

San Bernardino Meridian: T. 7 N., R. 5 W., secs. 2-11, and 14-18, except that portion of sec. 18, lying west of U.S. Highway 395; T. 7 N., R. 6 W., secs. 1-6, 12, and 13, except that portion of secs. 1, 12, and 13 lying westerly of U.S. Highway 395; T. 7 N., R. 7 W., secs. 1-6; T. 7 N., R. 8 W., secs. 1-4; T. 8 N., R. 4 W., secs. 6, 7, and 18; T. 8 N., R. 5 W., secs. 1-35 except secs. 24 and 25; T. 8 N., R. 6 W., secs. 1-36; T. 8 N., R. 7 W., secs. 1-36; T. 8 N., R. 8 W., secs. 1-28, and 33-36; T. 8 N., R. 9 W., secs. 1 and 7-24; T. 9 N., R. 4 W., secs. 2-11, 14-23, 30, and 31; T. 9 N., R. 5 W., secs. 1-36; T. 9 N., R. 6 W., secs. 1-36; T. 9 N., R. 7 W., secs. 1-4, 9-16, and 19-36; T. 9 N., R. 8 W., secs. 24, 25, and 31-36; T. 9 N., R. 9 W., sec. 36; T. 10 N., R. 4 W., secs. 6, 7, 18-20, and 29-34; T. 10 N., R. 5 W., secs. 1-36; T. 10 N., R. 6 W., secs. 1-36 except sec. 6; T. 10 N., R. 7 W., secs. 9-16, 21-28, and 33-36; T. 11 N., R. 5 W., secs. 2-11, 14-23, and 26-35; T. 11 N., R. 6 W., secs. 1-36, except that portion of secs. 6, 7, 18, 19, 30, and 31 lying westerly of U.S. Highway 395; T. 11 N., R. 7 W., that portion of sec. 1, lying easterly U.S. Highway 395; T. 12 N., R. 5 W., secs. 31-35; T. 12 N., R. 6 W., secs. 31-36; T. 12 N., R. 7 W., that portion of sec. 36 lying easterly of U.S. Highway 395.

FREMONT-KRAMER

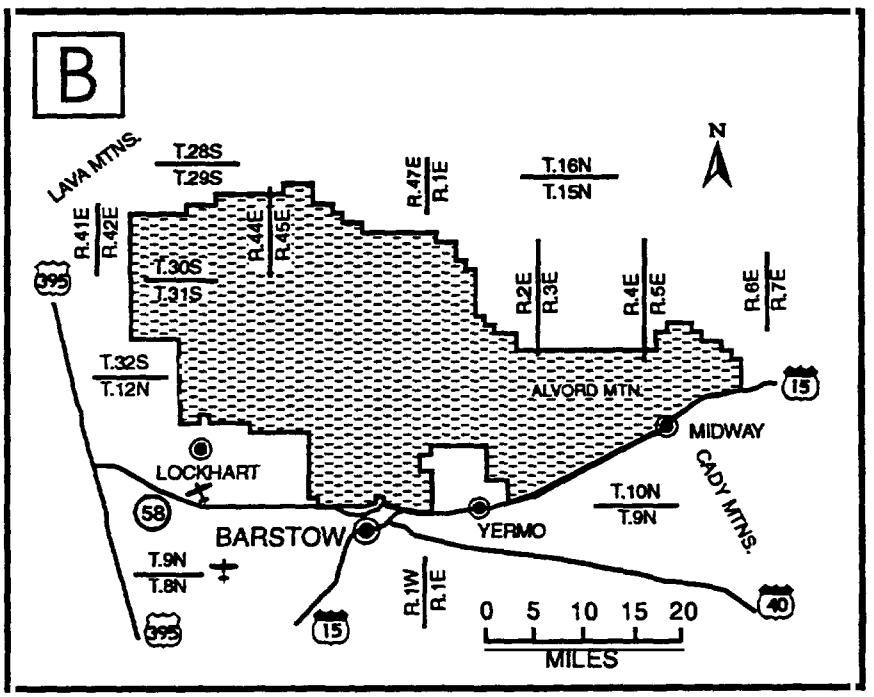


2. **Superior-Cronese Unit.** San Bernardino County. From Bureau of Land Management Maps: Cuddeback Lake 1978, Soda Mts. 1978, Victorville 1978, and Newberry Springs 1978. (Index map location B).

Mt. Diablo Meridian: T. 29 S., R. 42 E., secs. 35 and 36; T. 29 S., R. 43 E., secs. 25, 26, and 31-36; T. 29 S., R. 44 E., secs. 20-36; T. 29 S., R. 45 E., secs. 14-16, 19-23, and 25-36; T. 29 S., R. 46 E., secs. 30-32; T. 30 S., R. 42 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 30 S., R. 43 E., secs. 1-36; T. 30 S., R. 44 E., secs. 1-36; T. 30 S., R. 45 E., secs. 1-36; T. 30 S., R. 46 E., secs. 3-36; T. 30 S., R. 47 E., secs. 7-10, 15-22, and 27-34; T. 31 S., R. 42 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 31 S., R. 43 E., secs. 1-36; T. 31 S., R. 44 E., secs. 1-36; T. 31 S., R. 45 E., secs. 1-36; T. 31 S., R. 46 E., secs. 1-36; T. 31 S., R. 47 E., secs. 3-10, 15-22, and 27-34; T. 32 S., R. 43 E., secs. 1-3, 10-15, 22-27, and 34-36; T. 32 S., R. 44 E., secs. 1-36; T. 32 S., R. 45 E., secs. 1-36; T. 32 S., R. 46 E., secs. 1-36; T. 32 S., R. 47 E., secs. 3-10, 15-22, and 27-34.

San Bernardino Meridian: T. 9 N., R. 1 W., that portion of secs. 1 and 2 lying northerly of Interstate Highway 15; T. 9 N., R. 1 E., that portion of sec. 6 lying northerly of Interstate Highway 15; T. 10 N., R. 2 W., secs. 1-29; T. 10 N., R. 1 W., secs. 1-28, 30, and 33-36, except that portion of secs. 33-35 lying southwesterly of Interstate Highway 15; T. 10 N., R. 1 E., secs. 18, 19, 30, and 31; T. 10 N., R. 2 E., secs. 1-5, 8-17, and 22-34, except that portion of secs. 25, 26, and 34 lying southeasterly of Interstate Highway 15; T. 10 N., R. 3 E., secs. 1-12, 14-21, and 30, except that portion of secs. 11, 12, 14-16, 19-21, and 30 lying southeasterly of Interstate Highway 15; T. 10 N., R. 4 E., that portion of secs. 5-7 lying northwesterly of Interstate Highway 15; T. 11 N., R. 5 W., secs. 1 and 12; T. 11 N., R. 4 W., secs. 1-7, 9, 11, and 12; T. 11 N., R. 3 W., secs. 1-18; T. 11 N., R. 2 W., secs. 1-36; T. 11 N., R. 1 W., secs. 1-36; T. 11 N., R. 1 E., secs. 1-31; T. 11 N., R. 2 E., secs. 1-36 except sec. 31; T. 11 N., R. 3 E., secs. 1-36; T. 11 N., R. 4 E., secs. 1-34, except that portion of secs. 25, 26, 33, and 34 lying southeasterly of Interstate Highway 15; T. 11 N., R. 5 E., secs. 1-11 and 15-20, except that portion of secs. 1, 2, 10, 11, 15-17, 19, and 20 lying southeasterly of Interstate Highway 15; T. 12 N., R. 5 W., sec. 36; T. 12 N., R. 4 W., secs. 31-36; T. 12 N., R. 3 W., secs. 31-36; T. 12 N., R. 2 W., secs. 31-36; T. 12 N., R. 1 W., secs. 31-36; T. 12 N., R. 1 E., secs. 1-36; T. 12 N., R. 2 E., secs. 3-36; T. 12 N., R. 3 E., secs. 7-36; T. 12 N., R. 4 E., secs. 7-36; T. 12 N., R. 5 E., secs. 1-5 and 7-36; T. 12 N., R. 6 E., secs. 5-9, 15-22, and 27-34, except that portion of secs. 31-34 lying southerly of Interstate Highway 15; T. 13 N., R. 1 E., secs. 1-36; T. 13 N., R. 2 E., secs. 19 and 29-34; T. 13 N., R. 5 E., secs. 26-28 and 32-36; T. 14 N., R. 1 E., secs. 5-10, 15-23, and 24-36.

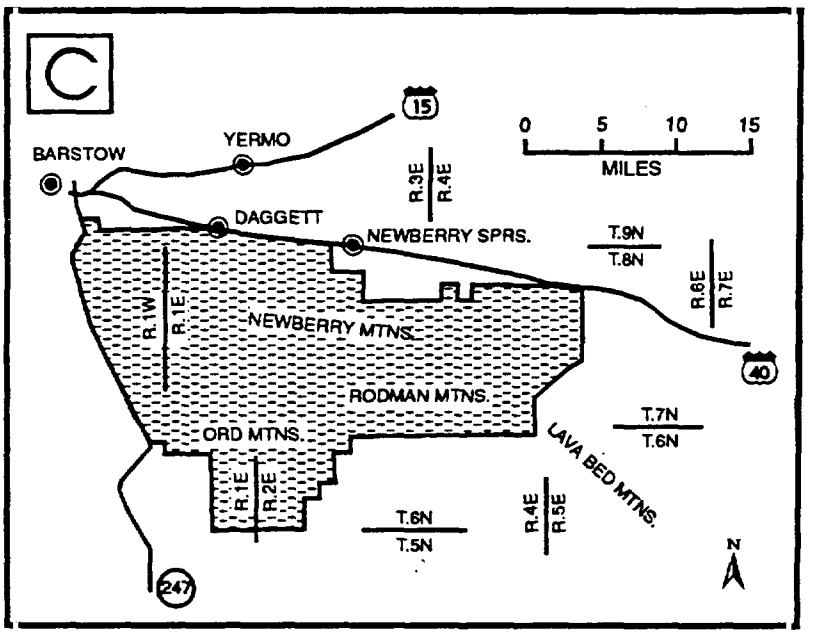
SUPERIOR-CRONESE



3. <u>Ord-Rodman Unit</u>. San Bernardino County. From Bureau of Land Management Maps: Newberry Springs 1978 and Victorville 1978. (Index map location C).

San Bernardino Meridian: T. 6 N., R. 1 E., secs. 1-6, 10-15, 22-27, and 34-36; T. 6 N., R. 2 E., secs. 1-11, 14-22, and 28-33; T. 7 N., R. 1 W., secs. 1-4, 9-15, 22-26, 35, and 36, except that portion of secs. 4, 9, 10, 15, 22, 23, 26, and 35 lying southwesterly of State Highway 247; T. 7 N., R. 1 E., secs. 1-36; T. 7 N., R. 2 E., secs. 1-36; T. 7 N., R. 3 E., secs. 1-36; T. 7 N., R. 4 E., secs. 1-36; T. 7 N., R. 5 E., secs. 4-9 and 17-19, except that portion of secs. 4, 8, 9, and 17-19 lying southerly of the northern boundary of Twentynine Palms Marine Corps Base; T. 8 N., R. 1 W., secs. 1-18, 20-29, and 32-36, except that portion of secs. 6, 7, 17, 18, 20, 29, 32, and 33 lying southwesterly of State Highway 247; T. 8 N., R. 1 E., secs. 1-36; T. 8 N., R. 2 E., secs. 2-36; T. 8 N., R. 3 E., secs. 7 and 18-36; T. 8 N., R. 4 E., secs. 13-16 and 18-36; T. 8 N., R. 5 E., secs. 16-18, 19-21, 28-30, and 31-33, except that portion of secs. 16 and 17 lying northerly of Interstate Highway 40; T. 9 N., R. 1 W., secs. 19, 20, and 25-36, except that portion of secs. 19, 20, and 29-31 lying westerly of State Highway 247; T. 9 N., R. 1 E., secs. 25-36, except that portion of secs. 25-27 lying northerly of Interstate Highway 40; T. 9 N., R. 2 E., secs. 27-35, except that portion of secs. 27-30 lying northerly of Interstate Highway 40.

ORD-RODMAN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R.1W
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NEWBERRY MTNS.
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RODMAN MTNS.
T.7N
T.6N
ORD MTNS.
LAVA BED MTNS.
R.1E
R.2E
T.6N
T.5N
R.4E
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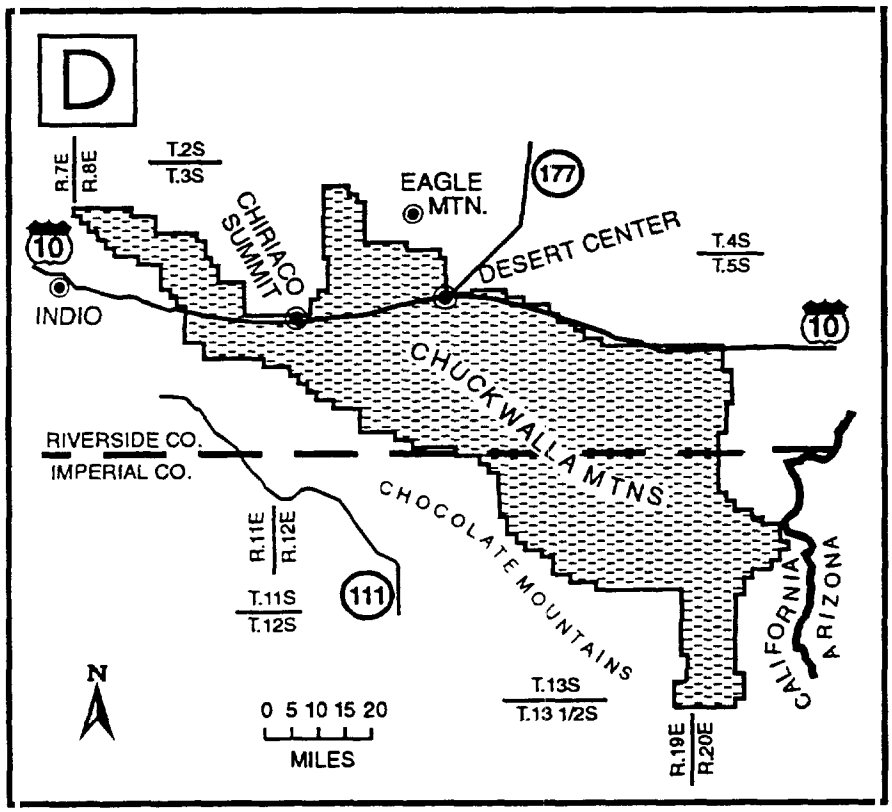
247

4. Chuckwalla Unit. Imperial and Riverside Counties. From Bureau of Land Management Maps: Chuckwalla #18 1978, Parker-Blythe #16 1978, Salton Sea #20 1978, and Midway Well #21 1979. (Index map location D).

San Bernardino Meridian: T. 3 S., R. 13 E., secs. 19-21 and 27-35; T. 4 S., R. 8 E., secs. 1-6, 8-16, 22-26, and 36; T. 4 S., R. 9 E., secs. 6-10, and 15-36; T. 4 S., R. 10 E., secs. 19-21, and 27-34; T. 4 S., R. 13 E., secs. 2-36 except secs. 12 and 13; T. 4 S., R. 14 E., secs. 27-36; T. 4 S., R. 15 E., secs. 31 and 32; T. 5 S., R. 9 E., secs. 1-4, 12, 13, and 24; T. 5 S., R. 10 E., secs. 2-36 except sec. 31; T. 5 S., R. 11 E., secs. 19-21 and 28-33; T. 5 S., R. 12 E., sec. 36; T. 5 S., R. 13 E., secs. 1-36 except secs. 6 and 7; T. 5 S., R. 14 E., secs. 1-36; T. 5 S., R. 15 E., secs. 4-9, 16-21, 25, S 1/2 sec. 26, S 1/2 sec. 27, and secs. 28-36; T. 5 S., R. 16 E., secs. 28-35; T. 6 S., R. 10 E., secs. 1-4, 9-16, 21-26, 35 and 36; T. 6 S., R. 11 E., secs. 4-36; T. 6 S., R. 12 E., secs. 1-36; T. 6 S., R. 13 E., secs. 1-36; T. 6 S., R. 14 E., secs. 1-36; T. 6 S., R. 15 E., secs. 1-36; T. 6 S., R. 16 E., secs. 1-36; T. 6 S., R. 17 E., secs. 5-9, and 14-36; T. 6 S., R. 18 E., secs. 29-36; T. 6 S., R. 19 E., secs. 31-36; T. 6 S., R. 20 E., secs. 31-34; T. 7 S., R. 11 E., sec. 1; T. 7 S., R. 12 E., secs. 1-6, 9-15, and 23-25; T. 7 S., R. 13 E., secs. 1-30 and 31-36; T. 7 S., R. 14 E., secs. 1-36; T. 7 S., R. 15 E., secs. 1-36; T. 7 S., R. 16 E., secs. 1-36; T. 7 S., R. 17 E., secs. 1-36; T. 7 S., R. 18 E., secs. 1-36; T. 7 S., R. 19 E., secs. 1-36; T. 7 S., R. 20 E., secs. 3-10, 14-23, and 26-35; T. 8 S., R. 13 E., secs. 1, 2, and 11-14; T. 8 S., R. 14 E., secs. 1-18, and secs. 21-26; T. 8 S., R. 15 E., secs. 1-30 and 34-36; T. 8 S., R. 16 E., secs. 1-36; T. 8 S., R. 17 E., secs. 1-36; T. 8 S., R. 18 E., secs. 1-36; T. 8 S., R. 19 E., secs. 1-36; T. 8 S., R. 20 E., secs. 3-10, 15-22, and 28-33; T. 9 S., R. 15 E., sec. 1; T. 9 S., R. 16 E., secs. 1-17, 20-29, and 32-36; T. 9 S., R. 17 E., secs. 1-36; T. 9 S., R. 18 E., secs. 1-36; T. 9 S., R. 19 E., secs. 1-36; T. 9 S., R. 20 E., secs. 5-8, 17-20, and 29-33; T. 10 S., R. 16 E., secs. 1-5, 9-16, and 22-26; T. 10 S., R. 17 E., secs. 1-36; T. 10 S., R. 18 E., secs. 1-36; T. 10 S., R. 19 E., secs. 1-36; T. 10 S., R. 20 E., secs. 3-36; T. 10 S., R. 21 E., secs. 18-21 and 28-34; T. 10 1/2 S., R. 21 E., secs. 31-33; T. 11 S., R. 17 E., secs. 1-5 and 8-15; T. 11 S., R. 18 E., secs. 1-24; T. 11 S., R. 19 E., secs. 1-26, 35, and 36; T. 11 S., R. 20 E., secs. 1-23 and 26-34; T. 11 S., R. 21 E., secs. 4-8; T. 12 S., R. 19 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 12 S., R. 20 E., secs. 3-10, 15-22, and 27-34; T. 13 S., R. 19 E., secs. 1, 2, 11, 12, 22-27, and 34-36; T. 13 S., R. 20 E., secs. 3-10, 14-23, and 26-34.

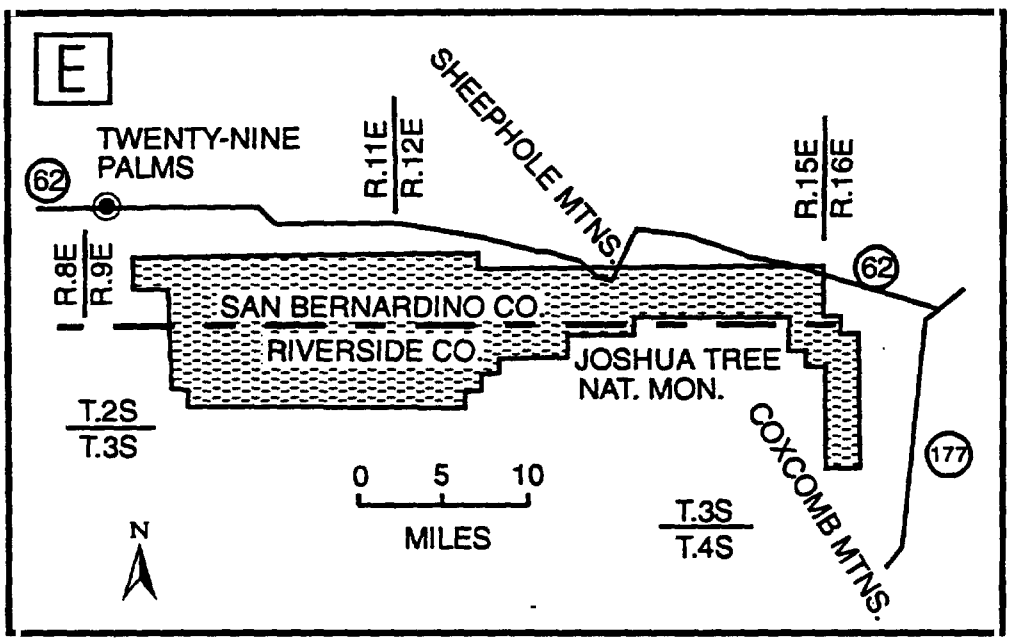
CHUCKWALLA


D
R.7E
R.8E
T.2S
T.3S
CHIRIACO SUMMIT
EAGLE MTN.
177
DESERT CENTER
T.4S
T.5S
10
INDIO
10
CHUCKWALLA MTNS
RIVERSIDE CO.
IMPERIAL CO.
CHOCOLATE MOUNTAINS
R.11E
R.12E
T.11S
T.12S
111
CALIFORNIA
ARIZONA
N
0 5 10 15 20
MILES
T.13S
T.13 1/2S
R.19E
R.20E

5. <u>Pinto Mountain Unit.</u> Riverside and San Bernardino Counties. From Bureau of Land Management Maps: Yucca Valley 1982, Sheep Hole Mountains 1978, Chuckwalla 1978, and Palm Springs #17 1978. (Index map location E).

San Bernardino Meridian: T. 1 S., R. 9 E., secs. 10-15, 24, 25, and 36; T. 1 S., R. 10 E., secs. 7-36; T. 1 S., R. 11 E., secs. 7-36; T. 1 S., R. 12 E., secs. 7-36 except sec. 12; T. 1 S., R. 13 E., secs. 13-36; T. 1 S., R. 14 E., secs. 13-32; T. 1 S., R. 15 E., secs. 13-30 and 36; T. 1 S., R. 16 E., secs. 18, 19, and 30-32; T. 2 S., R. 9 E., secs. 1, 12, and 13; T. 2 S., R. 10 E., secs. 1-24; T. 2 S., R. 11 E., secs. 1-24; T. 2 S., R. 12 E., secs. 1-22 except sec. 13; T. 2 S., R. 13 E., secs. 3-6; T. 2 S., R. 15 E., sec. 1; T. 2 S., R. 16 E., secs. 4-9, 16, 17, 20, 21, 28, 29, 32, and 33; T. 3 S., R. 16 E., secs. 4, 5, 8, and 9.

PINTO MOUNTAIN

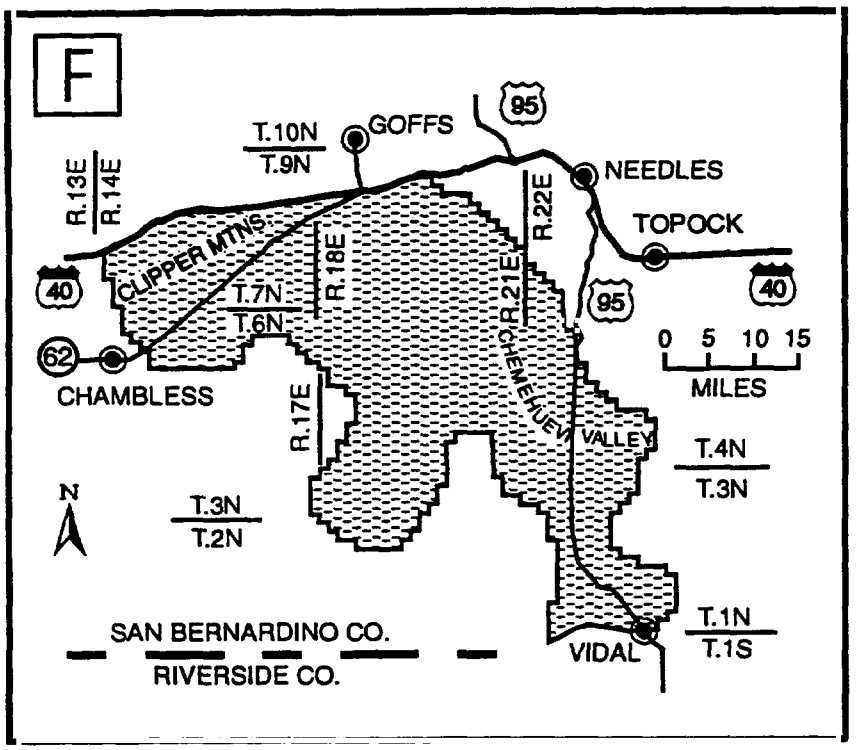


6. Chemehuevi Unit. San Bernardino County. From Bureau of Land Management Maps: Sheep Hole Mts. 1978, Parker 1979, Needles 1978, and Amboy 1991. (Index map location F).

San Bernardino Meridian: T. 1 S., R. 22 E., that portion of secs. 3-5, lying northwesterly of the Atchison Topeka and Santa Fe Railroad; T. 1 S., R. 23 E., that portion of secs. 1-3 lying northerly of the Atchison Topeka and Santa Fe Railroad, except that portion of sec. 1, lying easterly of U.S. Highway 95; T. 1 N., R. 22 E., secs. 1-4, 9-16, 20-29, and 32-36, except that portion of secs. 34-36 lying southerly of the Atchison Topeka and Santa Fe Railroad; T. 1 N., R. 23 E., secs. 1-36, except that portion of secs. 31-34 lying southerly of Atchison Topeka and Santa Fe Railroad; T. 1 N., R. 24 E., secs. 4-9, 16-21, and 29-31; T. 2 N., R. 18 E., secs. 1-5, and 9-14; T. 2 N., R. 19 E., secs. 2-10, and 16-18; T. 2 N., R. 22 E., secs. 1-5, 8-16, 21-28, and 33-36; T. 2 N., R. 23 E., secs. 5-8, 17-21, and 26-36; T. 2 N., R. 24 E., secs. 31 and 32; T. 3 N., R. 17 E., secs. 12, 13, 24, and 25; T. 3 N., R. 18 E., secs. 1-36; T. 3 N., R. 19 E., secs. 1-35; T. 3 N., R. 20 E., secs. 5-8, 18, and 19; T. 3 N., R. 21 E., secs. 1-5, 9-16, 23, and 24; T. 3 N., R. 22 E., secs. 1-36 except sec. 31; T. 3 N., R. 23 E., secs. 2-11, 14-22, and 28-32; T. 4 N., R. 18 E., secs. 1, 2, 10-15, 21-28, and 32-36; T. 4 N., R. 19 E., secs. 1-36; T. 4 N., R. 20 E., secs. 1-12, 16-20, and 29-32; T. 4 N., R. 21 E., secs. 1-17, 20-29, and 32-36; T. 4 N., R. 22 E., secs. 1-36; T. 4 N., R. 23 E., secs. 1-35; T. 4 N. R. 24 E., Secs 6, 7, 18, and 19; T. 5 N., R. 15 E., secs. 1-6; T. 5 N., R. 16 E., secs. 4-6; T. 5 N., R. 18 E., secs. 1-6, 8-17, 22-26, 35, and 36; T. 5 N., R. 19 E., secs. 1-36; T. 5 N., R. 20 E., secs. 1-36; T. 5 N., R. 21 E., secs. 1-36; T. 5 N., R. 22 E., secs. 2-36; (Unsurveyed) T. 5 N., R. 23 E., protracted secs. 19, and 29-33; T. 6 N., R. 14 E., secs. 1-3, 10-15, and 23-25; T. 6 N., R. 15 E., secs. 1-36; T. 6 N., R. 16 E., secs. 1-23, and 27-34; T. 6 N., R. 17 E., secs. 1-18, 22-26, and 36; T. 6 N., R. 18 E., secs. 1-36; T. 6 N., R. 19 E., secs. 1-36; T. 6 N., R. 20 E., secs. 1-36; T. 6 N., R. 21 E., secs. 1-36; T. 6 N., R. 22 E., secs. 3-10, 15-23, and 26-35; T. 7 N., R. 14 E., secs. 1-5, 8-17, 21-28, and 33-36; T. 7 N., R. 15 E., secs. 1-36; T. 7 N., R. 16 E., secs. 1-36; T. 7 N., R. 17 E., secs. 1-36; T. 7 N., R. 18 E., secs. 1-36; T. 7 N., R. 19 E., secs. 1-36; T. 7 N., R. 20 E., secs. 1-36; T. 7 N., R. 21 E., secs. 1-36; T. 7 N., R. 22 E., secs. 18-20, and 28-34; T. 8 N., R. 14 E., secs. 13, 23-28, and 31-36, except that portion of secs. 13, 23, 24, 26, 27, 28, 31, 32, and 33 lying northwesterly of Interstate Highway 40; T. 8 N., R. 15 E., secs. 9-36, except that portion of secs. 9-12, 17, and 18 lying northwesterly of Interstate Highway 40; T. 8 N., R. 16 E., secs. 1, 2, and 7-36, except that portion of secs. 1, 2, and 7-10 and 11 lying northerly of Interstate Highway 40; T. 8 N., R. 17 E., secs. 1-36, except that portion of secs. 1-6 lying northerly of Interstate Highway 40; T. 8 N., R. 18 E., secs. 1-36, except that portion of sec. 6 lying northerly of Interstate Highway 40; T. 8 N., R. 19 E., secs. 1-36; T. 8 N., R. 20 E., secs. 1-36; T. 8 N., R. 21 E., secs. 7, 17-21, and 27-35; T. 9 N., R. 18 E., that portion of secs. 31-36 lying southerly of Interstate

Highway 40; T. 9 N., R. 19 E., secs. 23-29, 31-36, except that portion of secs. 23, 24, 26-29, 31, and 32 lying northerly of Interstate Highway 40; T. 9 N., R. 20 E., secs. 19, 20, and 29-33, except that portion of secs. 19 and 20 lying northerly of Interstate Highway 40 and S 1/2 S 1/2 sec. 27, SW 1/4 SW 1/4 sec. 26, and W 1/2 W 1/2 sec. 35..

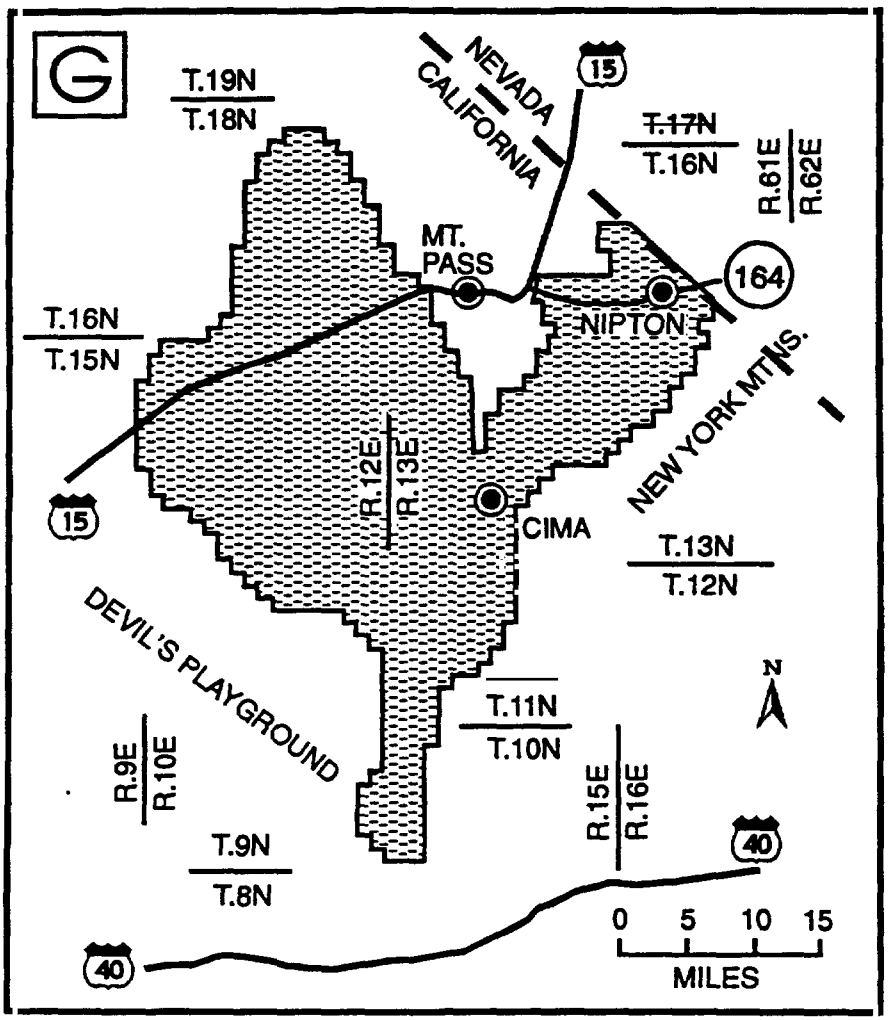
CHEMEHUEVI


F
T.10N
T.9N
GOFFS
95
NEEDLES
TOPOCK
R.13E
R.14E
R.22E
CLIPPER MTNS.
R. 18E
R.21E
40
T.7N
T.6N
95
40
0 5 10 15
MILES
62
CHAMBLESS
R.17E
CHEMEHUEVI
VALLEY
T.4N
T.3N
N
T.3N
T.2N
SAN BERNARDINO CO.
RIVERSIDE CO.
VIDAL
T.1N
T.1S

7. **Ivanpah Unit.** San Bernardino County. From Bureau of Land Management Maps: Amboy 1991, Ivanpah 1979, and Mesquite Lake 1990. (Index map location G).

San Bernardino Meridian: T. 9 N., R. 12 E., secs. 1, 2, 11-14, and 24; T. 9 N., R. 13 E., secs. 4-9, 16-21, and 28-30; T. 10 N., R. 12 E., secs. 25, 35, and 36; T. 10 N., R. 13 E., secs. 3-10, 16-21, and 28-33; T. 11 N., R. 12 E., secs. 1, 12, 13, 24, 25, and 36; T. 11 N., R. 13 E., secs. 1-12, 15-21, and 28-33; T. 11 N., R. 14 E., sec. 6; T. 12 N., R. 11 E., secs. 1-5 and 9-15; T. 12 N., R. 12 E., secs. 1-18, 21-27, 35, and 36; T. 12 N., R. 13 E., secs. 1-36; T. 12 N., R. 14 E., secs. 4-9, 16-21, and 29-32; T. 13 N., R. 10 E., secs. 1-5, 10-14, 24, and 25; T. 13 N., R. 11 E., secs. 1-36; T. 13 N., R. 12 E., secs. 1-36; T. 13 N., R. 13 E., secs. 1-36; T. 13 N., R. 14 E., secs. 3-9, 16-21, and 28-33; T. 14 N., R. 9 E., secs. 1, 12, 13, and 24; T. 14 N., R. 10 E., secs. 1-36; (Unsurveyed) T. 14 N., R. 11 E., Protracted secs. 1-35; T. 14 N., R. 11 E., sec. 36; T. 14 N., R. 12 E., secs. 1-36; T. 14 N., R. 13 E., secs. 1-36; T. 14 N., R. 14 E., secs. 1-5, 8-17, and 19-35; T. 14 N., R. 15 E., secs. 1-12, and 14-22; T. 14 N., R. 16 E., sec. 6; T. 15 N., R. 9 E., secs. 24, 25, and 36; T. 15 N., R. 10 E., secs. 1-36 except sec. 6; T. 15 N., R. 11 E., secs. 1-36; T. 15 N., R. 12 E., secs. 1-36; T. 15 N., R. 13 E., secs. 3-11 and 14-36; T. 15 N., R. 14 E., secs. 12, 13, 23-28, and 33-36; T. 15 N., R. 15 E., secs. 1-36; T. 15 N., R. 16 E., secs. 1-11, 14-22, and 28-33; T. 15 1/2 N., R. 14 E., secs. 24 and 25; T. 15 1/2 N., R. 15 E., secs. 19-36; T. 15 1/2 N., R. 16 E., secs. 19-35; T. 16 N., R. 10 E., secs. 25, 35, and 36; T. 16 N., R. 11 E., secs. 1-36; T. 16 N., R. 12 E., secs. 1-36; T. 16 N., R. 12 1/2 E., secs. 12, 13, 24, 25, and 36; T. 16 N., R. 13 E., secs. 7, 17-20, and 29-33; T. 16 N., R. 14 E., secs. 24, 25, 35 and 36, except that portion of secs. 24 and 35 lying northwesterly of Interstate Hwy. 15; T. 16 N., R. 15 E., secs. 1-3, 10-14, and 23-36; T. 16 N., R. 16 E., secs. 6-8, 16-22, and 26-36; T. 17 N., R. 11 E., secs. 1-5, 8-17, 20-29, an 31-36; T. 17 N., R. 12 E., secs. 3-10, 14-23, and 26-36; T. 18 N., R. 11 E., secs. 13, 14, 22-28, and 33-36; T. 18 N., R. 12 E., secs. 18-20, and 28-33.

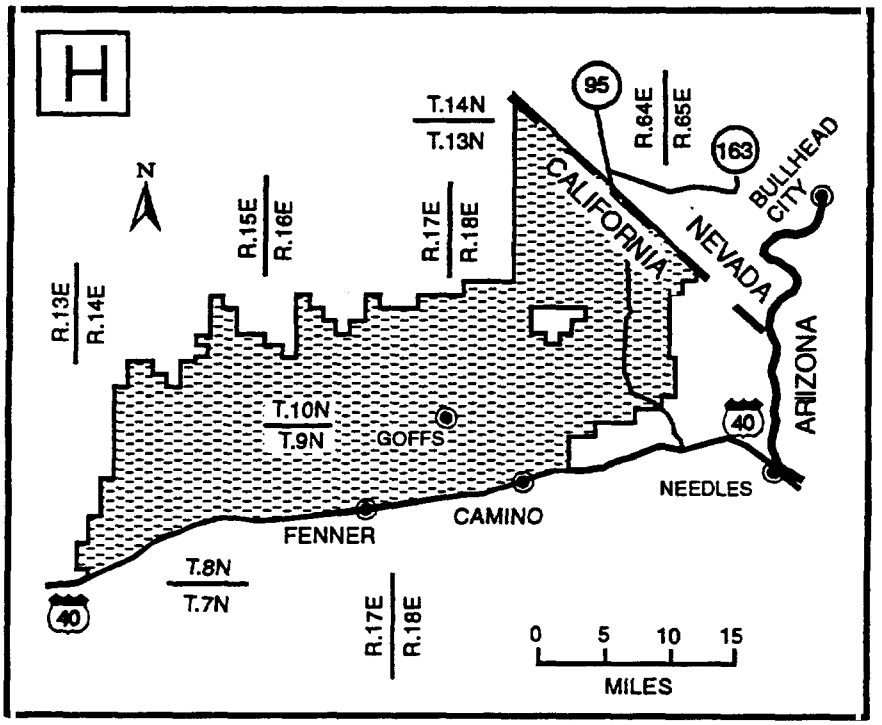
IVANPAH


G
T.19N
T.18N
NEVADA
CALIFORNIA
15
T.17N
T.16N
R.61E
R.62E
MT.
PASS
164
NIPTON
T.16N
T.15N
NEW YORK MTNS.
R.12E
R.13E
CIMA
15
T.13N
T.12N
DEVIL'S PLAYGROUND
N
T.11N
T.10N
R.9E
R.10E
R.15E
R.16E
T.9N
T.8N
40
40
0 5 10 15
MILES

8. <u>Piute-Eldorado Unit</u>. San Bernardino County. From Bureau of Land Management Maps: Amboy 1991, Needles 1978, and Ivanpah 1979. (Index map location H).

San Bernardino Meridian: T. 8 N., R. 14 E., secs. 1-4, 8-17, 19-24, 26-30, 32, and 33, except that portion of secs. 13, 23, 24, 26-28, 32 and 33 lying southeasterly of Interstate Highway 40; T. 8 N., R. 15 E., secs. 1-12, 17, and 18, except that portion of secs. 1, 8-12, 17, and 18 lying southeasterly of Interstate Highway 40; T. 8 N., R. 16 E., secs. 1-10, except that portion of sections 1-3 and 6-10 lying southerly of Interstate Highway 40; T. 8 N., R. 17 E., that portion of secs. 1-6, lying northerly of Interstate Highway 40; T. 9 N., R. 14 E., secs. 1-3, 10-15, 22-28, and 33-36; T. 9 N., R. 15 E., secs. 1-36; T. 9 N., R. 16 E., secs. 1-36; T. 9 N., R. 17 E., secs. 1-36, except that portion of sec. 36 lying southerly of Interstate Highway 40; T. 9 N., R. 18 E., secs. 1-36, except that portion of secs. 31-36 lying southerly of Interstate Highway 40; T. 9 N., R. 19 E., secs. 1-24 and 26-32, except that portion of secs. 26-29, 31, and 32 lying southerly of Interstate Highway 40; T. 9 N., R. 20 E., secs. 3-8 and 17-20, except that portion of secs. 19 and 20 lying southerly of Interstate Highway 40; T. 10 N., R. 14 E., secs. 11-14, 22-27, and 34-36; T. 10 N., R. 15 E., secs. 1-3, 9-16, and 18-36; T. 10 N., R. 16 E., secs. 1-36; T. 10 N., R. 17 E., secs. 1-36; T. 10 N., R. 18 E., secs. 1-36; T. 10 N., R. 19 E., secs. 1-36; T. 10 N., R. 20 E., secs. 1-36; T. 10 N., R. 21 E., secs. 3-10, 15-22, and 28-31; T. 11 N., R. 15 E., secs. 9, 15, 16, 21, 22, 25-29, and 33-36; T. 11 N., R. 16 E., secs. 9, 15, 16, 21-23, 25-28, 31, and 33-36; T. 11 N., R. 17 E., secs. 8, 12-17, and 19-36; T. 11 N., R. 18 E., secs. 1-4 and 7-36; T. 11 N., R. 19 E., secs. 1-13, 18, 19, 23-27, and 29-36; T. 11 N., R. 20 E., secs. 1-11, 14-23, and 26-35; T. 12 N., R. 19 E., secs. 1-36; T. 12 N., R. 20 E., secs. 3-11 and 13-36; T. 12 N., R. 21 E., secs. 19, 30, and 31; T. 13 N., R. 19 E., secs. 3-11 and 13-36; T. 13 N., R. 20 E., secs. 19 and 29-33; T. 14 N., R. 19 E., secs. 19 and 29-33.

PIUTE-ELDORADO, CALIFORNIA

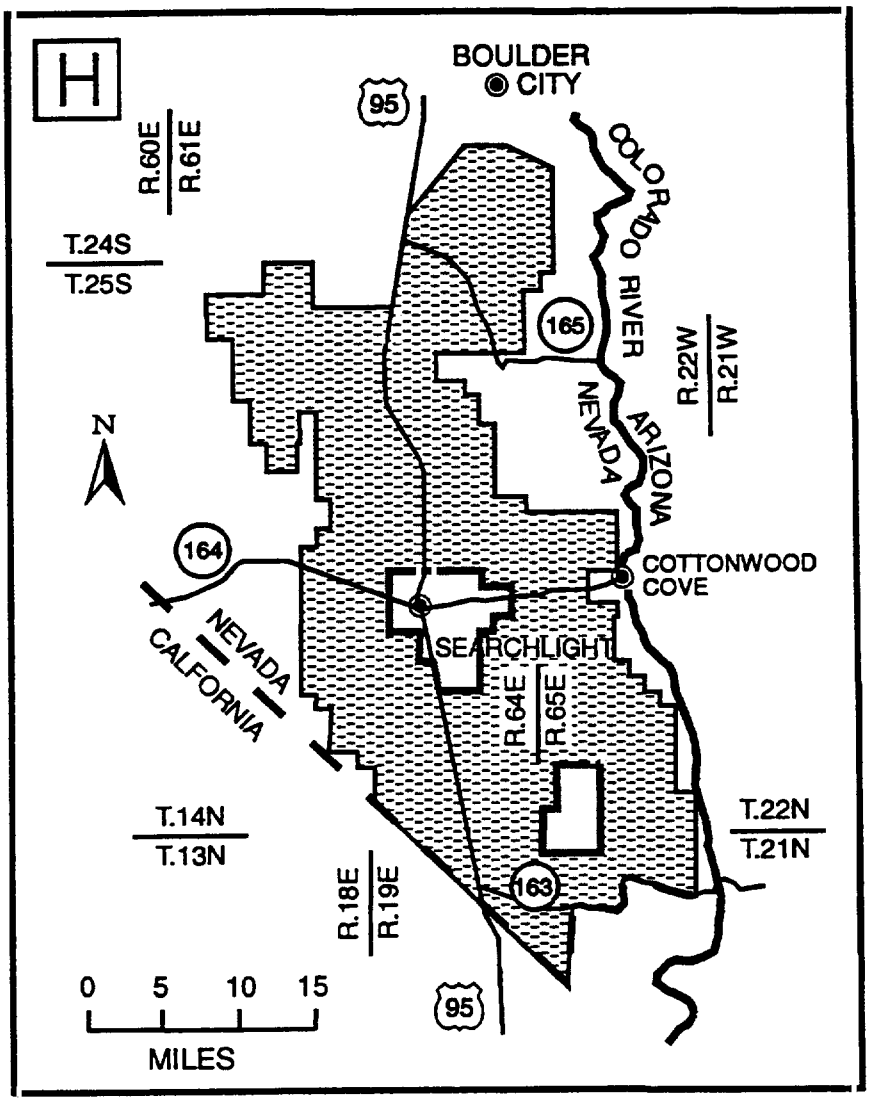


Nevada. Areas of land as follows:

9. Piute-Eldorado Unit. Clark County. From Bureau of Land Management Maps: Mesquite Lake 1990, Boulder City 1978, Ivanpah 1979, and Davis Dam 1979. (Index map location H).

Mt. Diablo Meridian: T. 23 S., R. 64 E., secs. 31-36, except that portion of sec. 31 lying northwesterly of the powerline and also except that portion of secs. 34-36 lying northeasterly of the powerline; T. 23 1/2 S., R. 64 E., secs. 31-36, except that portion of sec. 31 lying northwesterly of the powerline; T. 23 1/2 S., R. 65 E., that portion of sec. 31, lying southwesterly of the powerline; T. 24 S., R. 63 E., secs. 1, 2, 11-15, 22-28, and 33-36, except that portion of secs. 1, 2, 11, 14, and 15 lying northwesterly of the powerline and also except that portion of secs. 22, 27, 28, and 33 lying northwesterly of U.S. Highway 95; T. 24 S., R. 64 E., secs. 1-36; T. 24 S., R. 65 E., secs. 6, 7, 18, 19, 30, and 31; T. 25 S., R. 61 E., secs. 13-15, E 1/2 sec. 16, E 1/2 sec. 21, secs. 22-27, E 1/2 sec. 28, secs. 35 and 36; T. 25 S., R. 62 E., secs. 4-9, and secs. 16-36; T. 25 S., R. 63 E., secs. 1-4, 9-16, and 19-36, except that portion of secs. 4, 9, and 16 lying northwesterly of U.S. Highway 95; T. 25 S., R. 64 E., secs. 1-35 except secs. 13, 24, and 25,; T. 25 S. R. 65 E., sec. 6; T. 26 S., R. 61 E., secs. 1, 2, 11-14, 24, 25, and 36; T. 26 S., R. 62 E., secs. 1-36 except secs. 28 and 33; T. 26 S., R. 63 E., secs. 2-36 except sec. 12; T. 26 S., R. 64 E., secs. 18-20, and 29-33; T. 27 S., R. 62 E., secs. 1-3, 5-8, 10-15, 22-26, 35, and 36; T. 27 S., R. 62 1/2 E., secs. 1, 12, 13, 24, 25, and 36; T. 27 S., R. 63 E., secs. 1-36; T. 27 S., R. 64 E., secs. 4-9, 16-21, and 26-36; T. 27 S., R. 65 E., secs. 31-35; T. 28 S., R. 62 E., secs. 1-3, 9-16, 21-28, and 33-36; T. 28 S., R. 63 E., secs. 1-20, and 29-32; T. 28 S., R. 64 E., secs. 1-18, 21-26, 35, and 36; T. 28 S., R. 65 E., secs. 2-11, 14-21, and 28-35; T. 29 S., R. 62 E., secs. 1-4, 9-16, 21-28, 34, 35 and 36; T. 29 S., R. 63 E., secs. 5-10, 15-23, and 26-36; T. 29 S., R. 64 E., secs. 1-3, 9-16, 21-28, and 31-36; T. 29 S., R. 65 E., secs. 2-36 except secs. 12 and 13; T. 29 S., R. 66 E., secs. 30-32; T. 30 S., R. 62 E., secs. 1, 2, and 11-14; T. 30 S., R. 63 E., secs. 1-36 except secs. 30 and 31; T. 30 S., R. 64 E., secs. 1-36; T. 30 S., R. 65 E., secs. 1-26, 30, 31, 35, and 36; T. 30 S., R. 66 E., secs. 4-9, 16-21, and 28-33; T. 31 S., R. 63 E., secs. 1-5, 8-16, 22-26, and 36; T. 31 S., R. 64 E., secs. 1-36; T. 31 S., R. 65 E., secs. 1, 2, 6, 11-14, 23-36, except that portion of sec. 36 lying southwesterly of State Highway 163; T. 31 S., R. 66 E., secs. 3-10, 15-22, and 27-34, except that portion of sec. 31 lying southwesterly of State Highway 163; T. 32 S., R. 64 E., secs. 1-6, 8-16, 22-26, and 36; T. 32 S., R. 65 E., secs. 1-12, 17-20, and 29-32, except that portion of secs. 1, and 9-12 lying southeasterly or easterly of State Highway 163; T. 32 S., R. 66 E., that portion of secs. 3-6 lying northerly of State Highway 163; T. 33 S., R. 65 E., sec. 5.

PIUTE-ELDORADO, NEVADA



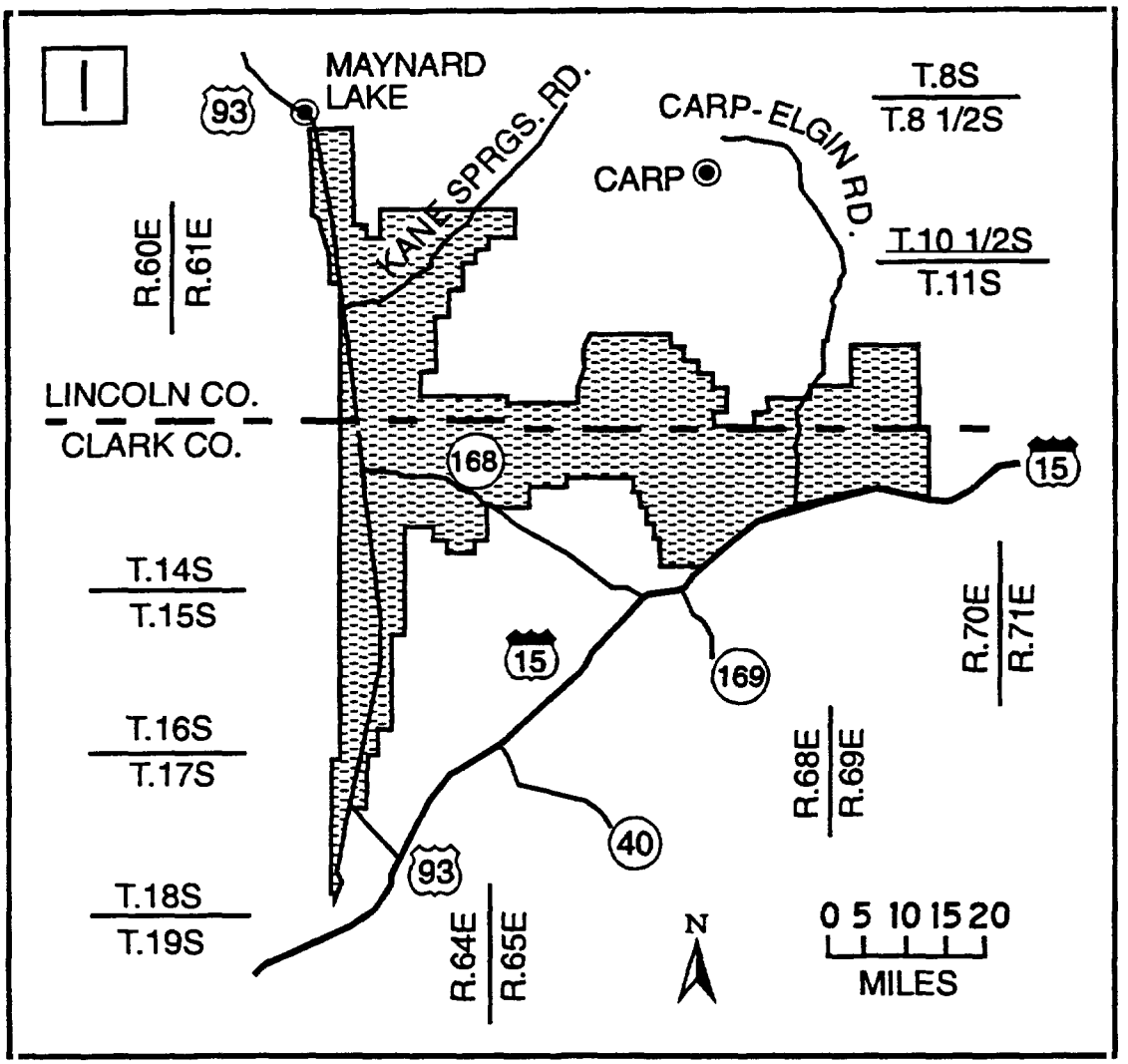
10. Mormon Mesa Unit. Clark and Lincoln Counties. From Bureau of Land Management Maps: Pahranagat 1978, Clover Mts. 1978, Overton 1978, Indian Springs 1979, Lake Mead 1979, and Las Vegas 1986. (Index map location I).

Mt. Diablo Meridian: T. 9 S., R. 62 E., secs. 13-15, 22-27, and 34-36, except that portion of secs. 15, 22, 27, and 34 lying westerly of the easterly boundary line of the Desert National Wildlife Range;

T. 9 S., R. 63 E., secs. 18, 19, 30, and 31; T. 10 S., R. 62 E., secs. 1, 2, 11-14, 23-25, and 36 except that portion of secs. 14, 23, 35, and 36 lying westerly of the easterly boundary line of the Desert National Wildlife Range;
T. 10 S., R. 63 E., secs. 6, 7, 13-15, 18-20, and 22-36; T. 10 S., R. 64 E., secs. 13-24 and 26-34; T. 10 S., R. 65 E., secs. 18, and 19; T. 11 S., R. 62 E., that portion of sec. 1 lying easterly of the easterly boundary line of the Desert National Wildlife Range; T. 11 S., R. 63 E., secs. 1-36; T. 11 S., R. 64 E., secs. 4-9, 17-20, 30, and 31; T. 11 S., R. 66 E., secs. 31-36; T. 12 S., R. 63 E., secs. 1-36; T. 12 S., R. 64 E., secs. 6, 7, and 25-36; T. 12 S., R. 65 E., secs. 1, 12, 13, and 24-36, except that portion of secs. 1, 2, 13, and 24 lying westerly of Union Pacific Railroad; T. 12 S., R. 66 E., secs. 1-36; T. 12 S., R. 67 E., secs. 6-8, 16-22, and 27-33; T. 12 S., R. 68 E., secs. 23-29 and 31-36; T. 12 S., R. 69 E., secs. 1-5, 8-17, and 19-36; T. 12 1/2 S., R. 62 E., that portion of sec. 36, lying easterly of the easterly boundary line of the Desert National Wildlife Range; T. 13 S., R. 62 E., that portion of secs. 1, 12, 13, 24, and 25 lying easterly of the easterly line of the Desert National Wildlife Range; T. 13 S., R. 63 E., secs. 1-36; T. 13 S., R. 64 E., secs. 1-36; T. 13 S., R. 65 E., secs. 1-24, N 1/2 26, N 1/2 27, N 1/2 and SW 1/4 sec. 28, 29-32, and W 1/2 33; T. 13 S., R. 66 E., secs. 1-26, W 1/2 sec. 27, 35, and 36; T. 13 S., R. 67 E., secs. 1-36; T. 13 S., R. 68 E., secs. 1-36, except that portion of secs. 25 and 33-36 lying southeasterly of Interstate Highway 15; T. 13 S., R. 69 E., secs. 1-30, except that portion of secs. 25-30 lying southerly of Interstate Highway 15; T. 13 S., R. 70 E., secs. 6, 7, 18, 19, 30, and 31, except that portion of secs. 30 and 31 lying southerly of Interstate Highway 15; T. 13 1/2 S., R. 63 E., secs. 31-36; T. 13 1/2 S., R. 64 E., secs. 31-36, except that portion of sec. 36 lying southwesterly of State Highway 168; T. 14 S., R. 63 E., secs. 1-23, and 26-35; T. 14 S., R. 64 E., secs. 2-6, 8-11, 15, and 16; T. 14 S., R. 66 E., secs. 1, E 1/2 sec. 2, 12, E 1/2 sec. 13, and E 1/2 sec. 24; T. 14 S., R. 67 E., secs. 1-12 and 14-22, except that portion of secs. 12, 14, 15, 21, and 22 lying southerly of Interstate Highway 15; T. 14 S., R. 68 E., that portion of secs. 4-7 lying northwesterly of Interstate Highway 15; T. 15 S., R. 63 E., secs. 2-11, 14-22, and 27-34; T. 16 S., R. 63 E., secs. 3-10, 15-22, and 28-33; T. 17 S., R. 63 E., secs. 7-9, 16-21, and 28-32, except that portion of secs. 29 and 32 lying easterly of the westerly boundary line of the Apex Disposal Road; T. 18 S., R. 63 E., secs. 5-8, 17-19, and 29-31, except that portion of secs. 5, 8, 17-19, and 29-31 lying easterly of the westerly boundary line of the Apex

Disposal Road, and that portion of sec. 31 lying westerly of the easterly boundary line of Desert National Wildlife Range.

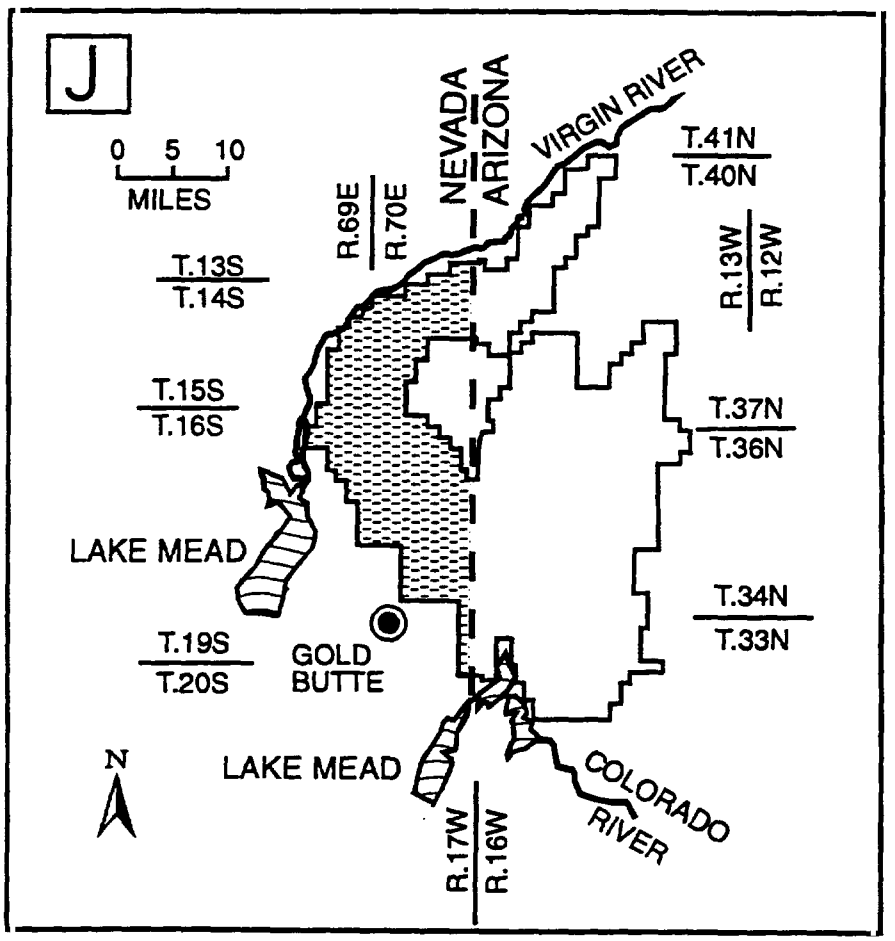
MORMON MESA


I
93
MAYNARD LAKE
KANE SPRGS. RD.
CARP-ELGIN RD.
CARP
T.8S
T.8 1/2S
T.10 1/2S
T.11S
R.60E
R.61E
LINCOLN CO.
CLARK CO.
168
15
T.14S
T.15S
T.16S
T.17S
T.18S
T.19S
15
169
40
93
R.64E
R.65E
R.68E
R.69E
R.70E
R.71E
N
0 5 10 15 20
MILES

11. <u>Gold Butte-Pakoon Unit</u>. Clark County. From Bureau of Land Management Maps: Overton 1978 and Lake Mead 1979. (Index map location J).

Mt. Diablo Meridian: T. 13 S., R. 71 E., secs. 32-34; T. 14 S., R. 69 E., secs. 24-26, and 34-36; T. 14 S., R. 70 E., secs. 1, and 10-36; T. 14 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 15 S., R. 69 E., secs. 1-3, 9-16, 21-28, and 33-36; T. 15 S., R. 70 E., secs. 2-11, 15-22, and 28-33; T. 16 S., R. 69 E., secs. 1-36 except secs. 6, 7, and 29-32; T. 16 S., R. 70 E., secs. 4-36 except sec. 12; T. 16 S., R. 71 E., secs. 19, and 29-32; T. 17 S., R. 69 E., secs. 1-3, 11-14, 24, 25, and 36; T. 17 S., R. 70 E., secs. 1-36; T. 17 S., R. 71 E., secs. 4-10, 15-22, and 27-34; T. 18 S., R. 69 E., sec. 1; T. 18 S., R. 70 E., secs. 1-6, 10-15, 22-27, and 34-36; T. 18 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 19 S., R. 71 E., secs. 3, 4, 9, 10, 15, 16, 21, 22, 27, 28, 33 and 34; T. 20 S., R. 71 E., secs. 3 and 4.

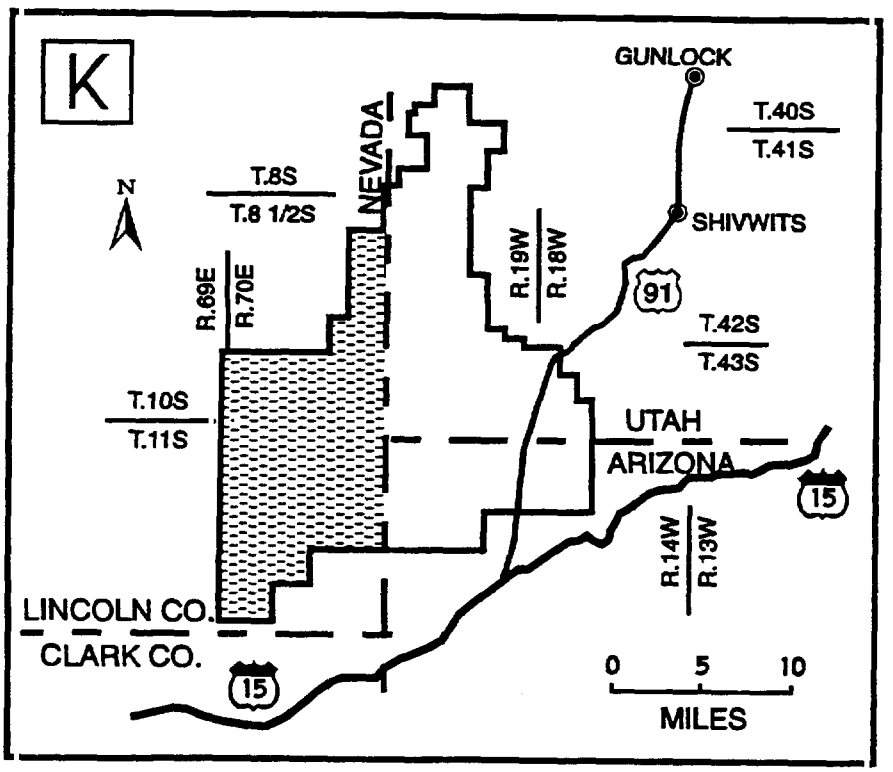
GOLD BUTTE-PAKOON
NEVADA



12. Beaver Dam Slope Unit. Lincoln County. From Bureau of Land Management Maps: Clover Mountains 1978 and Overton 1978. (Index map location K).

Mt. Diablo Meridian: T. 8 1/2 S., R. 71 E., that portion of sec. 34 lying south of a westerly extension of the north line of sec. 26, T. 41 S., R. 20 W. (Salt Lake Meridian), Washington County, Utah; T. 9 S., R. 71 E., secs. 3, 10, 15-17, 20-22, 27-29, and 32-34; T. 10 S., R. 70 E., secs. 19-36; T. 10 S., R. 71 E., secs. 3-5, 7-10, 15-22, and 27-34; T. 11 S., R. 70 E., secs. 1-36; T. 11 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 12 S., R. 70 E., secs. 1-12, 14-23, and 28-33; T. 12 S., R. 71 E., secs. 3-10.

BEAVER DAM SLOPE
NEVADA

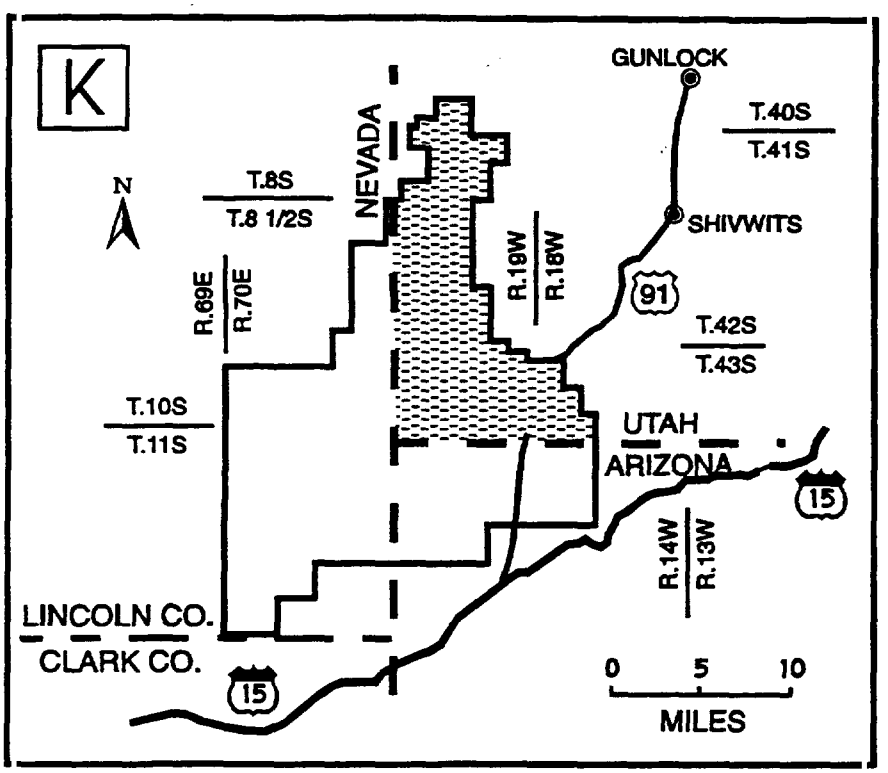


Utah. Areas of land as follows:

13. Beaver Dam Slope Unit. Washington County. From Bureau of Land Management Maps: St. George 1980 and Clover Mts. 1978. (Index map location K).

Salt Lake Meridian: T. 40 S., R. 19 W., S 1/2 sec. 28, S 1/2 sec. 29, S 1/2 sec. 31, secs. 32 and 33; T. 41 S., R. 19 W., S 1/2 sec. 2, S 1/2 sec. 3, secs. 4, 5, 6, E 1/2 sec. 7, secs. 8-11, 15-17, E 1/2 sec. 18, and secs. 19-22, and 28-33; T. 41 S., R. 20 W., E 1/2 sec. 1, secs. 24-26, 35, and 36; T. 42 S., R. 19 W., secs. 4-9, 16-22, and 27-34; T. 42 S., R. 20 W., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 43 S., R. 18 W., secs. 7, 8, S 1/2 sec. 16, secs. 17-21, and 27-34; T. 43 S., R. 19 W., secs. 1-36 except N 1/2 sec. 1; T. 43 S., R. 20 W., secs. 1, 2, 11-14, 23-26, 35, and 36.

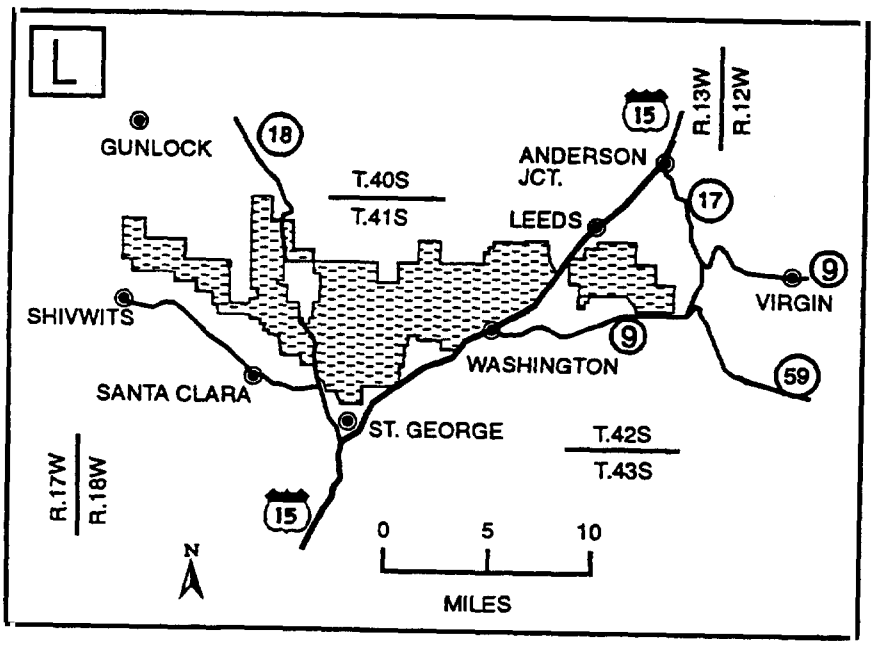
BEAVER DAM SLOPE
UTAH



14. <u>Upper Virgin River Unit</u>. Washington County. From Bureau of Land Management Map: St. George 1980. (Index map location L).

Salt Lake Meridian: T. 41 S., R. 13 W., secs. 17-21, except NW 1/4 NW 1/4 sec. 18, W 1/2 and W 1/2 E 1/2 sec. 27, 28, N 1/2 sec. 29, N 1/2 sec. 30, N 1/2 N 1/2 sec. 33, except that portion of secs. 28 and 33 lying westerly of Gould Wash, and N 1/2 NW 1/4 and NW 1/4 NE 1/4 sec. 34; T. 41 S., R. 14 W., S 1/2 S 1/2 and NE 1/4 SE 1/4 and SE 1/4 NE 1/4 sec. 13, that portion of sec. 14 lying westerly of Red Cliff Road, secs. 15-17 except N 1/2 NW 1/4 and SW 1/4 NW 1/4 sec. 17, secs. 19-22, that portion of sec. 23 lying westerly of Red Cliff Road and westerly of Interstate Highway 15, sec. 24, NE 1/4 and N 1/2 SE 1/4 and SW 1/4 SE 1/4 sec. 25, that portion of secs. 26, 27, and 32-34 lying northwesterly of Interstate Highway 15, and secs. 28-31; T. 41 S., R. 15 W., secs. 14, 19, 20, and 22-36; T. 41 S., R. 16 W., secs. 4, 9, 10, S 1/2 sec. 14, 15-16, 19, 21, W 1/2 sec. 22, secs. 24-25 except W 1/2 SW 1/4 sec. 24 and W 1/2 NW 1/4 and W 1/2 SW 1/4 sec. 25, and W 1/2 W 1/2 sec. 25, SW 1/4 NE 1/4 and NW 1/4 NW 1/4 and S 1/2 NW 1/4 and SW 1/4 and W 1/2 SE 1/4 sec. 27, E 1/2 and E 1/2 W 1/2 and NW 1/4 NW 1/4 and SW 1/4 SW 1/4 sec. 28, N 1/2 and SE 1/4 and E 1/2 SW 1/4 sec. 30, NE 1/4 sec. 31, N 1/2 sec. 32, N 1/2 and SE 1/4 and N 1/2 SW 1/4 sec. 33, sec. 34, SE 1/4 SE 1/4 and that portion of sec. 35 lying westerly of Utah Highway 18, and sec. 36; T. 41 S., R. 17 W., secs. 9, 14-16, NE 1/4 sec. 21, N 1/2 sec. 22, NW 1/4 and E 1/2 sec. 23, sec. 24, and NE 1/4 sec. 25; T. 42 S., R. 14 W., that portion of secs. 5 and 6 lying northwesterly of Interstate Highway 15; T. 42 S., R. 15 W., secs. 1, N 1/2 and N 1/2 S 1/2 sec. 2, NE 1/4 and W 1/2 sec. 3, secs. 4-9, W 1/2 W 1/2 sec. 10, N 1/2 N 1/2 sec. 12, secs. 16-18, N 1/2 and N 1/2 SE 1/4 and NE 1/4 SW 1/4 sec. 19, W 1/2 NW 1/4 and NW 1/4 SW 1/4 sec. 20, except that portion of secs. 1 and 12 lying southeasterly of Interstate Highway 15; T. 42 S., R. 16 W., secs. 1, 2, NW 1/4 and E 1/2 sec. 3, NE 1/4 NE 1/4 sec. 4, NE 1/4 sec. 10, NW 1/4 and E 1/2 sec. 11, sec. 12, E 1/2 and NW 1/4 and N 1/2 SW 1/4 sec. 13, N 1/2 NE 1/4 sec. 24, except that portion of sec. 13 lying westerly of Utah Highway 18.

UPPER VIRGIN RIVER

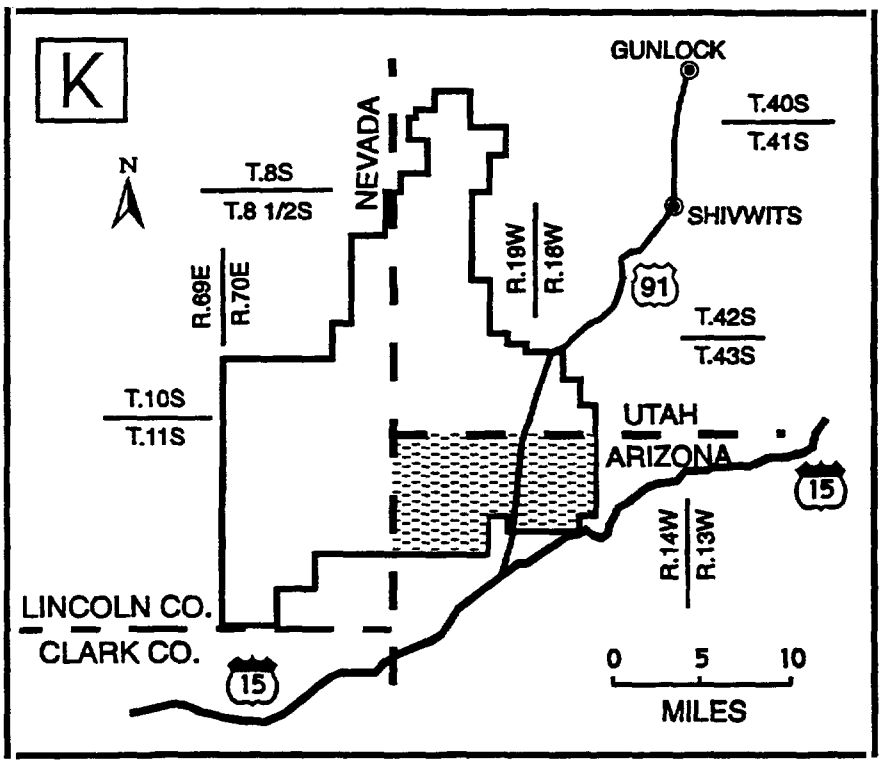


Arizona. Areas of land as follows:

15. Beaver Dam Slope Unit. Mohave County. From Bureau of Land Management Maps: Overton 1978 and Littlefield 1987. (Index map location K).

Gila and Salt River Meridian: T. 41 N., R. 14 W., secs. 6, 7, 18, and 19; T. 41 N., R. 15 W., secs. 1-24, 26-28, 30, and 31; T. 41 N., R. 16 W., secs. 1-5, 8-17, 20-29, and 32-36; T. 42 N., R. 14 W., sec. 31; T. 42 N., R. 15 W., secs. 31-36; T. 42 N., R. 16 W., secs. 32-36.

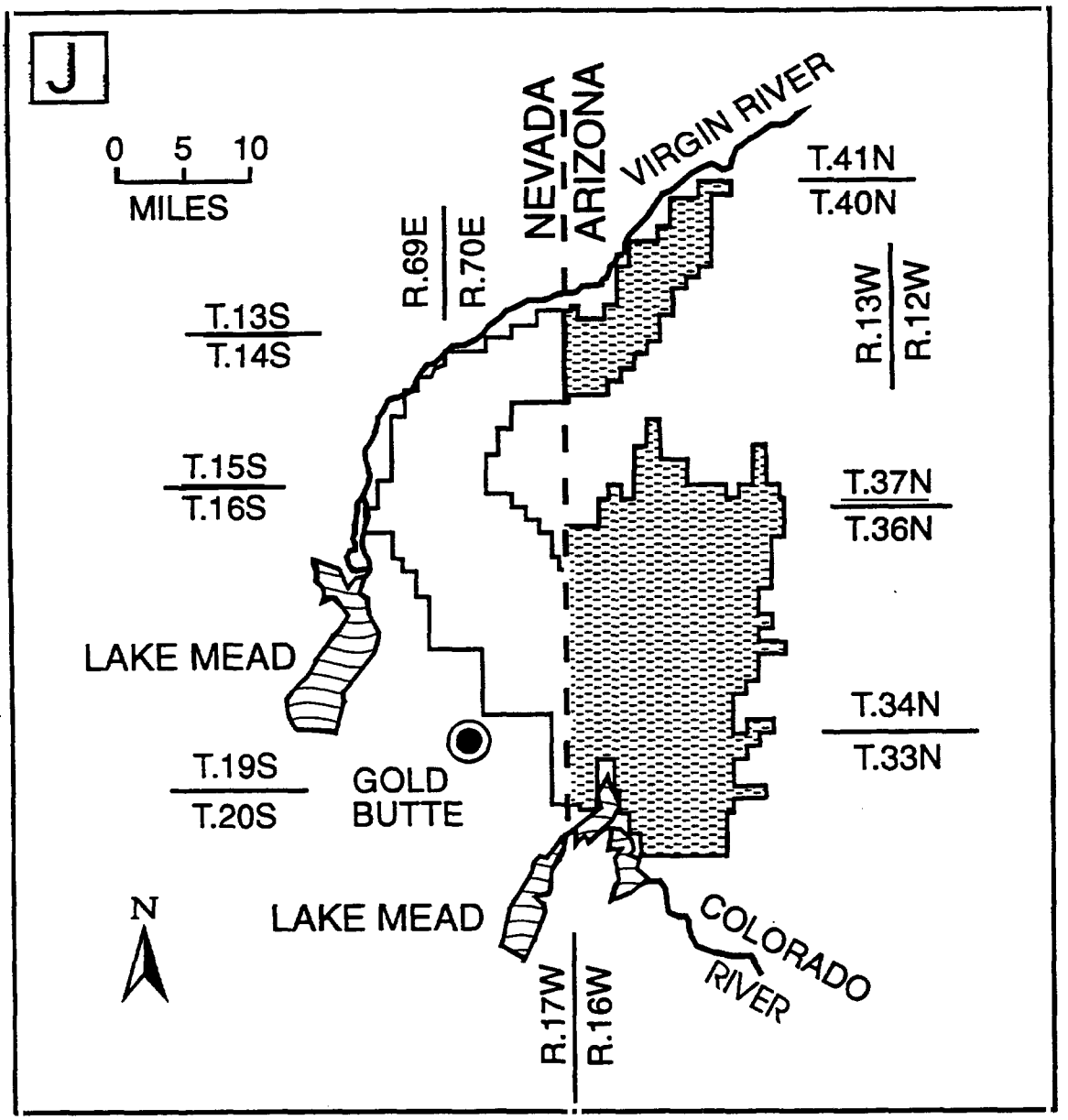
BEAVER DAM SLOPE
ARIZONA



16. <u>Gold Butte-Pakoon Unit</u>. Mohave County. From Bureau of Land Management Maps: Overton 1978, Littlefield 1987, Mount Trumbull 1986, and Lake Mead 1979. (Index map location J).

