U.S. Fish & Wildlife Service

Revised Recovery Plan for the Mojave Population of the Desert Tortoise

(Gopherus agassizii)

Revised Recovery Plan

for the Mojave Population of the

Desert Tortoise (*Gopherus agassizii*)

Region 8, Pacific Southwest Region
U.S. Fish and Wildlife Service
Sacramento, California

Approved: ______________________
Region 8 Director
U.S. Fish and Wildlife Service

Date: May 6, 2011

Preamble to the Desert Tortoise Recovery Plan Revision

The publication of the Final Desert Tortoise Recovery Plan Revision (Plan) is an exciting accomplishment for the U.S. Fish and Wildlife Service (Service) and an important milestone in recovery planning for this species. It represents many years of strategic thinking, productive collaboration, and careful consideration of the concerns of stakeholders. During this time, the Service's Desert Tortoise Recovery Office has provided sound guidance and leadership over efforts to revise the Plan through both internal and external dialogue. This included the incorporation of information and feedback from:

- The Desert Tortoise Science Advisory Committee
- Four planning workshops in California and Nevada in Winter and Spring 2007
- Two open houses in California and Nevada in Fall 2007
- Informal internal and stakeholder reviews of the draft plan revision in 2007
- Formal public comments collected following the publication of the draft plan revision in 2008
- Formal peer review comment in 2008
- Internal review from the Service's Southwest and Mountain-Prairie Regions in 2010

The result is a high-quality blueprint for the recovery of the Mojave population of the desert tortoise. The many individuals involved in this effort, both those providing input and those responding to input, deserve thanks and praise for a job well-done.

Development of the plan has been a dynamic process that has evolved over time. And because land use change and desert tortoise recovery implementation will continue to evolve, the Final Plan is being published as a living document which will similarly evolve in the future. For example, when Plan revision began we did not anticipate the extent to which the landscape of desert ecosystems in the Pacific Southwest might become modified as a result of the nation's renewable energy priorities (since 2009, an emphasis on renewable energy has resulted in a large increase in the number of proposed utility-scale projects within the range of the desert tortoise in California). This relatively new emphasis is the result of Presidential, Congressional, and Secretarial priorities. The President has placed a priority on investing in renewable energy in order to put America back in the lead of the global clean energy economy, create millions of jobs over time, and reduce our dependence on foreign fuel. The President's New Energy for America Plan sets a target of ensuring that10 percent of electricity will be generated from renewable sources by 2012 and 25 percent of electricity will be generated from renewable sources by 2025. Section 211, of the Energy Policy Act of 2005 provides that the Secretary of the Interior should, within 10 years of enactment of the Act, "…seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity". On February 14, 2009, Congress passed the American Recovery and Reinvestment Act which included more than $80 billion to generate renewable energy while creating new, sustainable jobs. And on March 11, 2009, Secretary Salazar issued his first

Secretarial Order making the production, development, and delivery of renewable energy a top priority for the department.

In the Plan, renewable energy development is discussed in a number of locations. Discussions under "Reasons for Listing and Continuing Threats, Factor A" and "Appendix A, Section A8" identify the threat of large-scale energy development and the potential impacts to desert tortoises and their habitat. Such impacts could be realized through habitat fragmentation, isolation of desert tortoise conservation areas, and the subsequent possibility of restricted gene flow between these areas. Implementation of a number of the recommended Recovery Actions, as articulated throughout the Plan, would make progress towards reducing threats associated with energy development:

- *Recovery Action 2.1, Conserve intact desert tortoise habitat* - Recommends that solar project facilities be sited outside Desert Wildlife Management Areas and Areas of Critical Environmental Concern, as well as the development of a cumulative impacts assessment to identify mitigation measures for this type of activity.
- *Recovery Action 2.9, Secure lands/habitat for conservation* - Recommends conserving sensitive areas that would connect functional habitat or improve management capability of surrounding areas, such as inholdings within tortoise conservation areas that may be open to renewable energy development.
- *Recovery Action 2.11, Connect functional habitat* - Recommends connecting blocks of desert tortoise habitat, such as tortoise conservation areas, in order to maintain gene flow between populations.
- *Recovery Action 4.3, Track changes in the quantity and quality of desert tortoise habitat* - Recommends quantifying the loss or restoration of habitat as it relates to potential energy and other projects.
- *Recovery Action 5.5, Determine the importance of corridors and physical barriers to desert tortoise distribution and gene flow* - This action, in part, would determine the effects of corridors and barriers like energy development, on desert tortoise movement and recovery.

Similarly, Strategic Element 1 in the Plan's "Recovery Strategy" specifies that activities of implementation teams at the local level will be coordinated with landscape and regional-level alternative-energy coordination efforts.

Still, the plan does not provide a single, comprehensive strategy for addressing renewable energy. To more comprehensively address this threat, the Service will soon add a renewable energy chapter to the living Plan that will act as a blueprint to allow the Service and our partners to comprehensively address renewable energy development and its relationship to desert tortoise recovery. This supplemental chapter will focus on renewable energy in a manner that could not have been envisioned when Plan revision began. The supplemental renewable energy chapter will make clear what recovery implementation will look like in light of renewable energy development and will provide specific recommendations to ensure recovery and continued habitat connectivity in light of such development. Given that, strategies for recovery implementation may be modified in the future. The chapter will reconcile recovery efforts with:

- Landscape level effects of renewable energy development on the desert tortoise. This includes identifying how such development may contribute to tortoise habitat loss and/or fragmentation.
- The role that desert tortoise translocation may play in mitigating potential impacts to desert tortoises as a result of renewable energy development.
- Other ongoing conservation strategies that have run parallel to Plan development (for example, the Desert Renewable Energy Conservation Plan, and the Bureau of Land Management's Solar Programmatic Environmental Impact Statement) to ensure that desert tortoise recovery moves forward in a well-coordinated manner.

In the U.S. Fish and Wildlife Service, Pacific Southwest Region, we are firmly committed to ensuring that responsible renewable energy development moves forward in a manner that concurrently addresses both the recovery concerns of desert tortoises and the broader conservation of desert ecosystems in the Pacific Southwest.

Ren Lohoefener
Regional Director
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Disclaimer

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and other affected and interested parties. 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 obligate other parties to undertake specific actions and may not represent the views nor the official positions or approval of any individuals or agencies involved in recovery plan formulation, other than our own. They represent our official position *only* after they have been signed by the Regional Director or Director as *approved*. Recovery plans are reviewed by the public and submitted to peer review before we adopt them as approved final documents. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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PLAN PREPARATION

This Recovery Plan was prepared by the Desert Tortoise Recovery Office with advice from the Desert Tortoise Science Advisory Committee and assistance from the Redlands Institute at the University of Redlands.

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EXECUTIVE SUMMARY

CURRENT SPECIES STATUS

The Mojave population of the desert tortoise (*Gopherus agassizii*) (all tortoises north and west of the Colorado River in Arizona, Utah, Nevada, and California) was listed as Threatened on April 2, 1990. A recovery plan was published in June 1994 together with a supplement identifying proposed Desert Wildlife Management Areas. Critical habitat was also designated in 1994 in all four states supporting the species. Based on information in this recovery plan, the recovery priority number is classified as 12C and is predicated upon a) a moderate degree of threat, which, although increased since 1994, does not place the species at imminent risk of extinction; b) a low potential for recovery, adjusted based on current uncertainties about various threats and our ability to manage them; c) listed population below the species level; and d) potential conflict with development or other forms of economic activity. We anticipate that implementation of this revised recovery plan will resolve key uncertainties about threats and management, thereby improving recovery potential.

HABITAT REQUIREMENTS AND LIMITING FACTORS

Desert tortoises occupy a variety of habitats from flats and slopes dominated by creosote bush scrub at lower elevations to rocky slopes in blackbrush and juniper woodland ecotones at higher elevations. Desert tortoises occur from below sea level to an elevation of 2,225 meters (7,300 feet). Throughout most of the Mojave Desert, tortoises occur most commonly on gently sloping terrain with sandy-gravel soils and where there is sparse cover of low-growing shrubs, which allows establishment of herbaceous plants. Soils must be friable enough for digging of burrows, but firm enough so that burrows do not collapse. Typical habitat for the desert tortoise in the Mojave Desert has been characterized as creosote bush scrub below 1,677 meters (5,500 feet), where precipitation ranges from 5 to 20 centimeters (2 to 8 inches), the diversity of perennial plants is relatively high, and production of ephemerals is high.

The vast majority of threats to the desert tortoise or its habitat are associated with human land uses. The threats identified in the 1994 Recovery Plan formed the basis for listing the tortoise as a threatened species and continue to affect the species today. However, despite clear demonstration that these threats impact individual tortoises, there are few data available to evaluate or quantify the effects of threats on desert tortoise populations. While current research results can lead to predictions about how local tortoise abundance should be affected by the presence of threats, quantitative estimates of the magnitude of these threats, or of their relative importance, have not yet been developed. Thus, a particular threat or subset of threats with discernable solutions that could be targeted to the exclusion of other threats has not been identified for the desert tortoise. In this revised recovery plan, we underscore the need to build on our understanding of individual threats, yet place new emphasis on understanding their multiple and synergistic effects due to the failure of simple threat models to inform us about tortoise abundance.

The desert tortoise requires 13 to 20 years to reach sexual maturity, has low reproductive rates during a long period of reproductive potential, and individuals experience relatively high mortality early in life. These factors make recovery of the species difficult. Even moderate downward fluctuations in adult survival rates can result in rapid population declines. Thus, high survivorship of adult desert tortoises is critical to the species' persistence, and the slow growth rate of populations can leave them susceptible to extirpation events in areas where adult survivorship has been reduced. Another factor integral to desert tortoise recovery is maintaining the genetic variability of the species and sufficient ecological heterogeneity within and among populations to allow tortoises to adapt to changes in the environment over time. Because desert tortoises occupy large home ranges, the long-term persistence of extensive, unfragmented habitats is essential for the survival of the species. The loss or degradation of these habitats to urbanization, habitat conversion from frequent wildfire, or other landscape-modifying activities place the desert tortoise at increased risk of extirpation.

RECOVERY STRATEGY

The 1994 Recovery Plan described a strategy for recovering the desert tortoise, which included the identification of six recovery units, recommendations for a system of Desert Wildlife Management Areas within the recovery units, and development and implementation of specific recovery actions. Maintaining high survivorship of adult desert tortoises was identified as the key factor in recovery, and because the list of threats to the species remains mostly unchanged, the requisite management or recovery actions also remain appropriate. The most significant challenge in implementing the 1994 Recovery Plan was not the number or types of actions implemented, but rather the coordination, description, documentation, and evaluation of implementation of the actions. As a result, the revised strategy builds upon the foundation laid by the 1994 Recovery Plan by emphasizing partnerships to direct and maintain focus on implementing recovery actions and a system to track implementation and effectiveness of recovery actions. Strategic elements within a multi-faceted approach designed to improve the 1994 Recovery Plan are:

1. Develop, support, and build partnerships to facilitate recovery.

2. Protect existing populations and habitat, instituting habitat restoration where necessary.

3. Augment depleted populations in a strategic manner.

4. Monitor progress toward recovery.

5. Conduct applied research and modeling in support of recovery efforts within a strategic framework.

6. Implement a formal adaptive management program.

The Desert Tortoise Management Oversight Group will be the partnership (Element 1) responsible for providing "executive-level" support and direction for recovery implementation, thus tying the entire program together. Regional Recovery Implementation Teams will include a member of the Desert Tortoise Recovery Office to provide guidance and coordination to land/wildlife managers and stakeholders on the teams, which will be responsible for developing step-down recovery-action plans and implementing those actions on the ground. The adaptive management program (Element 6) provides a formal framework through which the partnerships can make better, more informed, and more explicit or structured decisions. Through the partnership and adaptive management elements, habitat management (Element 2) and population augmentation (Element 3) actions will be prioritized, implemented, and reported. Aggressive management needs to be applied within existing tortoise conservation areas, as defined herein, or other important areas identified by Recovery Implementation Teams. Monitoring (Element 4) effects of these specific actions, as well as progress toward overall recovery, will again feed into the adaptive management system and inform managers on recovery progress. Finally, applied research and modeling (Element 5) will help us better understand desert tortoise ecology and refine our goals and expectations of management actions.

RECOVERY GOALS, OBJECTIVES, AND CRITERIA

The goals of the recovery plan are recovery and delisting of the desert tortoise. The recovery criteria represent our best assessment of the conditions that would most likely result in a determination that delisting of the desert tortoise is warranted. Recovery criteria should ideally include the management or elimination of threats, addressing the five statutory (de-)listing factors. However, even though a wide range of threats affect desert tortoises and their habitat, very little is known about their demographic impacts on tortoise populations or the relative contributions each threat makes to tortoise mortality. Therefore, specific and meaningful threats-based recovery criteria cannot be identified at this time. In the meantime, we assume that threat mitigation will have been successful if the current recovery criteria have been met (taking into consideration any head-starting or translocation efforts). Specific recovery actions, including research, must be implemented to identify sets of threats that contribute to a greater number of mortality mechanisms or affect size structure or fecundity. As quantitative information on threats and tortoise mortality is obtained, more specific threats-based recovery criteria may be defined during future recovery plan review and revision.

Recovery Objective 1 (Demography). Maintain self-sustaining populations of desert tortoises within each recovery unit into the future.

Recovery Criterion 1. Rates of population change (λ) for desert tortoises are increasing (*i.e.*, $\lambda > 1$) over at least 25 years (a single tortoise generation), as measured

a) by extensive, range-wide monitoring across tortoise conservation areas within each recovery unit, and

b) by direct monitoring and estimation of vital rates (recruitment, survival) from demographic study areas within each recovery unit.

Recovery Objective 2 (Distribution). Maintain well-distributed populations of desert tortoises throughout each recovery unit.

Recovery Criterion 2. Distribution of desert tortoises throughout each tortoise conservation area is increasing over at least 25 years (*i.e.*, ψ [occupancy] > 0).

Recovery Objective 3 (Habitat). Ensure that habitat within each recovery unit is protected and managed to support long-term viability of desert tortoise populations.

Recovery Criterion 3. The quantity of desert tortoise habitat within each desert tortoise conservation area is maintained with no net loss until tortoise population viability is ensured. When parameters relating habitat quality to tortoise populations are defined and a mechanism to track these parameters established, the condition of desert tortoise habitat should also be demonstrably improving.

RECOVERY ACTIONS

The recovery actions for each strategic element are as follows:

1. Develop, Support, and Build Partnerships to Facilitate Recovery
- **1.1.** Establish regional, inter-organizational Recovery Implementation Teams to prioritize and coordinate implementation of recovery actions.

2. Protect Existing Populations and Habitat
- **2.1.** Conserve intact desert tortoise habitat.
- **2.2.** Minimize factors contributing to disease (particularly upper respiratory tract disease).
- **2.3.** Establish/continue environmental education programs.
- **2.4.** Increase law enforcement.
- **2.5.** Restrict, designate, close, and fence roads.
- **2.6.** Restore desert tortoise habitat.
- **2.7.** Install and maintain urban or other barriers.
- **2.8.** Sign and fence boundaries of sensitive or impacted areas.
- **2.9.** Secure lands/habitat for conservation.
- **2.10.** Restrict off-highway vehicle events within desert tortoise habitat.
- **2.11.** Connect functional habitat.
- **2.12.** Limit mining and minimize its effects.
- **2.13.** Limit landfills and their effects.
- **2.14.** Minimize excessive predation on tortoises.
- **2.15.** Minimize impacts to tortoises from horses and burros.
- **2.16.** Minimize impacts to tortoises from livestock grazing.

3. Augment Depleted Populations through a Strategic Program
- **3.1.** Develop protocols and guidelines for the population augmentation program, including those specific to head-starting and translocation.
- **3.2.** Identify sites at which to implement population augmentation efforts.
- **3.3.** Secure facilities and obtain tortoises for use in augmentation efforts.

3.4. Implement translocations in target areas to augment populations using a scientifically rigorous, research-based approach.

4. Monitor Progress toward Recovery
- **4.1.** Monitor desert tortoise population growth.
- **4.2.** Monitor the extent of tortoise distribution in each recovery unit.
- **4.3.** Track changes in the quantity and quality of desert tortoise habitat.
- **4.4.** Quantify the presence and intensity of threats to the desert tortoise across the landscape.

5. Conduct applied research and modeling in support of recovery efforts within a strategic framework
- **5.1.** Determine factors that influence the distribution of desert tortoises.
- **5.2.** Conduct research on the restoration of desert tortoise habitat.
- **5.3.** Improve models of threats, threat mitigation, and desert tortoise demographics.
- **5.4.** Conduct research on desert tortoise diseases and their effects on tortoise populations.
- **5.5.** Determine the importance of corridors and physical barriers to desert tortoise distribution and gene flow.

6. Implement an Adaptive Management Program
- **6.1.** Revise and continue development of a recovery decision support system.
- **6.2.** Develop/revise recovery action plans.
- **6.3.** Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions.
- **6.4.** Incorporate scientific advice for recovery through the Science Advisory Committee.

TOTAL ESTIMATED COST OF RECOVERY

$159,000,000 plus additional costs that cannot be estimated at this time.

DATE OF RECOVERY

If recovery actions are implemented promptly and are effective, including continued implementation of the current monitoring program which began in 2001, recovery criteria could be met by approximately 2025.

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I. BACKGROUND

A. INTRODUCTION

1. Listing History

We, the United States Fish and Wildlife Service, listed the desert tortoise (*Gopherus agassizii*) on the Beaver Dam Slope in Utah as Threatened under the Endangered Species Act of 1973, as amended, and designated critical habitat in 1980 (U.S. Fish and Wildlife Service [USFWS] 1980). In 1984, we were petitioned by the Defenders of Wildlife, Natural Resources Defense Council, and Environmental Defense Fund to list the species as Endangered. The following year, we determined that listing the desert tortoise as Endangered was warranted, but higher priorities precluded any action.

On August 4, 1989, new information on mortality resulted in the emergency listing of desert tortoises north and west of the Colorado River (excluding the Beaver Dam Slope) as Endangered (USFWS 1989). On April 2, 1990, we listed the entire Mojave population (all tortoises north and west of the Colorado River in Arizona, Utah, Nevada, and California) as Threatened (USFWS 1990), and a recovery plan was published in June 1994 (USFWS 1994a). Previously, the species had a recovery priority number of 8C, which, according to the Recovery Priority Criteria, is based on a) moderate degree of threat, b) high potential for recovery, c) taxonomic classification as a species, and d) potential conflict with development or other forms of economic activity (USFWS 1983). Based on updated information, the recovery priority number has been reclassified as 12C and is predicated upon a) a moderate degree of threat, which, although increased since 1994, does not place the species at imminent risk of extinction; b) a low potential for recovery, adjusted based on current uncertainties about various threats and our ability to manage them; c) listed population below the species level; and d) potential conflict with development or other forms of economic activity (USFWS 1983). With regard to the "low potential for recovery" as defined in the Recovery Priority Criteria, we anticipate that implementation of this revised recovery plan will resolve key uncertainties about threats and management, thereby improving recovery potential.

The 1994 Recovery Plan described a strategy for recovering the Mojave population of the desert tortoise, which included the identification of six recovery units, recommendations for a system of Desert Wildlife Management Areas (DWMAs) within the recovery units, and development and implementation of specific recovery actions, especially within DWMAs. Establishment of recovery units and DWMAs was intended, in part, to facilitate an ecosystem approach to land management and desert tortoise recovery, as stipulated by section 2(b) of the Endangered Species Act (USFWS 1994a).

2. Management

The Desert Tortoise Management Oversight Group was established in 1988 to coordinate agency planning and management activities affecting the desert tortoise and to implement the management actions in the Bureau of Land Management's Desert Tortoise Range-wide Plan

(Spang *et al*. 1988). Charter members of the Management Oversight Group included the four Bureau of Land Management State Directors from Arizona, California, Nevada, and Utah; the four State Fish and Game Directors from these States; the three Fish and Wildlife Service Regional Directors that share tortoise management responsibilities; and a Bureau of Land Management Washington Office representative. Membership was subsequently expanded to include representatives of the National Park Service, Biological Resources Division of the U.S. Geological Survey, and officials of the four branches of the military (Army, Air Force, Navy, and Marine Corps) that have Mojave tortoise habitat. County governments within the range of the desert tortoise were also included in 2007.

The original charter of the Management Oversight Group called for it to a) standardize procedures for the analysis and interpretation of tortoise information, b) report on management actions completed for the benefit of the desert tortoise, c) recommend funding priorities, d) identify areas lacking sufficient information for habitat management, e) identify research needs to resolve management issues, f) identify threats and conflicts, g) complete annual status or progress reports, h) coordinate existing laws and guidance, and i) review ongoing research. Subsequent to the listing of the Mojave population as Threatened and following the publication of the 1994 Recovery Plan, the Management Oversight Group assumed a leadership role in coordinating agency activities directed toward recovery plan implementation.

The California Desert Managers Group was organized to provide a forum for government agencies to work together to conserve and enhance the California deserts. The Desert Managers Group is comprised of State- and field-level managers from agencies and county governments with land and resource management or regulatory responsibilities in the California deserts. It also includes the U.S. Geological Survey, which serves in a scientific support role to the managers. The Group's 5-year plan includes several topics related to desert tortoise management.

Like the Desert Managers Group, the Southern Nevada Agency Partnership does not focus specifically on desert tortoise issues, but was formed as an interagency partnership to address various initiatives including litter clean-up, volunteerism, resource protection, recreation, science and research, outdoor recreation education, law enforcement, and other issues. This partnership is comprised of the Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service.

The Mojave Desert Initiative was formed among State and Federal agencies (Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, Department of Defense, and the three State wildlife agencies) from Arizona, Nevada, and Utah in 2007 in response to the vast wildfires that occurred in the region in 2005 and 2006. The Mojave Desert Initiative is directly related to desert tortoise management because it collaboratively focuses on the fire and invasive species cycle and strategically restores portions of the damaged ecosystem.

In Arizona, both the Mojave and Sonoran populations of desert tortoise are considered Species of Greatest Conservation Need under Arizona's Comprehensive Wildlife Conservation Strategy: 2005-2015 (Arizona Game and Fish Department 2006). Desert tortoises are also protected under the Arizona Revised Statutes Title 17 laws and the Reptile and Amphibian

Regulations, under which it has been unlawful to collect this species since 1989. In California, State laws have been in place since 1939 to protect the desert tortoise. The species was listed as Threatened under the California Endangered Species Act in 1989 and is considered a Species at Risk under California's Wildlife Action Plan (Bunn *et al.* 2006). The California Department of Fish and Game manages over 19,670 hectares (48,000 acres) of land for the conservation of the desert tortoise, and additional lands continue to be acquired as mitigation for projects that result in impacts to the species. In Nevada, the desert tortoise is protected under the Nevada Administrative Code 503.080, wherein the species is listed as a State-protected reptile further classified as Threatened, and collection is prohibited under section 503.093. The desert tortoise is also considered a Species of Conservation Priority under the Nevada Wildlife Action Plan (Abele *et al.* 2006), which is being implemented by the Nevada Department of Wildlife. Desert tortoises are listed as State Endangered in Utah, where collection and importation are prohibited. Possession is controlled, meaning one must have a Certificate of Registration prior to possession of an individual animal. The species is protected under the Utah Division of Wildlife Resources Administrative Rule R657-53 and is considered a Species of Greatest Conservation Need under the Utah Comprehensive Wildlife Conservation Strategy: 2005-2015 (Gorrell *et al.* 2005).

3. Recovery Plan Review and Revision

The U.S. General Accounting Office report, *Endangered Species: Research Strategy and Long-Term Monitoring Needed for the Mojave Desert Tortoise Recovery Program* (General Accounting Office [GAO] 2002), found that the listing decision, critical habitat designation, and recommendations in the 1994 Recovery Plan were reasonable, given the available information. Unfortunately, the effectiveness of actions implemented by Federal agencies and others to benefit desert tortoises was not monitored adequately and remains largely unknown. Because much was unknown about the severity of specific threats to desert tortoises at the time the plan was written, the recommendations were made without establishing priorities that would reflect differences in the seriousness of the threats. The General Accounting Office report recommended that we develop and implement a coordinated research strategy for linking land management decisions with research results. Without such a strategy, recovery of the desert tortoise would be left to chance rather than to informed decisions based on science. In response, we initiated an in-depth review of the 1994 Recovery Plan.

In March 2003, we impaneled the Desert Tortoise Recovery Plan Assessment Committee to conduct a thorough review of the Recovery Plan in the context of scientific and analytical advances made since its publication in 1994. The assessment (Tracy *et al.* 2004) concluded that the 1994 Recovery Plan was fundamentally strong but could benefit substantially from modification. The assessment also identified strategies that would promote a more cohesive, scientifically powerful recovery program. Taking recommendations of the General Accounting Office report and 2004 assessment, we established the Desert Tortoise Recovery Office (DTRO) in 2004. The DTRO's staff focuses solely on the desert tortoise and its recovery. The DTRO coordinates recovery planning and implementation, research, monitoring, and recovery permitting, while working closely with those Fish and Wildlife Service biologists working on regulatory issues. The DTRO assists in coordination among land managers, research scientists, the interagency Desert Tortoise Management Oversight Group, the California Desert Managers

Group, and other local, state, or regional working groups. To complement the DTRO, we appointed a Desert Tortoise Science Advisory Committee in 2005. This committee was composed of seven scientists from diverse yet highly relevant backgrounds (see Plan Preparation) who are charged with providing recommendations relative to desert tortoise recovery implementation and approach, such that rigorous scientific standards are met. The scope of the Science Advisory Committee's recommendations to date has included recovery criteria, threats assessment, effectiveness monitoring, and key research priorities.

Based on recommendations in the recovery plan assessment, the Desert Tortoise Management Oversight Group recognized that the 1994 Recovery Plan should be revised with collaboration from scientists, managers, and stakeholders (Tracy *et al*. 2004), and an assessment of stakeholder input on recovery planning for the desert tortoise was conducted (U.S. Institute for Environmental Conflict Resolution and Center for Collaborative Policy 2006). To allow for broad participation, the Science Advisory Committee formed the base team for the scientific foundations, while government and non-government stakeholders were invited to participate and engage on management issues through various workshops, open houses, and review drafts of this plan. Thus, a collaborative effort resulted in this revised recovery plan for the Mojave population of the desert tortoise.

B. SPECIES DESCRIPTION AND TAXONOMY

The desert tortoise is a large, herbivorous (plant-eating) reptile that occurs in the Mojave and Sonoran deserts in southern California, southern Nevada, Arizona, and the southwestern tip of Utah in the U.S., as well as Sonora and northern Sinaloa in Mexico. The designated Mojave population of the desert tortoise includes those animals living north and west of the Colorado River in the Mojave Desert of California, Nevada, Arizona, and southwestern Utah, and in the Sonoran (Colorado) Desert in California (USFWS 1990; USFWS 1994a).

The generic assignment of the desert tortoise has gone through a series of changes since its original description by Cooper (1863) as *Xerobates agassizii*. It has also been referred to in the literature as *Scaptochelys agassizii*. Currently, the accepted scientific name is *Gopherus agassizii* (Crumly 1994). Differentiation between the Mojave and Sonoran assemblages of the desert tortoise are supported via multiple forms of evidence, including morphology, ecology, and genetics (Weinstein and Berry 1987; Lamb *et al.* 1989; Lamb and Lydehard 1994; Berry *et al.* 2002a; Van Devender 2002a,b; Murphy *et al*. 2007). Although fewer data are available to compare Sinaloan desert tortoises to the Sonoran and Mojave assemblages, the Sinaloan population is considerably more isolated, and differentiation in mitochondrial DNA is considerable (Lamb *et al.* 1989; Van Devender 2002b).

Desert tortoises reach 20 to 38 centimeters (8 to 15 inches) in carapace (upper shell) length and 10 to 15 centimeters (4 to 6 inches) in shell height. Hatchlings emerge from eggs at about 5 centimeters (2 inches) in length. Adults have a domed carapace and relatively flat, unhinged plastrons (lower shell). Their shells are greenish-tan to dark brown in color with tan scute (horny plate on the shell) centers. Adult desert tortoises weigh 3.6 to 6.8 kilograms (8 to 15 pounds). The forelimbs have heavy, claw-like scales and are flattened for digging. Hind limbs are more elephantine (Ernst and Lovich 2009).

Two other tortoise species in the genus *Gopherus* occur in the United States, and another occurs in Mexico. The Texas tortoise (*Gopherus berlandieri*) occurs in southern Texas and northeastern Mexico, and the gopher tortoise (*Gopherus polyphemus*) occurs in southwestern South Carolina, Florida, Georgia, Alabama, Mississippi, Louisiana, and extreme southeastern Texas. The Mexican species is the Bolson tortoise (*Gopherus flavomarginatus*), which is found in a very small area in Chihuahua and Durango, Mexico. The desert tortoise is distinguished from the other three species by a combination of characters that are described in detail in the final listing rule and 1994 Recovery Plan (USFWS 1990; USFWS 1994a). For additional information regarding the morphological characteristics and distinguishing features of these species, refer to Ernst and Lovich (2009) and the references cited therein.

Although there are significant differences genetically and ecologically, desert tortoises that belong to the Sonoran population could be confused visually with tortoises of the Mojave population. Because there are only minor visual differences between the animals in these populations, we determined at the time of listing that the Sonoran population also warranted protection as a threatened species under section 4(e) of the Endangered Species Act (similarity of appearance) when located outside of its natural range. This level of protection eliminates the need for law enforcement personnel to determine the origin of each individual when conducting enforcement activities under section 9 of the Endangered Species Act (USFWS 1990).

C. POPULATION TRENDS AND DISTRIBUTION

Before the 1970s, there was a limited amount of research directed at desert tortoise ecology, and there are correspondingly few sources of information about population sizes. Berry (1984a) used anecdotal accounts and interviews of long-time desert residents to portray the spatial distribution and relative numbers of tortoises in California during the period from 1920 to 1960. Acknowledging that historical numbers of tortoises will remain speculative, her summary concluded that tortoise range had contracted in some areas and that densities had decreased in many areas of the California deserts.

In the 1970s, the California desert region became the focus of more wide-spread efforts to describe distribution and numbers (GAO 2002; Tracy *et al.* 2004). The largest of these efforts was launched to aid Bureau of Land Management planning (Berry and Nicholson 1984a). These surveys were conducted using strip transects, which are also referred to in the literature as “triangular transects” because the total strip length is walked as an equilateral triangle. This became the most prevalent method for estimating tortoise numbers in local areas for the next few decades.

Tortoises are rarely encountered for the large amount of effort expended, so these triangular transect surveys relied on counts of more prevalent accumulated tortoise sign (primarily burrows, scat [droppings], and shells). These sign counts were then adjusted to avoid overcounting evidence in those instances when more than one form of sign were found together (scat in a burrow, for instance). Adjusted sign counts are referred to as "total corrected sign" (TCS). In order to translate TCS into a number of tortoises present, the method relied on existence of 2.6-kilometer^2 (1-mile^2) plots on which the number of tortoises was estimated using mark-recapture techniques. Surveyors walked triangular transects in both the survey area and in one or more of these study plots with more closely estimated tortoise numbers. For each surveyor, a relationship was estimated between TCS and tortoise numbers on the study plots; this relationship was applied to all areas where the surveyor collected data.

Data for the original Bureau of Land Management planning effort for the California Desert District came from over 1,000 such triangular transect surveys conducted between 1978 and 1983 and were used to build a reference map based on five classes of estimated abundance (0-20, 21-50, 51-100, 101-250, > 250 tortoises/mile^2 [tortoises/2.6 kilometer^2]; Berry and Nicholson 1984a). The use of classes was in part an acknowledgment that the count estimates were very imprecise. To make efficient use of resources for the planning effort, most transects were placed in areas with vegetation and slope characteristics that were expected to support desert tortoises. Transects were spaced to cover larger areas fairly evenly, and were set away from dirt roads and even farther from paved roads. Study plots for estimating tortoise numbers more accurately were set up for the first time during this study, and a set of permanent (long-term) study plots were selected from these to be followed over the years. Whereas the original study plots were placed in areas expected to host tortoises (Berry and Nicholson 1984a), only plots in higher-density areas were considered for use as long-term study plots for surveys at various intervals from 1979 through the present, and work at low-density plots was discontinued (Berry 1984b; K. Berry, U.S. Geological Survey, pers. comm. 2003, as reported in Tracy *et al.* 2004).

A total of 31 long-term study plots were in place range-wide when the desert tortoise was first listed under the Endangered Species Act (Tracy *et al.* 2004). The first long-term plot using 60-day mark-recapture estimation was established in 1976 and 1977 in California, but this technique was not implemented until later in Nevada and Utah (1981) and Arizona (1987). Because of the level of effort required, plots were resurveyed only every several years. While a substantial body of data has been collected from surveys of the original long-term study plots over the years, plot placement in non-representative (non-random) areas across the range is generally regarded as a factor limiting demographic and trend conclusions only to those specific areas.

In the 1994 Recovery Plan, we recommended using sampling plots to estimate abundance of desert tortoises (USFWS 1994). These plots were to cover at least 5 percent of each DWMA and be surveyed within a 3-year timeframe, after which a new set of plots was to be randomly selected. Preliminary study and additional scientific input resulted in the determination that this method was unreliable at the range-wide level, and it was never fully implemented. Subsequent efforts to develop a more robust method were hampered by the lack of funding and a designated coordinator (GAO 2002). By the time the General Accounting Office (2002) and Tracy *et al.* (2004) assessments were published, there were 49 long-term study plots in existence, but both of these reports concluded that it was not appropriate to extrapolate data from these plots to serve as a range-wide population baseline from which to assess recovery.

In the late 1990s, the Bureau of Land Management launched a second set of TCS surveys to update information from the original (Berry 1984c) description of tortoise distribution and abundance in California. This effort was part of preparations for its West Mojave Plan (Bureau of Land Management [BLM] *et al.* 2005) and was preceded by a set of analyses on the efficacy of TCS counts (BLM *et al.* 2005, Appendix K). The analyses concluded that although the predicted relationship between sign and tortoise counts was consistent, the correlation was relatively low and was only significant with large sample sizes. The low correlation meant that TCS was not reliably associated with tortoise numbers and was very likely to give an incorrect estimate of abundance class in a given survey. Further, the correlation between TCS and tortoise abundance was based primarily on burrow sign. Scat sign, which is much more common than burrows, was much less reliable at predicting tortoise counts, and shell counts were not correlated with live tortoise abundance. The analyses also noted that observers were similar in their reporting of burrow counts in any given study plot, whereas they usually differed in their counts of scat. For the above reasons, TCS data were used as an index of tortoise abundance, with relative sign counts assumed to reflect relative tortoise densities. For this planning effort, TCS were not used to estimate actual tortoise numbers.

In addition to data from the long-term study plots, Tracy *et al.* (2004) considered evidence from TCS and line distance surveys (see below). Similar to the case of BLM *et al.* (2005), they did not use the TCS data to estimate abundance, but to describe presence/failure to detect. They used a single year of tortoise observations collected along 2,977 kilometers (1,850 miles) of line distance transects in 2001 to assess the combined distribution of live and dead tortoises. Their preliminary spatial analyses revealed areas with higher probabilities of encountering both live and dead tortoises. In the western Mojave, Tracy *et al.* (2004) used logistic regression and kernel analyses (types of statistical analyses) to indicate areas with concentrations of dead tortoises without corresponding concentrations of live tortoises. These generally encompassed areas where declines had been reported in earlier studies, namely the northern portion of the Fremont-Kramer critical habitat unit and the northwestern part of the Superior-Cronese critical habitat unit. Using kernel analysis with limited data, Tracy *et al.* (2004) also described large areas where dead tortoises, but no live tortoises, were observed in the Piute-Eldorado Valley and northern Coyote Springs Valley, Nevada, and in the western and southern portions of the Ivanpah Valley, California. All of these areas are within designated critical habitat. Although they were able to make qualitative conclusions (conclusions not expressed in terms of quantity) about population trends in individual recovery units, Tracy *et al.* (2004) also concluded that estimating accurate, historic long-term trends of desert tortoise populations, habitat, and/or threats across the range was not feasible based on the combined suite of existing data and analyses.

Together, these data provide qualitative - not quantitative - insight into the range-wide status of the species and show appreciable declines at the local level in many areas (Berry 1984a, Luke *et al.* 1991; Berry 2003; Tracy *et al.* 2004). Tracy *et al.* (2004) concluded that the apparent downward trend in desert tortoise populations in the western portion of the range that was identified at the time of listing was valid and ongoing. Results from other portions of the range were inconclusive, but surveys of some populations found too few tortoises to produce population estimates (*e.g.*, 2000 survey of the Beaver Dam Slope, Arizona), suggesting that declines may have occurred more broadly.

Based on the 25-year horizon of the recovery criteria in the 1994 Recovery Plan (USFWS 1994a), a long-term monitoring program for the desert tortoise was implemented in 2001 (1999 in the Upper Virgin River Recovery Unit; McLuckie *et al.* 2002). This program was the first comprehensive effort undertaken to estimate densities across the range of the listed population (Table 1; USFWS 2006; USFWS 2009a) and continues today. The monitoring strategy uses annual range-wide surveys on line distance transects, with effort levels designed to detect long-term population trends. Long-term trends are expected to be relatively gradual; therefore, increasing trends over shorter time periods (*e.g.*, 2001 to 2005) would not be detectable. Over short periods of time, only catastrophic declines or remarkable population increases would be noticeable. Therefore, the first five years of the long-term monitoring project provided information on initial densities and annual and regional (between recovery unit) variability, but did not describe any meaningful population trends (USFWS 2006).

Density estimates of adult tortoises varied among recovery units and years. Over the first six years of range-wide monitoring (2001-2005, 2007), tortoises were least abundant in the Northeast Mojave Recovery Unit (1 to 3.7 tortoises per kilometer^2 [2 to 10 tortoises per mile^2]; USFWS 2009a), and the highest reported densities occurred in the Upper Virgin River Recovery Unit (15 to 27 tortoises per kilometer^2 [38 to 69 tortoises per mile^2]; McLuckie *et al.* 2007). Considerable decreases in density were reported in 2003 in the Eastern Colorado and Western Mojave recovery units (USFWS 2006). However, the variability between annual estimates among all years (Table 1) is consistent with variability due to sampling between years; only after several years of consistent patterns will the range-wide approach distinguish population trends from the variability due to sampling. Beyond noting that no range-wide population losses or gains were detected, inferences as to the meaning of these first years of data would be premature.

Please refer to *The Status of the Desert Tortoise (*Gopherus agassizii*) in the United States* (Berry 1984c) and the *Desert Tortoise Recovery Plan Assessment* (Tracy *et al.* 2004) for a detailed description of the methods and population trend and distribution analyses described above. In addition, *Range-wide Monitoring of the Mojave Population of the Desert Tortoise: 2007 Annual Report* (USFWS 2009a) provides information regarding the current monitoring effort.

Table 1. Summary of density estimates for each of the 1994-designated recovery units. "Adult tortoises" is the number of adults and subadults (midline carapace length ≥180mm). See USFWS (2006a, 2009a) for additional details.

Recovery Unit	**Year**	**No. of Transects**	**Length (km)**	**Adult Tortoises**	**Density (km^2)**	**Coefficient of Variation (%)**	**95% Confidence Interval**	
							Low	**High**
Northeast Mojave	2001	136	254.8	9	2.4	34.8	1.2	4.6
	2002	75	293.2	3	--[1]			
	2003	189	699.2	39	3.7[1]	43.1	1.5	8.3
	2004	96	947.3	18	1.2[1]	30.1	0.7	2.2
	2005	166	1754.4	40	1.8	25.8	1.1	3.0
	2007	240	2316.1	46	1.7	25.0	1.0	2.7
Eastern Mojave	2001	224	371.6	17	6.2	46.6	2.6	14.9
	2002	284	1120.4	56	4.1	22.1	2.6	6.2
	2003	59	215.1	11	--[1]			
	2004	140	1511.2	113	5.3	20.0	3.6	7.7
	2005	165	1839.5	108	7.2	20.1	4.9	10.7
	2007	76	803.9	40	5.8	25.0	3.6	9.3
Eastern Colorado	2001	205	328.0	54	10.1	18.3	7.0	14.4
	2002	104	416.7	42	7.7	28.8	4.4	13.4
	2003	108	431.7	32	4.0	22.7	2.6	6.3
	2004	132	1414.0	102	6.4	28.9	3.7	11.2
	2005	91	1094.3	74	7.9	26.7	4.7	13.2
	2007	100	1151.7	59	5.0	22.6	3.2	7.7
Northern Colorado	2001	201	321.6	39	7.2	22.6	4.6	11.2
	2002				--[1]			
	2003	112	445.2	54	6.3	20.6	4.2	9.3
	2004	76	835.9	79	6.9	22.8	4.5	10.8
	2005	94	1128.8	94	10.8	29.9	6.1	19.1
	2007	15	180.0	7	4.6	43.4	2.0	10.3
Western Mojave	2001	865	1384.0	160	5.6	13.8	4.3	7.4
	2002	547	2176.8	188	5.8	24.2	3.7	9.3
	2003	522	2083.2	218	3.8	10.6	3.0	4.6
	2004	166	1867.9	133	4.4	13.0	3.4	5.6
	2005	229	2746.6	173	6.1	17.2	4.4	8.5
	2007	97	1150.6	49	4.7	30.8	2.6	8.5
Upper Virgin River[2]	1999	158	306.5	168	27.3	14.8	20.4	36.5
	2000	153	301.9	170	28.1	14.2	21.2	37.1
	2001	159	313.8	169	26.8	13.4	20.6	39.9
	2003	157	309.1	97	15.6	12.8	12.1	20.1
	2005	155	304.5	151	24.7	12.6	19.3	31.7
	2007	157	308.3	92	14.9	13.7	11.3	19.5

[1]In the Northeastern Mojave, there are four long-term monitoring strata. Only one stratum could be analyzed in 2002, while in 2003 and 2004, three of the four could be analyzed. No recovery unit estimate is provided for 2002, and the 2003 and 2004 estimates are based on three of four strata. In the Eastern Mojave, only one of the three strata was surveyed in 2003, so no estimate is provided for the recovery unit. The single stratum in the Northern Colorado Recovery Unit was not surveyed in 2002.
[2]Data from McLuckie *et al.* (2007).

D. LIFE HISTORY AND ECOLOGY

Desert tortoises are well adapted to living in a highly variable and often harsh desert environment. They spend much of their lives in burrows, even during their seasons of activity. In late winter or early spring, they emerge from over-wintering burrows and typically remain active through fall. Activity decreases in summer, but tortoises often emerge after summer rain storms. Mating occurs during spring, summer, and fall (Black 1976; Rostal *et al.* 1994). During activity periods, desert tortoises eat a wide variety of herbaceous vegetation, particularly grasses and the flowers of annual plants (Berry 1974; Luckenbach 1982; Esque 1994). During periods of inactivity, they reduce their metabolism and water loss 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 and can apparently tolerate large imbalances in their water and energy budgets (Nagy and Medica 1986; Peterson 1996a,b; Henen *et al.* 1998).

The size of desert tortoise home ranges varies with respect to location and year (Berry 1986) and also serves as an indicator of resource availability and opportunity for reproduction and social interactions (O'Connor *et al.* 1994). Females have long-term home ranges that may be as little as or less than half that of the average male, which can range to 80 or more hectares (200 acres) (Burge 1977; Berry 1986; Duda *et al*. 1999; Harless *et al*. 2009). Core areas used within tortoises' larger home ranges depend on the number of burrows used within those areas (Harless *et al*. 2009). Over its lifetime, each desert tortoise may use more than 3.9 square kilometers (1.5 square miles) of habitat and may make periodic forays of more than 11 kilometers (7 miles) at a time (Berry 1986).

In drought years, the ability of tortoises to drink while surface water is available following rains may be crucial for survival (Nagy and Medica 1986). During unfavorable periods, desert tortoises decrease surface activity and remain mostly inactive or dormant underground (Duda *et al.* 1999), which reduces water loss and minimizes energy expenditures (Nagy and Medica 1986). Duda *et al.* (1999) showed that home range size, number of different burrows used, average distances traveled per day, and levels of surface activity were significantly reduced during drought years.

Tortoises are long-lived and grow slowly, requiring 13 to 20 years to reach sexual maturity, and have low reproductive rates during a long period of reproductive potential (Turner *et al.* 1984; Bury 1987; Germano 1994). Growth rates are greater in wet years with higher annual plant production (*e.g.*, an average of 12.3 millimeters [0.5 inches] in an El Niño year compared to 1.8 millimeters [0.07 inches] in a drought year in Rock Valley, Nevada; Medica *et al*. 1975). The number of eggs (1-10) as well as the number of clutches (0-3; set of eggs laid at a single time) that a female desert tortoise can produce in a season is dependent on a variety of factors including environment, habitat, availability of forage and drinking water, and physiological condition (Turner *et al.* 1986, 1987; Henen 1997; Mueller *et al*. 1998; McLuckie and Fridell 2002). Success rate of clutches has proven difficult to measure, but predation appears to play an important role in clutch failure (Germano 1994). Bjurlin and Bissonette (2004) found that nest predation was highly variable. They surmised that regular presence of researchers may facilitate predator detection of desert tortoises and that systematic studies should be undertaken to better understand predator behavior as it relates to research activities (Bjurlin and Bissonette 2004).

The most complete account of the biology, ecology, and natural history of a population of desert tortoises is that of Woodbury and Hardy (1948), wherein details regarding reproduction, growth and development, longevity, food habits, behavior, movement patterns, and general adaptations to desert conditions are provided for a population on the Beaver Dam Slope of Utah. These characteristics of tortoises do vary with changes in habitat and environment, and further information on the range, biology, and ecology of the desert tortoise is available in Bury (1982), Bury and Germano (1994), Ernst and Lovich (2009), Van Devender (2002c), and collected papers in Chelonian Conservation and Biology (2002, Vol. 4, No. 2), Herpetological Monographs (1994, No. 8), and the Desert Tortoise Council Proceedings.

E. HABITAT CHARACTERISTICS

The desert tortoise occurs in the broadest latitudinal range, climatic regimes, habitats, and biotic regions of any North American tortoise species (Auffenberg and Franz 1978; Bury 1982; Patterson 1982; Bury *et al.* 1994; Germano 1994). The species occupies a variety of habitats from flats and slopes typically characterized by creosote bush scrub dominated by *Larrea tridentata* (creosote bush) and *Ambrosia dumosa* (white bursage) at lower elevations to rocky slopes in blackbrush scrub and juniper woodland ecotones (transition zone) at higher elevations (Germano *et al.* 1994). Throughout most of the Mojave Desert, tortoises occur most commonly on gently sloping terrain with sandy-gravel soils and where there is sparse cover of low-growing shrubs, which allows establishment of herbaceous (non-woody) plants (Germano *et al.* 1994; USFWS 1994a). However, surveys at the Nevada Test Site revealed that tortoise sign (*e.g.*, scat, burrows, tracks, shells) was more abundant on upper alluvial fans and low mountain slopes than on the valley bottom (Rautenstrauch and O'Farrell 1998). Soils must be friable (easily crumbled) enough for digging burrows, but firm enough so that burrows do not collapse (USFWS 1994a). During the winter, tortoises will opportunistically use burrows of various lengths, deep caves, rock and caliche crevices, or overhangs for cover (Bury *et al.* 1994).

Records of desert tortoises range from below sea level to an elevation of 2,225 meters (7,300 feet) (Luckenbach 1982). Typical habitat for the desert tortoise in the Mojave Desert has been characterized as creosote bush scrub below 1,677 meters (5,500 feet) in which precipitation ranges from 5 to 20 centimeters (2 to 8 inches), where a diversity of perennial plants is relatively high, and production of ephemerals is high (Luckenbach 1982; Turner 1982; Turner and Brown 1982; Bury *et al*. 1994; Germano *et al.* 1994).

The Mojave Desert is relatively rich in winter annuals, which serve as an important food source for the desert tortoise. Tortoises will also forage on perennial grasses, woody perennials, and cacti as well as non-native species such as *Bromus rubens* (red brome) and *Erodium cicutarium* (red-stem filaree). Ninety percent of the precipitation that facilitates germination of important forage species for desert tortoise occurs in winter and sometimes in the form of snow (Germano *et al.* 1994). Tortoises in the eastern Mojave Desert are more likely to be subjected to freezing winter temperatures and prolonged drought than tortoises in the Sonoran Desert and Sinaloan region where freezing temperatures are rare and rainfall is more predictable (Germano 1994).

The U.S. Geological Survey developed a habitat model for the desert tortoise north and west of the Colorado River using 16 environmental variables such as precipitation, geology, vegetation, and slope (Figure 1) (Nussear *et al.* 2009). The model is based on desert tortoise occurrence data from sources spanning more than 80 years, especially including data from the 2001 to 2005 range-wide monitoring surveys (USFWS 2006), using 3,753 tortoise presence points to develop the model and 938 points to test the model.

The desert tortoise's range, outside the listed Mojave population, extends into the Sonoran Desert, where tortoises occur in the lower Colorado River valley, Arizona uplands, plains of Sonora, and the central Gulf Coast; the species has not been documented in northeastern Baja California (Germano *et al.* 1994). As in the Mojave Desert, *Larrea tridentata* is a dominant species in areas occupied by tortoises, although this dominance is tempered by the relatively high abundance of several tree species (Turner and Brown 1982; Germano *et al.* 1994). In the Sonoran Desert, tortoises tend to inhabit bajadas (slope at the base of a mountain) and

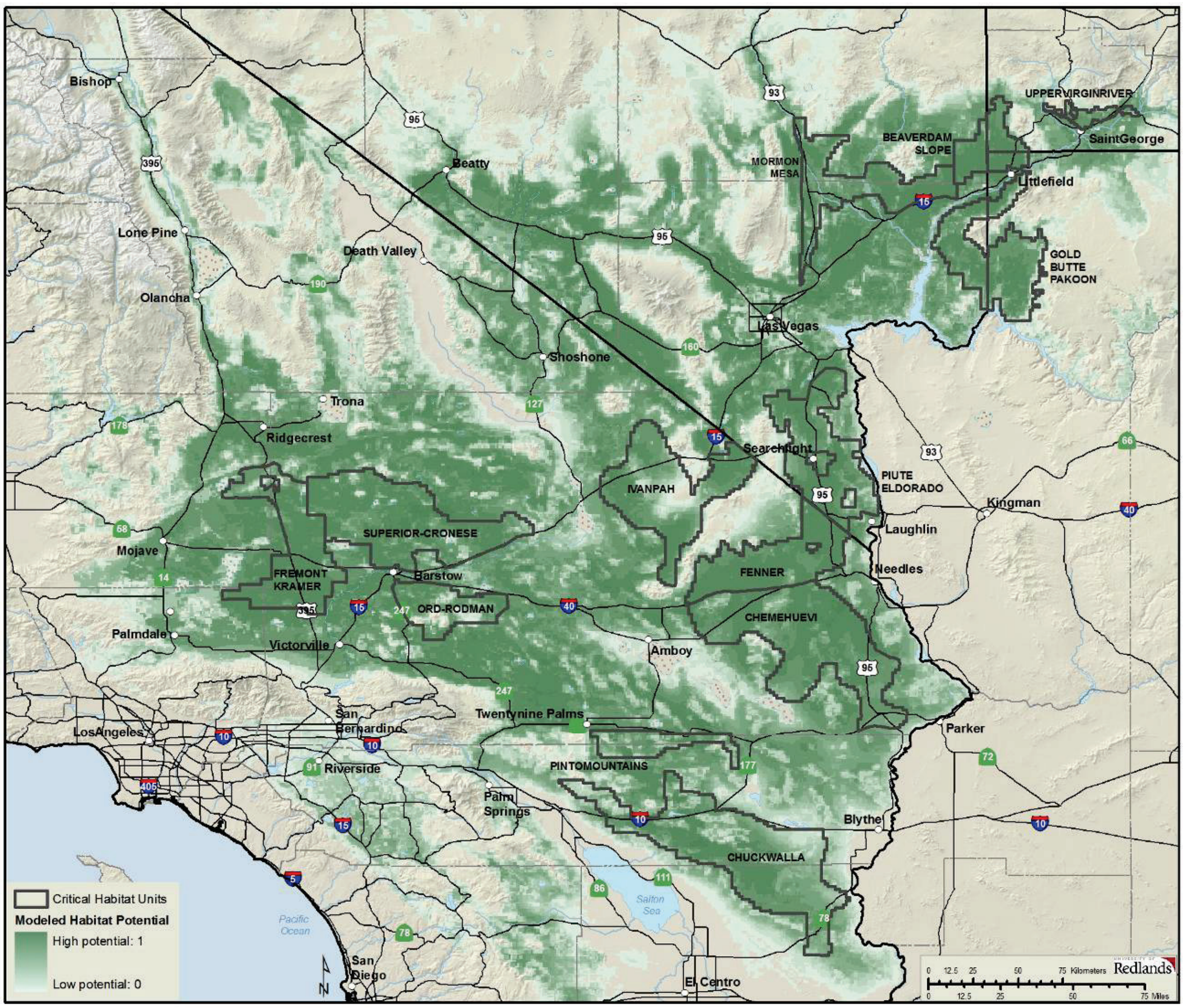

Figure 1. Desert tortoise critical habitat overlaid on the U.S. Geological Survey habitat model (Nussear *et al.* 2009).

steep, rocky slopes and are not common in the valleys (Germano 1994; Van Devender 2002a; Averill-Murray and Averill-Murray 2005). Desert tortoises are also found in the Sinaloan thornscrub, which is a transitional habitat between the Sonoran Desert and Sinaloan deciduous forest where the vegetation is dominated by drought-resistant shrubs and deciduous trees. The Sinaloan deciduous forests are differentiated from the thornscrub by taller plants with larger leaves and fewer thorny or succulent species (Germano *et al.* 1994; Fritts and Jennings 1994).

F. CRITICAL HABITAT

Under section 3 of the Endangered Species Act, **critical habitat** is defined as the specific areas supporting those physical and biological features that are essential for the conservation of the species and that may require special management considerations or protection (Box 1). The 1994 Recovery Plan identified general areas as proposed **Desert Wildlife Management Areas** where recovery efforts for the desert tortoise would be focused (Brussard *et al.* 1994; USFWS 1994a; Box 1). Based on the draft recovery plan, we designated critical habitat in February 1994, encompassing over 2,428,114 hectares (6,000,000 acres) in portions of the Mojave and Colorado deserts (Figure 1; Table 2). This designation includes primarily Federal lands in southwestern Utah, northwestern Arizona, southern Nevada, and southern California (USFWS 1994b).

Primary constituent elements for the desert tortoise are those physical and biological attributes that are necessary for the long-term survival of the species. These elements were identified as sufficient space to support viable populations within each of the six recovery units and to provide for movement, dispersal, and gene flow; sufficient quantity and quality of forage species and the proper soil conditions to provide for the growth of such species; suitable substrates for burrowing, nesting, and overwintering; burrows, caliche (hard layer of subsoil typically containing calcium carbonate) caves, and other shelter sites; sufficient vegetation for shelter from temperature extremes and predators; and habitat protected from disturbance and human-caused mortality (USFWS 1994b).

Table 2. Critical habitat by state and land management in hectares (1 hectare=2.47 acres); data from the Mojave Desert Ecosystem Program.

State / Management	Arizona	California	Nevada	Utah	Total
Bureau of Land Management	116,835	1,092,675	400,243	38,041	1,647,794
National Park Service	17,968	362,202	42,088		422,258
U.S. Fish and Wildlife			9,308		9,308
Bureau of Reclamation			1,350		1,350
Department of Defense		186,564			186,564
Department of Energy			202		202
Tribal Land				971	971
State Land	2,307	33,590		9,106	45,003
Private Land	1,012	243,221	41,279	4,006	289,518
Total	138,122	1,918,252	494,470	52,124	2,602,968

Box 1. Glossary of terminology relating to desert tortoise habitat:

Desert Wildlife Management Areas (DWMA) - General areas recommended by the 1994 Recovery Plan within which recovery efforts for the desert tortoise would be concentrated. DWMAs had no specific legal boundaries in the 1994 Recovery Plan. The Bureau of Land Management formalized the general DWMAs from the 1994 Recovery Plan through its planning process and administers them as Areas of Critical Environmental Concern (see below).

Critical Habitat – Specific, legally defined areas that are essential for the conservation of the desert tortoise, that support physical and biological features essential for desert tortoise survival, and that may require special management considerations or protection. Critical habitat for the desert tortoise was designated in 1994, largely based on proposed DWMAs in the draft Recovery Plan.

Area of Critical Environmental Concern (ACEC) – Specific, legally defined, Bureau of Land Management designation where special management is needed to protect and prevent irreparable damage to important historical, cultural, scenic values, fish and wildlife, and natural resources (in this case, the desert tortoise) or to protect life and safety from natural hazards. Designated critical habitat and ACEC boundaries generally, but not always, coincide along legal boundaries.

G. REASONS FOR LISTING AND CONTINUING THREATS

In determining whether to list, delist, or reclassify (change from endangered to threatened status, or *vice versa*) a taxon under the Endangered Species Act, we evaluate the role of five factors potentially affecting the species. These factors are:

A) The present or threatened destruction, modification, or curtailment of its habitat or range;

B) overutilization for commercial, recreational, scientific, or educational purposes;

C) disease or predation;

D) the inadequacy of existing regulatory mechanisms; and

E) other natural or manmade factors affecting its continued existence.