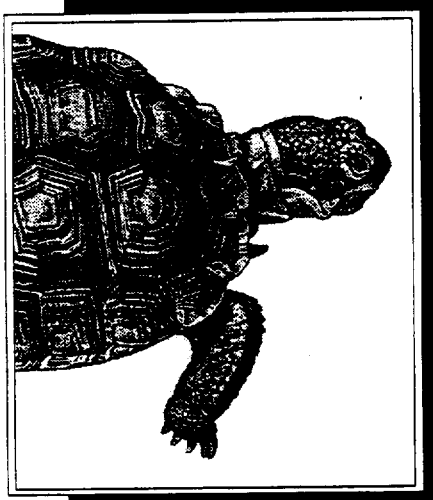
Gila and Salt River Meridian: T. 32 N., R. 15 W., secs. 1-18, except those portions of secs. 13-18 lying south of the Lake Mead National Recreation area boundary line; T. 32 N., R. 16 W., secs. 1, 2, 12, and 13; T. 32 1/2 N., R. 15 W., secs. 31-36; T. 32 1/2 N., R. 16 W., secs. 35 and 36; T. 33 N., R. 14 W., secs. 4-8, 18, 19, and 28-31; T. 33 N., R. 15 W., secs. 1-36; T. 33 N., R. 16 W., secs. 1-14, 17-20, 23-26, 29-32, 35, and 36; T. 34 N., R. 14 W., secs. 4-9, 17-19, 30, 31, 33, and 34; T. 34 N., R. 15 W., secs. 1-36; T. 34 N., R. 16 W., secs. 1-36; T. 35 N., R. 14 W., secs. 3-9, 16-22, and 28-35 ; T. 35 N., R. 15 W., secs. 1-36; T. 35 N., R. 16 W., secs. 1-36; T. 36 N., R. 14 W., secs. 2-11, 14-22, and 27-34; T. 36 N., R. 15 W., secs. 1-36; T. 36 N., R. 16 W., secs. 1-36 except secs. 4-9; T. 37 N., R. 14 W., secs. 15, 22, 27, 31, and 33-35; T. 37 N., R. 15 W., secs. 5, 8, 17-22, and 27-36; T. 37 N., R. 16 W., sec. 35; T. 38 N., R. 15 W., sec. 6; T. 38 N., R. 16 W., secs. 1-12 and
14-22 and 30; T. 39 N., R. 15 W., secs. 2-10, 16 -21, and 29-32; T. 39 N., R. 16 W., secs. 1, 12, 13, 20, 23-29, and 32-36; T. 40 N., R. 14 W., sec. 6; T. 40 N., R. 15 W., secs. 1, 10-15, and 21-36.

GOLD BUTTE-PAKOON
ARIZONA



Appendix I

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix I: Summary of the Agency and Public Comment on the Draft Desert Tortoise Recovery Plan

I. Summary of the Agency and Public Comment on the Draft Desert Tortoise Recovery Plan

In April, 1993, the U.S. Fish and Wildlife Service (Service) released the Draft Recovery Plan for the Desert Tortoise (Mojave Population) (Draft Plan) for a 60-day comment period ending on June 1, 1993 for Federal agencies, state and local governments, and members of the public (58 FR 16691). Due to the complexity of the plan, the Service extended this comment period an additional 30 days, ending on June 30, 1993 (58 FR 28894).

This section summarizes the content of significant comments on the Draft Plan. A total of 143 letters was received, each containing varying numbers of comments. Many specific comments re-occurred in letters.

This section provides a summary of general demographic information including the total number of letters received from various affiliations and states. It also provides a summary of the 21 major comments. A complete index of the commenters, by affiliation, is available from the U.S. Fish and Wildlife Service, Las Vegas Field Office, 1500 N. Decatur 01, Las Vegas, Nevada 89108. All letters of comment on the Draft Plan are kept on file in the Las Vegas Field Office.

Demographic Information

The following is a breakdown of the number of letters received from various affiliations:

Federal agencies	15 letters
state agencies	9 letters
local governments	6 letters
business/industry	12 letters
environmental/conservation organizations	15 letters
academia/professional	7 letters
multiple use/recreation organizations	9 letters
individual responses	70 letters

II. Summary of Comments and Service Responses

Executive Summary

Comment: The difference between the utility of Desert Wildlife Management Areas (DWMAs) and recovery units in the recovery and delisting of desert tortoises is unclear.

Response: As now defined in the Final Plan, the six recovery units are geographic areas which harbor evolutionarily distinct populations of the desert tortoise, and the 14 proposed DWMAs are the smaller administrative areas within each of the six geographic areas. DWMAs are the managed reserves which protect the desert tortoise populations until such time as recovery and delisting can occur while also maintaining and protecting other sensitive species and ecosystem functions. Each recovery unit should have at least one DWMA containing 1,000 square miles of desert tortoise habitat. Multiple 1,000 square mile DWMAs would provide additional protection in ensuring the persistence of the six evolutionarily distinct populations segments. Figure 6 further describes this concept in reserve design.

Comment: The budget numbers shown under "Need 1" are in three year increments after 1995. Does this mean that all the money will only be spent every third year? Additionally, these numbers do not appear to be consistent with the 10 year budget tables in the supplementary document "Proposed Desert Wildlife Management Areas for Recovery...."

Response: The expenditure of funds every 3 years reflects the 3-year cycle recommended in the Recovery Plan for monitoring desert tortoise populations. The 10-year tables shown in the supplementary document reflect what funding is projected to be necessary for implementation of all recovery actions. These figures will be revised following development of management plans for each DWMA, which will be much more site-specific and detailed.

Comment: The education budget listed under "Need 2" should be revised to allow some expenditures for public education throughout the term of the recovery plan, rather than spending all the money during the first year.

Response: As shown in the Implementation Schedule (Section III), continuing costs for implementing education programs are to be determined based on what is recommended in the environmental programs that are developed the first year.

Comment: What is Public Law 1010-618?

Response: Public Law 1010-618 is not relevant to this Recovery Plan, and the reference has been deleted.

Section I - Introduction

Comment: Based on an overview of the plant literature provided to Fish and Wildlife Service's Region 1 by the National Ecology Research Center (NERC), there is no scientific analysis of changes in perennial grass composition in the Mojave Desert.

Response: This information is reflected in D'Antonio and Vitousek's 1992 paper (see Literature Cited, Section IV) which was published after NERC's 1990 document.

Comment: It would be useful to provide the number of acres of desert tortoise habitat which is currently impacted by livestock grazing.

Response: Until DWMA boundaries are determined, it is not possible to estimate the number of acres within recovery areas impacted by livestock grazing.

Comment: Section 9 of the Endangered Species Act applies to endangered species only. The regulations at 50 CFR 1731 include threatened species such as the desert tortoise.

Response: Through section 4(d) of the Endangered Species Act, the Fish and Wildlife Service may issue regulations deemed necessary and advisable to provide for the conservation of threatened species. Through such regulation, the Fish and Wildlife Service may prohibit take of threatened species.

Section II - Recovery

Comment: Target densities for desert tortoise populations are specified without reference to or knowledge of predisturbance population levels. Many of the target densities appear unrealistically high and unobtainable. Under such circumstances delisting will not be possible in some recovery units.

Response: The Recovery Team agrees with this comment and has eliminated the reaching of target densities of desert tortoises within recovery units as a goal of recovery and delisting. Rather, the population within a recovery unit must show an upward or stationary (not declining) trend and maintain a population growth rate (Lambda) within each recovery unit equal to or greater than 1.0 for delisting to be considered by the Fish and Wildlife Service.

Comment: The definition of and prohibition within the Limited Use Zones (LUZs) should apply to the entire DWMA, provided that these parcels are being designated principally for the protection and preservation of Mojave Desert wildlife, including the desert tortoise; in this respect, the need for the special LUZ designation is questioned.

Response: The Recovery Team agrees with this comment, has eliminated the LUZ designation and extended LUZ-level protection to the entire DWMA, except where Experimental Management Zones (EMZs) are proposed. EMZs may only occupy 10% of a DWMA's total area and should be located on the periphery of the DWMA boundary where any negative effects from experimental activities will be less profoundly felt within the more protected area.

Comment: It is not clear when there is more than one DWMA established within a recovery unit if all DWMAs must meet the delisting criteria or can a recovery unit population be delisted if only one DWMA population meets the four criteria?

Response: Delisting is considered on a recovery unit basis. If more than one DWMA is established to meet the delisting criteria then the combined population trend and population growth rates (lambdas) are evaluated for recovery and delisting purposes.

Comment: Twelve years is too short a time period for evidence of upward trends in adult populations, upon which monitoring plans are based. Therefore, it is unrealistic to assume delisting can occur within this time frame.

Response: The Recovery Team agrees with this comment. The population within a recovery unit must exhibit a statistically significant upward tend or remain stationary for at least 25 years (one desert tortoise generation), thus allowing time for recruitment of baby and juvenile tortoises into the adult age class.

Comment: This method of population density estimation of desert tortoises is unrealistic in application due to the monetary expense and amount of time that would be required.

Response: The Recovery Team is aware of the potential problems associated with the recommended method, however, the proposal has initiated a useful dialogue on appropriate methodology for the estimation of desert tortoise population densities. Forthcoming (1994) will be a workshop at which statistically and economically acceptable methods will be discussed and recommended on an experimental basis.

Comment: The Desert Tortoise Management Oversight Group (MOG) is recommended as the group to facilitate interagency cooperation. As it is currently structured, this group's ability to perform this task is questioned. The Fish and Wildlife Service (FWS) should take the lead in facilitating interagency cooperation and coordination. The MOG has no formal status and it is a BLM-orchestrated group. If this is the group to be used, it should be restructured with the FWS assuming the leadership role.

Response: Because the majority of desert tortoise habitat is managed by the BLM, the MOG has proved to be a useful tool in implementing desert tortoise recovery efforts over the range of the desert tortoise in four states. The FWS will also be working closely with communities through the habitat conservation planning process to implement recovery on a local basis.

Comment Public education is not adequately addressed in the Recovery Plan.

Response: Both the Recovery Team and the FWS agree that public education is a vital component of desert tortoise recovery and has revised portions of the Recovery Plan to reflect more emphasis on public education. Cost estimates for development of a public information program are provided in the Implementation Schedule (Section III). The yearly costs for implementation of the program will be determined based on the requirements of the program.

Comment: The Recovery Plan makes no explicit recommendations for management of vehicle-caused mortalities on existing highways and roads in proposed DWMAs. Eleven of the 14 proposed DWMAs are bounded or transected by high traffic volume highways or roads.

Response: The Recovery Team agrees with this comment and has added an additional statement to Section II.E.2. of the Recovery Plan which recommends the establishment of fencing or other effective barriers along heavily-traveled roads to decrease desert tortoise mortality, and the installation of culverts that allow underpass of tortoises to alleviate habitat fragmentation.

Comment: The negative effects of human activities (including cattle grazing) on desert tortoises have not been demonstrated. Disallowing certain of these activities within DWMAs without providing quality supporting material which shows that these activities are contributing to declines in desert tortoise populations detracts from the credibility of the Recovery Plan.

Response: Desert tortoise recovery is the goal of management within DWMAs. Until data are forthcoming which show that these human activities can be compatible with recovery, it is important that they not be permitted.

Comment: The Service has failed to comply with the National Environmental Policy Act of 1969 (NEPA) by not preparing an Environmental Impact Statement (EIS) for this Plan.

Response: The Service is not required to comply with NEPA in development of recovery plans. Recovery plans are planning documents that list all tasks recommended for recovery of a species. These tasks involve potential actions by the Service, other Federal agencies, State and local governments, the private sector, or a combination of the above. Recovery plans impose no obligations on any agency, entity, or persons to implement the various tasks. Implementation of recovery actions will be subject to NEPA compliance, as appropriate, at the time they are actually "proposed" and an environmental assessment (EA) or EIS would be completed at that time.

Comment: The Service has failed to comply with Executive Order 12291.

Response: Executive Order 12291 requires Federal agencies to prepare regulatory impact analyses for any "major rule." A major rule is defined as any regulation that is likely to result in: (1) An annual effect on the economy of $100 million or more; (2) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or (3) significant or adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets (46 FR 13193). A recovery plan does not meet the definition of a regulation or rule as set forth in the Order. Recovery plans do not implement, interpret, or prescribe law or policy or describe the procedure or practice requirements of the Service. Therefore, the Service is not obligated to prepare a regulatory impact analysis.

Comment: The recommended desert tortoise habitat to be managed as DWMAs is unnecessary for recovery of the desert tortoise because existing reserved lands, such as national parks and wildlife refuges, provide sufficient land for the tortoise.

Response: The Service determined that the tortoise should be listed as a threatened species in 1990 (55 FR 12178) partly because insufficient habitat is protected within congressionally protected areas to adequately conserve desert tortoises. In addition, the Recovery Plan recognizes that

areas of sufficient size to support self-sustaining tortoise populations do not exist in already protected habitats.

Section III - Implementation Schedule

Comment: The budget in unconvincing. Where did the numbers come from?

Response: The numbers in the Implementation Schedule are estimates of what recovery will cost. The number will be revised as new information becomes available. Cost for full implementation of recovery actions will be based on the management plans that will be developed for each DWMA.

Comment: The Utah Division of Wildlife Resources (UDWR) is not included in the tasks for the Northeastern Mojave Recovery Unit, although a significant portion of the Beaver Dam Slope DWMA occurs in Utah. In addition, UDWR is included in the development activities for the Upper Virgin River DWMA, but is not included in the implementation and research sections. The UDWR is the lead agency on tortoise density research and monitoring, and reproductive research in Utah, as well as a cooperator on health and nutrition studies.

Response: The Implementation Schedule has been revised to reflect UDWR's role in the Northeastern Mojave Recovery Unit and in research and monitoring activities.

Acronyms Used in this Document

BLM	= Bureau of Land Management
BRTF	= Blue Ribbon Task Force of the BLM
CDSP	= California Department of State Parks
CFR	= Code of Federal Regulations
DTNA	= Desert Tortoise Natural Area
DWMA	= Desert Wildlife Management Area
ECRU	= Eastern Colorado recovery unit
EMRU	= Eastern Mojave recovery unit
EMZ	= Experimental Management Zone
ESU	= Ecologically significant unit
HCP	= Habitat conservation plan
kHz	= kilohertz
LUZ	= Limited Use Zone
mm	= millimeter
mtDNA	= mitochondrial deoxyribose nucleic acid
MVP	= Minimum viable population
NCRU	= Northern Colorado recovery unit
NEMRU	= Northeastern Mojave recovery unit
OHV	= off-highway vehicle
ORV	= off-road vehicle
PVA	= Population Viability Analysis
RECON	= Regional Environmental Consultants
TBD	= To be determined
UCLA	= University of California at Los Angeles
UDWR	= Utah Department of Wildlife Resources
USP	= Utah State Parks
URTD	= Upper Respiratory Tract Disease
U.S.C.	= United States Code
UVRRU	= Upper Virgin River recovery unit

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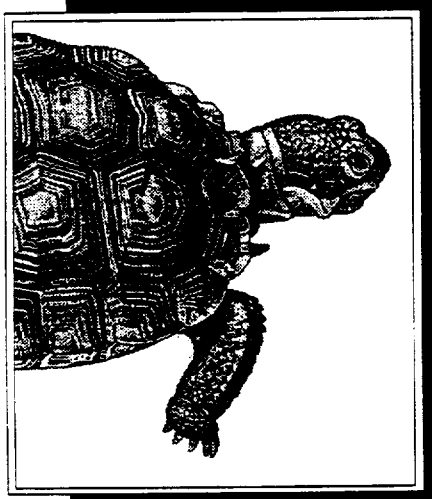
Desert Tortoise
(Mojave Population)



Recovery
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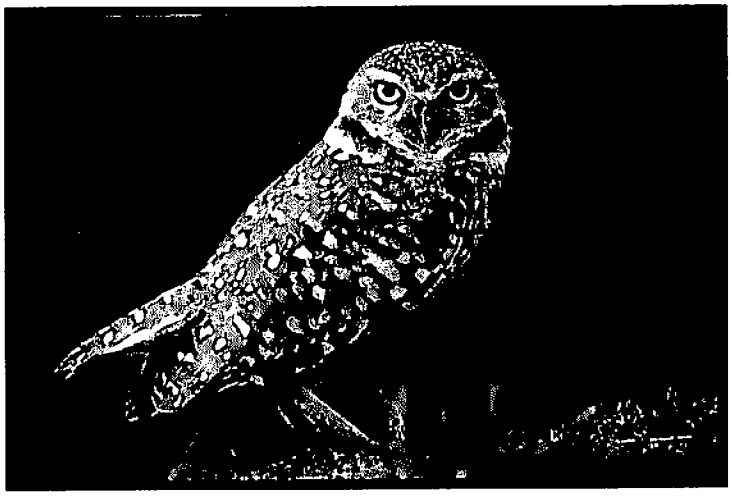
EXHIBIT 648

PETITION

TO THE STATE OF CALIFORNIA
FISH AND GAME COMMISSION
AND SUPPORTING INFORMATION FOR



LISTING THE CALIFORNIA POPULATION
OF THE WESTERN BURROWING OWL
(*ATHENE CUNICULARIA HYPUGAEA*)
AS AN ENDANGERED OR THREATENED SPECIES
UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

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Petitioners Center for Biological Diversity, Santa Clara Valley Audubon Society, Defenders of Wildlife, San Bernardino Valley Audubon Society, California State Park Rangers Association, and Tri-County Conservation League petition the California Fish and Game Commission to list the western burrowing owl as a state endangered or threatened species. Petitioners submit this petition pursuant to the California Endangered Species Act, Fish and Game Code §§ 2070 *et seq.*, on their own behalf and on behalf of their members and staff with an interest in protecting the western burrowing owl and its habitat in California.

Lead petitioner Center for Biological Diversity is a nonprofit environmental organization dedicated to the protection of native species and their habitats. The Center works to protect and restore natural ecosystems and imperiled species through science, education, policy, and environmental law.

The Santa Clara Valley Audubon Society works to maintain, preserve, and protect native animal and plant habitats and to foster a greater public awareness of our environment, with emphasis on birds and their ecosystems, particularly in Santa Clara County and the San Francisco Bay Area.

Defenders of Wildlife is a nonprofit organization dedicated to the protection of all native wild animals and plants in their natural communities. Defenders programs encourage protection of entire ecosystems and interconnected habitats while protecting predators that serve as indicator species for ecosystem health.

The San Bernardino Valley Audubon Society is a non-profit corporation dedicated to conserving and restoring natural ecosystems, focusing on birds and other wildlife for the benefit of humanity and the earth's biological diversity.

The California State Park Rangers Association is an organization of park professionals dedicated to advancement of the highest principles of public service, established to support and preserve California State Parks for present and future generations.

The Tri-County Conservation League, Inc. is a public interest corporation with a membership that promotes the educational, recreational and conservation values of the natural resources of the Santa Ana River and its drainage system in Riverside, San Bernardino, and Orange Counties.

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY. 5
II. STATUTORY FRAMEWORK AND REQUESTED ACTION. 7
III. ECOLOGY OF THE WESTERN BURROWING OWL. 9
A. DESCRIPTION. 9
B. TAXONOMY. 9
C. REPRODUCTION AND GROWTH. 9
D. MOVEMENT. 11
E. FEEDING. 12
F. PREDATION. 13

IV. HABITAT REQUIREMENTS. 14

V. RANGE. 16

VI. HISTORICAL AND RECENT DISTRIBUTION AND ABUNDANCE. 17
A. NORTHERN COASTAL CALIFORNIA. 18
B. NORTHERN DESERT RANGE. 18
C. CENTRAL VALLEY. 19
1. NORTHERN CENTRAL VALLEY. 19
2. MIDDLE CENTRAL VALLEY. 21
3. SOUTHERN CENTRAL VALLEY. 27
D. SAN FRANCISCO BAY AREA. 30
E. CENTRAL WESTERN CALIFORNIA. 37
F. SOUTHWESTERN CALIFORNIA. 39
G. IMPERIAL VALLEY. 48
H. COACHELLA VALLEY. 49
I. SOUTHERN DESERT RANGE. 49

VII. POPULATION TRENDS. 53

VIII. NATURE, DEGREE, AND IMMEDIACY OF THREAT. 56
A. URBAN DEVELOPMENT. 56
B. THREATS TO IMPERIAL VALLEY AND SOUTHERN CENTRAL VALLEY OWL POPULATIONS. 59
C. DESTRUCTION OF BURROWING RODENTS. 60
D. RELOCATION OF OWLS. 61
E. AGRICULTURAL PRACTICES. 63
F. PESTICIDES. 65
G. PREDATION. 67
H. DISEASE 68
I. SMALL POPULATION SIZES. 68
J. OTHER ANTHROPOGENIC FACTORS. 69

IX. INADEQUACY OF EXISTING MANAGEMENT EFFORTS. 72
A. FEDERAL REGULATORY MECHANISMS. 72
B. STATE REGULATORY MECHANISMS. 76
C. REGIONAL AND LOCAL GOVERNMENT PLANS. 81

X. RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS. 84
A. LIST THE BURROWING OWL AS A STATE ENDANGERED OR THREATENED SPECIES. 84
B. PROTECT REMAINING BREEDING GROUPS AND PAIRS AND PROTECT AND ENHANCE BREEDING HABITAT. 84
C. AMENDMENTS TO EXISTING MANAGEMENT AND LAND USE PLANS. 85
D. AGENCIES AND ORGANIZATIONS THAT SHOULD BE INVOLVED. 85
E. BURROWING OWL MANAGEMENT IMPACTS ON OTHER SPECIES. 85
F. MONITORING PROGRAMS AND STUDIES. 86

XI. SIGNATURE PAGE. 87

XII. INFORMATION SOURCES. 88
A. INDIVIDUALS SUPPORTING PETITIONED ACTION. 88
B. BIBLIOGRAPHY OF LITERATURE CITED. 89
C. PERSONAL COMMUNICATION SOURCES. 114

XIII. APPENDICES. 115
A. APPENDIX 1 – CALIFORNIA BURROWING OWL RANGE AND DISTRIBUTION MAP. 115
B. APPENDIX 2 – TABLE OF ESTIMATED DENSITY, BREEDING PAIRS, AND POPULATION TREND, BY REGION. 116
C. APPENDIX 3 – DESANTE ET AL. 1996, "THE DISTRIBUTION AND RELATIVE ABUNDANCE OF BURROWING OWLS IN CALIFORNIA: EVIDENCE FOR A DECLINING POPULATION" 118

I. EXECUTIVE SUMMARY

Petitioners Center for Biological Diversity, Santa Clara Valley Audubon Society, Defenders of Wildlife, San Bernardino Valley Audubon Society, California State Park Rangers Association, and Tri-County Conservation League submit this petition to list the California population of the western burrowing owl (*Athene cunicularia hypugaea*) as an endangered or threatened species under the California Endangered Species Act, Fish and Game Code §§ 2070 *et seq.* ("CESA"). This petition demonstrates that the western burrowing owl is in serious danger of becoming extinct throughout a significant portion of its range in California and clearly warrants listing under CESA, based on the factors discussed herein.

The western burrowing owl is a small ground-nesting bird of prairie and grassland habitats, which in many areas has adapted to human-altered habitats as urban development and agriculture have eliminated natural grasslands. Burrowing owls in the western United States rely upon burrows dug by burrowing mammals for nests, primarily those of ground squirrels in California. Burrowing owls also require open fields with adequate food supply for foraging habitat, low vegetative cover to allow owls to watch for predators, and adequate roosting sites. These owls can often be seen perched or standing by their burrow or hunting insects, rodents, amphibians, or small birds in open fields. Nesting season is from February through August, with most pairs usually fledging 4 or 5 young. After the nesting season, most owls in California remain throughout the winter as year-round residents and owls from others areas augment resident California populations. Burrowing owls are susceptible to predators that can access their nest chamber, such as foxes, coyotes, skunks, raccoons, and snakes, and are also preyed upon by various other raptor species, such as hawks, eagles, and other species of owls.

Burrowing owls in California historically ranged throughout the Central Valley, were found in suitable habitat in coastal areas from Marin County south to the Mexican border, and sparsely inhabited desert areas in the northeastern and southeastern portions of the state. Densities of owls in some areas of the state have increased with intensive agriculture, such as in the Imperial Valley, southern Central Valley, and lower Colorado River Valley.

Once a widely distributed and common grassland bird, the burrowing owl has been declining significantly in California for at least the last half century. Although early accounts of the burrowing owl reported the species as "probably one of the most common birds in California" and "abundant," "common," or "fairly common" range-wide in California, the species has been in continuous decline throughout the state since at least the 1940s. Severe localized declines of owl populations were evident by the early 1900s, for example in the Fresno area, in the region of Los Angeles, and in Orange County. Urbanization corresponding with human population growth has eliminated or greatly reduced breeding populations from large areas where the owl was formerly common, such as in San Diego, Orange, Santa Barbara, Santa Cruz, and Santa Clara Counties.

The decimation of breeding owl populations in Orange and San Diego Counties is indicative of the fate of the species in urbanizing areas of the state. The burrowing owl was once "common everywhere" in coastal San Diego County, with one ornithologist noting that in the late 1860s "burrowing owls stood on every little knoll" around San Diego. Even as late as 1975, burrowing owls were described as "abundant" and "bordering on ubiquitous" in suitable habitat in Orange County and were considered a "regular component" of the coastal environment. By 2001 only 9 or less breeding pairs remained in the entirety of Orange and San Diego Counties.

Breeding burrowing owls have been extirpated from approximately 8% of their former range in California during the last 10-15 years. A comprehensive statewide survey conducted in the early 1990s revealed that breeding owls were entirely eliminated from 5 counties (Napa, Marin, San Francisco, Santa Cruz, and Ventura) and the Coachella Valley, and were nearing extirpation in 6 other counties (Sonoma, San Mateo,

Monterey, San Luis Obispo, Santa Barbara, and Orange). Small breeding populations of owls have likely been extirpated from Humboldt and Mendocino Counties, southwestern Solano County, and western Contra Costa County as well, and breeding owls are rapidly disappearing from southern Los Angeles, western San Bernardino, western Riverside, and San Diego Counties.

Local extirpations of owls become cumulatively significant for the species as owl habitat is destroyed and owls are relocated from urbanizing areas. Burrowing owls have never been successfully reintroduced to a location where they have been extirpated, partly due to the owl's strong fidelity to burrow sites. Owls regularly reuse burrows from one year to the next, and for this reason are not easily forced to move to a different burrow, especially during nesting season.

Based on a survey of the majority of the owl's range in California, an estimated 9,450 nesting pairs of owls remained statewide in the mid-1990s, exclusive of the deserts and Great Basin areas. Recent urban development has eliminated or displaced some of these birds. The number of breeding owl colonies located in the survey area throughout California declined nearly 60% from the 1980s to the early 1990s, and the statewide number of owls is currently thought to be declining at about 8% per year.

Over 71% of California's breeding owls currently live in the margins of agricultural land in the Imperial Valley, an area that comprises only 2.5% percent of the land area of the state. Owls in the Imperial Valley, which primarily nest in burrows in earthen irrigation channels, are facing threats from conversion of agricultural lands to urban development, plans to line earthen canals with concrete, and ground squirrel eradication programs. Over 15% of the state's breeding owls reside in the southern Central Valley, an area undergoing explosive human population growth and rapid conversion of agricultural lands to urban development.

California's remaining burrowing owls are threatened primarily by habitat loss to urban development, persecution of ground squirrels and other burrowing rodents, and intensive agricultural practices. The state-approved practice of relocation of owls from development sites is accelerating local extirpations from rapidly urbanizing areas, such as in Santa Clara County. Other factors contributing to the decline of owls statewide include destruction of burrows through disking and grading, impacts of pesticides, increased predation by non-native or feral species, habitat fragmentation, and other human-caused mortality from vehicle strikes, electrified fences, collisions with wind turbines, shooting, and vandalism of nesting sites.

There are currently no state or federal laws that protect owl habitat and such habitat is rarely purchased by agencies for public lands. An estimated 91% of all owls remaining in California occur on private land, most of it under enormous development pressure. Although federally designated as a Species of Special Concern in 1994, federal regulatory mechanisms such as Habitat Conservation Plans have proved inadequate in protecting significant owl habitat or stopping the rapid decline of the species. State regulatory mechanisms, such as designation as a state Species of Special Concern in 1979, adoption of burrowing owl mitigation guidelines by the California Department of Fish and Game in 1995, state Fish and Game Codes protecting nesting raptors, and limited creation of mitigation banks to purchase habitat, have proved unsuccessful in protecting the burrowing owl and its habitat. The failure of owl conservation efforts in the San Francisco Bay Area is indicative of the limitations of attempts at regional and local conservation planning for non-listed species. To the detriment of burrowing owls, their management has been limited to project-by-project responses to development impacts, an approach that is inadequate for the long-term maintenance of the species in significant parts of its range in California.

Throughout the vast majority of the burrowing owl's range in California, breeding owls persist in only small, declining populations of birds that are highly susceptible to extirpation, as seen in the precipitous decline of owl populations in several areas of the state. The burrowing owl is in imminent danger of becoming extinct throughout a significant portion of its range in California, and requires immediate protection as an endangered or threatened species.

II. STATUTORY FRAMEWORK AND REQUESTED ACTION

Recognizing that certain species of plants and animals have gone extinct "as a consequence of man's activities, untempered by adequate concern for conservation," (Fish and Game Code §2051(a)) that other species are in danger of extinction, and that "[t]hese species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern," (Fish and Game Code §2051(c)) the California Legislature enacted the California Endangered Species Act ("CESA"). The purpose of CESA is to "conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat...." (Fish and Game Code §2052).

To this end, CESA provides for the listing of species as "threatened" and "endangered." "Threatened species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by CESA (Fish and Game Code §2067). "Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and Game Code §2062).

The California Fish and Game Commission ("Commission") is the administrative body that makes all final decisions as to which species shall be listed under CESA, while the California Department of Fish and Game ("Department") is the expert agency that makes recommendations as to which species warrant listing. The listing process may be set in motion in two ways: "any person" may petition the Commission to list a species, or the Department may on its own initiative put forward a species for consideration. In the case of a citizen petition such as this one, CESA sets forth a process for listing that contains several discrete steps.

Upon receipt of a petition to list a species, a 90-day review period ensues during which the Commission refers the petition to the Department, as the relevant expert agency, to prepare a detailed report. The Department's report must determine whether the petition, along with other relevant information possessed or received by the Department, contains sufficient information indicating that listing may be warranted (Fish and Game Code §2073.5). During this period interested persons are notified of the petition and the Commission accepts public comments (Fish and Game Code §2073.3).

After receipt of the Department's report, the Commission considers the petition at a public hearing (Fish and Game Code §2074). At this time the Commission is charged with its first substantive decision: determining whether the petition, together with the Department's written report, and comments and testimony received, present sufficient information to indicate that listing of the species "may be warranted" (Fish and Game Code §2074.2). A California Appellate Court has interpreted this standard as the amount of information sufficient to "lead a reasonable person to conclude there is a substantial possibility the requested listing could occur." *(Natural Resources Defense Council v. California Fish and Game Comm.* 28 Cal.App.4th at 1125, 1129.)

If the petition, together with the Department's report and comments received, indicates that listing "may be warranted," then the Commission must accept the petition and designate the species as a "candidate species" (Fish and Game Code §2074.2).

Once the Commission accepts the petition, then a more exacting level of review commences. The Department has twelve months from the date of the petition's acceptance to complete a full status review of the species and recommend whether such listing "is warranted." Following receipt of the Department's status

review, the Commission holds an additional public hearing and determines whether listing of the species "is warranted."

Notwithstanding these listing procedures, the Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species (Fish and Game Code §2076.5).

Through this petition, the petitioners request that the Commission list the western burrowing owl as an endangered or threatened species. This petition demonstrates that the western burrowing owl is in danger of becoming extinct throughout all or a significant portion of its range, and that therefore listing "is warranted." This petition far exceeds the threshold for demonstrating that listing of the western burrowing owl "may be warranted," and therefore must be accepted by the Commission at the first stage of the listing process.

III. ECOLOGY OF THE WESTERN BURROWING OWL

A. DESCRIPTION

The western burrowing owl (*Athene cunicularia hypugaea*) is a small, brown and white mottled, semi-fossorial[1] owl of prairie and grassland habitats. It is not easily confused with any other owl due to its ground-dwelling nature. Burrowing owls have long, almost bare, stilt-like legs and a stubby tail. Long legs help this ground owl to see over short-grass prairie vegetation in a landscape with few elevated perches, and also aid in running down insect prey. Burrowing owls have a round head lacking ear tufts, white eyebrows, yellow eyes, and a distinct oval facial ruff. Adults are a rich sandy-brown color on the head, back, and upper parts of the wings, and are thickly spotted with whites and buffs on the under-parts. This coloring provides good camouflage in dry grassland habitats. Males and females are difficult to distinguish in the field, although females are usually darker (males may appear faded from spending more time exposed to the sun during the breeding season) and, unlike many other raptors, the female is slightly smaller than the male, which may be an adaptation for squeezing into narrow burrows. Adult birds are about 19-25 cm (about 7-10 inches) tall and weigh an average of 150 grams (Zarn 1974a). Chicks are distinguished from adults by their completely buffy breast and white collar.

B. TAXONOMY

The western burrowing owl belongs to the Class Aves, Order Strigiformes (Owls), Family Strigidae (Typical Owls), Genus *Athene*, Species *cunicularia*, and Subspecies *hypugaea*. As of 1993, up to 18 subspecies of *Athene cunicularia* were recognized (Clark et al. 1978). Two of these occur in North America: the western burrowing owl, *A. c. hypugaea*, inhabiting North and Central America west of the eastern edge of the Great Plains south to Panama; and the Florida burrowing owl, *A. c. floridana*, found in Florida and on the Bahama Islands.

Molina originally classified the burrowing owl as *Strix cunicularia* in 1782. The species has since received several taxonomic changes and been variously placed in the genus *Speotyto* or *Athene*. It was designated as *Athene* by the American Ornithologists' Union ("AOU") in 1983 (AOU 1983), moved back to *Speotyto* in 1991 based on karyotypic evidence (AOU 1991), and reverted to *Athene* in 1997 (AOU 1997).

As for the owl's etymology, Athena was the Greek goddess associated with the owl, and Speotyto was derived from the Greek "speos" meaning cave and "tyto" meaning owl. The Latin "cunicularus" means "little miner." The burrowing owl is commonly known as the ground owl, prairie dog owl, or Billy owl, and is referred to as "Lechuza Llanera" in Hispanic cultures.

C. REPRODUCTION AND GROWTH

Western burrowing owls generally adopt burrows excavated by other animals, usually those of ground squirrels (*Spermophilus* spp.), prairie dogs (*Cynomys* spp.), American badgers (*Taxidea taxus*), or other small burrowing animals. Although some burrowing owls may dig their own burrows if the soil is soft enough (burrowing owls in Florida do this on a regular basis), they generally prefer to enlarge and adapt existing mammal burrows. Burrowing owls in California live primarily in ground squirrel burrows, for the most part taking over burrows abandoned by the squirrels. Where burrows are scarce, owls may attempt to nest in pipes, culverts, or artificial nest boxes.

Nest burrows are usually 1 to 3 meters long, with a downward slope of about 15 degrees, a J- or U-shaped bend, and an enlarged nest chamber at the end (Coulombe 1971). Adults usually return to the same

[1] Fossorial = adapted to digging.

burrow or a nearby area each year. Adult males often use one or more "satellite" burrows near the nest burrow during the nesting period, as do juvenile owls for a few weeks after they emerge from the nest. Both sexes prepare the burrow for nesting using their feet, beaks, and wings to scrape out dirt (Thomsen 1971; Martin 1973; Voous 1988). They often begin these renovations at several burrows, eventually selecting the best one as a nest site. The burrow is frequently lined with horse or cattle dung and other material such as grass, feathers, and other debris, but is sometimes left unlined (Thomsen 1971; Martin 1973; Evans 1982; Johnsgard 1988; Voous 1988). It has been speculated that the lining material acts as an absorbent, attracts dung beetles eaten by the owls, masks odors produced by the birds (making detection by predators more difficult), or produces heat by decomposition, controlling temperature and humidity within the nest cavity and aiding in the incubation of eggs (Martin 1973; Green and Anthony 1989). The habit of lining the burrow with manure is so strong that owls will promptly replace dung when it is removed (Martin 1973).

Burrowing owls often nest in loose colonies, which may be a response to local abundance of burrows and food, or an adaptation for mutual defense. Colony members can alert each other to the approach of predators and join in harassment of them. During the nesting season, adult males forage over home ranges 2 to 3 square kilometers in size and the ranges of neighboring males may overlap considerably. A small territory around the nest burrow is aggressively defended against intrusions by other burrowing owls, squirrels, and predators.

Nesting season for the burrowing owl in California (courtship and egg laying) occurs between February 1 and August 30 (CDFG 1994). In the Imperial Valley, pair formation begins as early as mid-January (Coulombe 1971). The male owl conducts courtship displays in front of the burrow. Capable of producing more than 17 vocalizations, the "primary song" is given only by adult males when near the burrow to attract a female. A two-syllable "who-who" is given at the entrance of a promising burrow. This call is also associated with breeding and territory defense. Once a female is enticed to the site, courtship antics involving various postures, vocalizations, and displays undertaken by both sexes, usually within 15 meters of the burrow. Nest site selection begins after pair formation, with the males gathering and distributing most of the nesting material (Anderson et al. 2001).

By February owls are pairing up and can be observed standing together outside the nest burrow. Actual breeding occurs anywhere from March through August, with the peak activity in April and May. Burrowing owls are primarily monogamous for the nesting season, and some pairs in the Imperial Valley may remain together throughout the year (Coulombe 1971).

Females usually produce only one clutch per year, but may lay a second clutch if the first is lost. Pairs are capable of laying a second clutch after the first brood successfully fledges (Gervais and Rosenberg 1999). Burrowing owls will lay up to 12 eggs in a chamber of the nest burrow, one of the largest clutch sizes of any raptor species, although 7 eggs is the norm (Haug et al. 1993). Eggs are laid between March and May depending upon location. The female incubates the eggs for approximately 3 to 4 weeks, while the male brings food to the female and stands guard near the burrow by day. After hatching, the chicks remain in the nest chamber for approximately 2 to 3 weeks. By this time the young are large and the burrow is very crowded, and young birds will often stand at the burrow entrance eagerly waiting for the parents to bring food.

Just before or just after they emerge (mid-May through early August), chicks lose their natal down and gain juvenal plumage. Chicks emerge from the burrow weighing approximately half to two thirds of adult weight and they reach adult weight within a month of emergence (Landry 1979; L. Trulio, pers. observ., 2002). Fledging (acquiring the feathers necessary for flight) occurs about one month post-emergence. Burrowing owl parents will feed young for another 6 to 8 weeks after emergence, with young remaining near the burrow with their parents until fall. By mid-September the young molt into adult plumage and disperse to find their own burrows.

Although there are not good published accounts for life expectancy of burrowing owls since returns of banded owls are sparse, an average longevity of 5 years is informally used (Kennard 1975). The record age for a banded owl in the wild is 8 years and 8 months (Kennard 1975).

Reproductive success may be the most important factor in maintaining population viability for species with relatively low survivorship and a short life span (Emlen and Pilkitch 1989). This is likely to be true for burrowing owls (Gervais and Rosenberg 1999). Burrowing owl adult and juvenile survivorship is highly variable among studies, with between-year return rates from 30-83% (Thomsen 1971; Haug et al. 1993; Clayton and Schmutz 1997).[2] Although up to 10 young per nest can be fledged in good reproductive years (Gervais and Rosenberg 1999), the number of young successfully fledged from nests in central California in recent years varied from 3 to 6, with most nests fledging 4 or 5 young (DeSante et al. 1997).[3] Anecdotal accounts from the early 1900s suggest that 6 to 8 young were usually fledged (Dawson 1923). This apparent reduction in fledging success corresponds with a documented decline of breeding populations of other avian predators in grassland habitats in central California in recent years, such as the loggerhead shrike (*Lanius ludovicianus*) and American kestrel (*Falco sparverius*) (DeSante et al. 1997). Average young fledged per nest was 2.5 in the Imperial Valley population (Rosenberg and Haley 2003).

D. MOVEMENT

Northern populations of the western burrowing owl are migratory, leaving their breeding grounds in the fall, and returning to the same or nearby burrows each spring. In 2000, 2 owls tagged in Canada were located wintering in Mexico (G. Holroyd, pers. comm., 2001). However, most owls nesting in California remain throughout the winter as year-round residents (Brenkle 1936; Ligon 1961; Thomsen 1971; Haug et al. 1993) or appear to wander within the region during the winter months (Coulombe 1971; Martin 1973; Botelho 1996), particularly in central and southern California. Burrowing owls observed in Oakland, California were thought to stay in the burrow during the winter or become strictly nocturnal (Thomsen 1971). In fall and winter, individual owls can appear in unexpected places, such as on the smaller California islands and even offshore (Lamb 1929; Unitt 1984).[4]

California has a large number of burrowing owls in the winter, relative to other portions of their North American breeding range. Migratory owls from other areas are thought to augment resident California populations during the winter months (Coulombe 1971). It is assumed that migrants may be arriving from northern areas that are covered in snow during the winter where their burrows and food may be inaccessible (possibly from as far away as Canada, Washington, Oregon, and Idaho). Migratory owls in central coastal California will leave in mass by the last week in March, and no breeding or pairing of migrants has been observed (J. Linthicum, B. Walton, pers. comm., as cited in Madden 2002).

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[2] Haug et al. (1993) found an adult survivorship of 33-58%. Thomsen (1974) calculated juvenile burrowing owl survival rate to be 30% and adult survivorship to be 81%, based on two years of study at the Oakland Airport in Alameda County. In a study of Canadian burrowing owls, Clayton and Schmutz (1997) found adult female survivorship to be 83%, while adult male survivorship was 46% and juvenile survivorship was 48%. Anderson et al. (2001) reported on annual survival for populations studied from 1997-2000 in the Bay Area (48%), Lemoore Naval Air Station (51%), Carrizo Plain (15%, extrapolated from 3 months of study), and the Imperial Valley (64%).

[3] Thomsen (1971) found an average of 3.9 chicks survived to fledging. Martin (1973) reported a mean reproductive success of 4.9 young per pair. At Moffett Field, Santa Clara County, Trulio (1994) found an average fledging success of 2.6 chicks per reproductive pair (s. d. = 1.4) and an average of 1.8 chicks per pair (s. d. = 1.7). Anderson et al. (2001) reported on the mean number of young/nest and young/successful nest for populations studied in the Bay Area (1.5/2.8), Lemoore Naval Air Station (3.1), Carrizo Plain (1.9/4.1), and the Imperial Valley (2.5/2.9) from 1997-2000. J. Barclay (pers. comm., 2002) estimated an overall productivity (number of young surviving to fledging) for the owl population at San Jose Airport from 1996 to 2002 of 3.54 young/pair. Productivity of owls in natural burrows was 2.97 young/pair, and in artificial burrows was 4.08 young/pair, but the natural burrow productivity may be biased on the low side, since Barclay dug up the artificial nests while relying upon visual surveys at the burrow entrance for natural nests (J. Barclay, pers. comm., 2002).

[4] Lamb (1929) reported on a burrowing owl that came onboard a steamer 8 miles off of southern Monterey County and another that came on board later that day off of Santa Barbara County, in September 1928. The species has been noted on several occasions flying far out at sea (Unitt 1984).

As of October 1993, the U. S. Fish and Wildlife Service Bird Banding Laboratory ("BBL") records contained 44 encounters of burrowing owls banded in California. Twenty-nine (66%) of these encounters occurred in the same 10-minute blocks where the owls were banded and 10 (23%) occurred in the 10-minute block adjacent to where they were banded. Of the remaining five recoveries, only two represented owls that had moved substantial distances. These were two owls banded in Orange County: a nestling banded in June that was recovered in Mexico (no specific location information) in October; and an owl banded in October that was recovered the following March in Nevada (J. Barclay, pers. comm. 2002).

Of 276 burrowing owls tracked during two consecutive South San Francisco Bay demography studies from 1998 through 2002, the average distance owls moved between breeding seasons was from 0.5 to 0.9 miles (D. Chromczak, unpublished data, 2002). Of the owls monitored, 27% stayed at the same nesting location, 14% moved less than 0.05 miles (~265 feet), 34% moved 0.05 to 0.5 miles, 8% moved 0.5 to 1.0 miles, 14% moved 1.0 to 5.0 miles, and only 2% moved 5.0 to 10.0 miles (D. Chromczak, unpublished data, 2002). Pairs of owls that failed in a breeding attempt have been noted to move up to tens of kilometers before breeding again, even within the same season (J. Gervais, pers. comm., 2003).

Within the breeding season, burrowing owls tend to spend most of their time in the vicinity of the burrow, but will go further afield to hunt (Coulombe 1971). Male owls will forage over home ranges from 2 to 3 square kilometers in size (Haug and Oliphant 1987), concentrating foraging efforts within 600 meters of the nest burrow (Gervais et al. 2003; Rosenberg and Haley 2003). Seasonal movements other than migration may occur. After the young learn to fly, family groups will often move from burrow to burrow, and in the fall young owls will appropriate their own burrow nearby. In the winter, pairs will investigate new burrows and territorial boundaries will be in flux as forming pairs choose their burrows (Thomsen 1971).

As far as daily movements, owls will generally spend most of the day near their burrows, coming out in the late afternoon to perch and beginning to forage at dusk. Adults with young to feed return to the burrow at night (Thomsen 1971).

E. FEEDING

Burrowing owls are primarily crepuscular (active at dusk and dawn) in their foraging, but hunting activity has been observed over 24 hours (Grant 1965; Coulombe 1971; Marti 1974). They will forage in natural, ruderal (areas such as roadsides where vegetation has been disturbed), or manicured grasslands. Burrowing owls prey primarily on large insects and small rodents but will take a wide variety of prey and are known to be opportunistic in their feeding habits (Thomsen 1971; Zarn 1974a). Burrowing owls may hunt from a perch, capturing prey after short flights or glides, or hovering while hunting and returning to the perch after catching their prey. Burrowing owls will also walk, run, or hop after prey on the ground. Hunting style varies with type and activity of prey pursued, time of day, and vegetative substrate (Thompson and Anderson 1988; Haug et al. 1993). Burrowing owls probably also take insects that live in their burrows (Coulombe 1971).

Important food items for burrowing owls include small rodents such as voles (*Microtus* spp.), mice (*Peromyscus* spp., *Mus* spp., *Reithrodontomys* spp., *Zapus* spp.), pocket mice (*Perognathus* spp.), pocket gophers (*Thomomys* spp.), kangaroo rats (*Dipodomys* spp.), and young ground squirrels (*Spermophilus* spp.). It is interesting to note that burrowing owls generally do not hunt the ground squirrels upon which they depend for burrows – although squirrel colonies have many defenses against predators, they do not employ them against burrowing owls (which weigh only one fifth of a full-grown ground squirrel). Burrowing owls also eat a wide array of arthropods (such as beetles, grasshoppers, crickets, dragonflies, and crustaceans),[5] reptiles, amphibians,

[5] Arthropods were found to be the main prey item of burrowing owls in the Colorado Desert in southeastern California (Coulombe 1971).

small birds, fish, and even carrion (Bent 1938; Glover 1953; Earhart and Johnson 1970; Thomsen 1971; Zarn 1974a; Gleason and Craig 1979; Conroy and Chesemore 1987; Haug and Oliphant 1990).

Birds documented as prey items of burrowing owls include killdeer (*Charadrius vociferous*), horned larks (*Eremophila alpestris*), western meadowlarks (*Sturnella neglecta*), Wilson's warbler (*Wilsonia pusilla*), American avocets (*Recurvirostra americana*), red-winged (*Agelaius phoeniceus*) and Brewer's blackbirds (*Euphagus cyanocephalus*), black-headed grosbeaks (*Hedymeles melanocephalus*), black terns (*Chlidonias niger*), California least terns (*Sterna antillarum*), mourning doves (*Zenaida macroura*), and various shorebirds (Stoner 1933a; Errington and Bennett 1935; Bent 1938; Neff 1941; Thomsen 1971; Gleason and Craig 1979; Warrick 1982; P. Bloom, pers. comm., 2002; Rosenberg and Haley 2003). Adult owls have also been documented preying on burrowing owl chicks (Botelho 1996; Rosenberg et al. 1998a).

Unexpected prey remains are occasionally found in burrowing owl pellets or burrows, such as remains of spadefoot toads (*Scaphiopus* spp.) found in pellets in Nevada (Bond 1942) and Kansas (Sperry 1941). Crayfish were the most common food item in a study in Colorado (Hamilton 1941) and attacks on large snakes have been documented (Fisher 1893). Pacific Coast newts (*Triturus torosus*) missing their heads were found in an owl burrow in Solano County (Stoner 1932a), and remains of snakes, scorpions, and centipedes have been found in burrows in Solano and Colusa Counties (Stoner 1933a; Neff 1941). Burrowing owls in California have also been known to feed on bats. Thomsen (1971) discovered the remains of a hoary bat (*Lasiurus cinereus*) in pellets collected in Oakland; Hoetker and Gobalet (1999) found the Mexican free-tailed bat (*Tadarida brasiliensis*) to be the dominant vertebrate prey item in 18 owl pellets collected in Bakersfield; and J. Barclay (pers comm., 2002) observed free-tailed bat remains in owl burrows in San Jose.

F. PREDATION

Predators of burrowing owls are of two general types: predators that enter or dig up burrows to eat eggs, nestlings, and/or adult females; or predators that prey on older nestlings and adults when they are above ground. Because burrowing owls are ground nesters, their eggs and young are quite susceptible to predation. Mammals that can access nest chambers and are known predators of the burrowing owl include skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*), foxes (*Vulpes vulpes*, *V. macrotis mutica*, and *Urocyon cinereoargentius*), raccoons (*Procyon lotor*), and various snakes, including rattlesnakes (*Crotalus* spp.) (Coulombe 1971; Kemper 1996). Species that mainly catch owls above ground include prairie falcons (*Falco mexicanus*), red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*Buteo swainsoni*), ferruginous hawks (*Buteo regalis*), northern harriers (*Circus cyaneus*), golden eagles (*Aquila chrysaetos*), great horned owls (*Bubo virginianus*), American crows (*Corvus brachyrhynchos*), coyotes (*Canis latrans*), and possibly short-eared owls (*Asio flammeus*) (Fowler 1931; Haug et al. 1993).

Burrowing owls will often line their burrow with dung, presumably to mask the burrow scent from predators (Martin 1973). In one study of burrowing owl nests in Oregon, only 2 of 15 nests (13%) lost to predation were lined with dung, while 23 of 32 successful nests (72%) were dung-lined (Green and Anthony 1989). Burrowing owls once used bison dung in natural habitats in other states, but now cattle dung is often used. If young owls are alarmed in the nest, they will make a rattlesnake-like buzz to deter predators (Voous 1988). Adults will give a short, low-level "chuck" call to warn of approaching predators, usually accompanied by bobbing the head up and down (Voous 1988).

IV. HABITAT REQUIREMENTS

Historically, western burrowing owls were found in natural areas of open prairies or open shrub-steppe habitat (Coulombe 1971; Butts 1973). The species is characteristic of flat arid areas that have rodent burrows and rare floods. In California, almost none of the owl's original prairie habitat remains. Human population growth and continuous land use changes have forced the species to use human-altered habitats ranging from agricultural irrigation ditches (Coulombe 1971) to urban habitats (Thomsen 1971; Collins and Landry 1977; Trulio 1995). Burrowing owls can tolerate a certain amount of non-threatening human activity, noise, and disturbance as long as other habitat requirements are met. Essential habitat requirements include suitable nesting and foraging habitat and available roosting sites (Coulombe 1971; Voous 1988; Johnsgard 1998).

Typical burrowing owl habitat is open, dry, sparsely vegetated land with available burrows (Zarn 1974a). The State of California Department of Fish and Game's Wildlife Habitat Relationships System (CDFG 1990) database lists 18 major habitat types that support burrowing owls. In most of these habitats, burrowing owls are generally found in open country, where tree or shrub canopies cover less than 30% of the habitat (DeSante et al. 1996). Typical habitats include annual and perennial grasslands, open agricultural areas, deserts, and vacant lots. Other habitats include oak savannah; grass, forb, and open shrub stages of pinyon-juniper and ponderosa pine habitat; sandy beaches; and river bottom lands. Burrowing owls inhabiting urban landscaped areas may live in vacant fields, airports, athletic fields, golf courses, city parks, drainage sumps, railroad beds, and road cuts. Other more subtle characteristics affect burrow suitability. These characteristics include percent vegetative cover, height of vegetation surrounding the burrow, presence of colonial fossorial mammals, soil texture, and presence of perches for horizontal visibility (Green 1983).

Burrow availability is a major factor in defining suitable burrowing owl habitat (Coulombe 1971; Green and Anthony 1989). DeSante et al. (1996) evaluated habitat-related factors associated with the probability of re-occupancy of breeding sites by owls. The presence of ground squirrels was the single highest predictor for re-occupancy. Higher re-occupancy rates were also observed for sites near irrigation canals, sites with more than one pair of owls, and areas with high densities of owls. Burrows excavated by fossorial mammals such as California ground squirrels, prairie dogs, badgers, and marmots (*Marmota flaviventris*) are necessary to the burrowing owl.

Throughout most of California, burrows of the California ground squirrel are used, although in southern desert areas owls use ground squirrel, desert tortoise (*Xerobates agassizii*), or American badger burrows (Weathers 1983). In addition to digging burrows which owls use, the presence of colonial rodents benefits burrowing owls in the form of burrow maintenance between nesting seasons and the two species may assist each other with shared alarm calling behavior warning of predators (Trulio 1994). Natural or unnatural cavities such as rock or lava outcroppings (Gleason and Johnson 1985; Rich 1986), limestone (Coulombe 1971), concrete or asphalt (Trulio 1994) and man-made artificial habitat (Collins and Landry 1977) can occasionally be suitable burrow sites. Artificial burrows require permanent maintenance to provide long-term nesting habitat, otherwise they can become buried (P. Bloom, pers. comm., 2002). Stoner (1933b) even found two burrowing owls occupying holes in hay piles near Dixon.

The burrow protects against predators (Butts 1973; Green and Anthony 1989) and adverse weather conditions (Coulombe 1971), and it creates a microhabitat for arthropods such as earwigs and crickets, which are part of the primary food source (Coulombe 1971). In the Columbia Basin, Oregon, Green and Anthony (1989) studied nest site characteristics in association with nesting failure. They concluded that soil texture was important to long-term suitability of a nest site. They also analyzed the presence, abundance, and height of perches and found particular habitats were used only if elevated perches were present.

Vegetation cover and height are significant habitat factors due to the ground-dwelling nature and small size of the burrowing owl (Coulombe 1971; Zarn 1974a; Green and Anthony 1989; Trulio 1994). Vegetation

cover that prevents the owl from observing approaching predators places the burrowing owl at a severe disadvantage. Vegetation cover between 44-57% was observed at occupied burrowing owl habitat in Santa Clara County, California (Trulio 1994) and in the Columbia Basin 28% cover was optimal (Green and Anthony 1989). Green and Anthony (1989) also found that owls selected areas with a greater percentage of bare ground. High vegetation presents similar disadvantages to owls in observing potential predators. In Oklahoma, owls occupied areas where the vegetation height was 4 inches or less (Butts 1973). In Santa Clara County, occupied burrows were found in areas with an average vegetation height of approximately 6 inches (Trulio 1994). Human-altered habitats that allow an owl to stand near the burrow entrance and effectively watch for approaching predators include grazed areas, areas sprayed with herbicide, and areas where vegetation is removed without harm to the burrow (Coulombe 1971; Green and Anthony 1989; Trulio 1994).

The four ecosystems in which burrowing owls are most prevalent in California are: grasslands adjacent to intensive agriculture; intensive agriculture in which owls nest along irrigation banks; large expansive grasslands; and small patches of grassland surrounded by urban development (Rosenberg and DeSante 1997).

V. RANGE

The western burrowing owl is distributed from the Mississippi River to the Pacific Ocean, north into the prairie provinces of Canada and south to Mexico and western Panama (Haug et al. 1993; Trulio 1998b). Grinnell and Miller (1944) characterized the historical range of the burrowing owl in California as follows:

> "Suitable areas (treeless and level) almost throughout the state, from the Oregon line east of the Siskiyou mountains south to the Mexican border, and from the Nevada border and Colorado River west to the ocean shore; includes practically all islands from the Farallones south. Mostly rare or wanting in coastal counties north of Marin and in all mountainous areas. Mainly Lower and Upper Sonoran life zones; but breeds locally in Transition zone, and vagrants go even higher. Altitudes of occurrence extend from 200' below sea level in Death Valley and around the Salton Sea up regularly to 5300 feet in Lassen County."

Historically, burrowing owls have been found to reach maximum abundances in wide, lowland, interior valley bottoms and in flat coastal lowlands (Grinnell and Miller 1944). Surveys by DeSante and Ruhlen (1995) found that fully 92% of the breeding owls located throughout California occurred in such lowland areas, generally below 60-300 meters in elevation. These types of habitat are under the most severe pressure from urban development.

Burrowing owls have apparently disappeared from about 8% of their former breeding range in California (J. Barclay, using data from DeSante et al. 1996). DeSante and Ruhlen (1995) determined that breeding burrowing owls had apparently been extirpated since the early 1980s from Marin, San Francisco, Santa Cruz, Napa, coastal San Luis Obispo, and Ventura counties, as well as from the Coachella Valley, and had nearly been extirpated from Sonoma, Santa Barbara, Orange, coastal Monterey, and San Mateo counties. Perhaps only one or two breeding pairs still exist in most of these latter counties. There is some evidence that breeding owls have been extirpated from Humboldt and Mendocino Counties, southwestern Solano County, and western Contra Costa County as well. The species is rapidly disappearing from southern Los Angeles, western San Bernardino, western Riverside, and San Diego Counties. See Appendix 1 for a map of the range of the burrowing owl in California.

VI. HISTORICAL AND RECENT DISTRIBUTION AND ABUNDANCE

The historical and recent distribution and abundance of breeding burrowing owls in California is discussed below, described by region and then by county. Historical literature sources, as well as a number of California and other western museum collections were searched for historical documentation of breeding burrowing owls.[6] From these sources, a site was considered confirmed as a breeding location if: 1) eggs were collected; 2) a bird was collected during breeding season that had mature reproductive parts; or 3) juvenile owls were seen during or immediately after the nesting season (February 1 through August 31).[7] A site was considered a probable breeding location if: there was evidence of owl occupation of burrows; single or multiple birds were collected or observed during the nesting season; pairs were observed outside of the nesting season; or multiple birds were observed year-round.

Although numerical data on the statewide historical abundance of burrowing owls do not exist, many early naturalists commented on the widespread abundance of the burrowing owl prior to widespread human population growth and development in California. As early as 1869, burrowing owls were observed in abundance in California, with Canfield (1869) reporting "I have seen them every day for years, hundreds and perhaps thousands of them in all." Baird (1870) considered the species to be "probably one of the most common birds in California." Keeler (1891) described the owl as "an abundant resident of the open valleys and foothills of the State." Grinnell (1915) and Dawson (1923) both noted it was a "common resident" within its range. Dawson (1923) observed that the species enjoyed "an almost unbroken distribution throughout the treeless or lightly timbered sections of the State, from the base of the Sierras down to the ocean's edge." Grinnell and Wythe (1927) listed the owl as a "fairly common resident" of the dry interior of the San Francisco Bay Area.

Even by 1944, when a widespread decline in abundance was noticeable, Grinnell and Miller (1944) observed that "numbers in favorable localities [are] large," although "latterly becoming scarce in settled parts of [the] state." By 1978, the Department of Fish and Game (Remsen 1978) commented that the "decline noticeable by the 1940s (Grinnell and Miller 1944) has continued through to the present time...the decline has been almost universal throughout California."

From 1991-1993, a comprehensive census of burrowing owls was conducted throughout most of the breeding range of the species in California (DeSante et al. 1996), which assessed changes in owl distribution from observations made in the 1980s. A copy of DeSante et al. (1996), "The distribution and relative abundance of burrowing owls in California: evidence for a declining population," is attached as Appendix 3. DeSante et al. (1996) located 1,995 breeding pairs of burrowing owls in California. Based on assumptions of sampling design and the actual area surveyed, DeSante et al. (1996) estimated that 9,266 breeding pairs of burrowing owls existed during 1991 to 1993 in their statewide survey area, which excluded the Great Basin, desert areas, and the Channel Islands. The 95% confidence limits on this estimate extended from 7,884 to 10,370 pairs.

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[6] Literature searched for historical breeding records included American Birds, the Auk, the Condor, North American Bird Bander, Ornithologist and Oologist, Pacific Coast Avifauna, and the Proceedings of the California Academy of Sciences. Museums collections reviewed for egg set data and breeding season collection records included the American Museum of Natural History, California Academy of Sciences, Chicago Academy of Sciences, Cleveland Museum of Natural History, California State University Chico, California State University Long Beach, California State University Northridge, Delaware Museum of Natural History, Field Museum of Natural History, Los Angeles County Museum, Museum of Southwest Biology, National Museum of Natural History, Occidental College, Oakland Museum, Pacific Grove Museum of Natural History, Santa Barbara Museum of Natural History, Smithsonian Museum, Slater Museum of Natural History, University of California Berkeley Museum of Vertebrate Zoology, University of California Los Angeles Fritz Hertzel Museum, University of California Santa Barbara Museum of Vertebrate Zoology, University of California Santa Cruz, University of Nevada Las Vegas, U. S. Geologic Survey Biological Survey, University of Washington Burke Museum, Western Foundation of Vertebrate Zoology, and Yale Peabody Museum. The California Department of Fish and Game's Natural Diversity Database was also searched.

[7] The California Department of Fish and Game considers February 1 through the end of August to be nesting season for burrowing owls (CDFG 1994).

DeSante et al. (1996) estimated that fully 71% (6,571 pairs) of the state's breeding population of burrowing owls occurred in the Imperial Valley, where they exist at very high densities (up to about 2.37 pairs per square kilometer). As the Imperial Valley comprises only 2.5% of the state's land base, this is a hugely disproportionate distribution of the species, and a circumstance dependent upon maintenance of current agricultural practices, as will be discussed below. DeSante et al. (1996) estimated 24% of breeding owls (2,221 pairs) occurred in the Central Valley, with over half of those owls (1,396 pairs) in the southern Central Valley, only 594 pairs in the middle Central Valley, and 231 pairs in the northern Central Valley. Only 474 pairs of owls were estimated to be present in the entire area of central western and southwestern California. Of these owls, it was estimated that 227 pairs were in the southern interior region, 165 pairs in the Bay Area interior region, and the remaining 82 pairs were scattered throughout the central coast (8 pairs), central interior (38 pairs), and southern coast (36 pairs) regions. No breeding pairs of owls are thought to remain in the coastal Bay Area and Coachella Valley regions. The findings of DeSante et al. (1996) are more fully discussed below in Section VII on population trends. See Appendix 1 for a map of the recent distribution of burrowing owls in California, and Appendix 2 for a table of current owl distribution and estimated density in California, by region and county.

A. NORTHERN COASTAL CALIFORNIA

The humid coastal belt of northwestern California has generally been considered outside of the range of the burrowing owl. Baird (1870) noted that "from Monterey north this species becomes very rare, or entirely absent on the west side of the Coast Range" and Grinnell (1915) knew of no records of the species north of Marin County in the humid coast strip proper. However, there is some historical evidence of probable breeding of burrowing owls in Humboldt County, near Carlotta and in the Mattole and Eel River Valleys in the early 1900s (Wilder 1916).[8] There is also a known breeding record from the Middle Fork Eel River drainage in Mendocino County (USDA and USDI 1996). These owl populations are presumably extirpated, as no recent observations of breeding owls in Humboldt or Mendocino County could be located.

B. NORTHERN DESERT RANGE

The northern desert range of the burrowing owl encompasses portions of eastern Siskiyou, Modoc, Lassen, eastern Plumas, and eastern Sierra Counties (DeSante et al. 1996). The owl was apparently never common in most of its northern desert range, except north of Mt. Shasta, where the species was reportedly common in the late 1800s (C. Townsend 1887; C. Merriam 1899). Subsequent accounts of burrowing owl distribution in the northeast part of the state (Dawson 1923; Grinnell and Miller 1944; Small 1974; Zeiner et al. 1990) did not describe local distribution or estimate the number of burrowing owls in the region. A statewide burrowing owl census by DeSante et al. (1996) did not include the northern desert range.

Barclay and Cull (1999) produced a recent population estimate of 90 to 149 pairs of owls within suitable owl habitat in northeastern California (presumed to be 2,647 square miles of portions of Lassen, Modoc, Plumas, Sierra, and Siskiyou Counties). The lower limit of this population estimate uses the mean population density of 0.53 owls/25 km^2 for the northern Central Valley from DeSante and Ruhlen (1995); the upper limit uses the average owl density of 1 adult/5,683 acres outside prairie dog towns in Oklahoma reported by Butts (1973).

Siskiyou County

Burrowing owls were reportedly common in the 1880s "on the sage-covered districts north of Mount Shasta," about 15 miles from the mountain (C. Townsend 1887; C. Merriam 1899). Historical records confirmed breeding at Gazelle in 1918; and indicated probable breeding at Yreka in 1883 and 1922, at Bray in

[8] According to Wilder (1916) burrowing owls were once occasionally found in suitable localities in Humboldt County, such as in the Mattole and Eel River Valleys. Wilder (1916) observed one owl occupying a burrow between Carlotta and Alton for a year or two.

1922, near Lava Beds National Monument in 1936 and 1937, and near the northwest corner of Lower Klamath Lake in 1940 (Bond 1939; South 1940; NMNH 2001; CAS 2002a).[9] Recent breeding season observations in Siskiyou County could not be located, but the species is reported to occur in Shasta Valley, Butte Valley, and in grasslands of the upper Klamath River.[10]

Modoc County

Historical records indicated probable breeding at Alturas in 1910 (MVZ 2001).[11] Recent breeding season observations in Modoc County could not be located.

Lassen County

Burrowing owls apparently regularly occurred at elevations as high as 5,300 feet in Lassen County (Grinnell and Miller 1944). Historical records indicated probable breeding in Petes Valley in 1929, near Herlong in 1963, and at Milford in 1975 (CSULB 2001; MVZ 2001).[12] Three pairs of owls were observed in the spring and summer of 1975 and 1976 east of Schaeffer Mountain (P. Bloom, pers. comm., 2002).

The only recent burrowing owl records in northeastern California are of nesting birds and other observations in the Honey Lake Basin in eastern Lassen County, from 1992 to 1998 (SAD 1992; Holmes and Novick 1993; BioSystems Analysis, Inc. 1993a, 1993b, 1994, 1995; KEA Environmental 1997, 1998; CNDDB 2001).

Plumas and Sierra Counties

Historical breeding season observations in Plumas and Sierra Counties could not be located. In the early 1990s, D. DeSante (pers. comm., 2003) located a small colony of about 5 pairs of breeding burrowing owls in Sierra Valley along the Plumas-Sierra County line. This colony was apparently well known to regular Sierra Valley birders for many years.

C. CENTRAL VALLEY

1. NORTHERN CENTRAL VALLEY

The range of the burrowing owl in the northern Central Valley encompasses the southwestern 20% of Shasta County; most of Tehama County; the western 70% of Butte County; the eastern 80% of Glenn County; the western 85% of Yuba County; the western 20% of Nevada County; all but the northwestern 5% of Colusa County; portions of Lake County; all of Sutter County; and the western 40% of Placer County (DeSante et al. 1996).

Although there are historical records of confirmed breeding in almost every county in the northern Central Valley, there are no historical data on abundance of the burrowing owl in this area. DeSante et al. (1996) estimated that 231 pairs of owls remained in the northern Central Valley in the mid 1990s, about 2.5% of the state breeding population. These pairs were associated to a large degree with agricultural lands although substantial numbers occurred in more urban settings and at airports.

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9 Eggs were collected at Gazelle on 5/9/18 (CAS 2002a). A single bird was collected at Yreka on 8/18/1883 (NMNH 2001). Single birds were collected on 6/8/22 at Yreka and Bray (CAS 2002a). Bond (1939) saw a pair of owls in 1936 and two pairs in 1937 at a cliff area near Lava Beds National Monument, and South (1940) saw an owl and an occupied burrow in January 1940 near the northwest corner of Lower Klamath Lake.

10 Ray Ekstrom reported "a few pairs" of owls breeding recently at the Siskiyou County Airport, northeast of Montague (D. Cooper, pers. comm., 2002).

11 An owl was collected from the South Fork Pitt River, Alturas, on June 10, 1910 (MVZ 2001).

12 Historical collections include from Petes Valley (3 birds) on 6/9/29; at Garnier Ranch, 2.4 miles south and 1.5 miles west of Herlong on 4/5/63; and from Milford August 1975; there is also a non-breeding season record from 5 miles north of Observation Peak on 10/17/24 (CSULB 2001; MVZ 2001).

Southwestern Shasta County

Historical or recent breeding season observations in southwestern Shasta County could not be located.

Tehama County

Historical records indicated probable breeding near Red Bluff in 1874, 1884, and 1924 (MVZ 2001; NMNH 2001).[13] England et al. (1988) failed to find any records or observe any burrowing owls during surveys of the Mill and Deer Creek drainages and higher elevation meadows in Tehama County, during 1980-1987 surveys. Recent observations confirmed breeding near Gerber in 1993 and 1994; and indicated probable breeding near Gerber in 1993 and near Red Bluff in 1994 (CNDDB 2001).[14]

Butte County

Historical records confirmed breeding at Biggs in 1906, and indicated probable breeding at Chico in 1975 (CSUC 2001; NMNH 2001).[15] Recent observations indicated possible breeding southwest of the Chico Airport in 1998 (CNDDB 2001).[16] This site is threatened by commercial development.

Glenn County

Historical records confirmed breeding at Willows in 1928; and indicated probable breeding at Saint John in 1906, and near Norman in 1934 (DMNH 2001; MVZ 2001; NMNH 2001).[17] Recent observations indicated probable breeding southwest of Orland and possible breeding at two other sites in the vicinity of Orland in 1992 (CNDDB 2001).[18]

Yuba County

Historical records confirmed breeding at Sheep Dip in 1906 (MVZ 2001).[19] Recent breeding season observations in Yuba County could not be located.

Nevada County

Historical records indicated probable breeding near Truckee in 1935 (MVZ 2001).[20] Recent breeding season observations in Nevada County could not be located.

Colusa County

Historical records confirmed breeding near Maxwell in 1932 (Neff 1941).[21] Recent observations confirmed a "good" breeding colony west of Antelope Valley in 1992 and 1993 (breeding in artificial burrows

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13 Single birds were collected at Red Bluff on 3/11/1874, and on 3/11 and 4/12, 1884 (NMNH 2001); a single bird was collected 7 miles south of Red Bluff on 5/6/24 (MVZ 2001). There are also non-breeding season records from near Red Bluff: at Dale's on Paine Creek on 1/17/28; and at Coyote Creek, 6 miles south of Red Bluff, on 12/28/27 (MVZ 2001).

14 Recent observations include: 1 adult owl at a burrow site at Little Salt Creek, 5 miles northeast of Red Bluff, on 10/16/92; 1 owl at a burrow site 1.1 miles northwest of Dales, on 2/9/93; 2 adults at a burrow site north of Elder Creek, west of Gerber, on 3/22/93; 2 adults and 5 young at a burrow site 4.5 miles southwest of Gerber on 3/93; 1 adult owl at a burrow at the south end of Dales Lake on 10/16/93; 1 adult 5 miles southwest of Gerber on 6/29/94; 3 adults (1 at the burrow) 4 miles south of Red Bluff, on 7/13/94; and an owl 2 miles northeast of Henleyville on 11/3/94 (possibly used only as a wintering site) (CNDDB 2001).

15 Single birds (including one juvenile) were collected from Biggs on 7/13 and 7/14, 1906 (NMNH 2001). A single bird was collected from Chico on 3/31/75 (CSUC 2001). There is a non-breeding season record from Gray Lodge Waterfowl Management Area, December 1966 (MVZ 2001).

16 Three adults were observed at 2 burrow sites southwest of Chico Airport on 11/12/98 (CNDDB 2001).

17 Four eggs were collected from Willows on 6/19/28 (DMNH 2001). A single bird was collected from Saint John on 6/10/06 (NMNH 2001), and two birds were collected 6 miles east of Norman on 8/5/34 (MVZ 2001).

18 CNDDB observations include: two adults at a burrow site southwest of Orland, on 4/14/92 (one owl was later killed on the road, the burrow was then completely abandoned); one owl a at burrow site southwest of Orland on 10/9/92; and one owl at a burrow site on the North Fork of Walker Creek, 3 miles east of the Orland Buttes, on 10/10/92 (CNDDB 2001).

19 Eggs were collected from Sheep Dip 5/19/06 (MVZ 2001).

20 A bird was collected two miles east of Truckee 3/16/35 (MVZ 2001).

21 An inhabited owl den was observed from April-August 1932, 10 miles northeast of Maxwell (Neff 1941). There is a non-breeding season collection record from Colusa Compton Ranch, 8 miles south-southwest of Princeton, on 11/26/26 (MVZ 2001).

after 22 natural burrows were destroyed in 1992); and indicated probable or possible breeding at 8 additional sites west of Arbuckle, Williams, and Maxwell in 1992 (CNDDB 2001).[22]

Lake County

Burrowing owl eggs have been collected from Lake County, but no specific locality or date is given (NMNH 2001). Historical records also indicated probable breeding at Upper Lake throughout the 1890s (Stephens 1895; McGregor 1898; NMNH 2001).[23] In the 1970s, the burrowing owl was still distributed in the Cache Creek and Stanton Creek watersheds (West 1973). Recent breeding season observations in Lake County could not be located.[24]

Sutter County

Historical breeding season observations in Sutter County could not be located.[25] Recent observations indicated a probable breeding colony near Pleasant Grove in 1993 (CNDDB 2001).[26]

Placer County

Historical breeding season observations in Placer County could not be located. Recent observations indicated probable breeding northwest of Roseville in 1998 (CNDDB 2001).[27]

2. MIDDLE CENTRAL VALLEY

The range of the burrowing owl in the middle Central Valley encompasses all of Yolo and Sacramento Counties; all but the southwestern 5% of Solano County; the eastern 50% of Contra Costa County; the eastern 20% of Alameda County; all of San Joaquin, Stanislaus, and Merced Counties; the western 30% of El Dorado County; the western 55% of Amador County; the western 70% of Calaveras County; the western 25% of Tuolumne County; and the western 60% of Mariposa County (DeSante et al. 1996).

Although there are historical records of confirmed breeding in almost every county in the middle Central Valley, there are little data on overall historical abundance of the burrowing owl in this area. However, the species was documented to have been locally abundant in Solano County (at Fairfield) and Merced County (at Los Banos) in the 1930s (WFVZ 2001), and in Yolo County (at U.C. Davis) and San Joaquin County (at Stockton) in the 1960s (Remsen 1978; Kemper 1996).

An estimated 595 (DeSante and Ruhlen 1995) to 600 (Kemper 1996) pairs of owls remained in the middle Central Valley in the mid 1990s, about 6.4% of the state breeding population. These pairs are thinly distributed in a crescent around the Delta region (in Yolo, Solano, Sacramento, Contra Costa, San Joaquin, Stanislaus, and Merced Counties), and are associated to a large degree with agricultural lands, although substantial numbers occur in more urban settings and at airports.

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22 CNDDB observations include: two owls flushed from burrows in the vicinity of the North Fork of Elk Creek, southwest of Arbuckle in 3/92; 5 burrows 5 miles southwest of Williams with castings present, 3/6/92; one owl flushed from a burrow 5 miles south-southwest of Williams on 3/9/92; an owl flushed from near a burrow 5 miles west of Arbuckle on 3/9/92; a colony of owls south of Mills Orchard April-September 1992 (5 pairs with 21 young) and in 1993 (21 owls - 7 adults, 14 juveniles); 11 miles northwest of Williams on 3/8/92; one owl at a burrow 10 miles northwest of Williams, on 2/11/92 (the burrow site was excavated on 3/8/92 for construction of a pipeline and the owls are possibly extirpated); 1 owl in a burrow complex 5.5 miles north of Mills Orchards, east of Antelope Valley, on 3/5/92 (also active during spring 2001); and castings and recent droppings, 3 miles east of Golden Gate on Funks Creek, on 3/5/92 (CNDDB 2001).

23 Birds were collected at Upper Lake on 5/29/1894 (Stephens 1895; NMNH 2001), and on 2/10 and 3/27, 1897 (McGregor 1898).

24 There has been a report of possible recent breeding activity in grasslands north of the town of Clearlake (D. Cooper, pers. comm., 2002).

25 There is a historical non-breeding season collection record from Butte Creek, six miles north of Merridian, on 11/27/25 (MVZ 2001).

26 Five individual owls were observed south-southwest of Pleasant Grove on 7/10/93 (CNDDB 2001).

27 Owls (never more than 2) were observed northwest of Roseville year-round during 1998 (CNDDB 2001).

Yolo County

Historical records confirmed breeding at Woodland in 1886 and indicated probable breeding there in 1922 (MVZ 2001; NMNH 2001).[28] Recent breeding season observations near Woodland could not be located.

Kemper (1996) reported a "dependable" owl colony on the U. C. Davis campus in 1962, noting that owls could be seen any time then. B. Johnson monitored this colony from 1981, when the colony had 22 pairs, to 1991, when the population plummeted to one adult. This colony increased to several pairs by the late 1990s, but is threatened by development (CNDDB 2001; B. Johnson, pers. comm., as cited in PHBA 2002). The overall burrowing owl population at Davis has likely declined 50% from 40 pairs in the mid-1980s to 20 pairs in the mid-1990s (PHBA 2002).[29] Other owl colonies north of Davis also severely declined or were extirpated in the 1980s: such as a burrowing owl colony adjacent to the Yolo County Airport that had 10 pairs of birds in 1976, that was extirpated by 1983 when the site was flooded to create a pond; and a colony of 3 to 5 pairs observed from 1978 to 1983, near road 102, 2 miles north of Davis, that had only one pair left by 1986 (CNDDB 2001).

In 1985, B. Johnson (pers. comm., as cited in PHBA 2002) estimated Yolo County's burrowing owl population on the order of 70 to 80 pairs. Since then, the species has "gone into serious decline in Yolo County," and as of 1996 the only remaining breeding owls were in pasturelands bordering the Yolo Bypass, south of El Macero, and a few pairs residing near Davis (Kemper 1996; CNDDB 2001).[30] Observations by B. Johnson (pers. comm., as cited in PHBA 2002) suggest that Yolo County's burrowing owl population has declined approximately 50% since 1985 to 30 or 40 pairs in 2000. As of 2001, owls were known to occupy sites at U. C. Davis, the Yolo Airport, and Mace Ranch Park (CDFG 2002a).

Sacramento County

Historical records confirmed breeding near Freeport in 1899 and near Sacramento in 1901 and 1907; and indicated probable breeding in Sacramento in 1867, 1912, 1926, and 1951 (Storer 1926; Kirsher 1951; MVZ 2001; NMNH 2001; CAS 2002a).[31] There were a number of nesting colonies of owls in downtown Sacramento as of 1974 (CNDDB 2001).[32] Recent observations confirmed nesting in the vicinity of Rio Linda from 1987-1993, at Mather Air Force Base in 1989, at the Sacramento Army Depot in 1990, and at a number of locations in southern Sacramento from 1991-2001 (CNDDB 2001).[33] Large populations remain at the Sacramento Army

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28 Five eggs were collected from Woodland on 4/5/1886 (NMNH 2001). A bird was collected from Woodland on 3/27/22 (MVZ 2001).