Documented threats to the Mojave population of the desert tortoise were described in the final listing rule in 1990 as they pertain to the five listing factors (USFWS 1990) and in the 1994 Recovery Plan (USFWS 1994a). The threats identified in the 1994 Recovery Plan, and that formed the basis for listing the tortoise as a threatened species (GAO 2002), continue to affect the species today. Extensive research shows that all of these individual threats directly kill or indirectly affect tortoises. Research has also clarified many mechanisms by which these threats act on tortoises. However, despite the clear demonstration that these threats impact individual tortoises, there are few data available to evaluate or quantify the effects of threats on desert tortoise populations (Boarman 2002). While current research results can lead to predictions about how local tortoise abundance should be affected by the presence of threats, quantitative estimates of the magnitude of these threats, or of their relative importance, have not yet been developed. Thus, a particular threat or subset of threats with discernable solutions that could be targeted to the exclusion of other threats has not been identified for the desert tortoise.

The assessment of the 1994 Recovery Plan emphasized the need for a greater appreciation of the implications of multiple, simultaneous threats facing tortoise populations and a better understanding of the relative contribution of multiple threats on demographic factors (*i.e.*, birth rate, survivorship, fecundity, and death rate; Tracy *et al.* 2004). The approach of focusing on individual threats may not have produced expected gains toward desert tortoise recovery since 1994 because multiple threats act simultaneously to suppress tortoise populations at any given location within the species' range. In this revised recovery plan, we underscore the need to build on our understanding of individual threats, yet place new emphasis on understanding their multiple and synergistic effects (interacting so that the combined effect is greater than the sum of individual effects) due to the failure of simple threat models to inform us about tortoise abundance. The following narrative provides a brief overview of the threats to the desert tortoise and its habitat as categorized by the five listing factors. A more detailed discussion of these threats is contained in Appendix A.

1. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range (Factor A)

Since the 1800s, portions of the desert southwest occupied by desert tortoises have been subject to a variety of impacts that cause habitat loss, fragmentation, and degradation, thereby threatening the long-term survival of the species (USFWS 1994a). Some of the most apparent threats are those that result in mortality and permanent habitat loss across large areas, such as urbanization, and those that fragment and degrade habitats, such as proliferation of roads and highways, off-highway vehicle activity, poor grazing management, and habitat invasion by non-native invasive species (Berry *et al.* 1996; Avery 1997; Jennings 1997; Boarman 2002; Boarman and Sazaki 2006). Indirect impacts to desert tortoise populations and habitat are also known to occur in areas that interface with intense human activity (Berry and Burge 1984; Berry and Nicholson 1984b).

Another threat that has come to the forefront is the increased frequency of wildfire due to the invasion of desert habitats by non-native plant species (USFWS 1994a; Brooks 1998). Changes in plant communities caused by non-native plants and recurrent fire can negatively affect the desert tortoise by altering habitat structure and species available as food plants (Brooks and Esque 2002). Off-highway vehicle activity, roads, livestock grazing, agricultural uses, and other activities contribute to the spread of non-native species (or the displacement of native species) and the direct loss and degradation of habitats (Brooks 1995; Avery 1998). For example, unmanaged livestock grazing, especially where plants are not adapted to large herbivorous mammals or where the non-native species are less palatable than the natives, can preferentially remove native vegetation, leaving non-native plants to grow under reduced competition (Wittenberg and Cock 2005:228).

Landfills and other waste disposal facilities potentially affect desert tortoises and their habitat through fragmentation and permanent loss of habitat, spread of garbage, introduction of toxic chemicals, increased road kill of tortoises on access roads, and increased predator populations (Boarman *et al.* 1995; Kristan and Boarman 2003). Military operations (*e.g.*, construction and operation of bases, field maneuvers) have taken place in the Mojave Desert since 1859 and can affect tortoises and their habitats similarly to other large human settlements (*i.e.*, illegal collection of tortoises, trash dumping, increased raven (*Corvus corax*) populations, domestic predators, off-highway vehicle use, increased exposure to disease, and increased mortality) (USFWS 1994a; Krzysik 1998; Boarman 2002).

As of November 2010, six solar projects in California and one in Nevada were approved on public lands within the range of the desert tortoise, constituting 3,037.5 megawatts (MW) on 9,683 hectares (23,926 acres) and 430 MW on 3,173 hectares (7,840 acres), respectively. Three additional solar projects on private lands in California have been approved totaling 1,063 MW on 1,686 hectares (4,165 acres). Seven solar projects on public lands were still pending, totaling 1,450 MW on 4,314 hectares (10,659 acres) in California and 900 MW on 6,955 hectares (17,186 acres) in Nevada. Three wind projects within the range of the desert tortoise were also pending, totaling 536.5 MW on 11,775 hectares (29,096 acres) of public and private rights-of-way; one of the California projects is proposed within designated critical habitat. No applications have been submitted for solar or wind projects on public lands within the range of the Mojave population of the desert tortoise in Arizona or Utah. Dozens of project sites have been proposed, and the Bureau of Land Management has committed to excluding these projects from designated critical habitat for the desert tortoise and Desert Wildlife Management Areas. However, potential long-term effects of large-scale energy development fragmenting or isolating desert tortoise conservation areas and cutting off gene flow between these areas have not been evaluated.

2. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes (Factor B)

Despite legal protection under Federal and State laws, deliberate maiming or killing of tortoises (previously referred to as vandalism) and collection of desert tortoises by humans for food or as pets were cited as potential threats to the species (USFWS 1994a). Data and anecdotal observations indicate that collection for personal or commercial purposes was significant in the past (USFWS 1994a). While illegal collection of desert tortoises still occurs and collection could possibly impact local populations, there is no quantitative estimate of the magnitude of this threat (Berry *et al.* 1996; Boarman 2002).

Research projects may result in injury or loss of individuals. These activities may be permitted under section 10 of the Endangered Species Act, when permitted. Terms and conditions to minimize injury and mortality of individuals are mandatory.

3. Disease or Predation (Factor C)

To date the available evidence indicates that upper respiratory tract disease, as caused by the bacteria *Mycoplasma agassizii* and *M. testudineum* (Jacobson *et al.* 1991), is probably the most important infectious disease affecting desert tortoises. Less is known about other diseases that have been identified in the desert tortoise (*e.g.*, herpesvirus, cutaneous dyskeratosis, shell necrosis, bacterial and fungal infections, and urolithiasis or bladder stones) (Jacobson *et al*. 1994;

Homer *et al.* 1998; Berry *et al.* 2002b; Origgi *et al.* 2002). There is evidence that any one disease may predispose an animal to other diseases (Christopher *et al*. 2003). However, it is not known whether this is a cause or effect. Additional research is needed to clarify the role of disease in desert tortoise population dynamics relative to other threats.

The role of environmental contaminants in directly inducing toxicosis-related diseases (*i.e.*, liver diseases) and increasing susceptibility to infectious diseases has recently been suggested as a significant source of mortality (Homer *et al.* 1994, 1996; Berry 1997; Boarman 2002; Christopher *et al*. 2003). Elevated mercury and arsenic levels have been associated with diseased tortoises in the wild (Jacobson *et al*. 1991; Homer *et al*. 1998; Seltzer and Berry 2005; Chaffee and Berry 2006). Necropsy and analyses of kidney, liver, and scute tissues suggested that tortoises from California with a variety of diseases (upper respiratory tract infection, urolithiasis, metabolic disease, and shell diseases) had statistically significantly higher levels of several potentially toxic elements as compared to healthy tortoises (Berry *et al*. 1997). Illegal dumping of hazardous wastes in the California deserts may expose tortoises to increased levels and possible consumption of toxic substances and affect populations on a localized level where these activities are concentrated (Boarman 2002). It has been postulated that elemental toxicity may compromise the immune system of desert tortoises or otherwise detrimentally affect physiological function, rendering them more susceptible to disease, but further investigation is needed.

Desert tortoises, particularly hatchlings and juveniles, are preyed upon by several native species of mammals, reptiles, and birds. The common raven (*Corvus corax*) has been the most highly visible predator of small tortoises, while coyotes (*Canis latrans*) have been commonly implicated in deaths of adult tortoises. The population-level effects of these or other predators are unknown. Except for extreme predation events brought on by unusual circumstances, predation by native predators alone would not be expected to cause dramatic population declines. This reiterates the importance of combined and synergistic effects of threats. For example, predation pressure by ravens is increased through elevated raven populations as a result of resource subsidies associated with human activities. Ravens obtain food in the form of organic garbage from landfills and trash containers, water from sewage ponds and municipal areas, and nesting substrates on billboards, utility towers, bridges, and buildings (Boarman *et al.* 2006).

Other avian predators of the desert tortoise include red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), loggerhead shrikes (*Lanius ludovicianus*), American kestrels (*Falco sparvarius*), burrowing owls (*Athene cunicularia*), and greater roadrunners (*Geococcyx californianus*) (Boarman 1993). Coyotes, kit foxes (*Vulpes macrotis*), mountain lions (*Felis concolor*), ground squirrels (*Spermophilus* spp.), and free-roaming dogs are some of the known mammalian predators (Bjurlin and Bissonette 2001; Boarman 2002; M. McDermott, Southern Nevada Environmental, Inc., pers. comm. 2006, K. Nagy, University of California-Los Angeles, pers. comm. 2006; Medica and Greger 2009). Invertebrate predators of eggs and hatchling tortoises include native fire ants (Nagy *et al.* 2007).

4. Inadequacy of Existing Regulatory Mechanisms (Factor D)

The final listing rule acknowledged that all four states within the range of the Mojave population of the desert tortoise have laws in place to protect the species. In addition, a great deal of effort has been dedicated to planning by the various land management agencies whose jurisdictions include desert tortoise habitat. Many of the existing plans include language specific to protection of the species, such as limiting off-highway vehicle use and competitive/organized events, grazing, vegetation harvest, and collection of desert tortoises. However, the multiple-use mandates under which the agencies function require a complex balance between conservation and use of public lands, and management agencies frequently do not have sufficient funding to enforce their regulations. Also, state law in Arizona, Nevada, and Utah does not regulate habitat degradation, making mitigation of impacts to potentially unoccupied but suitable habitat difficult.

Land exchanges and transfers may result in loss of desert tortoise habitat, increased fragmentation, and displacement of resident desert tortoises, because habitat that is exchanged out of Federal ownership into the private sector is at greater risk of urban development (Sievers *et al.* 1988; but see Conservation Efforts, Land Acquisitions and Habitat Conservation Plans, below). Energy and mineral development and extraction also pose a significant threat to desert tortoises through habitat loss and fragmentation (Luke *et al.* 1991; Lovich and Bainbridge 1999; LaRue and Dougherty 1999). For example, as of November 2010, the area of approved and pending solar and wind-energy applications on public lands in California exceeds 100,000 hectares (247,000 acres).

5. Other Natural or Manmade Factors Affecting its Continued Existence (Factor E)

Global climate change and drought are potentially important long-term considerations with respect to recovery of the desert tortoise. There is now sufficient evidence that recent climatic changes have affected a broad range of organisms with diverse geographical distributions (Walther *et al.* 2002). While little is known regarding specific direct effects of climate change on the desert tortoise or its habitat, predictions can be made about how global and regional precipitation regimes may be altered and about the consequences of these changes (Weltzin *et al.* 2003; Seager *et al.* 2007).

The Intergovernmental Panel on Climate Change has suggested that increasingly reliable regional climate change projections are available as the result of improved modeling capabilities and advanced understanding of climate systems (Christensen *et al*. 2007). Twenty-one Atmosphere-Ocean General Circulation Models were run to predict regional temperature and precipitation across the globe in 2080 through 2099 as changed from conditions that occurred between 1980 and 1999. Generally, predictions for the geographic range of the desert tortoise's listed population suggest a 3.5 to 4.0 degree Celsius (6.3 to 7.2 degree Fahrenheit) increase in annual mean temperature, with the greatest increases occurring in summer (June-July-August mean up to 5 degrees Celsius [9 degrees Fahrenheit] increase) (Christensen *et al*. 2007). Precipitation will likely decrease by 5 to 15 percent annually within the range of the desert tortoise with winter precipitation decreasing up to 20 percent (Christensen *et al*. 2007). Because germination of the tortoise's food plants is highly dependent on cool season rains, the forage base could be reduced due to increasing temperatures and decreasing precipitation in winter. Smith *et al.* (2009) review various types of global change relative to expected effects in the Mojave Desert, such as elevated carbon dioxide and altered precipitation regimes facilitating invasive plant species, thereby increasing fire frequency. Effects of altered nitrogen dynamics on the Mojave Desert are less clear. For example, increased nitrogen deposition from dust in the vicinity of metropolitan areas could result in higher plant production, exacerbating the effects from carbon dioxide noted above (Smith *et al*. 2009). Alternatively, increased temperatures may release nitrogen gases from Mojave Desert soils, reducing fertility of those soils and the ability to support plant life (McCalley and Sparks 2009). Further predictions need to be developed specifically for the desert tortoise to help inform recovery efforts.

Other activities that may impact the species include non-motorized recreation such as camping, hunting, target shooting, rock collecting, hiking, horseback riding, biking, and sight-seeing. These activities bring with them threats associated with increased human presence, such as loss of habitat from development of recreational facilities, handling and disturbance of tortoises, increased road kill and deliberate maiming or killing of tortoises, increased raven predation, degradation of vegetation, and soil compaction (USFWS 1994a; Averill-Murray 2002). Desert habitats are also disturbed by construction and maintenance of linear utility corridors and ancillary facilities and to some degree by vandalism and harvest of vegetation for personal or economic purposes (Olson 1996; LaRue and Dougherty 1999).

Another potential threat facing the desert tortoise is the unauthorized release or escape of pet tortoises to the wild. Captive releases have the potential to introduce disease into wild populations of desert tortoises (Johnson *et al*. 2006; Martel *et al*. 2009). Tomlinson and Hardenbrook (1993) reported that the highest prevalence of clinical signs of upper respiratory tract disease was observed in tortoises removed from areas where previous releases of captive animals had occurred. Release or escape of captive tortoises genetically different from the resident population could theoretically decrease fitness (Tallmon *et al*. 2004).

H. CONSERVATION EFFORTS

While precise correlations between threats and desert tortoise populations have not been clearly shown, a great deal of effort has been put forth by research scientists and land managers to actively conserve the species. For instance, substantive datasets pertaining to disease, non-native invasive plant species, and fire have been assembled over the years that will be used to inform decisions relative to recovery of the desert tortoise and its habitats. On-the-ground conservation actions such as land acquisitions, installing protective fencing, retiring grazing allotments, limiting off-highway vehicle access, and implementing restoration projects have been based on what we believe are threats to the desert tortoise at this time (see GAO 2002). The following are examples of existing guidance and strategies to further resource conservation.

1. Wildlife Conservation Strategies

In 2000, Congress enacted the State Wildlife Grants Program to fund activities that benefit species of concern and their habitats. To receive funding under this program, State wildlife agencies needed to complete a Fish and Wildlife Service-approved wildlife action plan (or comprehensive wildlife conservation strategy). All four states where the Mojave population of the desert tortoise occurs are currently implementing these strategies to guide species and habitat management through 2015 (Gorrell *et al.* 2005; Abele *et al.* 2006; Arizona Game and Fish Department 2006; Bunn *et al.* 2006).

Each state has identified conservation priorities and recommendations that are both species- and habitat-specific. Some of these actions include, but are not limited to, the following:

- improve stewardship on federally managed lands to protect wildlife diversity;
- work cooperatively with landowners/permittees by providing financial and technical assistance (through incentive programs) for conservation projects;
- work with city and county planners to incorporate wildlife values in urban/rural development plans;
- promote design and construction of overpasses, underpasses, or culverts to increase permeability of existing or planned roads;
- identify and protect key wildlife corridors for landscape connectivity;
- reduce off-highway vehicle damage to wildlife habitats;
- encourage revegetation and restoration of existing unauthorized roads and trails;
- improve efforts and partnerships for controlling existing occurrences of invasive species and prevent new introductions;
- rehabilitate burned and disturbed areas with native plants;
- pursue projects to limit spread of disease to sensitive wildlife populations;
- use fencing and/or increased law enforcement presence to reduce unauthorized use and access to sensitive habitats; and,
- implement a statistically robust range-wide monitoring program and adaptive management framework that captures population trends and impacts to the species.

2. Federal Land Management Plans

Land use management plans provide guidance and establish a mechanism by which Federal agencies implement actions on lands under their purview. Throughout the range of the desert tortoise, multiple Federal agencies are involved in the long-term management and conservation of the species as part of their respective missions. These include the Bureau of Land Management, National Park Service, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, Bureau of Reclamation, U.S. Forest Service, Department of Defense, and Department of Energy. In addition to Federal land use plans, counties and local jurisdictions draft general plans to guide their activities.

Within the range of the desert tortoise, the following programmatic-level documents are currently in place or in preparation. Many of the respective plans include language specific to the protection and conservation of natural resources including desert tortoises and their habitats.

These are often supplemented by more specific guiding documents, such as habitat management plans or wilderness management plans:

Bureau of Land Management:
- Arizona Strip Resource Management Plan Revision, Grand Canyon-Parashant National Monument Management Plan (jointly managed with the National Park Service), and Vermilion Cliffs National Monument Management Plan; Proposed Resource Management Plan/Final Environmental Impact Statement (BLM and National Park Service [NPS] 2007)
- California Desert Conservation Plan of 1980 as amended (BLM 1999a)
- Northern and Eastern Mojave Desert Management Plan (BLM 2002a)
- Northern and Eastern Colorado Desert Coordinated Management Plan (BLM 2002b)
- West Mojave Plan (BLM *et al.* 2005)
- Tonopah Resource Management Plan (BLM 1997)
- Las Vegas Resource Management Plan (BLM 1998a)
- Red Rock Canyon National Conservation Area Resource Management Plan (BLM 2001)
- Sloan Canyon National Conservation Area Resource Management Plan (BLM 2006)
- Nevada Test and Training Range Resource Management Plan (BLM 2004)
- Caliente Management Framework Plan (BLM 2000)
- St. George Resource Management Plan (BLM 1999b)

Fish and Wildlife Service:
- Desert National Wildlife Refuge Comprehensive Conservation Plan (USFWS 2009b)

National Park Service:
- Joshua Tree National Park General Management Plan, as amended (NPS 2000a)
- Death Valley National Park General Management Plan (NPS 2002a)
- Mojave National Preserve General Management Plan (NPS 2002b)
- Lake Mead National Recreation Area, Arizona and California, Strategic Plan Fiscal Year 2001-2005 (NPS 2000b)

U.S. Forest Service:
- General Management Plan for the Spring Mountains National Recreation Area, An Amendment to the Land and Resource Management Plan (U.S. Forest Service 1996)

Department of Defense:
- Draft Nellis AFB and Nevada Test and Training Range Integrated Natural Resources Management Plan (U.S. Air Force 2007)
- Marine Corps Air Ground Combat Center, Twentynine Palms, Integrated Natural Resources Management Plan, Fiscal Years 2007-2011 (U.S. Marine Corps 2007)
- National Training Center at Fort Irwin Integrated Natural Resources Management Plan (U.S. Army 2006)
- Marine Corps Logistics Base, Barstow, Integrated Natural Resources Management Plan (Tierra Data, Inc. 2005)

- Naval Air Weapons Station, China Lake, Comprehensive Land Use Management Plan and Integrated Natural Resources Management Plan (Naval Air Weapons Station, China Lake and BLM 2004)
- Edwards Air Force Base Integrated Natural Resources Management Plan (U.S. Air Force 2001)
- Yuma Training Range Complex, Arizona and California (U.S. Navy 2001)
- Nevada Test Site Resource Management Plan (U.S. Department of Energy 1998)

Among the most important recovery actions implemented pursuant to the 1994 Recovery Plan has been formalizing Desert Wildlife Management Areas (DWMAs; Box 1) through Federal land use planning processes (Figure 2). Particularly on Bureau of Land Management lands, DWMAs are administered and designated as **Areas of Critical Environmental Concern** (ACEC; Box 1; BLM 1998a, 1999b, 2000, 2002a, 2002b, BLM *et al.* 2005, BLM and NPS 2007). These ACECs define specific management areas based on the general recommendations for DWMAs in the 1994 Recovery Plan. Boundaries of the ACECs were refined slightly from the critical habitat designation based on various management and biological considerations. The Bureau of Land Management DWMAs/ACECs, together with National Park Service lands, designated wilderness areas, other lands allocated for resource conservation, as well as restricted-access military lands provide an extensive network of habitats that are managed either directly or indirectly (*e.g.*, wilderness areas outside desert tortoise ACECs) for desert tortoise conservation (Figures 2 and 3).

A recent example of landscape-scale conservation was the Bureau of Land Management's designation of ACECs and wildlife habitat areas under the Arizona Strip Resource Management Plan Revision and Grand Canyon-Parashant National Monument Management Plan (BLM and NPS 2007). On the Arizona Strip, lands managed to maintain wilderness characteristics were proposed on 87,100 hectares (215,345 acres) within the Grand Canyon-Parashant National Monument and on 14,120 hectares (34,900 acres) within the Arizona Strip field office's area of responsibility. Nearly 68,800 hectares (170,000 acres) are designated as ACECs on the Arizona Strip, which directly benefits the desert tortoise and its habitat. The Resource Management Plan contains the following goals:

- The Mojave population of desert tortoise would be recovered and delisted.
- There would be no net loss in the quality or quantity of desert tortoise habitat within the ACECs or wildlife habitat areas.
- Desert tortoise populations within the ACECs and DWMAs would be healthy and self-sustaining. Populations would be stable or increasing. Population declines would be halted.
- Desert tortoise populations outside of the ACECs and wildlife habitat areas would be healthy and stable. Declines in the wildlife habitat areas would be minimized to the extent possible through mitigation.
- Desert tortoise habitat would provide sufficient forage and cover attributes to support thriving populations of the species.
- Habitat connectivity would be maintained, providing sufficiently frequent contact between tortoises to maintain genetic diversity.

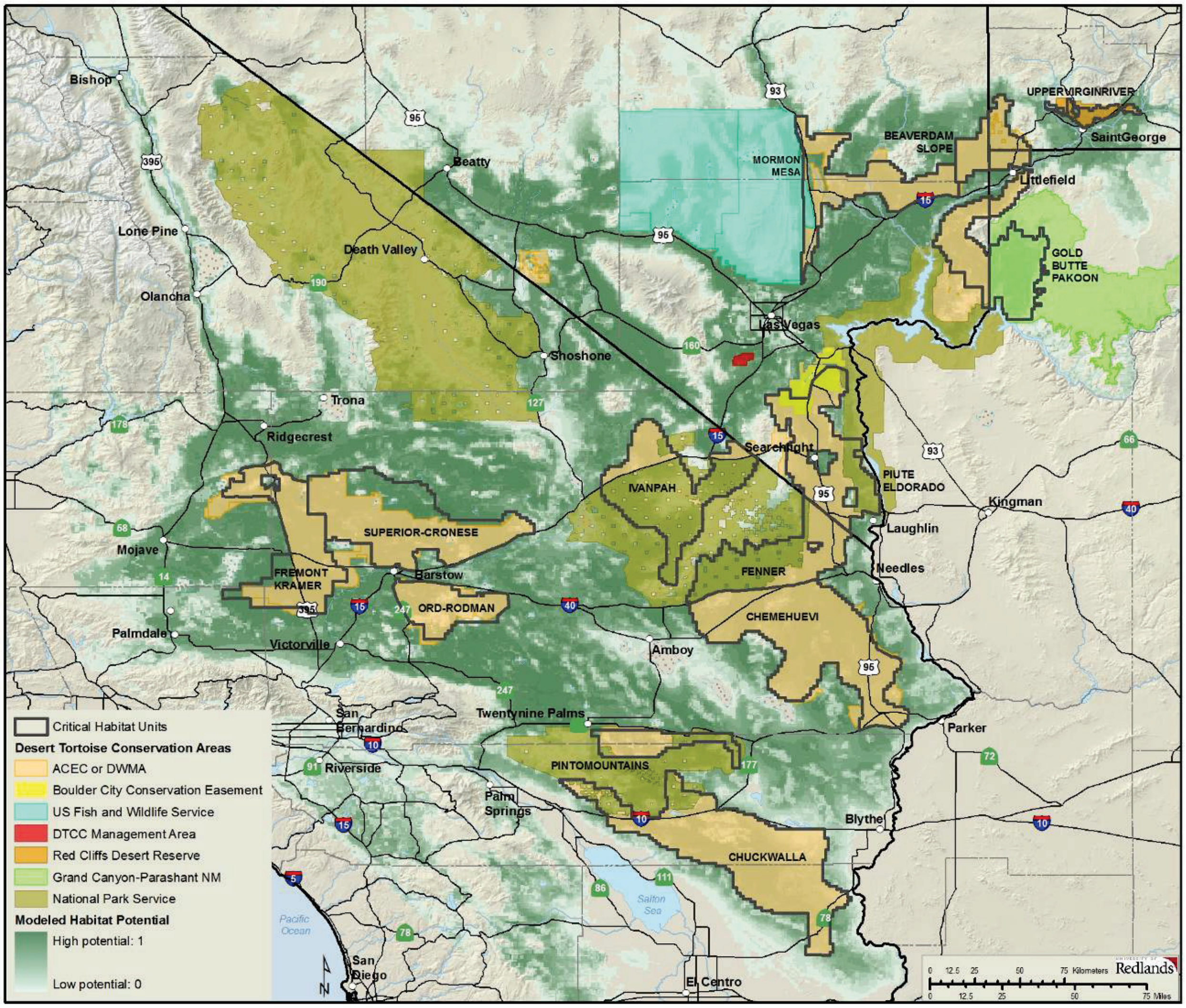

Figure 2. Desert tortoise conservation areas (see Box 2). DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern; DTCC = Desert Tortoise Conservation Center.

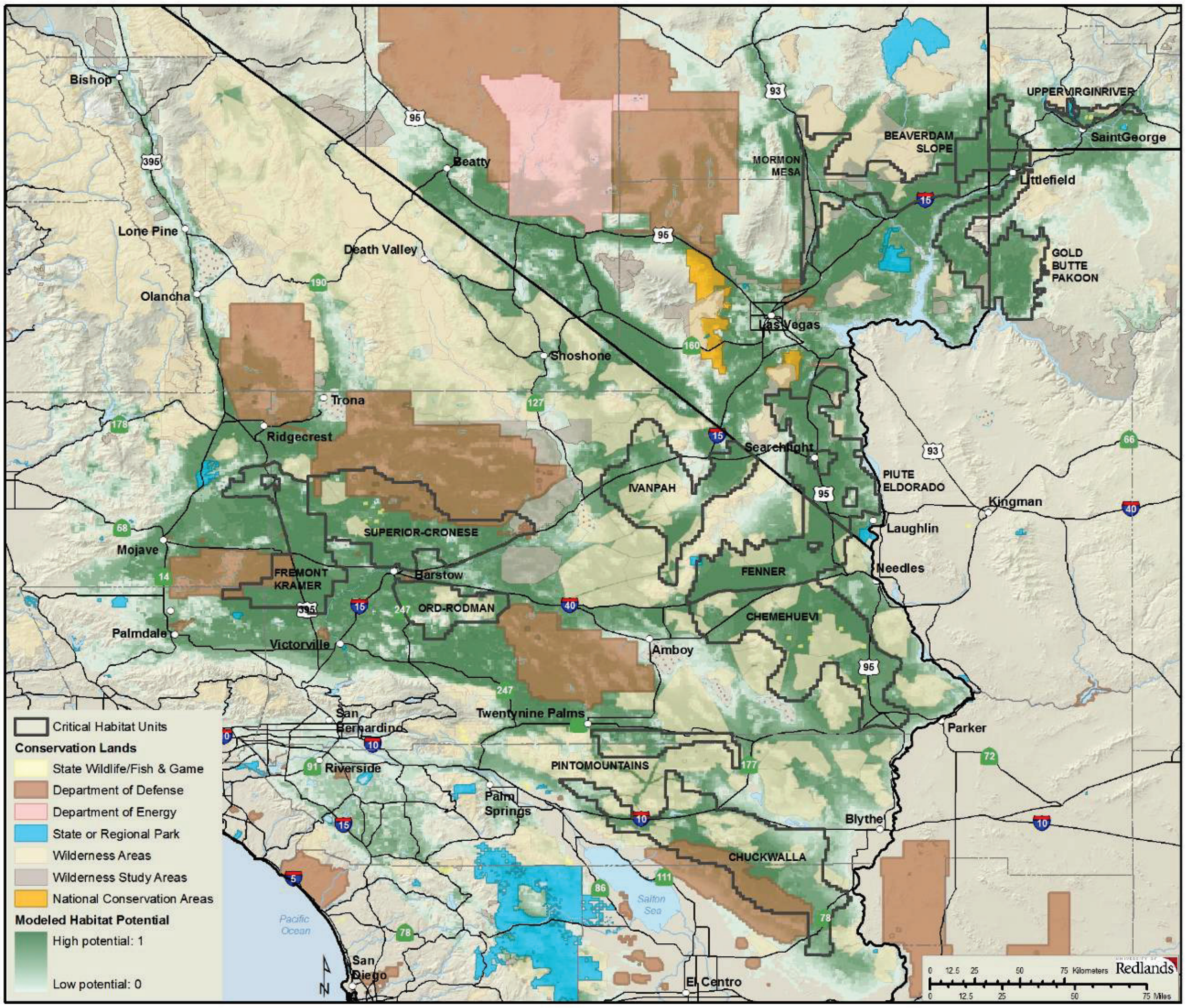

Figure 3. Additional land designations providing conservation benefits to the desert tortoise. Conservation areas for other species not shown (*e.g.,* Mohave ground squirrel [*Spermophilus mohavensis*], *Mimulus mohavensis* [Mojave monkeyflower]) may also provide benefit to the desert tortoise.