29 Recent CNDDB observations in the vicinity of Davis include: a pair nesting near County Roads 27 and 102B, approximately 4 miles north-northeast of Davis (possibly extirpated by development by 1989); 2 pairs along the north side of Covell Drain, north side of the city of Davis, on 6/30/90 (1 pair abandoned their nest site, probably due to dog/human disturbances); one owl at a burrow site near Hwy. 128, 3.7 miles east-northeast of Winters, on 3/17/92; 2 birds near Road 31 and Hwy. 113, Davis, on 4/25/95; and 2 owls at a burrow near Drew Ave. and Cowell Blvd. in Davis, on 3/12/2000 (though owls were not observed at this site during May-June 2000) (CNDDB 2001).

30 Recent CNDDB observations near the Yolo Bypass include: the vicinity of the Vaughn Ranch, in 1987 and 1989; 2 adults and 3 juveniles near the intersection of Midway Road and Levee Road, approximately 12.5 mi south of Davis, on 1/30/82 and 2/12/82 (on subsequent trips to this site in 1986, 1987, and 1989, no birds were found, and it appeared that the burrows had been disturbed); two family groupings (2 adults, 8 juveniles, and 1 unknown-age) on the east side of Road 104, between Thomsen Road and Midway Road, 12 mi east of Dixon, on 6/30/90, and 3 birds of unknown age on 7/23/96; 2 adults and 4 juveniles, near Road 152, east of Vaughn Ranch, 14 miles east of Dixon, on 6/30/90; 22 owls (at least 10 of which were young, in 4 family groupings) near Road 106, north of Glide Tule Ranch, 9 miles south of Davis, on 6/30/90; 2 adults and 4 juveniles near Road 155, 13 miles southeast of Dixon, on 6/30/90; at least 4 clusters of family groupings near Road 105 and Road 36, 6.5 miles south of Davis, in 1989 (several burrows and owls were seen at this site in 1993); and multiple sightings near Road 155 and West Levee Road, approximately 13 miles southeast of Dixon (1 adult was seen in 1989; 3 adults near a burrow, 5 young, and 2 owls of unknown-age at a burrow in 1990; 2 adults in 1993; and 2 adults on 7/19/96) (CNDDB 2001).

31 Eggs were taken one mile north of Freeport on 4/29/1899, from Haggin's Ranch, five miles north of Sacramento on 5/8/01, and from the vicinity of Sacramento on 4/27/07 (CAS 2002a). Single birds were collected from Sacramento on 6/20/1867 (NMNH 2001), and on 5/17/12 (MVZ 2001).

32 CNDDB observations in downtown Sacramento in 1974 include: several colonies with successful nesting in the vicinity of McKinley Park, southwest of the California State Exposition; several colonies with successful nesting immediately southwest of the junction of Howe Ave. and Fair Oaks Blvd. (this site is now completely developed, with no remaining habitat for burrowing owls); and several nesting colonies at Sacramento State College and adjacent levee areas along the American River (CNDDB 2001).

33 Recent CNDDB observations near Rio Linda include: an extensive burrow network with at least 2 to 3 family groups near Elkhorn Blvd, 2 miles west of Rio Linda, where owls have been observed since at least 1987 (in 1993, 2 adults were observed in mid-March, and by mid-July, 14

Depot, southeast of Sacramento Metro Airport, Consumnes River College, and the Sacramento Regional Wastewater Treatment Plant (CNDDB 2001; SRCSD 2002).[34]

Solano County

Historical records confirmed breeding near Dixon in 1932 and near Fairfield in 1936; and indicated probable breeding near Vacaville in 1894, and on eastern Grizzly Island in 1927 (Stoner 1933b; MVZ 2001; NMNH 2001; WFVZ 2001).[35] A. Anderson noted "lots of owls near Fairfield" in 1936 (WFVZ 2001).

There have been numerous observations in recent years indicating an abundance of breeding owls between the Yolo Bypass and Dixon (CNDDB 2001).[36] There have been numerous colonies observed recently in the vicinity of Vacaville (north of Vacaville and west of Hwy. 505, near the Vaca Dixon Airport, and near Travis Air Force Base) (CNDDB 2001).[37] Breeding owls have also been documented recently in the vicinity of

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individuals were observed); one adult owl roosting just west-northwest of 6th and "U" Streets in 1992, and two adults at a burrow here in 1993; and 2 adults and 2 juveniles approximately 4 miles west of Rio Linda, on 6/22/2001 (CBDDB 2001).

Recent CNDDB observations at Mather Air Force Base include: 1 adult at a burrow at Bldg 7001, on 4/28/89; 2 adults near Bldg. 7014, on 4/28/89 (a family of burrowing owls had been observed here in the past); at the BX parking lot on 4/28/89; 2 pairs of owls with 3 young at burrows east-northeast of Mather AFB, Rancho Cordova, on 6/14/89; and 1 adult with four young adjacent to the West Gate on 7/15/89 (CNDDB 2001).

Other recent CNDDB observations in southern Sacramento include: at least 6 nesting burrows with at least 14 individual owls at the Sacramento Army Depot, in 1990 (this site is threatened by potential closure of the Army Depot and conversion to development); a minimum of 8 adult owls at burrow sites and other burrows that also appeared active approximately 4 miles southeast of Sacramento Metro Airport, on 1/18/91 (the surrounding habitat is scheduled for a housing development); 4 burrows showing signs of recent occupation at the Kiefer landfill site, in April 1994 (area proposed for landfill expansion); 12 occupied burrows, with a total of at least 18 adults (6-12 pairs estimated), at the Cosumnes River College playing field, in 1994; a burrow near the Sacramento Regional Wastewater Treatment Plant, occupied on 2/19/92 and between 1998-2001; and at least 3 owls on 5/16/95 and 1 adult and 2 juveniles on 9/20/2001 near Elder Creek, just west of Franklin Blvd. (threatened by levee "improvements" - owls will be displaced by one-way burrow doors - and development of foraging habitat) (CNDDB 2001). An owl near a burrow was seen at the Metro Air Park development site, east of the airport, on 3/23/2000 (USFWS 2001).

34 According to the Sacramento Regional County Sanitation District, the burrowing owl population on 2,500 acres of buffer lands around the Sacramento Regional Wastewater Treatment Plant has increased from 12 resident owls in 1991 to more than 20 in 1997, with as many as 38 birds observed in one survey (SRCSD 2002).

35 Stoner (1933b) found two burrowing owls occupying holes in hay piles near Dixon in 1932. There are collection records from Elmira, near Vacaville on 3/4/1894 (NMNH 2001), and from eastern Grizzly Island on 4/24/27 (MVZ 2001). Grinnell and Wythe (1927) observed birds near Rio Vista. Eggs were collected from near Fairfield in April 1936 (WFVZ 2001).

36 Recent CNDDB observations between the Yolo Bypass and Dixon include: 2 owls (one adult and one of unknown age) near Etzel Road and the old Sacramento Northern RR tracks, approximately 6 miles north of Liberty Farms, on 7/2/89; 4 adults near Hackman Road and Buckley Road, on 7/2/89; 1 adult along Thomsen Road on 7/2/89; two adults near Buckley Road and Midway Road, on 7/2/89; a large colony near Yolano Road, King Road, and Liberty Island Road in 1987 (3 adults and road-killed fledgling seen in 1989, 2 adults in 1990); 1 owl near Miller Road and Robben Road, on 7/1/89; 1 owl near Midway Road and Robben Road on 7/1/89; 1 owl along Robben Road, north of Midway Road, on 7/1/89; 2 adult owls near an occupied burrow near Swan Road and Winship Road, on 6/30/90; 1 owl and several burrows showing owl sign near West Levee Road and Delhi Road, on 6/30/90; 2 family groups (approximately 10 individuals) near the Northern Pacific RR tracks, just north of Etzel Road, on 6/30/90; 1 owl near Robben Road and Midway Road, in 1989 and in 1990; two family groups (each with two adults and at least two young) near Maxwell Lane and Road 104, in 1990 (3 adult owls seen at a burrow here on 4/4/92); 1 owl near Buckley Road and Road 38A, on 6/20/90; Sikes Road, between Trefoil Road and Delhi Road (1 owl seen on 6/30/90, 1 owl seen on 11/29/99, but no owls present after 2/1/2000); 12 owls near Pedrick Road and Binghamton Road on 9/7/89 (3 owls seen at this burrow site in January 1992); 2 adults at a burrow site 4 miles southeast of Dixon on 7/23/96; 2 adults and 2 juveniles 4 miles south-southeast of Dixon, on 7/23/96; 1 adult and 2 juveniles 1 mile northeast of Dixon, on 7/19/96 (owls had inhabited this site year-round for at least the past two years); 2 adults and 2 unknown-age owls 2.5 miles north-northeast of Dixon, on 7/23/96; 2 pairs of adults, one with 4 juveniles 2 miles southeast of Libfarm, on 7/19/96; 5 adults and 8 juveniles 2 miles southeast of Libfarm on 7/23/96; 2 adults near Liberty Island Road and King Road, on 7/19/96; 4 owls of unknown-age near Bulkley Road and Hackman Road, on 7/19/96; 3 adults and 2 juveniles near County Road 104 and Hackman Road, on 7/23/96; 1 owl using two different pipes near Sikes Road and Swan Road, north-northeast of Dozier, on 11/29/99; 1 owl using burrows along Bunker Road, east-northeast of Maine Prairie School, between January-May 2000; 3 owls (2 adults/1 juvenile) using 2 burrows near Swan Road and Sikes Road, on 1/3/2000 and 1/24/2000; single owls at burrows near the Swan Road/Binghampton Road curve, on 1/19/ 2000 and 4/28/2000; and a breeding pair near Hwy. 113 and Midway Road, 2 miles south of Dixon, on 3/7/2000 (CNDDB 2001).

37 Recent CNDDB observations north of Vacaville and west of Hwy. 505 include: 2 adult owls and a burrow with owl sign west of I-505, 2 miles north of Sweany Creek, east of the English Hills, on 5/18/92 (a single owl was seen here on 3/18/92); 4 owls near Winters Road, about 5.5 miles south of Winters, on 7/12/94; 1 owl near Allendale Road, west of I-505, about 6 miles south of Winters, on 7/12/94; 2 adults and 4 juveniles near Vaca Valley Parkway and Ackerly Drive, on 6/22/98; and 2 pairs, one with 2 young, near I-505 and Gibson Canyon Creek (north fork), 2 miles west of Vaca Valley Raceway, on 6/18/2000 (this site has been active since at least 1997, with 1-2 pairs present) (CNDDB 2001).

Recent CNDDB observations near the Vaca Dixon Airport include: an unknown number of owls found in burrows at the old Vaca Valley Raceway, on 3/12/89 and 1 adult near Weber Road and Lewis Road, on 7/1/89 (CNDDB 2001). Recent CNDDB observations near Travis Air Force Base include: 2 adults and a burrow near Hay Road and Dally Road, east-southeast of Elmira, on 9/4/89 (3 owls and a burrow were observed at this site on 3/8/84); at least five burrows, with 8 adults (at least 3 pairs) near Meridian Road, 1 mile east of Travis Field, on 4/9/89; 1 owl at Aero Club Airport, near Peabody Road and Air Base Parkway, Travis AFB, on 3/12/89; yearly reports of owls breeding and residing year-round in the vicinity

Fairfield, and observations along Suisun Bay and the Delta confirmed breeding at Montezuma Slough, and indicated probable breeding in the Montezuma Hills and the vicinity of Rio Vista (USACE 1998; CNDDB 2001).[38]

Eastern Contra Costa County

Historical records confirmed breeding at Brentwood in 1915; and indicated probable breeding at Antioch in 1879 (MVZ 2001; NMNH 2001).[39] Owls were frequently observed in the vicinity of Byron in the 1980s (Richmond 1985; CNDDB 2001). There are remaining owl populations in Concord, Pittsburgh, Antioch, Brentwood, Oakley, Byron, the Los Vaqueros watershed, and Vasco Caves Regional Preserve (L. Trulio, pers. comm., 2001; CDFG 2002a; M. Ricketts, pers. comm., 2002; J. DiDonato, pers. comm., 2003).[40] Recent CNDDB records confirmed breeding at the Byron Airport in 1993 and 1994, and southeast of Antioch in 2001; and indicated probable breeding near Clifton Court Forebay in 1992, at Byron in 1999, and in the vicinity of Brentwood in 1999 (CNDDB 2001).[41]

Eastern Alameda County

(Stallcup and Greenberg 1974) observed that burrowing owl numbers continued to decline in eastern Alameda County through the 1970s. There have been numerous observations confirming breeding in the vicinity of Altamont Pass and Bethany Reservoir from 1973-2001 (CNDDB 2001).[42] There is an owl colony at

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of the officer's club at Travis AFB, since 1982; and in the vicinity of Travis elementary school, the post office, vet center, and base exchange, Travis AFB, on 3/12/89 (CNDDB 2001).

38 Recent CNDDB observations in the vicinity of Fairfield include: a breeding colony of many burrows (with 9 adults and 4 juveniles) near Cordelia Road and Orehr Road, in 1982; 3 owls occupying burrows near Hillside Drive and Dover Ave., in 1983 (this population was extirpated by a housing development and no owls were observed at this site in 1989); 1 owl near Cement Hill and Clay Bank Road, on 3/12/89; and single owls near Potrero Hills Lane, near the junction of Scalley Road and Hwy. 12, on 10/15/91 and 2/25/92 (this burrow appeared to be inactive on 5/7/92) (CNDDB 2001).

Burrowing owls breed along the interior levees and drainage canals at Montezuma Wetlands (USACE 1998). Recent CNDDB observations near Montezuma and near Rio vista include: 2 pairs (one with 5 young), and 1 pair, at 2 locations between Montezuma Slough and Collinsville Road, northwest of Collinsville, in March 2000; 1 adult at Montezuma Hills, on 12/8/99, as well as on several other occasions; 1 adult at a burrow near Montezuma Hills Road and Toland Lane intersection, Montezuma Hills, on 1/29/2000; 1 adult at a burrow site near Azevedo Road and Cartwright Road, northwest of Rio vista, on 4/28/2000 (later, the same owl (presumably) was found dead on the road); 1 adult near Emigh Road and Azevedo Road, west of Rio Vista, on 1/21/2000; 1 adult near Emigh Road and Anderson Road, west of Rio Vista, seen numerous times between 12/2/99 through February 2000; 3 adult owls at 3 adjacent burrows near Anderson Road and Montezuma Hills, southwest of Rio Vista, on 12/8/99; 1 adult at a fourth burrow near this site, on 1/3/2000 (this burrow was flooded on 1/24/2000); 1 adult near Robinson Road and Flannery Road, northwest of Rio Vista, seen on multiple visits between November 1999-April 2000; and 1 adult in a burrow near Montezuma Hills Road and Anderson Road, southwest of Rio Vista, on 1/13/2000 (CNDDB 2001).

39 Eggs were collected from Brentwood on 3/25/15 (MVZ 2001). A single bird was collected in Antioch on 5/20/1879 (NMNH 2001).

40 Two pairs of burrowing owls were observed in southeast Antioch throughout the summer of 2002, although no fledglings were ever seen (M. Ricketts, pers. comm., 2002). One of these pairs was evicted in September 2002 from a development site using standard "passive relocation" methods. A separate pair was observed on three occasions just outside the development area, but was not seen during August or September. Neither of the pairs or any other burrowing owls were seen during initial ground disturbance activities in early September and the current location and status of these owls is unknown.

There is a non-breeding season record of a bird collected from Sellers Ave. (by a canal) in Brentwood on 9/11/98 (MVZ 2001). Two other owl pairs were seen occupying burrows within 50 meters of each other on a development site in Brentwood (junction of Highway 4 and Brentwood Blvd.) in 2002 (M. Ricketts, pers. comm., 2002). One of these pairs was confirmed breeding and two young were at the burrow in early June. The other pair was only seen once and apparently did not remain at the site to breed. The breeding pair was not located in an area scheduled for grading in 2002, and the young fledged successfully (current whereabouts are unknown). This area is proposed for future development.

There is a population of 4 or 5 pairs of owls at Vasco Caves Regional Preserve east of Los Vaqueros watershed, with successful breeding recorded over the past few years; and a larger population on adjacent windfarm lands (J. DiDonato, pers. comm., 2003).

41 Recent CNDDB observations include: 2 owls and 4 burrows with owl sign, west and southwest of Clifton Court Forebay, on 6/12/92 (threatened by proposed pipeline); a colony of 6 breeding pairs (12 adults and 9 juveniles) near the Byron Airport, in 1994 (owls were passively relocated in 1993 from airport expansion construction areas); 2 adults at Byron on 4/2/99; 1 adult at a burrow 1.5 miles west of Brentwood, on 12/16/96 (threatened by a proposed housing project); 3 adults at 2 burrow sites 3 miles west of Brentwood, on 11/9/99 (threatened by development); and 4 adults and 3 juveniles at two burrow sites at Rolling Hills Ranch, 3 miles southeast of Antioch, on 6/30/2001 (threatened by fire control disking and residential development) (CNDDB 2001).

42 CNDDB observations in the vicinity of Altamont Pass include: several sightings of owls and/or burrows along Greenville Road near Tesla Road, between 1972 and 1979; several owls near Midway, in 1982; 2 owls and evidence of breeding near North Midway Road, reported in 1983; a burrow with 2 adults along Mendota Canal, 1 mile north of Mountain House, on 9/16/89 (this burrow remained occupied throughout the fall); 2 birds observed leaving a burrow north of Grant Line Road and south of Mountain House Creek, on 3 consecutive nights in May 1992; 2 nests between Patterson Pass and Midway, in 1999 (EBBC 1999); a colony along Altamont Pass Road, 1.5 miles southwest of Mountain House (a single bird was observed during the breeding season, on 4/30/73; owls were passively relocated from an 80-acre area for a proposed golf course in January 2001; 4

Lawrence Livermore Laboratory (L. Trulio, pers. comm., 2001), and a small number of burrowing owls have been observed breeding on the Lawrence Livermore Laboratory Site 300, on the north side of Corral Hollow Road (LLNL 1998; Jones & Stokes 2000).[43] No burrowing owls have been observed during field studies at the Carnegie State Vehicle Recreation Area conducted by Jones & Stokes and the California Department of Fish and Game (Jones & Stokes 2000).

San Joaquin County

Historical records confirmed breeding at Waterloo and near Stockton in 1882, near Lathrop in 1896; and indicated probable breeding in the San Joaquin Valley in 1905, at Tracy in 1911, and at Holt in 1930 (Ray 1906; MVZ 2001; WFVZ 2002; CAS 2002a).[44] In the Stockton area, known populations consisting of at least 17 pairs had dwindled to no more than three pairs from 1968-1978 (Remsen 1978). Burrowing owl colonies were reported in the 1980s at the Stockton Oxidation Ponds near Thornton, near the California Youth Authority facility southeast of Stockton, along Duck Creek northeast of Farmington, and just south-southeast of Mountain House (Richmond 1985; CNDDB 2001).

A large breeding population remains in the vicinity of Tracy; 41 adults were seen at a colony in southwest Tracy in August 1998 (CNDDB 2001).[45] Relatively large breeding colonies are found throughout southern Stockton, at the San Joaquin County Fairgrounds (15+ pairs in 1993), Moss Tract (7 adults in 1998), Walker Slough-French Camp Slough (6 adults and 6 juveniles in 1998), Stockton Metro Airport (4 adults and 6 juveniles in 1999), Stockton Railroad Yard, and Sharpe Depot (4 pairs in 1993, 8 pairs in 1997, 4 pairs in 1998, 7 pairs in 1999, and 13 pairs with 55 young in 2001) (CNDDB 2001).[46] There have also been recent

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adults were observed on 1/16/2001; 7 pairs and 8 juveniles were observed during monitoring from February-June 2001; all birds observed were outside of the proposed golf course area); 2 birds observed leaving burrow near Midway Road and I-580, on 2 consecutive nights in May 1992 (2 owls were seen here on 6/27/82); 8-10 active burrow sites near Kelso Road and Bruns Ave., north of Bethany Reservoir, between 1992 and 1994; 11 burrows (1 with owl sign) along a pipeline near Grantline Road and Mountain House Creek, on 9/30/92 (burrows were monitored, then excavated in spring 1993 - 1 burrow with an owl nearby seen here on 4/16/93); and 5 dens with owl sign and 1 owl at Altamont Speedway parking lot, on 10/10/97 (CNDDB 2001).

43 Twenty-one burrowing owl dens (it is not clear how many were occupied) have been recorded at Site 300 (LLNL 1998).

44 Eggs were collected from Waterloo and near Stockton on 5/12/1882 (CAS 2002a), and near Lathrop on 5/8/1896 (WFVZ 2001). Birds were collected from the San Joaquin Valley in summer 1905 (Ray 1906), from Tracy on 3/8 and 3/14, 1911, and from Holt on 4/22/30 (MVZ 2001). There is a non-breeding season collection record from Victoria Island on 1/11/39 (MVZ 2001).

45 Recent CNDDB observations in the vicinity of Tracy include: an active burrow with at least 2 resident owls near Jefferson Blvd. and Valpico Road, 2 miles south of Tracy, on 8/11/91; a burrow with 1 adult south of the intersection of Patterson Pass Road and I-580, 5 miles southwest of Tracy, on 7/3/92; 2 owls at a burrow site with owl sign between Delta-Mendota Canal and Schulte Road, 4 miles southwest of Tracy, on 9/28/92 (burrow was monitored, then excavated with CDFG approval – this site is extirpated); a burrow with owl sign (no owls) near Patterson Pass Road and I-205, southwest of Tracy, on 9/29/92; 1 owl at a burrow with owl sign near Patterson Pass Road and Hansen Road, southwest of Tracy, on 9/29/92; a pair of owls at a colony site near Patterson Pass Road and Hansen Road, southwest of Tracy, on 2/11/93 (this was one of several burrows monitored, then excavated with CDFG approval); 1 owl at a complex of 3 burrows with owl sign near Hansen Road and the Delta Mendota Canal, southwest of Tracy, on 4/6/93 (burrows were monitored, then excavated with CDFG approval during spring 1993); a large colony near Schulte Road and the SPRR tracks, Tracy (1 pair with 4 young and another pair with 5 young seen on 7/24/97, 18 adults seen on 5/4/98, 41 adults seen on 8/27/98); 1 adult at a burrow near Byron Road and West 11th Street, west of Tracy, on 8/3/98; 1 juvenile at a burrow near Kelso Road and Byron Bethany Road, southeast of Clifton Court Forebay, on 9/2/89; and 1 bird at a burrow near Tracy Blvd. and I-205, north of Tracy, on 5/30/94 (CNDDB 2001).

46 Recent CNDDB observations in southern Stockton include: 8 adults (4 pairs) at Stockton Airport and Sharpe Army Depot Complex, south of Stockton, on 6/19/93; 30+ adults (15+ pairs) and an unknown number of juveniles at the San Joaquin County Fairgrounds, Stockton, on 6/19/93; 2 adults at 2 adjacent burrows near Arch Road and Hwy. 99, northeast of Stockton Metropolitan Airport, on 6/12/95; 2 adults and 5 juveniles near Arch Road and Hwy. 99, northeast of Stockton Metropolitan Airport, on 7/2/95; 2 adults and 2 juveniles near Yosemite Ave. and McKinley Ave., southeast of Lathrop, on 7/24/97 (1 adult also observed on 1/21/00); a pair of owls, possibly with eggs, 0.75 miles east of Lathrop, on 3/14/97; 7 adults at a burrow site near Fresno Ave. and West 8th Street, in the Moss Tract area of Stockton, on 2/27/98; 2 adults at a burrow site along Duck Creek, near Airport Way, Stockton, on 3/20/98; 6 adults and 6 juveniles near Walker Slough/French Camp Slough confluence, south of Stockton, on 9/3/98; 1 adult at a burrow near Hammer Lane and Hwy. 99, east of Stockton, on 5/4/99; a small breeding colony 1 mile north of Stockton Metropolitan Airport (2 adults and 2 nearly-mature juveniles seen on 6/24/99, 4 adults and 6 juveniles seen on 7/6/99); 2 adults at a burrow near Fresno Ave. and West 8th Street, South Stockton, on 4/2/99 (the site was to be developed after the 1999 nesting season was over); 2 adults at a burrow near French Camp Road and I-5, south of Stockton, on 5/11/99; 2 adults at a burrow near Carolyn Weston Blvd., west of Manthey Road, south of Stockton, on 5/11/99; 2 adults at a burrow near French Camp Road and Manthey Road, south of Stockton, on 5/11/99; 1 adult at a burrow near junction of Walker Slough and Duck Creek, south of Stockton, on 8/26/99 (+ one dead owl observed that appeared to have been killed by a feral cat); 2 adults and 3 juveniles west of McLeod Lake, northeast of I-5, central Stockton, on 7/8/99; 2 adults at a burrow near French Camp Road and Wolfe Road, near San Joaquin River, Stockton, on 5/11/99; a large breeding colony at Sharpe Depot, Lathrop (8 breeding pairs estimated in 1997; 4 breeding pairs and young observed in 1998; 7 breeding pairs, 3 in natural burrows/4 in artificial burrows and young, observed in 1999; 13 pairs, 11 breeding, produced 55 young, 5/24-6/29, 2001); a large colony at the Stockton railroad yard, near Charter Way and Airport Way, 2 miles south of

observations indicating probable breeding in southwestern San Joaquin County south of I-580 (CNDDB 2001).[47]

Stanislaus County

Historical records confirmed breeding in 1928 in the Del Puerto Canyon area, on the San Joaquin side of the Mount Hamilton Range, and indicated probable breeding there in 1957 (Fowler 1931; MVZ 2001).[48] Beedy and Granholm (1985) reported that burrowing owls could be found in the foothills west of Yosemite National Park, for example northeast of Waterford in Stanislaus County. Recent records indicated probable breeding east of Oakdale, along Highway 120, in 1990 (SBMNH 2001).

Merced County

Historical records confirmed breeding near Dos Palos in 1923, at Los Banos in 1898, 1932, and 1933; and indicated probable breeding at Los Banos in 1903, at Snelling in 1925, and at Merced in 1908 and 1941 (Dawson 1923; AMNH 2001; MVZ 2001; UCLA 2001; WFVZ 2001).[49] Egg collector D. De Groot noted "many burrowing owls" in the vicinity of a nest he raided at Los Banos in 1932 (WFVZ 2001). There was a large resident burrowing owl population at the San Luis National Wildlife Refuge, near Los Banos, in the 1970s and 1980s (Stebbins and Taylor 1973; Richmond 1985) - the 1978 population was estimated at 25 pairs (Remsen 1978). Although no systematic surveys have been done, there is apparently still a "healthy" owl population at this Refuge, with recent observations of up to 26 owls in one hour (D. Warren, pers. comm., 2002).

Recent observations confirmed breeding colonies in the vicinity of Los Banos Reservoir (many of these sites are threatened by the proposed Los Banos Grandes Reservoir), and indicated probable breeding along the Hwy. I-5 corridor around San Luis Reservoir, the vicinity of Merced (many of these sites are threatened by the proposed 2000-acre UC Merced campus), and in northeastern Merced County near Kelsey Reservoir (CNDDB 2001).[50]

Stockton (over 90 burrows were counted in a 1.9 mile stretch of the railroad yard in 1999; 14 owls counted on 10/2 and 10/11, 1999; 18 owls counted on 11/10 and 11/11, 1999; and 1 owl banded on 11/11/99); 2 adults and 3 juveniles at a burrow near Mariposa Road and Hwy. 99, Stockton, on 7/19/00; 4 owls in the vicinity of many burrows near the confluence of Duck Creek and Walker Slough, south end of Stockton, on 10/16/00; and 3 juveniles at a burrow south of Stockton, on 7/9/99 (CNDDB 2001).

[47] Recent CNDDB observations in southwestern San Joaquin County include: 2 resident owls at a burrow and another active burrow site along Smiths Ridge, northeast of Lone Tree Mineral Spring on 10/20/91; 1 owl at a burrow along Hospital Creek, southwest of I-580 junction with I-5, on 9/14/92; and a pair of owls and sign at a burrow just northeast of Lone Tree Mineral Spring on 5/24/01 (no owls observed during a subsequent visit on 6/5/01) (CNDDB 2001).

[48] Fowler (1931) reported burrowing owl families living in the canyons on the San Joaquin side of the Mount Hamilton Range (likely the Del Puerto Canyon area) in the summer of 1928. Fowler found the remains of 8 burrowing owls (adults and juveniles) in prairie falcon nests in the area. A bird was collected from the mouth of del Puerto Canyon, four miles west of Patterson, on 4/19/57 (MVZ 2001). There is a recent non-breeding season record from Del Puerto Canyon on 10/17/91 (CNDDB 2001).

[49] Eggs were collected from unspecified locations in Merced County in 1896 and 1916; and from Los Banos on 6/8/1898, 5/29/32, and 5/30/33 (WFVZ 2001). Dawson (1923) found several owl burrows near Dos Palos. Breeding season collections include 2 birds from Los Banos on 6/22/03 (AMNH 2001), at Snelling on 4/8/25 (MVZ 2001), from Merced on 6/18/08 (UCLA 2001) and on 7/26/41 (MVZ 2001). There is also a non-breeding season collection record from Snelling on 1/9/15 (MVZ 2001).

[50] CNDDB observations near the Los Banos Reservoir include: 1 adult approximately 3 miles west of Los Banos Reservoir, on 8/9/94; 2 adults at a burrow site 1 mile north of Los Banos Valley, on 7/6/98; 1 adult along Salt Creek, 3 miles south of Los Banos Reservoir, on 7/13/98; 9 adults at a burrow site at the north end of Los Banos Valley, on 8/18/98; and 2 adults and 4 juveniles, 5 miles north-northwest of little Panoche Reservoir, on 7/26/2000 (CNDDB 2001). CNDDB observations along the I-5 corridor include: 5 burrows with owl sign along 1 mile of the California Aqueduct, southeast of Dos Amigos pumping plant, on 2/24/93; one adult at a burrow near the intersection of I-5 and Hwy. 152, on 9/3/92 and 2/13/93; one burrow with owl sign at Santa Nella Village, on 3/23/93; and 3 burrows with owl sign southwest of Gustine, on 3/23/93 (CNDDB 2001).

Recent observations in the vicinity of Merced include: 1 adult and a nearby active burrow 3 miles northeast of Planada, in May 1999; 6 observations of occupied burrows or burrowing owls along Le Grand Canal in 1999; 3 owls and 8 burrows with owl sign south of Yosemite Lake, north-northeast of Merced, on 2/1/2000; and several dozen burrowing owls north of the proposed UC Merced campus site (CNDDB 2001; URS 2002).

There was a breeding season observation of an owl near a burrow at Kelsey Ranch, just west of Kelsey Reservoir, on 5/1/99 (CNDDB 2001).

El Dorado County

The species has been recorded historically from near Latrobe (Barlow 1901). Recent breeding season observations in El Dorado County could not be located.

Amador County

Historical records indicated probable breeding in Amador County in 1896 (CAS 2002a).[51] Recent breeding season observations in Amador County could not be located.

Calaveras County

Historical breeding season observations in Calaveras County could not be located. There have been recent observations of burrowing owls along the lower Mokelumne River in Calaveras/San Joaquin Counties (EBMUD 2001), but it is unknown whether these were during breeding season.

Tuolumne County

Historical breeding season observations in Tuolumne County could not be located, other than a report by Beedy and Granholm (1985) that burrowing owls could be found in the foothills along Hwy. 120, west of Chinese Camp. Recent breeding season observations in Tuolumne County could not be located.

Mariposa County

Historical records indicated probable breeding east of Merced in 1941 (MVZ 2001).[52] Recent breeding season observations in Mariposa County could not be located.

3. SOUTHERN CENTRAL VALLEY

The range of the burrowing owl in the southern Central Valley encompasses the western 70% of Madera County; the southeastern 25% of San Benito County; the western 80% of Fresno County; all of Kings County; the western 50% of Tulare County; and the northwestern 55% of Kern County (DeSante et al. 1996).

Although there are historical records of confirmed breeding in almost every county in the southern Central Valley, there are little data on overall historical abundance of the burrowing owl in this area. However, the species was documented to have been locally abundant at a number of locations such as at Fresno in the early 1900s (Miller 1903; Tyler 1913a), in the Kettleman Hills in the 1940s (Wilson 1945), and at Tulare Lake in the early 1900s (Goldman 1908).

DeSante and Ruhlen (1995) estimated that 1,396 pairs of owls remained in the southern Central Valley in the mid 1990s, about 15.1% of the state breeding population. In contrast to most regions, a substantial number of these pairs (396 pairs) were estimated to live in uplands, although owls are primarily concentrated in low-lying agricultural areas surrounding the mostly dry lake basins, such as the Tulare Lake Basin in Tulare and Kern Counties. Some numbers still exist in remaining grasslands, which are in uplands. Only 14% of the remaining breeding sites were found within 15 meters of irrigation canals (DeSante et al. 1996).

Madera County

Historical records confirmed breeding near Madera in 1917 and 1920, and at Chowchilla in 1900; and indicated probable breeding at Madera in 1939 (CAS 2002a).[53] There is one recent breeding season observation northwest of Friant in 2000 (CNDDB 2001).[54]

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[51] A bird was collected from an unspecified location in Amador County on 5/13/1896 (CAS 2002a). There is also a non-breeding season collection record from Amador County in January 1896 (McGregor 1898).

[52] A bird was collected 20 miles east of Merced on 7/26/41 (MVZ 2001).

San Benito County

Historical records indicated probable breeding at Paicines in 1894 and 1897 (CAS 2002a).[55] There were several owl observations indicating probable breeding northwest of Hollister in the early 1990s (CNDDB 2001).[56] In 2001, Sam Fitton reported burrowing owls to be resident in small numbers in Panoche Valley (D. Cooper, pers. comm., 2002).

Fresno County

Historical records confirmed breeding near Wheatville in 1907, around Fresno in 1912 and 1913, near Monmouth in 1917, near Selma in 1917, near Cantua Creek in 1917, near Firebaugh in 1919, and at Kettleman Hills in 1944; and indicated probable breeding at Fresno and Visalia in the 1920s and near Cantua Creek in 1940 (Tyler 1913b; Storer 1926; Wilson 1945; WFVZ 2001; CAS 2002a).[57]

As early as 1903, Miller (1903) reported that the burrowing owl, "one of the most prevalent species formerly" in the Fresno area "is now becoming extinct wherever the country is thoroughly cultivated." Tyler (1913a) remarked that although burrowing owls could be heard throughout most of the Fresno region around the turn of the century, "civilization, cultivation, and squirrel extermination have now crowded these little owls farther and farther out to the edges of the Fresno District, to the west side plains and a few other unsettled areas." Tyler noted that a few owls could be found within cultivated areas, where they nested in waste fields and along roadsides, "but their numbers are limited and it seems only a matter of a few more years until we will be unable to number the Burrowing Owl among the birds of the Fresno District." Wilson (1945), who listed the species as a "fairly common resident" of the Kettleman Hills, observed owls occasionally during the year in the hills or on the flats and confirmed breeding there in 1944.[58] By the 1970s, burrowing owl numbers were further decreasing in the Fresno area (Remsen 1978). The population at the federally protected Mendota Wildlife Area was estimated at 30 pairs in 1978 (Remsen 1978).[59]

Currently, very few burrowing owls breed within the Mendota Wildlife Area, but recent observations indicated confirmed breeding along the San Luis Drain, northwest of the Mendota Wildlife Area, in 1987 and 1989; and probable breeding near Monocline Ridge in 1994 and near Huron in 2001; a population of at least 80 pairs nested in 2002 within cracked concrete along the San Luis Drain for a three-mile stretch adjacent to the western boundary of the Wildlife Area (CNDDB 2001; R. Huddleston, CDFG, pers. comm., 2002).[60]

Kings County

Historical records indicated probable breeding at Hanford in 1882 (CAS 2002a).[61] Goldman (1908) found the burrowing owl "abundant" in the region of Tulare Lake in the summer of 1907. There is currently a

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53 Egg sets were collected from 5 miles south of Madera on 5/13/17 and 5/8/20 (2 sets), and from Terry School (northeast of Lemoore NAS on 5/2/17 (CAS 2002a). Juvenile birds were collected from Chowchilla on 6/27, and 6/29, 1900; adult birds were collected from Chowchilla on 6/26/1900 and from Madera on 3/6/39 (CAS 2002a).

54 One adult was observed at a burrow site near Hwy. 41, 8 miles northwest of Friant, on 4/4/2000 (CNDDB 2001).

55 Birds were collected from Paicines on 4/1/1894, 1/29/1896, and 2/21/1897 (3 birds) (CAS 2002a).

56 Recent CNDDB observations include: 1 adult at a burrow site 2 miles west-northwest of Hollister Airport, on 2/12/91 and 2/17/91; an active burrow site along Hwy.. 25, south-southeast of the Pajaro River, in September 1992; and 1 adult bird observed at a burrow 1.2 miles south of the Hwy. 25 crossing over the Pajaro River, south-southeast of Gilroy, on 3/1/94 and 3/10/94 (CNDDB 2001).

57 Eggs were collected 10 miles north of Wheatville on 4/30/07; near Monmouth on 5/30/17; 3 miles west of Selma on 4/21/17; and near Firebaugh on 4/5/19 (WFVZ 2001). Tyler (1913b) found eggs and feathered young when he opened up four nesting burrows in Fresno County in April 1912. A single bird was collected from 20 miles south of Mendota (near Cantua Creek) on 3/23/40 (CAS 2002a).

58 Wilson (1945) saw 4 half-grown owls standing by a burrow near Huron in June 1944.

59 A large concentration of 19 burrowing owls was seen near Mendota on 6/14/74 (Stallcup and Greenberg 1974).

60 Recent CNDDB observations include: along the east bank of the San Luis Drain, northwest of the Mendota Wildlife Area, in 1989 (the number of juveniles, adults, and burrows was lower than the number observed in 1987, due to ORV's, indirect poisoning from poison bait stations, and possibly plinking); one adult at a nest site on the eastern edge of Monocline Ridge, in June 1994; and active burrow sites northeast and north-northwest of Huron, from 5/8-5/10, 2001 (CNDDB 2001).

61 There is a collection record from Hanford on 5/20/1882 (CAS 2002a).

significant population at Lemoore Naval Air Station ("NAS"), where owls nest in established wildlife areas, runway buffer strips, and adjacent to runways. The number of active burrowing owl nests at Lemoore NAS from 1997 to 2000 has fluctuated from 54 to 85 (Rosenberg and DeSante 1997; Rosenberg et al. 1998a, 1998b; Gervais and Anthony in press). Recent CNDDB observations indicated probable breeding at several locations in the Kettleman Hills in 1996 and 2001, in northeastern Kings County near Visalia in 1999, and in the Tulare Lakebed area in 2001 (CNDDB 2001).[62] At least 5-10 owl pairs were observed from 2001-2002 in the general vicinity of Corcoran along Tulare Lake Drainage District canals and evaporation basin ponds (N. Brown, pers. comm., 2002).

Tulare County

Historical records confirmed breeding on the valley floor at Tulare in 1894 and at Tipton in 1936; and indicated probable breeding at Visalia in 1880, at Earlimart in 1903, and at Tipton in 1911 (MVZ 2001; NMNH 2001; WFVZ 2001).[63] The burrowing owl had not been seen in Sequoia National Park since Fry observed them there in 1911 according to Dixon (1933). A former population of several pairs at Shepherd's Cove, on the north side of the Kaweah River, was gone by 1937 (USNPS 1937; Sumner and Dixon 1953). Beedy and Granholm (1985) noted a collection record from Ash Mountain, in Sequoia National Park.

During the decade from 1968-1978, there was an estimated 70% reduction in suitable burrowing owl habitat in Tulare County (Remsen 1978). Beedy and Granholm (1985) reported declines in Tulare County, but noted that burrowing owls were still fairly common in scattered localities in the lower foothills in the 1980s.

There was confirmed breeding at Pixley in 1998 (Rosenberg et al. 1998a) and recent CNDDB observations indicated probable breeding at two locations northwest of Visalia in 1990 and 1998, and west of Earlimart in 1990 (CNDDB 2001).[64] A colony of owls at Colonel Allensworth State Historic Park ("CASHP") consisted of 14 breeding pairs in 2002 (Van Mantgem 2002), down from 23 pairs in 1999 (N. Brown, pers. comm., 2002). There is ongoing reconstruction of historic buildings at this park in areas of occupied burrows and foraging habitat. Although there is a burrowing owl management and mitigation plan in place to minimize the impacts, apparently not all of the mitigations are being followed and burrows are being closed without providing new burrows (N. Brown, pers. comm., 2002). At least 1 owl pair nested just north of CASHP along Highway 43 in 2000 (N. Brown, pers. comm., 2002). There are currently several breeding pairs at a site in Alpaugh and 3 owls at the Hebert Preserve that appear to be resident birds (K. Kreitin, pers. comm., 2002). R. Hansen reports that the James K. Herbert Wetland Prairie Preserve, near Highway 137 and Road 168 (owned and managed by Los Tulares Land Trust) has at least 5 known burrowing owl nests, as well as at least 3 wintering owls (N. Brown, pers. comm., 2002).

Kern County

The burrowing owl is known to have occurred historically near Buena Vista Lake, although it was "not common" there in the summer of 1907 (Linton 1908b; DeMay 1942).[65] Sheldon (1909) reported the species to be "common" south of Poso Creek during the summer of 1908. Historical records confirmed breeding at Semi Tropic in 1917, at Tejon Ranch in 1941, at Grapevine in 1962, and in Antelope Valley in 1964; and indicated

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62 Recent CNDDB observations in the Kettleman Hills area include: 2 owls in the foothills on the east side of Kettleman Plain, in 1989; 3 locations along the California Aqueduct at the Kings/Kern County line, on 6/3/96 and 6/4/96; and along Blakeley Canal, southeast of Kettleman City, on 3/15 and 3/23, 2001. Active burrow sites were also observed near Cross Creek, 1 mile south of Settlers Ditch, northwest of Visalia (4 adults), on 3/1/99; 4 miles northeast of Kettleman City, on 3/15 and 3/23, 2001; and 3.5 miles east of Kettleman City (5 active burrow sites), on 3/15 and 3/23, 2001 (CNDDB 2001).

63 Eggs were collected from Tulare on 4/20/1894 (NMNH 2001) and from Tipton on 3/27/36, where 3 nesting pairs were also observed (WFVZ 2001). Breeding season collection records include from Visalia on 4/1/1880 (NMNH 2001), 3 birds from Earlimart on 6/18/03 (NMNH 2001), and 3 birds from Tipton on 4/27/11 (MVZ 2001).

64 Recent CNDDB observations include: 1 mile west of Road 112, approximately 9 miles north-northwest of Visalia, on 6/26/90; at Colonel Allensworth State Historic Park, on 5/17/90; south of Cross Creek, 4.5 miles southeast of Traver, on 4/10/98 (CNDDB 2001).

65 Burrowing owl bones (likely not more than 500 years old) were taken from a Native American kitchen midden on the southwest shores of Buena Vista Lake from 1933-1934 (DeMay 1942). According to Linton (1908b) the species was "not common" around the lake during May and June of 1907.

probable breeding at Walker Pass in 1891, and at Weldon in 1911 and 1984 (Wheeler et al. 1941; CSUC 2001; MSB 2001; MVZ 2001; NMNH 2001; UCSB 2001; WFVZ 2001).[66] The California State University at Bakersfield campus had a small plot (40 acres) with burrowing owls: 23 owls were captured in 17 trapping sessions in July 1987 (Barrentine and Ewing 1988). There have been numerous recent observations of owls during breeding season throughout Kern County; breeding has been documented at the Kern National Wildlife Refuge in 1987, in the vicinity of the Tule Elk State Reserve in 1989 and 1990, near the Antelope Plain in 1994, along the California Aqueduct in the vicinity of Buena Vista Lakebed in 1998 and 1999, and in the vicinity of Grapevine in 2001 (CNDDB 2001).[67]

D. SAN FRANCISCO BAY AREA

The range of the burrowing owl in the San Francisco Bay Area encompasses all of Sonoma, Napa, and Marin Counties; the southwestern 5% of Solano County; the western 50% of Contra Costa County; the western 80% of Alameda County; and all of San Francisco, San Mateo, Santa Clara, and Santa Cruz Counties (DeSante et al. 1996).

Although there are historical records of confirmed breeding in every county in the San Francisco Bay Area, there are little data on the overall historical abundance of the burrowing owl in this area. The burrowing owl in the San Francisco Bay Area was historically "most numerous in parts of Alameda, Contra Costa, and Santa Clara Counties" (Grinnell and Wythe 1927). The species was documented to have been locally abundant in southwestern Solano County (at Benicia) in the 1920s and 1930s (WFVZ 2001), in Alameda County (at Newark) in the early 1900s (WFVZ 2001) and at the Oakland Airport in the 1960s (Thomsen 1971), in San

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66 Eggs were collected at Semi Tropic Ranch on 4/26/17 (MSB 2001); at an unspecified location in Kern County on 4/18/35 (WFVZ 2001); at Grapevine on 4/30/62 (WFVZ 2001); and at Blackwells Corners (2 sets) on 4/5/64 (WFVZ 2001). Single birds were collected from Walker Pass on 7/2/1891 (NMNH 2001), and from Weldon on 7/2/11 (MVZ 2001) and in spring 1984 (UCSB 2001). Single birds were collected from El Tejon Ranch on 6/28/41 (Wheeler et al. 1941) and from an unknown location in Kern County on 3/16/52 (CSUC 2001). There are non-breeding season collection records from Kelso Valley, 2 miles north of Sorell Ranch, on 11/28/33; and from 2 miles north of McKittrick on 9/12/47 (MVZ 2001).

67 Recent CNDDB observations in northwestern Kern County include: a pair of owls and a single owl at a den along the California Aqueduct near Lost Hills Road, on 3/26/96 and 3/27/96; 1 adult at a burrow site along the California Aqueduct northwest of Lost Hills, on 6/4/96; 1 owl along the California Aqueduct, southwest of Barker Road in the Antelope Plain, on 6/3/96 (2 owls were also seen here in October 1995); 2 adult owls at another site along the California Aqueduct southwest of Barker Road in the Antelope Plain, on 6/3/96; 1 adult and 2 juvenile owls northeast of Kecks Corner, north of Antelope Valley, on 6/23/94 (3 owls were flushed from 3 separate burrows here on 11/17/93); 1 adult observed at a burrow 2.5 miles south-southeast of Lost Hills, on 12/21/95; a pair of owls at a den along the California Aqueduct 2 miles east of Lost Hills Road, south-southeast of Lost Hills, on 5/16/98; 1 owl at a burrow along the California Aqueduct south of Lost Hills Road, on 7/15/96 (a second owl was observed nearby on 5/16/96 and 7/15/96); 4 adults and 1 juvenile at the Kern National Wildlife Refuge, in 1987; an unknown number of owl colonies at 2 sites at Semitropic Ridge, between 6/13/82 and 6/19/82; and an unknown number of owl colonies 1 mile west of Delano, between 6/13/82-6/19/82 (CNDDB 2001).

Recent CNDDB observations in western Kern County include: 3 owls (1 flying from a burrow) northeast of Buena Vista Lake Bed, on 9/21/88; 3 owls at a burrow 2.5 miles north-northeast of Tupman, on 6/14/89 (2 adults and 2 juveniles were also seen at this site on 6/21/90); 1 owl near I-5 and Buttonwillow Road, 4 miles north of Buttonwillow, on 3/13/90; owls at 5 locations in the vicinity of Tule Elk State Reserve (3 adults and 4 juveniles were seen at a burrow here on 6/11/89 but by 6/14/89 the burrow had been run over; 2 adults and 6 juveniles were seen on/around the burrow on 6/23/90; 3 adults and 3 juveniles were seen at a 2nd burrow during June 1990; 3 adults and 3 juveniles were observed at a 3rd burrow during June 1990; 2 adults and 3 juveniles were seen at a 4th burrow during June 1990; 3 adults and 2 juveniles were observed at a 5th burrow during June 1990); 2 adults at a burrow along the California Aqueduct, near Tupman Road, on 10/3/94 (owls have used a cluster of burrows here for an extended period of time); 5 adults 3.2 air miles northwest of Tupman, on 6/5/96; 4 burrows and 4 owls northwest of Fellows, on 4/28/98; 1 adult and 1 juvenile along the California Aqueduct at Maricopa Flat, on 8/25/98; 2 adults at a burrow northwest of Fellows, on the western edge of Midway Valley, on 3/17/99; 2 owls at burrows 6 miles northeast of McKittrick on 3/24/99; 3 owls at a burrow west of Buttonwillow, on 4/15/99; 1 adult at a burrow near Crocker Canyon Road, 6.5 miles west of Fellows, on 4/21/99; 1 adult and 3 juveniles along the California Aqueduct southeast of Taft, on 4/27/99; 1 adult at a burrow along the California Aqueduct, on the west side of Buena Vista Lake Bed, on 2/8/2000; 2 adults at a burrow at Richfield oil pumping station, on the southwest side of Buena Vista Lake Bed, on 4/6/2000 (1 adult was observed here on 2/8/2000); and 1 adult at a burrow 3 miles east-southeast of the intersection of Skyline Road and Elk Hills Road, on 3/22/2000 (CNDDB 2001).

Recent CNDDB observations in the vicinity of Bakersfield include: 3 owls approximately 6 miles east of Edison, reported in 1987; 1 owl and a burrow near Brimhall Road and Calloway Drive, on the west edge of Bakersfield, reported in 1987; 1 owl near a burrow near Calloway Drive and Coffee Road, approximately 3 miles west of Bakersfield, reported in 1987; 2 burrow sites with at least 2 adults near Bear Mountain Blvd., east of Arvin, on 1/29/90 (CNDDD 2001).

Other recent CNDDB observations in Kern County include: 3 owls in the vicinity of Tejon Ranch, west of the Tehachapi Mts., on 1/29/90; 5 owls in the Rand Mountains, 6 miles southwest of Garlock, on 7/10/92; and 1 adult and 1 juvenile near I-5 and the California Aqueduct, southwest of Wheeler Ridge, on 7/9/2001 (CNDDB 2001).

Mateo County (at Redwood City) in the 1800s (WFVZ 2001), in Santa Clara County (at Palo Alto) in the early 1900s (WFVZ 2001), and in Santa Cruz County in the 1800s and early 1900s (Skirm 1884; McGregor 1901).

DeSante and Ruhlen (1995) estimated that 165 pairs of owls remained in the southern San Francisco Bay Area in the mid 1990s, about 1.8% of the state breeding population. This likely represented a decline of about 53% from the period 1986-1990 (DeSante and Ruhlen 1995; DeSante et al. 1997). Over 65% of Bay Area owl colonies known in the 1980s were gone by the 1990s, and even when new groups located during the 1990s were included, there was still a 51% decline in colonies (DeSante and Ruhlen 1995). Except for a few pairs in the Livermore Valley and a population at Camp Parks in Dublin, virtually all the remaining owls are located in a crescent extending around the southern end of San Francisco Bay, from Palo Alto to Milpitas, north of Highway 101. Almost all the birds are located in parks or in developed urban settings. Breeding owls have now been extirpated from Napa, Marin, San Francisco, and Santa Cruz Counties, and have been nearly eliminated from Sonoma and San Mateo Counties. No breeding pairs have been observed recently on the Bay Area coast, despite the fact that small populations existed in the 1980s. Burrowing owl populations around the north end of San Francisco, San Pablo, and Suisun Bays have been reduced to remnants or extirpated.

Sonoma County

Historical records confirmed breeding at Cotati in 1900, at Santa Rosa in 1901, at Stony Point in 1913, and near Petaluma in 1939; and indicated probable breeding at Petaluma and at Freestone in 1870, at Cotati in 1898 and 1900, and at Napa and Santa Rosa in the 1920s (Storer 1926; Grinnell and Wythe 1927; FMNH 2001; MVZ 2001; PMNH 2001; WFVZ 2001; CAS 2002a).[68]

By the 1970s, when a steady decline in numbers had been reported in Sonoma County for decades (Remsen 1978), the burrowing owl was still an uncommon permanent resident in the open areas of the county, becoming numerous and more widespread in winter (Bolander and Parmeter 1978). Breeding owls were nearly extirpated from Sonoma County by 1987 (Burridge 1995); an extensive census begun in 1991 (DeSante and Ruhlen 1995) confirmed that perhaps only one or two breeding pairs remained in the early 1990s. The last confirmed breeding in the county was at Skaggs Island in 1986 (Burridge 1995).[69]

Napa County

There are several historical non-breeding season records from Napa County, but no records of burrowing owls in northern Napa County since 1963 (Fisher 1900; Grinnell and Wythe 1927; Remsen 1978; MVZ 2001).[70] Breeding burrowing owls have been extirpated from Napa County since the 1980s (DeSante and Ruhlen 1995).[71]

Marin County

Mailliard (1900) as well as Stephens and Pringle (1933) noted the burrowing owl to be a year-round resident in limited areas of Marin County. Historical records indicated probable breeding at Nicasio in 1879

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68 Eggs were collected from an unspecified location in Sonoma County on 5/15/1891; from Cotati on 5/12/1900 (2 eggs sets), from the Walker Tract, Santa Rosa, on 5/13/01; from Stony Point on 5/10/13; and from 4 miles southeast of Petaluma on 5/10/39 (WFVZ 2001). A male and female were collected from Petaluma on 8/27/1870; a single bird was collected from Freestone on 8/29/1870 (PMNH 2001). Two juvenile birds were collected from Cotati on 6/7 and 7/7, 1900, and adult birds were collected there on 1/23, 1/24, and 6/9 (2 birds), 1898 and 7/7/1900 (FMNH 2001; CAS 2002a). There are non-breeding season records from Santa Rosa on 10/8/01 and 12/24/02 (MVZ 2001; CAS 2002a).

69 There were subsequent observations of single birds in Sonoma County, 1 near the old Santa Rosa Air Center in southwestern Santa Rosa (where burrowing owls had traditionally nested for many years), and another near Sears Point, close to Skaggs Island. The CNDDB has a record of an owl flushed from its burrow at upper Tubbs Island, approximately 1.5 miles northeast of Sears Point on 10/22/88 (CNDDB 2001). Surveys by the Madrone Audubon Society in 1997 at Skaggs Island and numerous other known historical nesting areas in Sonoma County found no breeding pairs (Leaves Newsletter, Volume 31, Number 1).

70 Owls were recorded from vicinity of Mt. St. Helena (Fisher 1900; Grinnell and Wythe 1927). Single birds were collected from Sears Point Cut-Off Road on 10/19/37 and from Huichica Creek on 11/24/39 (MVZ 2001).

71 A single bird was collected from Napa on 10/19/85 (MVZ 2001).

(CAS 2002a).[72] The owl was still a "relatively common resident" of open fields around Tomales Bay in 1971 (R. Johnson et al. 1971). Although there were several non-breeding season observations in the 1980s, the last evidence of breeding birds was at Terra Linda in 1976 and 1977, by which time the species was considered to be a very rare, very local breeder, with a very small overall breeding population (Shuford 1993; CNDDB 2001).[73] Breeding owls have been completely extirpated from Marin County since the 1980s (DeSante and Ruhlen 1995).[74]

Southwestern Solano County

Burrowing owls were apparently quite abundant at and near Benicia in the 1920s and 1930s; breeding owls were documented at Benicia before 1922, in 1927, 1930, 1932, 1933, and 1936 (Stoner 1922, 1932a, 1932b, 1933a; WFVZ 2001).[75] Burrowing owl nests were abundant enough that multiple sets of eggs were collected at Benicia; 7 sets on a single day in 1927, 4 sets over 3 days in 1930, 7 sets on a single day in 1932, and 5 sets on a single day in 1933 (WFVZ 2001). There were non-breeding season observations made northeast of Vallejo in the late 1970s and early 1980s (CNDDB 2001), but recent breeding season observations in southwestern Solano County could not be located.[76]

Western Contra Costa County

Historical records indicated probable breeding at Albany in 1922 and at Richmond in 1936 (MVZ 2001).[77] Recent breeding season observations from western Contra Costa County could not be located.

Alameda County

There are confirmed breeding records from Oakland in 1879 and 1881, Hayward in 1907, and numerous records in Newark from 1905 to 1914 (FMNH 2001; MVZ 2001; WFVZ 2001; CAS 2002a).[78] Historical records indicated probable breeding in Hayward and Fremont in the 1880s, in Berkeley in 1911, in Albany in 1922, and at Livermore in 1896 (FMNH 2001; MVZ 2001; PMNH 2001).[79] Burrowing owls were "fairly common" residents in Newark (as evidenced by large collections of eggs) through the 1950s, but suffered a "steady, marked decline" through the 1980s due to habitat loss from conversion of fields to urban and commercial development (CNDDB 2001; WFVZ 2001).

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72 There is a breeding season record from Nicasio on 3/24/1879 (CAS 2002a). Single birds were also collected from Tiburon in September 1897 (McGregor 1898), from Mill Valley on 9/30/28 (CAS 2002a), and from Fort Barry on 1/21/45 (MVZ 2001). Grinnell and Wythe (1927) observed the species in the drier portions of Marin County.

73 Non-breeding season records include: successive sightings of several owls residing near Abbott's Lagoon at Point Reyes National Seashore, in 1983; and a colony of at least 3 owls observed at St. Vincent School, approximately 1 mile south of Hamilton Air Force Base, on 1/30/84 and 2/6/84 (CNDDB 2001).

74 The U. S. Army Corps of Engineers reported burrowing owls nesting along airfield runways and levees at Hamilton Air Force Base through 1993 (USACE 1991, 1995), but owls were not found there during a 1994 field survey (USACE 1998).

75 Stoner (1922) reported capturing burrowing owls in Benicia before 1922. Stoner documented a "few" nests, a nesting female with eggs he had banded in 1930, a road-killed bird in 1932; and a few nests in 1933 (Stoner 1922, 1932a, 1932b, 1933a).

76 CNDDB records include an observation just off Susan Road, northeast edge of Vallejo in 1979; and non-breeding season observations made during the annual Benicia Christmas Bird Count on the lower slopes of Sulphur Springs Mountain, northeast of Vallejo (3 owls on 12/30/79; 1 owl on 12/28/80; 1 owl on 12/27/81; and 1 owl on 12/18/83), although no owls have been observed there since 1983 (CNDDB 2001).

77 A bird was collected from Albany on 3/13/22 (MVZ 2001). An owl was collected at Yacht Harbor in Richmond on 4/26/36 – birds were also collected there on 10/21/38 and in 1966 (MVZ 2001). Non-breeding season collection records include: from San Pablo on 12/27/08; from Point Richmond on 2/27/09; from Rogue Ranch, 4 miles from Concord on 1/7/20; and from El Sobrante on 11/28/73 (MVZ 2001).

78 Eggs were collected from Adams Pasture in Oakland on 4/25/1879 (MVZ 2001), and 2 female birds were collected and a nest with 5 fresh eggs observed in April 1881 in Oakland (FMNH 2001). Eggs were collected from Newark on 5/2/05; on 4/16 and 5/11, 1906; on 4/3/07; on 4/11/10; on 4/14 and 5/10, 1911; on 4/1/12; on 3/25/13; and on 4/4 and 4/10 (3 sets), 1914 (WFVZ 2001; CAS 2002a). Three juvenile birds were collected at Hayward on 7/4/07 (CAS 2002a).

79 A male bird was collected on 5/23 and a female collected on 9/29, 1881, in Hayward (PMNH 2001). A single bird was collected from Warm Springs in the Fremont area, on 4/12/1889 (MVZ 2001). A single bird was collected in Berkeley in March 1911 (MVZ 2001). Subsequent non-breeding season records from Berkeley include single birds collected at Carleton and Dana Streets on 11/22/36 and on the U. C. campus on 10/26/39 (MVZ 2001); and a bird seen on 1/10/37 (Carter 1937). A single bird was collected in Albany on 3/13/22 (MVZ 2001). A bird was found on Fruitvale Ave. on an unknown date in the 1930s (Grinnell 1936). A male bird was collected in Livermore on 4/7/1896 (FMNH 2001).

Formerly large owl colonies in Alameda County along the Bay shoreline have been severely reduced in size. A population at the Oakland Airport studied by Thomsen (1971) from 1964 to 1966 was once "one of the largest populations of burrowing owls in the Bay Area," with significant breeding populations remaining at the airport and around San Leandro Bay and Bay Farm Island in the 1970s and 1980s.[80] There are now very few birds left in this population (L. Trulio, pers. comm., 2001). A large former breeding colony at Jarvis Landing in Newark in the 1970s is now extirpated (CNDDB 2001).[81]

Along eastern San Francisco Bay, there are currently only 5-10 nesting pairs of owls remaining from Newark to Fremont, and also a few pairs near the bay edge (including at Don Edwards National Wildlife Refuge in Newark, Hayward Regional Shoreline in Hayward, the Oakland Airport and Martin Luther King Jr. Regional Shoreline in Oakland) up to Alameda (CNDDB 2001; L. Trulio, pers. comm., 2001, J. DiDonato, pers. comm., 2003).[82] Dwindling pairs of owls remain in scattered locations in Dublin (including a colony at Camp Parks), Pleasanton, and the Livermore Valley (CNDDB 2001; L. Trulio, pers. comm., 2001; M. Ricketts, pers. comm., 2002).[83]

San Francisco County

Historical records confirmed nesting in San Francisco, and indicated probable nesting on the San Francisco peninsula in 1909 and 1915 (Ray 1916; Hansen and Squires 1917; MVZ 2001; NMNH 2001).[84] Owls were historically observed as wanderers near Lake Merced (Grinnell and Wythe 1927), and were recorded in Golden Gate Park by Mailliard (1930). The last breeding season record from the City of San Francisco was in 1972 (MVZ 2001).

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80 The population at the Oakland Airport observed by Thomsen (1971) consisted of 18 breeding adults which produced 40 young in 1965 and 18 breeding adults which produced 31 young in 1966. Two pairs of owls were observed at Bay Farm Island, northwest of Oakland International Airport in 1983; and southeast of San Leandro Bay, several juveniles were observed in 1982 and 2 owls were seen at burrows in 1983 (CNDDB 2001).

81 There were repeated observations of up to 16 individual owls at Jarvis Landing, on the east end of the Dumbarton Bridge, between 1972 and 1979 (CNDDB 2001).

82 CNDDB records indicate that a population along the Hayward shoreline showed a marked decrease from 1990 when at least 4 owl pairs were present, to 1991, when a single owl pair was observed during breeding season (lack of grazing is cited as the reason for decline) (CNDDB 2001). Recent CNDDB records from Newark include: 2 adults and 5 juveniles at a burrow site on the east side of Coyote Hills, on 6/29/93 (the main threat here is predation by the introduced red fox); 2 pairs (1 pair with 2 young) in a burrow complex on Cherry Street, near Mowry Ave., from mid-June to mid-July, 1998; and 1 pair at another burrow site near the intersection of Cherry Street and Mowry Ave. on 7/22/98 (this site was threatened by disking) (CNDDB 2001). Burrowing owls nested at the Alameda Naval Air Station along the airfield runway and along the levees through 1993, but were not found there during a 1994 field survey (USACE 1998). There are small remnant non-breeding owl populations on East Bay Regional Park District lands at Hayward Shoreline (1 or 2 owls with no successful breeding – the population here has declined since the early 1990s mostly due to land management changes and predation by the red fox) and at Martin Luther King Jr. Shoreline Park (from 1 to 5 birds depending on the season, with no successful breeding) (J. DiDonato, pers. comm., 2003).

83 The Dougherty Valley in the San Ramon area south of Mt. Diablo is undergoing rapid urban development with associated owl habitat loss. According to the EIR for the Dougherty Valley Project, burrowing owls have been sighted recently throughout the Dougherty Valley, adjacent to Camp Parks in east Dublin (the entire valley is slated for intensive urban development). The complete number of breeding pairs in the Valley has not been quantified, but 2 pairs were confirmed breeding in 2001 in the middle of grading operations (M. Ricketts, pers. comm., 2002). One of the pairs fledged at least 6 young, while the other fledged 2. The young were excluded from their burrow complexes immediately after fledging (using one-way doors) to make way for grading. As with most passive relocation efforts, the final whereabouts of both the fledgling and adult owls are unknown. Subsequent passive relocation efforts in the winter of 2001-2002 prevented the establishment of nesting territories within the 2002 grading limits. Although the direct mortality of individuals was avoided, loss of nesting and foraging habitat continues in this area.

Five owls were observed at a burrow site near Coronado Lane and Hopyard Road in Pleasanton, on 10/17/90 (this site was threatened by continued development into a business park) (CNDDB 2001).

CNDDB observations in the Livermore valley include: individual sightings from 1979 to 1982 near Dagnino Road and Raymond Road, on the northeast edge of Livermore; many sightings from 1973 to 1978 (as many as 6 owls at one time) at Springtown, in northeast Livermore; 1 pair occupying a burrow at Springtown Alkali Sink, in 1993 (this site is threatened by ORV's, altered burn regime, refuse dumping, and invasion by exotic plants); a pair of owls near Dalton Ave. and Ames Street, in Livermore, on 4/20/93 and 5/10/93; and an unknown number of nesting owls near Hartford Ave. and North Livermore Ave., north of Livermore, between March and August 1997 (this site is threatened by a proposed development) (CNDDB 2001). Owls and evidence of occupied nests were observed from February-April 1999 in west Livermore (this site is threatened by a proposed business park, with no acknowledgement of the species' presence nor any mitigation), and near the Livermore Airport in 1999 and 2000 (L. Tung, pers. comm., 2000).

84 The NMNH (2001) has 3 eggs collected from San Francisco, unknown date. Two birds were collected from Ingleside Race Track, San Francisco on 3/15/09 (MVZ 2001). Three owls were spotted at the entrance of a used burrow just south of Visitacion Ave., in February 1915, and several other owl burrows were observed at the time (Ray 1916). A burrowing owl was also captured at 43rd Ave. and Fulton St. in February 1916 (Hansen and Squires 1917).

Burrowing owls historically bred on the Farallon Islands off of San Francisco. Indicative of probable breeding, Bryant (1888) recorded two birds there in the spring of 1887. Dawson (1911, 1923) found a single owl on S. E Farallon in 1911, reporting it to be "a sole survivor, we were informed, of a former breeding colony" that had been shot off because of their persecution of smaller migrant birds. A single burrowing owl egg collected on the Farallones in spring 1911 was donated to the Point Reyes Bird Observatory in 1971 (DeSante and Ainley 1980). DeSante and Ainley (1980) presumed owls must have nested there for only a few years, since there are no other reports of breeding, although remains of owls were found on South Farallon Island in June 1958, June 1964, and May 1965 (Bowman 1961; Tenaza 1967) and single birds were collected from Southeast Island in April 1972, March 1986, and June 1988 (MVZ 2001; CAS 2002a).[85]

Breeding burrowing owls have been extirpated since the 1980s from San Francisco County (DeSante and Ruhlen 1995).

San Mateo County

Historical records confirmed breeding at Redwood City in 1898 and indicated probable breeding at Menlo Park in 1906 (MVZ 2001; PMNH 2001; WFVZ 2001; CAS 2002a).[86] Collector C. Littlejohn, who collected 2 sets of eggs at Redwood City in the summer of 1898, remarked that although owls were "very numerous" previously, the nests he found were the first seen in 25 years of looking (WFVZ 2001).

Breeding owls were nearly extirpated from San Mateo County by the 1970s (Remsen 1978) and perhaps only 1 or 2 breeding pairs now remain (DeSante and Ruhlen 1995; C. Breon, pers. comm., 2001).

Santa Clara County

At the turn of the century, the western burrowing owl was a common bird of Santa Clara County (Price 1898; Van Denburgh 1899; Fisher 1904). Historical records confirmed breeding in the Santa Clara Valley in 1882, east of Los Gatos in 1890, southeast of Milpitas in 1892, in East San Jose in 1902, and near Palo Alto in 1892, 1901, 1909, 1911, and 1940 (FMNH 2001; MVZ 2001; SBMNH 2001; WFVZ 2001; CAS 2002a).[87] There are breeding season records of owls from Milpitas in 1883, Stanford in 1893, Alviso in 1901, Steven's Creek in 1903, and Jasper Ridge at Stanford University in 1909 (MVZ 2001; CAS 2002a).[88] Egg collector J. Snyder remarked that the species was common near Palo Alto in 1909 (WFVZ 2001). In 1927, Grinnell and Wythe wrote that the bird was still a "fairly common resident in the drier, unsettled interior parts of the [Bay Area] region," being most abundant in Alameda, Contra Costa, and Santa Clara Counties. However, accounts suggest that by the late 1930s and early 1940s the species was beginning to decline. J. Snyder found burrowing owls to be "very rare" in Palo Alto by 1939, due to lack of ground squirrels to prepare the nesting burrow (WFVZ 2001). The species was noted to be further decreasing in Palo Alto in the 1970s (Remsen 1978).[89]

In Santa Clara County, detailed records of owl locations and their fate are most complete from the early 1980s onward, when the county began experiencing explosive human population growth. In 1989, the

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85 DeSante and Ainley (1980) characterized the owl as an uncommon visitor to the South Farallon Islands in the fall (approximately 50 fall visitors had been recorded), and a rare resident in winter (a total of 15 birds were recorded, with from 1 to 3 individuals wintering each year), based on Point Reyes Bird Observatory bird counts from 1968-1975. Most wintering birds disappeared by March or April.

86 Eggs were collected from Redwood City on 6/13 and 7/9, 1898 (WFVZ 2001). Birds were collected from an unspecified location in San Mateo County on 2/6 and 5/4, 1896 (PMNH 2001); and 2 birds were collected from Menlo Park in 1906 (MVZ 2001). Non-breeding season records include from Palo Alto in October 1897 (McGregor 1898), and from Redwood City on 2/13/14, and 11/6, 11/10, 11/23, and 11/27, 1892 (CAS 2002a).

87 Eggs were collected from the Santa Clara Valley on 5/13/1882 (SBMNH 2001); from 8 miles east of Los Gatos on 5/31/1890 (CAS 2002a); from Stanford University on 5/28/1892 (CAS 2002a); from Berryessa, southeast of Milpitas, on 5/28/1892 (FMNH 2001); from East San Jose on 4/1/02 (WFVZ 2001); from near Palo Alto on 5/12/09 (WFVZ 2001) and 5/2/11 (MVZ 2001); and from East Palo Alto on 5/27/40. Juvenile birds were collected during breeding season from Palo Alto on 7/6 and 7/14, 1901 (CAS 2002a).

88 Breeding season records include from Steven's Creek on 3/10/03 (MVZ 2001); Milpitas on 8/20/1883 (CAS 2002a); Stanford on 8/28/1893 (CAS 2002a); Jasper Ridge at Stanford University on 3/31/09 (CAS 2002a); and Alviso on 5/4/01 (CAS 2002a).

89 A colony of 5 adults was documented near the Palo Alto dump on 7/3/74 (Stallcup and Greenberg 1974).

consulting firm of H.T. Harvey & Associates compiled a list of 215 sites where burrowing owls were observed between 1984 and 1988 (H. T. Harvey and Associates 1994). Many of these observations were anecdotal and many others were sites confirmed as part of on-going research or systematic owl observation. H.T. Harvey and Associates found that 97% of the sites supported fewer than 10 birds and 81% supported only 1 or 2 birds (H. T. Harvey and Associates 1994).

In the summers of 1995 and 1998, Trulio (1998a) re-surveyed 123 of the 215 occupied sites identified by H. T. Harvey and Associates (1994).[90] The sites were located in the cities of Palo Alto, Mountain View, Sunnyvale, Santa Clara, and San Jose, including Alviso. Moffett Airfield and San Jose Airport, 2 sites not available to development, were excluded from the survey. The survey results showed a steady decline in remaining owl habitat. In 10 years, 70 of 123 sites (57%) were lost to development, an average of almost 6% per year. Another 12 sites (10%) were reduced in size or habitat quality.[91] At this rate of loss, Trulio (1998a) predicted that all remaining sites on private or city owned land could be lost by 2005.

From their surveys, DeSante and Ruhlen (1995) estimated that approximately 60% of known owl locations in Santa Clara County were lost between the early 1980s and 1993. By 1997, the breeding owl population in the county had dwindled to about 120-141 pairs, distributed in a crescent around the southern San Francisco Bay, with most owls in Mountain View and San Jose (J. Barclay pers. comm., 2002). J. Barclay (pers. comm., 2002) estimates 43 to 47 owl pairs remained in San Jose in 1997 and 39 to 40 pairs remained in 2000, based on a thorough census of 50 previously known breeding locations.

In 2002, Trulio resurveyed 111 of the sites listed by H.T. Harvey that were located on private land. By 2002, only 27% of these 111 locations still contained suitable owl habitat; 66% had been developed completely and 7% were significantly reduced in size (Trulio in press). A number of large sites were not included in this survey because they were on public land and were the subject of more detailed observations. These sites, Bixby, Shoreline and Sunnyvale Baylands Parks, Moffett Federal Airfield, Mission College in Santa Clara, and the San Jose Airport, all continued to support more than 10 owls each in 2002 (J. Barclay, pers. comm., 2002). At these locations, researchers have collected specific data on the number of owls over time. These data show that the numbers of breeding owl pairs have fluctuated over the years.

At Bixby, Shoreline and Sunnyvale Baylands Parks, where little development has occurred, numbers have remained relatively stable since 1997. The 2002 owl population at Shoreline Park in Mountain View was 5 breeding pairs, up from an average of 3 pairs the previous 10 years (P. Delevoryas, pers. comm., 2002).[92] At Moffett Airfield, which has had little development, breeding owl pairs have fluctuated from a high of 30 pairs to a low of 15 (Trulio 2002, amplified by pers. comm., 2002).[93] During this period, the number of breeding pairs at Mission College declined from approximately 30 pairs (Buchanan 1996) to 9 active burrows (Trulio 2002, amplified by pers. comm., 2002); the decline is the result, in large part, of habitat loss at Mission College due to urban development.[94] At San Jose Airport, active management has helped to substantially increase the number of breeding pairs from approximately 15 pairs in 1988 to 40 pairs in 2002 (J. Barclay, pers. comm., 2002).

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90 H. T. Harvey and Associates (1994) found that on 97% of the sites there were 10 or fewer owls, and on 81% just 1 or 2 birds survived.

91 Trulio listed sites completely developed as "lost," those diminished in size or habitat quality as "reduced," and those which could still support a pair of owls as "extant."

92 4 adults and 2 fledglings were observed near Rengstorff Ave. and Charleston Ave., near Mountain View Shoreline Park, in late April 1982. Development of this site began in January 1983, and the last owl observation here was of 2 adults in February 1983. 8 adults (4 pairs) and an unknown number of juveniles were seen at Long Point shoreline at Mountain View Park, north of Moffett Naval Air Station, on 6/22/93 (CNDDB 2001). 13 adults and 16 young were seen at Shoreline Park in 2002 (P. Delevoryas, pers. comm., 2002).

93 Annual counts of breeding pairs at Moffett Field in recent years have fluctuated from 18 to 27 (CNDDB 2001); J. Barclay (pers. comm.. 2002) estimates 35 pairs currently reside at Moffett Field.

94 According to the Mission College web site the breeding population of owls there has recently fallen from 60 owls to about a dozen birds in recent years (15 pairs were recorded in 1998, 6 of which nested successfully, producing 14 chicks; 8 pairs in 1999, 3 of which nested successfully, producing 15 chicks; 7 pairs in 2000, 6 of which nested successfully, producing 13 chicks (only 10 fledged); and 8 pairs in 2001).

Small colonies of owls also persist in Alviso (currently estimated at 15 pairs), San Jose, Santa Clara, and Milpitas (CNDDB 2001; J. Barclay, pers. comm., 2002).[95] Formerly large owl populations in the northern San Jose/Alviso area and City of Santa Clara have been significantly impacted in recent years (CNDDB 2001; J. Barclay, pers. comm., 2002) and former colonies known in urban Sunnyvale in the 1980s and early 1990s have likely been extirpated (CNDDB 2001; D. Plumpton, pers. comm., 2002).[96] Breeding owls may have been extirpated recently from Morgan Hill as well (J. Barclay, pers. comm., 2002).[97]

Santa Cruz County

Historical records confirmed breeding at Santa Cruz in 1882 and 1901 (McGregor 1901; SBMNH 2001; WFVZ 2001).[98] Skirm (1884) described the species as "common" in Santa Cruz County and reported collecting eggs. McGregor (1901) described it as a "fairly common" breeding bird of Santa Cruz County, noting that "fresh eggs can be found at Santa Cruz about April 15." By mid-century, Streator (1947) reported that the species was "now rare due to the poisoning of ground squirrels" around Santa Cruz.

The species had "greatly declined" in Santa Cruz County by the 1970s (Remsen 1978), with only 2 recently reported sightings – one in February 1969 on the lower UC Santa Cruz campus; another near Moss Landing elementary school (Gordon 1974). Warrick (1982) reported on a population of about 20 burrowing owls inhabiting grasslands on the U. C. Santa Cruz campus that apparently wintered there, as well as nested (CNDDB 2001).[99] Burrowing owls have not been documented nesting on the campus since 1987, although owls of unknown origin still occur there in the winter (J. Barclay, J. Linthicum, pers. comm., 2002).

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95 A small owl colony (2 adults and 3+ juveniles seen on 6/14/2000; and 4 owls seen in January 2001) has been observed north of Hwy. 237, near Los Esteros Road and North First Street, in Alviso (CNDDB 2001).

Significant breeding populations remain in San Jose at the San Jose International Airport (28 adults/19 juveniles seen in 1990; 12 adults/11 juveniles in 1991; 30 adults/68 juveniles in 1997; 50 adults/92 juveniles in 1998; 48 adults/101 juveniles in 1999; and 62 adults/129 juveniles in 2001) (CNDDB 2001) and in the Coyote Valley (3 families of burrowing owls with 16 to 22 adults and chicks were seen there in 1998). Recent CNDDB observations in San Jose include: 2 adults near Karina Court and North First Street, on 4/1/92; 4 owls at a den at the end of Nortech Parkway, 1 mile east of Alviso, on 8/4/93; near Airport Parkway and Guadalupe Parkway, east of the airport (4 adults and 2 juveniles seen on 8/28/93, 9 owls (2 adults, 7 juveniles) banded in 1993); a burrow with owl sign near Monterey Road and Curtner Road, on 3/10/93; 1 owl near a possible burrow site at Silver Creek Hills, on 3/2/2000; a burrow near Tully Road (Swift Lane) and Capitol Expressway (2 adults seen on 6/19/99, 2 adults and 3 juveniles seen on 6/21/2000, and 2 adults and 3 juveniles seen on 7/1/2001); 4 adults and 4 juveniles using 2 burrows on the south side of Devcon Court, from 4/17/2001 to 9/4/2001 (2 owls found dead in July 2001, likely killed by feral animals); and 2 adult owls at a burrow site north of Meadowfair Park, near Aborn Road and King Road, on 3 occasions in July 2001 (CNDDB 2001).

There are breeding owls at 3Com Corp, near Hwy. 237 and Great America Parkway (5 dead adult owls were collected here on 8/31/91); and east of Great America Amusement Park (1 adult and 1 juvenile were seen at a burrow site on 6/16/99, and 3 adults and 1 juvenile were seen on 7/2/2001) (CAS 2001).

There were owl observations in Milpitas and along Arroyo de las Coches Creek in June 1975 (CDFG 1975). 2 adults and 1 juvenile seen at a burrow near Curtis Ave. and South Main, on 9/15/98 (these owls were "passively excluded" on 10/26/98); and 2-3 adults were documented breeding along Barber Lane, west of I-880, in 1999 (these owls were excluded from the site on 10/18/99) (CNDDB 2001). Both sites were subsequently developed and the owls are extirpated (CNDDB 2001).

96 A breeding pair of owls was seen between Patrick Henry Jr. High School and Peterson High School - each year from 1981 to 1983 (1 young fledged in 1981, 1 in 1982, and 0 in 1983); there were active owl colonies near Fairoaks Ave. and Alviso Fwy., and near Hwy. 101 and Mathilda Ave., in northern Sunnyvale in 1983; a colony southeast of the junction of Coyote Creek and Alviso Slough, north of Sunnyvale, was extirpated by 1983; 2 pairs of owl were seen off Caribbean Drive, near Lawrence Expy. and Hwy. 237, on 6/10/99 (CNDDB 2001).

97 Burrowing owls may now be extirpated from Morgan Hill (there were 2 known breeding pairs in 2000, only 1 adult in 2001, and no known owls in spring of 2002) (J. Barclay, pers. comm., 2002). Recent CNDDB observations in Morgan Hill include: 1 adult at a burrow site near Day Road, southeast of Lions Peak, south of Morgan Hill, on 12/24/92; 2 owls at burrows in Kirby Canyon, 3 miles north of Morgan Hill, from 1991-93; a burrow with signs of occupation, 2 adults, and 1 recently-fledged juvenile near Cochran Road and Hwy. 101, north of Morgan Hill, on 7/14/2000; and El Toro School, and near Calle Mazatlan and East Central Ave., Morgan Hill (1 owl seen on 6/3/98; 2 owls seen shortly after a disturbance created by grading; 2 adults and a maximum of 4 juveniles seen between 6/9/2000 to 8/2/2000; only 1 adult seen during several visits from June to August 2001) (CNDDB 2001). No adults were seen in Morgan Hill in 2002 (J. Barclay, pers. comm., 2002).

98 Eggs were collected from Santa Cruz on 5/20 and 6/1, 1882 (SBMNH 2001; WFVZ 2001) and on 4/15/01(McGregor 1901). There are non-breeding season records from San Andreas Road, in the vicinity of Watsonville on 12/29/37; and from Santa Cruz in 1900 and on 1/23/38 (MVZ 2001).

99 It was reported in 1987 that 2 adults and 2 juveniles were previously observed at the East Field, on the UC Santa Cruz Campus, north of Santa Cruz (this site was threatened by University expansion (CNDDB 2001). Fourteen owls were reported to winter on the campus in 1994, with an additional owl observed at a winter burrow site between Wilder Creek and Empire Grade, on 12/19/94 (CNDDB 2001).

Breeding burrowing owls have been extirpated from Santa Cruz County since the 1980s (DeSante and Ruhlen 1995), although wintering birds are often seen in dune and coastal grasslands (L. Trulio, pers. comm., 2001).

E. CENTRAL WESTERN CALIFORNIA

The range of the burrowing owl in central western California encompasses Monterey County; the western 75% of San Benito County; and San Luis Obispo and Santa Barbara Counties (DeSante et al. 1996).

Although there are historical records of confirmed breeding in every county in central Western California, there are little data on overall historical abundance of the burrowing owl in this area. The species was documented to have been locally abundant in Monterey County (around Aromas) in the 1930s (Gordon 1974), in San Benito County (at Paicines) in the late 1800s (Mailliard and Mailliard 1901), and in Santa Barbara County (at Santa Barbara) in the late 1800s (Streator 1886).

Breeding burrowing owls have been eliminated from these specific locations, extirpated from coastal San Luis Obispo County, and very nearly extirpated from coastal Monterey County and the western 75% of Santa Barbara County. DeSante and Ruhlen (1995) estimated that only 82 pairs of owls (0.5% of California's population) persist in the combined central coast, central interior, and southern coast regions. These owls are mostly in isolated pairs and very small groups, and are facing intense development pressure (DeSante et al. 1996).

Monterey County

Historical records confirmed breeding near Monterey in the 1890s and indicated probable breeding in Monterey in 1903 (FMNH 2001; MVZ 2001).[100] Burrowing owls were reported to be "fairly common" during summer (Willett 1908) and probably bred in the lower and upper Salinas Valley and surrounding foothills along the Monterey/San Luis Obispo County line (Roberson 1985; MVZ 2001).[101] Owls were probably breeding near Big Sur in 1903-1904 and in the Jolon Valley in 1909 (Pemberton and Carriger 1915),[102] but there are no known recent records of owls from these areas (Roberson 1985). Owls were "plentiful" around Aromas in the 1930s (Gordon 1974) and were found by Grinnell and Linsdale in 1934-1935 at Point Lobos Reserve (Drury 1953). Mowbray (1947) reported never seeing burrowing owls during 2 years of observations at Camp Roberts, in the Upper Salinas Valley, and concluded that they must be present in very small numbers if at all, as he visited all parts of the camp that were typical habitat for the owl.

Breeding was confirmed near Marina in 1972 and owls were thought to still occur within the Big Sur Planning Unit (coastal Monterey County south of Point Sur) in the 1970s (Gordon 1974; USDA 1978).[103] Roberson (1985) reported them to be a rare resident in the mouth of the Salinas Valley, noting that widespread cultivation had limited habitat to a few remaining colonies. A likely breeding colony was reported north of Castroville in the 1980s (CNDDB 2001).[104]

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100 Eggs were collected from 6 miles north of Monterey on 6/17/1897 and on 5/5/1899 (MVZ 2001). A single bird was collected from Monterey on 3/19/03 (FMNH 2001).

101 A single bird was collected from the Salinas Valley on 8/29/07, and 2 birds were taken 2 miles northeast of San Lucas on 7/16/19 (MVZ 2001). An owl was seen in June 1960 at Gonzales (Roberson 1985). There is a non-breeding season record from Blanco Road on the west side of Salinas on 10/3/36 (MVZ 2001).

102 Several owls were noted on bare hillsides near the ocean north of the Little Sur River during winter (December-January) of 1903-1904. Owls were seen from May-June of 1909 in the Jolon Valley, but according to Pemberton and Carriger (1915) the burrowing owl was "not a common bird at all" in this area.

103 In 1972 a family of burrowing owls was seen close to Hwy. 1, immediately north of Marina (Gordon 1974).

104 In 1983 owls were reported frequently observed (including a group of 8 owls) along Dolan Road, about 2 miles north of Castroville (CNDDB 2001).

Breeding burrowing owls have now been completely or very nearly extirpated (perhaps only 1 or 2 breeding pairs still exist) from coastal Monterey County (DeSante and Ruhlen 1995). A 1992 breeding owl survey located only 14 pairs in the entire county, centered near the City of Salinas and rangeland east of King City (Roberson 1993). Most recent observations of nesting colonies in Monterey County are from the Salinas River Valley (CNDDB 2001) and breeding was confirmed at the Salinas Airport in 1994 (J. Barclay, pers. comm., 2002).[105]

San Benito County

The burrowing owl was listed as a "common resident" (although scarce in some years) at Paicines, from 1888-1901 by Mailliard and Mailliard (1901). Historical records confirmed breeding at an unspecified location in San Benito County in 1889, and indicated probable breeding near Panoche in 1936 (MVZ 2001; OM 2001).[106] Other than a breeding pair of owls observed near Hollister since 1999 (P. Delevoryas, pers. comm., 2003), recent breeding season observations in San Benito County could not be located.[107]

San Luis Obispo County

Historical records confirmed breeding near San Luis Obispo in 1928, at McMillan Canyon in 1930, south of Coalinga in 1934, and near Simmler in 1949; and indicated possible breeding at Morro in 1939 and Cholame before 1940 (Roberson 1985; MVZ 2001; WFVZ 2001).[108] Breeding burrowing owls have been extirpated from coastal San Luis Obispo County since the 1980s (DeSante and Ruhlen 1995). A substantial breeding population of owls remains at the 200,000-acre Carrizo Plain Natural Area (managed by the Nature Conservancy, BLM, and CDFG) in eastern San Luis Obispo County, which is the largest area of undeveloped grassland habitat for burrowing owls in California (Rosenberg et al. 1998a; CNDDB 2001).[109] Large numbers of active owl nests can be found here during breeding season: 37 active nests were located in 1997, 32 nests in 1998, and 40 nests in 1999 (Rosenberg and DeSante 1997; Rosenberg et al. 1998b; Rosenberg 1999).[110]

Santa Barbara County

Historical records confirmed breeding at Santa Barbara in 1875 and 1885 (Streator 1886; NMNH 2001).[111] Streator (1886) noted that the burrowing owl was "common" at Santa Barbara in 1885. Bartholomew (1940) recorded 7 burrowing owl sightings in 1937 and 1938 in the upper Santa Ynez River and along the crest of the Santa Ynez Mountains.

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105 The species is currently known to occur within Monterey Bay Marine Sanctuary. Recent breeding season observations include: a single bird at King City on 4/14/94; several pairs of breeding owls at the Salinas Airport (2 adults and 4 juveniles observed on 7/10/94, and 1 pair observed in 1999); 6 birds reported and an additional 2 birds that appeared to have nested observed on 8/27/97 between Salinas and Santa Rita (this site was threatened by development); and 2-3 adult owls at Johnson Canyon, east-northeast of Gonzales, in April-May 1998, with 1 adult also observed there in December 1997 (this site was threatened by landfill expansion) (CNDDB 2001).

106 A clutch of 8 eggs were collected in San Benito County on 5/17/1889 (OM 2001), and an owl was collected from 3 miles northwest of Panoche on 7/10/36 (MVZ 2001).

107 A breeding pair of owls was seen north of the town of Hollister, 1 mile south of Shore Road along Highway 25. The birds were first observed in November, 1999 by John Delevoryas. A breeding pair of owls and young were observed from spring through fall in 2000, 2001, and 2002 by J. Delevoryas. Photographs were taken of 1 adult and 1 fledgling in June, 2002 by J. Delevoryas.

108 Eggs were collected 4 miles north of San Luis Obispo on 4/25/28; at McMillan Canyon on 4/9/30; at Cottonwood Pass, south of Coalinga on 3/24/34; and on the Carrizo Plains, near Simmler on 4/3/49 (WFVZ 2001). Single birds were collected from Morro on 1/13/39 and 2/7/39 (MVZ 2001). There is also a record from Cholame Flats pre-1940 (Roberson 1985).

109 Recent CNDDB observations at Carrizo Plain include 2 adults at the south end of Soda Lake, on 3/25/90, and numerous burrows with signs of occupation along Arrowbear Trail, on 3/25/90 (CNDDB 2001). Other recent non-breeding season observations in San Luis Obispo County include: 1 owl at a burrow and owl sign at several other burrows about 4 miles northeast of Cholame on 10/22/93 (all of these burrows were excavated in November 1993 with CDFG approval); 1 owl at a burrow at Camp Roberts Military Reservation, on 12/22/97; and single adult owls observed at 2 locations at Camp Roberts in 1998 (CNDDB 2001).

110 J. Gervais (pers. comm., 2003) believes the owl population at Carrizo Plains Natural Area is much larger than survey efforts indicate, due to a survey method limited to finding nesting pairs along roads.

111 An immature bird was collected at Santa Barbara on 7/1/1875 (NMNH 2001), and Streator (1886) noted that owls bred there in 1885.

There was probable breeding at Montecito and Santa Barbara in the 1970s (SBMNH 2001), but owl numbers had drastically declined in the Santa Barbara region by then (Remsen 1978).[112] The burrowing owl was uncommon, but not rare in the Santa Barbara area in the late 1970s and early 1980s, with owls seen at the U. C. Santa Barbara campus, Santa Barbara Airport, Goleta Slough, and Santa Barbara Community College (R. Panza, pers. comm., 2002).

Lehman (1994) noted that owls had been "formerly much more numerous," and were "nearly completely extirpated" from Santa Barbara County. By the 1990s only 1 or 2 pairs nested in fields west of Santa Maria and probably also in the Santa Ynez Valley (Lehman 1994).[113] The number of wintering birds had also declined severely during since the 1980s and an average of only 1 or 2 were seen each year along the South Coast east of Gaviota (Lehman 1994). Burrowing owls may possibly still nest in the San Marcos Foothills (SMFA 2002). Owls once nested at Vandenberg Air Force Base, but evidently have not bred there since 1979-1980 when 4-5 pairs nested in rangeland east of Pt. Arguello for 2 consecutive years (there have been only 3 summer records at Vandenberg AFB between 1977 and 1994); although there is still significant use of suitable habitat on the base by migrants and winter visitors (Holmgren and Collins 1999). Breeding burrowing owls have apparently been very nearly extirpated from the western 75% of Santa Barbara County (DeSante and Ruhlen 1995), and according to Lehman (1994), "the species' future [in Santa Barbara County] looks bleak."

F. SOUTHWESTERN CALIFORNIA

The range of the burrowing owl in southwestern California encompasses the southern 55% of Ventura County; the southern 50% of Los Angeles County; all of Orange County; the western 40% of San Diego County; the southern California islands; the western 25% of Riverside County; and the southwestern 5% of San Bernardino County (DeSante et al. 1996).

Although there are historical records of confirmed breeding in every county in southwestern California, there are little data on overall historical abundance of the burrowing owl in this area. The species was documented to have been locally abundant throughout Ventura County in the late 1800s (Evermann 1886), throughout western Los Angeles County from the late 1800s into the early 1900s (Willett 1912; FMNH 2001; MVZ 2001; NMNH 2001; WFVZ 2001), in western San Bernardino County (near Chino) in the early 1900s (WFVZ 2001), and throughout coastal San Diego County in the late 1800s (Emerson 1884; Van Dyke 1888; Sharp 1907).

Breeding burrowing owls have now been extirpated from coastal Ventura County and nearly eliminated from Orange, San Diego, and Los Angeles Counties (DeSante and Ruhlen 1995). The species is greatly reduced in numbers and is now quite local in coastal southern California. An estimated 260 nesting pairs (3% of California's population) persisted in the area in the early 1990s, representing a decline of about 57-85% since the mid 1980s (DeSante and Ruhlen 1995). Owls in Southern California west of the deserts exist at very low densities (much less than 0.01 pairs per square kilometer). Remaining owls in this area are now found only on undeveloped federal lands, having been almost entirely extirpated from private lands by urban sprawl. These owls are mostly in isolated pairs and very small groups, and are threatened by intense development pressure (DeSante et al. 1996).

Ventura County

In the late 1800s the burrowing owl was a "common and generally distributed" nesting bird throughout Ventura County (Evermann 1886). Historical records confirmed breeding at Simi in 1897; and indicated

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112 Single birds were collected from Sycamore Canyon, Montecito on 3/22/75, and from Child's Estate Zoo, Santa Barbara on 7/10/76 (SBMNH 2001).

113 Recent summer records from Santa Barbara County include an owl seen between July and October in 1984 on More Mesa in Goleta and pairs seen in June 1995 and June-July 1996 on the Santa Maria River levee; it is unknown whether the 1995 pair produced young and the 1996 nesting may have failed when the levee was graded and the nest destroyed (Holmgren and Collins 1999).

probable breeding at Ventura in 1906 and in the southern part of the county in 1911 (MVZ 2001; UCLA 2001; WFVZ 2001).[114] The species was known to occur in the 1970s in the Pine Mountain-Sespe-Wheeler Gorge area of the southern Los Padres National Forest, north of Ojai (Stebbins and Taylor 1973).

Breeding burrowing owls have been extirpated from coastal Ventura County since the 1980s (DeSante and Ruhlen 1995).[115]

Los Angeles County

Numerous historical records confirmed widespread breeding of owls throughout the entire region of what is now the urbanized Los Angeles area, from the 1880s through the 1930s (Hartzell 1888; McGregor 1898; Swarth 1900; Willett 1912; AMNH 2001; FMNH 2001; LACM 2001; MVZ 2001; NMNH 2001; UCLA 2001; WFVZ 2001; CAS 2002a).[116] The burrowing owl was apparently once an extremely abundant resident in the Los Angeles region (e.g. Willett 1912).

With urban development, burrowing owl numbers had gone way down in the Los Angeles region by the 1970s (Remsen 1978). There was confirmed breeding at Playa del Rey from the 1960s through the 1980s; probable breeding at Los Angeles and Hermosa Beach in the 1980s; and non-breeding season sightings in the Long Beach area from the 1950s through the 1970s (CNDDB 2001; CSULB 2001; LACM 2001; WFVZ 2001).[117] There were apparently "many" burrowing owls at the California State University, Long Beach campus in the past (C. Collins, pers. comm., 2002), but this population was extirpated by the early 1980s (P. Bloom, pers. comm., 2002). Breeding burrowing owls have most likely been nearly extirpated from southern Los Angeles County.[118] Small numbers of breeding burrowing owls persist in the Antelope Valley, in northeastern Los Angeles County; these birds are discussed in the section on the southern desert range, below. Recent raptor surveys throughout most of the Santa Monica Mountains National Recreation Area have bcated no nesting burrowing owls, although owls winter there (P. Bloom, pers. comm., 2002).

Orange County

Historical records confirmed breeding at Anaheim in the 1880s and in 1918; at Balboa Beach in 1920; at Buena Park in 1927, 1928, 1935, and 1938; at Newport Beach in 1931 and 1955-1964; near Sunset Beach in 1938; near Cypress in 1945, at Los Alamitos in 1958, Costa Mesa from 1955-1972, and Santa Ana from 1956-1959 (Robertson 1929, 1930; T. Howell 1964; FMNH 2001; LMDBL 2001; SBMNH 2001; WFVZ 2001; J.

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114 Eggs were collected at Simi on 5/10/1897 (WFVZ 2001). There are bird collection records from Ventura on 4/21/06 (MVZ 2001) and from the southern part of county on 5/27/11 (UCLA 2001).

115 There is 1 recent breeding season record from upper Dry Canyon, approximately 2 miles north of Simi Valley, on 3/27/90 (CNDDB 2001).

116 Eggs were collected from: El Monte on an unknown date (FMNH 2001); Los Angeles County in March 1884 (Hartzell 1888); the City of Los Angeles on several occasions in June 1885 (Hartzell 1888; WFVZ 2001), 6/4/1886 (FMNH 2001), 6/25/1887 (NMNH 2001), 1892, 5/30/1893, 5/8/1895, 5/15/1895, 4/11/1898, 4/14/1898, 5/9/1898, 5/24/03, 5/31/03, and 5/2/04 (WFVZ 2001); Anaheim on 5/21/1887 (NMNH 2001); Pasadena on 5/4/1889, 4/26/1892, and 6/11/1894, near Pasadena on 4/17/1895 (MVZ 2001; WFVZ 2001); Barley Field, near Harbor City, in June 1902 (Willett 1912), 4/29/04, 4/26/14, 5/17/14, 5/31/14, 4/18/16 (WFVZ 2001); San Pedro on 5/19/08 and 5/9/09 (FMNH 2001; WFVZ 2001); Hermon Hills, Los Angeles on 4/28/19 and on 5/5/20 (MVZ 2001); Cahuenga on 5/9/1895; 2 miles northwest of Claremont on 5/2/02; Gardena on 5/17/13; Athens on 5/14/21 (2 sets); near Redondo on 5/10/29 (2 sets); near Culver City in May 1934; and near Pomona in April 1938 (WFVZ 2001).

Breeding season records include: birds collected from Highland Park on 3/23/1887 (MVZ 2001); from Cahuenga (now Universal City) on 5/18/1888 (AMNH 2001); from Cienega on 3/7, 3/10, 3/26, and 3/27, 1890 (LACM 2001); from Long Beach in August 1894 (McGregor 1898; LACM 2001) and 3 birds on 7/9/00 (LACM 2001); from Pasadena on 5/22/1895 and 8/14/00 (LACM 2001); several pairs of breeding owls found in fields in northwestern Los Angeles (1 mile northwest of Westlake Park) from 1893 to 1900, when the area was ranch land (Swarth 1900); 3 birds from Point Firmin, near San Pedro on 9/15/06 (MVZ 2001); from Gardena on 3/7/15 (FMNH 2001) and on 6/17/32 (FMNH 2001); a male bird with sexually developed gonads from Redondo Beach on 3/1/08 (LACM 2001) and 5/28/17 (FMNH 2001); from Cedar Hill on 7/12/09 (LACM 2001); from Bixby on 5/29/08 (CAS 2002a); from Palmdale on 4/16/14 (CAS 2002a); from Dominguez on 8/22/17 (LACM 2001); and from Pomona on 3/27/15 (two birds) (UCLA 2001) and on 6/2/25 (MVZ 2001).

117 Eggs were collected from Playa del Rey on 4/3/64 (WFVZ 2001); and nesting was observed in the vicinity of Playa del Rey along Ballona Creek in 1981 (CNDDB 2001). Pettingill (1953) reported burrowing owls in the banks of Ballona Creek. There were breeding season observations at Los Angeles on 7/28/80 and at Hermosa Beach on 7/20/82 (LACM 2001). Observations in the vicinity of Long Beach include: Lakewood in October 1953; CSULB Campus in January and December 1954; and Long Beach in December 1972 and October 1975 (CSULB 2001).

118 The only known recent observation of a burrowing owl during breeding season in Los Angeles was on 7/13/94 (LACM 2001).

Bath, pers. comm., 2003).[119] There are probable breeding records from Santiago Springs in 1903, Seal Beach in 1908, Corona del Mar in 1957, and Irvine in 1968 (CSULB 2001; LACM 2001; NMNH 2001; UCSC 2001).[120] As early as the 1930s, the burrowing owl in western Orange County was noted to be "far less common than it used to be" according to Robertson (1931), due to the elimination of ground squirrels.

Further owl declines due to development and human impacts were evident in western Orange County before 1960, with documentation of local extirpations and habitat loss in Costa Mesa, Newport Beach, and Santa Ana (J. Bath, pers. comm., 2003).[121] Still, the burrowing owl in Orange County between 1960-1975 could best be described as "abundant," and for a raptor, "bordering on ubiquitous" throughout the grasslands and non-orchard agricultural areas (P. Bloom, pers. comm., 2002). Burrowing owls were at that time a "regular component" of the coastal Orange County environment in Seal Beach, Huntington Beach, Fountain Valley, Newport Beach, Irvine, Mission Viejo, Corona del Mar, Costa Mesa, Laguna Niguel, and portions of Santa Ana (P. Bloom, pers. comm., 2002). Most vacant fields or flat agricultural acreages greater than 5 acres within 5 miles of the coast had their own pair or colony of owls (P. Bloom, pers. comm., 2002).

Significant nesting burrowing owl colonies were noted along the coast of Orange County from the 1970s to the early 1990s (including Seal Beach, Bolsa Chica, Huntington Beach, Newport Beach, and Irvine), with nesting also observed in southeastern Orange County in 1973 (Wiley 1975; Collins and Landry 1977; UCI 1995; CNDDB 2001; CSULB 2001).[122] However, by 1985 less than 10 pairs of owls remained countywide,

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119 Eggs were collected from: Anaheim on 5/9/1886 and 5/19/1887 (FMNH 2001); an unspecified locality in Orange County on 5/2/1895 (4 sets) (SBMNH 2001); Anaheim Landing on 4/14/18; Newport Beach on 4/8/31; Buena Park on 5/8/35 and 5/7/38; Sunset Beach on 5/2/38; and near Cypress on 4/28/45 (WFVZ 2001). A burrowing owl nest with 6 eggs was photographed at Balboa Beach in April 1920 (LMDBL 2001). Robertson (1929, 1930) observed parents hunting for 6 young near Buena Park many times in June 1927, a brood of 4 young in 1928, and road-killed owls near Buena Park and Cypress. T. Howell (1964) reported on 2 owls taken from a burrow with 5 young birds at Los Alamitos in May 1958.

120 Breeding season collection records include from: Santiago Springs on 8/14/1903 (NMNH 2001); Seal Beach on 3/30/08 (LACM 2001); Corona del Mar in August 1957 (CSULB 2001), and Irvine on 8/21/68 (UCSC 2001). Burrowing owls were reported to inhabit Upper Newport Bay from 1940-1955 (J. Johnson 1990).

121 J. Bath, Professor of Zoology at California State Polytechnic University, Pomona, compiled historical data for burrowing owls in Orange County (pers. comm., 2003). In the City of Costa Mesa: 6 pairs regularly nested in the earthen sides of Fairview Channel east of Placentia Avenue since 1957 - only 1 pair is nesting in 2003 (impact: unknown, but possibly pesticides from the adjacent Costa Mesa Golf Course); 3 pairs were regularly observed in squirrel burrows in the cliff of the Upper Newport Bay nearest the present Yorktown Lane between 1955 and 1972. Owls were last seen here in September 1972 – at that time the cliff was heavily used for rifle target practice by teenagers (impact: hunting with rifle/target practice) (J. Bath, pers. comm., 2003). In the City of Newport Beach: 2 pairs were nesting between 1955 and 1962 in the walls of a ravine opposite 2161 Mesa Drive, at that time the "Santa Ana Heights" neighbourhood of unincorporated Orange County. They were last seen in June 1962 (impact: grading of land for horse ranch expansion); 5 pairs regularly nested in a large ravine, known locally as "Fossil Gorge" in the Upper Newport Bay between 1955 and 1963. The ravine, now covered, was at the intersection of the present Eastbluff Drive and Backbay Drive (impact: grading for development); 1 paired nested in a burrow in an ancient Indian midden adjacent to Jamboree Road (now Backbay Drive) in the Upper Newport Bay between 1955 and 1964. Last seen in October 1964 (probable impact: some form of human harassment due to its high visibility from the road) (J. Bath, pers. comm., 2003). In the City of Santa Ana: 3 pairs were seen nesting regularly between 1956 and 1958 on a vacant lot at the northeast intersection of Main Street and Warner Avenue - last seen in October 1958 (impact: grading for development); 2 pairs were seen regularly between 1956 and 1959 on a vacant lot at the northwest intersection of Main Street and Warner Avenue - last seen in May 1959 (impact: grading for development); 2 pairs were seen nesting regularly between 1956 and 1958 along the west side of Warner Avenue between Garnsey Street and Flower Street opposite Washington Elementary School (impact: grading for development); 2 pairs were seen nesting regularly between 1956and 1959 along the edges of a large agricultural field at the northwest corner of the intersection of Bristol Street and Warner Avenue (impact: grading for development) (J. Bath, pers. comm., 2003).

122 Twenty artificial nesting burrows were actively used by owls at Seal Beach Naval Weapons Station in 1975 (Collins and Landry 1977). Ten breeding pairs of owls were detected at Seal Beach in 1977; 2 birds were documented there in April 1980; and owls reportedly occupied the site in 1983 (CSULB 2001; CNDDB 2001). 1 adult owl at a burrow was observed in the vicinity of Bolsa Chica Ecological Reserve, northwest of Huntington Beach, on 1/3/93 (threats there included oil extraction operations, non-native predators, and development) (CNDDB 2001). A single owl was seen at Huntington Beach in May 1985 (CSULB 2001). 2-4 pairs of owls were observed at Upper Newport Bay Ecological Reserve, Newport Beach from 1980-1981, but none were observed in 1983 (this population is thought to be extirpated due to development and dredging to create Least Tern habitat). There is a non-breeding season record from Irvine in November 1981; a colony of 3-5 pairs of owls was observed northeast of UC Irvine in 1980 and 1981, but their status was unknown in 1988 (the area was under constant development pressure); 1 pair at a burrow site plus 3 other individual owls were observed at U. C. Irvine in April 1990 (the site was threatened by campus development) (CSULB 2001; CNDDB 2001). Historically, breeding occurred on the U. C. Irvine campus, including at the U. C. Irvine Ecological Preserve, but there have been no observations on the Preserve since 1990 and suitable habitat on campus for nesting has been cleared for faculty housing and construction (UCI 1995). Nesting was observed in southeastern Orange County in spring 1973 (Wiley 1975). There also is a non-breeding season record from Santa Ana in November 1974 (CSULB 2001).

outside of the population at the Naval Weapons Station, Seal Beach (P. Bloom, pers. comm., 2002).[123] Extensive raptor nest surveys throughout the county have confirmed that breeding burrowing owls have since been nearly extirpated from Orange County (DeSante and Ruhlen 1995; P. Bloom, pers. comm., 2002). Now, the last remaining pairs of breeding owls in Orange County are located at Seal Beach, where numbers were down to 3 pairs or less in 2001 (4-5 pairs nested there between 1990-2000) (P. Bloom, pers. comm., 2002), and Fairview Channel in the City of Costa Mesa, where only 1 nesting pair remains (down from 6 pairs that regularly nested there since 1957) (J. Bath, pers. comm., 2003).

San Diego County

The burrowing owl was once widespread and quite common in coastal San Diego County. Van Dyke (1888) claimed that in the late 1860s in San Diego, "burrowing owls stood on every little knoll." Emerson (1884) found the burrowing owl "not uncommon" in the Poway Valley in the 1880s, and Sharp (1907) noted it "common everywhere" around Escondido, based on 16 years of observations from 1891 to 1897. Historical records confirmed breeding at: Poway in 1884 and 1885; National City in 1895 and 1910; Escondido on numerous occasions from 1902 to 1931; La Presa before 1907; Point Loma in 1917, 1920, and 1922; near Santee in 1920 and 1921; Rancho Santa Fe in 1932; San Pasqual in 1902, 1906, 1907, 1910, and 1916; Oceanside in 1931; San Diego on numerous occasions from 1862 to 1936; and Crown Point in 1936. Probable breeding was documented at: San Diego in 1893 and 1894; Jacumba in 1894; San Onofre from 1904-1906; Chula Vista and San Luis Rey in 1908; Lemon Grove in 1914; Escondido in 1920; La Puerta Valley in 1922; and La Jolla in 1935 (Emerson 1884; Dixon 1906; Sharp 1907; Unitt 1984; AMNH 2001; CMNH 2001; FMNH 2001; MVZ 2001; NMNH 2001; SBMNH 2001; UCLA 2001; WFVZ 2001; CAS 2002a).[124] Breeding was confirmed at Twin Oaks between 1889 and 1894, at Witch Creek in 1906, and in the Santa Margarita Mountains in 1931. These observations as well as a specimen collected during breeding season at Oak Grove in 1892 suggest the species had occurred in the foothill zone of San Diego County as well (F. Merriam 1896; Unitt 1984; AMNH 2001; WFVZ 2001).[125]

Burrowing owls apparently persisted in urban areas of San Diego into the 1930s (Abbott 1930a). Abbott (1930) noted owls had been driven away from downtown, but subsisted "wherever there is any extent of vacant land," and were "common" between downtown and Mission Hills.[126] Further declines were noted in San Diego County in the 1970s (Remsen 1978). Usually only a single pair at a time was seen at a locality, with a maximum of 5 birds observed at North Island Naval Air Station, Coronado, in May 1978 (Unitt 1984).[127] Other localities still inhabited in the late 1970s included San Marcos, near Palomar Airport in Carlsbad, Mission Bay, Lower Otay Lake, and the Tijuana River Valley (Unitt 1984). Camp Pendleton had a small population of about 8 pairs of owls in 1972, but between 1975 and 2000 there have never been more than 2 pairs there and usually

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[123] Seal Beach Naval Weapons Station was apparently used as a release area for owls relocated from land used for development projects (D. Cooper, pers. comm., 2002).

[124] Eggs were collected from: Poway in April 1884 and on 4/5/1885 (Emerson 1884; WFVZ 2001; FMNH 2001); National City on 5/17/1895 and 5/1/10 (MVZ 2001; WFVZ 2001); Escondido on 4/25/02, 5/6/02, 4/5/03, 4/12/04, 4/26/04, 6/3/05, 4/22/06, 5/2/13, 6/6/17, 6/8/17, 5/1/19, 5/10/24, and 4/15/31 (MVZ 2001; WFVZ 2001; AMNH 2001); Crown Point on 5/2/36 (NMNH 2001); Point Loma on 5/2/17, 4/18/20, 5/1/20, and 5/1/22 (WFVZ 2001); near Santee on 5/13/20 and 4/16/21 (WFVZ 2001); Rancho Santa Fe on 5/12/32 (WFVZ 2001); San Pasqual on 4/20/02, 4/22/06, 4/21/07, 3/18/10, and 4/20/16 (WFVZ 2001); Oceanside on 4/12/31 and 4/15/31 (WFVZ 2001); and San Diego on 4/3/1862, 6/22/1880, 5/11/1881, 4/5/1894, 5/13/1894, 4/23/1897, 5/19/12, 4/28/15, 4/27/20, 5/7/20, 4/9/31, 5/2/32, and 4/18/36 (AMNH 2001; SBMNH 2001; NMNH 2001; WFVZ 2001; CAS 2002a). Two juvenile bird specimens taken by Sharp (1907) at La Presa on August 28 still had some down. Unitt (1984) noted 41 historical collection records of eggs, from April 5 to June 8. Breeding season collection records of birds include: from San Diego on 3/30/1893, 6/28/1893, 7/27/1893, and 5/23/1894 (AMNH 2001; CMNH 2002); from Jacumba on 5/24/1894 (NMNH 2001); from Chula Vista on 5/31 and 6/2, 1908 (AMNH 2001) and San Luis Rey on 7/10/08 (UCLA 2001) and 7/12/08 (2 birds) (CAS 2002a); from Lemon Grove on 8/28/14 (UCLA 2001); from Bernardo Mountain south of Escondido on 4/28/20; from La Puerta Valley on 3/12/22 (MVZ 2001); and from La Jolla on 4/10/35 (NMNH 2001). Dixon (1906) saw 2 owl pairs in San Onofre from 1904-1906, but noted the species was "not common" there.

[125] Eggs were collected from the Santa Margarita Mountains on 4/11/31 (WFVZ 2001). Two juveniles were collected from Witch Creek on 8/22/06; single birds were also collected there in 11/1894 and on 5/30 and 8/24, 1904 (AMNH 2001). Burrowing owls nested at Twin Oaks between 1889 and 1894. F. Merriam (1896) once saw 9 owls sitting around one burrow. A bird was collected at Oak Grove on 4/11/1892 (Unitt 1984).

[126] Abbott (1930) observed owls from 1921 to 1930 in the heart of the business district, and in culvert drains of El Cajon Blvd. before it was paved. Owls were also heard throughout April 1930 at Monte Vista Ranch, 15 miles east of San Diego (Abbott 1930b).

[127] R. Stanley (pers. comm., 2001) observed a colony of burrowing owls (somewhere between 5-10 birds) during 1975-1978, while stationed on North Island.

just 1 pair inhabiting the entire 196 square mile reservation (P. Bloom, pers. comm., 2002). By the 1980s, owls were an "uncommon and declining resident" with only 7 definite breeding locations and 7 probable breeding locations remaining in San Diego County in 1984 (Unitt 1984).[128] Their range still included the entire coastal lowland of San Diego County, but urbanization had "greatly restricted the extent of suitable habitat" (Unitt 1984).

The burrowing owl is now on the verge of extirpation in San Diego County. As of 2001, only 6 confirmed breeding locations, 1 probable breeding location, and 1 possible breeding location remained in the County (P. Unitt, pers. comm., 2001).[129] A single individual recorded near Upper Otay Lake (brought to the attention of P. Unitt by a bulldozer operator) was probably the last in that area, and only a single pair nested near Lake Henshaw in 2001. Only North Island, Ream Field (Imperial Beach), and Otay Mesa are left as sites of populations with even short-term viability. Most or all of the Otay Mesa habitat is slated for development, and at the other 2 colonies the owls are discouraged because they prey on Least Terns (P. Unitt, pers. comm., 2001).[130]

Southern California Islands

Grinnell (1915) noted that the species "occurs regularly on several of the Santa Barbara group of islands," and Dawson (1923) described the burrowing owl as "one of the characteristic birds of the Santa Barbara Islands." Although there have been observations of owls on all the islands off southern California, probable breeding records from all the islands except for San Miguel and Anacapa Islands, and apparent documented breeding on Santa Catalina, the resident status of the species has been controversial.[131]

Northern Channel Islands

Wintering owls are currently found on the northern Channel Islands but there are no breeding owls there (Jones and Collins 2003; B. Latta, pers. comm., 2003).

San Miguel Island

Local ranchers told Willett (1910) there were "a few" owls on San Miguel Island, but he observed none during June surveys. Owls were reportedly "numerous" in 1939 (Jones and Collins 2003). Not enough data are available prior to 1973 to assess its status earlier in the century (Jones and Collins 2003). Burrowing owls are currently an uncommon winter visitor to San Miguel Island and breeding at the present time is unlikely (Jones and Collins 2003).

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128 There was confirmed nesting reported during the 1980s in the Tijuana River Valley near the coast, at North Island Naval Air Station, and at Fiesta Island in Mission Bay; and reports of frequent owl sightings at southern "Delta Beach," on Coronado Island (CNDDB 2001).

129 Recent CNDDB observations include: 2 burrows, containing at least 8 birds, on Otay Mesa, on 7/26/93 (this site was threatened by extension of the Otay Mesa border crossing facility, but Caltrans was possibly to provide artificial burrows); an unknown number of birds and burrows at Kearny Mesa, in September/October 1993 (this site was threatened by development); and 1 adult owl along Black Mountain Road, east of Del Mar, on 3/4/99 (this site was threatened by residential development) (CNDDB 2001).

130 San Diego County Least Tern colonies have a long history of anti-predator measures conducted by U. S. D. A. Wildlife Services (formerly Animal Damage Control). The activities of this federal agency have contributed more to the recent extirpation pulse of burrowing owls along the San Diego coast than any other known form of mortality (P. Bloom, pers. comm., 2002).

131 There have potentially been several extirpations and immigrations on the islands. Lynch and Johnson (1974) characterized extirpations from the islands as "presumed," since to their knowledge owls had never been proved to nest on any of the California Islands. Hunt and Hunt (1974) believed that since the burrowing owl is a notoriously wide-ranging visitor and vagrant, and may be an opportunistic invader of unoccupied areas, these extirpations and immigrations were likely to have been entirely natural events unaffected by man. However, Garcelon and Roemer (1990) enumerated poisoning and persecution of ground squirrels in the 1950s and 1960s, historical shooting, egg collecting, nest destruction, and trapping of bald eagles on the Channel Islands, activities which may also have negatively impacted or extirpated burrowing owls. One problem of evaluating burrowing owl status on the islands has been that they are a species easily overlooked by a short survey, and because of their mostly nocturnal habits, they are not easily observed except around known roosting or nesting burrows, and therefore definitive evidence of breeding is difficult to obtain (Jones and Collins 2003).

Santa Rosa Island

Streator (1888) mentioned that owls were "not very common" on July 3, 1892. Pemberton (1928) believed the species "should be present" on Santa Rosa Island. Although he did not see owls, he was told the species was there and given an accurate description by residents - ranchers in 1927 said that it bred there. There is one breeding season collection record from East Point on 3/13/50 (MVZ 2001). A ranch foreman told Diamond (1969) on July 12, 1968 that he saw burrowing owls "about two months ago." The burrowing owl is currently an uncommon to infrequent winter visitor, and possibly a former breeding resident (Jones and Collins 2003).

Santa Cruz Island

Linton (1908a) reported owls to be "fairly common in suitable localities" on Santa Cruz Island. The burrowing owl is currently an uncommon winter visitor, with no indication of breeding, now or in the past (Jones and Collins 2003).

Anacapa Island

A. Howell (1917) reported owls were seen several times on Anacapa Island. All historical records but 1 (July 1967, 2-3 owls) are from October 1 to April 12 (Jones and Collins 2003). Burrowing owls apparently still inhabit Anacapa Island (Schoenherr et al. 1999; L. Dye, pers. comm., 2003), although a recent National Park Service project to poison invasive rats on the island reportedly killed 4 owls (FFA 2002).

Southern Channel Islands

Burrowing owls are thought to currently breed only on Santa Barbara and Santa Catalina Islands and appear to be only a transient or winter visitor on the other Channel Islands (Jones and Collins 2003).

Santa Barbara Island

A. Howell (1917) remarked that the species "seems to be lacking on Santa Barbara Island." Despite active searches (Jones and Diamond 1976), burrowing owls were not found on this island until March 1927, when Pemberton (1928) located 2 birds on the southern part of the island. Owls were absent during surveys in 1939, scarce or absent in 1950 and 1958, and common from 1954 to 1957 (Sumner unpublished report, as cited in Jones and Diamond 1976; Jones and Diamond 1976). These sightings represent 1 extirpation event and 2 invasions of burrowing owls on the island (Hunt and Hunt 1974).

Diamond (1969) found 6 pairs present during the summer of 1968, and Hunt and Hunt (1974) found at least 3 and possibly 6 pairs resident there May through July 1972. Owls were seen almost daily and regularly flushed from burrows in 1968, 1972, and 1973. One or 2 pairs were seen in 1974, and 2 pairs were seen in 1975 and 1976 (Jones and Diamond 1976), however Murray et al. (1983) reported burrows but no owls found from 1975 to 1979. Drost and McCluskey (1992) reported on a small population of approximately 20 burrowing owls extirpated by barn owls in 1984 and again in 1987, following crashes in the deer mouse population. Drost and McCluskey (1992) estimated a population of 20-25 birds on the island from 1982-1987, with direct counts of from 13-18 birds in mid-winter roosts. Owls have bred on the island in most or all recent years (Jones and Collins 2003).

San Nicolas Island

Streator (1888) first recorded the species on San Nicholas Island in autumn of 1886. According to A. Howell (1917), Keeler (1907) also recorded the species there, and there is a record of uncertain breeding significance for 1945 (Jones and Diamond 1976). In 1963, W. Townsend (pers. comm., as cited in Jones and Diamond 1976) found a year-round population and defended burrow. The claim by Lynch and Johnson (1974) that W. Townsend noted no evidence of breeding apparently contradicts personal communication by W. Townsend (Jones and Diamond 1976). Despite 36 visits and over 1000 hours of field observations by Jones, Schreiber (1970), Diamond, and others in 1968, 1973, 1974, and 1975, the sole records were single sightings in

October 1974 and September and November 1975. Several individuals were seen between January and May 1976, but all these owls had left the island by mid-May. One extirpation of the species from San Nicolas Island between 1963 and 1968 can be assumed conservatively (Jones and Diamond 1976).

A few recent summer records (from May to August) suggest that owls may now be breeding in small numbers (Jones and Collins 2003). An alternative explanation is that the recent intensive survey effort on this island is turning up a few mid-summer strays that may have been overlooked in the past (Jones and Collins 2003).

Santa Catalina Island

Grinnell (1898), who saw a single owl on a hilltop in the interior of Santa Catalina Island in December 1897, was told that the species became "quite numerous" on the island at times. A. Howell (1917) saw a single owl several times in April 1911. Birds were collected from the island during breeding season in 1940 and 1941 (FMNH 2001; LACM 2001).[132] According to Jones and Diamond (1976), breeding had been documented on the island. A maximum of 4 owls were seen on July 21, 1978 (Jones and Collins 2003). Burrowing owls were located during a survey of raptors on Santa Catalina Island between February and June 1994, and are still thought to be uncommon resident breeders on the island (CIC 2002; Jones and Collins 2003). Recent Breeding Bird Surveys suggest that numbers have declined on the island since the 1970s, but no direct comparisons are possible (Jones and Collins 2003). Some current and former breeding sites are Fisherman's Cove, Upper Buffalo Reservation, the vicinity of Little Harbor, and Middle Canyon (Jones and Collins 2003).

San Clemente Island

Breninger (1904), Keeler (1907), and Linton (1908c) all collected specimens here and referred to the species as "resident," and A. Howell (1917) noted that owls could be found in some numbers on certain parts of San Clemente Island. There is a breeding season collection record from the island on 3/24/18 (DMNH 2001). A nest with 2 or more small young was found during the summer of 1975 (Jones and Collins 2003), and according to Jones and Diamond (1976), breeding had been documented on the island. The burrowing owl is currently a regular winter visitor in small numbers, and has bred at least once recently (Jones and Collins 2003). With one exception, all modern records have been from September through April, with a maximum of 7 owls seen on November 10, 1996 (Jones and Collins 2003).

Western Riverside County

Historical records confirmed breeding at Riverside from 1878 to 1890 and at Norco in 1927; and indicated probable breeding in Riverside in 1892 and 1893, at San Jacinto Lake in 1895, at Lake Elsinore in 1907, at the base of the San Jacinto Mountains in 1908, and near Moreno in 1941 (Bailey 1917; AMNH 2001; MVZ 2001; NMNH 2001; UWBM 2001; WFVZ 2001; CAS 2002a).[133] Single nesting pairs documented in La Sierra and Norco in the 1980s were extirpated by the early 1990s (J. Bath, pers. comm., 2003).[134] Significant breeding colonies were documented at the San Jacinto Wildlife Area, near Lakeview, and at Lake Perris State Recreation Area ("SRA") in the 1980s (CNDDB 2001; LACM 2001).[135]

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132 There are collection records from an unknown location on 3/8/41 (LACM 2001), from Haypress Canyon on 3/1/40 (FMNH 2001), and from Little Harbor on 2/29/40 (FMNH 2001).

133 Eggs were collected at Riverside on 4/28/1878 (WFVZ 2001), 5/13/1882 (NMNH 2001), 4/16/1886 (WFVZ 2001), 4/13/1887 (WFVZ 2001), 5/8/1888 (UWBM 2001), and 4/14/1890 (UWBM 2001); and an immature bird was collected from Norco on 5/22/27 (MLZ 2001). Breeding season bird collection records include: Riverside in April 1893 (NMNH), 11/18/1887, 12/24/1891 (2 birds), on 4/8/1892, and 4/13/1892 (MVZ 2001); San Jacinto Lake on 6/25/1895 (AMNH 2001); Lake Elsinore in summer 1907 (Bailey 1917); the base of the San Jacinto Mts., at Cabazon on 5/23/08; Bannly (Banning?) on 6/12/08; Valle Vista on 9/2/08 and 9/4/08 (MVZ 2001); and 2 miles north and 2 miles west of Moreno on 3/9/41 (CAS 2002a).

134 In the City of La Sierra 1 pair was seen nesting between Collett Elementary School and Collett Park between 3/02/1985 through 8/1987 (impact: grading for development) and in the City of Norco 1 pair was seen regularly since 1982 at an open field at the northwest intersection of California Avenue and Seventh Street - last seen in 1992 (impact: burrows became over-grown with rye grass) (J. Bath, pers. comm., 2003).

135 A colony of "many" owls was observed in 1980 at Lake Perris State Recreation Area (CNDDB 2001). Sightings in 1982 at the San Jacinto Wildlife Area include: an active burrow with 2 adults and 5 fledged young, 2 miles north of Lakeview; an active burrow with 2 birds, 1.5 miles north-northeast of Lakeview; 2 birds one-half mile north of Lakeview, on May 26 and May 28; 2 adults and 4 fledged young approximately 2-4 miles

The U. C. Riverside database developed for the Western Riverside County Multi-Species Habitat Conservation Plan ("MSHCP") includes approximately 82 records of burrowing owls within the past 10 years in the area. The Western Riverside MSHCP documents that owls have been detected east of the Jurupa Mountains, along the Santa Ana River, at Lake Mathews, at Good Hope, Alberhill, Murrieta, March Air Reserve Base, the Lake Perris/Mystic Lake area, the Badlands, within the vicinity of Beaumont and Banning, San Jacinto, Valle Vista, between the San Jacinto River and Lakeview Mountains, west of Hemet, the area around Diamond Valley Lake, east and south of Lake Skinner, along Santa Gertrudis Creek and Tucalota Creek, in Long Canyon, and along De Portola Road (Dudek and Associates 2002). Historically, there were a large number of owl locations concentrated within the Moreno Valley area, however due to urban development, the number currently within this area is unknown (Dudek and Associates 2002).

Through 2001, there were small breeding populations of burrowing owls remaining in southwestern Riverside County in the vicinity of Perris, Lakeview, and Temecula, and a colony (15 adults and 10 juveniles in 1999) near the Pechanga Indian Reservation (CNDDB 2001).[136] California State Parks Inland Empire District staff conducted thorough burrowing owl surveys in suitable habitat at Lake Perris SRA and San Jacinto Wildlife Area ("SJWA") during the nesting season of 2002 (La Claire 2002). At Lake Perris SRA, a total of 12 owls and 7 sites were recorded, and at SJWA 32 owls and 10 sites were observed (La Claire 2002). Owls are currently nesting at March Air Force Base in artificial nest boxes, however portions of this base are now decommissioned and no agency or entity has responsibility for protecting or maintaining these nest boxes (P. Bloom, pers. comm., 2001). Most remaining owl colonies in western Riverside County are very small, highly fragmented, unprotected, and on the brink of extirpation through 2002 (P. Bloom, D. Cooper, pers. comm., 2002).

Southwestern San Bernardino County

Historical records confirmed breeding near Highlands in 1896 and 1897, near Chino in 1916, and at San Bernardino in 1883, 1885, 1886 and 1899; and indicated probable breeding at Redlands in 1902-03, near Oak Glen in 1910, near Chino in 1915 and 1926, and near San Bernardino in 1883, 1886, 1892, and 1928 (Hartzell 1888; Stephens 1902; Willett 1912; Van Rossem 1914; CHAS 2001; CMNH 2001; FMNH 2001; MVZ 2001; NMNH 2001; WFVZ 2001; CAS 2002a).[137] Egg collector H. Edwards reported owls to be "fairly common"

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north of Lakeview; an active burrow with 1-2 birds, 2.6 miles north of Lakeview, from September through early October; and up to 4 birds 2.8 miles north of Lakeview, during July (CNDDB 2001). Owls were also seen at Riverside on 8/31/1982 (LACM 2001), and near Romoland (2 burrows and 2 owls) on 10/7/89 (CNDDB 2001).

136 Recent CNDDB sightings in the vicinity of Perris include: 4 occupied burrow sites in 1997, located within a 2 mile stretch of the Perris Valley Drain, 1 mile east of Perris (2 burrows being used by 2 adults and at least 1 juvenile were seen during surveys May 19-27, 1997; 2 adults were observed at a burrow site during surveys May 19-27, 1997; 2 adults and at least 1 young were observed at one burrow and 2 adults and at least 4 young at a second burrow) (these owls were threatened by the pending excavation of the Perris Valley Drain and were to be passively relocated); 2 adults at a burrow off Goetz Road, 3.5 miles south of Perris, on 3/30/99; and 2 adults and 4+ juveniles at a nearby burrow on 5/10/99 (CNDDB 2001). Surveys at the Lake Perris State Recreation Area found 15 owls occupying 9 burrows in June 2000, 4 owls occupying at least 3 burrows in July 2001, and 12 owls at 7 burrows from May through July 2002 (California Department of Parks and Recreation, unpublished data).

Recent CNDDB sightings in the vicinity of Lakeview include: 2 adults and 2 active burrows approximately 2 miles southeast of Lakeview, in 1992 (these owls were threatened primarily by construction of a flood control dam, secondarily, by an increasing rural population); and 1 adult with 2 fledged juveniles near the junction of Hwy. 74 and Warren Road, San Jacinto Valley, on 10/7/98 (by 10/9/98 this site had been disked, and the owls had not been seen there since – their remaining habitat was threatened by disking and mowing and future development) (CNDDB 2001).

Recent CNDDB sightings in the vicinity of Temecula include: 1 owl at a burrow at Temecula, on 11/2/94 (owls here were threatened by development, grading and disking, roads, dumping, and burning); 2 adults at a burrow 1 mile south of Lake Skinner, from 3/11/98 through 4/27/98 (this site was threatened by a proposed residential subdivision); 1 adult at a burrow 1 mile southwest of Skunk Hollow, on 5/8/99 (this site was threatened by grading and disking and existing and planned development); 1 adult at a burrow on the south side of Wilson Valley, 3 miles north of Aguanga, from March to June 1999; and a large colony of 25 owls (15 adults, 10 juveniles) at Redhawk Golfcourse, just north of Pechanga Indian Reservation, on 7/1/99 (CNDDB 2001).

137 Eggs were collected from: an unspecified location in San Bernardino County in April 1887 (Hartzell 1888); east Highlands on 4/11/1896 and 4/3/1897 (Willett 1912; WFVZ 2001); San Bernardino on 4/28 and 4/29/1883 (Stephens 1902) and 5/2/1899 (WFVZ 2001); and near Chino (2 sets) on 4/16/16 (WFVZ 2001). An owl chick was collected from San Bernardino on 5/08/1885 (NMNH 2001). Breeding season collections and observations of birds include: San Bernardino on 4/20/1883, 3/18/1886, 5/31/1886 (2 birds), and 4/28/20 (CHAS 2001; CMNH 2002; CAS 2002a); Redlands (5 birds) between 12/31/02 and 2/14/03 (FMNH 2001); between Oak Glen and Beaumont in summer of 1910 (Van Rossem 1914); Los Serranos Country Club near Chino on 5/4/26 (MVZ 2001); Reche Canyon, 4 miles south of San Bernardino on 6/11/28 (MVZ 2001); and 3 miles south of Chino on 3/3/15 (FMNH 2001).

near Chino in 1916, noting a colony of several dozen pairs and collecting 2 egg sets (WFVZ 2001). Scattered observations around San Bernardino County include a breeding colony observed near Lockhart in the 1970s, and probable breeding at Joshua Tree National Monument in 1961 and in the Lucerne Valley in 1981 (CNDDB 2001; CSULB 2001; UCSB 2001).[138]

Small numbers of breeding owls in Redlands, Colton, Rancho Cucamonga, and Chino Hills have been extirpated recently (J. Bath, pers. comm., 2003).[139] Remaining breeding owl populations in western San Bernardino County in the vicinity of San Bernardino, Chino, and Ontario continue to decline due to impacts by development and human harassment (CNDDB 2001; J. Bath, pers. comm., 2003).[140] As of 2003, an estimated 56+ owl pairs remain in Chino and an estimated 40+ pairs remain in Ontario; all of these owls live in habitat

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138 3 pairs of owls (1 pair with at least 2 young) and a burrow with 4 immature owls were seen in the Harper Lake Marsh area, northeast of Lockhart, in 1978 (CNDDB 2001). Single owls were collected from Joshua Tree National Monument in May 1961 (CSULB 2001) and from Lucerne Valley on 8/3/1981 (UCSB 2001).

139 In the City of Redlands, 2 pairs were seen nesting at southwest corner of the intersection between California Street and Lugonia Avenue during the 1985-1991 seasons (impact: grading for development) (J. Bath, pers. comm., 2003).

In the City of Colton, within the "Agua Mansa District," approximately ¼ mile east of Pepper Avenue and approximately 1/8 mile north of Slover Avenue, 2 owl pairs were observed occupying abandoned coyote dens on August 31, 1991. This unusual site was vegetated by plant species consistent with the Delhi Sands segregate of the Riversidian form of Coastal Sage Shrub, and was also occupied by Delhi Sands Flower Loving Fly (***Rhaphiomidas terminatus abdominalis***) habitat. Grading of site by Union Pacific (?) Railroad, in part, triggered the listing of this fly on Sept. 23, 1993. Impact: grading of railroad easement for unknown reason. Another owl pair was seen nesting in Colton on 6/19/2002 in a rock outcropping between Pellister Road and La Cadena Lake, but these owls have not been seen since (impact: disturbance due to adjacent grading for development) (J. Bath, pers. comm., 2003).

In the City of Rancho Cucamonga, 3 pairs were seen occupying burrows in earthen flood control ditch at southwest corner of the intersection between Haven Avenue and Fourth Street between 1992 and 1999, but not since (impact: modification of earthen flood control channel and grading of adjacent land) (J. Bath, pers. comm., 2003).

In the City of Chino Hills, 1 pair nested between 1992 and 2002 on San Antonio Channel approximately 200 meters north of Grand Avenue – owls were last seen December 6, 2002 (impact: disturbance due to adjacent grading for development) (J. Bath, pers. comm., 2003).

140 In San Bernardino, an undetermined number of owls utilized a burrow site at Norton Air Force Base in 1983 (this site may be threatened by development due to base closure); 2 adults, 4 juveniles, and 4 burrows with signs of recent activity were observed in West Colton on 8/15/98 (this site was threatened by proposed development); and 2 adults were observed at a burrow site between south Fontana and Crestmore, on 8/20/98 (threats to these owls include disking and proposed development) (CNDDB 2001).

In the City of Chino: 1 pair was seen at the Agricultural Department grounds of Don Antonio Lugo High School between 4/03/1984 and 5/22/1988 (probable impact: increased student activity); 3 pairs nested at the southeastern corner of Chino Avenue and 12th Street (Hottinger Family Meats Company at 5437 Central Avenue) from 3/22/1982 to 8/03/1990, and 1 juvenile was found dead by road kill 5/13/1991 on Chino Avenue at the northern edge of this location (probable impacts: disturbance of habitat by freight trucks using site to turn around; trapping of squirrels – on several occasions a man was seen attempting to trap ground squirrels at the site by using a wooden crate); 1 pair nested at the rear corporate yard of a company at 13445 12th Street during the 1994 nesting season (impact: nest abandonment due to harassment - an employee was observed throwing rocks at the owls); 1 pair nested regularly in drainage pipe on the back lot of a shopping center opposite the U.S. Post Office on Walnut Avenue during the 1991 and 1992 nesting seasons - there was a sudden (after one week) disappearance of the owls and squirrels (suspected impact: grading and use of rodenticide - a man was observed placing a rodenticide into adjacent squirrel burrows); 1 pair was seen regularly nesting at 14622 Ramona Avenue (now the Caliber Collision Center) between 1982 and 1991 (impact: grading for development); 2 pairs were seen at 4201 Eucalyptus Avenue adjacent to San Antonio Channel between 10/05/1977 and 3/22/1986 (impact: grading for development); 1 pair was seen to nest 3/22/1982 to 12/26/1991 at the vacant dairy at the southwest corner of the intersection of Edison Avenue and Cypress Channel (impact: grading for development); 2 pairs were seen to nest 3/22/1982 to 12/26/1984 in a vacant lot at the northeast corner of the intersection of Edison Avenue and San Antonio Avenue (impact: grading for development); 1 pair nested regularly on the eastern bank of San Antonio Channel at the Inland Empire Utilities Agency's Waste Water Reclamation Facility at 14950 Telephone Avenue - the owls were last seen on 6/11/1996; 11 pairs occupied burrows since March 1976 in back lot corporate yards in the large area bounded by Chino Avenue (to the north), Benson Avenue (to the east), Schaefer Avenue (to the south), and 12th Street (to the west), declined due to grading of back lot corporate yards - 3 pairs continued nesting at 13382 Benson Avenue (front yard of Rapid Industrial Plastics Company, Inc.) until the nesting season of 1991 (impact: corporate workers plugged burrows with wire, bottles, and other objects during their lunch hour, landscaper of property plugged burrows with gravel and grass cuttings); 4 pairs were observed nesting on a vacant lot on 12th Street approximately 60 meters north of the County of San Bernardino County Junior Fair Grounds since 1988, declining to 2 pairs – a development proponent's consultant installed one-way doors on the burrows of these pairs (impact: grading for development, use of one-way doors); 1 pair was observed in a corporate graveled parking lot on 12th Street approximately 120 meters north of the County of San Bernardino County Junior Fair Grounds until 1993 (impact: a man was seen shooting at the owls and attempting to trap the owls with a wooden crate); 2 pairs were observed nesting on the grass parking lot of the County of San Bernardino County Junior Fair Grounds between 1983 and 1994 (impact: burrow destruction due to increased vehicular use) (J. Bath, pers. comm., 2003). Four active owl burrows with evidence of long-term use and 6 owls (including 3 juveniles) were observed along the southern bank of San Antonio Channel "Chino Creek," west of Chino State Prison, on 9/14/86, 3 adult owls were also seen here on 1/30/88 (CNDDB 2001); owls abandoned the site when the San Bernardino County Department of Transportation and Flood Control ceased weed abatement and tumbleweed (*Amaranthus albus*) overgrew the burrows (J. Bath, pers. comm., 2003).

In the City of Ontario, 3 pairs were seen occupying burrows until 2002 along fence line adjacent to Hwy. 15 (Ontario Freeway), approximately 460 yards north of Jurupa Avenue (impact: grading for development) (J. Bath, pers. comm., 2003).

An adult owl was observed northeast of Baldy Mesa from March 23 to June 10, 1989 (CNDDB 2001; USBLM 2002), but owls are unlikely to breed there (D. Cooper, pers. comm., 2002).

threatened by development (J. Bath, pers. comm., 2003).[141] Most remaining owl colonies in western San Bernardino County are small, highly fragmented, unprotected, and now on the brink of extirpation (P. Bloom, pers. comm., 2002).

G. IMPERIAL VALLEY

The majority (71%) of the state burrowing owl population, an estimated 5,600 to 6,570 nesting pairs, inhabits the Imperial Valley (DeSante and Ruhlen 1995; DeSante et al. in press). Burrowing owls in the Imperial Valley are commensal with the round-tailed ground squirrel (*Spermophilus tereticaudus*) and now occur almost exclusively in un-lined earthen banks along irrigation ditches. Historically, burrowing owls within the Imperial Valley were present in low densities, similar to populations in the undisturbed deserts surrounding the valley (DeSante et al. 1997; Rosenberg and Haley 2003). Along with the intensification of agriculture in the 1900s, the burrowing owl population in the Valley grew to one of the largest and most dense populations in California. Coulombe (1971) estimated 3.3 pairs/km^2 within an 8-km^2 area of the Imperial Valley during the 1966-67 breeding season. Coulombe (1971) also estimated that 20-25% of the Imperial Valley breeding owl population remains during the winter, with probable immigration from the north and emigration to the south. Even though there is winter immigration, Imperial Valley owls are thought to be reproductively isolated from owls in other areas (Rosenberg and Haley 2003).

Historical records confirmed breeding at Silsbee in 1909, at Toros in 1928, at an undisclosed location in the Imperial Valley in 1931, near Westmoreland and east of El Centro in 1934, at Greeson Slough in the 1960s, at Salton Sea National Wildlife Refuge in the 1980s, and at Palo Verde in 1984; and indicated probable breeding at Calipatria in 1922 and 1988, at Westmoreland in 1956, and at Seeley in 1977 (Coulombe 1971; CNDDB 2001; CSULB 2001; LACM 2001; MVZ 2001; SBCM 2001; UCLA 2001; UCSB 2001; WFVZ 2001).[142] Coulombe (1971) observed owls commonly during the 1960s along canal banks throughout the year, calling them a "conspicuous feature" of irrigated farmlands. Population studies conducted by Coulombe (1971) southwest of El Centro revealed owl densities ranging from 1 to 16.3 owls per mile along Greeson Slough and the New River. Coulombe (1971) was able to locate and band 19 owls from one-half mile of continuous habitat along the Dahlia Drain Canal, near El Centro, and estimated a density of 20-25 owls per square mile there from 1966-1967. There are insufficient data to determine if this population declined from the mid-1980s to the early 1990s (DeSante and Ruhlen 1995). Recent owl observations have been recorded near El Centro and at

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[141] In the City of Chino: there are approximately 30+ owl pairs in Chino's sphere of influence area known as "Subarea 2" currently under pre-annexation planning (General Plan Amendment EIR, SCH # 2000121036), with development recently approved on 3/25/2003 (2,447 acres are planned for 8,064 homes, commercial, and public facilities); there are 7 owl pairs on approximately 717 acres of "surplus real property" of the California Institute For Men that is being sold by the Department of General Services ("DGS") for the development of a 100-acre college campus, up to 2,200 residential homes, an elementary school, recreational parks, and a business center - an environmental impact report is expected to be circulated in 2003; 8 owl pairs reside on an additional 2,500 acres DGS is studying whether or not to sell for development; 14 pairs were documented nesting in 1980 on grass turf at the airport entrance of the Chino Airport, owned and operated by the County of San Bernardino – this population has declined to 6 pairs last seen on 2/15/2003 (impact: reduction of foraging habitat by grading, increase in airport pedestrian activity on turf) and is threatened by proposed urbanization under the Airport Master Plan revision; 9 pairs were seen on the banks of Cypress Channel between Chino Avenue and Edison Avenue since 1974 - these have declined to only 2 pairs seen on 3/21/2003 (impact: loss of adjacent foraging habitat by grading; plugging of nests by field crews of the County of San Bernardino Department of Transportation and Flood Control); and 3 pairs are currently nesting at the water detention basins of the Martin Verhoeven Dairy at 6718 Eucalyptus Avenue - this site is zoned for eventual residential development (J. Bath, pers. comm., 2003).

In the City of Ontario, approximately 40+ pairs of owls occurring on the 8,200 acres of the City of Ontario's Annexation Area No. 163 (formerly known as Ontario's Sphere of Influence of the San Bernardino's Agricultural Preserve) are threatened by future development (J. Bath, pers. comm., 2003).

[142] Confirmed breeding observations include eggs collected at: Silsbee on 4/5/09 and 4/6/09 (MVZ 2001); Toros in the Salton Sink on 4/1/28 (WFVZ 2001); an unidentified locale in the Imperial Valley on 5/26/31 (WFVZ 2001); 3.5 miles northeast of Westmoreland on 4/18/34 (SBCM 2001); 7 miles east of El Centro on 5/30/34 (SBCM 2001); and Palo Verde in April 1984 (WFVZ 2001). Coulombe (1971) documented extensive nesting along Greason Slough in the 1960s - at least 20 owls were seen along 1 to 1½ miles of irrigation canals near Vendel Road and Bannister Road, at the south end of the Salton Sea NWR. Probable breeding observations include birds collected at: Calipatria on 4/3/1922 (LACM 2001); Westmoreland (2 females) in February 1956 (CSULB 2001); Seeley on 8/06/1977 (UCLA 2001); Salton Sea Beach on 3/19/1983 (UCSB 2001); and at least a dozen owls and their burrows reported along Gentry Road, southwest of Calipatria, in 1988 (CNDDB 2001).

Calipatria (CNDDB 2001; LACM 2001).[143] Rosenberg and Haley (2003) estimated a current owl density of 8.3 pairs/km^2 at the southern rim of the Salton Sea in the Imperial Valley, one of the highest densities of burrowing owls reported.

H. COACHELLA VALLEY

Breeding populations of the burrowing owl historically resided in the Coachella Valley, which encompasses the central 15% of Riverside County, the northeastern 5% of San Diego County, and the central-northern 5% of Imperial County (DeSante et al. 1996).

Forty historical locations have been recorded for burrowing owls in the Coachella Valley (CVAG 2001), including confirmed breeding at Thermal and Indio in the 1920s (SBCM 2001).[144] The majority (36 of 40) of these observations were during the spring and summer months, which probably indicated resident birds, potentially on breeding territories (CVAG 2001). However, an influx of wintering burrowing owls may occur in the Coachella Valley, and the known location information for this species does not allow a determination of wintering birds, as the month of observation is not consistently reported (4 of the known locations report only the year of observation).

Prior to urban development, burrowing owls were regularly observed in empty lots along Washington Avenue in Bermuda Dunes and around the Palm Springs Airport (CVAG 2001). Surveys in the early 1990s found no owl pairs in the Coachella Valley despite the fact that small populations existed there in the 1980s, and breeding owls have apparently been extirpated from the Coachella Valley (DeSante et al. 1996).

There is some belief that some owls may still occur along roads and levees in agricultural areas at the eastern end of the Coachella Valley, within lands covered by the Coachella Valley Multi-Species Habitat Conservation Plan, and there are a handful of recent breeding season observations of owls in the Coachella Valley (USFWS 1995; CNDDB 2001; LACM 2001).[145] However, biologists from CDFG and the Coachella Valley Water District who routinely visit the agricultural drains and associated levees around the Salton Sea reported only 1 recent burrowing owl observation in the Coachella Valley (CVAG 2001).

I. SOUTHERN DESERT RANGE

The range of the burrowing owl in southern desert areas encompasses the eastern 85% of Inyo County (excluding the Panamint Range); the southeastern 30% of Kern County; all but the southwestern 15% of San Bernardino County; the northeastern 30% of Los Angeles County; the eastern 50% of Riverside County (excluding the Coachella Valley); the eastern 50% of San Diego County; and 50% of Imperial County (excluding the Imperial Valley) (DeSante et al. 1996).

Burrowing owls in the southern desert range are in small, scattered populations, and have historically never been common (DeSante et al. 1996). Grinnell and Swarth (1913) believed burrowing owls were "very rare or entirely absent on the desert side of the [Peninsular] range." Garrett and Dunn (1981) gave an overview of the owl's distribution in southern California deserts: "It is quite scarce on the northern deserts from the e [east] Mojave Desert north through Inyo Co...While it is largely resident in the region there is some winter

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143 Eight owls were seen along the Eucalyptus Lateral 2 Canal, 3 miles southwest of El Centro, on 12/11/90 (CNDDB 2001), and birds were collected from Calipatria on 6/18/1995 and 6/16/1999 (LACM 2001).

144 Eggs were collected at Indio on 3/20/27 and at Thermal on 4/21/29 (SBCM 2001). There are historical breeding season records from Indio on 3/2/42 and at an unspecified location in the Coachella Valley on 5/9/81 (LACM 2001). There are historical photographs from the Coachella Valley of 2 adult owls near a burrow at Thermal in August 1955, 2 birds south of Mecca in May 1955, and nest holes at Mecca in May 1955 (CAS 2002b).

145 Recent breeding season observations include 1 owl at Willow Hole on May 9-10, 1995 (USFWS 1995); 1 owl at Mecca on 8/2/96 (LACM 2001); and 1 owl near a burrow site near the Coachella Canal, northeast of Thermal, on 4/7/2000 (CNDDB 2001).

movement of more northerly birds into the southern and coastal parts of the region...Open desert scrub is widely but sparsely inhabited."

Displacement of owls due to development in the Coachella Valley may have slightly increased owl numbers in southern desert areas, as they became merely uncommon rather than rare (Weathers 1983). Breeding bird surveys between 1980 and 1989 indicated increasing numbers of owls in the lower Sonoran deserts and lower Colorado River Valley in southeastern California (Haug et al. 1993). It is thought that the burrowing owl may have expanded into the lower Colorado River Valley with the expansion of agriculture because this species was not reported from the valley in the early part of the century (Grinnell 1914; K. Rosenberg et al. 1991). Owls are now considered a fairly common resident in the valley (Rosenberg et al. 1991; D. DeSante, pers. comm., 2003), with a decrease in abundance in the northern areas of the valley in winter (Rosenberg et al. 1991).

DeSante et al. (1996) did not survey the southern desert range of the burrowing owl, and there is virtually no published literature on the distribution or seasonal movements of owls in the Mojave Desert (Campbell 1999). Campbell (1999) compiled 53 records (only 13 of which have specific locales and dates, with probable or confirmed breeding at 5 locales) of burrowing owls within the West Mojave Plan Area ("WMPA"), which are thought to represent a small sample of the locations where owls have recently been or are currently present. Although no focused owl surveys have been done, Campbell (1999) indicated that the species is currently "uncommon, local or patchy in occurrence, and currently in slow decline," and believes the total breeding population within the WMPA could be in the range of a few hundred pairs.[146] S. Myers, (pers. comm., 2002) believes that that owls are "locally rare to uncommon" and declining in the West Mojave, noting they have disappeared from a number of locations due to urban development.

Inyo County

There are historical records of breeding populations in the Owens Valley, Death Valley, and the Panamint Mountains and confirmed breeding at Bishop in 1939 (Fisher 1893; Grinnell 1923; Gilman 1934; Wauer 1962, 1964; MVZ 2001; NMNH 2001; SDMNH 2001).[147] Pettingill (1981) reported burrowing owls nesting at Death Valley National Monument and residing all year in the Owens Valley, from Bishop southward. Garrett and Dunn (1981) reported the species "quite scarce" on the northern deserts from the East Mojave Desert north through Inyo County. There are records of breeding owls at China Lake Naval Air Weapons Station ("NAWS") from 1978 to 1984 (USBLM 2002),[148] and there apparently was a small colony of about 6 pairs of owls there in the mid-1980s (P. Bloom, pers. comm., 2002). Burrowing owls still occur at China Lake NAWS, but the Base management plan offers no detailed information and does not provide any specific

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146 The 9.4 million-acre West Mojave Plan Area encompasses most of California's western Mojave Desert. It extends from Olancha in Inyo County on the north to the San Gabriel and San Bernardino Mountains on the south, and from the Antelope Valley on the west to the Mojave National Preserve on the east. Although most of this area coincides with the southern desert range excluded from surveys by DeSante et al. (1996), there is some overlap with areas in eastern Los Angeles County and southwestern San Bernardino County that are covered in Section VI.F on southwestern California.

147 Eggs were collected from Bishop on 6/30/39 (SDMNH 2001). In the Owens Valley, eggs were collected from Laws on 4/23/16 (MVZ 2001); and birds were collected during breeding season from the Owens Valley on 6/26/1891 (NMNH 2001), from Laws on 4/23/16 and 7/7/17 (MVZ 2001), from 2.5 miles southeast of Lone Pine on 6/12/17 (MVZ 2001), and from 2 miles north of Independence on 6/30/17 (MVZ 2001).

Grinnell (1923) concluded that burrowing owls were "native in, and doubtless breed 'at large' in" Death Valley, based on his 1917 study of the area. Gilman (1934) observed a burrowing owl in Death Valley from 1933 to 1934 and Wauer (1962) recorded the species there throughout the year, indicating that it was a permanent resident, and known to nest.

In the Panamint Mountains, Fisher (1893) found a nesting pair at Bennett Well; a single owl was collected from Emigrant Canyon, on 6/8/17 (MVZ 2001); and Wauer (1964), who noted that the owl was known to nest in valley alluvial fans of the eastern slope of the Panamint Range, found a single bird at its burrow on the Johnson Canyon fan in October 1961 and observed a single bird with no sign of a burrow or breeding near Harrisburg Flat in July 1959.

148 Historical observations at China Lake Naval Weapons Center include: "especially high" numbers in 1978 in valleys in the Mojave "B" ranges; 12 sightings in March 1979; 1 owl seen in October 1979; 1 owl at Haiwee Spring on 7/7/80; 2-3 adults and 3 juveniles at the NWC Golf Course on 8/24/80; 1 owl at the sewage treatment plant on 6/9/81; a family group of 4 owls at Amity Spring in June 1982; 1 owl at Mesquite Spring in June 1982; 2+ owls near Mirror Lake in March 1984; 1 owl near Mirror Lake on 5/15/84; and 2 owls at an unspecified location on 8/13/84 (USBLM 2002).

conservation measures since owl is not a listed species (China Lake NAWS 2002). There is a recent breeding season observation east of the White Mountains in 1994 (CNDDB 2001).[149]

Southeastern Kern County

Historical records confirmed breeding at the Desert Tortoise Natural Area, northeast of California City in the 1970s, and indicated probable breeding at Mohave in 1918 (Berry 1973; MVZ 2001).[150] Burrowing owls have been observed regularly within the last decade at the Desert Tortoise Natural Area (M. Conner, pers. comm., 2002). Campbell (1999) compiled 23 records of burrowing owls within the 301,000-acre Edwards Air Force Base ("AFB"); all of these have no specific locale or date. Although there have been no focused surveys, burrowing owls have been seen nesting since 1999 in as many as 6 sites simultaneously on the western half of the Base, where more typical owl habitat exists; preliminary data suggest that there are far fewer owls on the eastern half of the Base (R. Montijo, pers. comm., 2003). The Base management plan does not provide any specific conservation measures since owl is not a listed species (Edwards AFB 2001), but the known nest sites and owls are under no immediate threat from development or other activities and the population appears to be stable (S. Myers, pers. comm., 2002; R. Montijo, pers. comm., 2003). There are also 2 known nest sites immediately to the west and south of the Base, where human encroachment and activity appears to be a problem (R. Montijo, pers. comm., 2003).

San Bernardino County

Garrett and Dunn (1981) reported the burrowing owl "quite scarce" in the East Mojave Desert, but "rather common in agricultural areas" within the Colorado River Valley.[151] Burrowing owls were noted to breed in the Kingston Range, in northeast San Bernardino County, with observed owl densities of 1.4 birds/100 acres during summer surveys (Stone and Sumida 1983). There are historical reports of owls nesting at the train yards and the sewage plant in Barstow (USBLM 2002) and a burrow with up to 4 owls was observed at the train yards throughout the summer of 2002 (Rado 2002). There are recent breeding season records near Goffs (D. Cooper, pers. comm., 2002) and Victorville in the Mojave Desert (CNDDB 2001; USBLM 2002).[152] Burrowing owls still occur at Twentynine Palms Marine Corps Air Ground Combat Center ("MCAGCC"), but the management plan for the MCAGCC offers no detailed information and does not provide any specific conservation measures since the owl is not a listed species (MCAGCC 1996). Burrowing owls can still be found around Victorville (perhaps 10-15 pairs may remain), Apple Valley, Hesperia, and Lucerne Valley, but are declining due to rapid urban development (S. Myers, pers. comm., 2002). There is a report of a resident burrowing owl near El Mirage in 1991 (BWS 1991).

Northeastern Los Angeles County

There are historical nesting records from the Antelope Valley, in northeastern Los Angeles County (Daggett 1904; MVZ 2001; UCSB 2001).[153] It is conservatively estimated that a minimum of 10 breeding territories have been active in Antelope Valley most years between 1970-2000 (P. Bloom, pers. comm., 2002) and small numbers of breeding owls persist around Lancaster and Palmdale, however burrowing owls in northeastern Los Angeles County are declining and threatened by development pressure (CNDDB 2001; D. Cooper, S. Myers, pers. comm., 2002).[154]

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149 A single bird was observed southwest of Deep Springs College, east of the White Mountains, on 5/29/94 (CNDDB 2001).

150 A single owl was collected from Mohave on 3/15/18 (MVZ 2001), and Berry (1973) recorded breeding at the Desert Tortoise Natural Area, northeast of California City.

151 In the East Mojave, there is a non-breeding season collection record from 2 miles northeast of Kelso, on 1/3/38 (MVZ 2001). Along the Colorado River, it was reported in 1986 that a minimum of 5 owls were observed on the Fort Mojave Indian Reservation, approximately 5 miles north of Needles (CNDDB 2001).

152 A burrowing owl was seen roosting at a burrow site at Victorville on 4/3/97 (USBLM 2002).

153 Breeding season records of owls in the Antelope Valley include: Fairmont on 7/27/04 (MVZ 2001); Antelope Valley in June 1971; and Pearblossom on 6/11 and 6/12, 1972 (UCSB 2001). There are reportedly historical reports of owls nesting at the Poppy Preserve in Antelope Valley.

154 Recent CNDDB observations in Antelope Valley include: 10 fledglings seen 5 miles southwest of Rosamond, on 6/28/93; a fledged juvenile bird at Ave. B and 95th Street West, on 6/10/99; a family of owls at a burrow near Ave. B and 270th Street West in 1999 (1 owl in April and May, a female and young on June 6, and 2 adults and 6 juveniles on June 27); a burrow with fledged young near Ave. C and 250th Street West, on

Eastern Riverside County

Garrett and Dunn (1981) reported the burrowing owl to be "rather common in agricultural areas" within the Colorado River Valley.[155] Burrowing owls nested in Deep Canyon (south of Palm Desert), from the floor of the Coachella Valley to the base of the Santa Rosa Mountains (Ting and Jennings 1976; Weathers 1983). Other than reports of owls nesting in the Blythe area,[156] recent breeding season observations in eastern Riverside County could not be located.

Eastern San Diego County

Burrowing owls once nested in the Borrego Valley and probably in the Borrego Badlands in eastern San Diego County (Unitt 1984). A couple of pairs historically observed in the Borrego Springs area were apparently extirpated by the 1980s (Unitt 1984), but small numbers of owls are still likely to occur in the Anza-Borrego Desert (Unitt 2002). Recent breeding season observations in eastern San Diego County could not be located.

Imperial County (excluding the Imperial Valley)

Burrowing owls are reported to be common in agricultural areas within the lower Colorado River Valley (Garrett and Dunn 1981; Monson and Phillips 1981; Rosenberg et al. 1991; D. DeSante, pers. comm., 2003). Recent breeding season observations in eastern Imperial County could not be located.

6/11/99; an occupied burrow near 256th Street West and Ave. D, on 3/26/99; and an adult bird and presumed nesting near 110 Street West and Ave. B, on 5/19/99 (CNDDB 2001). 1 adult owl was observed at a burrow site in the Anaverde Valley, southwest of Palmdale, on 10/7/2000 (CNDDB 2001).

155 Two adults were presumed to be breeding at a site 4.5 miles northwest of Blythe, along the Colorado River, in 1974 (CNDDB 2001).

156 Burrowing owls are reported to be "scarce," in the Blythe area, with at best 12-14 pairs in the summer and 2 wintering pairs (R. Higson, pers. comm., 2002).

VII. POPULATION TRENDS

The western burrowing owl has declined significantly throughout its range in North America (Haug et al. 1993; DeSante et al. 1997; James and Espie 1997). The species was listed as endangered in 1995 in all the provinces in Canada in which it breeds (Haug et al. 1993) and is listed as threatened in Mexico (AGFD 1995). In the United States, it is listed as a federal Species of Special Concern. The majority of the mid-western and western states within the owl's range have listed the species: it is listed as endangered in Minnesota and Iowa (James and Ethier 1989; Marti and Marks 1989), threatened in Colorado (Anderson et al. 2001), and as a state Species of Special Concern in Kansas, Nebraska, Oklahoma, South Dakota, North Dakota, Montana, Idaho, Utah, Washington, Oregon, and California (Sheffield 1997a). It is estimated that California supports the largest remaining breeding and wintering populations of the species (James and Ethier 1989; DeSante et al. 1993; Anderson et al. 2001).

J. Barclay (pers. comm., 2001, using data from DeSante and Ruhlen 1995) estimates that breeding owls have been extirpated from approximately 8% of their former range in California during the last 10-15 years. Surveys by DeSante and Ruhlen (1995) and information in this petition document that breeding owls have been entirely eliminated from 5 counties (Napa, Marin, San Francisco, Santa Cruz, and Ventura) and the Coachella Valley, and likely have been extirpated from Humboldt and Mendocino Counties, southwestern Solano County, and western Contra Costa County as well. DeSante and Ruhlen (1995) documented that breeding owls are now near extirpation in 6 other counties (Sonoma, San Mateo, Monterey, western San Luis Obispo, Santa Barbara, and Orange) and information in this petition indicates the species is near extirpation in southern Los Angeles, western San Bernardino, western Riverside, and San Diego Counties as well. Excluding consideration of desert areas where the species has never been common, breeding owls have apparently been extirpated from at least 6,460 square miles, or 10.2% of their former range in California, and are trending toward extirpation in at least an additional 16,475 square miles, or 26.1% (see Appendix 2).[157]

From the 1980s to the mid-1990s, the California breeding owl population was estimated to be declining in abundance at a rate of 8% per year (DeSante and Ruhlen 1995; DeSante et al. 1996). The winter abundance of burrowing owls in California has also declined significantly since the 1970s, with Christmas Bird Count abundance data showing a mean decline of 1.2 % per year from 1959-1988 (James and Ethier 1989; Sauer et al. 1996).