Another example of landscape-level conservation is the withdrawal of locatable mineral entry within ACECs on the Southern Nevada District of the Bureau of Land Management (BLM 2009). Locatable minerals are those that have been described as "valuable mineral deposits" and include metal ores such as gold, silver, copper, or lead, and certain industrial minerals such as gypsum, chemical-grade limestone, and diatomaceous earth. Uncommon varieties of mineral materials such as pumice, rock, and cinders also are regulated as locatable minerals. The BLM withdrew approximately 382,000 hectares (944,000 acres) of public lands from locatable mineral entry under the United States mining laws for a period of 20 years to protect desert tortoise habitat, archaeological and cultural resources, and special wildlife and riparian values on 24 ACECs. Four of these ACECs coincide with desert tortoise critical habitat (Piute/Eldorado, Coyote Springs, Mormon Mesa, and Gold Butte critical habitat units). This action was included as one of the most important conservation actions in the Las Vegas Resource Management Plan (BLM 1998a). All valid existing rights including, but not limited to, mining, recreation, and/or rights of way remain unaffected (BLM 2009).

One of the most extensive land and resource management plans currently in place was developed for the 10,117,141-hectare (25,000,000-acre) California Desert Conservation Area. In 1976, Congress passed the Federal Land Policy Management Act to direct the management of the public lands of the United States. Under that law, the California Desert Conservation Area was established, with 4,856,228 hectares (12,000,000 acres) of public lands administered by the Bureau of Land Management. The California Desert Conservation Area Plan of 1980 as amended provides guidance relative to the use of the public lands and resources of the California Desert Conservation Area, including economic, educational, scientific, and recreational uses, in a manner that enhances wherever possible, and does not diminish the environmental, cultural, and aesthetic values of the desert and its productivity. Under the California Desert Conservation Area Plan, all state and federally listed species and their habitats are to be managed so that the continued existence of each is not jeopardized. Consultation for federally listed species would be conducted as appropriate (BLM 1999a).

The California Desert Conservation Area Plan was subsequently amended by regions that generally corresponded to the recovery units delineated in the 1994 Recovery Plan. The Northern and Eastern Mojave Desert Management Plan (BLM 2002a), the West Mojave Plan (BLM *et al.* 2005), and the Northern and Eastern Colorado Desert Coordinated Management Plan (BLM 2002b) all designated DWMAs/ACECs and included new management measures for desert tortoise conservation, including limiting various recreational activities, such as off-highway vehicle races, within the conservation areas.

The California Desert Conservation Area also encompasses the 10,117-hectare (25,000-acre) Desert Tortoise Natural Area, which was established in the western Mojave Desert in 1972. The Mojave National Preserve was created under the California Desert Protection Act in 1994 for which a general management plan was drafted in 2002 (NPS 2002b). The California Desert Protection Act also expanded the boundaries of both Death Valley and Joshua Tree National Parks and designated millions of acres of wilderness, which eliminated vehicle access to these areas.

Many of the actions recommended in the 1994 Recovery Plan have been incorporated into the land and resource management plans identified above, particularly within DWMAs/ACECs. Tracy *et al.* (2004) summarized the level of implementation of the management recommendations by reviewing land and wildlife managers' responses to surveys asking what recovery actions had been implemented. However, the survey responses were not explicit enough to quantify the level of implementation for each specific recovery action; therefore, the results only speak to whether or not some action had been taken. In addition, research and monitoring have not been targeted to evaluate the effectiveness of these actions (Boarman and Kristan 2006), and ongoing population monitoring has been performed at a regional scale rather than a local implementation scale. The main conclusion was that improved reporting and quantification of recovery actions is necessary to more accurately assess the progress of desert tortoise recovery (Tracy *et al.* 2004).

3. Improved Grazing Management

A specific example of landscape-scale conservation of desert tortoise habitat was improved grazing management on several allotments within designated critical habitat on public lands. This was identified in the 1994 Recovery Plan as an important component in the recovery of the species. For example, in 1995 the Desert Tortoise Preserve Committee and The Wildlands Conservancy bought the 550-hectare (1,360-acre) Blackwater Well Ranch in northwestern San Bernardino County and is managing grazing on the 19,830-hectare (49,000-acre) Pilot Knob cattle grazing allotment. The Bureau of Land Management removed grazing on nearly 1,214,000 hectares (3,000,000 acres) within the California portions of the Mojave and Sonoran deserts (BLM 2002a,b; BLM *et al.* 2005; USFWS 2005, 2006b). In addition, national Bureau of Land Management grazing administration regulations became effective in 1996, which provided direction for states to develop Standards for Rangeland Health and Guidelines for Grazing Management on Bureau of Land Management Lands (BLM 1996). All of the states within the range of the desert tortoise have incorporated standards and guidelines into their management plans.

Under the West Mojave Plan (BLM *et al.* 2005), grazing has been retired on several allotments mostly within designated critical habitat or DWMAs. Additional management improvements such as season of use and forage type (ephemeral or perennial) have also been instituted on some allotments within the plan area. Fort Irwin, which lies within the West Mojave Plan area, purchased fee lands within three cattle allotments in the Western Mojave Recovery Unit to partially offset the effects of its base expansion, and the Bureau of Land Management subsequently retired grazing on these allotments. The Bureau of Land Management has retired grazing from at least four other allotments in the plan area. Collectively, over 307,560 hectares (760,000 acres) in the West Mojave Plan area have been retired from grazing.

Within the West Mojave Plan area, the Bureau of Land Management has identified a number of conservation prescriptions to be implemented within cattle and sheep allotments. The Northern and Eastern Mojave Desert Management Plan (BLM 2002a) instituted improved grazing practices on approximately 126,260 hectares (312,000 acres), which constitutes all but about 5,261 hectares (13,000 acres) of critical habitat in the Shadow Valley and Ivanpah Valley DWMAs. Grazing remains on one allotment within the Ivanpah Valley DWMA with some utilization restrictions, and all ephemeral (seasonal) allotments within DWMAs will be terminated. The Northern and Eastern Colorado Desert Coordinated Management Plan (BLM 2002b) established two DWMAs that encompass over 647,500 hectares (1,600,000 acres). Only one allotment remains within designated critical habitat or a DWMA. Approximately 8,090 hectares (20,000 acres) of this active allotment was closed to grazing due to high tortoise densities, and in other portions of the allotment, utilization restrictions and season of use requirements will be implemented.

Under the Mojave National Preserve General Management Plan (NPS 2002b), grazing has been removed on nine allotments and remains active on another two (D. Hughson, NPS, pers. comm. 2007). The overall management goal is to remove grazing on the entire Preserve through voluntary relinquishment by lessees or acquisition of grazing permits and water rights by conservation organizations. These activities will be managed according to Bureau of Land Management allotment management plans and National Park Service grazing management plans, together with additional restrictions designed to improve resource protection (NPS 2002b). In Joshua Tree National Park, there are no active grazing allotments (M. Vamstad, Joshua Tree National Park, pers. comm. 2008).

Since 1994, the Bureau of Land Management and U.S. Forest Service have closed 70 ephemeral grazing allotments in Clark and southern Nye counties totaling over 2,023,400 hectares (5,000,000 acres). Approximately 22,600 hectares (56,000 acres) currently remain available for grazing in five allotments in Clark and southern Nye counties (E. Masters, BLM, pers. comm. 2007). According to the Las Vegas Resource Management Plan, no permitted grazing occurs within ACECs in Clark County and southern Nye County (BLM 1998a). Under the Clark County Multiple Species Habitat Conservation Plan (MSHCP) and its predecessor (see discussion below), which lies within the Southern Nevada District of the Bureau of Land Management, the County has been actively purchasing the rights to permanently remove grazing from over 809,370 hectares (2,000,000 acres) of public lands within and outside of DWMAs (J. Bair, USFWS, pers. comm. 2007).

Under the Caliente Management Framework Plan Amendment (Lincoln County, Nevada), all allotments or portions of allotments within ACECs were closed to livestock grazing (85,996 hectares [212,500 acres]). Outside ACECs, season of use on all perennial allotments was established through allotment evaluation and multiple-use decision processes. It was determined for areas outside ACECs, livestock use could occur between March 15 and October 15 provided forage utilization does not exceed 40 percent for key perennial grasses, forbs, and shrubs (BLM 2000).

Allotment closures and restrictions were also instituted on the Bureau of Land Management Arizona Strip District within ACECs and within the National Monuments (BLM 1998b; BLM 2007a). Livestock grazing is authorized on portions of 11 allotments that support desert tortoise habitat. Improved grazing management will be implemented in these areas; grazing use is limited to October 15 through March 15, generally coinciding with desert tortoise inactivity. Ecological site inventory (basic inventory of present and potential vegetation on BLM rangelands) data are expected to serve as the baseline for range conditions, and utilization is not to exceed 45 percent of the current year's growth. Overall, conditions must meet the Bureau of Land Management's Standards for Rangeland Health and National Park Service's Vital Sign Standards (BLM 2007a).

4. Land Acquisitions and Habitat Conservation Plans (HCPs)

Land acquisitions and transfers may negatively impact desert tortoises and their habitats when the intention is development. On the other hand, these transactions may result in conservation benefits. For instance, since 1986, California Department of Fish and Game has acquired over 19,670 hectares (48,000 acres) of desert tortoise habitat within critical habitat, and additional lands with endowment fees have been and continue to be acquired through mitigation for projects that impact desert tortoises. To ensure management of these lands, endowment fees are collected for each parcel acquired (Steele and Jones 2006). In addition, under the Southern

Nevada Public Lands Management Act (see Appendix A: Land Acquisitions, Exchanges, and Transfers), approximately 1,500 hectares (3,725 acres) within occupied or suitable desert tortoise habitat have been purchased since 2000 through the land acquisition program for environmentally sensitive lands (BLM 2007b).

In 1999, The Wildlands Conservancy facilitated the purchase of nearly 242,810 hectares (600,000 acres) under their California Desert Land Acquisition Project. It funded the purchase of over 34,425 hectares (85,000 acres) in the Mojave National Preserve, 8,100 hectares (20,000 acres) in Joshua Tree National Park, and over 85,050 hectares (210,000 acres) in 20 Bureau of Land Management wilderness areas and other important areas, including designated critical habitat for the desert tortoise. The acquisition of these lands will ensure landscape-level conservation into the future and will provide habitat connectivity and reduce the potential for fragmentation (The Wildlands Conservancy 2009).

The Department of the Army purchased approximately 39,285 hectares (97,000 acres) of lands formerly owned by the Catellus Development Corporation and fee lands within three cattle allotments in the Western Mojave Recovery Unit to partially offset the effects of the National Training Center expansion; the Bureau of Land Management subsequently retired these allotments on over 129,500 hectares (320,000 acres), the majority of which are within designated critical habitat for the desert tortoise (R. Bransfield, U.S. Fish and Wildlife Service, pers. comm. 2009).

Several HCPs have been developed for private lands within desert tortoise habitat that include provisions for acquisitions and transfers that would meet the objectives of the HCP as well as secure conservation lands for tortoises. However, land acquisition can be an expensive, time-consuming task. For example, 61 separate actions were necessary to acquire just over 3,760 hectares (9,300 acres) within the 25,090-hectare (62,000-acre) Red Cliffs Desert Reserve, which was established to provide protection for the desert tortoise and its habitat under the 1996 Washington County HCP in Utah. Approximately 2,995 hectares (7,400 acres) remain to be acquired within the present boundaries of the Reserve. The approximate value of the lands acquired stands at $87,073,000 (not adjusted for present value) (J. Crisp, BLM, pers. comm. 2007).

In southern Nevada, the Clark County Multiple Species Habitat Conservation Plan (MSHCP) was completed in 2000. The Clark County MSHCP superseded the Desert Conservation Plan, which was prepared in response to the Federal listing of the desert tortoise as a threatened species. The MSHCP plan area encompasses a total of 169,160 hectares (418,000 acres) (all of Clark County and, for the Nevada Department of Transportation, portions of Nye, Lincoln, Mineral, and Esmeralda counties, Nevada) (RECON 2000). The underlying purpose of the MSHCP is to achieve a balance between the long-term conservation of listed species and natural resources that are an important part of the natural heritage of Clark County and the economic development of Clark County (USFWS 2000a). As additional mitigation under the MSHCP, Clark County purchased a 34,800-hectare (86,000-acre), long-term conservation easement (50 years) from Boulder City.

Under the Clark County MSHCP, site-specific conservation management strategies were required for each of the DWMAs within the county; these include Coyote Springs, Gold Butte, Mormon Mesa, and Piute-Eldorado (Clark County 2007a,b,c,d, respectively). The purpose of each conservation management strategy is to guide species and habitat management using a coordinated, adaptively managed approach. Each strategy identifies management actions, protective measures, restoration efforts, public outreach and education, inventory and monitoring actions, applied research actions, and impact mitigation measures that will direct conservation of tortoises and their habitats.

Habitat conservation plans are also being developed for other parts of southern Nevada. An HCP for the Coyote Springs Valley in Lincoln County includes allowing development of 8,680 hectares (21,454 acres) over 40 years while setting aside a 5,570-hectare (13,767-acre) reserve for the desert tortoise and other sensitive species (ENTRIX *et al*. 2008). In addition, mitigation fees paid by the applicant for the loss of desert tortoise habitat would be used to fund management of the reserve and desert tortoise research. The Southeastern Lincoln County HCP is in the final planning stages. The plan area totals 720,400 hectares (1,780,140 acres), of which 311,365 hectares (769,400 acres) is desert tortoise habitat. Approximately 9,090 hectares (20,000 acres) of the tortoise habitat within the plan area will be developed over a 30-year time frame. The focus of this plan is to provide a mechanism to allow orderly growth and development north of Mesquite and urban expansion in the Alamo area in Lincoln County (J. Brown, USFWS, pers. comm. 2007). The loss of desert tortoise habitat will be mitigated through funding of restoration efforts within the Beaver Dam Slope and Mormon Mesa critical habitat units and various research and monitoring activities (J. Krueger, USFWS, pers. comm. 2009). In Nye County, efforts continue to work with landowners and local governments to develop HCPs for projects that may adversely affect desert tortoises in the Pahrump Valley.

The Coachella Valley MSHCP in Riverside County, California, would establish conservation areas and a reserve system for species and natural communities covered under the plan, including the desert tortoise. These lands constitute approximately 301,855 hectares (745,900 acres) within the 485,620-hectare (1,200,000-acre) plan area boundary. About 206,790 hectares (511,000 acres) of desert tortoise habitat lies within the areas identified for conservation under the Coachella Valley MSHCP, with about 65,150 hectares (161,000 acres) not yet secured for these purposes. The conserved lands include the 9,090-hectare (20,000-acre) Coachella Valley Preserve that was established in 1986 for Coachella Valley fringe-toed lizard (*Uma inornata*). Over 26,300 hectares (65,000 acres) (12 percent of all habitat and 28 percent of non-Federal land within the plan area) are subject to disturbance under the plan. This constitutes about 4,450 hectares (11,000 acres) of what is considered “core” habitat for various species as described in the Coachella Valley MSHCP. The plan was completed in 2007 (Coachella Valley Association of Governments 2007), and the associated record of decision and biological opinion were issued in October 2008 (USFWS 2008).

The California Desert Conservation Area Plan Amendment for the Coachella Valley specifically commits the Bureau of Land Management to conserving at least 99 percent of vegetation community types on the lands it administers within the MSHCP reserve system. In the portion of the MSHCP area where the Northern and Eastern Colorado Desert Coordinated Management Plan applies to federal land, new surface disturbance is cumulatively limited to 1 percent of the federal portion of each critical habitat unit, which is consistent with the other large regional plans (Coachella Valley Association of Governments 2007; BLM 2002c).

Within the region covered by the West Mojave Plan (BLM *et al.* 2005), a MSHCP is being drafted for development on approximately 1,214,000 hectares (3,000,000 acres) of private lands. This plan may cover as many as 15 species, including the desert tortoise. The MSHCP is still in the planning stages, and the specific goals and objectives have yet to be determined.

Desert tortoise population monitoring has occurred in association with the Washington County HCP and Clark County MSHCP. Sufficient time has not passed to allow for large-scale increases of tortoise populations because the reproductive rate of the desert tortoise is slow (see Population Trends and Distribution). Continued management and focused monitoring, similar to the recovery strategy outlined below, are required to determine whether the HCPs are meeting their objectives.

5. Other Activities

Over 404,685 hectares (1,000,000 acres) of Mojave Desert vegetation burned in wildfires in 2005 and 2006, fueled largely by invasive, non-native grasses. About half of the areas burned supports desert tortoise habitat, and if this trend continues, native plant communities and much of the diversity of the Mojave Desert ecosystem may eventually be lost. Because of this recent devastating fire activity in the Mojave Desert, research scientists, land managers, and agency biologists in Arizona, Nevada, and Utah have come together to develop an initiative designed to protect intact, functional habitats and restore key areas that have burned. This initiative is a collaborative effort among Federal, State, and local jurisdictions and will focus on fire management and habitat protection and restoration.

During the summer of 2005, wildfires burned approximately 36,180 hectares (89,400 acres) within the Pakoon Basin of the Grand Canyon Parashant National Monument; about 14,570 hectares (36,000 acres) are located within the Gold Butte-Pakoon critical habitat unit for the desert tortoise. As a result, the Arizona Strip District of the Bureau of Land Management initiated soil stabilization and revegetation efforts of desert tortoise habitats using a variety of treatments, including aerial seed application, mechanical seed incorporation, and grazing exclusion (fencing). Rehabilitation objectives and success criteria were developed and control efforts for invasive species initiated (USFWS 2006c). The Bureau of Land Management and the U.S. Geological Survey in Nevada have also implemented emergency rehabilitation projects after wildfires (DeFalco *et al*. 2007). Restoration efforts in response to wildfires and other land disturbances have been long practiced in the Mojave Desert. Because natural plant succession is variable over time subsequent to disturbance, land managers and researchers attempt to facilitate revegetation of disturbed sites and typically observe mixed results (Ostler *et al*. 2002; Warren and Ostler 2002; Ostler and Hansen 2003; Abella *et al*. 2007; DeFalco *et al*. 2007). Site treatment, soil amendments, timing of the projects, and the environmental conditions all work to influence effectiveness of these efforts.

To facilitate fire suppression activities, the Fish and Wildlife Service's California-Nevada Operations (now, Pacific Southwest Region) manager issued a memo to the Desert Tortoise

Management Oversight Group in May 2006 recommending that when feasible, implementing suppression techniques that minimize impacts to the habitat is desirable; however, reduction of total acreage lost to fire, especially in critical habitat, through the use of mobile attack with engines, fireline construction with bulldozers, aerial fire retardant, or other necessary techniques should be prioritized. Subsequently, the Mojave Desert Initiative developed more specific priorities and guidance for incident commanders. We are actively working with our partners to identify the most appropriate locations for firefighting personnel and ways to improve communication during incidents.

We are currently undertaking efforts to reduce human subsidies of food, water, and nest sites to the common raven in the California desert. Activities designed to reduce raven predation on desert tortoises include reducing trash availability at landfills, removing illegal dumps, fencing along highways to reduce road-kills, and removing or modifying nesting and roost sites. The program also provides immediate protection to hatchling and juvenile desert tortoises by identifying and removing ravens that have preyed or attempted to prey on desert tortoises. The environmental assessment we recently released provides a full description of the proposed activities (USFWS *et al.* 2008).

Bureau of Land Management's West Mojave Plan includes a series of recommendations to reduce raven predation on the desert tortoise including, but not limited to, controlling solid and organic wastes and standing water at and outside of sanitary landfills; encouraging livestock operators to reduce availability of food sources for ravens; limiting availability of nesting and perch substrates, especially in the urban interface; selectively removing problem ravens especially within the Desert Tortoise Natural Area, critical habitat units, and head-starting sites; conducting additional research on raven life history, behavior, and efficacy of control methods; and implementing adaptive management and public education programs (BLM *et al.* 2005). In addition, most of the counties and local jurisdictions, such as San Bernardino and Kern counties, have taken considerable steps to improve their operations to minimize windblown litter and bird vectors.

The California Desert Managers Group oversees a program to develop and implement an information and education campaign about the desert tortoise to build public support for, and involvement in, its recovery. The Clark County (Nevada) Desert Conservation Program also includes an education component that targets communities in southern Nevada and extends into portions of Arizona. The outreach efforts attempt to inform the public about desert tortoise conservation issues through brochures, surveys and feedback, and educational materials for schools.

I. BIOLOGICAL CONSTRAINTS AND NEEDS

The biological constraints that were identified in the 1994 Recovery Plan (*i.e.*, life history and reproductive characteristics and maintenance of genetic and ecological variability) remain important considerations in current and future recovery planning and implementation. Desert tortoises possess a combination of life history and reproductive characteristics that affect the ability of populations to survive external threats. For instance, this long-lived species requires 13 to 20 years to reach sexual maturity and has low reproductive rates during a long period of reproductive potential (Turner *et al.* 1984; Germano 1994). Also, similar to other turtles, desert tortoises experience relatively high mortality early in life. These factors 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 (USFWS 1994a). Delayed but prolonged reproduction 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 (Congdon *et al*. 1993; Doak *et al*. 1994; Wisdom *et al*. 2000). Thus, high survivorship of adult desert tortoises is critical to the species' persistence, and the slow growth rate of populations can leave them susceptible to extirpation events in areas where adult survivorship has been reduced (USFWS 1994a).

Another factor integral to desert tortoise recovery is maintaining the genetic variability of the species and sufficient ecological heterogeneity within and among populations (Murphy *et al*. 2007; Hagerty and Tracy 2010). This variation is necessary to allow tortoises to adapt to changes in the environment over time (USFWS 1994a). Finally, because desert tortoises occupy large home ranges, the long-term persistence of extensive, unfragmented habitats is essential for the survival of the species (USFWS 1994a). The loss or degradation of these habitats to urbanization, habitat conversion from frequent wildfire, or other landscape-modifying activities place the desert tortoise at increased risk of extirpation because the tortoise depends on the cover of shrubs and annuals for forage provided by contiguous native vegetation communities.

II. RECOVERY PROGRAM

A. RECOVERY STRATEGY

Recovery of the desert tortoise has been and will continue to be complex and challenging. Tortoise populations face a wide range of threats. Desert tortoises require over a decade to reach sexual maturity, have reproduction that varies through time, and juveniles have variable but low survival rates. Therefore, tortoise populations will be naturally slow to increase in response to strategies designed to ameliorate anthropogenic impacts. These life history characteristics, combined with reduced populations and extended time periods for recovery of desert ecosystems, also make it difficult to assess relative impacts of individual threats.

The 1994 Recovery Plan described a strategy for recovering the desert tortoise, which included the identification of six recovery units, recommendations for a system of Desert Wildlife Management Areas (DWMAs) within the recovery units, and development and implementation of specific recovery actions focused within the DWMAs. Maintaining high survivorship of adult desert tortoises was identified as the key factor in recovery, and because the list of threats to the species remains mostly unchanged, the requisite management or recovery actions also remain appropriate. We recognize that the most significant challenge in the implementation of the 1994 Recovery Plan was not the number or types of actions implemented, but rather the coordination, description, documentation, and evaluation of implementation of the actions (Tracy *et al*., 2004). As a result, the revised strategy described herein builds upon the foundation laid by the 1994 Recovery Plan by emphasizing partnerships to direct and maintain focus on implementing recovery actions and a system to track implementation and effectiveness of recovery actions. Strategic elements within a multi-faceted approach designed to improve the 1994 Recovery Plan are:

1. Develop, support, and build partnerships to facilitate recovery;

2. Protect existing populations and habitat, instituting habitat restoration where necessary;

3. Augment depleted populations in a strategic manner;

4. Monitor progress toward recovery;

5. Conduct applied research and modeling in support of recovery efforts within a strategic framework; and

6. Implement a formal adaptive management program through which information gained while implementing the above strategic elements is used to revise and improve the recovery plan and recommend management actions on a regular basis.

Each strategic element is described more fully below, but the recovery program does not provide a "cookbook" of prescriptions that will ensure recovery of the desert tortoise; therefore, the actions proposed do not constitute an exhaustive list. Instead, this program establishes a process by which recovery can be achieved.

1. Strategic Element 1: Develop, Support, and Build Partnerships to Facilitate Recovery

Implementing a recovery plan for a species with a wide distribution and facing such complex challenges requires many cooperators and diverse partnerships. As noted above, we believe the most significant challenge in the implementation of the 1994 Recovery Plan was not necessarily the number or types of actions implemented, but rather the coordination, description, documentation, and evaluation of implementation of the actions. The revised recovery plan emphasizes partnering across jurisdictional boundaries through standing Recovery Implementation Teams to maintain focus on implementing and tracking recovery actions. Therefore, this element relies on the successful establishment of regional, long-term Recovery Implementation Teams comprised of land managers, stakeholders, and scientists that will work together to develop recovery action plans, prioritize recovery actions on the ground, secure necessary resources, and compile results into a range-wide database and decision support system that can be applied at the local level (Element 6). Activities of implementation teams at the local level will be coordinated with landscape and regional-level alternative-energy coordination efforts. The Recovery Implementation Teams will also facilitate education and outreach activities to build support for, understanding of, and compliance with the recovery program. Organization of Recovery Implementation Teams generally will be based on recovery units, but it may vary depending on logistical practicalities among the representatives. Our Desert Tortoise Recovery Office will serve as the focal point for coordinating Recovery Implementation Teams in cooperation with the Desert Tortoise Management Oversight Group.

2. Strategic Element 2: Protect Existing Populations and Habitat

Since 1994, desert tortoise habitat has continued to be lost or degraded (*e.g.*, by urbanization, fire, invasive plants; see Appendix A), keeping tortoise populations in an insecure state, including those that may not be currently in decline. As a result, protecting existing populations and habitat is extremely important. The recommended actions in the 1994 Recovery Plan formed a logical basis for recovery (GAO 2002), and little information since 1994 contradicts these recommendations (Boarman and Kristan 2006). In fact, due to slow growth rates of individuals and populations, insufficient time has elapsed over which detectable increases in desert tortoise populations could be expected. In any case, applying uniform, highly restrictive regulations across the entire Mojave population is not feasible, even if we knew the precise mechanisms affecting population declines at each site. Therefore, aggressive management as generally recommended in the 1994 Recovery Plan needs to be applied within existing **tortoise conservation areas** (Box 2) or other important areas identified by Recovery Implementation Teams (*e.g.*, important genetic linkages identified by Hagerty *et al.* 2010) to ensure that populations remain distributed throughout the species' range (Element 1). Tortoise conservation areas capture the diversity of the Mojave population of the desert tortoise within each recovery unit, conserving the genetic breadth of the species, providing a

> **Box 2. Tortoise conservation areas,** collectively depicted in Figure 2, include desert tortoise habitat within critical habitat, Desert Wildlife Management Areas, Areas of Critical Environmental Concern, Grand Canyon-Parashant National Monument, Desert National Wildlife Refuge, National Park Service lands, Red Cliffs Desert Reserve, and other conservation areas or easements managed for desert tortoises.

margin of safety for the species to withstand catastrophic events, and providing potential opportunities for continued evolution and adaptive change (Mace and Purvis 2008). Especially given uncertainties related to the effects of climate change on desert tortoise populations and distribution, we consider tortoise conservation areas to be the minimum baseline within which to focus our recovery efforts. Much of the land contained within existing tortoise conservation areas is managed under multiple-use directives. It should also be recognized that activities occurring on lands beyond the boundaries of existing tortoise conservation areas can affect tortoise populations, important linkages between tortoise conservation areas, and the effectiveness of conservation actions occurring within the conservation area boundaries. Agencies should work within the context of their respective land use plans to determine how to effectively implement recovery actions contained within this plan.

Recovery Implementation Teams should use the decision support system (Element 6) to guide management both inside and outside tortoise conservation areas, according to different opportunities or constraints within different areas and jurisdictions. While recovery efforts may be prioritized within existing desert tortoise conservation areas, populations, habitats, and actions outside of these areas may also contribute to (or hamper) recovery of the species, and their importance is in no way diminished (other local, State, or Federal regulations may apply to actions potentially impacting tortoises and habitat outside tortoise conservation areas). For example, Department of Defense lands are subject to more dramatic changes in management or use than other Federal lands depending on the changing national security situation. However, the value of military lands to conservation has long been recognized (Stein *et al*. 2008). Similarly, wilderness designation on public lands entails restrictions on the types of activities that may be conducted there, precluding or otherwise limiting several forms of active management activities. Military lands, wilderness areas, and other land designations with conservation objectives include a great deal of desert tortoise habitat outside of and contiguous with tortoise conservation areas (see Figure 3), making them valuable components of the recovery landscape. In addition to habitat management recommendations, specific recommendations for managing desert tortoise populations relative to disease have been recommended by the Science Advisory Committee (Hudson *et al*. 2009) and are incorporated herein.