Although the burrowing owl was once considered to be "probably one of the most common birds in California" (Baird 1870), and was subsequently described as "abundant" (Keeler 1891), "common" (Grinnell 1915; Dawson 1923), or "fairly common" (Grinnell and Wythe 1927) range-wide in California, the species has been in continuous decline throughout the state since at least the 1940s (Grinnell and Miller 1944; Zarn 1974a; Arbib 1976; Remsen 1978). Localized declines of owl populations were noted by the early 1900s, for example in the Fresno area (Miller 1903; Tyler 1913a), in the region of Los Angeles (Willett 1912), and in Orange County (Robertson 1931).

Statewide, burrowing owl declines have accelerated greatly in the last 20 years (James and Ethier 1989; Trulio 1997; DeSante and Ruhlen 1995; DeSante et al. 1996; DeSante, et al. in press), Significant declines documented statewide (DeSante and Ruhlen 1995), in central California (DeSante et al. 1997), and in localized urban areas (e.g. Trulio 1998a) show an annual population loss of approximately 8% per year. The Institute for Bird Populations completed an extensive three-year study (1991-1993) of burrowing owl populations throughout the species' breeding range in California, exclusive of the Great Basin, desert areas, and the Channel

[157] Even including the large sparsely populated desert areas, breeding owls have been extirpated from 6.2% of their former range and are trending toward extirpation in an additional 15.9%.

Islands, where the species has never been common (DeSante and Ruhlen 1995; DeSante et al. 1996).[158] Based on the 1,995 breeding pairs of burrowing owls located by this survey, it was estimated that between 7,884 and 10,370 breeding pairs of burrowing owls existed statewide during 1991 to 1993 (DeSante and Ruhlen 1995; DeSante et al. 1996).[159] Although numerical survey data from earlier years with which to compare these estimates do not exist, early descriptions compared with current levels indicate the present abundance of burrowing owls in California is but a fraction of the historical level.

The current distribution of California's burrowing owl population is extremely heterogeneous and clumped. It is estimated that over 71% of the state's breeding owls, outside of the Great Basin and desert regions, inhabit the Imperial Valley, a very compact geographic area comprising only 2.5% the state's land mass (DeSante and Ruhlen 1995). DeSante and Ruhlen (1995) estimated 14% of California's owls reside in the southern Central Valley, and 11% breed in the central and northern Central Valley and southern San Francisco Bay Area combined. Only 2% of the state's breeding owls occur in the remainder of central and southern California west of the deserts, in small and extremely fragmented populations. Aside from the Imperial Valley population and the sparsely populated Great Basin and desert areas, only an estimated 2,731 breeding pairs of burrowing owls remain throughout the rest of California, and nearly half of these owls are concentrated in the southern portion of the Central Valley (DeSante and Ruhlen 1995).

Throughout the statewide census area, nearly 60% of the breeding groups of owls known to have existed during the 1980s had disappeared by the early 1990s (DeSante and Ruhlen 1995). This documented decrease in the numbers of breeding groups of owls during the decade of the 1980s was particularly heavy in the Central Valley (about 50% loss) and was astronomical in the heavily urbanized central-western and southwestern areas of California (about 70% loss) (DeSante and Ruhlen 1995). In the Central Valley alone, the fact that about half of the previously known breeding groups of owls disappeared within a decade suggests serious cause for concern for the future of this species in California.

A burrowing owl population survey was conducted focusing on central California in 1991 (DeSante et al. 1997).[160] Within the survey area, 83 breeding groups totaling 362 pairs of owls were previously known. In 1991, only 64 breeding groups totaling 318 pairs were found in a census of this area, despite the expenditure of 2,111 person hours searching 6,195 square kilometers for owls. Even using conservatively adjusted population estimates, the number of breeding groups in this region decreased 23-52%, and breeding pairs decreased 12-27% from 1986 to 1991. This is decrease of at least 4.6% per year for breeding groups and 2.4% per year for breeding pairs of owls. DeSante et al. (1997) re-surveyed the central California region in 1992 and 1993. Owl breeding groups in this region decreased a further 16.7% from 1991-92 and remained constant from 1992-93. The number of breeding pairs increased by 3.1% from 1991-92 (presumably because of excellent breeding success in 1991), but decreased by 5.2% from 1992-93.

DeSante et al. (1997) found the rate of population decline to be the greatest in the Outer Coast region (comprised of coastal Sonoma, Marin, San Francisco, coastal San Mateo, and Santa Cruz Counties). No owls were found in these areas during surveys in 1991. Only 103 owl pairs were located in the Bay Area region (comprised of interior Sonoma, Napa, western Contra Costa, Alameda, and Santa Clara Counties), and 233 pairs were located in the Central Valley region (comprised of Yolo, Sacramento, Solano, eastern Contra Costa, San Joaquin, Stanislaus, Merced, and the western portions of El Dorado, Amador, Calaveras, Tuolumne, and Mariposa Counties). Using conservative population estimates based on these surveys, DeSante et al. (1997)

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158 In this survey, DeSante and Ruhlen (1995) censused virtually all 5-km by 5-km blocks where burrowing owls were recorded as breeding birds during the decade of the 1980s, as well as a stratified random sample of nearly 500 additional 5-km by 5-km blocks. A total of 6,856 person-hours were spent surveying for burrowing owls during the 3 years of the census on 16,035 square kilometers of the California census area.

159 See Appendix 3 (DeSante et al. 1996) for an explanation of the methodology used for the survey and the statewide population estimate.

160 The central California survey region was bounded by Sonoma, Napa, Yolo, Sacramento, and El Dorado Counties inclusive on the north; Santa Cruz, Santa Clara, Merced, and Mariposa Counties inclusive on the south; by the 610-m contour line in the Sierra Nevada Mountains on the east; and by the Pacific Ocean on the west.

concluded there were 153 pairs in the Bay Area region (plus an additional small population of about 10 pairs in the Livermore area), and 720 pairs in the Central Valley region. No breeding pairs remain in the Outer Coast region. The number of owl pairs per breeding group also decreased, mostly in the San Francisco Bay Area, but also in the portions of the Central Valley included in the survey by DeSante et al. (1997).

Recent demographic studies of 4 of the largest remaining owl populations in California (Imperial Valley, Carrizo Plain, Lemoore NAS, and San Jose area) suggest variable population trends over 5 years, with each population experiencing good and bad years for survival and reproduction (D. K. Rosenberg et al., unpublished data; Gervais 2002, Ronan 2002, Rosenberg and Haley 2003). There appears there may be a meta-population dynamic linking at least populations among the Carrizo Plain, the San Jose area, and the Central Valley around Lemoore; owls banded at Naval Air Station Lemoore have been recovered as breeders at the Carrizo Plain and the San Jose area. In addition, the number of breeding pairs in the Central Valley (Naval Air Station Lemoore) and the Imperial Valley study sites remained nearly constant between 1997 and 2000, despite dramatic fluctuations in productivity and survival (Gervais 2002, Rosenberg and Haley 2003).

Because of its isolation, the apparently stable Imperial Valley owl population cannot be counted upon as a source population to augment the very small and declining populations inhabiting southwestern California and other areas of the state. Potential dispersal from the Imperial Valley population to declining populations elsewhere in the state may be limited by unsuitable intervening habitat and by the dispersal characteristics of the resident Imperial Valley population itself (DeSante and Ruhlen 1995; DeSante et al. in press). Imperial Valley owls may be reproductively isolated from other breeding owls in California except possibly a few desert-breeding pairs (Rosenberg and Haley 2003). The loss of breeding owls from any region in California is particularly significant because there are no known locations in the state where a breeding population of burrowing owls has been eliminated and subsequently been reestablished.

VIII. NATURE, DEGREE, AND IMMEDIACY OF THREAT

The burrowing owl is a species in crisis throughout most of its range in California. DeSante and Ruhlen (1995) estimated that at least 50% of the state's owl population was lost in the previous decade in both urban and agricultural areas of the state. This rate of decline was a loss of approximately 8% of the population per year. Breeding burrowing owls have recently been extirpated from 5 counties and nearly eliminated from 6 entire counties as well as portions of 4 others. Owls throughout the vast majority of the state persist in small fragmented populations or as individual pairs. The largest remaining owl populations face a host of direct and indirect threats.

The declines of burrowing owl populations are linked to land use trends throughout the state. Dramatic human population growth and urban development characterize the areas of greatest owl population losses. Direct habitat losses to urban conversion is the primary cause of decline, compounded by habitat quality reduction due to surface disturbances and elimination of burrowing rodents. The development pressures extirpating the state's burrowing owl population continue unabated.

Burrowing owls have continued to decline in California despite their habitat flexibility. Although owls have adapted to human-altered landscapes, essential habitat attributes must be present to support the species. Essential habitat attributes are the presence of suitable nesting habitat and adequate foraging habitat near or adjacent to nesting habitat. Suitable nesting habitat consists of burrows, semi-fossorial animals, short grass, and perches. Foraging habitat may be long or short grass and must support adequate populations of small rodents and large insects and other owl prey species.

The primary factors affecting the viability of the California burrowing owl population include:

- Loss of nesting and foraging habitat to human uses such as urbanization, which results in direct mortality and lower population numbers as available habitat decreases.
- Destruction of nests during urban development and agricultural activities by surface disturbances such as disking, blading, grading, and over covering, which may result in direct mortality of adults and young and may reduce the habitat quality and carrying capacity.
- Elimination of burrowing rodents, through means which may result in direct owl mortality, as well as ultimately making an area unsuitable for owls, thereby reducing available habitat.
- Relocation of owls out of occupied habitat to accommodate urban development, which rarely results in successful breeding at the relocation sites, and crowds remaining owls onto smaller and smaller patches of habitat.
- Predation of young birds by non-native and feral animals, which significantly reduces nesting success and productivity.
- Mortality due to vehicle collisions and other anthropogenic causes.

A. URBAN DEVELOPMENT

Over 85% of burrowing owls in California are found on agricultural land in the Imperial and Central Valleys (DeSante and Ruhlen 1995), the most rapidly urbanizing areas of the state, according to California Department of Finance ("CDF") population growth statistics (CDF 1993, 1994, 2001). These areas are threatened in the short and long-term by human population growth and rapid development, which is converting open fields and agricultural lands to residential and commercial uses. Unfortunately, the flat open grasslands preferred as habitat by burrowing owls are prime development sites and owls currently have little protection from powerful economic development pressures. By the year 2040, it is projected that 5 million acres of agricultural land in California, or 17% of today's farmland base, will be lost due to urban expansion (Medvitz and Sokolow 1995).

Loss of nesting and foraging habitat for owls is the biggest consequence of urban development (Zarn 1974; Konrad and Gilmer 1984; Barclay et al. 1998). If owls are not detected during studies required by the California Environmental Quality Act, they can be directly killed when their burrows are bulldozed. A significant indirect effect of urbanization is reduced reproductive success where construction occurs at a site without destroying the nests. A study in Florida showed fledging rates for remaining burrowing owls at sites where construction occurred were significantly less than at sites next to construction or with no construction (Millsap and Bear 1988).

Imperial County is an area of extremely rapid human population growth. In 1993, Imperial County had the highest human population growth rate of California's 58 counties and it ranked 6th in population growth in 2000, with virtually all growth concentrated in the Imperial Valley (CDF 1994, 2001). With an annual growth rate of 2.9 to 3.6 % (Medvitz and Sokolow 1995; CDF 2001), Imperial County's human population is projected to increase from 150,000 currently to 504,000 by 2040, an increase of 335% (CDF 2001). The California Department of Conservation ("CDOC") Farmland Conversion Report (CDOC 1994, 2000) documented the conversion of at least 3,544 acres in Imperial County from agricultural to urban and built-up land from 1990 to 1998 (with only 36% of lands mapped).

The Central Valley is also rapidly urbanizing. The CDOC Farmland Conversion Report (CDOC 1994, 2000) recorded 74,006 acres of land converted from agricultural to urban and built-up uses from 1990 to 1998 in all the Central Valley counties. The Association of Bay Area Governments ("ABAG") projects the population of the Central Valley is projected to double by 2020 (CDF 1993).

In the southern Central Valley, Madera, Kings, Tulare, Kern, and Fresno Counties ranked 2nd, 4th, 5th, 8th, and 10th in the state, respectively, in population growth rate as of 1993, with an average growth rate of over 3% (CDF 1994). Kings and Madera Counties ranked 4th and 7th in population growth in 2000, with 3.0% and 2.9% growth rates that year, and Kern County also had growth rate greater than 2% (CDF 2001). Development projects such as the proposed U. C. Merced campus at Lake Yosemite in Merced County, which will develop 10,300 acres of open space grassland with known nesting populations of owls in the next 20 years, threaten remaining large owl populations. The Tejon Ranch Company has approvals for a massive 1,460-acre industrial development in southern Kern County within the range of the owl, and has plans for a 23,000-unit residential development, resort development, golf courses, and more. Eventually all 270,00 acres of Tejon Ranch Company's agricultural and ranching land in southern Kern and northern Los Angeles Counties may be at risk of development.

Human population growth has also exploded in the northern and central portions of the Central Valley, where numerous sites occupied by burrowing owls within the past few years are threatened by commercial and residential development (CNDDB 2001; CDFG 2002a). Placer County was the fastest growing county in the state in 2000, with a 3.5% growth rate (CDF 2001). San Joaquin and Yolo Counties ranked 8th and 10th in growth in 2000, with 2.7% and 2.5% growth rates, and Sacramento County had a growth rate greater than 2% that year (CDF 2001). According to California Department of Fish and Game ("CDFG") documents, from 1995-2001, at least 9,000 acres of occupied owl habitat and over 15,000 acres of potential owl habitat in San Joaquin County were lost to development; an unknown amount of occupied habitat and over 13,000 acres of potential habitat were lost in Sacramento County, and at least 460 acres of occupied habitat and over 600 acres of potential habitat were lost in Solano County during the same time period (CDFG 2002a).[161]

[161] The actual amount is likely significantly higher, since the list of projects with potential impacts to owls is not comprehensive, and many sites considered potential habitat may have actually been occupied habitat.

Proposed development projects in Yolo and Solano Counties threaten significant owl populations there.[162] Recent development projects in eastern Alameda and Contra Costa Counties have impacted owl colonies and several proposed projects would impact occupied owl habitat.[163]

Remaining owl populations on private lands in the Bay Area face enormous development pressure, which has been particularly severe in the southern San Francisco Bay Area. For example, in Santa Clara County, over 90% of the agricultural land was abandoned during the past century, and for the most part urbanized, with over half the valley floor now developed (Bell et al. 1994). In Santa Clara County, the conversion of rural/agricultural lands to urban uses has resulted in a 60% decline in the owl population in that County in 10 years (DeSante and Ruhlen 1995; L. Trulio, pers. comm., 2001).[164] The burrowing owl population at the Oakland Airport, formerly one of the largest in the Bay Area, has now been significantly reduced and is threatened by further airport expansion.[165] Many of the remnant owl populations in Alameda and Contra Costa Counties have also been severely impacted and face future development threats.[166] Ongoing development projects threaten most of the remaining owls on private lands in Santa Clara County with imminent extirpation (L. Trulio, pers. comm., 2002).[167] The human population of Santa Clara County is projected to increase 47% by

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162 Burrowing owls have been documented at the Mace Ranch Park site in Davis since at least 1997, when agricultural cultivation ceased and before development began (PHBA 2002). A 1,000 home development with a school, shopping center, and park has been built at this site, with nesting owls occupying a 33-acre parcel surrounded by development. Burrowing owls continue to occupy the site even though it was disked annually from 1998 to 2000 during the nesting season. Weed abatement activities at this site during May 2000 may have resulted in the take of at least 1 burrowing owl and the destruction of at least 1 nest site (CDFG 2002a). At least 3 productive nests and 15 juveniles were observed here during summer 2000 (CNDDB 2001). The Davis City Council approved converting 5 of these acres to playing fields in September 2002, despite acknowledgement in the EIR of "potentially significant direct and indirect impacts on burrowing owls and burrowing owl habitat," and warnings by biologists that the remaining habitat patch after development will be too small to support owls (PHBA 2002). In 1998, the University of California, Davis transferred a site previously deemed an Open Space Reserve for burrowing owls to developers, for conversion to student housing. At Montezuma Marsh in Solano County, occupied owl habitat is to be buried in several feet of toxic dredge sediments as part of a "restoration" project. The Montezuma project is expected to directly impact 7 pairs of owls (CDFG 2002a).

163 In eastern Alameda County, the recent Mountain House Golf Course and PG&E projects directly impacted 4 pairs of owls, and the East Altamont Energy Center impacted an estimated 7-8 pairs (CDFG 2002a). In eastern Contra Costa County, the recent Equilon project in Byron and the Williamson Ranch Plaza project in Antioch each directly impacted 2 pairs of owls, and the Denova project in Concord directly impacted 1 pair (CDFG 2002a). Grading and disking for development threaten remnant owl populations in Antioch, Brentwood, and Oakley. The proposed expansion of Los Vaqueros Reservoir threatens occupied owl habitat there. A proposed golf course development threatens owl populations at Altamont Pass.

164 A number of recent development projects in San Jose (including Cisco, Novell, AMD, Agilent, Agnews Developmental Center, Agnews East, Pacific Bowie, FRIT, VTA, Mission College, 3Com, Santa Clara University, Sobrato, and Errante) directly impacted an estimated 42 pairs of owls (CDFG 2002a). The owl population at Mission College dropped recently from 60 owls to less than a dozen. In 1990, the college decided to lease about 70 of its 100 acres of open space to developers to build a shopping mall. As of 1998, only 12 of the original 16 pairs remained, and as of 2001, only 8 pairs remained. There may only be enough remaining habitat to support about 8 pairs in the long run (L. Trulio, pers. comm., 2002). The first week of February 2001, the college placed one-way doors over 92 squirrel holes so burrowing owls could no longer use them as shelter.

Development in the City of Morgan Hill has apparently recently extirpated the breeding owl population there, before a promised owl habitat conservation program could be implemented (J. Barclay, pers. comm.). The recent Cisco, Townsend Milpitas, and Caltrans projects in Milpitas directly impacted 4 pairs of owls (CDFG 2002a).

165 The Oakland Airport, which is undergoing a major expansion project, was ordered as a result of a lawsuit in 2001 to conduct a new Environmental Impact Report (EIR) for the project, because planners had ignored CDFG concerns about the impacts of the expansion on the burrowing owl population. CDFG indicated the mitigation proposed in the draft EIR for the burrowing owls "is not adequate for their protection and does not follow the Department's guidelines for the species." Among other things, CDFG questioned the adequacy of the draft EIR's proposed one-to-one replacement ratio for destroyed owl burrows, it requested more information about the location and size of the mitigation area, and it asked the airport to explain how it planned to permanently protect the mitigation site from conversion to other uses. The final EIR did not provide for new or modified mitigation measures in response to the CDFG comments, nor did it contain any new standards for replacement of burrows destroyed by construction. Also absent was any explanation, as requested by CDFG, why the number of acres proposed for the replacement habitat would be sufficient, how the replacement habitat will be protected, or where it will be specifically located. In spite of the fact that the airport had been alerted to some significant problems by the agency with technical expertise in species conservation, the mitigation measures proposed in the final EIR are essentially identical to those proposed in the draft EIR. CDFG subsequently made an agreement that will allow the airport to relocate many owls and "mitigate" with conservation land purchased in Byron, in eastern Contra Costa County.

166 The recent Port of Oakland Project directly impacted 6 pairs of owls and the recent Evershine, ESS, and Applied Materials projects in Fremont, and the Denova project in Concord each directly impacted a pairs of owls (CDFG 2002a). The proposed Catellus development in Fremont threatens a population of burrowing owls.

167 The City of San Jose expects to destroy over 2000 acres of owl habitat over the next 20 years (plus potentially an additional 1,250 acres intended as mitigation land, which was scrapped when the City's owl plan was abandoned). The proposed Cisco "campus" in Coyote Valley will develop 150 acres of open space that currently supports 3 families of burrowing owls (16 to 22 adults and chicks were located there in 1998), and will leave a remaining open space too small to support owls. The proposed Metcalf Energy Center will destroy 10 acres of grassland containing a burrow that was occupied in February 1999.

2040 (ABAG 1999). According to the CDFG, Central Coast Region, at least 84 owl pairs, approximately one-half of the Bay Area population (DeSante et al. 1997), have been directly impacted by development activities in the past 3 years, within the southern and eastern portions of the Bay Area (Contra Costa, Alameda, and Santa Clara Counties) (CDFG 2002a). The Association of Bay Area Governments ("ABAG") projects the population of the San Francisco Bay Area will have increased by 1.4 million people (22%) from 1995 to 2020 (ABAG 1999).

In southern California, planned developments in western Riverside and San Bernardino Counties threaten many of the significant breeding colonies remaining there.[168]

The ongoing closure of military bases and their conversion to commercial and residential development is a major threat that could reduce or extirpate significant owl populations. Large owl populations reside at Lemoore Naval Air Station in Kings County and Moffett Airfield in Santa Clara County; populations also occur at other bases such as Alameda Naval Air Station in Alameda County and southern San Diego County Naval Bases. If these sites are closed and their grasslands developed, their owl populations could be lost. For example, NASA plans to develop 500 acres of land (1,930 housing units) at Moffett Field in Mountain View, Santa Clara County, with only 81 acres protected as a burrowing owl preserve. The EIR will be approved in 2002, with construction through 2017. The potential closure and development of the Sacramento Army Depot and Norton Air Force Base in western San Bernardino County threaten burrowing owl colonies.

B. THREATS TO IMPERIAL VALLEY AND SOUTHERN CENTRAL VALLEY OWL POPULATIONS

The vast majority of California's breeding burrowing owls reside in the Imperial Valley (71%) and the southern Central Valley (14%) (DeSante and Ruhlen 1995). DeSante et al. (in press) note that "given the rapid development of much of the grassland and desert regions of California, the apparent extirpation of the species in the Coachella Valley immediately north of the Imperial Valley, the reduction in numbers in other parts of California, and the lack of a state-wide conservation strategy, the importance of the Imperial Valley population may increase."

The Imperial Valley owl population (which may be reproductively isolated from other populations) faces ongoing threats to its habitat and numbers, including habitat loss to development (as discussed in Section VIII.A above), cement lining of earthen canals or burying of conveyance structures, levee maintenance and repair operations including ground squirrel eradication, mowing, high exposure to agricultural poisons, a low-calcium diet, and relatively low reproductive success (DeSante et al. in press).

Because of the large numbers of owls that reside within the agricultural matrix of the Central and Imperial Valleys, changes in agricultural practices, particularly regarding water distribution and conveyance

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[168] A 2,028 acre urban development is proposed adjacent to the cities of Temecula and Murrieta in western Riverside County. Three public agencies and 9 private entities applied in July 2000 for a Habitat Conservation Plan and 30-year Incidental Take Permit for 19 urban development projects in this area. The burrowing owl is one of the covered species for the HCP. 554 acres of burrowing owl habitat would be destroyed by the project, with 61 acres of habitat conserved as "mitigation." Pacific Bay Properties applied in December 1999 for a 30-year Incidental Take Permit for a 2,000 home development within the Rancho Bella Vista Community Specific Plan Area, between state route 79 and Lake Skinner Reservoir, in western Riverside County.

In San Bernardino County, the City of Chino General Plan authorizes low to high-density housing development on most of the agricultural land around the Chino Airport, including the majority of occupied owl locations in the vicinity of Chino (J. Bath, pers. comm., 2003). In one case consultants installed one-way door devices on burrows to eliminate the owls before the CEQA process started, so that the project can go through with a Negative Declaration instead of an EIR; in another case the city issued a grading permit before public CEQA hearings were held (J. Bath, pers. comm., 2003). The Department of General Services is selling for development 717 acres of surplus state property in the City of Chino with one of the largest stable colonies of burrowing owls known in the Prado Basin area (J. Bath, pers. comm., 2003). The City of Ontario General Plan proposes to convert 8,200 acres of existing agricultural grasslands, and develop 31,000 homes, with only a mere 50 acres of raptor habitat provided as "mitigation" (G. Stewart, D. Guthrie, pers. comm., 1997). This plan, when combined with the 2,447-acre plan of the City of Chino, will impact the largest burrowing owl population in the Inland Empire (J. Bath, pers. comm., 2003).

(e.g., Clemings 1996), have the potential to quickly affect California's burrowing owl population (Anderson et al. 2001; Rosenberg and Haley 2003). Almost all of the owls in the Imperial Valley, and many owls in the southern Central Valley nest within or along water ditches, canals, and earthen drains.[169] Habitat destruction in the form of altered water conveyance structure is a major risk for owl populations in the Imperial Valley (Gervais et al. 2003). The state of California is currently lining up a series of water transfers from agricultural to urban areas, including a massive transfer from the Imperial Valley to San Diego. Part of this transfer involves efficiency improvements to Imperial Valley waterworks, including lining many of the earthen canals where burrowing owls live with concrete, converting open drains into pipeline drains (burrowing owls inhabit the inside banks of the drains), and fallowing large acreages of agricultural land which currently serve as foraging habitat. These activities could permanently eliminate owl burrows (CH2MHILL 2001) and reduce foraging habitat.

The main factor controlling owl abundance in the Imperial Valley seems to be availability of burrow sites (Coulombe 1971). Although 1,000 miles of canal banks were present in 1971, only a fraction of them are suitable habitat for owls at any given time. Canals that supply water are not suitable for nesting due to periodic rises in water level and the potential for flooding. About one-third of the canal mileage is drainage canals, which are subject to dredging every few years, which destroys established burrow sites. Coulombe (1971) and Rosenberg and Haley (2003) documented owl nests destroyed by dredging of drains and grading of roads in the Imperial Valley. Coulombe (1971) counted 13 pairs of owls along 4 miles of canal in 1966, but could find no owls 1 month later, after the canal was dredged. Flooding, caused by the overflow of delivery ditches, has caused nest destruction and killed young (Rosenberg and Haley 2003). The development of tall vegetation along the banks of canals or drains can also prevent owls from nesting (Rosenberg and Haley 2003). Thus, the only suitable habitat in the agricultural matrix is areas where agriculture is not in progress (Coulombe 1971).

Despite the high densities of burrowing owls in the Imperial Valley, reproductive success there is relatively low compared to other populations in California, with an average of only 2.5 young per nest (Rosenberg and Haley 2003). Imperial Valley owls produce smaller average clutch sizes relative to other California populations, but at least in some years owl productivity there was not limited by egg-laying (J. Gervais, pers. comm., 2003). Burrowing owls elsewhere in the state produce up to 11 eggs but owls only average 6 eggs in the Imperial Valley, and clutch sizes there have never exceeded 8 eggs; of those, few individuals fledge (Rosenberg and Haley 2003). This reduced productivity may be due to close nesting; e.g., in Oregon, nests closer to 110 meters to neighboring nests had lower reproductive success (Green and Anthony 1989). However, lack of calcium-rich vertebrate prey has been shown to reduce reproductive success of burrowing owls in the Imperial Valley. Year-round cultivation and flood irrigation presumably maintains very low rodent populations, thus rodents represented only 0.2% of the total prey found in burrowing owl stomachs in one study in the Imperial Valley, while in other locations, rodents and other vertebrate prey represented 8-52% of the diet (York et al. 2002). Small clutch sizes in the Imperial Valley have been attributed to the scarcity of rodents and other calcium-rich food items in the diet; in fact, owl productivity increased when the diet was supplemented with rodents (Haley 2002; York et al. 2002).

With 71% of the state's burrowing owl population occupying only 2.5% of the state, the Imperial Valley represents a single population of extreme importance. The size of this population is an inadvertent but fortunate by-product of agricultural land use. Should management or land use change even slightly, the most significant population of owls in California could be reduced or lost.

C. DESTRUCTION OF BURROWING RODENTS

Numerous researchers have identified elimination of burrowing rodents through control programs as the primary factor in the recent and historical decline of burrowing owl populations (Anderson et al. 2001).

[169] Most (92%) of the owls in the Imperial Valley nest within 15 meters of irrigation canal banks (DeSante et al. 1996).

Farmers and ranchers, with help from the federal government, have long practiced all-out warfare against burrowing rodents. For example, persecution of the prairie dog has reduced them to just 2% of their original numbers (Trulio 1998a). Widespread ground squirrel control programs were begun in as early as 1869, when the state legislature authorized the payment of bounties on squirrels (Gordon 1996), and are currently carried out on more than 9.9 million acres in California (Marsh 1987). In some primarily agricultural counties, the ground squirrel population has been reduced and maintained at perhaps 10-20% of the carrying capacity. Ground squirrels are still considered vermin and are the victims of ongoing eradication campaigns. Individual landowners and managers on grazing, vineyard, and crop production lands conduct extensive rodent control programs involving shooting, poisoning with acute toxicants, anticoagulants, and fumigants, trapping, and sealing burrows (Butts 1973; Salmon et al. 1982; Rosenberg et al. 1998a). Burrowing owls have been incidentally poisoned and their burrows destroyed during eradication programs aimed at rodent colonies (Zarn 1974b; Remsen 1978; Collins 1979; Gordon 1996; P. Bloom, pers. comm., 2002).

Acute toxicants used to eliminate squirrels have included zinc phosphide, strychnine, and sodium flouroacetate (Compound 1080 - which is no longer registered for use in California). These poisons may adversely affect burrowing owls. In Kings County, anticoagulants and fumigants are usually used (Rosenberg et al. 1998a). Anticoagulants include chlorophacinone, diphacinone, Fumarin, Pival, and warfarin. More effective second generation anticoagulants such as brodifacoum, difenacoum, and flocoumafen are also used to kill rodents, primarily in bait forms (Rosenberg et al. 1998a). Primary poisoning and secondary consumption through the ingestion of poisoned rodents are possible for burrowing owls. In an experiment where mice killed by anticoagulants were fed to Northern saw-whet (*Aegolius acadicus*), great horned (*Bubo virginianus*), and barn owls (*Tyto alba*), all the owls exposed to diphacinone and brodifacoum showed symptoms of poisoning and death resulted, while 1 of 6 died from ingesting bromadiolone-killed rats (Medenhall and Pank 1980). Barn owls also showed significant mortality when fed rodents killed by Flocoumafen and brodifacoum (Newton et al. 1994; Wyllie 1995). Fumigants used on ground squirrel burrows include aluminum phosphide, carbon bisulfide, and methyl bromide, with unknown, but potentially harmful effects on owls.

Healthy colonies of burrowing rodents are an essential attribute for burrowing owl habitat. Periodic elimination of ground squirrels inhibits the persistence of owls, which rely on squirrels for nest burrows (DeSante et al. 1996). Ground squirrels also benefit burrowing owls in the form of burrow maintenance between nesting seasons and shared alarm calling behavior (Trulio 1994). In agricultural areas such as the Central Valley and the Imperial Valley, rodenticides are often used on levees to control numbers of ground squirrels, which can undermine levees through their digging. Exposures to rodenticides and direct killing of owls by gassing (Zarn 1974a) could be problematic in areas like the Imperial Valley, where a large proportion of owls nest on or near levees.

D. RELOCATION OF OWLS

Burrowing owls in California are commonly discouraged from nesting at or translocated from occupied burrows, either through active or passive relocation or eviction, to accommodate urban development. Active relocation is the process of moving owls from occupied burrows to other burrows off-site, by trapping owls and temporarily holding them in enclosures on relocation sites, then releasing them at the relocation sites. Passive relocation is the process of encouraging owls to move from occupied burrows to other natural or artificial burrows, and may entail using one-way devices on burrows that force the subject owls to relocate. Eviction is forcing owls to evacuate previously occupied burrows by physically preventing them from re-occupying those burrows, without any provision of alternative burrows.[170] Such relocation activities are intended to avoid "take" (direct mortality or harm to owls) and are often encouraged by regulatory agencies such as the California Department of Fish and Game (CDFG 1995). Unfortunately, the potential for take is only part of the impacts of

[170] The sealing or plugging of occupied burrows is illegal, as nests are protected under the California Fish and Game Code. However, unoccupied burrows, even those owls have recently used for nesting, are not necessarily protected all year.

development projects, and relocation of owls is not designed to mitigate for the habitat loss, habitat fragmentation, and reduced owl survivorship caused by development.

Many of the active relocation efforts for burrowing owls that have been monitored have failed to establish viable owl populations at the relocation sites, with owls either disappearing completely, attempting to return to the capture site (where their burrows have often been destroyed), or exhibiting low breeding success at the relocation site (Harris 1987; Delevoryas 1997; Trulio 1997). One of the reasons for this is that burrowing owls are very site tenacious and are not easily forced to move to a different burrow, especially during nesting season (Trulio 1997). Such burrow fidelity is a widely recognized trait, with owls regularly reusing burrows from one year to the next (Martin 1973; Wedgwood 1976; Green 1983). A study by Green (1983) found an average of 76% of owl burrows were reoccupied the next year. Trulio (1994) reported that over a 3-year time span at a site in northern California, 73% of nest burrows or burrows within 100 meters were reoccupied the next year.

Many active relocation efforts involve moving owls to artificial burrows. A significant problem with artificial burrows is that they require permanent maintenance to provide long-term nesting habitat, otherwise they can become buried (P. Bloom, pers. comm., 2002). Another potential problem with active relocation is that moving owls in this manner likely stresses the birds (Trulio 1997). Another failure has been the lack of requirement for long-term management of owl habitat at release sites.

Harris (1987) noted that only 1 of 8 (12.5%) previous active burrowing owl relocations in California was even remotely successful in terms of establishing breeding at the new location, with 2 of the 6 relocated owls in that instance remaining and breeding on the site for up to 3 years. Owls released during 2 spring relocations returned to the capture site within 1 month of release (Feeney 1997). Three of the relocations were done in the fall, and the timing of the other relocations was unknown (H. T. Harvey and Associates 1993).

Delevoryas (1997) reported on the failed active relocation in 1990 of 5 pairs of owls from Mission College in Santa Clara to 2 sites 31 kilometers to the south. The owls were trapped in mid-February and released in mid-March, just as breeding season was getting underway. The first season 2 of the 5 pairs (40%) bred successfully, with only 2 nestlings surviving to fledging (it is unclear if the fledglings survived to the following breeding season). Of the 10 translocated owls, 5 left the site, 1 was killed, and 4 adults plus the 2 fledglings remained at the relocation sites in 1991. By 1992 only 2 owls remained, and by 1994 only 1 owl remained. The site was not maintained for burrowing owls after the first year - the site was disked, and artificial burrows were not maintained (P. Delevoryas, pers. comm., 2003).[171]

Trulio (1997) compiled known information on active burrowing owl relocations conducted in California. Of 27 owls relocated to new burrows, 17 (63%) disappeared within a year of release and 7 (26%) flew back to their original site. Only 4 owls (14%) attempted to breed at their new locations (1 owl bred at the new site before disappearing). Only 2 owls (7%) bred successfully, and only 1 owl (4%) stayed on the site for 2 breeding seasons. In addition to the failure of 93% of these owls to successfully breed at the relocation sites, the fate of most of the relocated owls was unknown, as the majority disappeared.

In 1997 H. T. Harvey & Associates successfully translocated 8 owl pairs to a relocation site at the San Jose/Santa Clara Water Pollution Control Plant buffer lands. All but 1 pair (which may have been moved too late in the breeding season) remained on the relocation site, and successfully raised chicks to the age of

[171] Several reasons were posited for the failure of the relocation effort. The mortality of 1 adult owl was due to inadequate closing of the nesting box by researchers, allowing access to predators. At 1 relocation site, the landowner (IBM Corporation) failed to follow the agreed-upon management plan, and the foraging habitat at the site was disked and left fallow during a period when nestlings and fledglings would need the most amount of food for growth. Also, researchers fed the owls too many mice while they were held in hack aviaries at the site, and surplus mice cached by owls in the burrows likely led to increased predation.

fledging; about 11 pairs nested at this relocation site in 2002, most of which nested in artificial replacement burrows constructed in 1997 (D. Plumpton, pers. comm., 2002).

The unfortunate result of most active relocation efforts has been the loss of known occupied owl habitat to development, with very little proven nesting success at relocation sites and the ultimate fate of most translocated owls unknown. Clearly, the practice of active relocation of burrowing owls as a "mitigation" for development impacts is detrimental to preserving owl populations.

For most passive relocations conducted in California, there is no way of knowing where the evicted owls go or whether they are able to breed successfully in other areas. The current lack of knowledge on the results of passive relocation is largely due to the failure of CDFG to require studies in areas where owls are evicted. The consultants that are hired to do this work do not conduct studies (e.g., color banding or radio-tracking) that evaluate the success of passive relocation. There is no legal requirement to do this, and developers rarely have any interest in the fate of the owls beyond moving them out of the way of development projects. For example, in the City of Chino, consultants are putting one-way door devices on burrows to eliminate owls before the CEQA process starts, so that projects can go through with a Negative Declaration instead of an EIR (J. Bath, pers. comm., 2002).

However, if the process of passive relocation is properly refined and used appropriately, it has the potential to be an important conservation tool, for example when applied to permanently protected lands such as large military reservations, used to discourage nesting in close proximity to airport runways, or used to avoid take for temporary disturbances (such as pipelines, paving, etc.) by moving owls short distances (J. Barclay, P. Bloom, pers. comm., 2002). Passive relocation of owls can work if the birds are moved short distances (i.e. under 5 miles) and the habitat they are moved to is managed for them. Burrowing owls should never be translocated or forced to move to unprotected private property. Predators must also be taken into consideration - if owls are moved from an urban area where they have only been exposed to feral cats, Red-tailed Hawks and Northern Harriers, they will probably do poorly if moved to an area with coyotes or red foxes (P. Delevoryas, pers. comm., 2003).

There have also been several failed reintroduction attempts (long distance movement to formerly occupied parts of their range) of burrowing owls. DeSmet (1997) reported that of 169 young and 85 adults captured in South Dakota and released into temporary aviaries and artificial burrows in Manitoba, Canada, only 1 of these birds (0.4%), a juvenile, was seen the next year. Martell et al. (1994) reintroduced 104 fledgling owls from South Dakota to hack sites in Minnesota, distances of 450 and 600 kilometers away. None of these birds were seen after the summer they were released. After a decade of owl family relocations from Washington State to British Columbia (Dyer 1988; Dyer pers. comm. as cited in Trulio 1997) the program has not successfully established a self-sustaining population.

The mixed results of active relocation, the failure of reintroduction efforts, and the misuse of passive relocation techniques indicates that it is imperative to protect remaining occupied burrowing owl habitat and owl populations in situ. Unfortunately, the CDFG is informally encouraging translocation of owls from occupied habitat in rapidly urbanizing areas (e.g. in Santa Clara County). The practice of translocating owls as "mitigation" eliminates occupied habitat without adequate mitigation for the true impacts of development. As a relatively adaptable species, all that burrowing owls must be afforded in order to survive is habitat, and if that habitat is systematically removed for the convenience of development, owls will predictably disappear.

E. AGRICULTURAL PRACTICES

Although agricultural environments can support very high densities of burrowing owls (Rosenberg and Haley 2003), they may also pose threats to owl populations through pesticide exposure, destruction of nest burrows by farm equipment, seasonal food scarcity exacerbated by farming practices, or extermination of

burrowing mammals (Desmond et al. 2000). Although intensive agricultural practices can have impacts on the productivity of burrowing owls, current agricultural practices in California are not thought to be a significant threat to the persistence of viable breeding owl populations, as evidenced by the apparent coexistence of high concentrations of burrowing owls with agricultural operations in the Imperial Valley and southern Central Valley. The California Endangered Species Act includes an agricultural exemption (California Fish and Game Code §2087(a)) allowing for "accidental take of candidate, threatened, or endangered species resulting from acts that occur on a farm or a ranch in the course of otherwise lawful routine and ongoing agricultural activities."

The dramatic alteration of 98% of the original prairie habitat in the United States has been linked to the reduction in western burrowing owl populations (Evans 1982; Sheffield 1997a; Trulio 1998a). As long ago as the 1930s it was recognized that intensive cultivation of grasslands and native prairies was a major factor in declining burrowing owl populations (Bent 1938). Conversion of pastures to cropland (Grant 1965; Konrad and Gilmer 1984; Ratcliff 1986), and cultivation of grasslands (Grant 1965; Faanes and Lingle 1995) limit burrowing owl populations through the destruction of nesting habitat.

Although many of the state's remaining burrowing owls survive in the margins of agricultural areas, such as along roadside embankments and earthen irrigation canals and drains, intensive agriculture can be detrimental to the survival of burrowing owls. The apparent strong selection of irrigation canals for nesting by burrowing owls in agricultural areas may not indicate that this habitat is preferred over habitat well removed from the canals, but rather because of the intensive agriculture and disking and plowing of fields, the levees may provide the only available nesting habitat (DeSante and Ruhlen 1995). Ninety percent of California's burrowing owls are concentrated in wide, flat lowland valleys, basin bottoms, and coastal plains – terrain where the majority of agricultural development has occurred and is expected to continue to occur. Intensive agriculture has been shown to result in the loss of burrows, loss of foraging habitat, creation of sub-optimal nesting habitat, and increased vulnerability to predation, and may also reduce the chance that unpaired owls will be able to find mates (Haug and Oliphant 1987; Haug et al. 1993). Because burrowing owls in agricultural systems spend a large proportion of their time foraging in fields (Rosenberg and Haley 2003), heavy pesticide use (discussed in Section VIII.F below) will also remain a potential threat to these populations.

Disking, Plowing, and Mowing

One obvious impact of intensive agriculture is disking and plowing of owl burrows. Disking or tilling of the land destroys burrows and potentially the owls in these burrows. Mowing is a preferable alternative, but tractors used to pull mowers, and occasionally the mowers, can cause mortality.[172] The use of large-tired mowers when mowing grasslands can reduce the risk of nest damage and restricted use of mowing when young chicks emerge (May-June) prevents destruction of young (Rosenberg et al. 1998a). In addition, fields which may be needed as foraging habitat can be disked and left fallow, reducing the prey base during a period when nestlings and fledglings would need the most amount of food for growth

Grazing

Livestock grazing can have positive benefits for burrowing owl habitat, as many researchers have noted that burrowing owls prefer grasslands grazed by cattle or rodents (Anderson et al. 2001). Grazed areas may attract ground squirrels, increasing burrow availability, and also provide habitat with low vegetation height and reduced ground cover, allowing owls to stand near the burrow entrance and effectively watch for approaching predators (Coulombe 1971; Green and Anthony 1989; Trulio 1994). One of the largest populations of burrowing owls in the San Joaquin Valley was found in grassland on private land that was heavily grazed, although not to the point of exposure of bare soil (Rosenberg et al. 1998a). However, heavily grazed pastures tend to have a very low relative abundance of prey; thus heavy grazing in burrowing owl foraging areas may be

[172] Mowers used at Lemoore Naval Air Station have crushed a small number of burrows and in one incident, owl chicks were killed when they were flushed away from the burrow rather than into it as the mower passed overhead (J. Gervais, pers. comm., 2003).

detrimental to the species (Dechant et al. 1999). The major negative impact of livestock grazing is control of ground squirrels in the name of enhancing livestock production (see Section VIII.C above, discussing destruction of burrowing rodents). Range management practices associated with grazing potentially affect population densities of prey species for burrowing owls, such as California vole (*Microtus californicus*), western harvest mouse, and deer mouse; these species do poorly in heavily grazed pastures, as they need a minimum build-up of thatch to achieve moderate population densities (Holmgren and Collins 1999). Grazing can positively affect owls if it is effectively managed and monitored (Rosenberg et al. 1998a), but the complete effects of grazing on burrowing owl habitat and populations are unknown (Anderson et al. 2001).

Other Agricultural Impacts

Many owls nesting along the California Aqueduct in the Central Valley face threats from maintenance and repair of embankments. Heavy irrigation has been known to drown both squirrels and owls (Miller 1903). Robertson (1931) noted instances of burrowing owls drowning in irrigation pipes (where they were forced to nest for lack of nesting holes) in western Orange County. The federal government and private landowners undertake extensive eradication programs to rid agricultural lands of predators and "pest" species. Although not targeted, burrowing owls are occasionally taken in leg hold traps (ADC 1993, 1994, 1995). Burrowing owl mortality from entanglement in barbed-wire fencing has also been documented (Lohoefener and Ely 1978). Deliberate destruction and filling in of owl nest burrows has been noted recently along irrigation canals in agricultural areas in Arizona, specifically in Tucson, Phoenix, and Yuma (Brown and Mannan 2002), and similar vandalism may be occurring in agricultural areas in California. None of these impacts are likely to pose population-level threats to owls.

F. PESTICIDES

Use of insecticides and rodenticides in burrowing owl habitat can reduce the food supply and the number of burrowing mammals, and may also be toxic to owls (Ratcliff 1986; James and Fox 1987; James et al. 1990; Baril 1993; PMRA 1995; Hjertaas 1997; Sheffield 1997b). Burrowing owls have been reported to ingest poisoned rodents and to forage on the ground for insects in areas littered with poison grains (Butts 1973; James et al. 1990).

The largest breeding concentrations of burrowing owls are located in the Imperial Valley and in the southern San Joaquin Valley (DeSante et al. 1997), some of the most intensively farmed lands in the U. S. (Gilmer et al. 1982; Griggs 1992). The pervasive use of agricultural chemicals, including organochlorine, organophosphorus, and carbamate pesticides, and the existence of trace elements such as selenium, can potentially impact individual owls in these areas. Owls can be exposed by direct contact, ingestion from preening feathers, and through their diet, which includes insects, small vertebrates, crayfish from irrigation ditches, and potentially contaminated fish carrion (Gervais et al. 1997). Burrowing owls are known to scavenge dead rodents and other prey items, making them highly susceptible to secondary poisoning (Sheffield 1997b). Even low levels of chronic pesticide exposure may be detrimental to burrowing owls when combined with other stressors, although documentation of persistent pesticides in a biotic system does not infer the origin of contamination or its potential effects (Gervais and Anthony in press). It is unclear whether owls selectively use agricultural fields and whether they will do so following pesticide application, when large pulses of dead and dying invertebrate prey may suddenly be available (Gervais 2002). Studies at Lemoore NAS by Gervais (2002) and Gervais et al. (2003) did not find selection or avoidance by owls of fields recently treated with pesticides, and no owls appeared to have died following use of treated fields.

Burrowing owl populations in the San Joaquin Valley (Lemoore Naval Air Station), the Imperial Valley (Salton Sea National Wildlife Refuge), and Carrizo Plain Natural Area were sampled for contaminants in 1996 (Gervais et al. 1997). These sample sites were chosen to be representative of the general agricultural practices in the area. Gervais et al. (1997) found that burrowing owl eggs from Lemoore contained high concentrations of DDE, ranging from 1.5 to 33 ppm wet weight. Feathers from owls nesting at Lemoore that were also

contaminated with DDE indicated recent local exposure. Eggs from Salton Sea NWR and Carrizo Plain contained up to 0.38 and 3.4 ppm DDE, respectively. Eggs collected near Pixley in Tulare County in 1998 also contained traces of DDE (Rosenberg et al. 1998b). Although the burrowing owls in this study did reproduce successfully, the contaminant loads may make them much more vulnerable to unrelated stresses, such as exposure to other toxicants or weather. Some owl populations maintain substantial body burdens of persistent pesticides that may inhibit reproduction (Gervais et al. 2000).

In a follow-up study from 1998 to 2001, Gervais and Anthony (in press) sampled burrowing owl eggs at Lemoore NAS, and found levels of DDE varying over 4 levels of magnitude, but only 2 eggs with DDE levels worthy of serious concern (J. Gervais, pers. comm., 2003). DDE levels were not by themselves associated with reproductive failure, but contaminant concentrations in combination with low rodent abundance in the diet were related to reduced productivity (Gervais and Anthony in press). Variation within and among egg contaminants within years suggested that egg contaminant patterns may be the result of immigrating owls from more contaminated sites, and to a lesser extent, to varying patterns in prey availability.

Despite a long-standing ban on the use of DDT, its degradation product DDE remains a threat to wildlife in the San Joaquin Valley (Anderson et al. 2001). DDE has been documented in the eggs of terns (*Sterna* spp.), egrets (*Egretta thula*, snowy egret and *Ardea alba*, great egret), and herons (*Ardea herodias*, great blue heron and *Nicticorax nicticorax*, black crowned night heron) in San Francisco Bay (Ohlendorf and Fleming 1988; Ohlendorf and Marois 1990; Hothem et al. 1995), of herons and egrets in the Imperial Valley (Ohlendorf and Marois 1990), and of prairie falcons in Pinnacles National Monument, where it was associated with impaired reproduction (Jarman et al. 1996).

Gervais et al. (1997) also compared current eggshell thickness to burrowing owl eggs from 45 nests from central and southern California collected prior to 1937, and found that eggshell thickness in 1996 had declined over 20%. Eggs from Lemoore in the San Joaquin Valley were significantly thinner than those from the Salton Sea NWR or Carrizo Plain. Chemicals such as dicofol, used as a miticide on cotton and citrus crops, can cause eggshell thinning and toxicity in at least some captive raptors (Schwarzbach 1991), including the screech owl (*Otus* spp.) (Rohm and Haas Co. 1991). However, the effects of dicofol on captive birds have never been documented in the field and dicofol is apparently not a risk to wild bird populations although it is possible that individual birds are occasionally impaired (J. Gervais, pers. comm., 2003). Large amounts of difocol are used in the Imperial Valley and southern Central Valley: the average annual application of difocol was over 7,000 pounds in Imperial County from 1990-1999 (CDPR 2001), 175,000 pounds in Fresno County from 1993-1995, and 67,000 pounds in Kings County from 1993-1995 (CDPR, as cited in Anderson et al. 2001). Dicofol was never detected in the eggs of owls at Lemoore NAS, despite the wide use of the chemical there (Gervais and Anthony in press).

Exposure to the organophosphorus pesticide chloropyrifos was detected at Lemoore by footwash samples (Gervais et al. 1997) even though none was reported used within 1 kilometer of the study site prior to the sampling. Although organophosphorus compounds do not bioaccumulate and have relatively low environmental persistence, they pose some threat to owls through direct mortality. For example, organophosphorus insecticide exposure was documented to cause red-tailed hawk mortality in California orchards (Hooper et al. 1999). Large amounts of chloropyrifos are used in the Imperial Valley and southern Central Valley: from 1993-1995, an annual average of 110,000 pounds was applied in Imperial County, 497,000 pounds was applied in Fresno County, and 229,000 pounds was applied in Kings County (CDPR, as cited in Anderson et al. 2001). Organochloride residues have been found in adult and juvenile burrowing owls in Saskatchewan, but no effect on reproduction was noted (Haug and Oliphant 1987).

Carbamate compounds such as carbofuran and aldicarb, which share similar chemical and toxicological properties with organophosphorus pesticides, have also caused wildlife mortality (Mineau et al. 1999). Available evidence indicates that carbamate insecticides such as carbofuran and carbaryl negatively impact

burrowing owl populations (PMRA 1995; Sheffield 1997a, 1997b). Carbofuran, an insecticide, has caused a significant negative impact on survival and reproductive success of owls when sprayed over nest burrows (James and Fox 1987). The impact was believed to be due to direct toxicity, but indirect mortality as a result of contaminated prey may also be significant (Haug et al. 1993). Carbofuran is highly toxic to many birds, with one granule being sufficient to kill a small bird. Bird kills have occurred when birds ingested carbofuran granules, which resemble grain seeds in size and shape, or when predatory or scavenging birds have ingested small birds or mammals that have eaten carbofuran pellets (USEPA 1991). Red-shouldered hawks (*Buteo lineatus*) have been poisoned after eating prey from carbofuran-treated fields (Smith 1992), and Eastern screech owls (*Otus asio*) showed mortality from secondary poisoning when fed rodents killed by carbofuran (Sheffield 1997b). To protect birds, the EPA initiated a ban on all granular formulations of carbofuran in 1994, however there is no ban on liquid formulations of carbofuran. Of particular danger to burrowing owls are uses of this chemical in corn and alfalfa fields (Anderson et al. 2001). Large amounts of carbofuran and aldicarb are used in the Imperial Valley and southern Central Valley: an annual average of over 47,000 pounds of carbofuran was applied to forage crops in Imperial County from 1990-1999 (CDPR 2001); from 1993-1995 an annual average of over 7,900 pounds of aldicarb was applied in Imperial County, 55,000 pounds was applied in Fresno County, and 63,000 pounds was applied in Kings County (CDPR, as cited in Anderson et al. 2001).

Chemicals used for rodent control or as pesticides could adversely affect the reproductive success, survivorship, and prey base available to owls as they rear their offspring in agricultural areas (Peakall 1970; Henny et al. 1984; James and Fox 1987; Wiemeyer et al. 1989). Rodenticides and herbicides are often used to control numbers of ground squirrels and plant growth on levees. This is problematic in areas where a large proportion of owls nest in levee banks, such as in the Imperial Valley. In pastures where strychnine-coated grain is used to control ground squirrels, weights of breeding burrowing owls were found to be significantly lower than on control pastures and owls had slightly decreased breeding success compared to control owls (James et al. 1990), suggesting a sub-lethal effect or that less was food available. Anti-coagulants (such as brodifacoum) and other types of rodenticides (such as strychnine) have been shown to cause mortality in many different owl species, with the ingestion of as little as one poisoned prey item (Sheffield 1997b). The National Park Service has aerially dropped grain pellets laced with broadifacoum 3 times since 2001 on Anacapa Island in southern California to control invasive black rats (*Rattus rattus*), killing 4 burrowing owls on the island (FFA 2002).

The burrowing owl's habit of feeding on aquatic organisms from agricultural drainage ditches makes it vulnerable to selenium, a naturally occurring element that is leached from soils through irrigation. Selenium has caused considerable damage to other bird species in the Central Valley (Ohlendorf et al. 1986, 1987, 1988). A number of pesticides deserve attention and further research as potentially negatively affecting burrowing owls, including Aldicarb, Chloropyrifos, Def, Diazinon, Dicofocl, Endosulfan, Lindane, Metam sodium, Methidathion, and Paraquat dicholoride (Rosenberg et al. 1998a).

Although agricultural contaminants can impact owls, studies of reproduction and survival in agricultural areas found no population-level effects of pesticides on owls (Gervais et al. 1997; Gervais 2002; Gervais et al. 2003; Gervais and Anthony in press). Because owls are central-place foragers, pesticide risks may be mitigated by avoiding pesticide applications near nest burrows and by maintaining a 500-600 meter buffer zone to prevent most primary and secondary poisonings (Gervais et al. 2003).

G. PREDATION

Introduced predators and changes in concentrations of natural predators due to anthropogenic ecosystem changes have impacted burrowing owls and continue to be a threat. As habitats have been altered and top predators exterminated, subsequent increases in mesocarnivores such as foxes, coyotes, and badgers may be taking a large toll on burrowing owls (Sheffield 1997a; Wellicome 1997). On Santa Barbara Island, California, a small population of approximately 20 burrowing owls was extirpated by barn owls in 1984 and again in 1987

following crashes in the deer mouse (*Peromyscus maniculatus elusus*) population (Drost and McCluskey 1992). In healthy burrowing owl populations natural predation is probably not a significant threat, but it may cause a significant decrease in viability for fragmented and remnant owl populations, especially when combined with other impacts, such as development, persecution of burrowing rodents, pesticides, or predation by nonnative species.

Predation by introduced red foxes (*Vulpes vulpes*) and feral cats is a serious problem for the burrowing owl, and urbanization has increased predation upon owls by domestic dogs (*Canis familiaris*) and domestic cats (*Felis domesticus*) (Coulombe 1971; Martin 1973; Green and Anthony 1989). Domestic cats accounted for 6 (30%) of the known owl deaths at a Florida study site (Millsap and Bear 1988). Feral cats are reported to be killing burrowing owls at Shoreline Park in Mountain View, Santa Clara County (P. Delevoryas, pers. comm., 2002). Dogs can also damage owl habitat: Thomsen (1971) estimated that dogs caused 20% of the observed damage to burrows at a study site in Oakland.

H. DISEASE

Diseases and parasites have not been documented to have direct impacts on burrowing owl populations. However, burrowing owls in California may be vulnerable to the West Nile virus (*Flavivirus* spp.). Since 1999, West Nile virus has been identified in more than in 138 species of birds found dead in the United States, including 7 species of owls (CDC 2002). This mosquito-borne virus is rapidly spreading westward across the United States (and is expected to take hold in California by summer of 2003) and has recently begun killing numerous raptors in the Midwest, including red-tailed hawks and great horned owls by the thousands, as well as black vultures (*Coragyps atratus*) and bald eagles (*Haliaeetus leucocephalus*) (Rappole et al. 2000; Russell 2002). Epizootics of sylvatic plague (*Yersinia pestis*) that affect rodent colonies could negatively impact and even eliminate burrowing owl populations indirectly by reducing available habitat (Dechant et al. 1999). Regarding parasites, fleas (*Echidnophaga gallinacea*) are frequently mentioned in the literature as common inhabitants of owl burrows and some birds have been known to carry lice (*Colpocephalum pectinatum*) (Thomsen 1971)

I. SMALL POPULATION SIZES

Small population size is a significant concern for California's burrowing owl population, since owls persist only in small fragmented and remnant colonies or small numbers of breeding pairs throughout the majority of their range in California. Although there is no good information on what population size of owls is vulnerable to local extinction, the viability of small populations partially depends upon the likelihood of immigration. A small effective population size predisposes small owl populations to a higher risk of extinction.

It is a widely recognized ecological principle that, in general, small isolated or fragmented populations are more vulnerable to extinction than large ones (Pimm 1991; Noss and Cooperrider 1994). Noss and Cooperrider (1994) identified four major factors that predispose small populations to extinction: (1) environmental variation and natural catastrophes like unusually harsh weather, fires, or other unpredictable environmental phenomena; (2) chance variation in age and sex ratios or other population parameters (demographic stochasticity); (3) genetic deterioration resulting in inbreeding depression and genetic drift (random changes in gene frequencies); and (4) disruption of metapopulation dynamics (i.e., some species are distributed as systems of local populations linked by occasional dispersal, which wards off demographic or genetic deterioration).

Many remaining owl populations in California are presumed to be reproductively isolated populations, making them more vulnerable to localized extirpations, absent the possibility of significant immigration of breeding owls from other areas (DeSante et al. 1997). Owls in the Imperial Valley are thought to be reproductively isolated from other populations to the west and thus not available as a source population to

augment the very small and declining populations inhabiting southwestern California and other areas of the state (DeSante et al. 1997). However, from recent banding studies conducted on fledglings at Lemoore NAS, there is some evidence that some burrowing owls are capable of dispersing widely and recruiting successfully into other populations (Gervais 2002).[173] Additionally, recent genetic analyses of burrowing owls from 3 demographic study sites (Lemoore NAS, Carrizo Plains, and the Imperial Valley) failed to identify population differentiation or evidence for genetic inbreeding or population isolation (Korfanta 2001).

Small owl populations have an increased likelihood of extirpation due to natural or anthropogenic impacts, can suffer from reproductive isolation and inbreeding, and are susceptible to increased predation. Stochastic environmental factors such as drought or prey reduction are more likely to eliminate small populations of burrowing owls (Trulio, unpubl. data, as cited in Buchanan 1997; DeSante and Ruhlen, unpubl. data). A population of burrowing owls studied in Davis, California showed higher genetic similarity than a collection of geographically separated owls, suggesting that some inbreeding was occurring in this wild population, likely as a result of small population size due to population subdivision (B. Johnson 1997a, 1997b).

The persistence of burrowing owl colonies in Saskatchewan was strongly correlated with higher habitat continuity, less patch edge, and more neighboring colonies (Warnock 1996, 1997; Warnock and James 1997). Fragmentation of remaining grassland habitat has been shown to increase populations of burrowing owl predators in Canada (Wellicome and Haug 1995; Warnock 1997) and may allow predators to find owl nests easily (James et al. 1997; Warnock and James 1997). In fragmented landscapes, burrowing owls may forage greater distances within larger home ranges and spend more time away from the nest, making them more vulnerable to predators (Haug 1985). In Saskatchewan, crowding of owls into smaller habitat patches may increase nest abandonment through events such as depredation (both intra- and inter-specific), foraging interference, and aggression (Warnock and James 1997). Fragmented agricultural landscapes may also increase vehicle collisions with owls (Clayton and Schmutz 1997).

Johnson (1997a) reported on the extinction of a small population of burrowing owls in less time than a population viability model predicted. Even large burrowing owl populations can decline at rapid rates. Owl numbers in Canada have been declining at a staggering rate of 16% per year nationwide since the early 1980s, and in excess of 20% per year in the Prairie Provinces (Saskatchewan, Alberta, and British Columbia) (Haug et al. 1993; Shyry et al. 2001; Wellicome and Holroyd 2001). In Nebraska, a population of burrowing owls in one area fell by 63% between 1990 and 1996 (Desmond et al. 2000).

J. OTHER ANTHROPOGENIC FACTORS

Fire Control

In many urban areas with burrowing owl habitat, open fields are disked for weed control to reduce the threat of fires. Disking or tilling of the land destroys burrows and potentially the owls in these burrows (Trulio 1998b). Mowing is a viable alternative that does not destroy birds or burrows. Several Bay Area entities, such as Moffett Federal Airfield and the cities of Palo Alto and Mountain View, have changed from disking to mowing on their lands to prevent the destruction of owls. The City of San Jose passed an ordinance in April 2001 prohibiting disking, with some exceptions (J. Barclay, pers. comm., 2002).[174] The Santa Clara Valley Fire Marshall's Office is currently reviewing its weed abatement policy. However, most cities within the range of the owl have no such ordinances or policies. Private landowners throughout California are still permitted to disk their lands, and 91% of remaining burrowing owls are on private land (DeSante et al. 1996).

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[173] Gervais (2002) found evidence that owls fledged at NAS Lemoore recruited into other breeding populations in the San Jose area and Carrizo Plain National Monument, up to 160 km away.

[174] These exemptions are for: property less than 2 acres, land used for the production of agricultural products, fire breaks up to 30 feet wide, 400 acres of water pollution control plant lands used to dispose of reclaimed water, and lands identified by a qualified ornithologist as having little or no potential as burrowing owl nesting habitat.

Vehicle Strikes

The propensity of burrowing owls for nesting in roadside banks makes them particularly vulnerable to being hit by vehicles. Vehicular strikes are often a significant source of burrowing owl mortality (Konrad and Gilmer 1984; Haug and Oliphant 1987; Millsap and Bear 1988; Haug et al. 1993; Kemper 1996; Clayton and Schmutz 1997), because owls have a relatively high tolerance for vehicular disturbance (Coulombe 1971; Plumpton and Lutz 1993) and often fly low to the ground (Anderson et al. 2001). Vehicle collisions are the primary mortality factor for adult owls in some fragmented environments (Clayton and Schmutz 1997). Vehicle strikes of owls were once common in Orange County before the near-extirpation of the species, including strikes of several banded birds in the early 1970s (P. Bloom, pers. comm., 2002). Vehicle caused mortality is a concern for the owl population at the Carrizo Plain Natural Area (Rosenberg 1999) and has been documented frequently at Lemoore Naval Air Station (J. Gervais, pers. comm., 2003).

Naive juveniles are particularly vulnerable when feeding on road-kills or on insects attracted by warm pavement at night. Rosenberg (1999) noted that as chicks at Carrizo Plain became capable of flight, they commonly began to hunt as a family group, frequently on roads. The risk of vehicle collision is likely greater in developed areas with dense human population or along areas where owls nest predominately near roads (Anderson et al. 2001). Higher post-fledging mortality due to vehicle collisions was noted to occur in agricultural landscapes with more than 90% of the land area under cultivation compared to an un-fragmented rangeland with less than 20% cultivation (Clayton and Schmutz 1997; Paige 1998). Off-road vehicle activity is also a threat to owl habitat as their burrows can be crushed and their nest sites disturbed (CVAG 2001).

Aircraft Strikes

Although burrowing owls are an unlikely species for bird air strikes, there have been documented deaths from collisions along runways (Rosenberg et al. 1998a). Powerful jets have the ability to "inhale" birds from some distance away (Rosenberg et al. 1998a). Another potential cause of mortality in and around airports is the powerful "wake turbulence" from aircraft wings (J. Barclay, pers. comm., 2002). Several colonies of burrowing owls at airports nest in close proximity to runways, such as at Oakland Airport in Alameda County, Moffett Airfield and San Jose International Airport in Santa Clara County, Lemoore Naval Air Station in Kings County, and North Island Naval Air Station in San Diego County. Military aircraft are especially prone to strikes because they frequently fly at high speeds and at low altitudes where birds are most active. Lemoore NAS and North Island NAS reported 130 and 132 aircraft/bird collision incidents, respectively, from 1981 to 1998 (BASH 2002). China Lake NAWS reported 27 such incidents from 1981 to 1992 (NAWS China Lake 2002). It is unclear whether any of these strikes involved owls. A study of bird-aircraft strikes at 11 naval bases in California and Arizona reported raptors composed 4.4% of known bird-strikes from 1981 to 1991 (Kuenzi and Morrison 1998). Lemoore Naval Air Station has a management plan that reduces the number of owls near the airfields by altering habitat and blocking burrows adjacent to runways (Rosenberg et al. 1998a), and although large numbers of owls nested along runways and taxiways there, aircraft strikes appeared to be very rare (J. Gervais, pers. comm., 2003). San Jose Airport has also approved a burrowing owl management plan that manages owls away from the center of runways (J. Barclay, pers. comm., 2002).

Electrified Fences

Electrified security fences killed more than 3,000 protected birds, including 144 burrowing owls, at 13 California state prisons from 1993 to 1998 (USFWS 1998). The highest kill was 102 burrowing owls from 1993-1997 on the electrified fence at Calipatria State Prison, Imperial County, prior to modifications by the California Department of Corrections (CDC) (CDFG 2002a; York et al. 2002). Protective netting, expected to cut the number of bird deaths by 90%, was installed in 1998 at 13 of the state's then 25 prisons with electrified fences. However, roughly half the remaining prison fences are presumably still killing owls. The CDC is already retrofitting many other existing prisons with electrified fences, but no further installation of protective netting is planned. The proliferation of prisons in rural areas with electric fences can be expected to kill burrowing owls in those areas. A 50-year CDC Electric Fence Habitat Conservation Plan currently being

prepared presumes that 15-17 owls will be killed per year (850 owls total), with only 72 acres of protected land proposed as mitigation (CDFG 2002a).

Wind Turbines

Turbines at wind energy facilities at Altamont Pass in eastern Alameda and Contra Costa Counties and the Montezuma Hills in Solano County kill large numbers of raptors through collision or electrocution, including burrowing owls (Estep 1989; Howell 1997). Six years of raptor mortality studies in the early 1990s determined that a mean of 2.8 raptors were killed annually per 100 turbines at study sites in both areas (Howell 1997). Burrowing owl mortality is reportedly a "common occurrence" at the Altamont Pass wind facilities (G. Hunt, pers. comm., 2003). There are other major developed wind resource areas at Tehachapi Pass in Kern County and San Gorgonio Pass in Riverside County, but it is unknown if there is owl mortality at these locations.

Shooting

Shooting has been a significant source of burrowing owl mortality in former times (Grinnell and Miller 1944). Between the 1860s up until the 1970s, collectors shot literally thousands of burrowing owls - these specimens now reside in museums and collections. Although shooting for collecting purposes is no longer a problem, shooting by vandals is still an issue (e.g. Zarn 1974). Shooting caused 66% of the known mortality at a study of burrowing owl sites in Oklahoma (Butts 1973). Wedgwood (1978) discussed 3 burrowing owl colonies in Canada destroyed by shooting, Evans (1982) identified shooting as a problem in Sonoma County, a Boy Scout shot 4 owls at Laguna Niguel in Orange County (P. Bloom, pers. comm., 2002), and a small colony at Upper Newport Bay was apparently extirpated by shooting in the 1970s (J. Bath, pers. comm., 2003). Shooting remains a likely cause of at least limited mortality in the Mojave Desert (Campbell 1999) and in Santa Clara County (C. Breon, pers. comm., 2003).

Vandalism

Thomsen (1971) estimated that 65% of the damage to burrows at her owl study site at the Oakland Airport was caused by humans, and cited plugging of burrows as a possible cause of loss of eggs and young. Some of the recent owl declines in the Cypress Channel owl population in Chino have been due to plugging of burrows (J. Bath, pers. comm., 2003).[175] Illegal trash dumping has also been observed to impact burrowing owls (CVAG 2001; J. Bath, pers. comm., 2003). Remsen (1978) reported on an owl burrow deliberately destroyed by vandals. J. Bath (pers. comm., 2003) has documented several instances of human harassment that likely contributed to localized extirpations of owls in western San Bernardino County (see footnote 140 on page 47). Human harassment of burrowing owls and vandalism of burrows will likely increase with urbanization.

Other Mortality

Burrowing owls have been found dead apparently trapped in pipes and PVC mining claim posts (Brattstrom 1995; CNDDB 2001).[176] Falconers flying their birds at rabbits once commonly killed burrowing owls in southern California (P. Bloom, pers. comm., 2002). There is a long history of anti-predator measures at Least Tern colonies in San Diego County, conducted by the Wildlife Services Agency (formerly Animal Damage Control), under the U. S. Department of Agriculture. The activities of this federal agency have contributed more to the recent extirpation pulse of burrowing owls along the San Diego coast than any other known form of mortality (P. Bloom, pers. comm., 2002). Owls in southern California observed preying on Least Tern chicks have been shot and killed (even owls breeding nearby with young), with no attempt made to capture or relocate the owls (P. Delevoryas, pers. comm., 2003).

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175 Field crews with the San Bernardino Department of Transportation and Flood Control have been plugging burrows known to have been formerly occupied during nesting season, claiming to have an agreement to do so with the California Department of Fish and Game (J. Bath, pers. comm., 2003, conversation with Ken Miller of SBDTFC).

176 Five adult owls were found dead in a pipe at 3-Com Corp. in Santa Clara, in Santa Clara County, on 8/31/91 (CNDDB 2001); and burrowing owls were found dead in PVC mining claim posts in the Hackberry and Castle Mountains in San Bernardino County in January 1990 (Brattstrom 1995).

IX. INADEQUACY OF EXISTING MANAGEMENT EFFORTS

Federal, state, and local regulatory mechanisms have failed to protect the burrowing owl and its habitat in California. Although numerous federal, state, and local agencies manage burrowing owls and their habitat, they have failed to adequately protect or compensate for the loss of owl habitats (Anderson et al. 2001). Grasslands are not specifically protected by law and are rarely protected by state, federal or municipal reserve systems. Protections for other endangered, threatened and rare grassland species may serve to protect some fraction of owl habitats in some parts of California. However, there is no specific habitat protection for burrowing owl habitat, and in parts of the state where listed species do not exist, owl habitat cannot currently be protected. Because no recovery plans currently exist for the burrowing owl, management of owls has generally been incidental or as a byproduct of other management purposes (i.e. mowing at airports) and taken the form of local impact mitigation included in environmental impact assessment documents. This mitigation often includes the translocation of owls and localized extirpation of breeding colonies. Burrowing owl management has been limited to project-by-project responses to development impacts and is inadequate for the long-term maintenance of the species in significant parts of its range in California. Without statewide protection of burrowing owls and their habitat, the predictable outcome of present trends is the extirpation of the species throughout most of its range in California.

A. FEDERAL REGULATORY MECHANISMS

1. Federal Designation as a Species of Special Concern Under the Endangered Species Act

The U.S. Fish and Wildlife Service listed the western burrowing owl under the Endangered Species Act ("ESA") as a federal Category 2 Candidate Species in 1994 (USDI 1994). This designation was changed to a "Migratory Nongame Species of Management Concern" in 1995 (OMBM 1995), and it was subsequently re-classified as a Species of Special Concern ("SSC") in 1996. In 1996 the Category 2 designation was discontinued. None of these designations provide formal protection to the species. Neither the protections of Section 9 of the ESA (prohibiting "take" of the species) nor the protections of Section 7 (requiring all federal agencies to ensure that their activities do not jeopardize the continued existence of the species) apply to SSC species. SSC species will not have critical habitat designated, nor will they receive recovery plans.

The stated purpose of the SSC designation is to allow landowners and other project proponents to plan early for the protection of species that are not yet listed but are likely to become listed in the future. Some Habitat Conservation Plans, completed under Section 10 of the ESA by project proponents in order to obtain a permit for take of species that would otherwise be prohibited under Section 9, do contain some mitigation for SSC species. In addition, the U. S. Fish and Wildlife Service does encourage federal agencies to consider SSC species during Section 7 consultation. However, these informal protections are implemented only at the discretion of the landowner and do not provide sufficient protection for the burrowing owl. As noted above, 91% of the burrowing owls remaining in the state are located on private lands (DeSante et al. 1996) and the threats to these populations are not subject to any federal regulation.

2. Federal Listing of Other Species Within the Range of the Burrowing Owl

Listing under the federal ESA for other species that overlap with the burrowing owl in habitat and range could conceivably provide some protection to the species. Suitable habitat for burrowing owls overlaps somewhat with habitat for federally listed species and species of concern such as the San Joaquin kit fox (*Vulpes macrotis mutica*), blunt-nosed leopard lizard (*Gambelia sila*), listed and special-status kangaroo rats (*Dipodomys ingens, D. nitratoides nitratoides, D. n. exilis, D. n. brevinasus*), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*), San Joaquin pocket mouse (*Perognathus inornatus inornatus*), Tulare grasshopper mouse (*Onychomys torridus tularensis*), desert tortoise, and Mohave ground squirrel (*Spermophilus mohavensis*). The primary way in which the burrowing owl could benefit from the listing of

these species is through protection of owl nesting and foraging habitat shared with these species. Many, if not all, of these species have continued to decline since listing, raising questions as to whether federal listing has adequately protected these species themselves, let alone species that merely overlap somewhat in range. Additionally, the vast majority of remaining burrowing owls live in the margins of agricultural areas, which are not protected habitat for any listed species.

3. Habitat Conservation Plans

There are a number of federal Habitat Conservation Plans ("HCP's) in California under which the western burrowing owl is a covered species. However, the burrowing owl is not a federally listed species, and since HCPs are not required to benefit non-listed species, they are not a mechanism adequate to protect burrowing owls.

The HCP provisions of the ESA were intended to provide a net benefit to threatened and endangered species, in return for providing landowners with regulatory certainty and permits to impact or otherwise "take" listed species and their habitats. In theory, HCPs can help protect and restore habitat, including habitat for non-listed species covered under the plan. Unfortunately, most HCPs fail to live up to this promise, and simply function as exemptions from the ESA's species and habitat protection policies. Arguably, a few HCPs make the best of difficult situations on private lands, and may even help species' recovery to some extent. However, since HCPs are not required to have a net benefit to listed species or contribute to their recovery, there is considerable reason to be skeptical of the ability of HCPs to protect populations and habitat for covered non-listed species such as the burrowing owl.

A nationwide study of HCPs by the National Center for Ecological Analysis & Synthesis and the American Institute of Biological Sciences (Kareiva et al. 1999) found that most HCPs contribute to habitat losses for the targeted species, fail to meet recovery goals, and suffer from poor planning and plan evaluation. Among the failures of HCPs discussed by Kareiva et al. (1999): nearly 30% of HCPs "take" 100% of the focal species' populations or habitat in the permit area; about 50% of HCPs allow 50% or more of the species' populations or habitat in the plan area to be "taken"; 43% of the time, HCPs failed to provide sufficient mitigation measures; 23% of the time, species and their habitats will be "taken" before mitigation measures have been implemented and found effective - most HCPs fail to reduce allowed "take" levels or use other more conservative approaches in the face of inadequate information or uncertainties; 33% of HCPs failed to secure up-front funding to ensure that mitigation actually occurs; and 81% of HCPs studied will have irreversible impacts.

Not surprisingly, Kareiva et al. (1999) found that HCPs which fail to adequately conserve species also tend to lack rigorous impact assessments and planning. The Kareiva et al. (1999) study found that: 75% of the time, impacts to species were not adequately studied by HCPs; 42% to 49% of the time, HCPs failed to quantify how much of a species' habitat and population, respectively, will be "taken"; most HCPs used low quality data to evaluate their mitigation measures; and 25% of the time, sufficient information did not exist to determine how HCPs would affect the species' viability.

These inadequacies should be kept in mind while reviewing HCPs approved in California. Of the approximately one dozen approved HCPs (of more than 100 acres) that specifically cover the burrowing owl, none are in the Imperial Valley, where 71% of state's breeding owl population resides. There are also no approved HCPs covering the northern Central Valley, where 6.4% of the state owl population lives, nor in the Bay Area or central western California, areas containing 1.8%, and 0.5% of the state's owl population, respectively.

There are 6 approved HCPs covering over 163,000 acres within the range of the owl in the southern Central Valley, where 15% of the state population lives. These include ARCO Western Energy HCP (120,320

acres), Nuevo-Torch HCP (21,800 acres), Kern Water Bank HCP (19,900 acres), Seneca and Enron Oil and Gas HCP (650 acres), and Corrections Corporation of America HCP (425 acres), all in Kern County and portions of Tulare and Kings Counties. The Kern Water Bank HCP mentions no specific protections or mitigations for the burrowing owl.

Three approved HCPs cover about 55,000 acres within the range of the owl in the middle Central Valley, where 2.5% of the state population exists. These are the Natomas Basin, City of Sacramento HCP (53,342 acres), Natomas Basin Metro Air Park HCP (1,981 acres), and the Tiechert Vernalis Project HCP, Phases 1&2 (300 acres). These are all 50-year plans.

Most of the remaining approved HCPs are in San Diego County, including the San Diego MSCP, encompassing a 582,243 acre planning area, Fieldstone/La Coasta HCP (1,955 acres), and San Diego Gas & Electric HCP (124 to 400 acres). The Fieldstone/La Coasta HCP will conserve 55 acres on-site and "take" 280 acres of potential owl habitat. Only 31% of the existing grasslands and 45% of the presumed potential owl habitat will be conserved under the San Diego MSCP, which will impact 8 known owl breeding locations and conserve 12 known historic locations. Unfortunately, only 1 protected owl population within the San Diego MSCP (at Otay Mesa) has any long-term viability (P. Unitt, pers. comm., 2001).

The Lake Mathews HCP (5,993 acres) and North Peak Development Project HCP (997 acres) fall within the range of the owl in Riverside County. The Lake Matthews HCP protects 710 acres off-site in Metropolitan mitigation bank lands, and "takes" 344 of 3,046 acres (11%) of the occupied owl habitat on the site. The North Peak Development Project HCP protects 31 acres on-site and 100 acres off-site, and "takes" 147 acres of potential owl habitat.

There are a few pending HCPs that specifically cover the burrowing owl, including the Pleasant Valley, City of Coalinga HCP (250 acres) in Fresno County, and Assessment District 161 HCP, covering 19 projects (3,094 acres) and Pacific Bay Properties HCP (798 acres) in Riverside County. The Pacific Bay Properties HCP would impact 87 acres and preserve 108 acres of potential owl habitat. The Western Riverside County Multiple Species HCP (1,260,000 acres) covers the burrowing owl as well as 141 other species, but will only conserve 9% of remaining agricultural lands, 27.5% of remaining grasslands, and 54% of remaining coastal sage scrub habitat, and will not adequately protect the owl. In fact, only 50% of 12 known populations in Western Riverside County would be protected in the most optimistic circumstances if the plan is approved as currently written (see below). As these HCPs are not yet in place, they cannot be counted on to provide even minimal protection to the burrowing owl. There are a few approved HCPs that do not specifically cover the burrowing owl but may overlap its habitat, including the San Joaquin County HCP, Metro Bakersfield HCP, and Stephen's Kangaroo Rat HCP, but there is no guarantee that these HCPs will protect the burrowing owl. The Kern County Valley Floor HCP (1,990,400 acres) is being developed in the southern San Joaquin Valley within the range of the burrowing owl, but again the owl is not a covered species in that plan.

Roughly 85% of the state's remaining owls have no coverage under approved or pending HCPs. Of the 15% that may have coverage, the HCPs allow for varying levels of development and destruction of occupied or potential burrowing owl habitat, with appropriate "mitigations." Although some owl habitat is theoretically protected for the 20-50 year life of these plans (assuming there are no problems with monitoring, funding, etc.), the overall result of these HCPs is a net loss of burrowing owl habitat.