3. Strategic Element 3: Augment Depleted Populations through a Strategic Program

Due to appreciable declines of tortoise populations across the range, in conjunction with multi-faceted interacting threats, we see the need to introduce population augmentation as a tool for conservation of the desert tortoise. While tortoises seem to respond well to translocation itself, unaddressed threats which remain on the landscape and affect all tortoises, regardless of origin, may make the goal of population growth challenging to realize. Augmentation will be approached experimentally, in terms of both the continued development and evaluation of techniques and through the use of augmentation to help assess specific threats and recovery actions (Tracy *et al*. 2004; Armstrong and Seddon 2007). Population augmentation in conjunction with threats management and restoration activities (Element 2), as well as research (Element 5) designed to investigate the effectiveness of these actions is a means to gain insights into causes of declines and to increase the rate at which depleted populations could be revived. It is important to realize that if the causes of tortoise population declines are not addressed, simply increasing population numbers in the wild through augmentation will not result in recovery.

Augmentation will not be a long-term strategy for conservation of the desert tortoise, but rather an intermediate strategy aimed at increasing populations more rapidly than possible through natural processes.

An augmentation strategy will be developed by the Desert Tortoise Recovery Office, with advice and input from the Science Advisory Committee, topical experts, and representatives from pertinent regulatory and land management agencies. The strategy will include specific guidance on head-starting and translocation, which are fundamental aspects of the augmentation program, and on the need to consider a multitude of factors that include genetics and disease. Locally depleted or extirpated populations, particularly within desert tortoise conservation areas, will be identified. Translocation and head-starting (described below) will be used to augment (or re-establish) these populations in conjunction with elevated threat management and/or habitat restoration (Element 2) or directed research on the factors affecting success of the augmentation strategy (Element 5).

Head-starting is the raising of young in captivity to allow them to reach sizes at which they are less vulnerable to certain threats, such as predation by ravens, before translocation to the wild. Head-starting has proven helpful in the conservation of other tortoise species, most notably in the Galapagos Islands where predators had greatly reduced juvenile survival in already extremely depressed populations (Caporaso 1991). On the other hand, head-starting and release of young desert tortoises may be relatively inefficient in meeting population growth goals compared to addressing other life stages. Nevertheless, this tool may be valuable in research programs designed to evaluate effectiveness of management actions or to assess the presence of threats by providing statistically suitable numbers of study animals for analysis (Tracy *et al*. 2004; Reed *et al*. 2009). Currently, experiments in head-starting desert tortoises are taking place at several locations in California. Research at the National Training Center's Fort Irwin Study Sites (FISS 1 and FISS 2), Edwards Air Force Base, and the Marine Corps Air Ground Combat Center at Twentynine Palms has laid a foundation on which to build (see Morafka *et al.* 1997; Dickson *et al.* 2006; Henen *et al.* 2007; Nagy 2008), and facilities at these sites will likely be important in a collaborative head-starting effort. Head-starting facilities are lacking in Arizona, Nevada, and Utah, but proposals are being developed to use the Desert Tortoise Conservation Center in Las Vegas as the site for new facilities servicing surrounding recovery units. The Desert Tortoise Recovery Office will coordinate development of guidelines and protocols for the head-starting of desert tortoises range-wide in accordance with our controlled propagation policy (USFWS 2000b).

Augmentation also involves translocation of tortoises to pre-selected sites. The efficacy of translocation itself has been questioned over the years. Early studies did not provide sufficient evidence to support or refute translocation as a conservation strategy (see Berry 1974; Cook *et al.* 1978; Cook 1983). More recent studies have shown initial success in translocation to be high (Field *et al.* 2000; Nussear 2004; Field *et al.* 2007). Predators, especially during drought, have been shown to negatively impact tortoise populations across their range. Despite data to the contrary (Nussear 2004; Field *et al.* 2007; Esque *et al.* 2010), many critics have been quick to deem translocation an unsuitable conservation tool for desert tortoises because of the impacts predators may have. Because desert tortoises do appear to be suitable candidates for translocation, instances where predators have impacted translocated tortoises do not indicate that translocation should be abandoned but rather emphasize the need to address threats which impact all tortoises regardless of origin. As noted above, the Desert Tortoise Recovery Office, with advice from the Science Advisory Committee, topical experts, and representatives from pertinent regulatory and land management agencies, will develop translocation guidelines and protocols to be implemented range-wide, taking into account guidelines for addressing disease issues in translocation developed by the Science Advisory Committee (Hudson *et al.* 2009).

4. Strategic Element 4: Monitor Progress toward Recovery

Monitoring is a fundamental requirement for adaptive management (Element 6). It is one process by which information is updated and the success of recovery actions can be evaluated. This information can be used adaptively, to refine management during the course of recovery, to evaluate progress toward achieving recovery criteria, and to help evaluate whether delisting the species may be appropriate. While the 1994 Recovery Plan focused exclusively on monitoring desert tortoise populations, a multi-dimensional monitoring program is necessary to assess the status of tortoise populations, habitat, and threats (Tracy *et al.* 2004). Monitoring activities described in this plan are therefore tied directly to individual recovery criteria related to the status of populations, habitat, and threats. Recovery progress will be measured by monitoring trends in tortoise distribution, abundance, and population growth. The quantity and quality of habitat and the distribution of threats across the landscape also will require monitoring over time.

The protracted life history and longevity of the desert tortoise, as well as the long time frame necessary for habitat restoration in the desert, require long-term monitoring to measure success. However, evaluations at 5-year intervals will identify potential trends, will feed into 5-year status reviews, and will provide an opportunity to adjust management based on any observed trends. Effectiveness monitoring of specific management actions is also needed (Boarman and Kristan 2006) and is discussed below as applied research (Element 5). It is also important that monitoring be conducted as an integrated effort, coordinated through the Desert Tortoise Recovery Office, to ensure that efficiency of the recovery program and review of its progress are maximized. Consistent agency reporting through the decision support system (Elements 1 and 6) will help identify correlations between management efforts or threat reduction and tortoise populations, which can signify successful management.

5. Strategic Element 5: Conduct Applied Research and Modeling in Support of Recovery Efforts within a Strategic Framework

In this plan we update the research recommendations from the 1994 Recovery Plan with new priorities. Although scientists have studied desert tortoises for over three decades, many important questions remain unanswered. In particular, we have a relatively poor understanding of how some human activities interact with ecological factors to affect tortoise populations and what threat-abatement measures might counteract those effects. As mentioned above, the desert tortoise's life history makes it difficult to tease apart relative impacts of individual threats (although some impacts, such as widespread habitat loss, are fairly straightforward in that, if unchecked, they eliminate populations completely). As a result, studying most individual threats/management actions in isolation from other possible threats/actions is impractical. However, such topics should be studied experimentally whenever possible. Given the difficulties surrounding applied ecological research on the desert tortoise, ecological models should be co-developed with management actions to make and test predictions about tortoise population responses to threats or management actions. These models then can be modified as new information becomes available (Element 6). Finally, similar to the coordination required of the monitoring program (Element 4), research should be coordinated through the Desert Tortoise Recovery Office (with advice from the Science Advisory Committee and input from the Recovery Implementation Teams) to ensure that principles of strategic habitat conservation are used.

6. Strategic Element 6: Implement a Formal Adaptive Management Program

Integrating the results of recovery actions into a formal adaptive management program is critical to recovering the desert tortoise and serves as the foundation of an effective recovery plan if successfully implemented. Even though the 1994 Recovery Plan called for regular updates based on new information, a formal process for accomplishing this task was not established. Using research and monitoring to revise management efforts on an *ad hoc* basis is inefficient and has contributed to slow progress in the recovery of desert tortoise since 1994. The Department of Interior technical guide on adaptive management provides an operating definition adopted from the National Research Council:

> *Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders* (Williams *et al*. 2007).

Adaptive management is a structured approach (implementation-monitoring-evaluation-adjustment) that emphasizes accountability and explicitness in decision making (Williams *et al.* 2007). The decision analysis process requires clear objectives (*e.g.*, related to desert tortoise populations or habitat), a set of potential actions, and some expectation of the consequences of each possible action relative to the objectives, described through conceptual models (Lyons *et al*. 2008). Implementing a formal structured decision-making/adaptive management program, integrated among agencies as much as possible, will enable us to continually update and improve models and the accuracy of predictions regarding the effects of management actions. Expectations of adaptive management should recognize, however, that the life history of desert tortoises and the complex interactions among tortoise populations, habitat, and threats will typically result in extended learning cycles over which improvements in understanding and management will occur. Therefore, we should not expect rapid cycles of implementation-monitoring-evaluation-adjustment. In many cases, intermediate or indirect benchmarks will be needed to measure progress.

Given the complexities of desert tortoise recovery described above, fully *active* adaptive management that vigorously pursues learning through management under structured experimental designs (Williams *et al.* 2007) will not always be possible. In these cases, *passive* adaptive management can be used to focus monitoring on resource status and other system attributes (Schwarz 1998; Williams *et al.* 2007). An assessment of the monitoring results can then be applied to on-the-ground management actions as we continue to learn and better understand the recovery needs of the species. In either case, the use of structured decision making and a decision support system will facilitate the adaptive management process (Ralls and Starfield 1995; Rauscher 1999; Williams *et al.* 2007). A decision support system is an interactive system that computes the output of a set of models (*e.g.*, effects of a threat on a tortoise population) based on underlying databases (*e.g.*, the spatial extent of the threat, tortoise population, and management actions). In fact, a decision support system will provide a vehicle for implementing adaptive management (Starfield and Bleloch 1991). The recovery decision support system recommended in this plan will incorporate a range-wide, geospatial database of current management activities, threats, and tortoise populations, providing managers a better framework for recognizing and implementing successful recovery actions. Through the use of conceptual models and research and monitoring results (Element 5), the decision support system will provide an explicit, well-documented process for making decisions.

Importantly, adaptive management requires an ongoing commitment of executive leadership, including management involvement and funding throughout the life of the recovery effort (Williams *et al.* 2007). It will also require effective communication among the various groups. Therefore, the Desert Tortoise Recovery Office will serve as the focal point for coordinating among agencies and researchers, through Recovery Implementation Teams (Element 1), to maintain and improve the decision support system. Finally, the Desert Tortoise Recovery Office will continue to coordinate with the Science Advisory Committee, which serves in an advisory role to the Fish and Wildife Service, to the interagency Desert Tortoise Management Oversight Group, and to the Recovery Implementation Teams to ensure that recovery action plans, recovery action effectiveness, research and monitoring, and recovery plan revision meet rigorous scientific standards.

7. Synthesis and Implementation

The different strategic elements of the Desert Tortoise Recovery Program fit within an adaptive framework (Figure 4). For example, the Land Management and Population Augmentation strategic elements fit within the *design* and *implementation* phases of adaptive management while the strategic elements of Monitoring and Research naturally fit within the *monitoring* phase of adaptive management. Partnerships are paramount throughout the adaptive management cycle, while the Decision Support System itself utilizes an adaptive management process. Regional Recovery Implementation Teams will include a member of the Desert Tortoise Recovery Office to provide guidance and coordination to land/wildlife managers and stakeholders on the teams, which will be responsible for developing step-down recovery action plans and implementing those actions on the ground. The Recovery Implementation Teams may leverage existing management partnerships such as the California Desert Managers Group or the Southern Nevada Agency Partnership. The Management Oversight Group will review the recovery-action plans, and the Recovery Implementation Teams will report to the Management Oversight Group on an annual basis to review progress. The Desert Tortoise Recovery Office will provide linkages between the Management Oversight Group, Recovery Implementation Teams, and Science Advisory Committee.

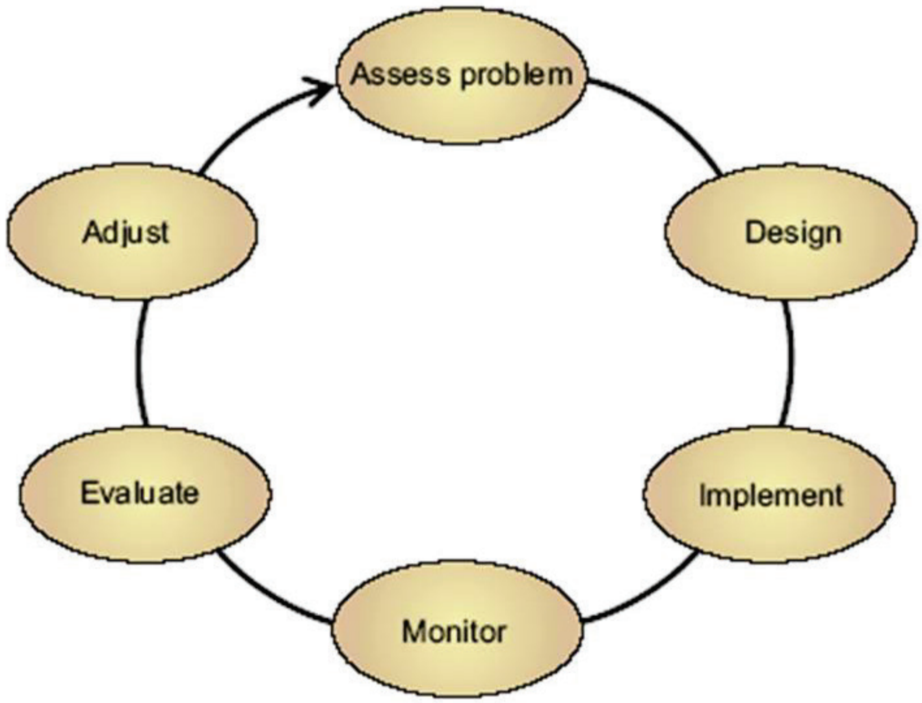

Figure 4. Diagram of the adaptive management process (from Williams *et al*. 2007).

Implementation of recovery actions within each strategic element will result in more visible progress toward recovery of the desert tortoise. Likewise, mitigation of activities harmful to desert tortoises should draw on the suite of opportunities provided by these elements, with the flexibility to apply an action most appropriate to the situation. Communication between Fish and Wildlife field offices, the Desert Tortoise Recovery Office, Recovery Implementation Teams, and other agency staff through section 7 and 10 activities will ensure that these activities are consistent with the Recovery Implementation Teams' recovery-action plans and this recovery program.

B. RECOVERY UNITS

1. Background and Assessment of Recovery Units

> **Box 3. Recovery units** for the desert tortoise are special units that are geographically identifiable and are essential to the recovery of the entire listed population, *i.e.*, recovery units are individually necessary to conserve the genetic, behavioral, morphological, and ecological diversity necessary for long-term sustainability of the entire listed population. Recovery criteria (described below) must be evaluated for each individual recovery unit for the entire listed population of the desert tortoise to be considered for delisting.
>
> Recovery units collectively cover the entire range of the species. Critical habitat and other management designations included within "tortoise conservation areas" are focal areas for recovery within each recovery unit. As a result, evaluation of recovery criteria for each recovery unit and implementation of most recovery actions will be focused within tortoise conservation areas as defined in Box 2 and Figure 2.

The 1994 Recovery Plan identified six **recovery units** (Box 3): Upper Virgin River, Northeastern Mojave, Eastern Mojave, Eastern Colorado, Northern Colorado, and Western Mojave (Figure 5). When the recovery units were initially delineated, genetic, morphological, ecological, and behavioral differences were identified at a species-wide scale, and finer differentiation with the Mojave population was acknowledged (*e.g.*, Woodbury and Hardy 1948; Burge 1977; Jennings 1985; Turner *et al.* 1986; Weinstein and Berry 1987; Lamb *et al.* 1989; Glenn *et al.* 1990; Germano 1993; Lamb and Lydehard 1994; USFWS 1994a). Since 1994, we have gained greater insight into patterns of both ecological and genetic variation within the Mojave desert tortoise population. Our approach is to examine the 1994 recovery unit boundaries in light of new information with the goal of defining recovery units which balance both distinctiveness and variability within the Mojave desert tortoise. Conserving meaningful distinctiveness through the recognition of appropriate recovery units within the species ensures that local adaptation as well as critical genetic diversity are maintained. Conversely, splitting a species into inappropriate subunits for conservation can result in artificial fragmentation and further loss of variability, increase extinction risk, and compromise future resiliency (Mace and Purvis 2008). Thus, appropriately defining conservation units which balance both distinctiveness and variability within the species is important for recovery.

(a) Ecological variation. The Mojave Desert is a transitional vegetation type wedged between the Great Basin and Sonoran deserts (Rowlands *et al*. 1982; Turner 1982; MacMahon 1992:47). Previously described subdivisions have broad, indistinct boundaries due to gradational transitions among subregions and with surrounding areas (Webb *et al*. 2009b). The Mojave Desert straddles the Great Basin Section of the Basin and Range Province to the north and the Sonoran Desert Section to the south. These two physiographic (*i.e.*, related to the physical geography of the landscape) sections meet just south of Las Vegas, Nevada, and the Utah-Arizona border. However, the biological boundaries between Great Basin and Sonoran desert affinities are farther north, near Beatty, Nevada, and St. George, Utah, respectively (MacMahon 1992:47). The lack of coincidence of the physiographic and biological subdivisions of the Mojave Desert demonstrates the Mojave Desert's transitional position.

Figure 5. Recovery units as delineated in the 1994 Recovery Plan. Recovery units encompass the entire range of the listed species, so the only "hard" peripheral edge is along the Colorado River; the northern, western, and southern boundaries are defined by the actual distributional limits of the desert tortoise.

The Colorado Desert (a subdivision of the Sonoran Desert) is both in the southeastern-most part of California and in the Mojave population of the desert tortoise's range; it is recognized as a distinct biome with a different climate than the Mojave Desert (Brown 1982). However, the separation of the Mojave Desert along its boundary with Sonoran (Colorado) desert scrub is commonly blurred because distinct coincidental breaks in indicator species' ranges are lacking (Turner 1982). In addition, climate variables vary linearly across the range of the desert tortoise (*e.g.*, winter:summer rainfall; Figure 6; Table 3). The central Mojave is topographically and climatically transitional between the southwestern and eastern Mojave desert. The south-central Mojave is a transitional region to the Colorado/Sonoran Desert, and the southern half of this region is similar climatically and floristically to the eastern Mojave. Many

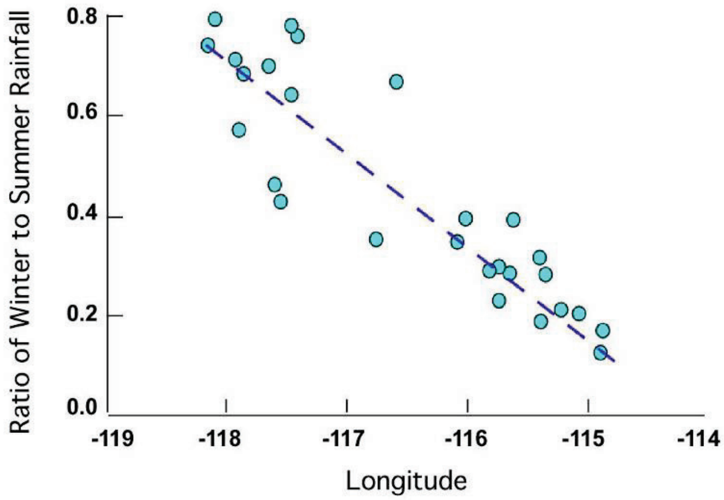

Figure 6. Ratio of rainfall in winter compared to summer in the Mojave Desert. Graph reprinted from Tracy *et al.* (2004).

of the differences in vegetation can be explained by differences in climate (Rowlands 1995). Given the broad or incongruent transitions between identified subdivisions of the Mojave and Sonoran deserts, and continuous tortoise habitat and distribution within these transitions, we minimize the use of these areas in identifying recovery units where other supporting data are absent.

Modeling desert tortoise habitat relates occurrence information to spatial data on plant communities, soils, topography, and geology. A recent habitat model uses desert tortoise occurrence data from sources spanning more than 80 years, especially including data from the 2001 to 2005 range-wide monitoring surveys (USFWS 2006) and 16 environmental variables such as precipitation, geology, vegetation, and slope (Figure 1) (Nussear *et al.* 2009). This model elucidates areas of continuous habitat, as well as imporant topographic barriers, both of which we use in defining recovery units.

(b) Genetic variation. The U.S. Fish and Wildlife Service (USFWS 1994a) and Tracy *et al.* (2004) acknowledged that additional genetic analysis would be valuable to delineate recovery units. Two population genetic analyses have been recently completed; the authors of each suggest different recovery unit delineations (Murphy *et al.* 2007; Hagerty and Tracy 2010). As we considered how to delineate recovery units in this plan, we were cognizant that modern molecular genetic tools increasingly make it possible to find genetic differences between population subunits, whether or not those differences are biologically significant (Hedrick 1999). Such differences potentially confound the goal of conserving the evolutionary potential of a species; they can over-emphasize differences between population subunits and lead to separately conserving any subunit that shows evidence of genetic differentiation. Management based on dividing a species into more subunits than is appropriate can result in loss of variability within the species that is vital for recovery (*i.e.*, artificially segregating population segments needed to maintain the inherent variation within a larger whole; Mace and Purvis 2008).

All recent genetic studies of the desert tortoise have suggested that its population structure is characterized by isolation-by-distance (Britten *et al*. 1997; Edwards *et al.* 2004a; Murphy *et al*. 2007; Hagerty and Tracy 2010). That is, populations at the farthest extremes of the distribution are the most differentiated, but a gradient of genetic differentiation occurs between those populations, across the range of the species. This genetic gradient is similar to the ecological gradient across the Mojave and Colorado deserts.

Recent genetic work also suggests that, historically, levels of gene flow among subpopulations were likely high, corresponding to high levels of connectivity among habitat types (Murphy *et al.* 2007; Hagerty 2008; Hagerty and Tracy 2010; Hagerty *et al.* 2010). The capability for long-distance dispersal (Berry 1986; Edwards *et al*. 2004b), combined with longevity and opportunities to reproduce annually throughout adulthood, indicates high potential for gene exchange outside of local areas. Free genetic exchange throughout the distribution will be constrained, however, by the large range of the species given the relatively much smaller home range size and dispersal ability of individuals (see Allendorf and Luikart 2007:209). Topographic features (*e.g.*, mountain ranges) and other potential barriers (*e.g.*, impassable habitat types, extreme climate conditions) can structure regional populations and lead to variable exchange of migrants among populations, allowing populations to differentiate over time by means of genetic drift and natural selection.

Based on the relatively continuous distribution of habitat occupied by the Mojave population of the desert tortoise, especially relative to the more fragmented habitat occupied by the Sonoran population (Figure 1; see also Germano *et al.* 1994), genetic differentiation within the Mojave population is generally consistent with isolation by distance in a continuous-distribution model of gene flow. The continuous-distribution model of gene flow describes a situation in which populations of a particular neighborhood size could be identified anywhere (such as the sample sites of Murphy *et al*. 2007), and individuals inside those neighborhoods would represent a panmictic (randomly mating) group (Allendorf and Luikart 2007:209-211). To describe genetic relationships within species, particularly boundaries between divergent units, methods require analysis of many individuals sampled across relatively evenly spaced locations to avoid wrongly inferring genetic discontinuities between disjunct sampling locations (Pritchard *et al*. 2000; Allendorf and Luikart 2007:400; see also criticism of sampling from discrete study plots established for other purposes in Berry *et al*. [2002]). An assessment of gene flow among subunits of the Mojave population revealed broad patterns of migration interrupted by major topographic barriers (Hagerty *et al.* 2010). The apparent isolation-by-distance and pattern of gene flow among desert tortoise populations leads us to use genetic information to validate or reinforce other ecological or topographic boundaries, rather than as the primary means of identifying recovery units.

2. Revised Recovery Units

Given the generally continuous variation in genetic structure and biomes across the Mojave desert tortoise's range, our approach in delineating revised recovery units stresses identification of geographic discontinuities or barriers that coincide with any observed variation among tortoise populations. Several potential barriers are evident from topographic maps, the U.S. Geological Survey habitat model (Figure 1), and landscape genetic analyses (Hagerty *et al.*

2010). We used differences in genetic, ecological, and physiological characteristics to help highlight boundaries or other differences between units. In doing this, we considered demographic, ecological, and behavioral considerations to be of greater importance than genetic issues alone, as have been suggested by researchers providing recommendations on the formulation of conservation plans for threatened or endangered species (Avise 2004:486-487; Mace and Purvis 2008).

With the aid of modern GIS tools we are able to map boundaries of each recovery unit (Figure 7) much more precisely than in 1994, although as indicated above, transitions between recovery units are not always as precise on the ground as depicted by lines on a map. We have reduced the number of recovery units from six to five and have changed some boundaries of the 1994 recovery units, as described and justified below. Note that we drew the peripheral boundaries depicted in Figure 7, other than the Colorado River, with the intention of simply encapsulating the entirety of the desert tortoise's current range, not to precisely circumscribe current desert tortoise habitat or populations (Box 3).

Descriptions of vegetation communities and complexes as well as related desert tortoise ecology are as generally described by Rowlands *et al.* (1982) and USFWS (1994a) except where otherwise noted. Finally, we note that variation in genetics, behavior, morphology, ecology, or other evidence *within* recovery units emphasizes the need, when evaluating management actions (particularly head-starting and translocation), to consider whether environmental conditions or habitat-type differences have been different for many generations. If so, this could lead to adaptations that are important for the long-term persistence of the species even in the face of high gene flow (Allendorf and Luikart 2007:415; Murphy *et al*. 2007). The recovery criteria (described in the next section) emphasize conserving tortoise populations and habitat within each recovery unit (Box 3), thus conserving the diversity present within each recovery unit.

Even though the 1994 Recovery Plan described the initial recovery units as "distinct population segments" (DPSs), recovery units should not be confused with DPSs. Designation of DPSs can only be done through a formal rule-making process; they cannot be designated in recovery plans. Policy enacted following publication of the 1994 Recovery Plan states that vertebrate populations that are "discrete" and "significant" and formally designated as DPSs can be considered for listing or delisting (USFWS 1996). While the listed Mojave population does meet the DPS criteria, individual subunits do not qualify as DPSs under the 1996 policy (USFWS 2010). As described above, (historically) occupied habitat and genetic differentiation across the Mojave DPS are relatively continuously distributed, and variation in other characteristics are likely related to the transitional nature of, or environmental gradations between, subdivisions of the Mojave and Colorado deserts. These factors disqualify subunits of the Mojave DPS according to the discreteness criterion of the policy. As a result, under current policy, status changes (*i.e.*, uplisting or delisting) may only be applied to the entire Mojave DPS based on evaluation of the recovery criteria and analysis of the five listing factors.

(a) Upper Virgin River Recovery Unit. This recovery unit is equivalent to the original Upper Virgin River Recovery Unit in the 1994 Recovery Plan (USFWS 1994a) and encompasses all desert tortoise habitat in Washington County, Utah, east of the Beaver Dam Mountains (Figure 8).

Figure 7. Revised recovery units for the Mojave population of the desert tortoise. Recovery units encompass the entire range of the listed species, so the only "hard" peripheral edge is along the Colorado River; the northern, western, and southern boundaries are defined by the actual distributional limits of the desert tortoise.

Unique habitat characteristics and tortoise behavior in this region justify separating the most northern extreme of the tortoise's range, east of the Beaver Dam Mountains, into a separate recovery unit (Figure 8). The 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), as well as mild summers during which the tortoises are continually active (Table 3). 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 (*Artemisia* spp.) scrub, creosote bush scrub, blackbrush scrub, and a psammophytic (sandy-soil) community. Desert tortoises often use sandstone and lava caves instead of burrows, travel to sand dunes for egg laying, and use still other habitats for foraging.

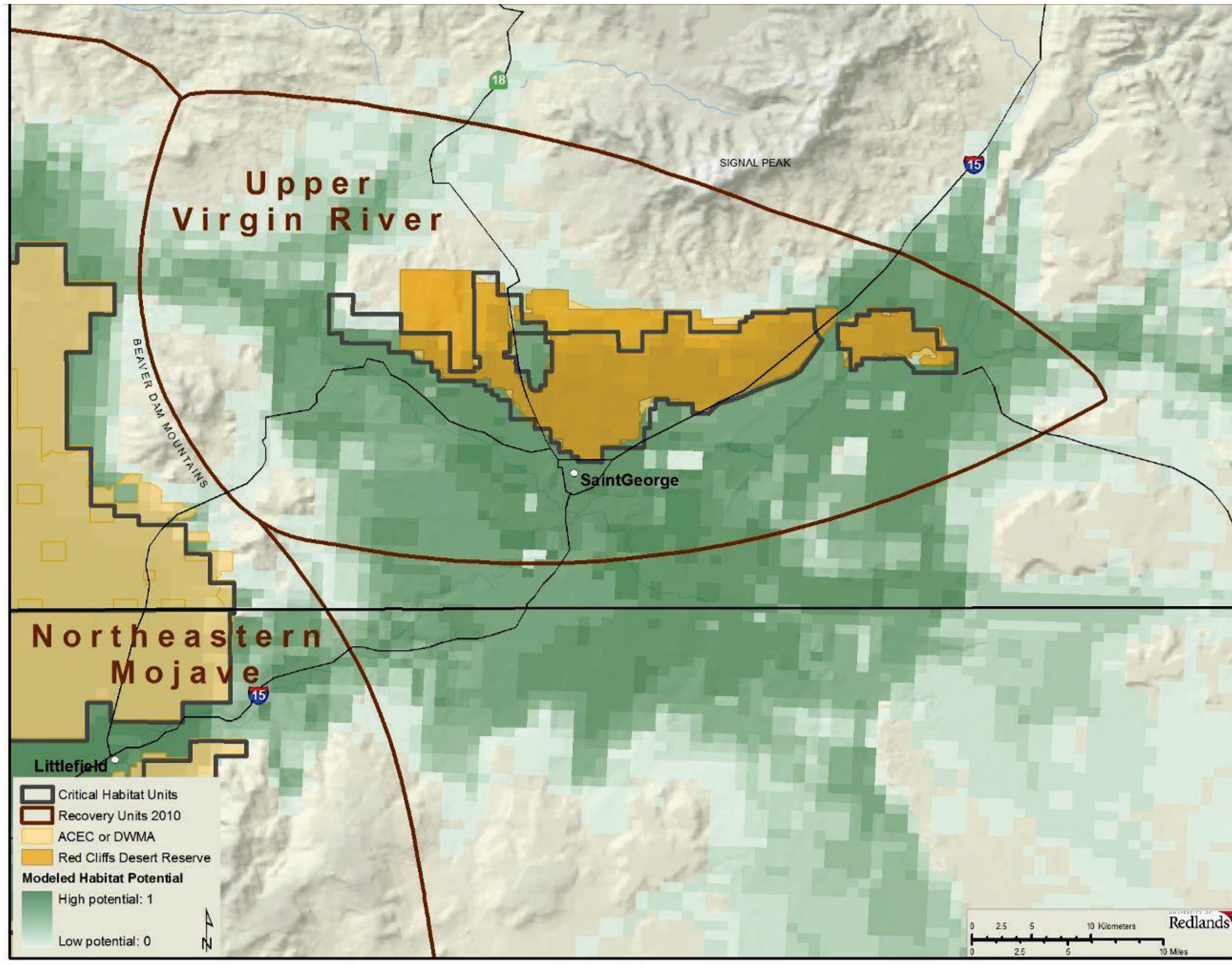

Figure 8. Upper Virgin River Recovery Unit. Modeled tortoise habitat depicted directly south of the Red Cliffs Reserve and extending into Arizona has either been lost to urbanization or is not known to have ever been occupied (Bury *et al*. 1994). DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern.

Recent DNA microsatellite[1] evidence (Hagerty and Tracy 2010) suggests that there is little genetic differentiation between the Upper Virgin River and the neighboring recovery unit, which supports findings from allozyme (protein) and mitochondrial DNA (mtDNA) markers (Lamb *et al*. 1989; Britten *et al*. 1997). Although assignment tests correctly placed 95 percent of individuals in the Upper Virgin River Recovery Unit (Murphy *et al*. 2007), samples from nearby populations west of the Beaver Dam Mountains were not included in the study.

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[1] A variety of genetic tools are available to assess genetic variation or genetic structure in organisms. These tools are often referred to as "genetic markers." Allozymes are proteins which are used as genetic markers because DNA contains information that is used by cells to build protein. Molecular techniques, such as microsatellites and mtDNA, allow biologists to examine variation in DNA directly, rather than looking at the product derived from DNA (*i.e.*, protein). It is important to be aware of which genetic marker has been used because different markers have different characteristics, and these characteristics influence how genetic data are best and most reliably interpreted (described in detail in Parker *et al*. 1988 and Avise 2004).

The recovery unit includes the Upper Virgin River critical habitat unit and Washington County's Red Cliffs Desert Reserve. Modeled tortoise habitat depicted directly south of the Red Cliffs Reserve and extending into Arizona has either been lost to urbanization or is not known to have ever been occupied (Bury *et al*. 1994).

(b) Northeastern Mojave Recovery Unit. The Northeastern Mojave Recovery Unit is similar to the original Northeastern Mojave Recovery Unit (USFWS 1994a), extending into extreme southwestern Utah and northwestern Arizona, but excluding portions south of Las Vegas (Figure 9). The east end of the unit extends south from the Beaver Dam Mountains, across the north end of the Virgin Mountains, down to the Colorado River. From the Colorado River at Las Vegas Bay, the southern boundary extends west generally along Las Vegas Wash through the city of Las Vegas to the Spring Mountains. From here, the western boundary extends north up the Sheep Mountains.

Recent DNA microsatellite data indicate that this unit is genetically similar to the Upper Virgin River Recovery Unit, but the Northeastern Mojave Recovery Unit does contain distinct microsatellite differences compared to the remainder of the range (Hagerty and Tracy 2010). The Sheep Mountains down to the Spring Mountains act as a near barrier for the western portion of this unit. Some variation may occur to the south and west from the Mormon Mesa, but genetic breaks appear to be ambiguous relative to at least semi-permeable topographic barriers to gene flow, such as the Muddy Mountains. An allozyme cluster at one locus from populations in the Mormon Mesa critical habitat unit overlaps another cluster identified from populations in Piute Valley in the Eastern Mojave Recovery Unit (Britten *et al*. 1997). A distinct shell phenotype also occurs in the Beaver Dam Slope region (USFWS 1994a; Britten *et al*. 1997), but these tortoises are not genetically isolated from adjacent populations within the recovery unit (Bury *et al*. 1994).

Desert tortoises in this recovery unit 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 blackbrush scrub. Desert tortoises are often active in late summer and early fall, in addition to spring, reflecting the fact that this region receives up to about 40 percent of its annual rainfall in summer (Table 3) and supports two distinct annual floras on which tortoises can feed. Average daily winter temperatures usually fluctuate above freezing, and summer temperatures are typically a few degrees cooler than in the western Mojave and Colorado deserts. Two or more desert tortoises often den together in caliche caves in bajadas and washes or caves in sandstone rock outcrops, and they typically eat summer and winter annuals, cacti, and perennial grasses.

This recovery unit includes the Beaver Dam Slope, Gold Butte-Pakoon, and Mormon Mesa critical habitat units (Figure 9). It also includes Lake Mead National Recreation Area south to Las Vegas Bay, Grand Canyon-Parashant National Monument on the Arizona Strip, and the eastern edge of Desert National Wildlife Range.

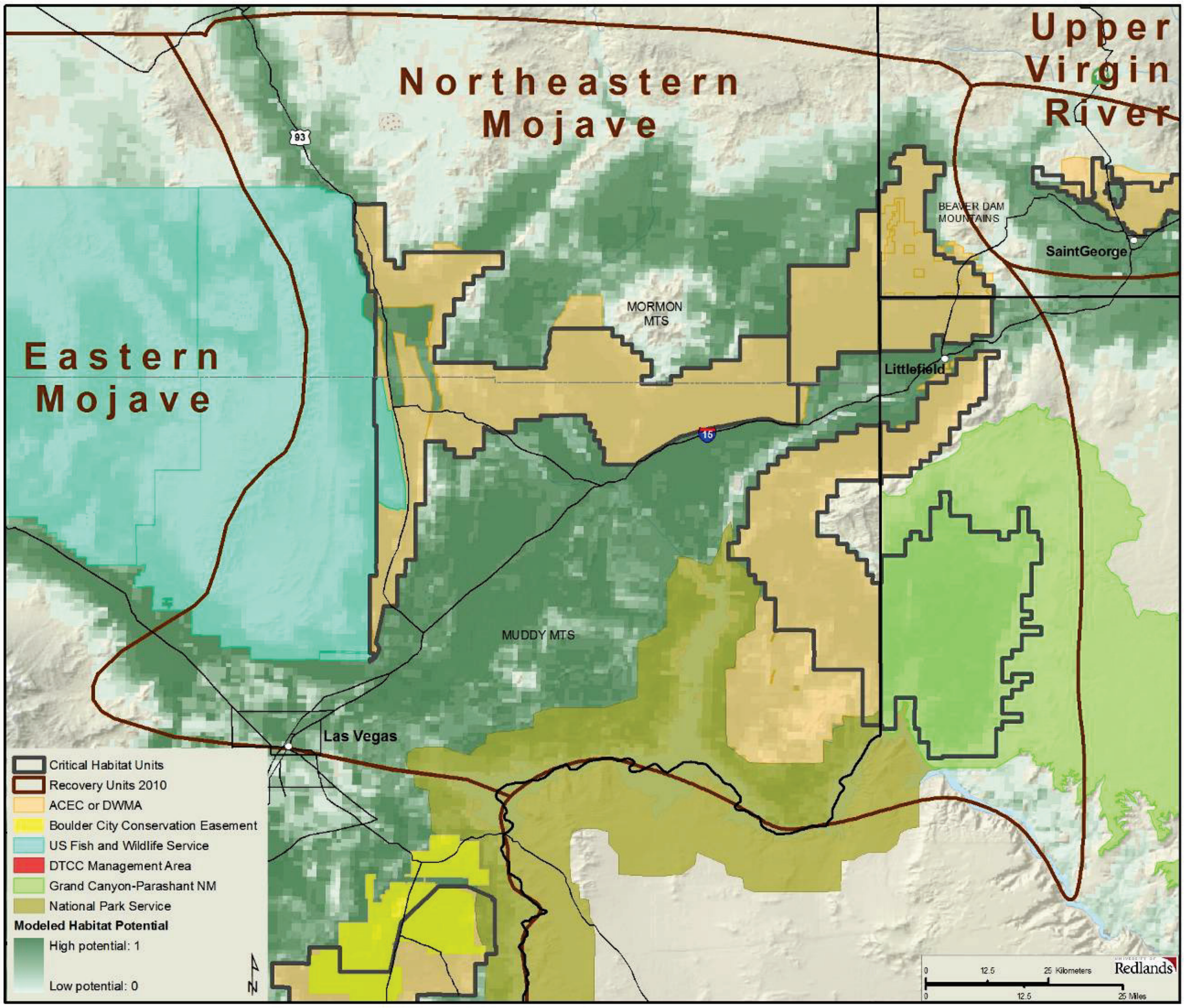

Figure 9. Northeastern Mojave Recovery Unit. DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern.

(c) Eastern Mojave Recovery Unit. The Eastern Mojave Recovery Unit is similar to the original Eastern Mojave Recovery Unit (USFWS 1994a), spanning the Nevada-California border, including Oasis Valley, Amargosa Desert, Pahrump Valley, and extending south into Shadow Valley, but now including habitat north of the Spring Mountains east to the Sheep Mountains as well as Las Vegas and Eldorado valleys north to the city of Las Vegas (Figure 10). The Eastern Mojave Recovery Unit borders the Northeastern Mojave Recovery Unit to the east, extending down the Sheep Mountains to the Spring Mountains, east to Las Vegas Bay on Lake Mead, then down the Colorado River. From the Colorado River at approximately Cottonwood Cove, the southern boundary extends west through Searchlight, down the New York and Providence mountains to the Granite Mountains. From there the western boundary extends north through the Bristol Mountains, Soda Lake, and Silurian and Death valleys. The Spring Mountains, which provided much of the separation between the former Northeastern Mojave and Eastern Mojave recovery units, narrowly channel gene flow through habitat corridors to the north and south, connecting this recovery unit to the Northeastern Mojave Recovery Unit (Figure 10; Hagerty 2008; Hagerty *et al.* 2010).

A majority of this unit had not been sampled previously; however, recent microsatellite data reflect unique nuclear allele frequencies, indicating that this area is relatively isolated from other recovery units (Hagerty and Tracy 2010). Allele frequencies from tortoises at Amargosa Desert and Pahrump Valley sites also form a homogeneous cluster different from other Nevada sites (Britten *et al*. 1997). The Sheep Mountains appear to form a barrier to tortoise movement between the eastern side of the recovery unit and the Northeastern Mojave Recovery Unit. The New York and Providence mountains isolate Ivanpah/Shadow valleys from Eldorado/Fenner valleys in the Colorado Desert Recovery Unit to the east. Saline Valley and Death Valley extending south into Silurian Valley and Soda Dry Lake act as a barrier between this recovery unit and the Western Mojave Recovery Unit. Although gene flow likely occurred intermittently

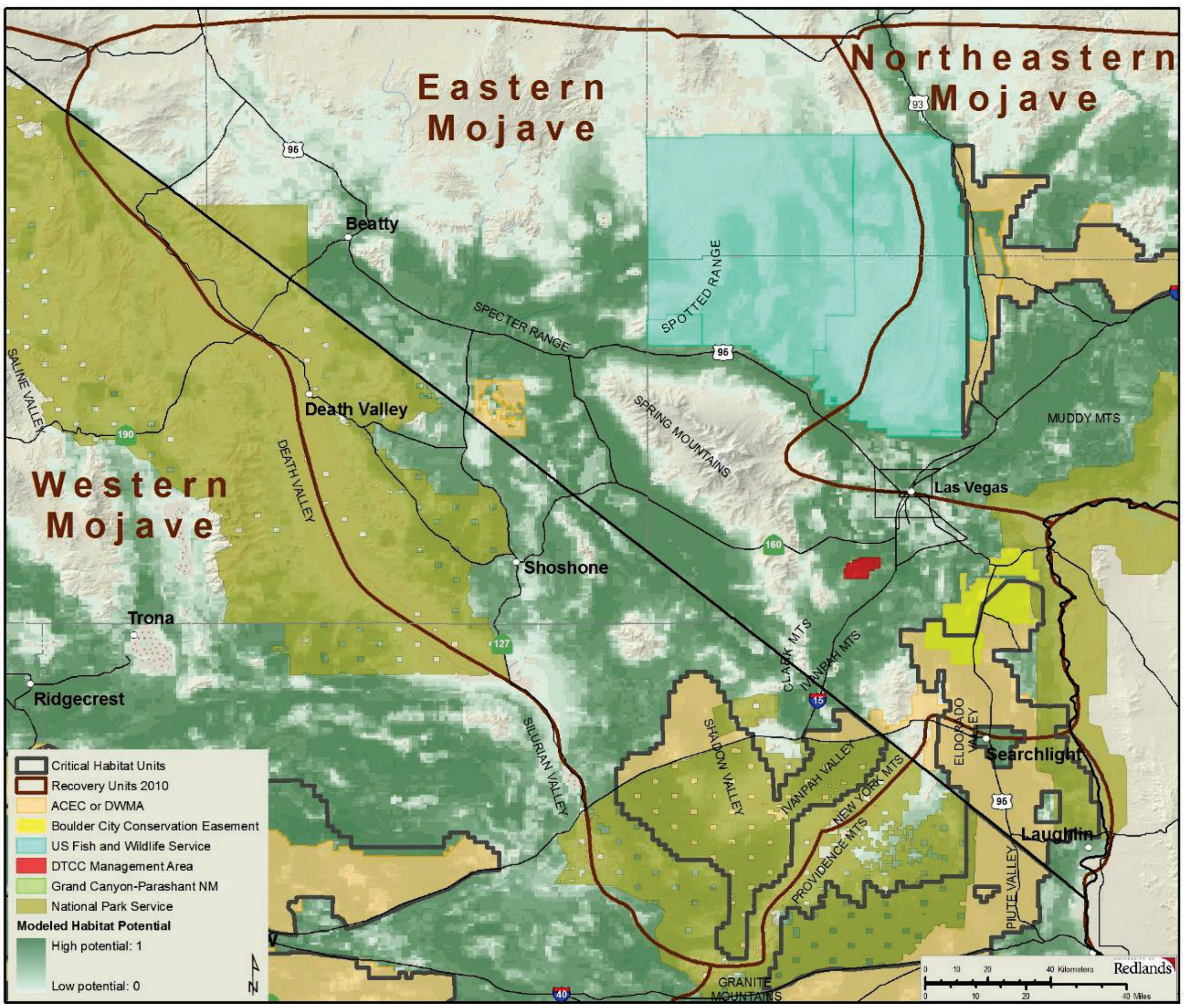

Figure 10. Eastern Mojave Recovery Unit. DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern; DTCC = Desert Tortoise Conservation Center.

during favorable conditions across this western edge of the recovery unit, this area contains a portion of the Baker Sink, a low-elevation, extremely hot and arid strip that extends from Death Valley to Bristol Dry Lake. This area is generally inhospitable for desert tortoises.

Desert tortoises in this recovery unit 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 blackbrush scrub. As in the northeastern Mojave Desert, desert tortoises are often active in this recovery unit in late summer and early fall, in addition to spring, reflecting the fact that this region receives up to about 40 percent of its annual rainfall in summer (Table 3) and supports two distinct annual floras on which tortoises can feed. They typically eat summer and winter annuals, cacti, perennial grasses, and herbaceous perennials. Average daily winter temperatures usually fluctuate above freezing, except in the higher elevations. Summer temperatures are typically a few degrees cooler, except in the lowest elevations of Death Valley, than the recovery units to the south and west (Table 3).

The recovery unit includes the east side of Death Valley National Park, much of Mojave National Preserve, and Lake Mead National Recreation Area between Las Vegas Bay and Cottonwood Cove, as well as the Nevada Test Site and the western end of Desert National Wildlife Range. It also includes the Ivanpah Valley critical habitat unit and the Eldorado Valley portion of the Piute-Eldorado critical habitat unit (Figure 10). A lack of desert tortoise habitat dedicated to conservation to the west of the Spring Mountains and in Las Vegas Valley highlights the need for careful management in these areas to maintain connectivity among populations and the genetic variation within this recovery unit. Corridors north and south of the Spring Mountains warrant particular management attention to prevent genetic isolation of populations on either side of this mountain range.

(d) Colorado Desert Recovery Unit. This recovery unit combines the 1994 (USFWS 1994a) Eastern Colorado and Northern Colorado recovery units, as well as a portion of the Eastern Mojave Recovery Unit in Piute and Fenner valleys. It is primarily found in California, though it extends into Piute Valley, Nevada, in the northern corner (Figure 11). Patchy habitat southeast of the Cadiz Valley appears to provide some linkage and gene flow, at least historically, between the former Northern and Eastern Colorado recovery units (Figure 11; Nussear *et al.* 2009; Hagerty *et al.* 2010). This linkage, combined with minimal genetic differentiation and a gradient of environmental variation between units (see below), eliminates the biological justification for maintaining these as separate recovery units. Piute and Fenner valleys span the northern border of the northern Colorado Desert and southern edge of the eastern Mojave Desert. The recovery unit shares its north and west boundaries with the Eastern Mojave Recovery Unit: west from Cottonwood Cove Road, through Searchlight, down the New York and Providence mountains, to the Granite Mountains. From the Granite Mountains, the boundary extends through the Old Dad and Bristol mountains, southeast through Bristol Lake and Cadiz Valley, to the southern end of the Calumet Mountains. From there, the boundary drops down to and extends west along California State Highway 62 all the way to the San Bernardino Mountains, including the Morongo Basin. The southern boundary circumscribes the tortoise's range east to the Colorado River.

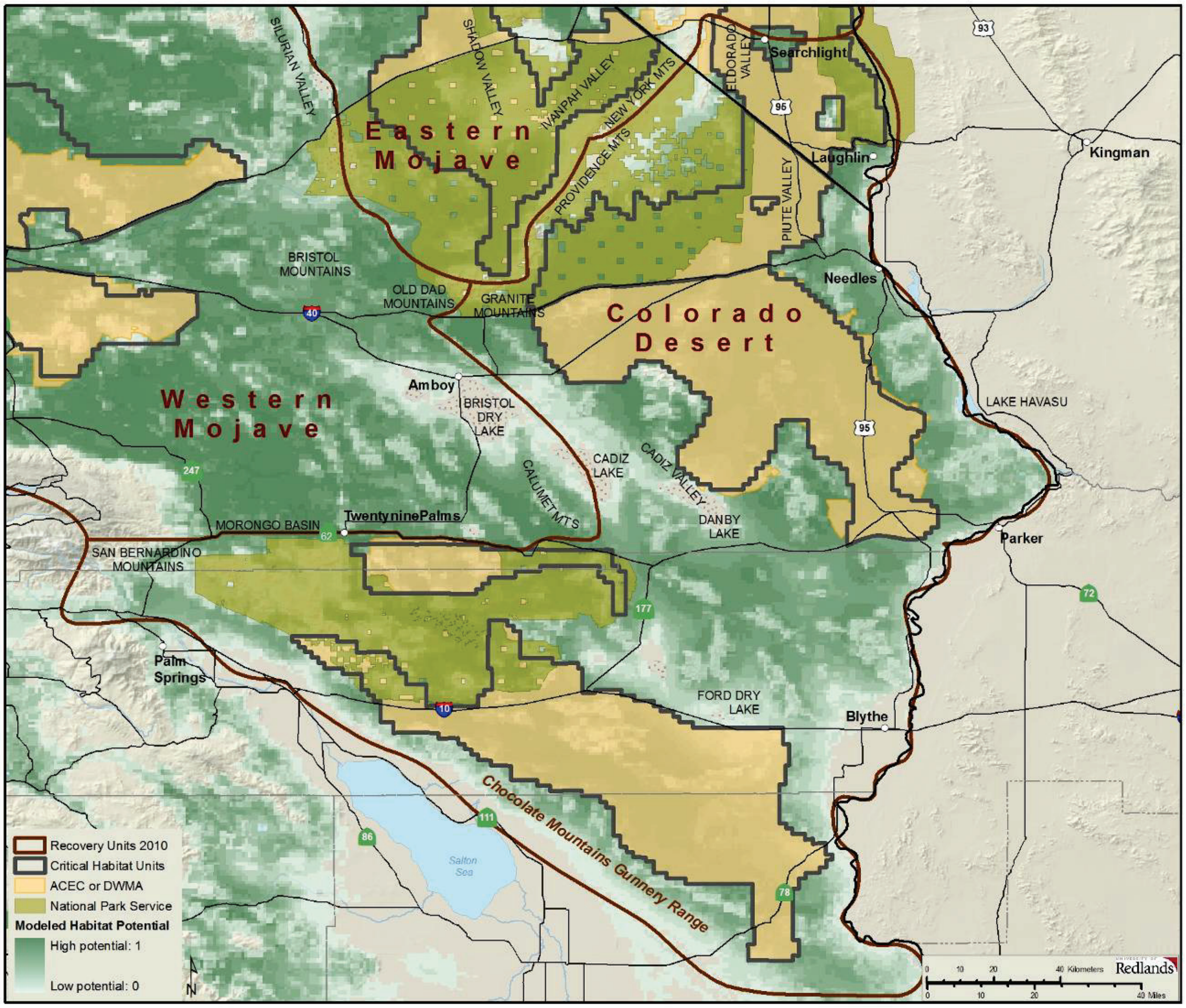

Figure 11. Colorado Desert Recovery Unit. DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern.

The prominent Providence and New York mountain ranges, which transect Mojave National Preserve, largely isolate this recovery unit from the Eastern Mojave Recovery Unit to the west (Figure 11). Searchlight Pass is the northern boundary, which separates Eldorado and Piute valleys. The central portion of this recovery unit is separated from the Western Mojave Recovery Unit by the Baker Sink, a low-elevation, extremely hot and arid strip that extends from Death Valley to Bristol Dry Lake and Cadiz Valley. To the south, the transition between the Colorado and Mojave deserts is more subtle. However, urban development along California State Highway 62 now largely separates the two recovery units; use of this highway as the recovery unit boundary is justified based on the broad transition between the two deserts (Turner 1982) and the lack of a natural break in desert tortoise habitat. While the Baker Sink almost divides this recovery unit in half, as generally reflected in the 1994 Northern and Eastern Colorado recovery units (Figure 5), the Colorado Desert is a distinct biome that encompasses a continuum of climatic and floristic characteristics (Turner 1982) and only subtle differences were originally noted in these recovery unit descriptions (USFWS 1994a). Furthermore, substantial historic gene flow is now recognized within the entire Colorado Desert biome (Murphy *et al*. 2007; Hagerty *et al.* 2010; Hagerty and Tracy 2010). Tortoises from the northern and eastern Colorado deserts lumped within the same basal genetic clusters in two different analytic models (Hagerty 2008). What little genetic differentiation that has been observed between the former Northern and Eastern Colorado recovery units is likely due to an absence of sampling from (at least historical) populations in the central part of the combined unit, south of Highway 62 and east of Highway 177 (*cf*. Allendorf and Luikart 2007:400; Figures 7 and 11).

Desert tortoises in this recovery unit share mtDNA haplotypes (sets of closely linked genetic markers on a single chromosome that tend to be inherited together; a chromosome is a long strand of DNA on which genes are found) with the Western Mojave Recovery Unit (Lamb *et al*. 1989; Murphy *et al*. 2007) and possess the California shell type (USFWS 1994a). They are differentiated from desert tortoises in the Northeastern Mojave and Western Mojave recovery units at several allozyme loci (Rainboth *et al*. 1989; Britten *et al*. 1997). Microsatellite data also support the boundary between the Colorado Desert and Northeastern Mojave and Eastern Mojave recovery units (Murphy *et al*. 2007), but less so with the Western Mojave Recovery Unit (Hagerty 2008; see also the continuous-distribution model discussion above). Inclusion of the Fenner and Piute valleys in this recovery unit is justified by the contiguous habitat, the failure to reliably assign sampled tortoises to the correct site between Fenner and Chemehuevi valleys (Murphy *et al*. 2007), and the inclusion of individuals from these valleys as part of the Colorado Desert subunit in more extensive genetic analyses (Hagerty and Tracy 2010).

In the Colorado Desert Recovery Unit, desert tortoises are found in the valleys, on bajadas, desert pavements, rocky slopes, and in the broad, well-developed washes (especially to the south). Vegetation is characterized by relatively species-rich succulent scrub, creosote bush scrub, and blue paloverde (*Parkinsonia florida*)-ironwood (*Olneya tesota*)-smoke tree (*Psorothamnus spinosus*) communities. Tortoises feed on both summer and winter annuals, because this region receives about 1/3 of its annual rainfall in summer (Table 3) and supports two distinct annual floras on which they can feed. The climate is somewhat warmer than in other recovery units, with very few freezing days per year (Table 3). Tortoises within this recovery unit near Goffs produce relatively smaller eggs, produce more eggs overall, lay their second clutches earlier, and are smaller overall than tortoises in the Desert Tortoise Research Natural Area in the Western Mojave Recovery Unit (Wallis *et al*. 1999). They also produce more eggs than similarly sized females at the Nevada Test Site in the Eastern Mojave Recovery Unit (Mueller *et al*. 1998).

The recovery unit includes the Piute-Eldorado critical habitat unit (south of Eldorado Valley) and the Chemehuevi, Pinto Mountains, and Chuckwalla critical habitat units. This unit encompasses the eastern end of Mojave National Preserve, the southernmost limits of Lake Mead National Recreation Area, Joshua Tree National Park, and the Chocolate Mountains Gunnery Range. Unprotected habitat southeast of the Cadiz Valley may provide important connectivity necessary to maintain overall genetic variability among populations in this recovery unit.

(e) Western Mojave Recovery Unit. This recovery unit is generally equivalent to the original Western Mojave Recovery Unit in the 1994 Recovery Plan (USFWS 1994a) and is found entirely in California (Figure 12). It includes the central, southwestern, south-central, and part of the northern Mojave regions described by Rowlands *et al*. (1982). The eastern boundary, which it shares with the Eastern Mojave Recovery Unit, extends down Death and Saline valleys, through Soda Lake and the Bristol Mountains, to the Granite Mountains. The eastern boundary continues down the low-lying Baker sink and Cadiz Valley, separating it from the Colorado Desert Recovery Unit. The boundary extends west along California State Highway 62 to the San Bernardino Mountains.

Habitat in California was well connected prior to human development, allowing gene flow to occur over long geographic distances and multiple vegetation types (Murphy *et al*. 2007) and which is evidenced by results from a landscape-genetic analysis which illustrated diffuse gene flow throughout the recovery unit (Hagerty *et al.* 2010). The north half of this recovery unit borders the Eastern Mojave Recovery Unit along the Baker Sink, a low-elevation, extremely hot and arid strip that extends from Death Valley to Bristol Dry Lake and Cadiz Valley (Figure 12). To the south, the transition between the Colorado and Mojave deserts is more subtle. However, urban development along California State Highway 62 now largely separates the Western Mojave and Colorado Desert recovery units.