For example, burrowing owls are known to occur throughout the entire 21,800 acres covered by the Nuevo-Torch HCP in Kern County. The plan estimates 13% of this habitat (1,700 acres) will be "disturbed" by oil and gas activities authorized by the plan. Potential threats identified are that owls will be "directly injured or killed by land clearing and compaction, by vehicle strikes resulting from increased project related traffic, through inadvertent entrapment in collapsed dens or burrows, by oil spills, and by wildfires...started during construction activities...may be subject to harassment resulting from increased levels of disturbance, vehicle

use, and through the implementation of certain mitigation measures, such as excavation of burrows." Note that the mitigation measure allowing excavation of burrows, which will be "excavated by hand and refilled to prevent reoccupation," sanctions destruction of owl habitat. While this mitigation avoids direct "take" of owls, it does not adequately mitigate for the habitat loss.

The Nuevo-Torch HCP acknowledges significant impacts to burrowing owls: "oil and gas activities involving ground disturbance may impact the species. Destruction of the burrows may result in a net reduction of burrowing habitat used by these animals for shelter, reproduction, and escape cover. Animals may be displaced into adjacent areas resulting in increased predation, exposure, or stress through disorientation and loss of shelter."

The Natomas Basin site in Sacramento has an estimated 247 miles of canals and ditches and associated agricultural fields that are potential burrowing owl habitat, and 2,187 acres of "enhanced upland reserve habitat" would be established for the owl. However, mitigation measures include not disturbing occupied burrows during the nesting season unless juveniles are determined to be able to survive on their own, and maintaining a 300 foot buffer around occupied burrows during construction (relocation will take place if that is not "feasible"). Thus, the HCP permits urban encroachment to within 300 feet of burrows, and allows for relocation.

The Metro Air Park development HCP establishes 2% of the project area as habitat reserve land, only ¼ of which would be potentially suitable habitat for the burrowing owl. If burrowing owls are found during surveys on the other 98% of the project area, the "mitigations" include not disturbing occupied burrows during nesting season (as already required by state Fish and Game Code) unless "approved by a biologist;" acquiring and permanently protecting a minimum of 6.5 acres of foraging habitat adjacent to occupied burrowing owl habitat per paired or unpaired bird (although it is not specified whether this will be on-site); enhancing existing or creating new burrows at a 2:1 ratio when destruction of a burrow is "unavoidable;" use of passive relocation techniques (i.e. preventing owls from reoccupying nests); and a caveat that the project sponsor "should" provide funding for long term management and monitoring. The amount of habitat protected and mitigation measures proposed do not inspire confidence that burrowing owls will persist on this site to be managed and monitored.

The Tiechert Vernalis HCP goes one step further, conceding that the preservation and persistence of the burrowing owl is "not a priority," and offers no mitigation for loss of burrowing owl habitat. The plan advocates destroying ground squirrels and their burrows and planting vegetation taller than 36", so as not to attract burrowing owls to the site. If no burrowing owls, California red-legged frogs, California tiger salamanders, or San Joaquin kit foxes are found during surveys, plowing or disking of the land is authorized. If owls are found, they will not be disturbed during breeding season unless "approved by a biologist," and passive relocation (i.e. preventing owls from reoccupying nests) is the preferred option. The stated intent of this HCP is to remove burrowing owls from the project site and destroy burrowing owl habitat.

An HCP being prepared for the West Mojave planning area, which covers 9.5 million acres, has proposed to include the burrowing owl as a covered species. The target species of the West Mojave HCP are the desert tortoise and the Mojave ground squirrel. The plan would allow take of burrowing owls throughout much of the planning area where owls do not co-occur with the target species, such as in urbanized areas. The only potential protection for burrowing owls in the plan is through land acquisition and creation of a small, unspecified owl conservation area near the Antelope Valley Poppy Preserve. One problem with the plan is that there are no surveys or baseline data to determine how many owls are in the area or how many will be taken through activities allowed under the plan (M. Connor, pers. comm., 2002).

The Western Riverside MSHCP, with preparation nearing the final stages, intends to conserve only 6 of the 12 core populations of burrowing owls at Lake Skinner area, Diamond Valley Lake area, the playa west of Hemet, Mystic Lake, Lake Mathews, and along the Santa Ana River, with sufficiently large blocks of habitat to

maintain viable populations. Only 16 of the 38 precise point locations for burrowing owls (and of 82 overall locations in the region from the past 10 years) fall within the proposed assembled reserve. Additionally, only 21% of the primary habitat for burrowing owls throughout western Riverside county (agriculture, grassland, playa, and vernal pool habitats) is proposed for inclusion within the assembled reserve, and reserve lands are to be purchased from willing sellers only and thus protection is not assured. The plan also relies heavily on presumed successful translocation of burrowing owls into the reserve areas from development sites.

A draft HCP is currently being prepared for the Imperial Irrigation District ("IID") Water Conservation and Transfer Project. The proposed project would involve IID conserving and transferring the right to use up to 300,000 acre-feet per year of Colorado River water to San Diego County Water Authority, Coachella Valley Water District, and/or the Metropolitan Water District. The IID plans to line a small percentage of their earthen irrigation canals with concrete.[177] The HCP also covers operations and maintenance activities along IID drains and canals. IID cleans 20% of its canals and ditches each year, through chaining, disking, side scraping, and use of Roundup, Rodeo, and Direx. The Draft HCP specifies avoidance and mitigation measures for burrowing owls, but has been criticized for having vague adaptive management provisions and guidelines and for failing to address the potential impacts of pesticides on owls.[178]

4. Conservation Banks

The U. S. Fish and Wildlife Service acknowledges a small number of conservation banks in California where land can be purchased by developers, essentially as "mitigation" credits for habitat destruction elsewhere. The ideal is to allow for larger habitat areas protected in banks that are more efficient and cost effective to manage instead of small, isolated properties. However, the conservation bank approach for burrowing owls implicitly endorses extirpation of owls from areas of high development by not requiring on-site conservation measures, ensuring that owls will eventually be eradicated from urban areas. Additionally, the small number of conservation banks with owl habitat, their extremely small size, and the rising cost of purchasing suitable land for habitat make this approach incapable of protecting significant populations of owls. So far the only conservation bank formally identified by the Fish and Wildlife Service with suitable habitat for burrowing owls in California is a small area (251 acres) at Dolan Ranch in Colusa County. It is unclear how many, if any, breeding owls occur there.

B. STATE REGULATORY MECHANISMS

1. State Designation as a Species of Special Concern Under the California Endangered Species Act

The burrowing owl was designated as a state Species of Special Concern ("SSC") by the California Department of Fish and Game in 1979. The practical benefit of this designation to the burrowing owl has been

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[177] There are 1,667 miles of IID canals in the Imperial Valley; about 70% of these are lined, and about 537 miles are earthen channels. While up to 100% of currently unlined canals will be available to line (537 miles) under the HCP, only 1.74 miles of canal (0.1% of the entire system) are currently proposed for lining. The estimated abundance of owls along canals in the Imperial Valley is 4.7 pairs/mile; lining 1.74 miles would likely displace 16 owls. The IID expects to construct about 72 miles of lateral canals that would potentially provide suitable owl habitat. It is estimated that about 4 owls could be displaced per year because of drain and canal rerouting (this is not a permanent habitat loss, as the owls can relocate to the new canals) and maintenance.

[178] The Draft HCP proposes to implement a worker and farmer education program; minimize the potential for operations and maintenance activities to injure individual owls by avoidance of burrows that do not compromise the integrity of the channel embankment and lining; filling or impacting burrows from October through February after surveying by a biologist to ensure an owl is not present in the burrow; careful management of grading spoils; and replacement of impacted burrows by a two-to-one ratio in appropriate areas (regardless of whether the burrow was currently in use). The IID will also conduct a 12-15 year demographic study of the Imperial Valley burrowing owl population.

According to the Western Environmental Law Center (WELC 2002), the Draft HCP fails to adequately identify, evaluate, and provide mitigation for the increased concentrations of toxic chemicals, including pesticides, which will occur in agricultural runoff in the drains and canals within the IID service area. The HCP does not address the extent to which herbicides will be sprayed directly on occupied burrows, the potential direct toxicity impacts on owls, or indirect impacts from contact with water or prey with elevated levels of pollutants.

minimal. Such status may call attention to the species and prompt more information to be collected about the loss of its habitat in Environmental Impact Reports and other documents, but it has not halted the habitat loss or other factors causing the decline of the species.

The inadequacy of the SSC designation to protect burrowing owls is vividly demonstrated by the current status of the species in Santa Clara County. Because occupied habitat in Santa Clara County is so minimal, it may already be too late to preserve suitable mitigation sites (adequate breeding and foraging habitat for viable long-term survival of healthy breeding colonies) within the county, due to the fast pace of development project approval and construction. CDFG's current mitigation policy for the area is to evict owls from Santa Clara County and preserve habitat in Byron in Contra Costa County. There are no supporting data that the loss of owls in Santa Clara County will be compensated for in Byron, which is approximately 50 miles away, outside the Bay Area.

2. California Environmental Quality Act

The environmental review process under the California Environmental Quality Act ("CEQA") should theoretically provide some protection to burrowing owls. CEQA declares that it is the policy of the state to "[p]revent the elimination of fish or wildlife species due to man's activities, ensure that fish and wildlife populations do not drop below self-perpetuating levels, and preserve for future generations representations of all plant and animal communities." (California Public Resources Code, Section 21001(c)). When the CEQA process is triggered, it requires full disclosure of the potential impacts of proposed projects. The operative document for major projects is usually the Environmental Impact Report (EIR).

Theoretically, besides ensuring environmental protection through procedural and informational means, CEQA also has substantive mandates for environmental protection. The most important of these is the provision requiring public agencies to deny approval of a project with significant impacts when feasible alternatives or feasible mitigation measures can substantially lessen such effects. In practice, this mandate is rarely implemented, especially with regard to the burrowing owl. Project proponents and approving agencies almost universally dismiss alternatives that would protect burrowing owls and other wildlife as "infeasible".

CEQA requires a full public disclosure of the potential environmental impacts of proposed projects. The public agency with primary authority or jurisdiction over the project is designated as the lead agency and is responsible for conducting a review of the project and consulting with other agencies concerned with resources affected by the project. Section 15065 of the CEQA guidelines require a finding of significance if a project has the potential to "reduce the number or restrict the range of a rare or endangered plant or animal." Species that are eligible for listing as rare, threatened, or endangered but are not so listed are given the same protection as those species that are officially listed with the state.

Once significant impacts are identified, the lead agency has the option to require mitigation for effects through changes in the project, claim a categorical exemption, or to decide that overriding considerations make mitigation infeasible. In the latter case, projects may be approved that cause significant environmental damage, such as destruction of sensitive species. Protection of listed species through CEQA is therefore at the discretion of the lead agency involved. CEQA provides that when overriding social and economic considerations can be demonstrated, project proposals may go forward, even in cases where the continued existence of the species may be threatened, or where adverse impacts are not mitigated to the point of insignificance.

For example, Trulio (1998a) documented the utter failure of the CEQA process to protect burrowing owl habitat in Santa Clara County. Surveys by Trulio (1998a) of 123 of 215 known owl occupancy sites in Santa Clara County (H. T. Harvey and Associates 1994) showed a steady decline in remaining owl habitat. In 10 years, 70 of 123 sites (57%) were lost to development, an average of almost 6% per year. Another 12 sites

(10%) were reduced in size or habitat quality.[179] At this rate of loss, Trulio (1998a) predicted the remaining sites on private or city owned land could be lost by 2005, despite the existence of CEQA. Trulio (1998a) noted that the following factors likely explain the failure of CEQA to protect owl habitat: lack of CEQA review, failure to identify owl habitat during CEQA review, use of Categorical Exemptions, use of Overriding Considerations, and ineffective mitigation measures. Many lead agencies declare significant impacts to owls, then approve the project despite those impacts pursuant to a Statement of Overriding Considerations which concludes that the benefits of the project outweigh the harm to the owls. This was the case when the City of Alviso, in Santa Clara County, approved its General Plan in 1998, with 18 significant, unavoidable impacts, including loss of habitat for burrowing owls.

The burrowing owl is a species frequently overlooked during the CEQA process and often detected just prior to ground-disturbance, too late in the CEQA process to allow for adequate mitigation planning. This results in last-minute efforts to mitigate impacts to burrowing owls, such as relocation out of development areas. Trulio (1998a) noted that in her experience, when owl habitat is identified during the CEQA process, mitigation other than avoidance is nearly always proposed, meaning that owl habitat is nearly always destroyed or reduced.

Another problem is that the treatment of burrowing owls has been wildly inconsistent between regulatory agencies and between different regional branches within a single agency, such as CDFG. At best, CDFG occasionally requires mitigation for destruction of burrowing owl habitat by purchase of mitigation bank habitat at a ratio of 6.5 acres/owl pair, which is in no way based on the biological needs of the species (see the discussion below). CDFG does not even require that this habitat be in the general vicinity of the habitat-destroying project, virtually ensuring that breeding burrowing owls will continue to be systematically extirpated from the most rapidly urbanizing areas of its range. Even if mitigation banking were consistently applied and implemented, this requirement would be inadequate to protect the species from extirpation through most of its range. Many mitigations do not even approach this 6.5 acre figure, such as the Cisco Systems development in north San Jose, where CDFG protested, but declined to challenge an EIR proposing to set aside 21.7 acres of owl habitat for a colony of 16-22 owls (roughly 2 acres/pair) and destroy 130.9 acres.

The active relocation of burrowing owls has become a widespread management technique in California (Trulio 1995; Delevoryas 1997; Feeney 1997). Standard procedure for lead agencies statewide has been to declare that significant impacts could be avoided by simply moving owls out of the way of development, thereby avoiding take. Relocation does avoid direct owl mortality, but does not mitigate for habitat loss. There also has been little success at establishing long-term nesting of owls at relocation sites. There are little data supporting the premise that owls moved long distances (greater than 300 feet) or evicted from their burrows can survive or reproduce successfully (Trulio 1997), yet this continues to be the most common "mitigation" for development projects which result in the destruction or alteration of owl habitat. Rarely does mitigation require the creation or restoration of owl habitat to replace the habitat that will be destroyed, nor are there often requirements to manage for long-term viability of owls at release sites. Of owls that have been moved, the vast majority generally will disappear from or abandon the new location, often returning to the eviction site (Harris 1987; Dyer 1988; H. T. Harvey and Associates 1993; Martell et al. 1994; Delevoryas 1997; DeSmet 1997; Feeney 1997; Trulio 1997).

The movement of owls out of the way of development has resulted in a net loss of owl habitat and fails to preserve owl populations at existing locations. Translocation is an incomplete mitigation, as it may function to prevent the direct killing of birds, but birds are eventually lost as available habitat decreases. Current mitigation and other management plans do <u>not</u> function to prevent the ultimate decline of the owl population. Despite the CDFG publication of a "Draft Staff Report on Burrowing Owl Mitigation" in 1995 (discussed more fully below), the limitations with CEQA still remain.

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[179] Trulio listed sites completely developed as "lost," those diminished in size or habitat quality as "reduced," and those which could still support a pair of owls as "extant".

3. CDFG Mitigation Guidelines

In the absence of endangered species laws or state agency guidelines to protect an obviously declining species, and in an attempt to develop a consistent, logical means for avoiding direct owl mortality, defining impacts, and suggesting reasonable mitigation, the biological community formed the California Burrowing Owl Consortium ("CBOC") in 1989. The CBOC prepared a document entitled "Burrowing Owl Survey Protocol and Mitigation Guidelines" in 1993, intended to standardize determinations of owl presence and impact assessment (CBOC 1997). After submission of this document, the Department of Fish and Game subsequently prepared a "Draft Staff Report on Burrowing Owl Mitigation," which borrowed extensively from the CBOC's document (CDFG 1995).

The CBOC guidelines were intended to assist individuals (in the private or agency sectors) faced with mitigating direct impacts to burrowing owls; this document was not intended to address region-wide, long-term conservation planning for the species. The guidelines have been widely used by agency and private biologists from 1994 to the present, but have also been badly misused and misinterpreted.

In trying to determine a number that represented an impact threshold, CBOC took into account the fact that owls move, sometimes long distances (e.g., Haug and Oliphant 1990), and also nest in areas that might appear to have only a small proportion of suitable habitat. The threshold question hinged on how close development could come to a burrow without a significant impact and whether projects with a modest footprint (e.g., pipelines and transmission lines) could be declared to have significant impacts to an owl home range encompassing scores, if not hundreds of acres. Using a combination of intuited disturbance distances (a few dozen meters) and territorial considerations, biologists with the CBOC selected a 300-foot radius around an occupied burrow (6.5 acres) as the amount of habitat estimated to be a threshold where significant impacts should be considered. This area was <u>not</u> purported to be the amount of habitat needed to support a pair of burrowing owls, nor was it meant to be used as a way to manage for a sustainable population of owls.

However, in 1999, CDFG agreed to a development project in the City of Santa Clara on a site that supported 9 pairs of owls, and declared the number of owl pairs multiplied by the 6.5 acre figure was acceptable mitigation. The replacement acreage did not have to be in the vicinity of the project and it did not have to be in place for 2 years. There is now an unofficial "owl bank" for south Bay projects located in Byron in eastern Contra Costa County, re-enforcing the perception that CDFG has abandoned efforts to protect owls in the urban Bay Area. According to the CDFG, Central Coast Region, this mitigation requirement of conservation and long-term management of 6.5 acres of existing burrowing owl habitat has been applied to at least 84 owl pairs directly impacted by development activities in the past 3 years, within the southern and eastern portions of the Bay Area (Contra Costa, Alameda, and Santa Clara Counties) (CDFG 2002a). The required mitigation acreage has been purchased at 3 small mitigation banks in eastern Alameda and Contra Costa Counties (CDFG 2002a). Use of these conservation banks as acceptable mitigation preserves only a very small amount of burrowing owl habitat in exchange for the likely eventual extirpation of owl populations from the eastern and southern Bay Area.

4. California Fish and Game Codes

State protection of California's burrowing owls exists only in the form of Fish and Game Codes that protect bird nests (§3503) and birds of prey and their nests (§3503.5). Fish and Game Code §3503 states "it is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto," and under California Fish and Game Code §3503.5 "it is unlawful to take, possess, or destroy any birds in the orders Falconiformes or Strigiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto." While these code sections prohibit the actual destruction of nests or

intentional killing of birds, they have provided inadequate protection for habitat. These codes do not protect unoccupied burrows or previously occupied burrows outside of the nesting season that provide potential future nesting habitat. Also, because of their subterranean habitats, burrowing owls can go undetected and be inadvertently destroyed by ground-disturbing activities such as permitted bulldozing and unregulated activities such as plowing, disking, or grading, which kill burrowing owls and destroy nests in the process. There does not seem to be any enforcement of these codes and it is unknown whether these codes have ever been used to prosecute illegal "taking" of burrowing owls or owl nests and eggs. Illegal take of burrowing owls is certainly occurring in California, with documented instances of bulldozing of burrows, shooting, vandalism and other activities, as discussed in Section VIII above. These Fish and Game Codes also fail to address the fact that "take" of owls is occurring through active and passive relocation of owls, activities that are a significant mechanism of extirpation of owls from urbanizing areas. State-sanctioned relocation efforts often result in disguised or delayed "take" of owls, as discussed in Section VIII.D above.

5. Natural Community Conservation Plans

The state "Natural Communities Conservation Planning Act" was enacted in 1991, purportedly to provide for comprehensive, regional multi-species planning. The entirely voluntary Natural Communities Conservation Planning ("NCCP") program is intended to preserve blocks of contiguous habitat large enough to sustain viable populations of listed species and to prevent the need for additional listings, while still allowing for "compatible and appropriate" economic growth and development. However, the NCCP Act, unlike the federal ESA, contains no regulatory standards for plan approval and implementation.

Only 3 NCCPs have been approved within the range of the burrowing owl, all in San Diego and Orange Counties, where there are perhaps less than a dozen breeding pairs of owls left. These NCCPs have been set up too late to capture any long-term viable nesting habitat for the species. P. Bloom has surveyed all existing and potential Orange County NCCP lands and found no nesting owls (P. Bloom, pers. comm., 2002). Similarly, the San Diego County NCCPs do not contain any viable long-term nesting habitat. While the NCCP areas constitute significant habitat preservation efforts, the burrowing owl nesting habitat that has been protected is too small and therefore of marginal significance for burrowing owl protection. On a positive note, wintering burrowing owls utilize NCCP and proposed NCCP lands on a regular basis in Orange and San Diego Counties (P. Bloom, pers. comm., 2002).

The San Diego Multi-Species Conservation Plan ("MSCP"), an NCCP that is also a federal HCP, only has the potential to protect 1 viable breeding population of owls, as discussed in the section on HCPs above. The other 2 NCCPs are the Orange County Sub-regional Plan ("SRP"), and the San Diego Gas & Electric Co. NCCP. As for the Orange County SRP, the Central-Coastal portion of the SRP has been approved, and mentions the burrowing owl as a species of concern. No direct protection or mitigation was proposed for the species as of 1996. The Notice of Preparation for the Southern portion of the SRP was released in September 2001, but does not specifically address the burrowing owl. No information is available on the Northern portion of the NRP, which is pending. The San Diego Gas & Electric Co. NCCP will modify 400 acres, identified as potential habitat for 110 species of concern, including the burrowing owl. The plan identifies the potential impacts as "direct killing, or injury to, individual animals," especially those animals that may be in nests or in burrows...in the ground." Among the flaws of the southern California NCCPs are their lack of clear standards, lack of reliable sources of funding, and failure to provide for adequate independent scientific input (Jasny 1997).

No NCCPs are approved or planned in the Imperial Valley, where 71% of the state's breeding owls reside, nor in the southern or northern Central Valley, which support 15% and 6.4% of the state owl population, respectively. A few NCCPs are pending within the southern range of the burrowing owl, including the Joint Water Agencies Sub-regional Plan, Western Riverside County MSHCP, San Bernardino Valley-wide MSHCP, and Palos Verdes Peninsula Sub-regional Plan. In the middle Central Valley, Merced County is now in the

planning stages for an NCCP, and the following areas are anticipated to implement future NCCP Planning Agreements: South Placer Legacy Area, Yolo County, Solano County, and South Sacramento County.

The NCCP program is still experimental in nature and cannot be relied upon to protect or recover burrowing owl populations in California. Very few NCCPs have been approved or implemented, and significant unanswered questions remain about their biological integrity and long-term viability. Some of the problems with the NCCP process are that it is heavily weighted in favor of economic development, rather than species recovery goals; it is politically driven, rather than science driven; there are insufficient monitoring mechanisms; the voluntary nature of the program limits its effectiveness; landowner and industry representatives and their consultants dominate the planning process; and the program does not ensure adequate funding to carry out NCCP acquisition programs (Jasny 1997; Mueller 2001). Unfortunately, the NCCP process is also being used to undermine other state protections for species and to weakens citizens' and local governments' ability to obtain and/or enforce species protections through other legal mechanisms, which may provide stronger protection than the NCCP process (Mueller 2001).

6. Mitigation Banks

The California Department of Fish and Game acknowledges 43 mitigation banks in existence or in the process of being created in California, where land can be purchased by developers, essentially as "mitigation" credits for habitat destruction elsewhere. The ideal of these mitigation banks is to consolidate the acquisition of mitigation land, and credits for mitigation, into large and biologically meaningful parcels (CDFG 2002b). However, the mitigation bank approach for burrowing owls implicitly endorses extirpation of owls from areas of high development by not requiring on-site conservation measures, ensuring that owls will eventually be eradicated from urban areas.

The California Environmental Resources Evaluation System (CERES) only identifies 1 mitigation bank in California with habitat and conservation credits for burrowing owls, the 92.5 acre Springtown Reserve in Livermore, Alameda County, which is still under development (CERES 2002). The California Department of Fish and Game has unofficially sanctioned the use of several other small mitigation banks in eastern Alameda and Contra Costa Counties to "mitigate" for the loss of burrowing owl habitat to urban development in eastern and southern San Francisco Bay Area. These include the Byron Conservation Bank (120-142 acres), Brushy Creek Conservation Bank (120 acres), and the Haera Conservation Bank (299 acres plus the potential for expansion by several hundred acres). There is a also a small mitigation bank in Placer County (315 acres) with potential habitat for burrowing owls, but it is unclear how many owls are there.

The small number of mitigation banks with owl habitat, their extremely small size, and the rising cost of purchasing suitable land for habitat make this approach incapable of protecting significant populations of owls.

C. REGIONAL AND LOCAL GOVERNMENT PLANS

The lack of statewide consistency in interpreting owl protection guidelines developed for (but never formally adopted by) the California Department of Fish and Game has led to confusion, conflict, and disarray in the regulatory community and among consulting biologists. Failed conservation efforts in the San Francisco Bay Area are indicative of the limitations of attempts at regional and local owl conservation planning for non-listed species.

<u>Regional Plans</u>

Members of the CBOC met with the California Secretary of the Resources Agency in 1995 and the Director of the Department of Fish and Game in 1998 to discuss ways to enhance burrowing owl conservation in the San Francisco Bay Area other than listing the species (there was a perception that listing might lead to intentional eradication of burrows from private lands through disking). An approach involving regional

conservation planning by the Department of Fish and Game and local/municipal habitat conservation was agreed upon, and the California Audubon Society introduced a bill to the California legislature in 1999. This bill would have provided funds for the Department of Fish and Game to prepare a Burrowing Owl Conservation Strategy for the Bay Area, however during legislative review this bill was amended to apply to other species and eventually was not funded.

It is worth noting that every city in the southern San Francisco Bay that was approached with the concept of cooperating on a multi-city (i.e., regional) plan opted instead for its own separate plan. The result was a different approach to similar problems of habitat loss in the same locality, and the need to reinvent the process multiple times as a result of these decisions.

County Plans

The General Plans for the 37 California counties that still have breeding burrowing owls (excluding the counties in the desert range of the species, where owls have always been sparse) were reviewed, and none of these plans mention or require any mitigation for loss of burrowing owl habitat.

The Fresno County General Plan typifies the treatment of special status species under county level planning efforts. Protection policies are couched in qualifiers, such as "where possible," and there is no guaranteed protection of sensitive habitat if it is "not practicable." For example, the plan commits to "*support efforts* to avoid the "net" loss of important wildlife habitat *where practicable*" and "ensure the conservation of large, continuous expanses of native vegetation to provide suitable habitat for maintaining abundant and diverse wildlife populations, *as long as this preservation does not threaten the economic well-being of the county*" [italics added]. The plan does not specifically mention the burrowing owl, but does discuss protecting the San Joaquin kit fox in the context of mandating that the County "shall promote effective methods of pest (e. g. ground squirrel) control on croplands bordering sensitive habitat that do not place special-status species at risk, such as the San Joaquin kit fox." Of course, effective ground squirrel control puts the long-term survival of burrowing owl populations at risk.

Under the Fresno County General Plan, if protecting wildlife habitat is deemed unfeasible, "mitigation" is required. However, compliance with existing environmental laws, such as CDFG codes, U. S. Fish and Wildlife Service regulations, and the Migratory Bird Treaty Act are considered part of the mitigations. The County acknowledges that development under the plan will destroy specific habitat types that support special-status animals, and that although implementation of its mitigation policies would somewhat reduce impacts for development within the County's jurisdiction, they would not be reduced to a less-than-significant level. The impacts of future development under the plan are deemed to be significant and unavoidable for development within the County and other city jurisdictions.

City Plans

Repeated conflicts between burrowing owls and development projects, especially in southern San Francisco Bay, have led some municipalities to consider preparing city-wide burrowing owl conservation programs for their respective jurisdictions.

The City of San Jose, in Santa Clara County, attempted the most ambitious such project in 1998 and spent 2 years developing a Burrowing Owl Habitat Conservation Strategy and Implementation Plan ("Plan"), which was fashioned after the Habitat Conservation Plan model for federally-listed species. The Plan would have provided a consistent way to evaluate impacts to burrowing owls and burrowing owl habitat from development according to their General Plan through 2020. The Plan proposed a development fee for every acre of open space land developed (although the fee was the most obvious way to fund the Plan, the Plan also contained other funding mechanisms) to create an endowment fund to maintain and monitor owl habitat. This funding mechanism would have resulted in the management of several hundred acres of burrowing owl habitat on dual-purpose land in San Jose, without the need to purchase prohibitively costly land (in the range of $1

million/acre). Development was expected to consume over 2,000 acres of owl habitat over 20 years, which would be mitigated by 1,250 managed acres of owl habitat within the City's urban service area. Unfortunately, the City Council denied the Plan in May 2000 without even bothering to read it, due to objections by the building industry over the proposed development fee, concerns by the City that it would cause undue restraint of commercial development in San Jose, and the perception that they were being held to a higher standard of mitigation than neighboring entities (as in the 6.5 acres/pair mitigation for owl habitat in Byron allowed for development in Santa Clara). Shortly after the rejection of the Plan, the City, in a self-serving interpretation of the CBOC guidelines, offered a "less than significant" free pass to a development project at Lake Cunningham Park, because it impacted less than 6.5 acres of owl habitat.

The City of Morgan Hill, in Santa Clara County, began preparing a city-wide burrowing owl habitat conservation program in 2000. The City committed in 1999 to prepare such a plan as part of the approval of a development project that affected burrowing owl habitat. Unfortunately, breeding burrowing owls may have been extirpated from Morgan Hill during the time the plan was being prepared (J. Barclay, pers. comm., 2002).

In San Bernardino County, the City of Chino General Plan authorizes low to high-density housing development on much of the agricultural land around the Chino Airport, including the majority of occupied owl locations in the vicinity of Chino (J. Bath, pers. comm., 2001). The City of Ontario General Plan proposed to convert 8,200 acres of existing agricultural grasslands, and develop 31,000 homes in an area that supports a large burrowing owl population in the Inland Empire with only a mere 50 acres of raptor habitat provided as "mitigation" (G. Stewart, D. Guthrie, pers. comm., 1997). Litigation over this plan resulted in a settlement offering some burrow owl protection measures, which are likely inadequate to protect the owls (J. Bath, pers. comm., 2003).[180]

A local management plan emphasizing on-site relocation and off-site habitat replacement (outside of the Santa Clara Valley) was recently developed for the Mission College owl population in Santa Clara County, where owls numbers have fallen from 30 pairs to 8 pairs in 5 years (Trulio 2002). This type of offsite habitat replacement is detrimental to local owl populations in the Santa Clara Valley region and the affected owls will lose most of their foraging habitat to development under this plan. The inevitable loss of the Mission College population is a perfect example of the simple relationship between habitat loss and species extirpation. (Delevoryas 1997; Trulio 1998a, 2002).

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[180] The settlement measures for the litigation on the Ontario General Plan ("Settlement") include consultation by the City of Ontario with CDFG to determine long-term suitable owl habitat and require avoidance measures (Settlement Page 3, Item 2b). Unfortunately a consultation with CDFG does not guarantee protection for the owls, as CDFG has a record of signing off on other projects in the area that have harmed owls and destroyed owl habitat. If Ontario determines that an "unconstitutional taking" would occur in protecting the owl habitat, then the alternative measure for mitigating impacts will consist of a mitigation fee (Settlement Page 4, Item 2c) of $2,000 per acre (Settlement Page 3, 1st paragraph). A land trust would be formed (Settlement Page 6, Item 5) to receive mitigation fees, with up to 25% of the mitigation fee expenditures allowed for recovery of the endangered Delhi Sands Fly ("DSF") rather than burrowing owls (Settlement Page 4, Item 2 d). Although Ontario has not surveyed for the DSF or burrowing owls, it arbitrarily claims (Settlement Page 4, Item 2d) that habitat that benefits the DSF can be expected to benefit burrowing owls. The mitigation fee of $2,000 per acre is grossly insufficient to purchase the 6.5 acres per burrowing owl nest called for in the CDFG protocol. The appraised value of land per acre in this area ranges between approximately $60,000 and $160,000, and low-end parcels in Chino are expected to rise in value after Chino approves their Subarea 2 General Plan Master on 3/25/2003. The land trust can use the mitigation funds to purchase "offsite mitigation lands," (Settlement, page 6, section 4 b [iii]), but there has been no showing that there are "offsite mitigation lands" suitable for the owls.

X. RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS

This petition has documented significant local extirpations and ongoing and dramatic population declines of burrowing owls throughout the majority of their range in California, as well as the complete failure of regulatory agencies and current management efforts to reverse this trend. The factors causing burrowing owl declines and the threats to the majority of remaining owl populations can only be addressed by providing elevated legal protection to the species. Without endangered or threatened status, future management policy will continue to emphasize protecting individual birds without addressing cumulative habitat loss or other factors reducing the survivorship of owls. Ultimately, the protection of the burrowing owl in California hinges on strong habitat protection regulations.

The California Burrowing Owl Consortium has recommended management and recovery actions for the burrowing owl. These include: protecting remaining breeding pairs (especially those that are part of large breeding groups); protecting and enhancing breeding habitat; and amending management and land use plans to ensure recovery of the species.

A. LIST THE BURROWING OWL AS A STATE ENDANGERED OR THREATENED SPECIES

The western burrowing owl should be immediately listed as endangered or threatened throughout its range in California. Listing the burrowing owl will allow the California Department of Fish and Game to apply consistent protection measures for breeding owls and for essential owl habitat. Listing would also allow for the development of a statewide recovery plan and prioritization of recovery efforts.

B. PROTECT REMAINING BREEDING GROUPS AND PAIRS AND PROTECT AND ENHANCE BREEDING HABITAT

Owl populations at risk in agricultural and urban areas should be identified and guidelines developed for managing and protecting owl habitat. Nest protection and habitat management efforts in agricultural areas will differ from those in urban settings.

In agricultural areas, protecting nests is a primary goal. Although little is known about how owls use the agricultural landscape, owls have been found nesting in burrows along levees and berms, and they most likely forage in agricultural fields. Nest sites are at risk if burrows are filled or squirrels are killed to protect levees, so promoting protection and tolerance of ground squirrel populations where owls exist or might be encouraged to re-colonize is essential.

Urban owls require both nest site and foraging area protection, as both are constantly being lost to development. Protection of nest sites can be achieved more easily than preventing the loss of foraging lands. Management in urban landscapes requires incorporating owl requirements into open space planning and providing foraging habitat in areas compatible with human uses. Where several adjacent development projects are scheduled, they should be planned to maximize the amount of open habitat by clustering buildings, parking lots, and facilities to allow owls the use of contiguous foraging habitat. Cities and counties could begin a program of setting aside areas of suitable owl habitat into perpetuity, guaranteeing that owls have adequate breeding, foraging, and wintering habitat and ensuring the continuance of the species.

Cities and counties with resident and/or migratory burrowing owls within their jurisdictions should adopt weed abatement measures that are not destructive to owls or their nests. To that end, mowing rather than disking should be encouraged for both publicly and privately owned lands, and municipalities should adopt alternate methods of weed control to curb herbicide spraying.

Native grasslands should be retained and restored. Most burrowing owls now live at an artificially high population density in a narrow niche on the margins of agricultural lands. If management practices change slightly, these populations cannot be depended upon to buffer environmental perturbations. Burrowing owls should be reintroduced and their native grassland habitat restored wherever possible.

C. AMENDMENTS TO EXISTING MANAGEMENT AND LAND USE PLANS

Because the burrowing owl is a widely distributed species that occurs in patches, effective protection can likely be achieved only through large scale planning efforts. A statewide recovery plan, which would be enabled by listing the species, should be developed through the California Department of Fish and Game. This plan must address owl habitat needs in the face of current land-use trends. The statewide plan should also quantify the number of owls and amount of habitat in easily managed areas such as on public lands and on lands owned by willing private landholders. Nest protection and habitat management can more easily be implemented under these conditions. County and city general plans should then address the protection and restoration of owl habitat appropriate for their areas, while remaining consistent with the CDFG recovery plan. Environmental impact documents for projects which impact owls must then comply with local planning documents and CDFG requirements. Municipalities must be required to implement statewide burrowing owl recovery guidelines as part of the CEQA and planning process.

D. AGENCIES AND ORGANIZATIONS THAT SHOULD BE INVOLVED

The agencies and organizations that should be involved in planning and implementing burrowing owl recovery plans include: federal agencies such as the U. S. Fish and Wildlife Service, U. S. Bureau of Land Management, U. S. Army Corps of Engineers, U. S. D. A. Wildlife Services, and the USGS Biological Resources Division; state agencies such as the Department of Fish and Game, California Coastal Commission, and Department of Water Resources; and regional agencies such as the San Francisco Bay Conservation and Development Commission and the Association of Bay Area Governments. The Burrowing Owl Consortium and landowners and managers with owl populations, such as counties, cities, water districts, park districts, military bases, golf courses, airports, the Farm Bureau, and private landowners should all be involved in the development and implementation of a recovery plan.

E. BURROWING OWL MANAGEMENT IMPACTS ON OTHER SPECIES

Several other wildlife species may benefit from increased protection for burrowing owls in different parts of the burrowing owl's range in California. Increased grassland habitat protection for burrowing owls in the southern San Joaquin Valley would complement conservation efforts for the San Joaquin kit fox (*Vulpes macrotis mutica*), blunt-nosed leopard lizard (*Gambelia sila*), various listed and special-status kangaroo rats (*Dipodomys ingens, D. nitratoides nitratoides, D. n. exilis, D. n. brevinasus*), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*), San Joaquin pocket mouse (*Perognathus inornatus inornatus*), and Tulare grasshopper mouse (*Onychomys torridus tularensis*).

Increased protection of burrowing owls would also benefit Swainson's hawks (*Buteo swainsoni*), California horned larks (*Otocoris alpestris actia*), American badgers (*Taxidea taxus*), and Salinas pocket mice (*Perognathus inornatus psammophilus*) in the overlapping portions of their respective ranges. In the Mojave Desert, increased protection of burrowing owls would complement protection of desert tortoises (*Xerobates agassizi*) and Mohave ground squirrels (*Spermophilus mohavensis*). The habitat of the endangered Delhi Sands Flower Loving Fly (*Rhaphiomidas terminatus abdominalis*) in Colton, Fontana and Mira Loma overlaps with probable burrowing owl habitat.

Management and recovery of burrowing owls is not expected to significantly negatively impact other wildlife species. Increased owl numbers could impact local populations or concentrations of some prey species.

Burrowing owls are known to prey on California least terns (*Sterna antillarum brownii*), a federally endangered species, at colonies on North Island and Ream Field (Imperial Beach) in San Diego County (P. Unitt, pers. comm., 2001). Owls are hazed away from tern nests at Ocean Beach and also discouraged in the vicinity of snowy plover (*Charadrius alexandrinus nivosus*) nesting areas in the region.

F. MONITORING PROGRAMS AND STUDIES

Researchers and trained volunteers will be needed to monitor the effectiveness of any management guidelines to recover burrowing owls. The following monitoring programs and studies are critical to successful habitat management:

* Continued refinement of the statewide population estimate;
* Defined demographic parameters in stable, decreasing, and increasing populations to determine causes of declines and mechanisms to reverse declines;
* Development of realistic population goals for long-term species survival;
* Studies of dispersal, adult and juvenile survivorship, and causes of mortality in natural, agricultural, and urban environments;
* Studies of reproductive success and survivorship of birds under varying management schemes;
* Studies determining the impact of pesticides on birds in agricultural settings;
* Studies of immigration of birds into local populations from other populations in and outside the state;
* Studies determining the necessary effective population size for long-term persistence; and
* Studies of methods that are most effective at increasing existing populations.

Burrowing owl research is currently being conducted on these topics by the following researchers:

* Genetic relationship of California burrowing owls: Clark Winchell, North Island, San Diego
* Population viability, reproductive effort, dispersal, and passive relocation: Lynne Trulio, San Jose State University
* Demography study of burrowing owl populations in urban, agricultural, and grassland habitats: Daniel Rosenberg, Institute for Bird Populations
* Population monitoring, demography, and management at San Jose Airport since 1990: Jack Barclay

XI. SIGNATURE PAGE

Submitted this 7th day of April, 2003

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Michael Connor, Executive Director, Desert Tortoise Preserve Committee, Riverside, CA
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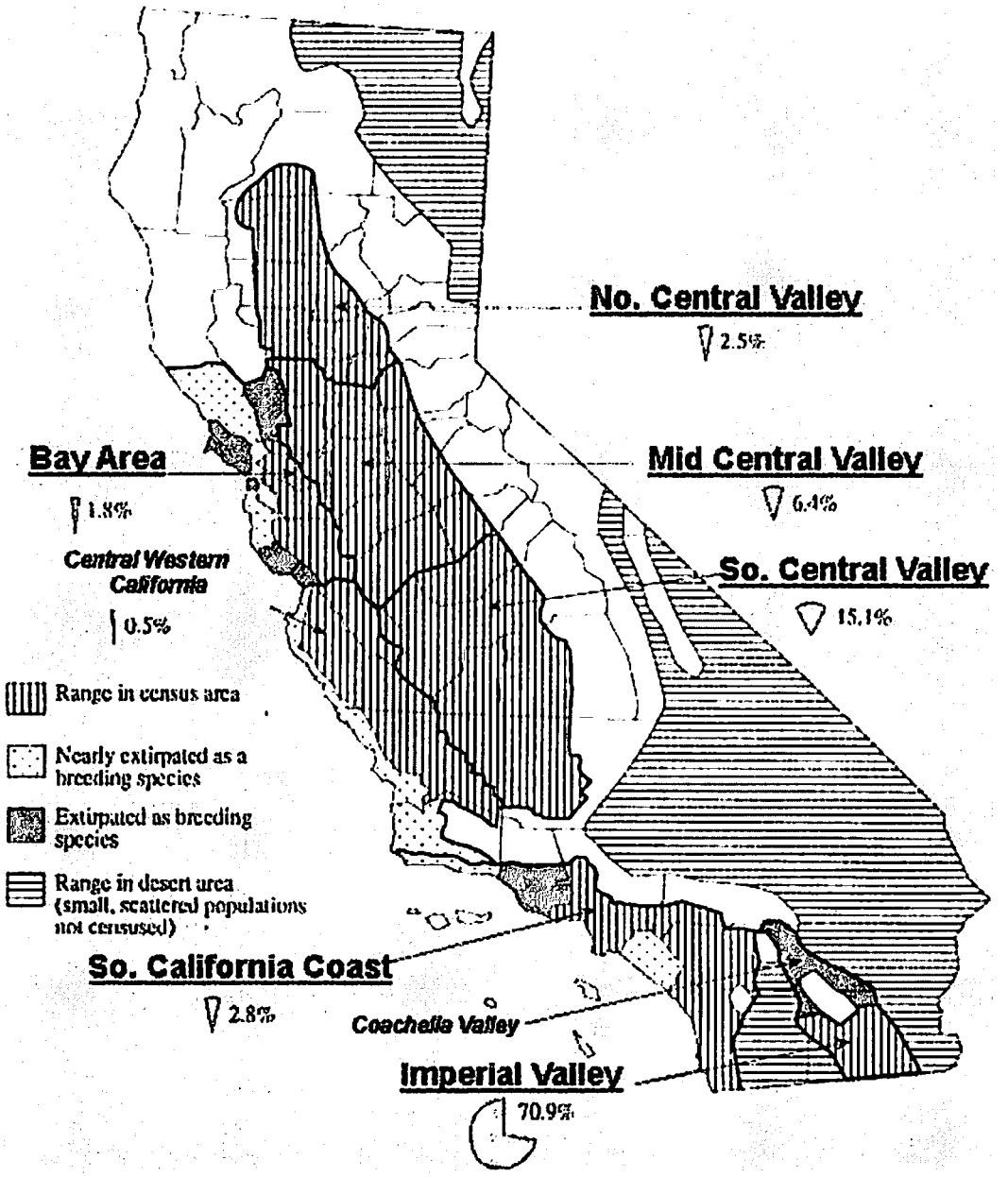
XII. APPENDICES

A. APPENDIX 1 – CALIFORNIA BURROWING OWL RANGE AND DISTRIBUTION MAP



State Map: Produced by John H. Barclay, using data derived from a census of burrowing owls in California 1991-1993, David F. DeSante and Eric D. Ruhlen. Institute for Bird Populations, 1995.

B. APPENDIX 2 – TABLE OF ESTIMATED DENSITY, BREEDING PAIRS, AND POPULATION TREND, BY REGION*

Region (County)	Area Within Burrowing Owl Range (mi^2)	Estimated Density ($pairs/km^2$)	Estimated # of Breeding Owl Pairs (Year of Estimate)	Population Trend
Northern Desert Range	**2,650**	**0.021-0.035**	**90-149** (1999)	**unknown**
E Siskiyou	945		32-53 (1999)	unknown
Modoc	615		21-35 (1999)	unknown
Lassen	910		31-51 (1999)	unknown
E Plumas	130		4-7 (1999)	unknown
E Sierra	50		2-3 (1999)	unknown
Northern Central Valley	**8,275**	**0-0.02**	**231-244** (1993)	**unknown**
SW Shasta	770		unknown	unknown
Tehama	2,230		unknown	unknown
Butte	1,165		unknown	unknown
Glenn	1,055		unknown	unknown
Yuba	545		unknown	unknown
W Nevada	200		unknown	unknown
Colusa	1,100		unknown	unknown
Lake	unknown, small		unknown	unknown
Sutter	605		unknown	unknown
W Placer	605		unknown	unknown
Middle Central Valley	**11,450**	**<0.01-0.03**	**594-597** (1993)	**unknown**
Yolo	1,035		30-40 (2000)[a]	50% decline since 1985[a]
Sacramento	1,015		unknown	unknown
Solano	830		unknown	unknown
E Contra Costa	400		unknown	unknown
E Alameda	165		unknown	unknown - hist. declines[b]
San Joaquin	1,435		unknown	unknown - hist. declines[c]
Stanislaus	1,520		unknown	unknown
Merced	2,010		unknown	unknown
W El Dorado	540		unknown	unknown
W Amador	330		unknown	unknown
Calaveras	720		unknown	unknown
W Tuolumne	575		unknown	unknown
W Mariposa	875		unknown	unknown
Southern Central Valley	**15,000**	**0.03-0.05**	**1,363-1,396** (1993)	**unknown**
Madera	1,500		unknown	unknown
SE San Benito	350		unknown	unknown
Fresno	4,800		unknown	unknown - hist. declines[d]
Kings	1,435		unknown	unknown
W Tulare	2,420		unknown	unknown - hist. declines[e]
NW Kern	4,495		unknown	unknown

* Density and population estimates from DeSante and Ruhlen (1995), DeSante et al. (1996), and information in this petition unless otherwise noted, except northern desert range estimates from Barclay and Cull (1999) using density values from DeSante and Ruhlen (1995) and Butts (1973). Area within burrowing owl range derived from Barclay state map in Appendix 1.

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[a] Estimate by B. Johnson (pers. comm., as cited in PHBA 2002).

[b] Declined through the 1970s (Stallcup and Greenberg 1974).

[c] Declines were noted in the Stockton area 1968-1978 (Remsen 1978).

[d] Miller (1903), Tyler (1913a), and Remsen (1978) reported declines in the Fresno area.

[e] Remsen (1978) and Beedy and Granholm (1985) noted declines.

Region (County)	Area Within Burrowing Owl Range (mi^2)	Estimated Density ($pairs/km^2$)	Estimated # of Breeding Owl Pairs (Year of Estimate)	Population Trend
S. F. Bay Area	**6,465**	**<0.01**	**165-170** (1993)	**50% decline since mid-1980s**
Sonoma	1,600	0	1-2 (1993)	nearly extirpated
Napa	795	0	0 (1993)	extirpated
Marin	590	0	0 (1993)	extirpated
SW Solano	45	<0.01	0? (2002)	nearly extirpated
W Contra Costa	400	<0.01	0? (2002)	nearly extirpated
Alameda	660	<0.01	unknown	declining
San Francisco	90	0	0 (1993)	extirpated
San Mateo	530	0	1-2 (2001)	nearly extirpated
Santa Clara	1,315		120-141 (1997)[f]	declining
Santa Cruz	440	0	0 (1993)	extirpated
Central Western CA	**9,895**	**<0.01**	**46** (1993)	**declining**
Monterey	3,325		~14 (1992)[g]	nearly extirpated
San Benito	1,050		unknown	unknown
Coastal San Luis Obispo	3,015	0	0 (1993)	extirpated
Santa Barbara	2,195		unknown	nearly extirpated
Carrizo Plain (Eastern SLO)	**310**		**>32-40** (2003)[h]	**apparently stable**[h]
Southwestern CA	**8,380**	**<0.01-0.11**	**263-311** (1993)	**57-85% decline since mid-1980s**
S Ventura	1,025		unknown	nearly extirpated
S Los Angeles	2,040		0? (2002)	nearly extirpated
Orange	785		≤3 (2002)	nearly extirpated
W San Diego	1,710		6-8 (2001)	nearly extirpated
Southern CA Islands	unknown, small		unknown, very few	unknown
W Riverside	1,810		unknown	declining - near extirp.?[i]
SW San Bernardino	1,010		unknown	declining - near extirp.?[i]
Imperial Valley	**1,840**	**0.08-2.37**	**6,571-6,719** (1993)	**apparently stable**
Coachella Valley	**1,530**	**0**	**0** (1993)	**extirpated**
Central Riverside	1,090	0	0 (1993)	extirpated
NE San Diego	210	0	0 (1993)	extirpated
N Imperial	230	0	0 (1993)	extirpated
Southern Desert Range	**37,450**	**unknown**	**unknown**	**unknown**
Inyo	8,580		unknown	unknown
SE Kern	2,450		unknown	unknown
San Bernardino	17,140		unknown	declining[j]
NE Los Angeles	1,220		≥10 (2000)[j]	declining[j]
E Riverside	3,620		unknown	unknown
E San Diego	2,140		unknown	unknown
Imperial	2,300		unknown	unknown
Statewide Total	**103,245**		**9,365-9,682+**	**declining 8% per year**

[f] 1997 Santa Clara countywide estimate by J. Barclay (pers. comm., 2002).

[g] 1992 survey by Roberson (1993).

[h] The owl population at Carrizo Plain, which was missed by the DeSante et al. (1996) surveys, may be larger than recent surveys (Rosenberg and DeSante 1997; Rosenberg et al. 1998b; Rosenberg 1999) indicate (J. Gervais, pers. comm., 2003).

[i] Estimate by P. Bloom (pers. comm., 2002).

[j] Estimate by S. Myers (pers. comm., 2002).

C. APPENDIX 3 - DESANTE ET AL. 1996, "THE DISTRIBUTION AND RELATIVE ABUNDANCE OF BURROWING OWLS IN CALIFORNIA: EVIDENCE FOR A DECLINING POPULATION"

EXHIBIT 649

Journal of Mammalogy, 85(3):000–000, 2004

HOME-RANGE SIZE AND USE OF SPACE BY ADULT MOHAVE GROUND SQUIRRELS, *SPERMOPHILUS MOHAVENSIS*

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Using radiotelemetry we studied home range and movements of 32 adult female and 16 adult male Mohave ground squirrels (*Spermophilus mohavensis*) in the western Mojave Desert of California during 1990 and from 1994 to 1997. In 3 of the 5 years of study (1990, 1994, and 1996), early winter precipitation (October–January) was <30 mm, and no reproduction occurred at the study site. Postmating home ranges of females varied considerably among years, with annual medians for minimum convex polygons ranging from 0.29 to 1.90 ha. Females used the largest home ranges both during years of ample rainfall and reproduction (1995 and 1997) and during the year of most extreme drought and no reproduction (1990). We hypothesize that variation in home-range size among drought years may result from varying levels of food availability. In 1997, we also studied movements of adults during the mating season, from mid-February to mid-March. During this period, adult males made extensive movements, resulting in median minimum convex polygons much larger (6.73 ha) than those of females (0.74 ha). Such movements would have made it possible for males to locate adult females soon after their emergence from hibernation. Patterns of variation in home-range size and movements observed during this study may reflect adaptive responses of this small herbivore to a highly variable, arid environment.

Key words: home range, Mohave ground squirrel, Mojave Desert, movements, productivity, radiotelemetry, *Spermophilus mohavensis*

The size of an animal's home range may reflect its resource needs, distribution and abundance of resources, or population density. McNab (1963) showed that home-range size varies among mammal species as a function of body mass and trophic level. Harestad and Bunnell (1979) argued that differences in habitat productivity (e.g., between seasons or years) should affect home-range size: as habitat productivity increases, a smaller area is required to meet resource needs, resulting in a smaller home range. Food supplementation experiments (reviewed by Boutin 1990) have shown the expected inverse relationship between increased food availability and decreased home range for a variety of vertebrates, including reptiles, birds, and mammals. However, increased intruder pressure, attraction of competing species to supplemental food, or clumped distribution of resources may lead to results differing from the predicted inverse relationship (Kodric-Brown and Brown 1978; McShea and Schwede 1993; Slade et al. 1997). Studies examining the relationship between seasonal variation in resource availability (Beier and McCullough 1990; Bobek 1977; Singer et al. 1981) or spatial variation in resource abundance (Relyea et al. 2000) and home range are less common.

The Mohave ground squirrel (*Spermophilus mohavensis*) is found only in the western Mojave Desert of California, where it occurs in desert scrub habitats, usually on flat to gently sloping terrain with alluvial soils (Best 1995). Because of habitat loss and fragmentation, it currently is listed as threatened under the California Endangered Species Act. Mohave ground squirrels, like other mammals in arid environments, must survive and ?2 reproduce not only when habitat productivity is very low and highly seasonal but also when it varies greatly from year to year. Therefore, home-range size and use of space by Mohave ground squirrels might change in response to annual variations in resource availability.

Foliage and seeds of native shrubs and forbs make up most of the Mohave ground squirrel's diet. During the mating season, shrub foliage is the most important dietary component (Best 1995). In years with sufficient winter rainfall, forbs dominate the diet during the subsequent late spring and early summer. During drought years, production of forbs is much reduced, and shrub foliage remains the predominant food resource throughout the active period. Winter drought makes it particularly difficult for

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adult females to meet energy demands of reproduction and then accumulate fat reserves needed for dormancy. In years with low winter rainfall, female Mohave ground squirrels do not produce offspring and may enter hibernation as early as the end of April.

We predicted that adult home-range size in this species should decrease in years of high winter rainfall and habitat productivity, increasing in size when rainfall and productivity are low, in accordance with the habitat-productivity hypothesis. Size of home ranges of adult female should increase during reproductive years because of energy requirements of reproduction. Home ranges of adult males should be larger in the mating season to increase access to receptive females (Dobson 1984; Schwagmeyer 1988).

We studied postmating home range and movements of adult Mohave ground squirrels in 1990 and from 1994 through 1997 and movements during the mating season in 1997. In 3 of these years, winter rainfall and primary productivity were low, and we observed no evidence of production of young. In the 2 other years, winter rainfall and food production were sufficient to support recruitment of young. Thus, this 5-year study allowed us to assess home-range size and movements relative to considerable variation in habitat productivity and in energy requirements of reproductive females.

Materials and Methods

Study site and subjects.—Mohave ground squirrels are small (100–150 g adult posthibernation mass) diurnal rodents that are usually active aboveground from February through July but spend the rest of the year in dormancy (Bartholomew and Hudson 1960). The single annual mating season occurs immediately after emergence from hibernation in February and early March (Best 1995). Young are usually born in late March and early April, and lactation continues through mid-May (Pengelley 1966). Litters generally appear aboveground in early to mid-May.

We conducted our study in the northwestern Mojave Desert, Inyo County, California (36°04′N, 117°48′W). The 47-ha study site was a small valley within the rugged uplands of the Coso Range, a desert mountain range about 20 km east of the Sierra Nevada. Elevation of the study site was 1,400–1,500 m, and slopes ranged from 2–15%. Deep alluvial soils were classified as loamy coarse sands. Vegetation was a mixed desert scrub community. Important shrub species included spiny hopsage (*Grayia spinosa*), fourwing saltbush (*Atriplex canescens*), shadscale (*A. confertifolia*), cheesebush (*Hymenoclea salsola*), Cooper's boxthorn (*Lycium cooperi*), and winterfat (*Krascheninnikovia lanata*). This community is typical of the transition between Mojave and Great Basin desert biomes (Beatley 1975). Mean annual precipitation (1949–1999) was 163 mm at Haiwee Power Plant (elevation 1,160 m), 15 km to the northwest of the study site. Winter rainfall predominated, with 79% of annual precipitation received between 1 October and 31 March during the 51-year period of record. Primary productivity in the western Mojave Desert occurs mainly from March through May and is closely related to winter rainfall (Beatley 1974), which is highly variable from year to year. We maintained a rain gauge on the study site and collected precipitation data monthly.

A 22-ha portion of the study site, with trap stations placed at 50-m intervals, was used exclusively for radiotelemetry studies in 1990 and 1994–1997. The remaining 25-ha portion of the site, with trap stations at 25-m intervals, was used primarily for demographic studies from 1988 to 1996. We also carried out radiotelemetry in this portion of the study area in 1990 and 1997.

Capture procedures.—Ground squirrels were captured with Pymatuning (10 × 11 × 39 cm, Warren Grieser, Pymatuning, Pennsylvania) or Sherman (8 × 9 × 30 cm, H. B. Sherman, Tallahassee, Florida) traps placed under shrubs at each trap station and baited with commercial horse feed composed of corn, oats, barley, and molasses. Traps were set in early morning, checked at midday and late afternoon, and then closed for the night. Weight, sex, age, and reproductive condition were recorded for all captured ground squirrels. We marked ground squirrels for permanent identification with passive integrated transponder tags implanted subcutaneously between the scapulae with a hypodermic needle. Adults could be distinguished from juveniles by body mass and pelage. Adults that had been captured and marked previously as juveniles could be assigned to a specific age class. Reproductive condition of adult males was based on position of the testes (abdominal or scrotal). Adult females were examined for swelling of the vulva and nipple size and condition and palpated for evidence of pregnancy. They were then categorized as nonreproductive, receptive, pregnant, lactating, or postlactating.

Radiotracking.—We equipped 56 adult ground squirrels (36 females and 20 males) with radiotransmitters (Model SM-1, AVM Instrument Co., Livermore, California) mounted on flexible collars. The numbers of each sex equipped with radiocollars reflected the sex ratio of captured animals. Six adult females were radiocollared during more than 1 year of study, including 2 individuals that were studied during 4 consecutive years. Radiocollars weighed 5 g and were less than 5% of adult body mass. We located radiocollared individuals during daylight hours using portable receivers (AVM Instrument Co.) and handheld, 2-element Yagi antennas (Telonics Inc., Mesa, Arizona). We followed radio signals on foot until a ground squirrel was either seen or located underground to within 5 m by signal strength and direction. Locations were recorded using compass bearing and distance from the nearest trap station.

We attempted to recapture radiocollared animals at various times to collect data on mass and reproductive condition before their immergence into hibernation. This allowed us to monitor their condition and examine the fit of radiocollars. We attempted to retrieve radiocollars after emergence from hibernation the following spring by trapping in the vicinity of know hibernation locations. Although no radios were transmitting after this time interval, we recovered 39% of radios by this method.

Radiotracking was conducted periodically during the active season (February–July). For analysis, we divided radiotelemetry data into 2 categories: mating season, the period between emergence from dormancy in February through 15 March, and postmating season, the period from 16 March through 30 June. The end of the mating season was established by working backward from the emergence of young from their natal burrows, using data on gestation and development of young (Pengelley 1966). We collected data from the postmating period in all 5 years of the study and from the mating season in 1997. Adults generally were trapped and equipped with radiocollars during an intensive sampling period in late March and early April. During this period, we attempted to locate each animal 2–3 times daily (morning, midday, and evening if possible). Another period of intensive radiotracking occurred from mid-May to mid-June. Between these intensive sampling periods, we made shorter visits to the study area, during which we typically located animals 1–2 times daily over a 1–3-day period. Radiotelemetry studies continued until animals entered hibernation, the timing of which varied considerably among years. The study was expanded in 1997 by adding intensive sampling during the mating season. Seven males and 6 females were equipped with radio

transmitters beginning on 14 February. During the 1997 mating season, we usually obtained locations for each individual 1–3 times per day.

Data analysis and home-range estimation.—Home-range size was estimated for adult Mohave ground squirrels by using all map locations derived both from radiotelemetry and live-trap captures. We calculated postmating home ranges for those adult Mohave ground squirrels for ?3 which we had $\geq$12 locations and radiotelemetry data in $\geq$3 weeks. Forty-eight Mohave ground squirrels (32 females and 16 males) met our criteria for calculating home ranges. The mean number of locations per individual was 27.1 ($\pm$11.5 *SD*). We found no relationship between number of locations and postmating 100% minimum convex polygons (MCP—White and Garrott 1990; $r^2 = 0.005$, $P = 0.628$). To compare postmating home ranges among years, we eliminated records from before 16 March and after 30 June. Home ranges for the mating season of 1997 were calculated for 13 Mohave ground squirrels (7 males and 6 females) for which there were $\geq$10 locations. The mean number of locations per individual was 30.6 ($\pm$12.9). We found no relationship between number of locations and mating season MCP for either males ($r^2 = 0.009$, $P = 0.837$) or females ($r^2 = 0.417$, $P = 0.144$).

The mean time difference between locations, for those locations that fell on the same day, was 234 min ($\pm$59 min, n = 1,213) for the postmating period and 214 min ($\pm$18 min, n = 385) for the mating season of 1997. We excluded the few locations that were determined <2 h apart. These resulted from having checked the location of an animal more than once during a sampling period. White and Garrott (1990) suggest that locations could be considered independent if the ?4 time interval were sufficient for the animal to traverse its home range. Maximum observed rates of travel were lowest for females in the postmating season (maximum of 260 m/h) and highest for males in the mating season (maximum of 1 km/h). These rates of travel were such that animals were capable of traversing their home ranges within a 2-h period.

Location data for radiocollared Mohave ground squirrels were plotted on maps of the study area, and home-range size was calculated with the software program CALHOME (Kie et al., 1996). Two estimates of home range were made for each individual: the 100% MCP and the 95% adaptive kernel. Because no males were radiocollared in 1995 and only 1 in 1994, males and females were analyzed separately for differences among years. Differences were tested initially using Kruskal–Wallis 1-way nonparametric analysis of variance, followed by Dunn's test for multiple pairwise comparisons (Zar 1984) when the analysis of variance indicated significant variation among years. We compared sexes within years using the Mann–Whitney *U*-test and between seasons in 1997 using paired Wilcoxon rank-sign tests. The 100% MCP has the advantage of simplicity and long historical use in the literature. However, it includes unused space, gives no indication of relative intensity of use, and is very sensitive to small sample size and extreme outlying locations (White and Garrott 1990; Worton 1987). Kernel methods use a sample of locations to create a probability density estimate that may be interpreted as a utilization distribution (Van Winkle 1975; Worton 1989, 1995) and is not dependent on parametric assumptions. The bandwidth, a smoothing parameter, was selected by the least squares cross-validation method (Worton 1995).

Unusually long movements by adult males were observed during the 1997 mating season. Therefore, in addition to comparing home-range sizes between seasons, we compared movement distances of males and females between mating and postmating seasons, and we compared males and females within each season. We used 2 measures of movement: maximum movement (straight-line distance between 2 points) for each individual within 1 day and the proportion of all within-day movements that were >200 m, a distance that exceeded the diameter of the postmating home ranges of most females. Within-day movements were calculated for each case in which $\pm$2 locations existed ?5 for an animal within 1 day and at least 1 of the locations was not a nocturnal burrow site. Maximum movements were compared for sexes between seasons using paired Wilcoxon rank-sign tests and for seasons between sexes using Mann–Whitney *U*-tests. Proportions of within-day movements >200 m were analyzed with logistic regression using generalized estimating equations (Liang and Zeger 1986), which allowed the incorporation of variation in proportions among individuals.

Results

Winter rainfall and reproduction.—Rainfall totals in winter (1 October–31 March) at the study site varied greatly, ranging from only 13.7 mm in 1989–1990 to 197.8 mm in 1994–1995 (Table 1). In 3 years (1990, 1994, and 1996) we found no evidence of pregnancy, lactation, or presence of young, whereas in 1995 and 1997 all radiocollared females appeared to have produced litters. In general, low rainfall was associated with reproductive failure, but the timing of precipitation also may have been important. Although total winter rainfall preceding the 1997 active season was only slightly higher than that preceding the 1994 and 1996 seasons, all winter rainfall was received by the end of January and therefore may have been more effective in promoting germination of annual plants. In contrast, the 3 years in which squirrels failed to produce litters had had <30 mm of rainfall by the end of January. Two of the years (1994 and 1996) had significant rainfall in February and March, yet Mohave ground squirrels did not produce litters. The 2 years in which reproduction was observed differed in total and spring rainfall, with no spring rainfall in 1997.

Postmating home ranges of females.—Size of postmating home ranges varied considerably among years for adult females (Fig. 1). The 3 females captured in 1995 were individuals that were also captured in other years, and 3 of the 4 largest home ranges in 1997 corresponded to individuals that were captured in other years. To ensure independence of observations, we restricted our analysis to 1990, 1994, and 1996, all of which were drought years with no reproduction. Size of home ranges differed among drought years for adult female MCP ($H = 13.29$, $d.f. = 2$, $P < 0.01$) and adaptive kernels ($H = 12.41$, $d.f. = 2$, $P < 0.01$) (Fig. 1). MCP in 1994 were significantly smaller ($Q = 3.61$, $P < 0.001$) than those in 1990, and 1996 MCP were also significantly smaller than those in 1990 ($Q = 2.43$, $P < 0.05$). Adaptive kernels in 1994 ($Q = 3.50$, $P < 0.001$) and in 1996 ($Q = 2.42$, $P < 0.05$) were significantly smaller than those in 1990.

Postmating home ranges of males.—Because no males were captured in 1995 and only a single male in 1994, only 3 years were available for comparison (1990, 1996, and 1997). Postmating home ranges did not differ significantly among years for MCP ($H = 4.84$, $d.f. = 3$, $P > 0.05$) or adaptive kernels ($H = 7.14$, $d.f. = 3$, $P > 0.05$). No significant differences in MCP between males and females were found during postmating seasons of 1990 ($U = 3.0$, $P > 0.05$) or 1996 ($U = 9.0$, $P > 0.05$), but male postmating MCP were larger than those of females in 1997 ($U = 11.0$, $P < 0.05$) Similarly, adaptive kernels did not differ between sexes in 1990 ($U = 3.0$, $P > 0.05$)

TABLE 1.—Monthly rainfall (mm), annual winter rainfall totals, and occurrence of reproduction for the Mohave ground squirrel, Coso Range, Inyo County, California. Years in which no evidence of pregnancy, lactation, or weaning of litters was detected are indicated as years of no reproduction. In years for which reproduction is indicated, virtually all adult females were lactating and juveniles were produced.

	October	November	December	January	February	March	Total	Reproduction
1989–1990	6.0	0.0	4.0	3.7	0.0	0.0	13.7	No
1993–1994	0.0	8.6	1.0	0.0	26.5	26.5	59.1	No
1994–1995	1.2	4.1	9.4	135.8	7.4	39.9	197.8	Yes
1995–1996	0.0	0.0	11.8	14.9	0.0	24.8	51.5	No
1996–1997	13.6	12.2	31.0	10.0	0.0	0.0	66.8	Yes

or 1996 ($U = 12.0, P > 0.05$) but was different in 1997 ($U = 8.0$, $P < 0.05$).

Mating season home ranges of males and females.—Male Mohave ground squirrels had very large MCPs during the 1997 mating season (median 6.73 ha, range 4.26–40.14 ha, $n = 7$) compared to those of adult females during the same season (median 0.74 ha, range 0.29–0.93 ha, $n = 6$). Male adaptive kernels (median 12.80 ha, range 5.13–44.28 ha, $n = 7$) were also larger than those of females (median 0.95 ha, range 0.58–1.43 ha, $n = 6$). Both MCPs ($U = 42, P < 0.01$) and adaptive kernels ($U = 42, P < 0.01$) were different. MCPs for males were larger ($z = 2.37$, $n = 7$, $P < 0.05$) during the mating season than postmating season (Fig. 1c), even though the postmating period was considerably longer in duration. However, adaptive kernels in the postmating season (Fig. 1d) did not differ ($z = 1.52, P > 0.05$) from mating season home ranges. For females, both MCP (Fig. 1a; $z = 2.21, P < 0.05$) and adaptive kernel (Fig. 1b; $z = 1.99, P < 0.05$) home ranges were larger during the postmating season than during the mating season for the 6 individuals that were present in both seasons.

The maximum distance moved within days for males during the mating season (median 391 m, range 274–1,491 m) was greater than for the postmating season, (median 130 m, range 46–427 m; $z = 2.37$, $n = 7$, $P < 0.05$). Maximum within-day movements by females during the mating season (median 138 m, range 96–213 m) did not differ ($z = 0.314$, $n = 6$, $P > 0.5$) from postmating movements (median 205 m, range 24–371 m). Maximum within-day movements for males and females were different for the mating season ($U = 42, P < 0.01$) but not for the postmating season ($U = 20.0$, $P > 0.05$).

During the mating season, 40.2% of within-day movements by males ($n = 7$) were >200 m, and this proportion dropped to 13.8% during the postmating period ($\chi^2 = 6.06$, $d.f. = 1$, $P < 0.05$). Females had a much lower proportion (1.5%) of within-day movements >200 m in the mating season. Although this proportion increased to 6.1% during the postmating season, this difference was not significant ($\chi^2 = 2.11$, $d.f. = 1$, $P > 0.10$). The proportion of movements >200 m differed between males and females for the mating season ($\chi^2 = 13.51$, $d.f. = 1$, $P < 0.001$) but not for the postmating season ($\chi^2 = 0.65$, $d.f. = 1$, $P > 0.40$).

Site fidelity of female ground squirrels.—In 9 cases, representing 5 individual females, a radiocollared female from 1 year of the study was found in the subsequent year. Mean proportional overlap of home ranges across years was 0.41 ± 0.16 *SD*, and home ranges overlapped between years for all possible cases. In 4 cases, the home range from 1 year was contained entirely within the home range occupied during another year. Two individuals were studied for 4 years; in both cases, portions of their home ranges were used during all 4 years.

DISCUSSION

Home-range size should reflect the balance of energy demands and resource availability. The habitat-productivity hypothesis (Harestad and Bunnell 1979) predicts that home-range size should decline with increased habitat productivity because a smaller area should meet resource needs when productivity increases. This hypothesis has been tested experimentally by food supplementation (Boutin 1990) and observationally by comparing home range in areas of different productivity. Food supplementation has led to smaller home ranges in a number of small mammals, including *Tamias townsendii* (Sullivan et al. 1983), *Microtus californicus* (Ostfeld 1986), *M. townsendii* (Taitt and Krebs 1981, 1983), *Peromyscus maniculatus* (Taitt 1981), *Sciurus carolinensis* (Kenward 1985), and *Tamiasciurus hudsonicus* (Hurly and Robertson 1987). However, Slade et al. (1997) found increased movements in *M. ochrogaster* on supplemental food areas and also found that movements of reproductive voles were greater than those of nonreproductive individuals for both sexes. These authors invoked increased intruder pressure due to increased density to explain the greater movement on supplemental food grids. Mares et al. (1976, 1982) controlled population density of *Tamias striatus*, and hence intruder pressure, during a food supplementation experiment that resulted in smaller home ranges. Observational studies have also supported the general relationship between habitat productivity and home-range size (e.g., Beier and McCullough 1990; Jones 1990; Relyea et al. 2000; Rusch and Reeder 1978). However, patchy resource distribution may lead to conflicting results. For example, McShea and Schwede (1993) found that animals might expand their home ranges to include productive oaks during mast years.

Female Mohave ground squirrels varied among years in the size of their postmating home ranges. Male home-range size did not differ from that of females in 2 drought years but was greater in a year (1997) in which reproduction occurred. Because we lacked data from 2 years (1994 and 1995) for males, we did not see significant variation among years. Variation in home-range size of postmating females was associated with variation in precipitation, which in turn is related to forage availability for these small herbivores. The pattern of variation in home-range

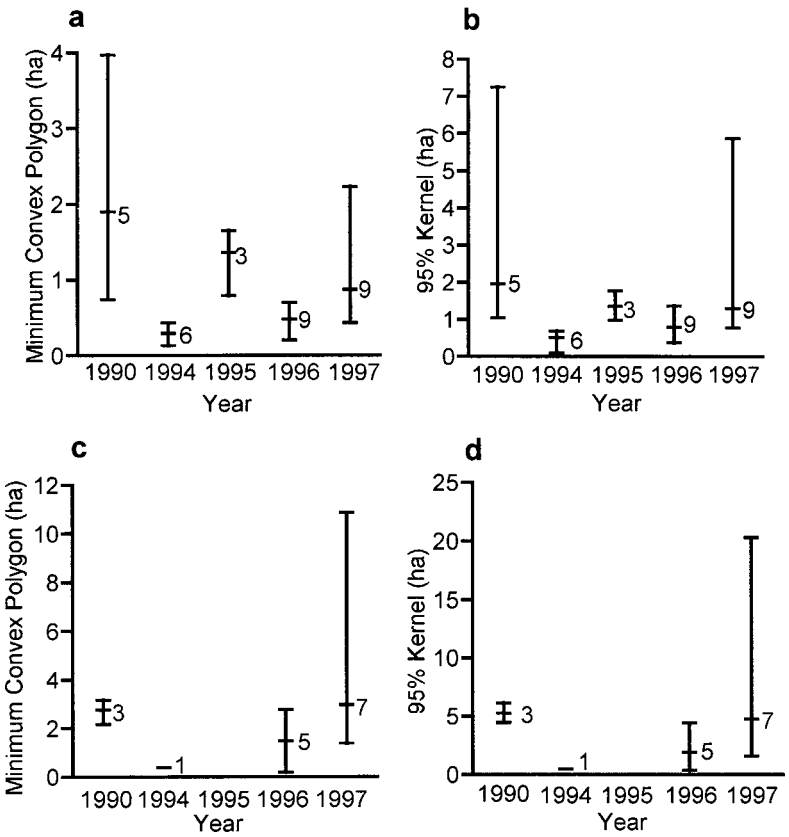

Fig. 1.—Home-range size for postmating Mohave ground squirrels. Sizes for females are given as a) minimum convex polygons and b) 95% adaptive kernels; sizes for males as c) minimum convex polygons and ?6 d) 95% adaptive kernels. Range, median, and number of individuals are shown for each sample.

size during drought years showed an inverse relation to precipitation, as one might expect based on the habitat-productivity hypothesis. During drought years, no reproduction occurred; thus, energy demands were similar among years: female ground squirrels had to obtain sufficient food to prepare for hibernation. Home ranges in 1990 (the 2nd of 2 consecutive drought years and the year with lowest precipitation during the study) were larger than those of 1994 and 1996, the 2 years of moderate drought. The size of home ranges during drought years thus fits the pattern predicted by the habitat-productivity hypothesis: a larger home range is required to meet energy needs. A few individuals during the extreme drought year 1990 were observed making movements >200 m from nocturnal burrow locations to daily foraging areas, suggesting that they had located patches of habitat with higher food availability. Also, some individuals entered hibernation earlier in 1994 and 1996 than any of those that hibernated in 1990, suggesting that higher food availability allowed animals to prepare for hibernation at an earlier date. The contraction of home range during the years of moderate drought, in combination with the lack of reproduction, may represent a strategy of reducing energy expenditures and entering dormancy as soon as possible, a strategy also employed by other desert vertebrates (Duda et al. 1999).

Comparison of home ranges between years of moderate drought and years of higher precipitation was not possible because of a lack of independent samples. However, relatively large home ranges were observed among 3 adult females in 1995 and 4 in 1997, years of the highest precipitation and resource availability. Reproduction occurred in both of these years, which would significantly increase the energy required by reproductive females for gestation and lactation. Energy demands for lactation in ground squirrels and other small mammals may equal or exceed the mother's own metabolic requirements (Michener 1998; Michener and McLean 1996; Millar 1978; Rickart 1982). The increase in home-range size of females from the mating season to the postmating season in 1997 suggests that the increased energy demand is associated with costs of producing a litter rather than with potential costs of mating. We hypothesize that these costs associated with reproduction should result in larger home ranges, even though habitat productivity is relatively high.

Although females exhibited considerable variation in home-range size, those that were followed for >1 year showed a high degree of site fidelity. Overlap between years was considerable, and we observed no cases of nonoverlap between any 2 home ranges, even for the 2 females that were followed for 4 years.

Behavior of males during the mating season was strikingly different from that of females. Home ranges of males in the mating season were very large, several times larger than the largest female home ranges. Large home ranges in the mating season were associated with long-distance movements. Movements within 1 day were sometimes such that a male could have traversed home ranges of several females. The proportion of

movements >200 m was much greater for males in the mating than in the postmating season, and females rarely made such movements. Although long-distance movements declined in the postmating season, males continued occasionally to make such movements early in the postmating period, resulting in large home ranges.

Increase in home-range size of males during the mating season has been reported for at least 6 other ground squirrel species (Dobson 1984). This behavior occurs in ground squirrels with territorial defense polygyny, such as *S. richardsonii* (Michener 1979, 1983) or *S. columbianus* (Murie and Harris 1978), and those with nondefense polygyny, such as *S. tereticaudus* (Dunford 1977) or *S. tridecemlineatus* (Schwagmeyer 1988). Nondefense polygyny, or scramble competition, may be favored when female density is so low that the cost of traveling between females is prohibitive or when population density is so high that the cost of defense is prohibitive (Dobson 1984). The former situation appears to apply for Mohave ground squirrels, in which female home ranges may be separated by distances >100 m and males cover large areas, making territorial defense impossible. Interactions between males or evidence of wounding by other ground squirrels were not observed during our study, an observation perhaps related to the relative scarcity of males compared to females (sex ratio of 0.27:1.0, males to females). Other anecdotal evidence supports the model of scramble competition for mates. On 1 occasion, we captured 3 different scrotal males at the burrow of a hibernating female on 3 consecutive trapping periods early in the mating season. None of these males were observed again on the study area. They may have been investigating the female's hibernation site in an attempt to mate immediately after she emerged. Male mating success is associated with mobility in *S. tridecemlineatus* (Schwagmeyer 1988), and the high degree of mobility observed in *S. mohavensis* may be associated with mate-searching behavior.

Altering size of the home range appears to be 1 mechanism by which this small herbivore adapts to an arid, variable environment. Size of female home ranges in years of no reproduction appears to vary in response to food availability. Females show a high degree of site fidelity and occupy home ranges that may be separated from one another by distances exceeding the diameter of a typical home range. Extensive male movements may be an appropriate strategy for mate searching in populations with patchy distribution and low density.

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LONG-DISTANCE MOVEMENTS OF JUVENILE MOHAVE GROUND SQUIRRELS, *SPERMOPHILUS MOHAVENSIS*

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ABSTRACT—We studied movements of 36 juvenile Mohave ground squirrels (*Spermophilus mohavensis*) during their first active season, until immergence into hibernation, a period that lasted from late May to late August. For all radiocollared individuals, the mean greatest distance between any 2 locations was 1,520 m for males (range 110 to 6,230 m) and 505 m for females (range 105 to 3,862 m). Eleven individuals (6 females, 5 males) with known litter affiliations were followed from their initial capture until inactive underground: males moved a mean distance of 2,920 m (range 0 to 6,230 m), and females moved a mean distance of 753 m (range 0 to 3,862 m) between their natal area and hibernation site. Ten individuals (8 males, 2 females) moved distances >1 km. Individuals making long-distance movements were likely to have traversed habitat that would be considered marginal for adult Mohave ground squirrels. Long-distance movement by juveniles might be critical for connecting local populations and recolonizing sites after local, drought-related extirpation.

RESUMEN—Estudiamos los desplazamientos de 36 jóvenes de la ardilla de tierra de Mohave (*Spermophilus mohavensis*) durante su primera temporada activa hasta que comenzaron la invernada, o sea durante el periodo de finales de mayo a finales de agosto. Para todos los individuos con radiotransmisores al cuello, la mayor distancia media entre cualquiera de dos lugares fue de 1,520 m para los machos (rango 110 a 6,230 m) y de 505 m para las hembras (rango 105 a 3,862 m). Once individuos (6 hembras y 5 machos) con conocidas afiliaciones de camada fueron seguidos desde su captura inicial hasta su inactividad subterránea: los machos se desplazaron una distancia media de 2,920 m (rango 0 a 6,230 m) y las hembras una distancia de 753 m (rango 0 a 3,862 m) entre su área natal y el sitio de la invernada. Diez sujetos (8 machos, 2 hembras) se desplazaron una distancia de >1 km. Los individuos que se desplazaron una larga distancia probablemente cruzaron hábitat que se consideraría subóptimo para los adultos de la ardilla de tierra de Mohave. Los desplazamientos de distancia larga de las ardillas jóvenes pueden ser decisivos para conectar las poblaciones locales y para volver a colonizar los sitios después de la extinción local debido a la sequía.