Microsatellite evidence concerning the degree of differentiation between the Western Mojave and Colorado Desert recovery units is conflicting, although genetic differentiation is generally low (Murphy *et al*. 2007; Hagerty and Tracy 2010). Morphological characteristics and mtDNA from populations in the Western Mojave also overlap those in the Colorado Desert Recovery Unit (Lamb *et al*. 1989; USFWS 1994a; Murphy *et al*. 2007). Yet, tortoises in the west Mojave from the Kramer Hills region are differentiated from desert tortoises at in the Chemehuevi Valley in the Colorado Desert Recovery Unit at several allozyme loci (Rainboth *et al*. 1989). There is significant genetic differentiation between the Western Mojave Recovery Unit and the adjacent Eastern Mojave Recovery Unit (Murphy *et al*. 2007; Hagerty and Tracy 2010). There also may be some sub-structuring within the Western Mojave Recovery Unit (Murphy *et al*. 2007), which, like the differentiation between this and the Colorado Desert Recovery Unit, may be an artifact of discrete sampling within generally continuous habitat (Allendorf and Luikart 2007:400). Substructuring within the Western Mojave Recovery Unit was not found under more continuous sampling (Hagerty and Tracy 2010).

A pronounced difference between the Western Mojave and other recovery units, including the closely allied Colorado Desert Recovery Unit, is in timing of rainfall and the resulting vegetation. In the Western Mojave Recovery Unit, most rainfall occurs in fall and winter (Table 3) and produces winter annuals, which are the primary food source of tortoises. The Western Mojave Recovery Unit contains a unique combination of vegetation types, including the Mojave saltbush (*Atriplex* spp.)-allscale (*A. polycarpa*) scrub complex, blackbrush scrub, cheesebush (*Hymenoclea salsola*) scrub, iodinebush (*Allenrolfea occidentalis*)-alkali scrub complex, desert needlegrass (*Achnatherum speciosum*) scrub steppe, big galleta (*Pleuraphis rigida*) scrub steppe, and the Indian ricegrass (*Achnatherum hymenoides*) scrub-steppe complex, extending slightly into the southwestern Colorado Desert (USFWS 1994a). Above-ground activity occurs primarily (but not exclusively) 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. The extreme differences in precipitation and food availability relative to the other recovery units correspond to different foraging and activity patterns as well as to different life history characteristics. Tortoises dig deep burrows (usually located under shrubs on bajadas) for winter hibernation and summer estivation due to generally warm summers and cold winters (Table 3). Tortoises in the Desert Tortoise Research Natural Area within this recovery unit produce relatively larger eggs, produce fewer eggs overall, lay their second clutches later, and are larger overall than tortoises near Goffs in the Colorado Desert Recovery Unit (Wallis *et al*. 1999). Tortoises in the western Mojave Desert have the smallest reported minimum size at first reproduction (less than 18 centimeters [7 inches]) compared to populations in other recovery units (Germano 1994). Behaviorally, western Mojave tortoises are much less active during summer than are tortoises in other recovery units.

The recovery unit includes the Fremont-Kramer, Superior-Cronese, and Ord-Rodman critical habitat units. The recovery unit also includes the western half of Death Valley National Park, Marine Corps Air Ground Combat Center, Fort Irwin National Training Center, China Lake Naval Weapons Center, and Edwards Air Force Base.

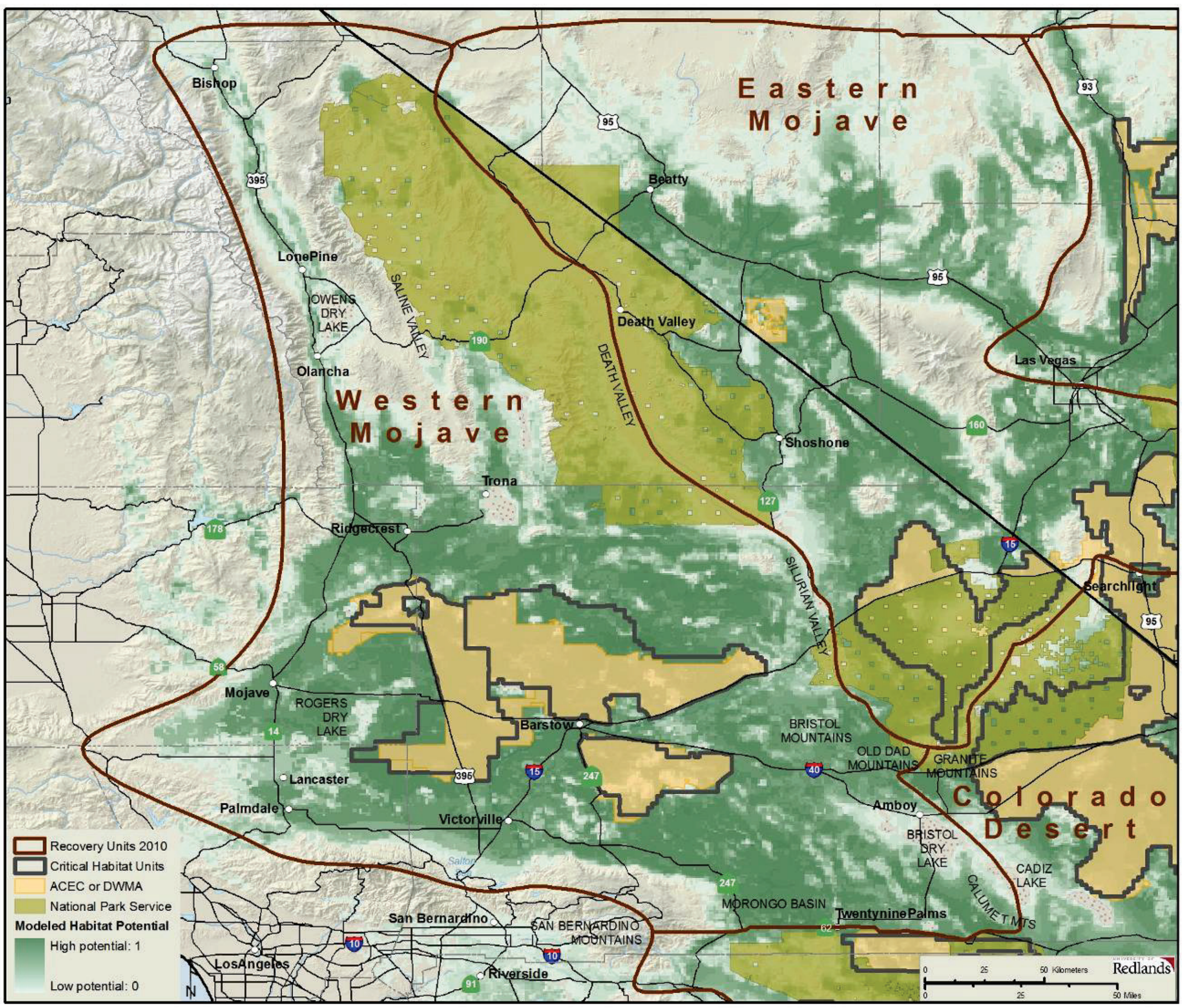

Figure 12. Western Mojave Recovery Unit. DWMA = Desert Wildlife Management Area; ACEC = Areas of Critical Environmental Concern.

Table 3. Climatic summary for weather stations within desert tortoise recovery units. %J-S = percent of precipitation falling in summer; W and S = number of winter and summer days with 2.5 mm precipitation. Some stations are listed more than once where they occur near the boundary of multiple recovery units. Superscripts are initials of recovery units which particular stations border. Table modified from Table E1 in USFWS (1994a).

		Temperature (ºC)				**Precipitation (mm)**		**No. Days with 2.5 mm Ppt**	
Station	**Elev (m)**	**Mean Ann Min**	**Mean Jan**	**Mean July Max**	**No. Days Freeze**	**Mean Ann**	**%J-S**	**W**	**S**
Upper Virgin River Recovery Unit									
St. George	823	15.6	-5.3	38.4	96	209.6	29.2	16	4
Northeastern Mojave Recovery Unit									
Littlefield	567	18.2	-1.1	40.3	74	157.5	23.8	15	3
Las Vegas WPAP[EM]	659	18.9	-0.1	40.1	46	99.1	40.0	8	3
Desert NWR[EM]	890	16.8	-1.5	38.2	127	103.9	27.1	6	3
Eastern Mojave Recovery Unit									
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
Baker[WM]	319	---	0.9	42.9	---	75.2	20.7	8	1
Las Vegas WPAP[NM]	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
Desert NWR[NM]	890	16.8	-1.5	38.2	127	103.9	27.1	6	3
Beatty	1010	15.3	-2.4	37.5	88	118.0	14.9	11	2
Searchlight[CD]	1070	17.5	1.7	36.1	34	208.7	37.3	11	5
Mountain Pass	1442	---	-2.0	34.8	---	173.0	31.2	---	---
Colorado Desert Recovery Unit									
Thermal	-37	22.8	3.9	41.8	12	70.1	21.4	4	1
Indio	3	22.9	3.4	41.6	15	79.8	19.7	4	0
Blythe	81	22.2	2.0	42.2	12	100.3	32.7	5	1
Palm Springs	128	22.3	4.4	42.2	12	138.9	11.2	9	2
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
Eagle Mtn	297	23.0	5.6	41.0	1	82.8	36.5	5	1
Hayfield	418	21.1	3.4	40.5	15	95.6	31.9	6	1
Twentynine Palms[WM]	602	19.7	1.6	37.2	29	104.4	36.3	5	4
Joshua Tree[WM]	838	---	---	---	---	123.7	23.4	---	---
Searchlight[NE]	1070	17.5	1.7	36.1	34	208.7	37.3	11	5

Table 3. Continued.

Station	Elev (m)	Temperature (ºC) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	%J-S	No. Days with 2.5 mm Ppt W	S
Western Mojave Recovery Unit									
Baker	319	---	0.9	42.9	---	75.2	20.7	8	1
Trona	517	18.9	-0.6	41.3	47	82.0	8.4	8	0
Twentynine Palms[CD]	602	19.7	1.6	37.2	29	104.4	36.3	5	4
Barstow	653	17.7	-0.4	39.1	57	108.5	27.2	10	2
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
Joshua Tree[CD]	838	---	---	---	---	123.7	23.4	---	---
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
Lucerne Valley	919	15.8	-2.4	38.9	104	108.2	18.1	10	3
Fairmont	933	15.7	2.2	32.6	29	376.7	2.3	20	0
Hesperia	974	---	---	---	---	157.7	6.3	---	---
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
Wildrose RS	1250	---	-1.6	35.1	---	185.2	19.8	---	---
Kee Ranch	1318	---	---	---	---	167.6	9.2	7	2

C. RECOVERY GOAL, OBJECTIVES, AND CRITERIA

Downlisting or delisting is warranted when a listed species no longer meets the definition of threatened or endangered under the Endangered Species Act. We set recovery criteria to serve as objective, measurable *guidelines* to assist us in determining when a species has recovered to the point that the protections afforded by the Endangered Species Act are no longer necessary. However, the actual change in listing status is not solely dependent upon achieving the recovery criteria set forth in a recovery plan; it requires a formal rule-making process based upon an analysis of the same five factors considered in the listing of a species (Reasons for Listing and Continuing Threats). The recovery criteria presented in this recovery plan thus represent our best assessment of the conditions that would most likely result in a determination that delisting of the desert tortoise is warranted as the outcome of a formal five-factor analysis in a subsequent regulatory rule-making.

Box 4. Definitions according to section 3 of the Endangered Species Act.

Endangered Species – Any species that is in danger of extinction throughout all or a significant portion of its range.

Threatened Species – Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

The recovery criteria can be viewed as the targets (rather than strict rules) by which progress toward achievement of recovery objectives can be measured. The revised criteria address a) representation (conserving the breadth of the genetic makeup of the species to conserve its adaptive capabilities), b) resiliency (ensuring that each population is sufficiently large to withstand stochastic events), and c) redundancy (ensuring a sufficient number of populations to provide a margin of safety for the species to withstand catastrophic events). Recovery criteria must be measurable and objective, but they need not all be quantitative.

Importantly, recovery criteria should also include the management or elimination of threats, addressing the five statutory (de-)listing factors. However, even though a wide range of threats affect desert tortoises and their habitat (and some such as disease and fire have attracted much recent attention), very little is known about their demographic impacts on tortoise populations or the relative contributions each threat makes to tortoise mortality (Boarman 2002; Tracy *et al.* 2004). As described previously, the facts that desert tortoises require over a decade to reach maturity, they have temporally variable reproduction, and juveniles have low survival rates, make it difficult to tease apart relative impacts of individual threats (although some impacts, such as habitat loss, are fairly straightforward in that they eliminate populations completely). Therefore, specific and meaningful threats-based recovery criteria cannot be identified at this time. For example, we lack quantitative data on the specific contribution of raven predation, disease, or other individual threats on tortoise population declines. Specific criteria to reduce one or more of these threats by a specified amount may ultimately be unnecessary as we learn more about, and better manage, other particular threats.

In the meantime, threats are addressed in the recovery actions outlined in the next section, and we assume that threat mitigation will have been successful if the current recovery criteria have been met (taking into consideration any head-starting or translocation efforts). While it is important to understand as much as possible about the direct links between threats and tortoise population response (*i.e.*, cause and effect), the number of potential threats affecting desert tortoises and the nature of the species' life history (long generation time) may make it impractical to reach this level of understanding completely. However, evaluating the extent and intensity of threats across the landscape over time will allow recovery efforts to be better tailored to specific areas in conjunction with information gained through research (see Recovery Action 4.4). Specific recovery actions, including research, must be implemented to identify sets of threats that contribute to a greater number of mortality mechanisms or affect size structure or fecundity. Experimental (or, in some cases, observational) studies should be applied to specific plots or areas to better understand the relationship of threats, management actions, and tortoise populations (Recovery Actions 3.4, 5.4, 5.5).

The relative strengths of postulated connections between threats and mortality must also be evaluated (some individual linkages may be more important than multiple linkages from other threats). This assessment should be based on data from research designed specifically to elucidate relationships between threats and mortality. As quantitative information on threats and tortoise mortality is obtained, more specific threats-based recovery criteria may be defined during future recovery plan review and revision, and effective management actions can be identified, prioritized, and implemented through land use plans, cooperative agreements, or other recovery management agreements. In fact, given the list of – and uncertainty surrounding the relative importance of – threats to the desert tortoise, the desert tortoise may well fit within the concept of a conservation-reliant species, requiring ongoing, concerted management efforts even after our recovery criteria have been achieved (Scott *et al*. 2005).

1. Recovery Goal

The goal of the recovery plan is recovery and delisting of the desert tortoise.

2. Recovery Objectives and Criteria

Recovery objectives and criteria are outlined below, followed by more detailed explanation and rationale. Note that the recovery criteria generally will be measured within tortoise conservation areas or other areas identified by Recovery Implementation Teams (see Recovery Action 1), and they are not independent of each other but must be evaluated collectively. Recovery does not depend on absolute numbers of tortoises or comparisons to pre-listing estimates of tortoise populations, but rather the reversal of downward population trends and elimination or reduction of threats that initiated the listing.

(a) Recovery Objective 1 (Demography). Maintain self-sustaining populations of desert tortoises within each recovery unit into the future.

Recovery Criterion 1. Rates of population change (λ) for desert tortoises are increasing (*i.e.*, $\lambda > 1$) over at least 25 years (a single tortoise generation), as measured

a) by extensive, range-wide monitoring across tortoise conservation areas within each recovery unit, and

b) by direct monitoring and estimation of vital rates (recruitment, survival) from demographic study areas within each recovery unit.

(b) Recovery Objective 2 (Distribution). Maintain well-distributed populations of desert tortoises in each recovery unit.

Recovery Criterion 2. Distribution of desert tortoises throughout each tortoise conservation area is increasing over at least 25 years (*i.e.*, ψ [occupancy] > 0).

(c) Recovery Objective 3 (Habitat). Ensure that habitat within each recovery unit is protected and managed to support long-term viability of desert tortoise populations.

Recovery Criterion 3. The quantity of desert tortoise habitat within each desert tortoise conservation area is maintained with no net loss until tortoise population viability is ensured. When parameters relating habitat quality to tortoise populations are defined and a mechanism to track these parameters established, the condition of degraded desert tortoise habitat should also be demonstrably improving.

3. Rationale

(a) Recovery Objective/Criterion 1 (Demography). *This objective and associated criteria emphasize the need to increase desert tortoise populations across tortoise conservation areas in each recovery unit over 25 years (a tortoise generation). Achievement of these criteria will indicate that all listing factors (A-E) will have successfully been addressed.*

The original listing of the desert tortoise was based on documented downward trends in a number of populations rather than on absolute numbers of tortoises being below a threshold level (USFWS 1990). In addition, while we have some historical information on desert tortoise densities within some localized areas, no historical (pre-listing) information exists on regional population levels. Therefore, evidence that the ecological processes maintaining tortoise populations have been sufficiently restored to warrant consideration for delisting will be based on observation of a positive population trend over a period of at least 25 years. Basing the criteria on trends has an advantage over setting specific target numbers (*e.g.*, 40 tortoises per $kilometer^2$ [104 tortoises per $mile^2$]), because absolute tortoise numbers may show considerable variation between regions as a result of ecological differences or other factors, but a positive population trend is a clear indication that mechanisms leading to recovery are in place and that recovery is occurring. For example, there is evidence that historic natural population densities differed between the Upper Virgin River and Colorado Desert recovery units (USFWS 2006), but the reason for different population densities is not known. There is no reason to think that a single target density should be applied to all recovery units, yet attempting to set unique targets for each recovery unit would not be prudent given the lack of data on both historic population numbers and what numbers would constitute sustainable populations in the current environment. However, if all areas demonstrate a positive population trend regardless of actual population counts, the interpretation will be that recovery is occurring.

The way ecologists estimate whether a population is increasing or decreasing is by using a variable called lambda (λ), which indicates population change. When λ is greater than one, the population is considered to be increasing and when it is less than one, the population is decreasing. Several kinds of data (*e.g.*, counts of individuals, recruitment and survival rates) can be used to derive estimates of λ. This is reflected in our use of two recovery criteria here. Recovery Criterion 1a is based on data that are relatively easy to gather over large areas using range-wide monitoring with counts of individuals (*i.e.*, line distance sampling), while Recovery Criterion 1b is based on data that are more difficult to gather but that may give us a more precise indication of population change using vital rates such as recruitment and survival from demographic study areas.

Natural variability in population size and inherent measurement error make it extremely difficult to detect realistic natural increases (*i.e.*, less than 2 percent per year) in desert tortoise populations in as few as 25 years (USFWS 2006). For this and other reasons, the Science Advisory Committee recommended the recovery criteria rely on a suite of measures instead of relying primarily on a single quantitative estimate that is difficult to measure in a species with a low intrinsic growth rate and is difficult to detect. At the same time, the Science Advisory Committee suggested using a 90 percent confidence band ($\alpha = 0.10$) to describe population trends. For an increasing trend, the lower 90 percent confidence limit for each estimate of λ should exceed 1. This precision level makes it possible to distinguish a small (less than 2 percent per year) trend from a non-growth trend, but is still fairly conservative. Although an arbitrary convention exists to use 95 percent confidence intervals ($\alpha = 0.05$) for many statistical tests, setting $\alpha = 0.10$ has the conservative effect of guarding against incorrectly concluding a decline in tortoise density has *not* occurred at the expense of a slightly increased possibility that an increasing or declining trend is "detected" when, in fact, the population is stable (Shrader-Frechette and McCoy 1993:155-156; see also McGarvey 2007). Anderson and Burnham (1996), proposed $\alpha = 0.15$ for this monitoring program at the time they proposed the design. The Science Advisory Committee also noted that combined use of independent measures of recovery (population trends, habitat quantity and quality, threat abatement) provides additional assurance that detected trends are meaningful.

<u>Range-wide monitoring (Criterion 1a)</u>. The number of tortoises in each recovery unit is related to the density of tortoises estimated by line distance sampling techniques (USFWS 2006). It can also be related to the extent of the habitat occupied by tortoises and how that extent expands or contracts over time (*e.g.*, Royle *et al*. 2005; see Recovery Criterion 2). Either approach can relate changes in an index (density or occupancy) to changes in time to estimate the population growth rate λ. Either density or occupancy will focus on particular size classes, often neglecting the smallest size class, for instance. This approach therefore assumes that if the focal size class is increasing, this is because it is recruited from and contributing to the neighboring size classes, which must also be increasing. When evaluating an endangered species, however, this assumption should be validated by independent evidence that the other size classes are recruiting as well, hence we will also validate the recovery-unit-wide estimates through more intensive study of the underlying recruitment and survival rates on smaller scales within recovery units (Criterion 1b).

Vital rates (Criterion 1b). Validating that vital rates are at increasing levels will be important to ensure that populations are able to maintain their size or trajectory upon delisting. Demographic (vital) rates describe the proportion of each size class, for instance, that grows into the next size class and/or produces offspring in a given time period. These rates also include mortality rates, estimating the proportion of each size class that dies during that time interval. These rates allow us to describe how a population changes from one time period to the next. Because the total number of tortoises changes from one time period to the next, dynamic models should be used to provide an independent estimate of the population growth rate λ.

However, measuring recruitment and survival across the entire range of the tortoise is logistically difficult and prohibitively expensive. Therefore, the concept of "demographic study areas" is introduced to focus sampling efforts at a scale at which statistically defensible trends of the desired population parameters can be measured (see Recovery Actions 4.1, 5.1). The number, size, and sampling frequency of demographic study areas remain to be defined, with advice from the Science Advisory Committee and Recovery Implementation Teams, but they should be small relative to the size of each recovery unit, and they should be representative of each recovery unit. Existing permanent study plots may be incorporated into the set of demographic study areas within each recovery unit, if appropriate. Measuring recruitment and survivorship rates within demographic study areas within each recovery unit addresses the recovery concepts of representation and resiliency.

(b) Recovery Objective/Criterion 2 (Distribution). *This objective and associated criterion emphasize increasing the distribution of desert tortoises (within tortoise conservation areas) over at least 25 years. As such, it applies to Listing Factor A, the present or threatened destruction, modification, or curtailment of the tortoise's habitat or range.*

Recovery Criterion 1 focuses on population growth. Recovery Criterion 2 focuses on the distribution of tortoises across the landscape. The 1994 Recovery Plan only indirectly addressed this issue by recommending enough habitat be conserved to ensure viable tortoise populations, but it did not directly address population processes acting across the spatial scale of entire recovery units. The purpose of Criterion 2 is to prevent range contraction of the desert tortoise. To detect changes in desert tortoise distribution, we will monitor the ratio of samples at which tortoises are detected across tortoise conservation areas within each recovery unit. The probability that randomly sampled sites are occupied by the desert tortoise is referred to as occupancy (indicated by ψ; MacKenzie *et al.* 2006). Similar to λ in Recovery Criterion 1, we specify that the lower 90 percent confidence limit be used to evaluate the slope of ψ within each recovery unit (which must exceed 0). An average increase in tortoise density in a recovery unit reflected by growth only in highly localized areas, while tortoises in other areas are extirpated, would not reflect recovery.

This recovery objective provides for representative, resilient, and redundant populations. Although habitat is explicitly addressed by Recovery Objective 3, implicit in Objective 2 is the maintenance of sufficient habitat to sustain tortoises on the landscape. That is, increasing tortoise distributions, even if augmented by translocation or head-starting, can only be achieved by managing habitat appropriately. Establishing a precise geographic baseline across all lands within tortoise conservation areas will help ensure that habitat loss does not result in a comparison of similar relative measures of tortoise occupancy across smaller absolute areas in the future.

(c) Recovery Objective/Criterion 3 (Habitat). *This objective and associated criterion emphasize maintaining desert tortoise habitat within desert tortoise conservation areas, but are not meant to diminish the importance of populations and habitat outside the conservation areas. Therefore, they directly apply to Listing Factor A, the present or threatened destruction, modification, or curtailment of the tortoise's habitat or range.*

Habitat is the suite of resources (food, shelter) and environmental conditions (abiotic variables such as temperature and biotic variables such as competitors and predators) that determine the presence, survival, and reproduction of a population (Caughley and Sinclair 1994). Quality of habitat can affect reproductive success and survival of individuals occupying the habitat (Pulliam 1996), and declining or extirpated populations typically require intensive habitat management to stabilize and reverse trends. Much is known about what constitutes desert tortoise habitat, and a range-wide model of habitat for the Mojave population of the desert tortoise has been recently completed (Nussear *et al*. 2009).

> **Box 5. Terms related to monitoring habitat.**
>
> **"Habitat loss"** (evaluated under Recovery Criterion 3) is considered here as acreage subject to the complete or absolute removal of elements necessary for desert tortoise occupation (*i.e.*, grading or paving of the landscape so that no food or shelter resources are available) or other identified thresholds of habitat quality fall below that which can support desert tortoises.
>
> **"No net loss"** of desert tortoise habitat refers to balancing acreage of habitat loss on public lands within tortoise conservation areas with new, restored, or enhanced acreage of habitat, such that at least the minimum conditions for desert tortoise occupation are met. No net loss of habitat may be relaxed under special circumstances in which we determine greater recovery benefits can be achieved through other means, and it will be evaluated over the expected 25-year recovery period.
>
> **"Habitat degradation"** involves impacts to desert tortoise habitat, short of absolute habitat loss, that compromise its ability to support desert tortoises (*e.g.*, invasion of fire-adapted, non-native vegetation or increased incidence of unauthorized off-highway vehicle trails).
>
> **"Potential desert tortoise habitat"** as defined here is based on the U.S. Geological Survey habitat model, regardless of current occupancy by desert tortoises.

Criterion 3 establishes a target for **no net loss** (Box 5) of current habitat *within tortoise conservation areas*. The geographic baseline over which trends in habitat quantity will be monitored includes all **potential desert tortoise habitat** (Box 5) within tortoise conservation areas at the time of publication of the final, revised recovery plan (see Recovery Action 4.3). This baseline will be "memorialized" in a range-wide recovery database (managed by the Desert Tortoise Recovery Office) by applying the U.S. Geological Survey habitat model to habitat data at the time the recovery plan is published, in coordination with Recovery Implementation Teams (see Recovery Action 6.1). **Habitat degradation** or **loss** in some areas should be balanced with habitat acquisition or restoration of degraded habitat in other areas, as specified in the West Mojave Plan for example (BLM *et al.* 2005), thus achieving the no-net-loss standard and maintaining tortoise occupancy through maintenance of (quality) available habitat. However, the target for no net loss established by Recovery Criterion 3 may be relaxed on a *limited*, case-by-case basis, if we determine that greater recovery benefits can be achieved through other means than replacing every acre of lost habitat with another acre elsewhere. Given that tortoise conservation areas include both designated critical habitat and BLM's Desert Wildlife Management Areas and Areas of Critical Environmental Concern, which do not always coincide, the Recovery Implementation Teams will refine and recommend the geographic baseline for measuring no net loss of habitat, using available tortoise data in coordination with and approval by the Desert Tortoise Recovery Office.

Given the vast amount of desert tortoise habitat already under Federal management, Criterion 3 does not apply generally to private lands. However, private or other non-Federal lands under conservation management for desert tortoises are included in tortoise conservation areas (see Box 2, page 34) and can contribute substantially to this recovery objective. In addition, habitat loss and degradation elsewhere must be minimized and mitigated, while not appreciably reducing the likelihood of survival and recovery of the tortoise, pursuant to section 10(a)(2) of the Endangered Species Act.

In order to manage desert tortoise habitat well enough to meet Objectives 1 and 2, we would also benefit from statistical models linking habitat data to tortoise demographic data (see Recovery Action 5.1). Information from this type of model would allow us to identify minimum habitat conditions for potential tortoise occupancy and, therefore, to analyze occupancy as a function of habitat characteristics. We ultimately need to define specific parameters that relate to the quality of desert tortoise habitat (see Recovery Action 5.1) and to develop and implement a system for tracking habitat quality over time. In particular, we need to identify thresholds below which habitat degradation is so severe that the habitat fails to provide the minimum conditions for potential occupancy (*e.g.*, due to fires). Measures related to habitat quality could include miles of roads and trails or the number and size of habitat fragment polygons created by roads. Incorporating a GIS "ledger" of habitat status into the range-wide recovery database, accounting for restored areas on the positive side and degraded or lost areas on the negative side, will enable managers to quantitatively measure the amount of occupied habitat, the amount of newly available (restored) habitat for tortoises to disperse into, the rate that restored habitat is occupied, and effectiveness of the restoration (*e.g.*, BLM 2002b: Appendix G). Through the Recovery Implementation Teams, management agencies should report habitat status (particularly habitat loss/gains) on their lands (Recovery Action 1.1).