Movement capabilities of a species influence landscape-scale patterns of habitat use and genetic structure of populations (Dobson, 1994; Price et al., 1994; Diffendorfer et al., 1995; Peacock, 1997). Movement patterns might help to identify possible travel corridors between populations. Movements of different age and sex classes of mammals are often quite different (Gaines and McClenaghan, 1980; Greenwood, 1980; Holekamp, 1984*a,* 1986). For example, in ground squirrels, movements during the mating season (Dobson, 1984; Schwagmeyer, 1988) and natal dispersal (Dobson, 1982; Holekamp, 1984*a,* 1984*b*; Wiggett and Boag, 1989*b*; Waterman, 1992; Olson and Van Horne, 1998; Byrom and Krebs, 1999) are usually sex-biased, with males making more extensive movements. We studied the movements of juvenile Mohave ground squirrels (*Spermophilus mohavensis*) during the time of year when dispersal or other exploratory movements would be likely to occur: between emergence from the natal burrow and entry into first hibernation (Holekamp, 1984*a*).

The Mohave ground squirrel is a small (adult post-hibernation mass of 100 to 150 g), herbivorous rodent found in desert-scrub habitats of the western Mojave Desert (Best, 1995).

The active season for adults usually extends from February through July, with the rest of the year spent in dormancy (Bartholomew and Hudson, 1960). The single annual mating season occurs immediately after emergence from hibernation in February and early March. Young are usually born in late March and early April, and lactation can continue through mid May. Litters generally first appear above ground from late April to mid May. The species is frequently described as uncommon and having a patchy distribution (Burt, 1936; Zembal and Gall, 1980), and it is listed as threatened under the California Endangered Species Act. Within the geographic range of the species, patchy distribution might be related to landscape factors, such as the basin-and-range topography of the western Mojave Desert, soil type, shrub size and density, and plant community composition. Particular shrub species that are patchily distributed can be an important part of the diet (Best, 1995). Mohave ground squirrels would be expected to exhibit metapopulation dynamics in which local populations differ in productivity and persistence through drought periods. We observed drought-related local extirpation from 1989 to 1992 at one of our study sites. Despite extensive searching for suitable habitat and trapping at several locations near the site, no nearby populations were located. Recolonization occurred in 1993, following 2 consecutive years of higher rainfall and ground squirrel reproduction at other sites in the region. These events suggested that data on the dispersal movements of juvenile males and females might help to explain local distribution patterns.

There is no published information on movements in *S. mohavensis,* although dispersal has been studied in a number of other ground squirrels (Holekamp, 1984*a,* 1984*b*; Ortega, 1988; Wiggett and Boag, 1989*a*; Wiggett et al., 1989; Waterman, 1992; Olson and Van Horne, 1998; Byrom and Krebs, 1999). Hafner (1992) and Hafner and Yates (1983) hypothesized that low mobility might be one of several possible explanations for the persistence of a stable contact zone between *S. mohavensis* and *S. tereticaudus,* a closely related, allopatric species. As part of a study of habitat use and population dynamics in *S. mohavensis,* we studied the movements and home range of adult Mohave ground squirrels (Harris and Leitner, 2004). We found that adults rarely move distances >200 m during the postmating season, and that home-range sizes of adult females vary depending on rainfall and plant productivity. We also found that adult males move longer distances during the mating season than the postmating season, whereas female movements are similar in the mating and postmating seasons. In this paper, we present the results of radiotelemetry observations of movements by juvenile Mohave ground squirrels during their first summer.

METHODS—*Study Site*—We conducted our study in the Coso Range, a desert mountain range about 20 km east of the Sierra Nevada in the northwestern Mojave Desert, Inyo County, California (36°04′N, 117°48′W). Elevation of the study site was 1,400 to 1,500 m, and slopes ranged from 2 to 15%. Alluvial soils at the study site were loamy, coarse sands. The vegetation was a mixed desert-scrub community including spiny hopsage (*Grayia spinosa*), fourwing saltbush (*Atriplex canescens*), shadscale (*A. confertifolia*), cheesebush (*Hymenoclea salsola*), Cooper's boxthorn (*Lycium cooperi*), and winterfat (*Krascheninnikovia lanata*). This community is typical of the transition between Mojave and Great Basin desert biomes (Beatley, 1975). The rugged uplands between alluvial basins were rocky or gravelly, with a sparse cover of shrubs, often including California buckwheat (*Eriogonum fasciculatum*) and needle-leaved rabbitbrush (*Chrysothamnus teretifolius*). Mean annual precipitation (1949 through 1999) was 163 mm at Haiwee Power Plant (elevation 1,160 m), 15 km to the northwest of the study site. Winter rainfall predominated, with 79% of annual precipitation received between 1 October and 31 March over the 51-y period of record.

Studies took place on a 47-ha site located in an alluvial basin southeast of Cactus Peak. A 22-ha portion of the site, with trap stations placed at 50-m intervals in an 8 by 15 array, was used exclusively for radiotelemetry studies in 1990 and from 1994 through 1997 (Harris and Leitner, 2004). Juvenile Mohave ground squirrels were radiocollared on this portion of the study site in 1995. A 25-ha portion of the site, with trap stations at 25-m spacing in a 21 by 21 array, was used for demographic studies from 1988 through 1996. We radiocollared juvenile Mohave ground squirrels on this portion of the study site during 1997. Radiocollared animals freely used both portions of the study area.

Capture Procedures—Ground squirrels were captured with Pymatuning (10 by 11 by 39 cm) or Sherman (8 by 9 by 30 cm) traps baited with a commercial horse feed and placed under shrubs at each trap

station. Traps were set in early morning, checked at mid-day and late afternoon, and then closed for the night. All captured ground squirrels were weighed, and their sex, age, and reproductive condition recorded. Adults could be distinguished from juveniles by body mass and pelage. Adult females were examined for evidence of pregnancy or lactation to facilitate the location of litters. We marked ground squirrels for permanent identification with passive integrated transponder (PIT) tags implanted subcutaneously between the scapulae with a 12-gauge hypodermic needle (Schooley et al., 1993). Additional traps were used as needed to capture particular previously collared animals to obtain information about the condition of animals and body mass, collect fecal samples, or capture juvenile ground squirrels at their natal burrows.

Radiotelemetry Procedures—We radiocollared 13 juvenile Mohave ground squirrels in 1995 (9 females, 4 males) and 23 juveniles in 1997 (12 females, 11 males). These 2 years of successful reproduction were separated by a drought year in which there was no evidence of pregnancy and no juveniles were observed. Juvenile ground squirrels generally began to appear near their natal burrows in mid May. We equipped juveniles with PIT tags at the first capture and with radiocollars when they reached a body mass of about 80 g. All captured juveniles that met this weight criterion were equipped with radiocollars. This weight criterion was adopted in part to ensure that the radiocollar could accommodate any size increase due to growth. The dates on which juveniles were radiocollared differed between the 2 years of study (7 to 9 June in 1995 and 19 May to 3 June 1997) due to differences in birth dates of juveniles between the 2 years. Radiotelemetry continued until mid August, when most surviving juveniles had entered hibernation.

We equipped juvenile Mohave ground squirrels with 5-g transmitters (Model SM1, AVM Instrument Co., Livermore, California) with flexible collars fitting around the neck of the animal. The fit of collars was such as to allow some space for growth. We attempted to recapture radiocollared juveniles to obtain body mass data and to examine the fit of collars. Radiocollared Mohave ground squirrels were located using portable receivers (Model LA-12, AVM Instrument Co.) and hand-held two-element Yagi antennas (Telonics, Inc., Mesa, Arizona). On 16 July and 9 August 1997, we used an aircraft provided by the California Department of Fish and Game to locate juveniles that had made long-distance movements. Animals detected from the air were later located on the ground. Ground locations were determined by following radio signals until a squirrel was either seen or localized in a burrow within 5 m by signal strength and direction. On the study site, each location was recorded by measuring compass bearing and distance of the animal from the nearest trap station. Locations off the study site were determined using a Garmin Model 12XL GPS receiver (Garmin International, Inc., Olathe, Kansas). Distances between locations, or between distant locations and the point of origin of an animal on the study site, were calculated using the program CALHOME (Kie et al., 1996). We attempted to locate each juvenile Mohave ground squirrel twice per day during its diurnal active period: once in the morning and once in the afternoon.

A ground squirrel was judged to be hibernating if it was located by radiotelemetry in the same burrow on 3 or more consecutive days. To confirm that it was inactive, several baited traps were placed in the immediate vicinity of the burrow. Because this method was generally quite effective in capturing nonhibernating, radiocollared Mohave ground squirrels, lack of capture success was considered to be another indication that the animal had entered hibernation. On each subsequent radiotelemetry session, all dormant animals were checked to determine that there had been no movement. This method cannot exclude the possibility that an animal had died underground, though in no case did the individuals judged to have entered hibernation seem to be in poor condition prior to the observed inactivity. During the following spring, we attempted to recapture those individuals for which hibernation sites were known so we could remove radiocollars, but were able to recover only 2 animals in this manner. Because this time period exceeded the battery life of radiotransmitters, it was difficult to relocate animals that had moved away from the study grid.

We recovered some radiocollars with evidence suggesting that the radiocollared individuals had been taken by an avian or mammalian predator. These indications included some combination of blood or tooth marks on the collar or discovery of the collar at a potential raptor or raven perch site. We considered these individuals to have been probable victims of predation, in contrast to those cases in which a signal could no longer be detected, which we categorized as disappearance. These individuals either moved out of detection range or had radios that failed.

Measures of Movement—We determined the distance between natal area and hibernation site for those individuals that survived to hibernation and were associated with a known litter. We established litter associations by observing and capturing juveniles at natal burrows or by patterns of association between individuals. In 1995, we were able to observe juveniles in the first few days after emergence from natal burrows. Most of the radiocollared juveniles in 1995 were captured while still active in a small area surrounding the natal burrow. Individuals were often in close association with siblings and their

TABLE 1—Distances (m) moved and fates of juvenile Mohave ground squirrels (*Spermophilus mohavensis*) in California during 1995 and 1997. The litter affiliation and fate of each animal is shown, if known. Dispersal distance is the distance between natal area and hibernation site. Maximum distance is the maximum distance between any 2 locations for each animal.

Animal	Sex	Year	Litter	Dispersal distance	Maximum distance	Fate
F152	F	1997	5		198	Died
F030	F	1995	1		213	Disappeared
F346	F	1995	1		304	Disappeared
F988	F	1995	2		175	Disappeared
F264	F	1997	5		130	Disappeared
M156	M	1995	1		110	Disappeared
M607	M	1995	3		662	Disappeared
M145	M	1997	6		110	Disappeared
M274	M	1997	4		1,778	Disappeared
F115	F	1995	2	75	118	Hibernation
F740	F	1995	1	380	513	Hibernation
F878	F	1995	3	100	218	Hibernation
F898	F	1995			195	Hibernation
F951	F	1995			263	Hibernation
F066	F	1997	7	3,862	3,862	Hibernation
F101	F	1997	6	0	158	Hibernation
F203	F	1997			188	Hibernation
F294	F	1997	4	100	382	Hibernation
M780	M	1995	3	1,400	1,455	Hibernation
M165	M	1997	7	4,548	4,548	Hibernation
M172	M	1997	7	6,230	6,230	Hibernation
M184	M	1997	6	390	655	Hibernation
M192	M	1997	7	2,031	2,031	Hibernation
M333	M	1997			1,664	Hibernation
F760	F	1995	2		111	Predation
F092	F	1997	5		295	Predation
F123	F	1997			625	Predation
F254	F	1997	6		105	Predation
F285	F	1997	4		168	Predation
F304	F	1997	4		1,913	Predation
F343	F	1997	6		478	Predation
M180	M	1995	1		358	Predation
M025	M	1997			165	Predation
M113	M	1997	7		1,937	Predation
M222	M	1997			90	Predation
M308	M	1997	4		1,256	Predation

mother. Eleven of 13 juveniles could be associated with 1 of 3 litters. In contrast, because emergence from the natal burrow occurred earlier in 1997, we did not observe juveniles in the first few days of emergence. Nevertheless, patterns of association of individuals during daily activity, and common occupancy of nocturnal burrows, allowed us to associate 18 of 23 radiocollared juveniles with 1 of 4 different litters.

In addition to determining the distance between natal area and hibernation site, we also determined the greatest distance between any 2 locations for each individual. This distance simply gives an indication of the maximum movement potential of an individual. Differences in movement measures between males and females were tested using a *t*-test on log-transformed movement data.

RESULTS—*Fates of Individuals*—Litter affiliations were established for 29 juveniles. Eleven of these were determined to have entered hibernation at the end of their first active season (Table 1). Nine of the other 18 that had known

litter affiliations probably were taken by predators, 8 disappeared and were never relocated, and 1 was found dead in a Joshua tree (*Yucca brevifolia*). Some of these individuals made long-distance movements prior to disappearance or predation. Seven individuals did not have a clear litter affiliation; 4 of these entered hibernation and 3 were probably taken by predators, in some cases after long-distance movements.

Distance from Natal Area to Hibernation Site—For those 11 animals that had both a known litter affiliation and hibernation site, the mean distance from natal area to hibernation site (Table 1) was 1,738 m (range 0 to 6,230 m). The mean distance for males was 2,920 m (range 390 to 6,230 m, $n = 5$), and the mean distance for females was 753 m (range 0 to 3,862 m, $n = 6$, $t = 2.29$, $df = 9$, $P < 0.05$). Five individuals moved distances greater than 1 km (4 of 5 males, 1 of 6 females). With the single exception of an individual that moved 3,862 m, distances from natal area to hibernation site for females were <500 m. Three females were the only individuals with known litter affiliations that hibernated and never moved >200 m between consecutive locations.

Maximum Distances Moved—The mean maximum distance between any 2 locations (Table 1) was 1,520 m for males (range 110 to 6,230 m) and 505 m for females (range 105 to 3,862 m, $t = 2.58$, $P = 0.01$, $df = 34$). In 4 cases, the maximum distance was the same as the distance from natal area to hibernation site. For 13 individuals, the greatest distance between consecutive locations was the only such movement >200 m; 8 individuals had multiple movements >200 m. In some cases, these movements occurred during multiple round-trips between the natal area and a remote location. Eight of 15 males moved distances >1 km, whereas 2 of 21 females made such movements ($\chi^2 = 8.37$, $df = 1$, $P < 0.05$).

Relationship of Long-distance Movements to Topography—With a single exception, juveniles that moved >1 km moved out of the alluvial basin in which the study area was located. In all cases, the most direct pathway would have required passing over rocky terrain with less shrub cover than the study area. Two individuals that moved in a westerly direction from the study site crossed dirt roads to reach their final known locations. Four individuals that moved in a northerly direction from the study site were found near the edge of an extensive, barren playa. Three of these animals seemed to have stopped when they reached the playa, while the fourth seemed to have moved northeastward along the edge of the playa for several hundred meters to reach its final known location.

Discussion—We found that juvenile Mohave ground squirrels can move relatively long-distances during their first summer, prior to hibernation. Ten individuals made movements >1 km (range 1,000 to 6,230 m). These distances are straight-line distances from point of origin on the study site to the last known location. Twenty-one individuals had maximum movement distances >200 m (11 of 15 males, 10 of 21 females). Such movements are relatively uncommon in adults, with the exception of males during the mating season (Harris and Leitner, 2004).

In all but one case, individuals that moved >1 km simply disappeared from the study site on a particular day and were found later at a distant location. Therefore, they had moved out of radio reception range (approximately 400 to 500 m) within one day. Thus, these individuals reached their final known locations without evidence of exploratory movements to these locations. A few other juveniles made regular daily movements of several hundred meters but returned to their natal areas at night, but exploratory behavior was not observed in all juveniles. It is possible that short exploratory movements might have been made between the times that individuals were located on a given day. Sudden dispersal movements within a period of 1 to 2 days have also been noted for *S. columbianus* (Wiggett et al., 1989) and *S. parryii* (Byrom and Krebs, 1999). This behavior contrasts with the gradual increase of home range followed by a fissioning of new and old home range described for *S. beldingi* (Holekamp, 1984*a*).

Natal dispersal in Mohave ground squirrels seems to be male-biased, as it is in most other ground squirrel species (Dobson, 1982; Holekamp, 1984*a*, 1984*b*; Wiggett and Boag, 1989; Waterman, 1992; Olson and Van Horne, 1998; Byrom and Krebs, 1999). Both the maximum distance between any 2 locations, and the distance from natal area to hibernation site were

significantly greater for males than females. Eight of the 10 individuals that made movements >1 km were males.

Long-distance natal dispersal has been recorded in several other species of ground squirrels. A maximum natal dispersal distance of 9.6 km has been documented for *S. richardsonii* (Quanstrom, 1971), a distance of 8.5 km was reported for an individual of *S. columbianus* (Wigget and Boag, 1989), and a distance of 3.9 km was reported for an individual of *S. variegatus* (Ortega, 1988). Dispersal distances >1 km also have been reported for *S. beldingi* (Holekamp, 1984*b*) and *S. townsendii* (Olson and Van Horne, 1998). However, Holekamp (1984*a*) found that dispersal distances in most ground squirrels were <1 km, and that no ground squirrel species that had been studied to date had a mean dispersal distance >0.55 km. A later study of *S. columbianus* (Wigget and Boag, 1989; Wigget et al., 1989) found that individuals dispersing among a set of fragmented colonies had mean dispersal distances of 2.0 km for males and 1.8 km for females. Olson and Van Horne (1998) reported a mean dispersal distance for *S. townsendii* of 515 m, with a maximum dispersal distance of 1,076 m. Byrom and Krebs (1999) reported mean dispersal distances for *S. parryii* of 120 m for females and 515 m for males. Although our sample of individuals from known litters that made long-distance movements during their first summer was small, the distances moved, combined with the long-distance movements of several other individuals, suggest that Mohave ground squirrels might have a greater dispersal distance than most other ground squirrel species.

Our results suggest that many, if not most, juvenile Mohave ground squirrels disperse in their first summer. We cannot rule out the possibility that some of the individuals that remained in or near their natal area might have made significant movements during their second summer. Dispersal in the first summer is prevalent in ground squirrels (Holekamp, 1984*a*), although yearling dispersal is found in *S. columbianus* (Festa-Bianchet and King, 1984; Wiggett and Boag, 1989; Waterman, 1992). Several other species, including *S. beldingi* (Holekamp, 1984*b*), *S. elegans* (Pfeifer, 1982), *S. richardsonii* (Michener and Michener, 1977), and *S. tridecemlineatus* (Rongstad, 1965; McCarley, 1966), exhibit some yearling dispersal, though most individuals disperse in their first summer. Among those species that disperse in their first summer, most make dispersal movements between 4 and 12 weeks after emergence from the natal burrow (Holekamp, 1984*a*). We were able to determine a dispersal date for 3 individuals in 1995 (8 through 10 June) and 10 in 1997 (25 May through 1 June). These observations suggest that juvenile Mohave ground squirrels disperse during the early portion of the 4-week to 12-week post-emergence interval observed for other species.

Juveniles that moved long-distances were likely to have traveled through habitats considered marginal for permanent occupancy (Fig. 1). For example, all juveniles that moved >1 km probably traveled through habitat with rocky or gravelly soils, and over elevation changes of several hundred meters. However, several juveniles did not cross a barren playa that they encountered in their movements. A reasonable conclusion from these observations is that large unvegetated areas might constitute barriers to dispersal, but that rough terrain and rocky soils might be traversed if some shrub cover is available. This behavior seems to be in contrast to that of many rodent species, which tend to remain in habitat suitable for adults while dispersing (Holekamp, 1984*b*; Garrett and Franklin, 1988; Wiggett and Boag, 1989). Despite having traveled long-distances, those individuals that moved >1 km did not seem to sustain a higher predation rate: 3 of 10 (30%) individuals making such movements were preyed upon, whereas 9 of 26 (34.6%) individuals that did not make such movements were preyed upon. This observation seems to contradict the common assumption that dispersers suffer a higher rate of predation (Gaines and McClenaghan, 1980), although data from other ground squirrel species are equivocal. Byrom and Krebs (1999) reported a maximum survival rate of 40% for dispersing *S. parryii*. They also found that risk of mortality for *S. parryii* was higher with greater dispersal distance and that males had higher mortality rates than females. However, Olson and Van Horne (1998) found no difference in mortality rate between dispersing and philopatric individuals for *S. townsendii,* and Wiggett et al. (1989) concluded that risk of predation was not high for dispersing *S. columbianus,* though they did not directly contrast mortality rates of

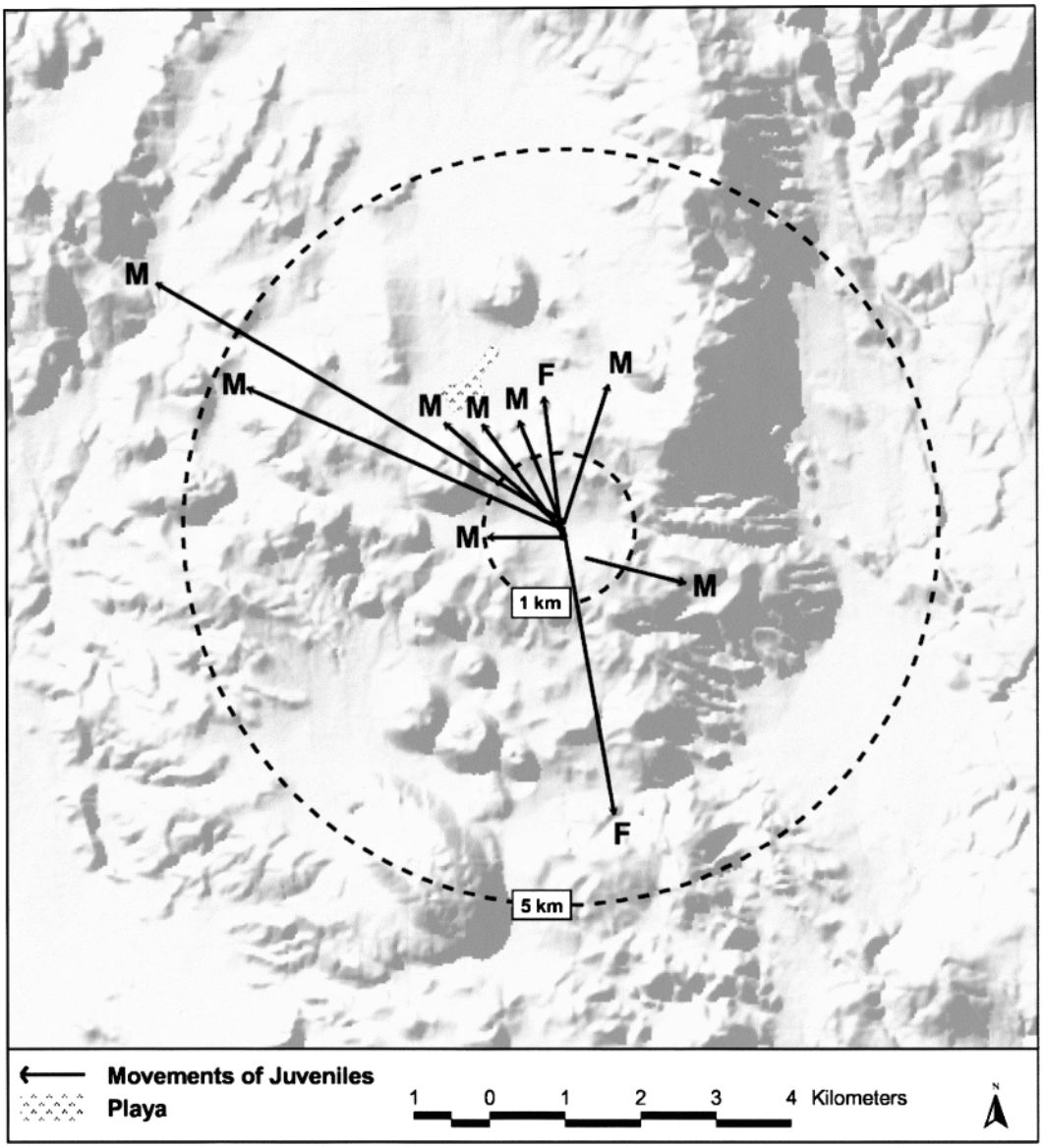

FIG. 1—Long-distance movements (>1 km) of juvenile Mohave ground squirrels (*Spermophilus mohavensis*) in relation to topography. The sex of the individual is shown at the terminus of each arrow. A radius of 1 km is shown from the center of the trapping grid in which the ground squirrels were captured and equipped with radio transmitters.

dispersers with non-dispersing individuals. Nunes and Holekamp (1996) concluded that juvenile *S. beldingii* disperse after reaching a threshold body mass and that this behavior might delay dispersal until the animal is better prepared for the demands of dispersal, including avoiding predation. In addition, the apparently short period of time during which individuals made long-distance movements might have reduced predation rate (Harrison, 1992).

Our observations of movements by juvenile Mohave ground squirrels suggested that this species is relatively mobile compared to other ground squirrel species, particularly those in

grasslands or mesic habitats (Holekamp, 1984*a*). Bowman et al. (2002) suggested that home range might be a better predictor of dispersal distance than body size. The Mohave ground squirrel seems to be consistent with this hypothesis, as its home range might be larger than those of ground squirrels of similar size. Postmating home ranges of females ranged from a median of 0.29 to 1.90 ha among 5 years of study (Harris and Leitner, 2004). Dispersal distance in mammals generally is less than 5 home range diameters (Harrison, 1992). Mohave ground squirrels would seem to have unusually long dispersal movements by this standard as well.

Although long-distance movements were male-biased, the small proportion of females that make such movements could have great significance for recolonization of sites that had suffered local extinction. The ability of juveniles to travel long-distances is a potential mechanism for achieving gene flow between local populations. Such movements could connect populations that are separated by habitat that is not suitable for permanent occupancy. The recolonization of sites after local, drought-related extirpation can be explained readily by juvenile movements from sites with populations that have persisted through drought. Long-distance movements by juveniles might have adaptive value to this patchily distributed, uncommon species.

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MOHAVE GROUND SQUIRREL SURVEY, 1972 1/

by

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ABSTRACT

A search of literature revealed a scarcity of knowledge concerning the Mohave ground squirrel (Citellus mohavensis). Based on knowledge gained from museums and interviews and contact with the few informed scientists, areas of known species occurrence were live trapped. Eight localities sampled resulted in the trapping and/or sighting of 33 Mohave ground squirrels in 4 locations. Further search of the Mohave Desert was discontinued because of lack of information regarding sites historically occupied by this rare mammal.

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George Bartholomew

The Mohave ground squirrel is distinguished from the Antelope ground squirrel by its larger size, uniform-grizzled grayish brown back and lack of white stripe on each side. The round-tailed ground squirrel resembles the Mohave ground squirrel but has a round uniformly colored tail and does not normally hold its tail over its back.

INTRODUCTION

In addition to its value as an endemic California species, the Mohave ground squirrel (Citellus mohavensis) is of interest to scientists for several reasons. It has one of the most restricted distributions of any species of ground squirrels. A satisfactory explanation of this fact is still lacking, but is of interest to zoogeographers and population ecologists alike. Its strategy for survival in a severe environment and in the face of competition with one of the most successful species of ground squirrels, the antelope ground squirrel (Ammospermophilus leucurus) has been partially elucidated, but is of potential further interest to ecologists, physiologists and behaviorists. As a member of a vast complex of variously related species of ground squirrels, the Mohave ground squirrel is of potential interest to scientists studying physiological and haemotological correlates of evolution and hibernation, and to population ecologists. Numerous local investigators have recently noticed an increasing scarcity of this species in areas where, previously, it has been moderately easy to trap. Accordingly, on May 21, 1971, the California Fish and Game Commission officially designated the Mohave ground squirrel a rare species.

DESCRIPTION

The Mohave ground squirrel is somewhat larger than the antelope ground squirrel and shorter, but heavier, than the round-tailed ground squirrel (Cittelus tereticaudus). These are the two species with which it is most likely to be confused. The Mohave ground squirrel averages 224 mm. total length as opposed to 247 mm. for the round-tailed ground squirrel and 213 mm. for the antelope ground squirrel (Howell, 1938). Adults captured in the course of this study averaged 140 grams; but one individual weighing 198 grams was captured, and under artificial conditions weights of nearly 300 grams have been reported (Pengelley and Kelley, 1966). Antelope ground squirrels are reported to average 104 grams (Hall and Kelson, 1959), and the round-tailed ground squirrel is reported to average 120 grams (Hudson, 1964). The Mohave ground squirrel is colored a uniformly-grizzled grayish brown above and a soiled white below. When clearly seen, it is easily distinguished from the antelope ground squirrel which has a white stripe on each side of its body. The round-tailed ground squirrel is uniformly brown colored, much like the Mohave ground squirrel. Both the antelope and Mohave ground squirrels have short, flat tails which are brown above and whitish below. The tail of the round-tailed ground squirrel is longer, round, and uniformly colored. Both the antelope and Mohave ground squirrels usually hold their tails up over their backs, thereby displaying the white ventral side, while the round-tailed ground squirrel normally does not do so. The antelope ground squirrel is said to flick its tail nervously back and forth much more frequently than the Mohave ground squirrel.

SCOPE OF STUDY

The present study was undertaken to: (1) Determine the distribution and abundance of the Mohave ground squirrel; and (2) Evaluate its current status and factors threatening its survival.

RESULTS

Library Search

A complete literature search was conducted using the Zoological Record and Science Citation Index. The following 10 articles comprise the entire scientific literature on Citellus mohavensis:

Adest, Gary. 1972. Intraspecific and interspecific behavior of Ammospermophilus leucurus and Citellus mohavensis. Masters Thesis, California State College at Los Angeles. (Mohave ground squirrels exhibit greater Interspecific and Intraspecific Agression.)

Bartholomew, G.A. and Hudson, J.W. 1960. Aestivation in the Mohave ground squirrel Citellus mohavensis. Bull. Mus. Comp. Zool. 124:193. (The Physiology of hypothermia.)

Bartholomew, G.A. and Hudson, J.W. 1961. Desert ground squirrels. Sci. Am. 205:107 (Summary of role of thermoregulation and behavior in reducing competition between Mohave ground squirrel and antelope ground squirrel.)

Burt, W.H. 1936. Notes on the habits of the Mohave ground squirrel. J. Mammalogy 17:221. (Only published observations of behavior under natural conditions. Based on 2-3 animals.)

Grinnell, J. and Dixon, J. 1918. Natural history of the ground squirrels of California. Monthly Bull. of the State Commission of Horticulture 7:667. (An early description of distribution and taxonomy.)

Howell, A.H. 1938. A revision of the ground squirrels of North America. North American Fauna #56:30. (Taxonomic characteristics and relationships.)

Merriam, C.H. 1889. Description of a new spermophile from Southern California. North American Fauna 2:15. (Original description of species.)

Pengelley, E.T. 1966. Differential developmental patterns and their adaptive value in various species of the genus Citellus. Growth 30:137-142. (Reproductive information; length of gestation, time and size of litter, growth rate.)

Pengelley, E.T. 1969. Influence of light on hibernation in the Mohave ground squirrel (Citellus mohavensis). In Physiological Systems in Semi-Arid Environments, Ed. C.C. Hoff and M.L. Riedesel. Univ. of New Mexico Press. (Investigation of a theory relating to endogenous rhythms.)

Pengelley, E.T. and Kelley, K.H. 1966. A "Circannian" rhythm in hibernating specie of the genus Citellus with observations on their physiological evolution. Comp. Biochem. Physiol. 19:603. (Demonstration of endogenous annual rhythms of torpor and weight.)

Museum Survey

Fifteen American museums with the largest mammal collections were surveyed for specimens of the Mohave ground squirrel. Fifty-five specimens were reported from

collections. None of the curators knew of any other collections which might contain additional specimens of this species. The data collected is summarized in Table 1:

TABLE 1

Mohave Ground Squirrel Collections

Museum	Specimen No.	Locality Collected
D.R. Dickey Collection	18,645	Palmdale
University of California	18,646	
Los Angeles	18,661	
	18,669	
Los Angeles County Museum	---	Palmdale
	---	Walker Pass-East Side
	---	Ridgecrest - 6 Mi. West
Museum of Vertebrate Zoology	31,515	Oro Grande
University of California	99,826	Kramer Jct. - 2 Mi. West
Berkeley	81,813	Barstow - 15 Mi. West
	125,679	Palmdale - 18 Mi. East
	31,158	Palmdale - 2 Mi. North
	31,160	Palmdale - 2 Mi. North
	31,960	Palmdale - 1 Mi. North
	44,285	Lovejoy Spr. - 1 Mi. North
	31,967	Lancaster - 2 Mi. S & 1/2 Mi. E.
	28,674	Little Lake
	28,675	Little Lake
University of Michigan	77,651	Palmdale - 2 Mi. North
San Diego Natural History Museum	402	Mohave Desert
	403	Rabbit Spr.
	404	Mohave R.
	9,381	Trona - 10 Mi. North
	9,516	Freeman
	9,629	Palmdale - 1 Mi. East
	9,623	Palmdale - 2 Mi. East
	9,624	Palmdale - 2 Mi. East
	9,708-9,710	Palmdale - 2 Mi. East
	9,726	Palmdale - 2 Mi. East
U. S. National Museum	28,740	Haiwee Meadows
	135,838	Mohave Desert
	192,752	Mohave Desert
	192,753	Mohave Desert
	15,974	Mohave River
	15,975	Mohave River
	192,754-192,756	Rabbit Spr.
	186,469	Rabbit Spr.
	---	Victorville
	28,741-28,747	Salt Wells Valley

TABLE 1 (Continued)

Museum	Specimen No.	Locality Collected
University of Kansas	63,589	Victorville - 15 Mi.
American Museum of Natural History	1,177-1,181 13,844	Mohave River Sears Cattle Ranch, K

Scientists and Trappers

The following scientists and trappers were interviewed to discover localities where the animals have been trapped in recent years:

George A. Bartholomew
Department of Biology
University of California
Los Angeles, California 90024

Eric T. Pengelley
Department of Zoology
University of California
Riverside, California

Richard E. MacMillen
Department of Population and Environmental Biology
University of California
Irvine, California 92644

William Wertz
Department of Zoology
Pomona College
Claremont, California 91711

Bruce Kenyon
3177 Tapa Canyon
Simi Valley, California

Carl Tegan
38639 33rd Street
Palmdale, California

All localities suggested by these individuals were trapped in the course of the study.

Trapping

Eight different localities were visited within the area of distribution reported in Hall and Kelson (1959). An average of 100 Serman Live Traps were set for two days at each location. A combination of peanut butter, shredded coconut, and coconut extract appeared to be the most effective bait; but, one animal was trapped using

bird seed, and other workers have been successful using bird seed, bacon, or oranges. Mohave ground squirrels were trapped at four locations. At two locations sightings of several animals augmented the trapping record, but at the other locations only three animals were trapped and no others were sighted. The trapping record is summarized below:

Location	Number Trapped	Number Sighted (Approx.)
Shadow Mountains	1	0
Boron County Dump	2	0
China Lake	5	5-10
Keel's Ranch	1	10-15

(The exact locations and trapping records are detailed in the appendix.) At two of the four localities where no animals were trapped, populations were known to have existed in the past but to have declined in recent years. Populations at these localities may no longer exist.

Preferred Habitat

A conscious effort was made to evaluate the habitat at each trapping location in order to gain more specific information about the animals' habitat preference. All animals were located within or immediately adjacent to Creosote Scrub. With the exception of areas immediately associated with dry lake beds, this plant community is nearly ubiquitous in the Mohave Desert; but, it shows considerable variability in its composition and density. The localities where the Mohave ground squirrels were trapped represented the same range in composition and density of the Creosote Scrub Community as the Western Mohave Desert as a whole. It is not possible, therefore, to specify any distinctive habitat requirements other than the moderately variable Creosote Scrub.

Distribution and Abundance

Due to the extreme difficulty encountered in trapping the animals, it is not possible at this time to make any exact or quantitative statements about the animal's present distribution or abundance. However, a few qualitative generalizations can be made.

Adest's study of aggressive behavior indicates that the animals may be found at low densities due to intense intraspecific aggression and not declining population levels. Maintenance of low population densities may be part of the animal's strategy of optimal resource utilization.

While the significance of negative evidence is doubly questionable, due to the difficulty in trapping animals in an area where several have been sighted, it still appears that the population is very discontinuously distributed. One possible explanation of this might be that the species may be in the final stages of extinction due to competition with the closely related, more abundant, antelope ground squirrel. Such a natural occurrence would probably be happening

on such a long-time scale that it would be hard to detect. The effect of human disturbances would also be hard to determine and make the interpretation of any data more difficult.

An alternate hypothesis might be that the animal has an, as yet undetermined, stringent habitat requirement which is only discontinuously satisfied in the Mohave Desert. No direct evidence for this is presently available, but it remains a possibility.

It is not possible at this time to decide whether the species is truly endangered. Two of the known extant populations are in the immediate vicinity of human habitation. The population at China Lake is probably quite secure due to the Navy's protection of its land. The animals associated with alfalfa fields were seen to make frequent trips to the fields. They seem to be dependent on the fields and could be easily exterminated by the State Rodent Control Program. The population at Boron may be fairly secure if it occupies very much of the Edwards Air Force Base, Rocket Test Site. Both of the populations which have apparently recently gone extinct were in the southern end of the Mohave Desert. This appears to be the area of the Mohave Desert which is being most extensively developed, and this may mean the eventual loss of much favorable habitat.

RECOMMENDATIONS

1. The Mohave ground squirrel be retained on the rare species list.

2. A program be established whereby information is actively sought from people working in the Mohave Desert. This be done by providing field workers as well as local zoology departments with a survey form requesting that they report Mohave ground squirrel sightings to the Department of Fish and Game.

3. Studies be initiated immediately to more closely identify those areas reported to be populated by the Mohave ground squirrel and how these can best be preserved.

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Pengelley, E. T. and Kelley, K. H. 1966. A "Circannian" rhythm in hibernating species of the genus Citellus with observations on their physiological evolution. Comp. Biochem. Physiol. 19:603.

APPENDIX

TRAPPING RECORD

Locality: Shadow Mountains, San Bernardino County. Three and one-half miles west of U. S. Highway 395, the Shadow Mountain Road is intersected by a small dirt road which runs to the south. Traps were set in a broad wash which crossed this road about 0.8 miles south of the Shadow Mountain Road.

Description: One animal was caught at the edge of the wash. Only a few plants of the Creosote Scrub Community were present and they were fairly stunted and widely spaced. Plants present in the desert immediately adjacent to the wash included: Creosote Bush, Joshua Tree, Atriplex canescens, Hymenoclea salsola. No plants grew in the bed of the wash, but several cacti and Atriplex canescens were on the edge of the wash and on small islands in the middle of the wash.

Date: March 29, 1972

Trap Days: 200

Results: 1 trapped, 0 sighted

Observations: When released, the animal entered a burrow under a Creosote bush.

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Locality: Boron County Dump, San Bernardino County. A dirt road extends into the desert south of the dump. Traps were set all around the perimeter of the dump. Two animals were caught south of the dump and east of the road, in an area currently being used for dirt and large debris.

Description: There was very little, if any, organic matter in the dump, so it probably does not represent an artificially augmented food source.

The desert appeared very productive. All of the major components of the Creosote Scrub Community were present and at least six different species of annuals were in bloom. The perennials were large, fairly closely spaced and very healthy in appearance.

Date: May 21, 1972

Trap Days: 80

Results: 2 trapped, 0 sighted

Observations: Burrows appeared to be located at the bases of Creosote bushes. One knowledgeable individual contacted in the area stated that the Mohave ground squirrels frequently climb the Joshua Trees.

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Location: China Lake, Naval Weapons Center, San Bernardino County. Traps were set running east of the dirt road on the eastern side of the golf-course, about 0.15 miles from its intersection with Knox Road. Traps were also set running North of the road at the northwest corner of the Stables. Information and permission to trap were provided by Mrs. Tilly C. Barling, Public Works Department, Code 70026, China Lake, California 93555, phone number (714) 939-2349.

Description: The desert was moderately productive with abundant, fairly large Creosote and a limited number of the other plants of the Creosote Scrub Community. No annuals were in bloom.

Date: June 14 and 15, 1972

Trap Days: 200

Results: 5 trapped, 10 sighted

Observations: One animal was observed sitting upright and motionless with its back to the sun for 45 minutes one morning. The air was cool, the sun quite warm, and a slight breeze was blowing. The back of the animal appeared darker than normal, and the animal may have been "basking."

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Location: Keels Ranch, Palmdale, California, Los Angeles County. Traps were set on the south and west sides of an alfalfa field located south of Avenue P and about 1 mile east of the road to El Mirage Soaring School. They were also set along another dirt road, about 1/4 mile east of the first field. This road bordered the land of a factory run by Anadite Inc.

Description: The Creosote Scrub Plant Community was moderately productive but the animals were closely associated with the alfalfa fields and probably were deriving their food from the fields, and not the desert.

Date: June 25, 1972

Trap Days: 80

Results: 1 trapped, 15 sighted

Observations: Numerous animals were noted running back and forth between the alfalfa fields, and their burrows on the desert side of the dirt road.

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Localities Where Populations Apparently No Longer Exist

Bob's Gap: 165th Street, Palmdale, California. George A. Bartholomew reported that a significant population existed in about 1960, just above and just below the place where 165th Street passed through Bob's Gap. On February 12th and 13th, 240 trap days yielded no Mohave ground squirrels.

Lovejoy Butte: E. T. Pengelley reported that a significant population had existed around the southern edge of Lovejoy Butte in the mid 1960's, but that recent attempts to trap in the same locality had been unsuccessful. On February 19th and 20th, 240 trap days yielded no Mohave ground squirrels.

EXHIBIT 651

CNPS Botanical Survey Guidelines

CALIFORNIA NATIVE PLANT SOCIETY
December 9, 1983
Revised June 2, 2001

The following recommendations are intended to help those who prepare and review environmental documents determine when a botanical survey is needed, who should be considered qualified to conduct such surveys, how surveys should be conducted, and what information should be contained in the survey report. The California Native Plant Society recommends that lead agencies not accept the results of surveys unless they are conducted and reported according to these guidelines.

1. Botanical surveys are conducted in order to determine the environmental effects of proposed projects on all botanical resources, including special status plants (rare, threatened, and endangered plants) and plant (vegetation) communities. Special status plants are not limited to those that have been listed by state and federal agencies but include any plants that, based on all available data, can be shown to be rare, threatened, or endangered under the following definitions:

   > A species, subspecies, or variety of plant is “endangered” when the prospects of its survival and reproduction are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, over-exploitation, predation, competition, or disease. A plant is "threatened" when it is likely to become endangered in the foreseeable future in the absence of protection measures. A plant is "rare" when, although not presently threatened with extinction, the species, subspecies, or variety is found in such small numbers throughout its range that it may be endangered if its environment worsens.[1]

   Rare plant (vegetation) communities are those communities that are of highly limited distribution. These communities may or may not contain special status plants. The most current version of the California Natural Diversity Database's *List of California Terrestrial Natural Communities*[2] should be used as a guide to the names and status of communities.

   Consistent with the California Native Plant Society’s goal of preserving plant biodiversity on a regional and local scale, and with California Environmental Quality Act environmental impact assessment criteria[3], surveys should also assess impacts to locally significant plants. Both plants and plant communities can be considered significant if their local occurrence is on the outer limits of known distribution, a range extension, a rediscovery, or rare or uncommon in a local context (such as within a county or region). Lead agencies should address impacts to these locally unique botanical resources regardless of their status elsewhere in the state.

2. Botanical surveys must be conducted to determine if, or to the extent that, special status or locally significant plants and plant communities will be affected by a proposed project when any natural vegetation occurs on the site and the project has the potential for direct or indirect effects on vegetation.

3. Those conducting botanical surveys must possess the following qualifications:
   a. Experience conducting floristic field surveys;
   b. Knowledge of plant taxonomy and plant community ecology and classification;
   c. Familiarity with the plants of the area, including special status and locally significant plants;

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[1] California Environmental Quality Act Guidelines, §15065 and §15380.
[2] List of California Terrestrial Natural Communities. California Department of Fish and Game Natural Diversity Database. Sacramento, CA.
[3] California Environmental Quality Act Guidelines, Appendix G (Initial Study Environmental Checklist).

d. Familiarity with the appropriate state and federal statutes related to plants and plant collecting; and,
e. Experience with analyzing impacts of a project on native plants and communities.

4. Botanical surveys should be conducted in a manner that will locate any special status or locally significant plants or plant communities that may be present. Specifically, botanical surveys should be:

   a. Conducted in the field at the proper times of year when special status and locally significant plants are both evident and identifiable. When special status plants are known to occur in the type(s) of habitat present in the project area, nearby accessible occurrences of the plants (reference sites) should be observed to determine that the plants are identifiable at the time of survey.

   b. Floristic in nature. A floristic survey requires that every plant observed be identified to species, subspecies, or variety as applicable. In order to properly characterize the site, a complete list of plants observed on the site shall be included in every botanical survey report. In addition, a sufficient number of visits spaced throughout the growing season is necessary to prepare an accurate inventory of all plants that exist on the site. The number of visits and the timing between visits must be determined by geographic location, the plant communities present, and the weather patterns of the year(s) in which the surveys are conducted.

   c. Conducted in a manner that is consistent with conservation ethics and accepted plant collection and documentation techniques[4,5]. Collections (voucher specimens) of special status and locally significant plants should be made, unless such actions would jeopardize the continued existence of the population. A single sheet should be collected and deposited at a recognized public herbarium for future reference. All collections shall be made in accordance with applicable state and federal permit requirements. Photography may be used to document plant identification only when the population cannot withstand collection of voucher specimens.

   d. Conducted using systematic field techniques in all habitats of the site to ensure a thorough coverage of potential impact areas. All habitats within the project site must be surveyed thoroughly in order to properly inventory and document the plants present. The level of effort required per given area and habitat is dependent upon the vegetation and its overall diversity and structural complexity.

   e. Well documented. When a special status plant (or rare plant community) is located, a California Native Species (or Community) Field Survey Form or equivalent written form, accompanied by a copy of the appropriate portion of a 7.5-minute topographic map with the occurrence mapped, shall be completed, included within the survey report, and separately submitted to the California Natural Diversity Database. Population boundaries should be mapped as accurately as possible. The number of individuals in each population should be counted or estimated, as appropriate.

5. Complete reports of botanical surveys shall be included with all environmental assessment documents, including Negative Declarations and Mitigated Negative Declarations, Timber Harvesting Plans, Environmental Impact Reports, and Environmental Impact Statements. Survey reports shall contain the following information:

   a. <u>Project location and description</u>**,** including:

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[4] Collecting Guidelines and Documentation Techniques. California Native Plant Society Policy (adopted March 4, 1995).

[5] Ferren, W.R., Jr., D.L. Magney, and T.A. Sholars. 1995. The Future of California Floristics and Systematics: Collecting Guidelines and Documentation Techniques. *Madroño* 42(2):197-210.

1) A detailed map of the location and footprint of the proposed project.
2) A detailed description of the proposed project, including one-time activities and ongoing activities that may affect botanical resources.
3) A description of the general biological setting of the project area.

b. Methods, including:
1) Survey methods for each of the habitats present, and rationale for the methods used.
2) Description of reference site(s) visited and phenological development of the target special status plants, with an assessment of any conditions differing from the project site that may affect their identification.
3) Dates of surveys and rationale for timing and intervals; names of personnel conducting the surveys; and total hours spent in the field for each surveyor on each date.
4) Location of deposited voucher specimens and herbaria visited.

c. Results, including:
1) A description and map of the vegetation communities on the project site. The current standard for vegetation classification, *A Manual of California Vegetation*[6], should be used as a basis for the habitat descriptions and the vegetation map. If another vegetation classification system is used, the report must reference the system and provide the reason for its use.
2) A description of the phenology of each of the plant communities at the time of each survey date.
3) A list of all plants observed on the project site using accepted scientific nomenclature, along with any special status designation. The reference(s) used for scientific nomenclature shall be cited.
4) Written description and detailed map(s) showing the location of each special status or locally significant plant found, the size of each population, and method used to estimate or census the population.
5) Copies of all California Native Species Field Survey Forms or Natural Community Field Survey Forms and accompanying maps.

d. Discussion**,** including:
1) Any factors that may have affected the results of the surveys (*e.g*., drought, human disturbance, recent fire).
2) Discussion of any special local or range-wide significance of any plant population or community on the site.
3) An assessment of potential impacts. This shall include a map showing the distribution of special status and locally significant plants and communities on the site in relation to the proposed activities. Direct, indirect, and cumulative impacts to the plants and communities shall be discussed.
4) Recommended measures to avoid and/or minimize direct, indirect, and cumulative impacts.

e. References cited and persons contacted.

f. Qualifications of field personnel including any special experience with the habitats and special status plants present on the site.

[6] Sawyer, J.O. and T. Keeler-Wolf. 1995. *A Manual of California Vegetation*. California Native Plant Society. Sacramento, CA. 471 pp.

EXHIBIT 652

CURRENT STATUS OF THE MOHAVE GROUND SQUIRREL

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ABSTRACT: The Mohave ground squirrel (*Spermophilus mohavensis*) is found only in the western Mojave Desert of California. Although it is listed as Threatened by the State of California, there is little published information regarding its current distribution and status. I have assembled a comprehensive database covering unpublished field studies, surveys, and incidental observations conducted over the 10-year period from 1998-2007. This database contains records of 1140 trapping sessions, only 102 of which were successful in capturing ≥1 Mohave ground squirrels. In addition, there are 96 incidental observations in which the species was detected. An analysis of these 198 positive records identifies 4 core areas that continue to support relatively abundant Mohave ground squirrel populations and 4 other areas in which there are multiple recent records of the species. Although the southern portion of the range has been most intensively sampled, the only recent occurrences there are from a single core population on Edwards Air Force Base plus an additional 4 detections from Victor Valley. There are extensive areas within the geographic range where the status of the species is unknown, especially on the China Lake Naval Air Weapons Station and Fort Irwin. I present recommendations for surveys in areas where no recent studies have been carried out. I also identify potential corridors between known populations and recommend studies to determine if these connections are actually occupied by the species. Finally, I indicate conservation measures needed to ensure that known populations and corridors are adequately protected from habitat loss and degradation.

TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 44:11-29

Key words: Mohave ground squirrel, *Spermophilus mohavensis*, California, Mojave Desert, threatened species, core populations, corridors, conservation

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The Mohave ground squirrel (*Spermophilus mohavensis*) is found only in the western Mojave Desert of California (Best 1995). Its historic range (Figure 1) totaled about 20,000 km^2 (Gustafson 1993). It has been found from the area of Palmdale and Victorville in the south to Owens Lake in the north. The eastern escarpment of the Sierra Nevada forms much of the western boundary of its range, while in the east its distribution extends to the Mojave River Valley and to the Fort Irwin military reservation. This region has experienced rapid growth over the past few decades. Urban development in the Antelope Valley, Indian Wells Valley, and along the Mojave River from Victorville to Barstow has resulted in a human population in excess of 700,000. Three large military bases conduct extensive training and testing operations. Much of the western Mojave Desert is used for motorized outdoor recreation, mining, and livestock grazing. There is an expanding transportation infrastructure, including highways, railroads, airports, pipelines, and electric transmission lines. Recent government policies have stimulated great interest in siting renewable energy facilities in this region, especially wind farms and solar installations.

Because of these multiple development pressures, there has been significant and on-going loss of wildlife habitat in the western Mojave Desert as well as widespread habitat degradation and fragmentation. There has been concern about the conservation status of the Mohave ground squirrel since 1971, when it was first listed as Rare under the California Endangered Species Act (CESA). After the reauthorization of CESA in 1984, the species was classified as Threatened. Its subsequent regulatory history has been highly controversial. In 1993, the California Fish and Game Commission acted to remove it from the list of threatened species, a decision that was set aside in 1997 following judicial review. A petition to list the Mohave ground squirrel under the federal Endangered Species Act (ESA) was rejected by the US Fish and Wildlife Service in 1995. The US Fish and Wildlife Service is currently (2008) reviewing a new petition to list the species as endangered under the ESA.

In 2006, the US Bureau of Land Management (BLM) approved the West Mojave Plan, which was designed to conserve a number of sensitive species throughout the western Mojave Desert, with special emphasis on the desert tortoise (*Gopherus agassizii*) and Mohave ground squirrel (Bureau of Land Management 2006). The alternative version of the plan as adopted established a Mohave Ground Squirrel Conservation Area consisting of 6,988 km^2 of public lands managed by the BLM. (Fig. 1) These conservation measures do not apply to private and military lands within the historic range of the species.

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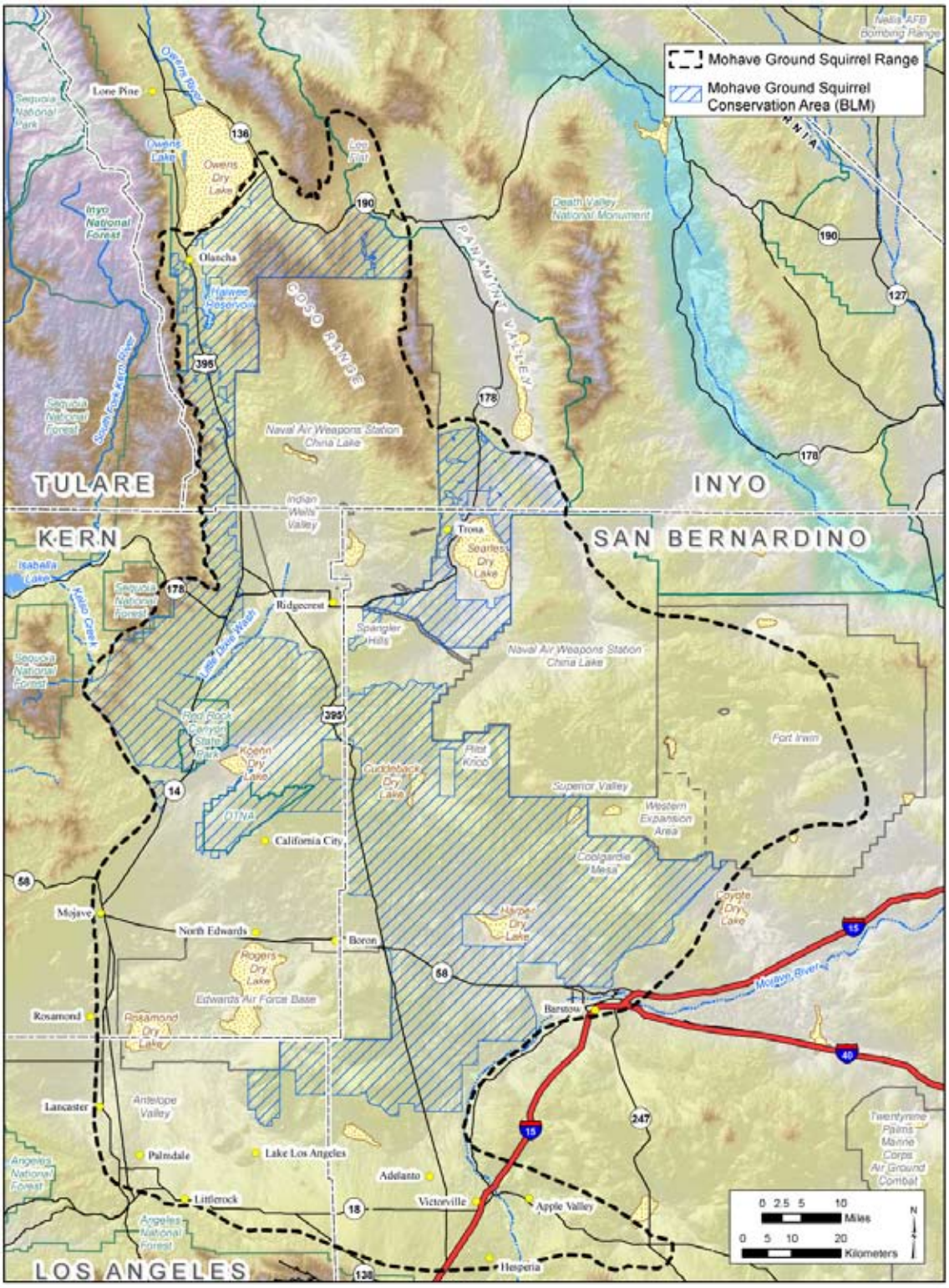

Figure 1. The historic range of the Mohave ground squirrel in the western Mojave Desert of California, with important place names indicated. The Mohave Ground Squirrel Conservation Area is shown as established in the West Mojave Plan (U.S. Bureau of Land Management (2005).

Although the Mohave ground squirrel has been designated as a state-listed species since 1971 and has been the focus of a major conservation planning effort by the BLM, there is still little published information on its distribution, abundance, and population trends. Brooks and Matchett (2002) reviewed 19 reported studies of the species, covering the period from 1918 to 2001. Only 2 of these studies were published in scientific journals. Since this review by Brooks and Matchett, a great deal of new information has become available, most of it unpublished. Two radiotelemetry studies describing home range dynamics and juvenile dispersal were recently published in peer-reviewed journals (Harris and Leitner 2004, 2005). Several state and federal agencies, as well as private conservation groups, have sponsored field research designed to determine the status of the species in particular areas. In addition, the California Department of Fish and Game (CDFG) requires trapping surveys at proposed development sites according to a prescribed protocol (CDGF 2003).

This paper brings together the data from unpublished field studies and surveys conducted during the 10-year period from 1998-2007. I have obtained reports for all sponsored research surveys and have received information on protocol trapping surveys from many consulting biologists. The information presented here includes both positive records documenting Mohave ground squirrel occurrence and negative results from trapping surveys in which the species was not detected. The objectives of this review are to:

1. Document the geographic distribution of Mohave ground squirrel occurrences,
2. Summarize the distribution and relative intensity of survey efforts,
3. Identify important areas and corridors for conservation based on available occurrence data, and
4. Recommend areas where additional survey effort is needed.

METHODS

I utilized 4 sources of information regarding the distribution and occurrence of the Mohave ground squirrel during the period 1998-2007: the California Natural Diversity Database, regional field studies, protocol trapping at proposed development sites, and incidental observations as reported by field biologists.

The California Natural Diversity Database (CNDDB) is a state-wide inventory of the status and locations of rare species and natural communities. The CDFG produces and regularly updates this computerized catalog, which contains records of occurrence submitted by state and federal agencies, consulting firms, and individual biologists. It contains positive records of occurrence only and generally does not include data documenting the absence of a species from a particular locality.

The CNDDB contained a total of 293 occurrence records for the Mohave ground squirrel as of August 4, 2007 (CNDDB 2007). Twenty-eight new occurrences were submitted during the period from 1998-2007 and there were also 2 new records at previously known locations for the species. These records were obtained from regional field studies, protocol trapping, and incidental observations. I incorporated these 30 records into the data base used in this analysis.

A number of regional field studies have been conducted during the past 10 years, many of them funded by public agencies and private conservation groups. I have reviewed 19 unpublished reports that describe the results of such trapping surveys and have also obtained data from several biologists whose surveys have not been documented in formal reports (Appendix A).

The third source of data was trapping surveys carried out at proposed development sites, as required by the CDFG (CDFG 2003). The CDFG guidelines specify that surveys be conducted on proposed project sites that support desert scrub vegetation and are within or adjacent to the Mohave ground squirrel geographic range. The surveys must be carried out by a qualified biologist operating under authority of a Memorandum of Understanding (MOU) with CDFG. The protocol mandates an initial visual survey of the project site. If no Mohave ground squirrel is detected visually, live-trapping is required for up to 3 sessions of 5 consecutive days each. The trapping sessions must be conducted during the periods March 15-April 30, May 1-31, and June 15-July 15. Trapping grids normally consist of 100 traps arranged in a 4x25 array (linear projects) or in a 10x10 array (other projects).

If a Mohave ground squirrel is detected on the site, the project proponent must apply to CDFG for an Incidental Take Permit and provide compensation, usually in the form of mitigation lands. If no Mohave ground squirrel is observed or captured, it is not necessarily evidence that the site is unoccupied or is not potential habitat. Nonetheless, CDFG will stipulate for a period of 1 year that the project site harbors no Mohave ground squirrels. Most protocol surveys carried out in recent years have not resulted in detection of the species.

In order to obtain the results of protocol trapping surveys for the period 1998-2007, I contacted all biologists who were known to possess an MOU authorizing take of Mohave ground squirrels. The great majority responded by providing their survey data, including dates of trapping sessions, coordinates of grid centers, number of trap-days of sampling effort, and

whether or not Mohave ground squirrels were detected. Although I have not obtained data for all protocol trapping efforts, I have collected a total of 943 records that represent 426,615 trap-days of sampling. I estimate that I obtained records for >95% of the total protocol trapping effort for the period 1998-2007.

I have classified as incidental observations all reports by biologists who observed or captured Mohave ground squirrels incidental to other field studies. This category includes visual and auditory detections, captures made while trapping for other species, and highway mortalities.

For regional and protocol surveys, a record is defined as a single trapping session, usually consisting of 5 successive days. Records from trapping surveys can be negative, with no Mohave ground squirrel captures, or positive, indicating a session with at least 1 capture. On the other hand, records from incidental observations were always positive, indicating the detection of at least 1 Mohave ground squirrel at a specific location. Table 1 lists the number of records obtained for this review from regional surveys, protocol trapping, and incidental observations. The regional and protocol trapping surveys provided a total of 1,038 negative records, as compared to only 102 trapping sessions in which at least 1 Mohave ground squirrel was captured. Although the regional studies involved only 21.6% of the total trapping effort, they accounted for 69.6% of the positive records. On the other hand, the protocol surveys made up 78.4% of trapping effort, but contributed only 30.4% of Mohave ground squirrel detections.

Table 1. A summary of the data sources used for this review. For regional and protocol surveys, a record is defined as a single trapping session (usually 5 days) at a specific grid location. If no Mohave ground squirrels were detected, such records were considered negative, while a positive record was a trapping session in which >1 Mohave ground squirrels were captured. For incidental observations, all records are positive. Each record indicates the detection of >1 Mohave ground squirrels at a particular location. The sampling effort for regional and protocol surveys is calculated as the number of traps operated per day times the number of days per trapping session summed over all trapping sessions.

Type of Data	Total	Positive Records	Trap-days
Regional Surveys	197	71	111,710
Protocol Surveys	943	31	426,615
Incidental Observations	96	96	N/A
Totals	1,236	198	538,325

I entered data from all sources into an Excel spreadsheet and then imported that into an Access database. This permitted data to be manipulated and extracted through the query process. A series of base maps covering the geographic range of the Mohave ground squirrel was developed using Geographic Information System (GIS) techniques. All records, both positive and negative, were plotted on these digital maps for visual analysis. In this way, the distribution of Mohave ground squirrel occurrences for the last 10 years could be visualized in relation to the distribution of sampling effort.

RESULTS

General Distribution of Mohave Ground Squirrel Records

The geographic distribution of both positive and negative Mohave ground squirrel records over the period 1998-2007 is shown in Figure 2. There has been no attempt at either systematic or random range-wide sampling and the records tend to be concentrated in certain well-defined regions. The great majority of trapping effort has been conducted in the southern part of the geographic range, south of State Route 58. In spite of this very intensive sampling, Mohave ground squirrels have been detected in only 2 areas south of State Route 58, one on Edwards Air Force Base and the other in the vicinity of Victorville. The northern part of the geographic range is in Inyo County, where almost all trapping has been conducted in the Coso region on China Lake Naval Air Weapons Stations (China Lake NAWS) and in the vicinity of Olancha and Haiwee Reservoir. Outside of these 2 areas, there have been only 5 widely scattered detections in the entire northern part of the range over the past 10 years. In the central part of the range, from Ridgecrest south to State Route 58, most positive records have been concentrated in 6 distinct regions. Trapping in the vicinity of Ridgecrest has resulted in the capture of a number of Mohave ground squirrels and there are abundant records for the extensive valley (Little Dixie Wash) between Inyokern and Red Rock Canyon State Park. To the south, there is a cluster of detections associated with the Desert Tortoise Natural Area (DTNA) and another in the Pilot Knob region east of Cuddeback Dry Lake. There are many records from the broad plateau that lies north of Barstow (Coolgardie Mesa and Superior Valley) and there are also several detections in the area just north of Boron.

It is clear that there are extensive areas within the range of the Mohave ground squirrel that have not been

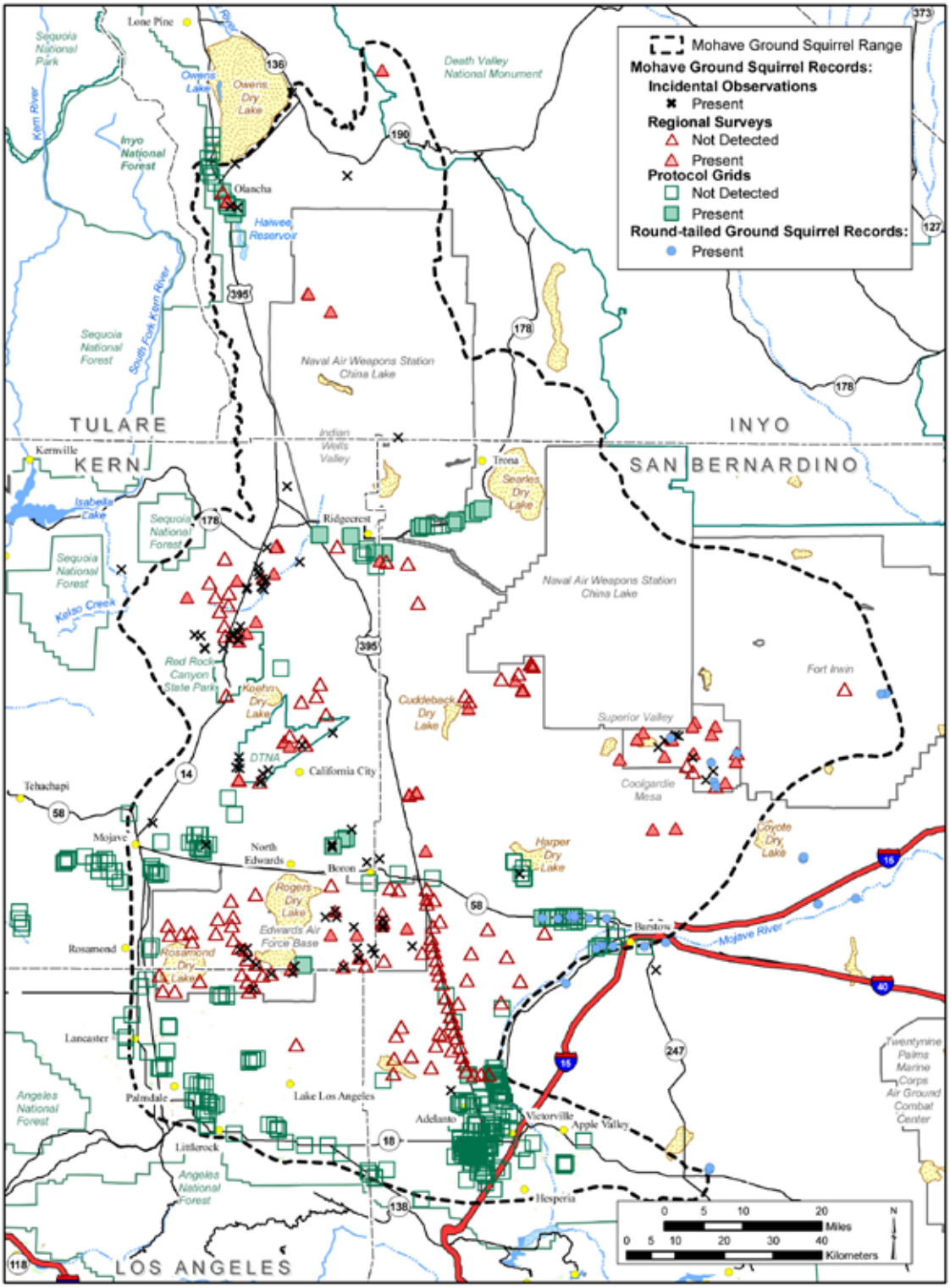

Figure 2. The geographic distribution of all Mohave ground squirrel records for the period 1998-2007. A total of 1,236 records are plotted, which include 1,140 trapping sessions conducted for regional and protocol surveys and 96 incidental observations. Solid triangles and squares represent locations of trapping grids at which >1 Mohave ground squirrels were captured. Crosses show sites of the 96 incidental observations at which >1 Mohave ground squirrels were detected.

effectively sampled. Figure 3 shows a 10x10 km sampling frame superimposed on the geographic range, with the sampling units color-coded to indicate the number of records (both positive and negative) for each unit during the period 1998-2007. It can be seen that sampling efforts have been heavily concentrated in the southern part of the range, especially to the west and north of Victorville, in the Palmdale-Lancaster area, around Barstow, and in the vicinity of the town of Mojave. Approximately 67% of all trapping efforts have been located in the region from State Route 58 south. The lack of recent data on Mohave ground squirrel occurrence in the northern part of the range is obvious, but there are also large gaps in our knowledge in the central part of the range. Except for the Coso area, there have been no surveys on either the north or south ranges of China Lake NAWS during the past 10 years. The Western Expansion Area of Fort Irwin has been well sampled using a randomized method of selecting trapping sites. However, only 1 trapping attempt has been recorded elsewhere on Fort Irwin over the period 1998-2007. In contrast, Edwards Air Force Base has sponsored extensive surveys on a randomized sampling basis, so that the distribution of the species is known there in great detail.

Regional Analysis of Mohave Ground Squirrel Records

In this section, I present detailed information on Mohave ground squirrel distribution and abundance during the period 1998-2007 for a number of regions within the geographic range. This regional analysis is supported by a series of 7 maps that are available as Supplemental Online Material at the website of The Western Section of The Wildlife Society: http://tws-west.org/transactions/TWSWS_Transactions_directory.htm

Inyo County.—Inyo County includes the northernmost region occupied by Mohave ground squirrels. Records are concentrated in the area between Olancha and Haiwee Reservoir and in the Coso Range, within the China Lake NAWS. The species has been detected at 5 protocol trapping grids to the south of Olancha, beginning in 2002. Mohave ground squirrel populations at 2 sites in the Coso Range have been monitored by regular spring trapping sessions. Animals have been captured on both grids at every trapping occasion. In 2007, a Mohave ground squirrel was captured at Lee Flat just inside the boundary of Death Valley National Park, which marks the northernmost record for the species. The other 4 records for Inyo County are incidental observations, including an individual that was stuck by a vehicle in northern Panamint Valley, several kilometers east of the generally-accepted limits of the range.

Ridgecrest Area.—Trapping has been conducted at 10 grids in the vicinity of Ridgecrest, with Mohave ground squirrels detected at 5 of these sites. In addition, protocol trapping at 10 grids along State Route 178 east of Ridgecrest in 2006 yielded captures at 6 locations. However, no Mohave ground squirrels were captured in 2002 at 2 sites in the Spangler Hills southeast of Ridgecrest.

Little Dixie Wash.—The Little Dixie Wash region is a broad valley extending from Inyokern southwest to Red Rock Canyon State Park. Two extensive trapping studies have detected Mohave ground squirrels throughout this region. In 2002, the species was captured at 6 of 7 grids widely scattered across this valley. There have been more than 20 incidental observations as well, suggesting that Mohave ground squirrels are widely distributed here. In 2007, a visual sighting established the first record to the west of the mountain crest in the Kelso Creek drainage.

Fremont Valley to Edwards Air Force Base.—The Fremont Valley extends northeast from the vicinity of Cantil toward Garlock and Johannesburg. No Mohave ground squirrels have been detected here during the past 10 years, despite trapping efforts at 6 grids. There are 13 positive records around the periphery of the DTNA and out a few kilometers to the east. No trapping has been carried out in the interior of the DTNA, but it is likely that Mohave ground squirrels are present there as well. Two incidental records exist for the area just to the north and east of the town of Mojave, but repeated protocol trapping efforts here have been unsuccessful. Finally, there are 10 trapping records and incidental observations in the area to the north of Boron and Kramer Junction. These records suggest a fairly widespread population across this region.

Wind Farm Area Southwest of Mojave.—Protocol trapping surveys have been conducted at 24 grids located on wind energy development sites southwest of the town of Mojave. Although this area is outside the generally-accepted boundaries of the geographic range, much of the habitat here seems suitable for the species. To date, no Mohave ground squirrels have been detected during these trapping efforts. Two recent visual observations are listed in the CNDDB, but confirmation through trapping is needed.

Edwards Air Force Base.—Edwards Air Force Base has been carrying out an extensive monitoring program to document the distribution of Mohave ground squirrels within the military reservation. From 2003 through 2007, trapping has been conducted at 40 randomly-located grids across the base, resulting in detection of the species at 6 of these sites. In combination with other trapping efforts and incidental observations, this program has clearly defined the area in which Mohave ground squirrel populations are present.

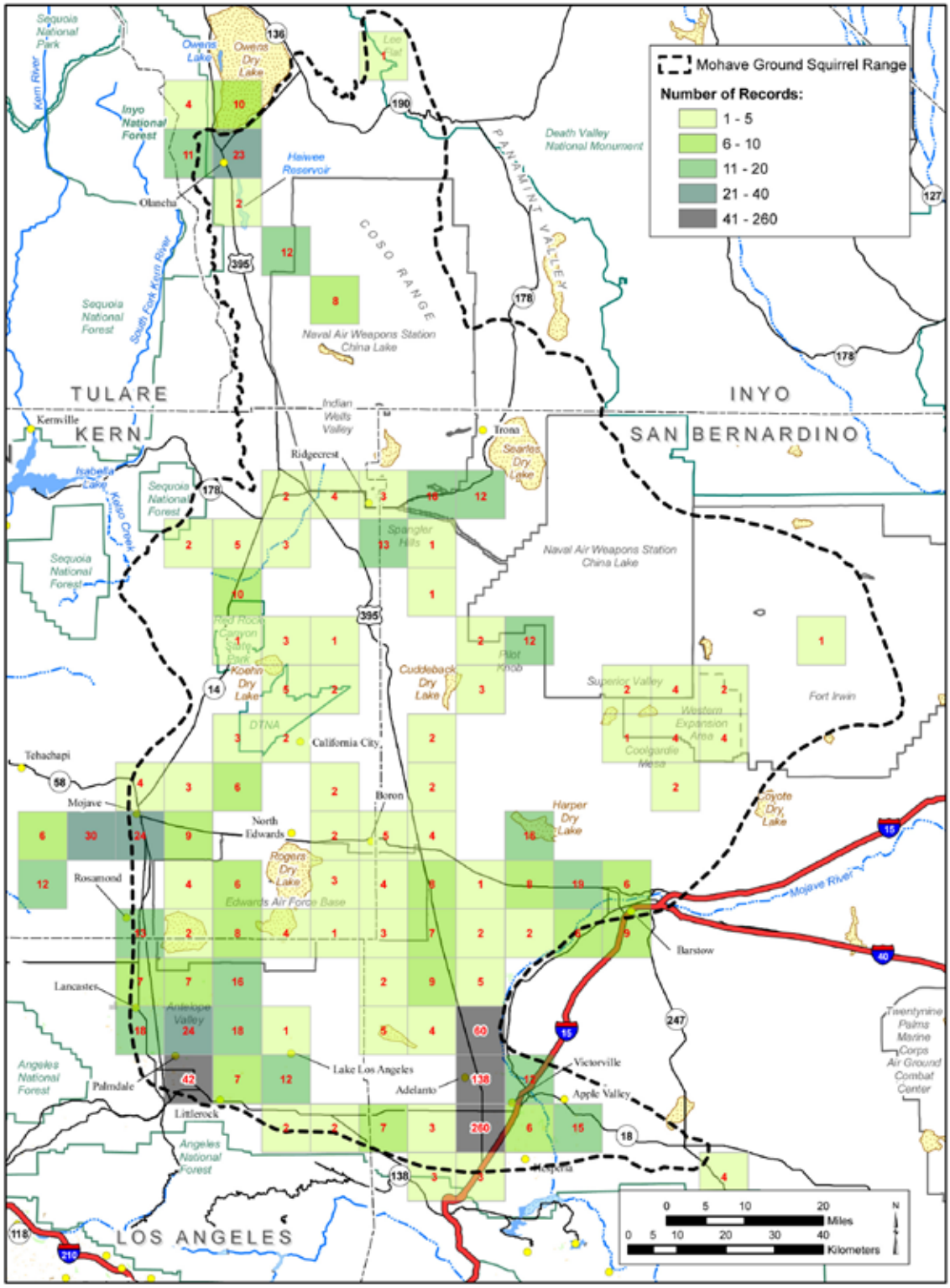

Figure 3. The distribution of sampling effort throughout the historic range of the Mohave ground squirrel for the period 1998-2007. A 10 x 10 kilometer sampling frame is set over the region and the total number of records (both positive and negative) are indicated for each 10 x 10 km block. These records are the trapping sessions conducted for regional and protocol surveys. Incidental observations are not plotted here.

Los Angeles County.—Protocol trapping has been conducted at 52 grid locations in the desert portion of Los Angeles County during the period 1998-2007, but no Mohave ground squirrels have been detected by this method. The only positive records in Los Angeles County have been 4 detections in a small area near Rogers Dry Lake on Edwards Air Force Base.

Victor Valley to Barstow.—Intensive protocol trapping has been conducted in the Adelanto area and on the western outskirts of Victorville, resulting in the capture of Mohave ground squirrels at 3 separate locations. The 2 trapping records north of Adelanto plus a visual sighting just to the west suggest the presence of a residual population in this area. Capture of a juvenile female well to the south near the intersection of US 395 and I-15 indicates that another population may exist here as well. There have been no records east of the Mojave River since 1955 but, as shown in Figure 2, this area has not been effectively sampled in the last 10 years. Three major trapping studies have been conducted from El Mirage Dry Lake north and east toward Barstow. There have been no detections of Mohave ground squirrels over this extensive area.

Barstow Area.—There were only 3 Mohave ground squirrel records in the Barstow area during the period 1998-2007. In 2005, a Mohave ground squirrel was observed about 6 km south of Barstow near the city landfill, in an area outside the generally-accepted range boundary. Two other occurrences were documented in 2007 to the west of Barstow. Mohave ground squirrels were detected at the edge of an alfalfa field near Harper Dry Lake and 1 was trapped about 10 km west of Hinkley near State Route 58.

Coolgardie Mesa and Superior Valley.—To the north of Barstow is a broad, gently-sloping plateau that extends from Coolgardie Mesa in the south to Superior Valley in the north. Three trapping studies have been conducted in this region over the past 10 years and all have documented Mohave ground squirrel occurrences. There have also been at least 7 incidental observations.

Pilot Knob Area.—Trapping studies in the Pilot Knob area, from Cuddeback Dry Lake east to the boundary of China Lake NAWS, have detected Mohave ground squirrels at 5 different sites.

Contact Zone with Round-tailed Ground Squirrel

The Mohave ground squirrel and the round-tailed ground squirrel (*Spermophilus tereticaudus*) are closely related (Hafner and Yates 1983). The 2 species are very similar in general appearance, the most obvious difference being the much longer tail of the round-tailed ground squirrel. The round-tailed ground squirrel is found throughout the eastern Mojave Desert of California and its geographic range adjoins that of the Mohave ground squirrel. The contact zone between the 2 species extends from Lucerne Valley along the Mojave River to Barstow and then northeast through Fort Irwin (Fig. 4). During the period 1998-2007, a total of 30 round-tailed ground squirrel occurrences have been recorded in this contact zone. Round-tailed ground squirrels are common in the area around Barstow, especially in disturbed habitats. The species has also been observed in Lucerne Valley, near Hodge on the Mojave River, near Coyote Dry Lake, and on the eastern side of Fort Irwin. In addition, round-tailed ground squirrels have been detected in 2 areas well within the historic range of the Mohave ground squirrel. There have been 5 reports from the Western Expansion Area of Fort Irwin, as much as 24 km inside the generally-accepted boundary of the Mohave ground squirrel range. The other area of interest is west of Barstow along State Route 58, where round-tailed ground squirrels were trapped at 8 sites in 2006 and 2007. Individuals of both species were captured on a grid about 20 km west of the range boundary. Lack of historical baseline data makes it impossible to determine if the round-tailed ground squirrel is actively extending its distribution at the expense of the Mohave ground squirrel.

DISCUSSION

General Distribution of Mohave Ground Squirrel Records

It is important to be clear about the significance of positive records that indicate Mohave ground squirrel presence during the past 10 years. These positive records are highly concentrated in just 8 distinct areas, in which 93.4% (185/198) of all Mohave ground squirrel occurrences have been documented (Fig. 5). It is of interest that there are at least some Mohave ground squirrel records prior to 1998 in each of these 8 areas, suggesting that recent trapping effort has focused on areas with historic records. However, much of the Mohave ground squirrel range has never been surveyed. This is especially true in Inyo County, which includes large areas where no surveys or protocol trapping have ever been carried out. The situation is similar, although not as extreme, in the central part of the range. There are 6 areas here where recent evidence indicates the presence of Mohave ground squirrel populations. However, little trapping has been conducted outside the areas that support these known populations. In the southern part of the range, south of State Route 58, there has been much greater trapping effort and the sampling has been much more widely distributed. Even here, there are still a few relatively restricted areas that have not been surveyed since 1998. In all 3 sections of the Mohave ground squirrel range, additional populations may well

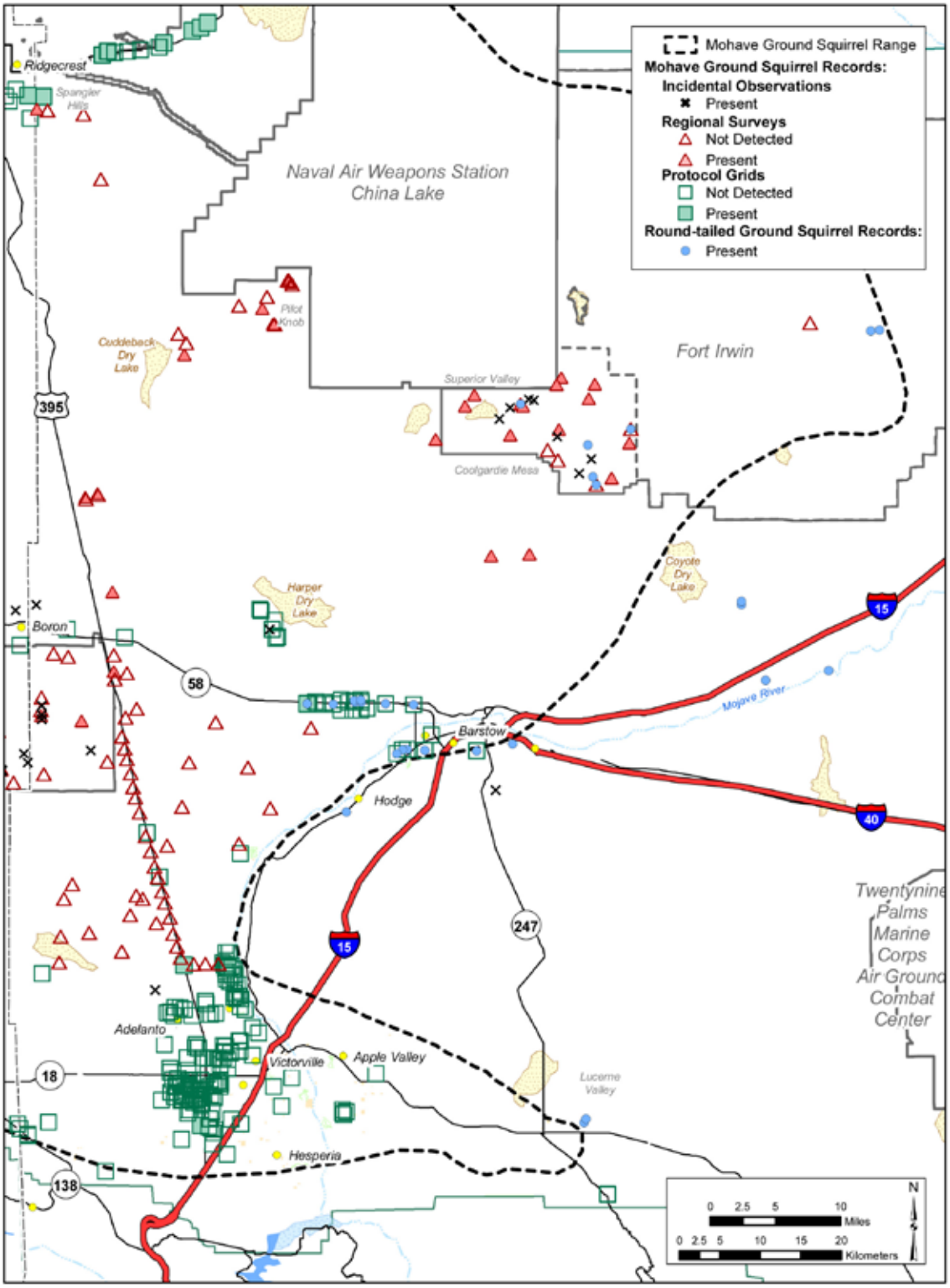

Figure 4. The contact zone between the Mohave ground squirrel and the round-tailed ground squirrel. This shows the distribution of trapping sessions conducted for regional and protocol surveys, as well as incidental observations of Mohave ground squirrels. Circles show sites where round-tailed ground squirrels have observed or captured. These data cover the period 1998-2007.

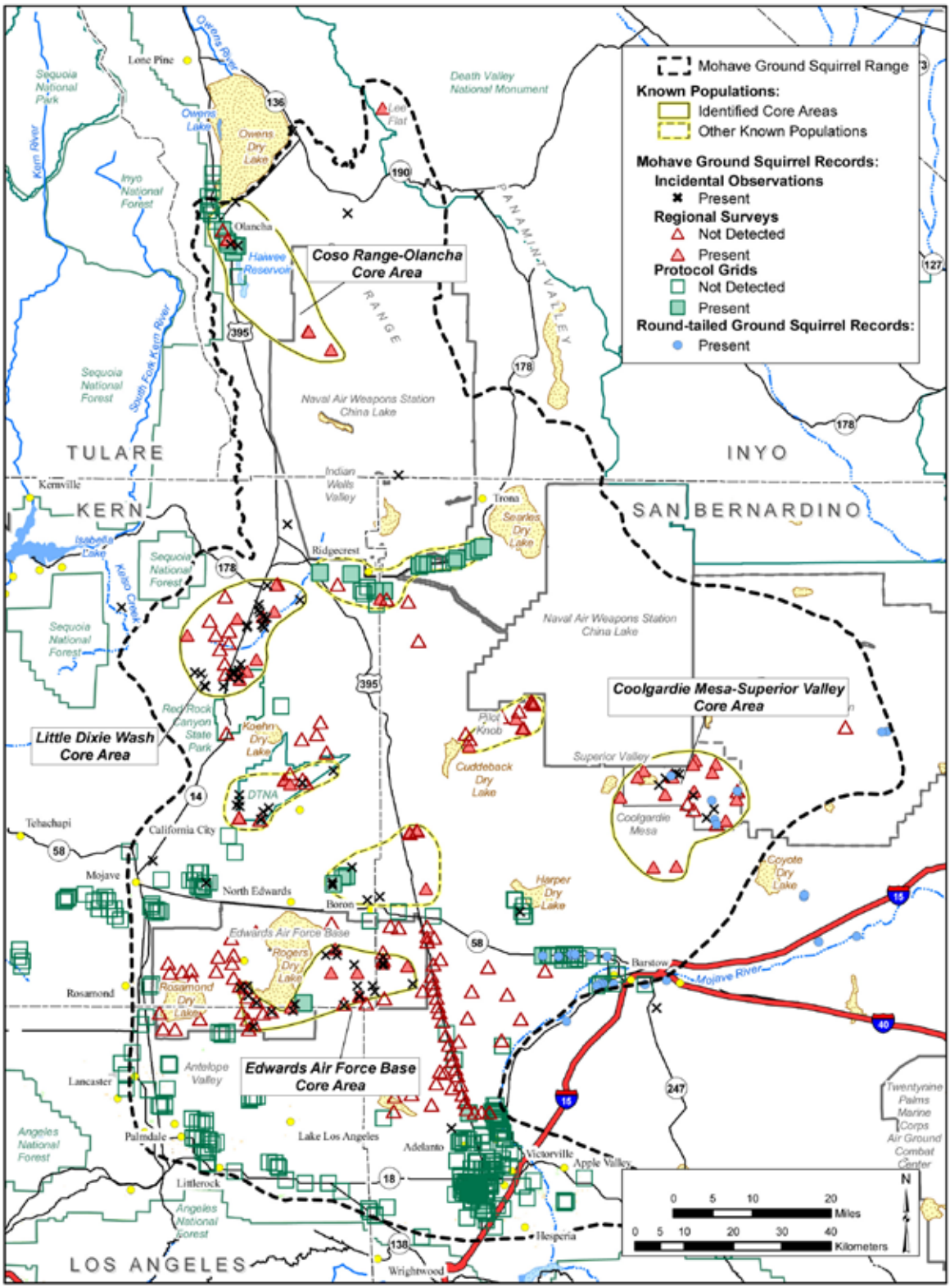

Figure 5. The geographic locations of currently known Mohave ground squirrel populations, including 4 identified core populations and 4 other populations.

exist outside the 8 areas in which recent positive records are concentrated.

The significance of negative records must be interpreted carefully as well. When regional surveys or protocol trapping fail to detect Mohave ground squirrels, it is important to keep in mind that this in itself cannot be used as evidence that the species is absent or that the area does not provide habitat for the species. There are a number of other circumstances that could result in lack of captures, such as locating a trapping grid in a small patch of marginal or unsuitable habitat, abundance of natural foods that reduce the attractiveness of the bait, low population density due to a series of dry years, or trapping early in the season before juveniles begin their dispersal movements. If trapping grids are not randomly sited, it is not valid to infer from a lack of captures at the grid sites that Mohave ground squirrels are absent in the surrounding habitat. Any conclusions would apply only to the grid sites themselves. In general, the most that can be concluded from lack of captures is that the negative results provide no evidence that the species is present. However, if repeated trapping efforts over a period of several years fail to detect Mohave ground squirrels, it becomes more and more probable that the species is very rare, if not absent, from the study area.

The distribution of trapping effort among private, military, and public land ownerships has been distinctly uneven over the past 10 years. Almost all protocol trapping surveys have been conducted on private lands or on highway rights-of-way, because of the regulatory requirement to determine presence or absence of the Mohave ground squirrel on proposed project sites. Military lands make up about 37% of the land surface within the range boundaries, but have been the locations for only 7.4% of all trapping records (Table 2). While Edwards Air Force Base and the Western Expansion Area of Fort Irwin have been sampled intensively, very little trapping effort has been expended on the remainder of Fort Irwin or on China Lake NAWS.

Core Areas

Data collected over the past 10 years has made it possible to identify 4 areas within the range of the Mohave ground squirrel that still support relatively abundant and widespread populations. These core areas are defined by 3 criteria. First, there must be evidence that Mohave ground squirrel populations have persisted for a substantial period of time, on the order of 2-3 decades. Second, the species must be currently found at a minimum of 6 locations throughout the area. Third, the total number of individuals detected since 1998 must be $\geq$30. The 4 areas that are currently known to satisfy these criteria are Coso/Olancha, Little Dixie Wash, Coolgardie Mesa/Superior Valley, and Edwards Air Force Base (Fig. 5). These 4 core areas total about 1,672 km^2, or about 8.4% of the entire historic range (Table 3). During the period 1998-2007, there have been 135 positive records in core areas, accounting for 68.2% of the total 198 positive records. It is important to emphasize that these identified core areas are simply the only important population centers that have been identified thus far. There are very likely to be other core areas in parts of the geographic range that have not been adequately sampled in the last 10 years.

Coso/Olancha Core Area.—China Lake NAWS sponsored field studies of the Coso Hot Springs area

Table 2. An analysis of trapping effort on military lands within the range of the Mohave ground squirrel (MGS) during the period 1998-2007. The number of sites refers to the number of distinct trapping grid locations, while the number of records is the total number of trapping sessions at all sites, regardless of whether Mohave ground squirrels were captured.

Military Base	Area (km^2)	% MGS Range	No. Sites	No. Records	% Records
China Lake NAWS	4400	22%	2	20	1.8%
Fort Irwin	1800	9%	18	19	1.7%
Edwards AFB	1200	6%	43	43	3.9%
Totals	7400	37%	63	82	7.4%

in 1978 that detected 35 Mohave ground squirrels at a number of sites through trapping and visual observations (Zembal and Gall 1980). In the following year, trapping was carried out at 8 sites throughout the Coso Range and in Rose Valley to the west (Leitner 1980). A total of 124 individual Mohave ground squirrels were captured at 7 of the 8 trapping grids. A monitoring program in the Coso Range and Rose Valley from 1988 through 1996 resulted in the capture of over 1400 juvenile and adult Mohave ground squirrels (Leitner and Leitner 1998). Aardahl and Roush (1985) failed to trap the species at a site near Olancha in 1980, but did observe several individuals in the same general area.

During each of the past 7 years (2001-2007), Mohave ground squirrels have been trapped at 2 permanent grids in the Coso Range (Leitner 2001, 2006, 2008). A total of 89 adults have been captured over this period. The species has also been detected regularly in the Olancha area, where 29 adult captures were recorded at 5 sites from 2002 to 2005. The Coso/Olancha area clearly qualifies as an important core area, based upon the persistence of Mohave ground squirrel populations here for 30 years, the presence of the species at many sites, and the number of animals detected.

Little Dixie Wash Core Area.—Mohave ground squirrels were first recorded in the Little Dixie Wash region in 1931 and 1932, when specimens were collected at Freeman Junction and on the east side of Walker Pass (CNDDB Occ. #21 and #52). Trapping surveys by the BLM in 1974 and 1975 resulted in 17 captures at 7 localities in Dove Springs Canyon and Bird Spring Canyon (CNDDB Occ. #84, #174, #175, and #191-194). Aardahl and Roush (1985) reported capturing a total of 94 individuals (both adults and juveniles) at 6 grids in the Little Dixie Wash area from April-July 1980. Finally, trapping at 2 sites in 1994 yielded a total of 12 Mohave ground squirrels (Scarry et al. 1996). Additional occurrences were documented at 10 other locations in this region during the period 1974-1990. Thus, Mohave ground squirrels were recorded at 27 locations in the Little Dixie Wash area from 1931 through 1996.

Recent field studies have been conducted in the Little Dixie Wash area during the period 2002-2007. In 2002, a total of 19 adult Mohave ground squirrels were captured at 6 of 7 grid locations (Leitner 2008). This was followed by more intensive studies at the Freeman Gulch site, with a total of 108 adults and 101 juveniles recorded from 2003 through 2007. Pit-fall trapping for reptiles in the Dove Springs Open Area resulted in the incidental capture of 6 Mohave ground squirrels at 4 different locations. Finally, a trapping survey in 2007 yielded 7 adults at 4 grids near the northern boundary of Red Rock Canyon State Park (Leitner 2008). The Little Dixie Wash core area has supported Mohave ground squirrel populations for over 70 years and recent records confirm that the species is abundant and widespread here.

Coolgardie Mesa/Superior Valley Core Area.—Mohave ground squirrels were first discovered in 1977 north of Barstow on the plateau that stretches from Coolgardie Mesa north to Superior Valley (Wessman 1977). The species was detected at 9 locations, with 1-3 individuals reported at each site. In 1980, Aardahl and Roush (1985) trapped 2 grids in Superior Valley, capturing 24 individuals (both adults and juveniles). A total of 24 Mohave ground squirrels were subsequently recorded at 5 sites in 1981 and 1982 (CNDDB Occ. #206-210). In 1994, 4 individuals were captured at 2 trapping grids in this area (Scarry et al. 1996).

Two recent surveys have been carried out in the Coolgardie Mesa/Superior Valley area. Trapping at 4 sites in 2002 yielded Mohave ground squirrel captures at each location for a total of 14 adults. A more extensive survey of the Western Expansion Area of Fort Irwin in 2006 and 2007 resulted in 36 individuals captured at 10 of 12 trapping grids. There is clear evidence that Mohave ground squirrels have persisted here for at

Table 3. The estimated sizes of the 4 identified core areas, as measured in square kilometers and in acres. The number of positive Mohave ground squirrel records for the period 1998-2007 is given for each core area.

Core Area Name	Area (km^2)	Area (acres)	Number of Positive Records
Coso / Olancha	452	111,690	33
Little Dixie Wash	393	97,172	44
Coolgardie Mesa / Superior Valley	516	127,450	23
Edwards Air Force Base	311	76,761	35

least 30 years. Recent surveys have documented that the species was present at 14 of 16 trapping sites and in several cases a substantial number of individuals was captured. This core area is at the eastern edge of the range and several captures or observations of animals that appear to be round-tailed ground squirrels have been recorded here. The potential for hybridization in this area between these 2 closely related species should be carefully investigated.

Edwards Air Force Base Core Area.—A number of surveys have documented the past occurrence of Mohave ground squirrels on Edwards Air Force Base, with most records located to the north, east, and south of Rogers Dry Lake. The earliest observations were made during the period 1973-1977 in the area south of Rogers Dry Lake (CNDDB Occ. #265). Seventeen Mohave ground squirrels were trapped in 1988 at 3 sites northeast of Rogers Dry Lake (ERC Environmental and Energy Services Company 1989). Additional trapping in 1993 in this same area resulted in captures of many adults and juveniles (Deal et al. 1993, Mitchell et al. 1993). Surveys at Mt. Mesa to the southeast of Rogers Dry Lake yielded 9 Mohave ground squirrels in 1992 (U.S. Fish & Wildlife Service 1993) and over 30 individuals in 1993 (Deal et al. 1993, Mitchell et al. 1993). A total of 13 Mohave ground squirrels were trapped in 1994 at 4 sites in halophytic saltbush scrub to the south and southwest of Rogers Dry Lake (Buescher et al. 1995). The species was recorded at 4 additional locations to the east of Rogers Dry Lake during the period 1981-1991.

Recent field studies have clearly delineated a core area on Edwards Air Force Base, with all Mohave ground squirrel records since 2000 localized to the east and south of Rogers Dry Lake. Trapping surveys were conducted at 19 grids in this area during the period 2000-2005, with a total of 29 adults and 4 juveniles captured at 8 of the study sites (Vanherweg 2000, Leitner 2003, Air Force Field Test Center 2004 and 2005, Leitner 2008). Although no captures were recorded at the 8 grids south of Rogers Dry Lake in 2005, Mohave ground squirrels are known to be present here, based upon 6 incidental observations. Mohave ground squirrel populations have been known in this core area for over 30 years and the large numbers of recent records demonstrate that the species is still well-distributed here. To date, this is the only core area known to exist in the southern part of the range.

Connectivity between Core Areas

The 4 core areas are isolated from each other by distances ranging from 48-80 km. It will be an important conservation goal to ensure sufficient connectivity between them to allow gene flow. Figure 6 shows the locations of the core areas with possible habitat corridors illustrated.

The potential corridor between the Coso/Olancha core area and Little Dixie Wash follows a narrow strip of public land between the Sierra escarpment and the boundary of China Lake NAWS. It is not clear that this corridor is effective because of its minimal width (1-4 km) and because there is no firm evidence that it is currently occupied. There may well be an alternative corridor through China Lake NAWS, but the U.S. Navy cannot guarantee permanent protection and, again, there is no proof that continuous Mohave ground squirrel populations exist here.

Connectivity between the Little Dixie Wash core area and Edwards Air Force Base is most likely to be achieved by protection of a north-south habitat corridor along US Highway 395. This linkage appears to provide the highest quality habitat connection between these 2 core areas. It would also help to provide connectivity among other known populations in the Ridgecrest area, the DTNA, Pilot Knob, and the Boron region. There are no recent Mohave ground squirrel records along much of this corridor, so it is not clear that it is currently occupied.

The most effective corridor linking the Coolgardie Mesa/Superior Valley core area with other populations is probably thorough the Pilot Knob region. This connection is relatively short and crosses apparently good quality habitat. Although the most direct route is across a corner of the China Lake NAWS, public lands just to the south could also provide connectivity. An alternative linkage would be to the southwest toward Edwards Air Force Base across the broad valley centered on Harper Dry Lake. However, this route is lower in elevation, receives less rainfall, and habitat here is of lesser quality.

The lack of data concerning the existence or status of Mohave ground squirrel populations in these potential corridors is a serious problem. While these routes may seem geographically appropriate in providing linkages between populations, it will be important to conduct field studies to determine whether or not they are actually occupied.

MANAGEMENT RECOMMENDATIONS

The database of Mohave ground squirrel records that has been assembled for this analysis should be maintained by CDFG or another suitable public agency and made available for on-line access by interested researchers, agency staff, consultants, and conservation organizations. An interactive mapping system should be developed in conjunction with the database, so that

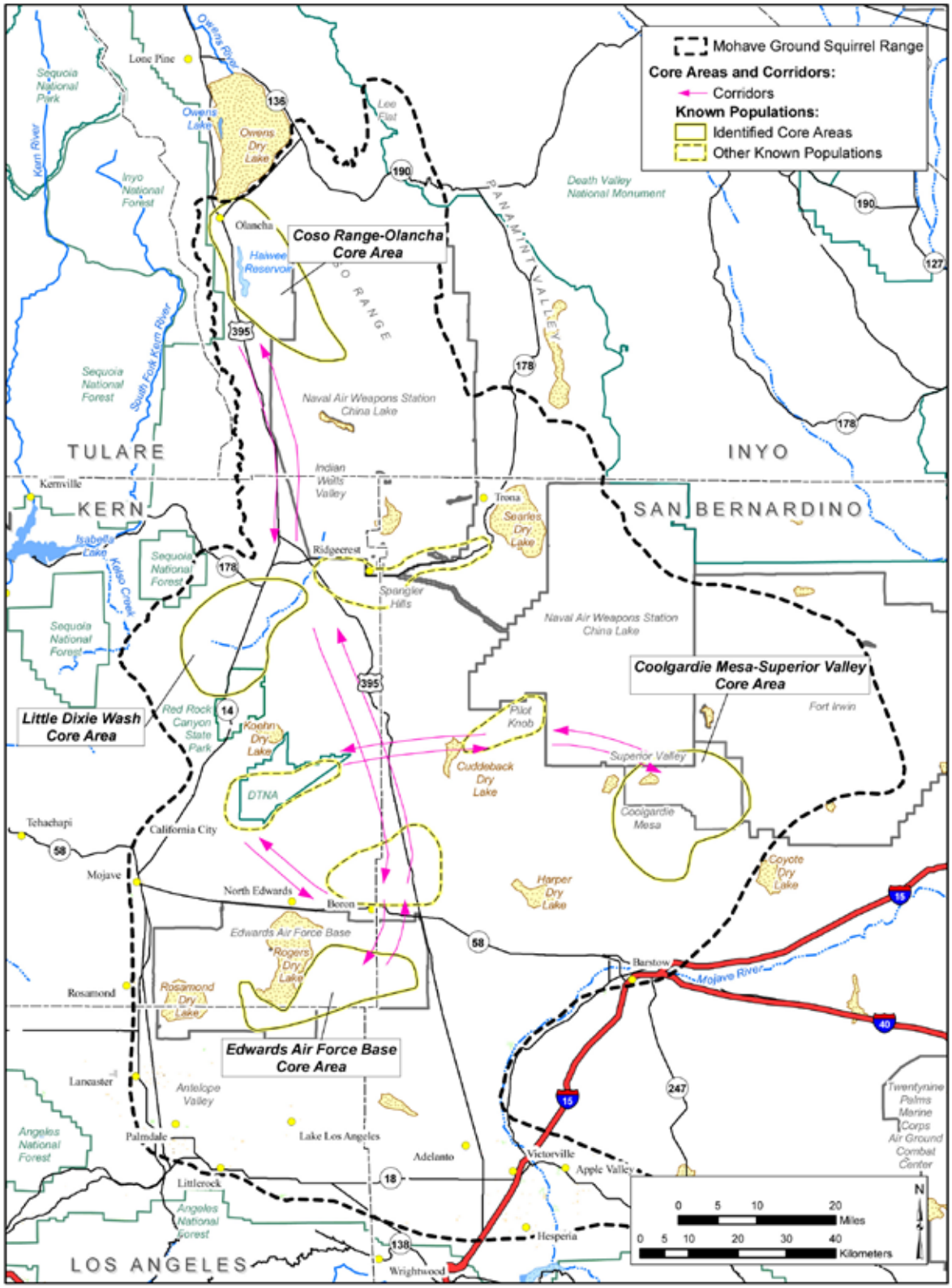

Figure 6. Map of potential habitat corridors that may provide connectivity between identified core areas and other known Mohave ground squirrel populations.

users could obtain map displays of areas of interest. As recommended by Brooks and Matchett (2002), a system should be developed to collect both positive and negative data on a continuing basis from biologists, agency staff, and consultants. It would be desirable to issue an annual report with appropriate maps to provide updated information on Mohave ground squirrel occurrences.

It is clear that additional field surveys are urgently needed to provide a more comprehensive picture of Mohave ground squirrel occurrence and status throughout its range. It is also clear that surveys to date have been seriously inadequate in documenting patterns of Mohave ground squirrel distribution because trapping sites have for the most part not been selected according to a randomized scheme. In the absence of a randomized sampling procedure, the results of such surveys apply only to the trapping site and cannot be extrapolated to the general region. It is recommended that a range-wide survey be conducted, with sampling locations determined on a randomized basis. Since this would be an expensive and logistically difficult undertaking, it may be more realistic to develop a survey plan that could be implemented gradually over several years as funding becomes available. The first step could be to establish a sampling frame covering the entire Mohave ground squirrel range, with the area divided into sampling units, perhaps 10 x 10 km or smaller. When a survey is planned for a particular region, trapping grids could be sited in sampling units chosen at random. This system would be quite flexible, since it could be implemented at different scales as appropriate for the purposes of the sponsoring organization. It is recommended that the Mohave Ground Squirrel Technical Advisory Group develop such a range-wide randomized sampling plan and submit it to the CDFG, BLM, and military installations for consideration.

It appears to be of critical importance to acquire more data concerning the status of the species in the northern and central parts of its range (Fig. 7). Surveys should be carried out on both the north and south ranges of China Lake NAWS, on Fort Irwin, and along the corridor north from EAFB to Ridgecrest. There has

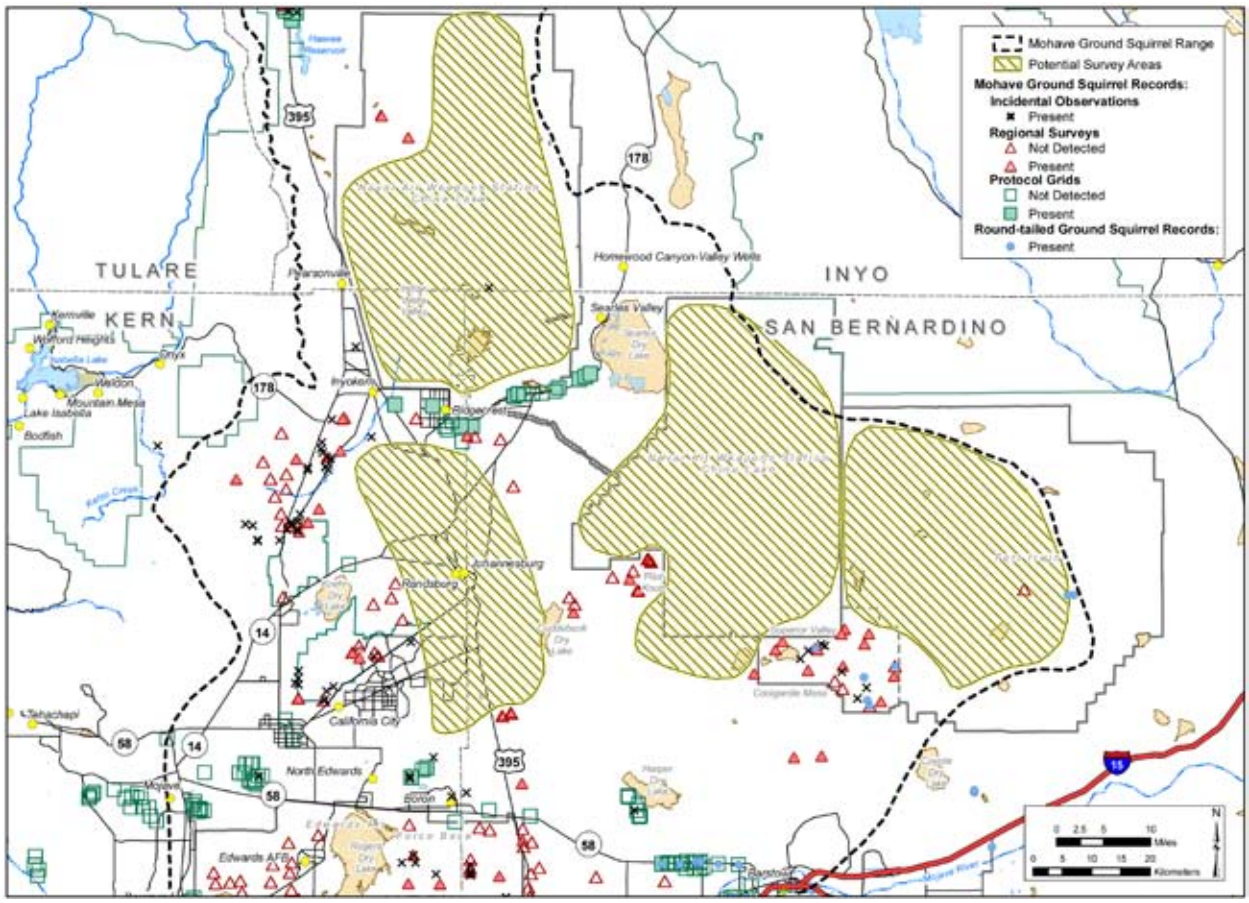

Figure 7. Potential survey areas in the northern and central portions of the Mohave ground squirrel range, showing their geographic relationship to survey efforts during the period 1998-2007.

been little or no sampling during the period 1998-2007 in these 4 extensive areas. A careful study plan should be developed to ensure adequate survey coverage within each area.

It is also recommended that field surveys be conducted in key areas within the southern range of the species in order to determine whether viable populations still remain outside of EAFB (Fig. 8). The trapping surveys could focus on public lands, but a serious attempt should be made to obtain permission for surveys on private lands as well. Because of the pace of development within the southern portion of the Mohave ground squirrel range, this exploratory work needs to be carried out with urgency.

The region southwest of the town of Mojave was identified in the West Mojave Plan (BLM 2003) as the Kern County Study Area. The West Mojave Plan recommended that Mohave ground squirrel trapping surveys be conducted here on public lands. The possibility was left open that the boundary of the Mohave Ground Squirrel Conservation Area could be modified to include these public lands if justified by survey results. A number of protocol trapping surveys have recently been carried out on private land in this area in connection with proposed wind energy projects. Although no Mohave ground squirrels have been trapped thus far, there have been 2 reported visual detections. It is recommended that additional trapping surveys be authorized on both public and private property, especially in areas that have not yet been investigated.

More information is needed about the relationship between the Mohave ground squirrel and its sibling species, the round-tailed ground squirrel. There are recent reports of round-tailed ground squirrel occurrences well inside the historic Mohave ground squirrel range to the west of Barstow and in the Western Expansion Area of Fort Irwin. Round-tailed ground squirrels seem well-adapted to land disturbance in agricultural areas and on the outskirts of towns. It is possible that hybridization is occurring where the 2 species come in contact. It is

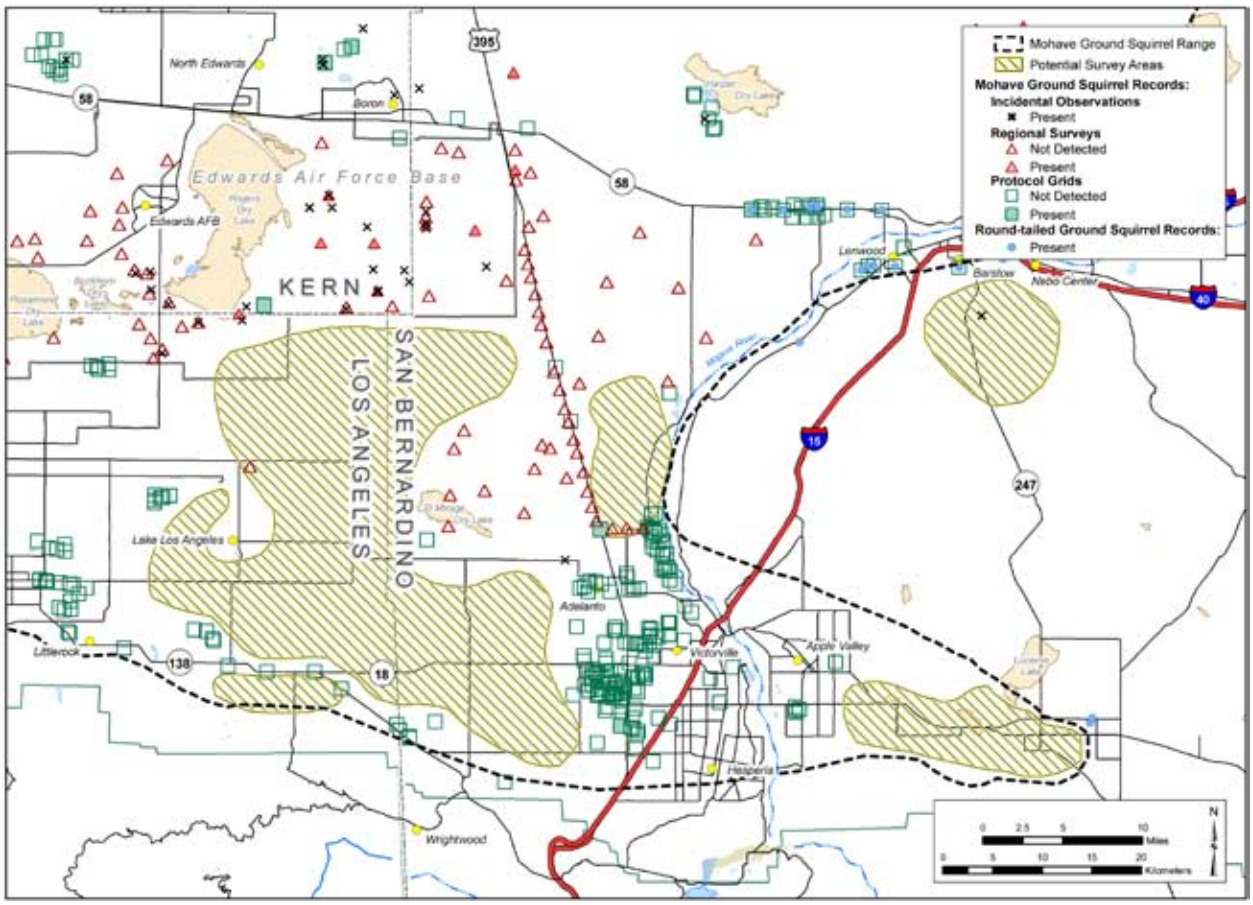

Figure 8. Potential survey areas in the southern portion of the Mohave ground squirrel range, showing their geographic relationship to survey efforts during the period 1998-2007.

recommended that surveys be carried out to determine the current eastern limits of the Mohave ground squirrel range and establish a baseline so that future westward movement of round-tailed ground squirrels could be detected. It is also recommended that genetic studies be undertaken in the contact zone to investigate the extent of hybridization where the 2 species co-occur.

Although trapping is the most effective method of identifying areas that support Mohave ground squirrel populations, it is recommended that certain modifications of current trapping procedures be tested. Trained wildlife dogs could be used to screen large areas and help focus trapping efforts on the most promising sites. Most trapping efforts to date have used large 100-trap grids. It would be of interest to try other trap configurations, such as more numerous small grids (for example, arrays of 20 traps) and long (>1000 meter) linear transects. Finally, such alternative trap configurations could be used in combination with adaptive cluster sampling (Thompson et al. 1998), which would allow for increased effort adjacent to a sampling unit where a Mohave ground squirrel is detected.

It is essential to protect BLM lands within the Mohave Ground Squirrel Conservation Area by enforcing the 1% limitation on ground disturbance (Fig. 1) called for under the West Mojave Plan (BLM 2005). In addition, acquisition of private lands that are included within the boundaries of the Conservation Area should be pursued aggressively, especially land that is included within known core areas. Finally, there may be important Mohave ground squirrel populations outside the Conservation Area that could protected by acquisition of private lands and careful management of BLM lands. The area stretching from the DTNA southeast toward Boron may be a good example of such a conservation opportunity.

ACKNOWLEDGMENTS

This review was funded by Edwards Air Force Base through a subcontract with Tetra Tech, Inc. I am very grateful to Shannon Collis and Donald Clark for their support and guidance throughout this project. Carrie Munill provided outstanding assistance with the GIS mapping effort. A number of biologists generously contributed their data, including Mark Allaback, Patrick Kelly, Tom Kucera, David Laabs, Denise LaBerteaux, Steven Myers, Michael O'Farrell, William Vanherweg, and Ryan Young. The following agencies and organizations gave permission to include data collected in studies that they sponsored: California Department of Fish and Game, California Department of Parks and Recreation, California Department of Transportation, Desert Tortoise Preserve Committee, Edwards Air Force Base, Fort Irwin, and US Bureau of Land Management. I greatly appreciate the helpful comments on the manuscript by B. Cypher, J. Harris, and 1 anonymous reviewer.

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APPENDIX 1
UNPUBLISHED REPORTS OF REGIONAL TRAPPING STUDIES CONDUCTED DURING THE PERIOD 1998-2007

Air Force Flight Test Center. 2004. Inventory for Presence of Mohave Ground Squirrel at Edwards Air Force Base, California. 26 pp. + appendices.

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Starr, Michael J. 2001. Population Distribution and Abundance of Antelope Ground Squirrels (*Ammospermophilus leucurus*) and Mohave Ground Squirrels (*Spermophilus mohavensis*), in the Western Mojave Desert, Spring 2001. 9 pp. + appendix.

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EXHIBIT 653

DECLARATION OF MICHAEL A. BIAS

I, Michael A. Bias, declare as follows

1. I am a principal ecologist with the firm of Ecosystem Restoration Sciences, Inc. I make this declaration from my personal knowledge and if called as a witness, I could testify competently to the facts stated in this declaration.

2. Exhibit 640 is a true and correct copy of Hailey J, and D Bainbridge. 1999. Desert Restoration: Do something or wait a thousand years? [abstract] Mojave Desert Science Symposium; 1999 Feb 25-27, Las Vegas. USGS, Western Ecological Research Center [internet]. Available from: http://www.werc.usgs.gov/mojave-symposium/

3. Exhibit 641 is a true and correct copy of US Fish and Wildlife Service. 2009. Preparing for any action that may occur within the range of the Mojave desert tortoise (*Gopherus agassizii*). Available at: http://www.fws.gov/ventura/speciesinfo/protocols_guidelines/docs/dt/DT_Pre-project_SurveyProtocol_FieldSeason.pdf.

4. Exhibit 642 is a true and correct copy of US Fish and Wildlife Service. 1992. Field survey protocol for any non-federal action that may occur within the range of the desert tortoise. Available from: Fish and Wildlife Service, Ventura (CA).

5. Exhibit 643 is a true and correct copy of Boarman WI, WB Kristan. 2006. Evaluation of Evidence Supporting the Effectiveness of Desert Tortoise Recovery Actions. Scientific Investigations Report 2006-5143. US Geological Survey, Sacramento (CA).

6. Exhibit 644 is a true and correct copy of Boarman WI. 2002. Threats to Desert Tortoise Populations: A Critical Review of the Literature. U.S. Geological Survey, Western Ecological Research Center. Sacramento (CA): 86 p.

7. Exhibit 645 is a true and correct copy of the Schamberger ML, FB Turner. 1986. The application of habitat modeling to the desert tortoise (*Gopherus agassizii*). Herpetologica 42:134-138.

8. Exhibit 646 is a true and correct copy of Klute DS, LW Ayers, MT Green, WH Howe, SL Jones, JA Shaffer, SR Sheffield, TS Zimmerman. 2003. Status assessment and conservation plan for the western Burrowing Owl in the United States. Bio Tech Pub FWS/BTP-R6001-2003. Washington: US Fish and Wildlife.

9. Exhibit 647 is a true and correct copy of Desert Tortoise (Mojave Population) Recovery Plan, U.S. Fish & Wildlife Service, June 1994.

10. Exhibit 648 is a true and correct copy of Petition to the State of California Fish and Game Commission and Supporting Information for Listing the California Population of the Western Burrowing Owl (Athene Cunicularia Hypugaea) as an Endangered or Threatened Species Under the California Endangered Species Act, April 7, 2003.

11. Exhibit 649 is a true and correct copy of Home-Range Size and Use of Space by Adult Mohave Ground Squirrels, Spemophilus Mohavensis, John H. Harris and Philip Leitner, Journal of Mammalogy 2004; Long-Distance Movements of Juvenile Mohave Ground Squirrels, Spermophilus Mohavensis, John H. Harris and Philip Leitner, the Southwestern Naturalist, June 2005.

12. Exhibit 650 is a true and correct copy of Hoyt DF. 1972. Mohave Ground Squirrel Survey. California Department of Fish and Game. Sacramento (CA): Special Wildlife Investigations Report.

13. Exhibit 651 is a true and correct copy of CNPS Botanical Survey Guidelines, California Native Plant Society, June 2, 2001

14. Exhibit 652 is a true and correct copy of Current Status of the Mohave Ground Squirrel, Philip Leitner

I declare under penalty of perjury that the foregoing is true and correct. Executed at Twin Bridges MT this 17th day of March, 2010.

Michael A. Bias

EXHIBIT 654

Body of http://www.ladwp.com/ladwp/cms/ladwp009508.jsp

BARREN RIDGE RENEWABLE TRANSMISSION PROJECT

What Is the Barren Ridge Renewable Transmission Project? (***Updated January 2010***)

Barren Ridge Renewable Transmission Project Fact Sheet (3-28-08) – PDF Document

Project Location (***Updated January 2010***)

Purpose and Need (***Updated January 2010***)

Proposed Action (***Updated January 2010***)

Environmental Review
  Notice of Intent (PDF Document)
  Notice of Preparation (PDF Document)

Project Newsletters (***Updated January 2010***)

Public Scoping Meetings (April/May 2008)
  Scoping Report

February 2009 Public Information Meetings

Project Timeline

Public Involvement Update – March 2009

Alternatives Development (***New, January 2010***)

Opportunities To Provide Comments

Lead Agency Contacts

BRRTP Project Decision Makers

What is the Barren Ridge Renewable Transmission Project

LADWP is proposing the Barren Ridge Renewable Transmission Project to access clean, renewable energy resources in the Tehachapi Mountain and Mojave Desert areas of Southern California. The project is in Kern and Los Angeles Counties, and is approximately 75 miles in length from Barren Ridge Switching Station to Rinaldi Substation and 12 miles in length from Castaic Power Plant to the proposed Haskell Switching Station. The project will consist of:

1. Construction of a 230 kilovolt (kV) transmission line from the LADWP Barren Ridge Switching Station to Haskell Canyon on double-circuit structures (involving approximately 13 miles of National Forest System (FS) lands and 4 miles of Bureau of Land Management (BLM) managed public lands);

2. Addition of a 230 kV circuit on the existing double-circuit structures from Haskell Canyon to the Castaic Power Plant (involving approximately 4 miles of FS lands and 300 feet of BLM managed public lands);

3. Upgrade the existing Barren Ridge – Rinaldi 230 kV transmission line with larger capacity conductors between the Barren Ridge Switching Station to Rinaldi Substation (involving approximately 13 miles of FS lands and 4 miles of BLM managed public lands);

4. Construction of a new electrical switching station at Haskell Canyon.

5. Expansion of the existing Barren Ridge Switching Station

Barren Ridge Renewable Transmission Project Fact Sheet (March 2008)

Project Location

The Barren Ridge Renewable Transmission Project spans a distance of approximately 75 miles from the Mojave Desert south to the San Fernando Valley. The project is located within northwestern Los Angeles County and southwestern Kern County. The project study area is generally defined by the following limits: the northern boundary is the southern slopes of the Tehachapi Mountains, eastern boundary parallels State Route 14, southern boundary generally parallels the Santa Clara River, and the western boundary parallels Interstate 5. The study area measures approximately 1,280 square miles.

Within this study area several routing possibilities were identified that traversed through the Antelope Valley, across Angeles National Forest, and public lands located in the Mojave Desert. Please refer to the Preliminary Alternative Route map (June 2009) for a more detailed view of the proposed project and *preliminary alternatives* that were considered. The routes shown in these maps were **preliminary only** and did not necessarily represent the final alternatives that have been selected to be carried through for analysis in the EIS/EIR. They do, however, represent the planning and evaluation process that was followed to arrive at the alternatives carried forward in the EIS/EIR.

Please refer to the Proposed Project and Alternatives map to see the alternatives that have been selected to be carried forward in the EIS/EIR analysis. More detailed views of the proposed project and alternatives maybe viewed here:

Proposed Project and Alternatives – Northern Portion

Proposed Project and Alternatives – Southern Portion

Proposed Project and Alternatives – Elizabeth Lakes and Green Valley Inset

Proposed Project and Alternatives – Agua Dulce Inset

Proposed Project and Alternatives – Haskell Inset

If you'd like to reference your individual property in reference to the proposed project, please email your property address to BRRTP@powereng.com.

Purpose and Need

The primary purpose and need for the proposed project is to meet Renewable Portfolio Standard (RPS) goals and reduce the environmental impacts associated with greenhouse gases (GHG) and emissions of other air pollutants. Current LADWP RPS goals call for 20% renewable energy by 2010 and 35% by 2020. GHG goals are set for CO2 emission reductions of 35% below the 1990 levels by 2030.

In order to reach these goals, a second purpose of this action is for additional transmission capacity necessary for the City of Los Angeles to reach and integrate the many proposed renewable energy projects located in the Mojave Desert and Owens Valley areas of Southern California. LADWP is developing two wind projects that would total 270 MW combined in the mountains northeast of Tehachapi. Furthermore, LADWP currently has several interconnection requests for approximately 1200 megawatts (MW) of renewable energy within the same geographical area. These renewable projects are proposed to interconnect to, or deliver power through, the Barren Ridge Switching Station which is being constructed approximately 12 miles north of Mojave on the Barren Ridge – Rinaldi line (BR-RIN) to interconnect LADWP's Pine Tree Wind Project.

The existing BR-RIN 230 kV transmission line, which has a 400 MW transfer capacity, currently is loaded with 160 MW of electrical load leaving only 240 MW of excess capacity. Maximizing the capacity of the existing BR-RIN corridor is the second need for the project to not only meet the current interconnection requests, but to utilize future renewable energy sources in this area which are projected by the California Energy Commission at over 4000 MW of wind and over 2000 MW of solar.

The project will also increase system reliability and flexibility. A new switching station would help LADWP meet NERC and WECC reliability requirements while providing greater flexibility in the utilization of both the proposed wind and solar energy within their electrical system.

Lastly, the project will increase the efficient utilization of the Castaic Power Plant. The power plant is a pump-storage hydroelectric generation facility that would be used to integrate the intermittent renewable energy (wind, solar). This will allow LADWP to utilize its power plants transmission network in a more efficient manner as well as reduce its power system losses.

The project will cross both public lands managed by the BLM and FS and both agencies are responding to the applications from LADWP for a Special Use Authorization, Right of Way Grant, and amendments to existing authorizations/grants.

Proposed Action

LADWP is proposing the following components to meet the purpose and need of the project:

• Construct approximately 60 miles of a new 230 kV double circuit structure system from the Barren Ridge Switching Station to Haskell Canyon. This proposed line would cross approximately 13 miles of National Forest System lands and four miles of public lands managed by BLM;

• Install approximately 12 miles of a 230 kV circuit onto existing double circuit transmission line structures from Haskell Canyon to the Castaic Power Plant. This proposed line would cross approximately four miles of National Forest System lands and less than one mile of public lands managed by BLM;

• Reconductor approximately 75 miles of the existing BR-RIN Transmission Line with larger capacity conductors from the Barren Ridge Switching Station to the Rinaldi Substation located in the San Fernando Valley. Approximately 13 miles of National Forest System lands and four miles of public lands managed by BLM would be affected by the reconductoring.

• Construct a new 400 foot by 600 foot (approximately 5.5. acres) Haskell Switching Station on LADWP-owned property north of Santa Clarita and just south of the Angeles National Forest managed lands.
• Expand the existing 250 foot by 500 foot Barren Ridge Switching Station by 235 feet by 500 feet, for a total station size of 485 feet by 500 feet (approximately 5.5 acres.)

Please refer to the Proposed Project and Alternatives map to see the alternatives that have been selected to be carried forward in the EIS/EIR analysis.

Environmental Review

Based on the nature and scope of the proposed project, LADWP has determined that the proposed project is a major federal and state action that may have a significant adverse impact to the environmental from construction, operation and maintenance of the project. Both the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) are concerned with identifying, analyzing, and disclosing the potential environmental effects of a proposed project prior to its implementation. The Forest Service, BLM, and LADWP will prepare a joint Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the Barren Ridge Renewable Transmission Project. The Forest Service and BLM will serve as the NEPA co-lead agencies in preparation of the EIS. LADWP is the lead agency for compliance with CEQA and preparation of the EIR.

All public documents related to the CEQA and NEPA review process for the Barren Ridge Renewable Transmission Project will be available at this website. A Notice of Intent was published in the Federal Register on April 9, 2008. Agencies, elected officials, organizations, Native American Tribes, and interested individuals were sent a Notice of Preparation. A newsletter (#1) was sent to interested individuals and all property owners within 500 feet on either side of the proposed transmission centerline and preliminary alternative routes.

Project Newsletters

Newsletter Number 1 – April 2008

Newsletter Number 2- December 2008

Newsletter Number 3 (Postcard) – January 2009

Newsletter Number 4 - January 2010

Public Scoping Meetings

Scoping is a process for determining the issues to be addressed, and identifying the range of actions, alternatives, mitigation measures, and significant effects to be analyzed in depth in an EIS/EIR. The Forest Service, BLM and LADWP conducted a public scoping period to allow the regulatory agencies and the public an opportunity to comment on the project. The public scoping period began April 7, 2008 when a Notice of Preparation (NOP) was issued, and the Notice of Intent (NOI) to prepare a joint EIS/EIR was published in the Federal Register. Newsletter #1 was sent out to agency representatives, elected officials, Native American Tribes, interested parties and organizations, and property owners within 500 feet of both sides of the proposed project and preliminary alternatives in Los Angeles and Kern Counties. The newsletter contained the project description, purpose and need for the project, a map, description of the environmental review process, announcement of the public scoping meetings, and contact information.

From April 22 through May 1, 2008, LADWP, Forest Service and BLM conducted seven public scoping meetings in the cities of Santa Clarita, Agua Dulce, Castaic, Lake Hughes, Lebec, Palmdale and California City. The purpose of these meetings was to share information regarding the proposed project and the decision-making processes, and to listen to public and agency views on the range of issues to be considered during the preparation of the Draft EIS/EIR.

The meetings consisted of a several hand outs, a brief formal presentation (video), and several stations located around the room representing different topics and aspects of the project. (Welcome, Purpose and Need, Project Description, Environmental Review Process, Alternative Routes Development.) There were also several handouts. The meeting materials are all available in the Appendix of the Scoping Report.

The formal presentation consisted of the following 16 minute video available for viewing below:

Click here to view streaming video (April 2008)

Scoping Report

The resulting Scoping Report summarizes the public scoping effort conducted for the BRRTP EIS/EIR and documents issues and concerns expressed during the public scoping period. Over 200 comments were received from the public and agencies during the BRRTP scoping period. All comments received through July 2008 were incorporated into the Scoping report. The following is a summary of the issues and comments raised by the public and agencies:

Public Comments

Residents submitted many recommendations including:

- Using tubular steel mono poles and/or underground lines.
- Using a one tower-system (multi-circuits)
- Alternate routes
- Using Direct Current (DC) lines
- LADWP share or combine lines with other utility companies
- Use of Niobium wire
- Generating electricity within the City of Los Angeles
- Use line easements for trails and community farms, open space, soccer fields, etc.
- Purchase nature preserves.
- Extending public comment and review period
- Increased notification to property owners

Residents also commented on or provided comments regarding:

- The transmission of renewable energy to the Los Angeles basin
- The amount of renewable energy available to LADWP
- Determining criteria for future energy requirements and needs
- Other renewable energy projects that could meet the needs of the BRRTP
- Increased EMF emissions
- Adverse affects on fire suppression efforts (in and adjacent to the Angeles National Forest)
- Acquisition of private property
- Increased noise levels
- Decreased property values
- Impacts to public health and the environment
- Illegal off-road activity along transmission
- Effects of multiple siting of high voltage transmission lines
- New waste and hazardous waste generation
- Construction traffic

Agency Comments

The BLM and Forest Service inquired about upgrading the electrical transmission system to a 500 kV instead of 230 kV. Concerns from agencies such as the BLM, Forest Service, Air Quality Management District, Southern California Association of Governments (SCAG), Pacific Crest Trail Association, Department of Transportation, City of Lancaster and the Regional Water Quality Control Board included (but were not limited to) the potential for impacts to:

- Cultural, Biological, Paleontological, Mineralogical and Recreational resources
- Rare, threatened, endangered and special status species and habitats
- Increased raptor predation of sensitive species
- Wildlife movement and migration paths
- Air quality
- Fire suppression flight paths and staging areas
- Wildernesses, Wildlife corridors and open space
- Wild and Scenic River Corridors
- The Antelope Valley California Poppy Natural Reserve, the Angeles National Forest, the Pacific Crest Trial, and the San Andreas Rift Zone Significant Ecological Area (SEA)
- Future projects and developments in the project area (cumulative impacts)
- Consistency with SCAG's Regional Comprehensive Plan and Guide
- Increased illegal off-highway vehicle use, illegal hunting, plant-collecting and other unauthorized access
- Encroachment upon State transportation facilities and local roads, and increased construction traffic
- Sensitive areas from long-term maintenance plans for access roads
- Spread of invasive plant species (including noxious weeds) during construction
- Trash and micro-trash generation during construction
- Storm water run-off, drainages, wetlands, Waters of the State, Waters of the U.S. and blue-line streams
- From grading and sub-grading roads for maintenance

Comments received during the public scoping period assisted the Forest Service, BLM and LADWP to determine the scope and significant issues to be analyzed in the Draft EIS/EIR. These significant issues are:

Resource	**Potential Significant Issues**
Biological Resources	• Potential for adverse effects to rare, threatened, and endangered and special status species. • Considerable concern for Riparian Conservation Areas and the spread of noxious weeds throughout Angeles National Forest lands. • Impacts to avian species and increased raptor predation of sensitive species due to the use of lattice towers. • Potential for loss of habitat.
Cultural Resources	• Impacts to historical, cultural and archaeological resources in the Project area.
Earth Resources	• Adverse impacts to soils throughout the proposed Project area, including sedimentary rocks and fossils.
Fire	• Impacts to fire suppression efforts

Management and Safety	
Water Resources	• Impacts to drainages, wetlands, Waters of the State, Waters of the U.S., and blue-line streams.
Land Use	• Acquisition of private property, eminent domain, and the expansion of transmission line right-of-way and easements. • Decreased property values with additional transmission lines. • Conflicts with land use and recreation policies of the Forest Plan
Recreation	• Impacts to recreational facilities and trails. • Impacts to the quality of the Antelope Valley Poppy Reserve, Pacific Crest Trail, Wild and Scenic River Corridor and wilderness.
Visual Resource	• Adverse affects to visual resources of the area, especially those important to the character of the ridgelines, as well as from homes, communities, businesses, trails, State Parks, Angeles national Forest, BLM-Managed Lands, and other public lands.

February 2009 Public Information Meetings

As part of the public outreach efforts of the BRRTP, five informational public meetings in Lake Hughes, Mojave, Agua Dulce, Saugus, and Leona Valley were conducted February 17-26, 2009 to provide updates on the BRRTP's progress. The meetings included an open house between 5:30PM – 8:30PM with a presentation scheduled for 7:00PM. Dates and locations were as follows:

A fact sheet was handed out at the meeting and informational boards were situated around the room that the public was invited to view and comment or ask questions about.

The formal presentation consisted of the following 15 minute video available for viewing below:

Click here to view streaming video

The information boards available for viewing during the February 2009 Public Meetings open house are available individually below. All the board in one file is available by clicking here.

Project Map Board (February 2009)

Project Description Board (February 2009)

Typical Structures Board (February 2009)

Construction Sequence Board (February 2009)

Project Purpose Board (February 2009)

Environmental Benefits Board (February 2009)

Renewable Resources Board (February 2009)

Project Timeline Board (February 2009)

Summary of 2008 Public Scoping Board (February 2009)

Significant Issues Board (February 2009)

Project Modifications Board(February 2009)

Recommended for Elimination Board (February 2009)

Alternative Routes Board (February 2009)

Project Timeline

Public Information Meetings	February 2009
Public Release of Draft EIS/EIR	Summer 2010
Formal Public Meetings	Summer 2010
Final EIS/EIR	Winter 2011
NOD/ROD	Spring 2011
Design & Engineering	2011 – 2012
Construction	2012 – 2014
Target In-Service Date	Spring 2014

Public Involvement Update – March 2009

Public involvement activities and opportunities from May 2008 to March 2009 are documented in the following Public Involvement Update, March 2009, and related appendices, below:

Appendix A: Public Meeting Fact Sheet

Appendix B 1: Boards from Feb 2009 Public Meeting

Appendix B 2: Meeting Question and Comment Summary

Appendix C: LADWP Press Release

Appendix D 1: December 2008 Newsletter

Appendix D 2: February 2009 Postcard

Appendix E 1: Newspaper Advertisement

Appendix E 2: Spanish Newspaper Advertisement

Alternatives Development

NEPA and CEQA both require consideration of a reasonable range of alternatives to the proposed Project that would feasibly attain most of the basic objectives of the Project, but avoid or substantially lessen any of the significant or adverse effects of the Project. To determine which alternatives would be analyzed in the Draft EIS/EIR, alternatives were evaluated to determine whether they would:

1. Attain the purpose and need of the Project, as well as most of the basic objectives of the Project.

2. Have the potential to avoid or substantially lessen any of the significant or adverse effects of the Project.

3. Be considered feasible

Information gathered during scoping, the informational public meetings, and preliminary studies were considered in the alternatives development. Some of the preliminary routing opportunities (referred to as Segments A through I) were eliminated from further study and the remaining segments were combined to create end-to-end routing alternatives for the proposed double-circuit 230 kV transmission line between Barren Ridge Switching Station and the proposed Haskell Canyon Switching Station

Alternatives in the EIS/EIR

The following alternatives below were identified as a reasonable range of alternatives to the Project that would feasibly attain most of the basic objectives of the Project, but avoid or substantially lessen any of the significant or adverse effects of the Project. The No Action Alternative will also be analyzed in compliance with NEPA Regulations and CEQA Guidelines.

No Action Alternative

Under the No Action Alternative, the construction of a new 230 kV transmission line, installation of new 230 kV circuit, the construction of a new Haskell Canyon Switching Station, or the expansion of the existing Barren Ridge Switching Station would not occur.

Alternative 1 (Segments A, C, and D)

Alternative 1 consists of five project components discussed below. The only difference is the location of the new double-circuit 230 kV transmission line along Segments (83 miles long).

1. Construction of 83 miles of a new double-circuit 230 kV transmission line system along Segments A, C, and D.
2. Installation of approximately 12 miles of a new 230 kV circuit onto existing double-circuit transmission line structures from Haskell Canyon to the Castaic Power Plant;
3. Reconductoring of the existing Barren Ridge-Rinaldi (BR-RIN) 230 kV Transmission Line with larger-capacity conductors from the Barren Ridge Switching Station to the Rinaldi Substation.
4. Construction of the new Haskell Canyon Switching Station on LADWP-owned property north of Santa Clarita and just south of the Angeles National Forest managed lands; and

5. Expansion of the existing Barren Ridge Switching Station.

Alternative 2 (Segments A, B, and G)

1. Alternative 2 is LADWP's Proposed Action and contains the same five project components as Alternative The only difference is the location of the new double circuit 230 kV transmission line along Segments A, C, and G.

a.) The Green Valley Alternative would be a localized alternative to the proposed action. It is approximately 5.5 miles long and would avoid potential impacts of a new transmission line to the Community of Green Valley.

Alternative 3 (Segments A, B, F, and I)

Alternative 3 is also consists of the same five project components listed above. However, Alternative 3 is 76 miles long and would be located along Segments A, B, F, and I.

WE WANT TO HEAR FROM YOU!

Opportunities to Provide Comments

The project team welcomes comments and involvement throughout the project and appreciates your feedback. Comments concerning the scope of the environmental analysis are requested by May 8, 2008. If you have questions or comments about the project, or would like to be added to the project mailing list, please contact the project team in one of the following ways:

- Attend one of the public scoping meetings
- Call the toll free Barren Ridge Hotline (877) 440-3592
- Visit the project website www.ladwp.com/barrenridge/
- Send an email to BRRTP@powereng.com
- Send written comments to: Forest Service/BLM/LADWP c/o POWER Engineers, Inc., 731 E. Ball Road, Suite 100, Anaheim, CA 92805

In addition to the on going public and agency participation process, formal opportunities for public participation would be provided upon publication of the Draft EIS/EIR.

CONTACT US!

Lead Agency Contacts

Charles Holloway
Manager of Environmental Assessment
Los Angeles Department of Water and Power
111 North Hope Street, Room 1044
Los Angeles, CA 90012
Charles.Holloway@ladwp.com

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Linn Gum
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BRRTP Project Team
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731 E. Ball Road, Suite 100
Anaheim, CA 92805
www.ladwp.com/barrenridge
BRRTP@powereng.com
(877) 440-3592 toll-free

BRRTP Project Decision Makers

Following the completion of the environmental review and planning process and release of the Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR), anticipated in winter 2010, the lead agencies' decision makers will make a final determination on the project and which alternative is approved for construction. The information outlined within the EIS/EIR, which includes but is not limited to summaries of potential impacts to land uses, biological resources, cultural resources, noise, traffic, air quality as well as summaries of public comment and feedback collected during the environmental review process, will be used to inform and guide the decision makers on their determination.

The United States Forest Service (USFS), from whom the Los Angeles Department of Water and Power is seeking a Special Use Authorization, will make a decision for portions of the project on National Forest System Lands administered by the USFS.

The Bureau of Land Management (BLM), from whom the Los Angeles Department of Water and Power is seeking a Right-of-way Grant, will make a decision for portions of the project on federal lands administered by the BLM.

The Los Angeles Department of Water and Power's Board of Commissioners will make a decision and determination on the project in relation to all other lands.

The names and contact information of primary decision makers at each of the three agencies is outlined below.

Angeles National Forest – NEPA Co-Lead Agency
Supervisor's Office
701 N. Santa Anita Ave.
Arcadia, CA 91006
Jody Noiron, Forest Supervisor
Phone: (626) 574-1613
FAX (626) 574-5233

Bureau of Land Management – NEPA Co-Lead Agency
Ridgecrest Field Office
Hector Villalobos, Field Manager
300 S. Richmond Rd.
Ridgecrest, CA 93555
Phone: (760) 384-5400
Fax: (760) 384-5499

City of Los Angeles Board of Water and Power Commissioners – CEQA Lead Agency
Lee Kanon Alpert, President
Edith Ramirez, Vice President
Forescee Hogan-Rowles, Commissioner
Jonathan Parfrey, Commissioner
Los Angeles Department of Water and Power
Room 1555-H, 15th Floor
111 North Hope Street
Los Angeles, CA 90012
Phone: (213) 367-4211
Fax: (213) 367-1423

DECLARATION OF DAVID MARCUS

I, David Marcus, declare as follows:

1. Attached is a true and correct copy of Los Angeles Department of Water and Power's website for the Barren Ridge Renewable Transmission Project. I downloaded and printed this document on March 16, 2010 from http://www.ladwp.com/ladwp/cms/ladwp009508.jsp, a website purporting to be maintained by the Los Angeles Department of Water and Power.

2. I declare under penalty of perjury that the foregoing is true and correct.

Executed at Berkeley, California this 17 day of March 2010.

David Marcus

EXHIBIT 655

Tanya A. Gulesserian

From: Tanya A. Gulesserian
Sent: Wednesday, March 17, 2010 11:44 AM
To: David Marcus
Subject: Fwd: Beacon TSE Conference Call

See attached

Begin forwarded message:

> **From:** Sudath Edirisuriya <Sedirisu@energy.state.ca.us>
> **Date:** March 17, 2010 11:42:11 AM PDT
> **To:** "Tanya A. Gulesserian" <TGulesserian@adamsbroadwell.com>
> **Cc:** "JLuckhardt@DowneyBrand.com" <JLuckhardt@DowneyBrand.com>, "duane.mccloud@nexteraenergy.com" <duane.mccloud@nexteraenergy.com>
> **Subject: Fwd: Beacon TSE Conference Call**
>
> Tanya,
> This e-mail I received yesterday from the LADWP. Please be kind to forward to Mr.David Marcus.
> Thanks
> Sudath A. Edirisuriya
>
> Mr. Edirisuriya,
>
> This e-mail is providing an update of the Beacon Solar Project (BSP):
>
> 1) The Barren Ridge- Rinaldi 230 kV is currently rated at 459 MVA. LADWP is planning to upgrade its rating from 459 MVA to 530 MVA by installing the Dynamic Rating Equipment (DRE). The hardware of the DRE was already installed along the line. It was proposed that the new rating can be achieved by November 2010.
>
> 2) BSP is entering in the Facilities Study phase. In this phase, LADWP will consider a Remedial Action Scheme (RAS) that will mitigate possible overload of the Barren Ridge-Rinaldi 230 kV Line, prior to the construction of Barren Ridge Renewable Transmission Project (BRRTP). This RAS would include ramping down BSP generation or tripping BSP and would be temporarily in-place until the completion of the BRRTP.
>
> Regards,

Ly Le

LADWP - Transmission Studies

(213) 367-0302

"Tanya A. Gulesserian" <TGulesserian@adamsbroadwell.com>
3/16/2010 7:08 PM >>>

Wednesday 3:15 pm

Conference call in number: 1 (218) 862-6420; Pass Code: 129156#

Tanya A. Gulesserian
Adams Broadwell Joseph & Cardozo
601 Gateway Boulevard, Suite 1000
South San Francisco, CA 94080
Phone (650) 589-1660
Fax (650) 589-5062
tgulesserian@adamsbroadwell.com

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From: Tanya A. Gulesserian
Sent: Tuesday, March 16, 2010 6:20 PM
To: Eric Solorio; JLuckhardt@DowneyBrand.com; David Marcus
Cc: Sudath Edirisuriya; Jared Babula; Mark Hesters
Subject: Re: RE :Beacon TSE

It looks like 3:15 wednesday works for CURE and Staff. I have not heard from the Applicant. In the interest of moving this along, I am confirming this time. I will send a conference call in number by tomorrow morning.
Thank you.
Tanya

On Mar 16, 2010, at 3:03 PM, "Eric Solorio" <ESolorio@energy.state.ca.us> wrote:

Works for me

-----Original Message-----
From: Sudath Edirisuriya
To: Tanya A. Gulesserian <TGulesserian@adamsbroadwell.com>
Cc: Eric Solorio <ESolorio@energy.state.ca.us>
Cc: Jared Babula <Jbabula@energy.state.ca.us>
Cc: Mark Hesters <Mhesters@energy.state.ca.us>

Sent: 3/16/2010 2:15:16 PM
Subject: RE :Beacon TSE

I am available at 3:00 PM tomorrow.
916-654-4851
Sudath

"Tanya A. Gulesserian" <
TGulesserian@adamsbroadwell.com
>
3/16/2010 1:48 PM >>>

David Marcus is available for a call today after 3:45 and tomorrow anytime except between 2 and 3. Let us know if your people are available then.

Thank you,
Tanya

-----Original Message-----
From: Luckhardt, Jane [mailto:JLuckhardt@DowneyBrand.com]
Sent: Tuesday, March 16, 2010 9:57 AM
To: 'Eric Solorio'; Tanya A. Gulesserian; Jared Babula; Sudath Edirisuriya; Scott Busa
Cc: ' duane.mccloud@nexteraenergy.com '
Subject: RE: RIDGECREST_TSE

We would like our folks to join the call. Please let us know when you all schedule the call. Jane

Jane Luckhardt
DOWNEY BRAND
621 Capitol Mall, 18th Floor
Sacramento, CA 95814
916/520-5348 Direct
916/520-5748 Fax
jluckhardt@downeybrand.com
http://www.downeybrand.com

-----Original Message-----
From: Eric Solorio [mailto:ESolorio@energy.state.ca.us]
Sent: Tuesday, March 16, 2010 9:55 AM
To: Tanya A. Gulesserian; Luckhardt, Jane; Jared Babula; Sudath Edirisuriya; Scott Busa
Subject: RIDGECREST_TSE

** High Priority **

Tanya,
Please put your technical expert in contact with our technical expert, Sudath Arachchige, to discuss the Transmission System Engineering issue. I've copied Sudath and FPL, here. I believe this issue can be quickly resolved with a conference call. We can email any necessary docs or point you to them on the docket. Thank you.

Respectfully,
Eric K. Solorio, Project Manager

California Energy Commission
Siting, Transmission and Environmental Protection Division
1516 Ninth Street, MS-15
Sacramento, CA 95814

(916) 651-0966

CONFIDENTIALITY NOTICE: This communication and any accompanying document(s) are confidential and privileged. They are intended for the sole use of the addressee. If you receive this transmission in error, you are advised that any disclosure, copying, distribution, or the taking of any action in reliance upon the communication is strictly prohibited. Moreover, any such inadvertent disclosure shall not compromise or waive the attorney-client privilege as to this communication or otherwise. If you have received this communication in error, please contact our IS Department at its Internet address (is@downeybrand.com), or by telephone at (916)444-1000x5325. Thank you.

DECLARATION OF DAVID MARCUS

I, David Marcus, declare as follows:

1. I received an email on March 17, 2010 from Tanya Gulesserian in which Sudath Edirisuriya requested that Tanya Gulesserian forward Sudath Edirisuriya's email to David Marcus.

2. The forwarded email consists of the body but not the header of an email which Sudath Edirisuriya says he received from LADWP on March 16, 2010.

3. I have reviewed the attached print out and declare that it is a true and correct copy of the email that I received from Tanya Gulesserian.

4. I make this declaration from my personal knowledge and if called as a witness, I could testify competently to the facts stated in this declaration.

5. Exhibit 655 is a true and correct copy of the March 17, 2010 email from Tanya Gulesserian to David Marcus.

I declare under penalty of perjury that the foregoing is true and correct. Executed at Berkeley, California this 17th day of March 2010.

David Marcus

2162-081a

EXHIBIT 656

REQUEST FOR ENVIRONMENTAL IMPACT ANALYSIS

Report Control Symbol
RCS: 09-0622

INSTRUCTIONS: *Section I to be completed by Proponent; Sections II and III to be completed by Environmental Planning Function. Continue on separate sheets as necessary. Reference appropriate item number(s).*

DOCKET
08-AFC-2
DATE 08/21/09
RECD. 08/24/09

SECTION I - PROPONENT INFORMATION

1. TO *(Environmental Planning Function)*	2. FROM *(Proponent organization and functional address symbol)*	2a. TELEPHONE NO.
95 ABW/CEV	95 ABW/CER	4-2405

3. TITLE OF PROPOSED ACTION
Rosamond Tertiary Water Pipeline

4. PURPOSE AND NEED FOR ACTION *(Identify decision to be made and need date)*
Install a pipeline to convey tertiary treated water from the Rosamond Wastewater Treatment Plant to Edwards AFB. The water would support proposed enhanced use lease projects to include a solar thermal and/or hospital site.

5. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES *(DOPAA) (Provide sufficient details for evaluation of the total action.)*
Trench and install a 36" recycled water line proceeding east from the Rosamond WWTP at Patterson Road and then proceeding north along Division Blvd directly adjacent to or underneath the existing SCE transmission line easement.

6. PROPONENT APPROVAL *(Name and Grade)*	6a. SIGNATURE	6b. DATE
Sharon McLain, YA-2	electronic request on file	20090814

SECTION II - PRELIMINARY ENVIRONMENTAL SURVEY. *(Check appropriate box and describe potential environmental effects including cumulative effects.) (+ = positive effect; 0 = no effect; - = adverse effect; U= unknown effect)*

	+	0	-	U
7. AIR INSTALLATION COMPATIBLE USE ZONE/LAND USE *(Noise, accident potential, encroachment, etc.)*	☐	☐	☑	☐
8. AIR QUALITY *(Emissions, attainment status, state implementation plan, etc.)*	☐	☐	☑	☐
9. WATER RESOURCES *(Quality, quantity, source, etc.)*	☑	☐	☑	☐
10. SAFETY AND OCCUPATIONAL HEALTH *(Asbestos/radiation/chemical exposure, explosives safety quantity-distance, bird/wildlife aircraft hazard, etc.)*	☐	☑	☐	☐
11. HAZARDOUS MATERIALS/WASTE *(Use/storage/generation, solid waste, etc.)*	☐	☐	☑	☐
12. BIOLOGICAL RESOURCES *(Wetlands/floodplains, threatened or endangered species, etc.)*	☐	☐	☑	☐
13. CULTURAL RESOURCES *(Native American burial sites, archaeological, historical, etc.)*	☐	☐	☑	☐
14. GEOLOGY AND SOILS *(Topography, minerals, geothermal, Installation Restoration Program, seismicity, etc.)*	☐	☑	☐	☐
15. SOCIOECONOMIC *(Employment/population projections, school and local fiscal impacts, etc.)*	☑	☐	☐	☐
16. OTHER *(Potential impacts not addressed above.)*	☐	☐	☐	☐

SECTION III - ENVIRONMENTAL ANALYSIS DETERMINATION

17. ☑ PROPOSED ACTION QUALIFIES FOR CATEGORICAL EXCLUSION (CATEX) #A2.3.12 ; OR
☐ PROPOSED ACTION DOES NOT QUALIFY FOR A CATEX; FURTHER ENVIRONMENTAL ANALYSIS IS REQUIRED.

18. REMARKS
The proposed project was approved by the Assessment Review Group on 11 August 2009. The project qualifies for CATEX A2.3.12: Installing, operating, modifying, and routinely repairing and replacing utility and communication systems, data processing cable, and similar electronic equipment that use existing rights of way, easements, distribution systems or facilities. The project activities are de minimis with respect to the Clean Air Act. Air letter and calculations are on file with 95 ABW/EM. The project is approved by 95 ABW/EM contingent upon compliance with the attached Requirements Checklist.

19. ENVIRONMENTAL PLANNING FUNCTION CERTIFICATION *(Name and Grade)*	19a. SIGNATURE	19b. DATE
Keith Dyas, YD-2	Keith Dyas	21 Aug 09

REQUIREMENTS CHECKLIST

This project (Control No. 09-0622, *Rosamond Tertiary Water Pipeline*) qualifies for categorical exclusion A2.3.12 (Installing, operating, modifying, and routinely repairing and replacing utility and communication systems, data processing cable, and similar electronic equipment that use existing rights of way, easements, distribution systems or facilities). The project is approved contingent upon compliance with the following minimization measures.

General Compliance

1. The contractor selected to perform construction will be responsible for complying with all federal and applicable state environmental laws.

Planning

2. All project sitings may require approval by the Base Planning and Zoning (P&Z) Committee. Contact Civil Engineering (95 ABW/CEC) at (661) 277-9456 for coordination on your project.

Air Quality

3. Maintain speed limits on unpaved roads on base between 5 and 35 miles per hour (mph).

4. Suspend grading, disking, and all other earthwork projects at wind speeds exceeding 25 mph.

5. Water or apply dust suppressants to roads and open areas, upon which work is performed, in order to suppress dust. If winds produce visible emissions in excess of Ringlemann 1, erect wind barriers.

6. All vehicles hauling bulk materials or debris must be covered.

7. Install temporary coverings for open storage piles.

8. All in-use off-road diesel vehicles (i.e., loaders, crawler tractors, skid steers, backhoes, forklifts, etc.) 25 horsepower (hp) or greater have to meet fleet requirements which require the application of exhaust retrofits that capture pollutants before they are emitted into the air. The earliest date for the regulation implementation is year 2010. The regulation is posted at the webpage of the California Air Resources Board (CARB) at http://www.arb.ca.gov/msprog/ordiesel/ordiesel.htm. Contact 95 ABW/EMC's J-TECH contractor at (661) 277-1471.

9. The proposed project shall use diesel fuel meeting CARB specifications, including the 15 parts per million (ppm) sulphur content requirement.

10. Project activities that would result in the removal of any vegetation in an area that was previously undisturbed (includes areas that were once disturbed and now contain vegetation) may require revegetation/restoration in accordance with the *Edwards Air Force Base Revegetation Plan* (AFFTC 1994). Please coordinate with 95 ABW/EMX's J-TECH contractor at (661) 277-1401 for additional information.

Hazardous Materials/Waste

11. All spills or releases of hazardous materials or hazardous wastes that occur during this project (regardless of quantity or location of spill) must be reported immediately to the 95 ABW/EM Customer Service Desk at (661) 277-1401.

Best Management Practices

12. Per Air Force Instruction (AFI) 32-7041, *Water Quality Compliance*, the proponent/contractor shall prepare and submit a Storm Water Pollution Prevention Plan (SWPPP) to include site-specific control measures and best management practices that would be implemented during construction activities. This plan shall be reviewed by 95 ABW/EMC for approval prior to the implementation of the plan. Contact 95 ABW/EMC's J-TECH contractor at (661) 277-1401 for more information.

Traffic

13. This project may interrupt/delay traffic flow. The proponent/contractor shall file a traffic control plan with Security Police (95 ABW/SPOL) at (661) 277-3340, Fire Protection Division (95 ABW/CEFT) at (661) 277-3643, and Public Affairs Office (AFFTC/PA) at (661) 277-3510.

Natural Resources

14. All project personnel working in the area shall attend desert tortoise awareness training prior to commencing work or visiting the work site. Contact the Natural Resources contractor at (661) 277-1401 **no less than 3 days and no more than 5 days** before work begins to schedule a half hour desert tortoise awareness briefing.

15. A desert tortoise presurvey is required prior to commencing work. The presurvey will be scheduled by contacting the Natural Resources contractor **no less than 3 days and no more than 5 days** before work begins. If project activities cannot be completed within 2 consecutive days, notify Natural Resources contractor at *(661)* 277-1401 at least 3 days before work resumes for additional desert tortoise surveys.

16. Excavations left unsecured during the workday shall be checked three times per day (morning, midday, and late afternoon) for trapped animals. If any animals are found in an excavation, immediately notify 95 ABW/EMX Customer Service Desk at (661) 277-1401.

17. Habitat disturbance shall be contained to pre-disturbed areas as much as possible.

18. Any pipes stored within the area shall be capped on open ends or elevated at least 12 inches off the ground to prevent entry by desert tortoise or other wildlife.

Cultural Resources

19. Depending upon the exact APE for the pipeline project the APE may have received 100% survey for Cultural Resources. An area approximately 330 feet wide along Division Street south of Rosamond Blvd has been surveyed, including Space Shuttle Road. Division Street north of Rosamond Blvd has had an area approximately 130 feet wide surveyed for Cultural Resources. If the APE falls within the surveyed area no further survey would be necessary.

20. A total of 22 archaeological sites have been recorded in the surveyed area. Of these, two sites have been found eligible for the National Register of Historic Places (NRHP). Four have been found not eligible for the NRHP and 16 have not yet been evaluated for the NRHP. If it is not possible to avoid impacts to the eligible and not evaluated sites, other mitigation measures would be necessary. Sites not evaluated would need to have a Phase II evaluation for the NRHP. All of the sites found eligible for NHRP would need Phase III data recovery or other mitigation measures.

21. All costs to comply with the requirements of the National Historic Preservation Act (NHPA), Section 106, for this undertaking shall be borne by the proponent. Proponent is further responsible for coordinating the Section 106 requirements through the Edwards Air Force Base, Base Historic Preservation Officer.

Permits

22. This project will require an AFFTC IMT 5926, *Edwards AFB Civil Engineering Work Clearance Request* (digging permit). The proponent/contractor shall coordinate the digging permit. Contact the Base Civil Engineer Infrastructure Controller (95 ABW/CEOU) at (661) 277-2936 for specific requirements.

Security

23. This project may need to be reviewed and approved by the base Security Office. Please contact 95 ABW/SFS at (661) 277-3340 for specific requirements.

Declaration

I, Janet M. Laurain, declare as follows:

1. I am a paralegal at Adams Broadwell Joseph & Cardozo. I make this declaration from my personal knowledge. If called as a witness, I could testify competently to facts stated in this declaration.

2. Attached is a true and correct copy of Edwards Air Force Base Request for Environmental Analysis dated August 21, 2009, which I downloaded and printed on March 18, 2010 from the California Energy Commission website for the Beacon Solar Energy Project, http://www.energy.ca.gov/sitingcases/beacon/documents/2009-08-21_Edwards_AFB_Form813-Rosamond_TN-52940.pdf.

3. I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed this 18 day of March, 2010, at South San Francisco, California.

Janet M. Laurain

Janet M. Laurain

2162-084a