Land management agencies must work within the context of their respective land use plans, including the provisions of adaptive management such as Recovery Actions 6.2-6.3 contained within this recovery plan, to determine measures to assure no net loss and to improve quality of existing desert tortoise habitat. Until better population/habitat viability models are developed (see Recovery Action 5.3), land managers should also strive to limit the loss of desert tortoise habitat outside conservation areas as much as possible, although we reiterate that the most aggressive recovery efforts are targeted toward tortoise conservation areas. A variety of means are available to improve existing desert tortoise habitat both within and outside conservation areas. Re-establishment of native vegetation on burned landscapes may increase desert tortoise populations (see Recovery Action 2.6, especially for associated research needs). Closure of unnecessary or illegal routes of travel can create larger unfragmented blocks of habitat. Additional mitigation for habitat impacts outside conservation areas could include options such as habitat acquisition or restoration of degraded habitat in other areas or recovery units, contributions to research, or facilitating population augmentation programs within conservation areas, depending on current needs, priorities, and opportunities.

Actions or projects occurring outside tortoise conservation areas, which will be reviewed under existing State laws and the Federal section 7 and 10 processes, should seek to minimize (1) negative impacts in adjacent areas, (2) creation of edge effects (impacts within an area from projects or activities outside that area) within the conservation areas, or (3) the severing of genetic linkages between tortoise conservation areas (see Hagerty *et al*. 2010). This approach recognizes the need for large natural areas to accommodate stochastic events (*i.e.*, resiliency). Tortoise conservation areas should be as undisturbed as possible and include intensive restoration or other management (*e.g.*, weed management), as necessary. Modeling should help better quantify what proportion of the habitat needs to be occupied or is available to be occupied for population sustainability.

D. RECOVERY ACTIONS

As noted previously, the recommended actions in the 1994 Recovery Plan formed a logical basis for recovery (GAO 2002), little information since 1994 contradicts these recommendations (Boarman and Kristan 2006), and insufficient time has elapsed over which detectable increases in desert tortoise populations or natural recovery of habitat could be realistically expected as a result of actions implemented to date. Therefore, many of the specific recommendations listed below, especially under Strategic Element 2, are adapted from the 1994 Recovery Plan. However, the revised plan places a greater emphasis on solidifying partnerships across jurisdictional boundaries to maintain focus on continuing to implement the recommended actions and on conducting applied research, modeling, and effectiveness monitoring to evaluate actions in a structured adaptive management context. As previously discussed, recovery actions will be focused within tortoise conservation areas; however, this does not preclude implementation of recovery or management actions outside these boundaries. Table 4 at the end of this section provides a side-by-side comparison of recovery actions recommended in the revised plan with those in the 1994 Recovery Plan. Table 5 identifies the listing factors and recovery objectives addressed by each major recovery action.

1. Develop, Support, and Build Partnerships to Facilitate Recovery

1.1. Establish regional, inter-organizational Recovery Implementation Teams to prioritize and coordinate implementation of recovery actions. Implementation of this recovery plan throughout the four-state range of the desert tortoise is a daunting prospect. However, if approached from a coordinated, regional or local level, recovery becomes much more feasible. Therefore, regional Recovery Implementation Teams need to be established within six months of publication of the final recovery plan to develop step-down plans and maintain focus on implementing recovery actions. Recovery Implementation Teams will encourage cross-jurisdictional, landscape-level action that will be tracked, monitored, and evaluated.

The Recovery Implementation Teams will be formed pursuant to section 4(f)(2) of the Endangered Species Act and are exempt from the Federal Advisory Committee Act. The teams should have broad representation by communities and the public involved in the recovery effort. The Desert Tortoise Recovery Office will work with interested managers and stakeholders in coordination with the Desert Tortoise Management Oversight Group to identify prospective participants, but members ultimately will be appointed by the Fish and Wildlife Service Region 8 Director. Both technical experts and stakeholders should be represented. Representatives on the Recovery Implementation Teams are encouraged to coordinate among their interest groups.

Organization of Recovery Implementation Teams should be based on a combination of recovery units and land management planning areas configured to be logistically practical for implementation activities from an agency jurisdictional perspective (such as Western Mojave Desert, Eastern Mojave Desert, Colorado Desert, Arizona-Nevada-Utah, and Upper Virgin River), rather than in strict congruence with individual recovery units. Recovery Implementation Teams will either coordinate directly with or perform as workgroups of existing regional partnerships, such as the California Desert Manager's Group, Southern Nevada Agency Partnership, and Washington County Habitat Conservation Plan's Adaptive Management Team, as appropriate. Recovery Implementation Teams will report annually to existing regional groups and Management Oversight Group meetings, both of which are open to the public and will provide a forum for further public input into team recommendations.

Specific tasks for each Recovery Implementation Team are to:
1. Develop a coordinated, science-based, implementable five-year recovery action plan for the assigned geographical area through a process of informed consent;
2. Coordinate implementation of recovery actions contained in the recovery action plan through the development of annual work plans;
3. Provide/secure the necessary resources for implementation of annual work plans;
4. Assess effectiveness of implemented recovery actions;
5. Compile up-to-date information on threats and recovery action implementation and effectiveness into a range-wide database and local-level decision support system;
6. Annually report findings and status to appropriate regional groups and the Management Oversight Group;
7. Annually review recovery action plans and revise as necessary.

Recovery Implementation Teams are the fundamental partnerships tying the adaptive management process together (Strategic Element 6; Figure 4). As a result, it is important that their regional/local efforts are productive and contribute to the range-wide effort. In order to ensure timely performance of tasks and cooperation between groups with disparate views, we recommend the following procedures:

- Each Recovery Implementation Team should have a chair to facilitate each meeting, and the Desert Tortoise Recovery Office should help organize activities through its regional recovery coordination staff. Independent facilitation should be secured, if necessary.

- Once the Recovery Implementation Team is constituted, the minimum list of participants to go forward with any meeting will be set. Unless decisions are adopted by all relevant parties, the Recovery Implementation Team is not making progress.

- The Recovery Implementation Team chair will alert participants to deadlines and ensure that all parties are aware of the need and schedule for moving the process forward.

Recovery Implementation Teams should also identify areas not included within existing tortoise conservation areas that may warrant focused management efforts to ensure recovery of the desert tortoise within their respective recovery units. Additional tasks of the Recovery Implementation Teams are described under Recovery Action 6 within the context of implementing the adaptive management program.

2. Protect Existing Populations and Habitat

A prototype decision support system (Strategic Element 6, Appendix C), using information provided by managers during recovery planning workshops, produced preliminary recovery action priorities relative to protecting desert tortoise populations and habitat for each recovery unit. While general priorities for each recovery unit are included in the descriptions of the remaining actions below, relative priorities for each action may change as additional information is integrated into the decision support system at local levels within each recovery unit or as new information is gained through research and monitoring. Most of the actions described below have been implemented to a greater or lesser extent in various parts of the desert tortoise's range. Inclusion in the revised plan reflects an emphasis on maintaining these actions where implemented, although general priorities may be lessened for actions that have been more broadly implemented (*e.g.*, managed livestock grazing) and effectiveness generally needs to be more specifically evaluated. Note that other State or Federal agency policies and regulations may impose specific measures or processes to determine appropriate compensation or mitigation both within and outside of tortoise conservation areas.

At this stage (*i.e.*, prior to development of regional step-down recovery action plans), the following actions serve as guidelines, especially within tortoise conservation areas as defined in Box 2, that management agencies should implement according to their respective land-use or similar plans. For example, specific measures designed to minimize or mitigate habitat loss (*i.e.*, maintain the "no net loss" standard of Recovery Criterion 3) or habitat degradation should be implemented by each land management agency in coordination with their respective Recovery Implementation Teams according to the local situation (*e.g.*, short-term or long-term impact, effect to high-quality or low-quality habitat) and governing authorities. Deviations from the following actions may be appropriate in some cases, but they should be supported by scientific rationale or justification as to how they can contribute to recovery. Again, quantifying the effectiveness of these or modified recovery actions is important, as specified under Action 5.4.

2.1. Conserve intact desert tortoise habitat. Land disturbances should be precluded within tortoise conservation areas. Disturbances to be avoided include those caused by development, off-highway-vehicle use, overgrazing by domestic livestock, construction of roads or other linear facilities, increased fire frequency, and other surface disturbing activities. For example, fire prevention and management should be pursued throughout the Mojave and Colorado deserts to contain the grass-fire cycle. Minimizing the size and intensity of fires will ease subsequent restoration efforts (2.6), even in previously burned areas. Fire suppression would also minimize direct and indirect effects on individual tortoises. Identifying and mapping priority areas and developing a fire plan for habitat protection, fire-crew access, and the use of natural or created fuel breaks could help limit response time and fire spread.

Development of alternative energy sources has also recently come to the forefront as a necessary and congressionally mandated use of public lands that could have large-scale impacts to desert tortoise habitat. Pursuant to the Bureau of Land Management land use plans, solar project facilities will be sited outside Desert Wildlife Management Areas and Areas of Critical Environmental Concern. Current proposals for energy projects within these land allocations should be relocated so that impacts to these areas are avoided. A cumulative impacts assessment should be conducted and appropriate areas and mitigation measures for this type of activity should be identified.

2.2. Minimize factors contributing to disease. Strategies for managing natural populations depend on the disease status of the population, deemed broadly as a) uninfected, b) recently infected with infection spreading, or c) infection status endemic. An endemic-status population is defined as one where the proportion that is seropositive is above zero and remains stable over time, although actually determining the disease status of populations is extremely challenging. Specific recommendations are listed below.

- Do not release infected individuals into the wild (Hudson *et al.* 2009).
- All tortoises found in the wild that may have been released from captivity without a health evaluation should be removed from the wild and used for breeding, adoption, or research programs unless they are determined to be uninfected and are genetically acceptable for that population (Hudson *et al.* 2009).
- No action should be taken to remove infectious or seropositive individuals from wild populations, particularly where data indicate the disease status of that population is endemic. This recommendation seeks to prevent the removal of individuals that are resistant to infection (Hudson *et al.* 2009).

  In populations where less than two percent of individuals are known to be infected, individual tortoises exhibiting clinical signs of acute infection can be removed for further testing, but should be returned to the point of capture if diagnostic tests confirm they are uninfected. Uninfected populations that have recently become infected should be carefully monitored with the removal of all individuals exhibiting acute infections (Hudson *et al* 2009).

- Site quarantines may be considered should an acute outbreak or chronic issue of disease be determined to put the larger population at risk.

- Prior to any human-facilitated movement of tortoises (translocation), tortoises must undergo a health assessment that includes disease screening as described in the most recent guidance issued by the U.S. Fish and Wildlife Service.

- Implement disease minimization measures based on the results of research conducted under Recovery Action 5.4 and evaluate and update these actions through Recovery Action 6's adaptive management program.

2.3. **Establish/continue environmental education programs.** Environmental education, a high priority in all recovery units, is a preventative action that has been shown to effectively change learned behavior and can be used to reduce stakeholder conflict before it happens (Hungerford and Volk 1990). An educated public is more likely to be aware of the consequences they can have on desert tortoises and to be more willing to take responsibility for their actions than those with less knowledge (Vaske and Donnelly 2007). Aggressive and widespread efforts in schools (such as the Mojave Max program in Clark County, Nevada), museums, hunting clubs, and in Bureau of Land Management and National Park Service visitor centers and interpretive sites are needed to inform the public about the status of the desert tortoise and its recovery needs.

Interpretive kiosks or visitor centers should be used to disseminate information about the desert tortoise and the need for regulated access and use of habitat. The Desert Tortoise Conservation Center in Las Vegas provides an opportunity for development of a regional education and research facility for these purposes. Education programs should include such subjects as husbandry and adoption programs for captive tortoises, the importance of discouraging unauthorized breeding of desert tortoises in captivity, and the illegality under State laws of releasing captive tortoises into wildlands. Education efforts should be focused on groups that use the desert on a regular basis, such as rock-hounds and off-highway vehicle enthusiasts. A permit system for access to sensitive areas would offer one way to educate desert recreationists. Additional educational tools include public service announcements, news releases, informational videos, brochures and newsletters, websites, and volunteer opportunities.

2.4. **Increase law enforcement.** People may conduct illegal activities either because they are unaware of the laws, they do not realize the consequence of their behavior, or they enjoy some personal benefit that outweighs the risk of being caught. Increased law enforcement presence is a relatively high priority in all recovery units (especially

Upper Virgin River) and includes enforcing regulations pertinent to the specific recommendations to protect tortoises or their habitat listed below. This action also includes using existing officers to ensure law enforcement presence during peak recreational use periods, such as weekends and holidays, on a rotational basis so enforcement activity is not lost on casual users during standard work-week hours. Increasing fines and establishing agreements between offices of adjacent management authorities to enforce regulations across jurisdictional lines would also improve the effectiveness of law enforcement efforts.

An increased law enforcement presence need not be restricted to commissioned peace officers, but could also include "rangers" or other personnel with a physical presence in the field who would make contact with public land users, communicate with law enforcement officers, and conduct other activities, as necessary (*e.g.*, minor restoration or trash removal). Such personnel, while unable to issue citations and warnings, should be coordinated with the appropriate agencies to focus on particular issues in their respective areas. Brochures identifying and encouraging reporting of problem illegal activities could be developed and distributed to management agencies for further distribution to recreationists or others. The following is a list of illegal activities known to negatively affect the desert tortoise and warrant increased enforcement.

- <u>Unauthorized off-road vehicle travel</u>. Across all recovery units, this aspect of law enforcement is the most important. Impacts from off-highway vehicle use include 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; damage or destruction of soil crusts; soil erosion; proliferation of weeds; and increases in numbers and locations of wildfires. Unauthorized off-highway vehicle use also results in increased human access and associated impacts such as deliberate maiming, killing, and removal of tortoises.

- <u>Deliberate maiming and killing of tortoises</u>. Formerly referred to as vandalism (Luke *et al.* 1991), specific examples include shooting, crushing, driving over, flipping over, and decapitating tortoises. Shooting (also called "plinking"), by far, is the most prevalent method (Boarman 2002). Preventing the discharge of firearms, except for hunting authorized by State wildlife agencies, in problem or other sensitive areas could help minimize this threat.

- <u>Unauthorized breeding and release of captive tortoises</u>. Captive release of tortoises (not limited to desert tortoises) poses numerous problems to wild resident populations. Examples include genetic pollution, hybridization between populations and possibly other tortoise species, the potential for introducing or spreading disease (*e.g.*, upper respiratory tract disease), and disturbance to the social structure of the resident population. Unauthorized breeding and release of pet desert tortoises particularly contributes to genetic pollution and disease spread. Placement of excess tortoises in adoption or translocation programs places a large burden (*e.g.*, cost of pick-up services, health testing, placement or adoption efforts) on resources that would otherwise be available for more productive recovery efforts. New State or local regulations may be necessary to prohibit unauthorized breeding of desert tortoises, and (increased) fines may be warranted for the release of captive tortoises into the wild. New State and/or local regulations regarding keeping tortoises as pets may be necessary and existing regulations should be enforced. New regulations to reduce the risk of disease introduction should restrict the number of desert tortoises a household can possess, restrict or ban contact with other tortoises species, require health assessments, and specify containment conditions to minimize the chances of escape. Regulations to reduce the risk of genetic contamination should restrict the number of desert tortoises a household can possess, prohibit the movement of captive desert tortoises from one geographic area to another, limit breeding, and specify containment conditions to minimize the chances of escape.

- Uncontrolled dogs. Domestic and feral free-roaming dogs are documented threats to captive and wild tortoises (Bjurlin and Bissonette 2001; see Boarman 2002). 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, may roam miles from home, dig up, and injure desert tortoises. This action entails implementing measures to control off-leash dogs (domestic dogs should at least be within sight and voice control), live-trapping free-ranging dogs, and developing free-ranging dog management plans.

- Dumping and littering. Dumping and littering provide subsidies to predators, thus elevating their populations and predation pressure on tortoise populations. It can also introduce toxic chemicals or hazardous materials to the environment. Release of balloons also contributes to litter in the desert and poses a threats to tortoises through entanglement or if balloons are ingested (Burge 1989; Walde *et al*. 2007).

2.5. **Restrict, designate, close, and fence roads.** Paved highways, unpaved and paved roads, trails, and tracks have significant 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 paved roads. Roads also fragment habitat and facilitate invasion of non-native vegetation. Collectively, the actions described below are of relatively high priority in all recovery units.

- Establishment of new roads should be avoided to the extent practicable within desert tortoise habitat within tortoise conservation areas; tortoise conservation areas should have a minimum goal of "no net gain" of roads.

- Existing roads should be designated as open, closed, or limited. This action is especially pertinent for closed or limited designations, which can help mitigate impacts mentioned above. Maintenance of route designation signs may also be required due to vandalism. Route designation is a particularly high priority in all recovery units except Upper Virgin River (moderate priority).

- <u>Non-essential or redundant routes should be closed, especially within tortoise conservation areas</u>. Emergency closures of dirt roads and routes may also be needed to reduce human access and disturbance in areas where human-caused mortality of desert tortoises is a problem. Road closures are a particularly high priority in all recovery units except Upper Virgin River (moderate priority).

- <u>Tortoise-barrier fencing should be installed, according to specifications provided in Appendix C, and maintained along highways in desert tortoise habitat</u>. In particular, all highways and paved roads within or adjacent to tortoise conservation areas should be fenced with appropriate modification to avoid population fragmentation. Fencing projects need to be completely implemented and maintained to ensure effectiveness.

  "Hot-spots" of road mortality should be identified and prioritized, but fencing roads is a particularly high priority in the Upper Virgin River Recovery Unit. Other areas in California in need of fencing include parts of US-395, I-40, and SR-247 in the Western Mojave Recovery Unit and US-95, I-10, I-15, I-40, redundant roads within Mojave National Preserve and Joshua Tree National Park, and the Union Pacific rail line in the Eastern Mojave and Colorado Desert recovery units. Many roads have already been fenced in Clark County, Nevada, but remaining areas include US-93 from I-15 to Pahranagat, SR-75 (Valley of Fire Road) from I-15 to State Park Boundary, SR-168 from I-15 to US-93, Cal-Nev-Ari (tie in fencing to US-95), and Cottonwood Cove Road.

Recovery Unit	**Roads and Railways where Tortoise Fence is Needed**		
		kilometers	*miles*
Western Mojave	Road	178	110
	Rail	72	45
North-East Mojave	Road	186	116
	Rail	142	88
Colorado Desert	Road	271	168
	Rail	154	96
Upper Virgin River	Road	17	11
	Rail	0	0
Total	**Road**	**652**	**405**
	Rail	**368**	**229**

  Alternatives to fencing may be investigated in areas of high-maintenance (*e.g.*, subject to flash flooding) or viewshed concern. Culverts and underpasses should be incorporated into road-fencing projects as well as any State or Federal road or highway improvement/expansion to minimize the fragmenting effects of the road (2.11).

- Consideration should also be given to posting speed limits on appropriate rural paved and all unpaved roads at 40 kilometers per hour (25 miles per hour). This speed limit will reduce the likelihood of vehicles hitting tortoises on the road, reduce the need for road grading due to washboarding, and allow law enforcement to cite people for speeding or driving off-road in conservation areas.

- While graded roads typically need not be fenced, berms should be maintained such that tortoises do not get trapped in the roadbed. This is a particular issue in the Colorado Desert Recovery Unit, as well as throughout the Mojave National Preserve.

2.6. **Restore desert tortoise habitat.** Habitat restoration is a countermeasure to many of the impacts discussed above, such as grazing, military operations, off-highway vehicle use, roads and trails, construction, mining, horses and burros, invasive species, fire, environmental contaminants, and utility corridors. As such, this action is highly prioritized within the Western Mojave and Colorado Desert recovery units and moderately prioritized within other recovery units. The specific restoration activities may vary by recovery unit and management agency.

A first step in restoration is assessing habitat status and desired conditions, then targeting restoration (or protection) efforts to meet those conditions. Natural recovery of severely degraded desert scrub is expected to occur over centuries, not decades (Webb *et al.* 2009a), so active restoration efforts will be required in such areas. A great deal of research has been conducted on restoration and rehabilitation of habitats in arid and semi-arid ecosystems with varied results (see Bainbridge 2007; Weigand and Rodgers 2009). Previous and ongoing studies should be used to inform implementation of restoration activities in desert tortoise habitats.

In general, because of the uncertainties and costs associated with revegetation and the long periods required for natural recovery, the first priorities in habitat conservation should be to preclude land disturbance in the first place and to conserve remaining, intact habitats (2.1). Even so, incentive programs to restore habitat through habitat rehabilitation credits or mitigation banking could be used to encourage persons or entities to rehabilitate degraded habitat (BLM *et al.* 2005). Several restoration activities warrant specific attention below, although methods for successful implementation for most need to be developed or refined.

- Eradicate or suppress invasive weeds. Methods for weed suppression or eradication on large scales are currently unavailable, but the use of herbicides or other measures may be particularly appropriate on smaller scales in tortoise conservation areas.

- Revegetate degraded areas with native plants of high nutritive quality to desert tortoises, as well as shrubs needed for cover. Given the vast scales of recent wildfires, post-fire rehabilitation should be approached strategically toward areas determined to have a higher likelihood of successful restoration, considering fire severity, soil types, biological connectivity of native source plants, etc. Non-native, invasive species should not be included in seed mixes used in restoration efforts. This action may also be appropriate for smaller-scale applications such as mitigating utility corridor disturbances.

- Collection of native seed is recommended to ensure adequate seed is available to conduct restoration. Agencies should seek partnerships where possible to grow native plants for restoration.

- Obscure closed segments of roads/routes and illegal incursions within tortoise conservation areas that are visible from points along nearby open routes. In areas where revegetating is viable, native vegetation should be planted in the roadbed of the closed route segments. In areas where revegetating is likely to fail or invite invasive species, vertical coarse debris ("vertical mulching") should be used to obscure the closed routes. If obliteration is not possible, closed roads or routes should be physically blocked at the entrance and wherever they intersect open roads, routes, and non-motorized trails (see Recovery Action 2.7).

- Remove toxicants and unexploded ordnance. Areas with elevated levels of elemental toxicants associated with mining, other industrial operations, unexploded ordnance, and unauthorized dump sites should be identified and remediated where possible.

2.7. Install and maintain urban or other barriers. Urban development indirectly affects desert tortoise populations through spillover of human impacts, such as unauthorized off-highway vehicle use and free-roaming dogs, into the surrounding habitat.

This action entails installing and maintaining appropriate barriers at the urban-wildland interface or adjacent to other uses incompatible with desert tortoise populations, particularly adjacent to tortoise conservation areas. Depending on the particular impacts of interest, the actual type of barrier may differ. For example, tortoise-proof fencing (Appendix C) may be sufficient adjacent to aqueducts or off-highway vehicle areas, but larger fences or block walls may be necessary adjacent to urban development to limit off-highway vehicle use and free-roaming dogs. Priority areas for this action include:

- around the Red Cliffs Desert Reserve in the Upper Virgin River Recovery Unit;

- around areas that are currently dedicated to off-highway vehicle activity and that are located adjacent to tortoise conservation areas, such as Johnson Valley OHV area;

- around new developments (*e.g.*, Coyote Springs Valley) and the edges of the Las Vegas metropolitan area in the Eastern and Northeastern Mojave recovery units;

- around the Desert Tortoise Natural Area, Helendale, Barstow/Daggett, Yucca Valley, Joshua Tree, and Twentynine Palms in the Western Mojave Recovery Unit; and
- around the town of Goffs in the Colorado Desert Recovery Unit.

2.8. Sign and fence boundaries of sensitive or impacted areas. This action (relatively high priority in the Upper Virgin River Recovery Unit and moderate priority elsewhere) entails marking boundaries of particularly sensitive or heavily impacted areas with signs and fencing to regulate authorized use and to discourage unauthorized use. This can include physically blocking or marking boundaries of protected areas, mitigation lands, translocation areas, research sites, off-highway vehicle routes, roads, military lands, and parks, particularly when an area is vulnerable to vehicular or livestock intrusion. Signs or kiosks may also be used for educational purposes and to raise awareness.

2.9. Secure lands/habitat for conservation. This action is of moderate priority in all recovery units. It counters habitat loss and protects tortoises, provided secured lands are suitable habitat (see Action 2.1) or can serve as corridors or buffers. Given the vast amount of desert tortoise habitat already under Federal management or primary conservation use, land acquisition should be strategic, focusing on particularly sensitive areas that would connect functional habitat or improve management capability of the surrounding area. For example, some tortoise conservation areas have significant inholdings of private land on which development and associated access roads would threaten the conservation value of these areas. Land acquisitions should include surface and subsurface mineral rights whenever possible. Conservation agreements and other private-landowner incentives could also be developed to protect desert tortoise habitat in such areas.

Land managers should coordinate with the Department of Defense on efforts such as the Readiness and Environmental Preparedness Initiative and the Army Compatibility Use Buffer program to acquire lands that would serve a dual purpose of preventing encroachment on military installations and conserving desert tortoise habitat.

Areas of particular emphasis noted by managers for this recovery action include the Western Mojave Recovery Unit and inholdings within National Parks. In addition, consolidating private lands within the Red Cliffs Desert Reserve is important for habitat connectivity.

The following actions typically ranked as mid- to lower-level priorities should be addressed as higher priority actions are implemented, as part of elevated management within tortoise conservation areas, or as other opportunities or needs arise.

2.10. Restrict off-highway vehicle events within desert tortoise habitat. This action refers to large- or small-scale competitive races or non-competitive events involving up to thousands of motorcycles and other recreational off-highway vehicles. Prior to the implementation of current permitting and management practices (see for example BLM 1998a), competitive off-highway vehicle events led to the widening of old routes, creation of new routes, camping and staging by race participants and observers in unauthorized areas, littering, and inability of race monitors to prevent unauthorized activities.

This action entails prohibiting or demonstrably minimizing the effects of such events within tortoise habitat; limiting the number of events per year, limiting events to the winter season, and limiting the number of participants per event; and ensuring all participants stay on designated roads. Event planning should avoid existing tortoise conservation areas to the extent practicable.

2.11. **Connect functional habitat.** Connecting fragmented habitat helps to maintain gene flow between isolated populations. This action improves species fitness (ability to maintain or increase its numbers in succeeding generations) by maintaining diversity, allowing populations to interbreed, and providing access to larger habitats (Forman *et al.* 2003). 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 populations (Wilcox and Murphy 1985).

This action is of consistently moderate priority among recovery units. It entails connecting isolated blocks of desert tortoise habitat, particularly through corridors of natural habitat for large-scale connectivity (*e.g.*, habitat corridor around the north end of the Spring Mountains, Nevada), as well as culverts for smaller-scale connectivity across fenced roads and railroads.

2.12. **Limit mining and minimize its effects.** Impacts from mining can include habitat destruction and direct mortality from off-road exploratory travel; habitat loss to road and development construction, sand and gravel extraction, leachate ponds, tailings, and trash; introduction of toxins; fugitive dust and soil erosion; development of ancillary facilities to support large mining operations; temporary (short- or long-term oil and gas leases) use of public lands; refuse of stakes and wire from seismic testing; and creation of disturbance zones for invasive plant species to establish.

Within tortoise conservation areas and where indirect effects would affect these areas, mining should be withdrawn (if feasible) or limited through mining plans of operations. Monitoring plans and mitigation/minimization measures should be implemented at mining sites.

2.13. **Limit landfills and their effects.** Landfills impact tortoise populations by removing habitat, spreading garbage, introducing toxic chemicals, increasing road kills by vehicles going to and from the landfill, and facilitating proliferation of predators. Predator proliferation is considered the most significant of these impacts with landfills providing food subsidies for ravens and coyotes, leading to more young that move into adjacent areas in the spring to prey upon tortoises (Boarman 2002). Proper landfill management (including dumps and sewage ponds) can help reduce several threats to tortoises, but especially from ravens (Boarman and Kristan 2006).

This action entails reducing or eliminating the use of authorized landfills or other waste-disposal facilities by tortoise predators, siting new facilities outside of desert tortoise habitat, and/or precluding new facilities within 8 kilometers (5 miles; as recommended by the West Mojave Plan [BLM *et al.* 2005]) of existing tortoise conservation area boundaries.

2.14. Minimize excessive predation on tortoises. Desert tortoises have several natural predators, including coyotes, kit foxes, feral dogs, bobcats, skunks, badgers, common ravens, and golden eagles (Boarman 2002). The dominant predator probably varies temporally (through time), spatially, and with the size of the tortoise. Coyotes have been seen preying upon numerous adult desert tortoises within local areas, especially in times of drought. Predation by the common raven is generally focused on younger age classes of the desert tortoise. During the first 5 to 7 years of life, the tortoise shell is incompletely ossified and so is soft and easy to puncture and open.

Several other recovery actions (2.4, 2.5, 2.13) address predator management by limiting human subsidies (*e.g.*, food obtained at landfills and from roadkills, as per Boarman [2003]). In addition, predator access to concentrated anthropogenic (caused by humans) resources, including commercial trash bins, confined livestock feeding operations such as dairies and stables, sewer and evaporation ponds, and campgrounds, should be reduced (W.C. Webb *et al*. 2009).

This action also emphasizes direct predator-control programs to reduce predation on tortoises where specific problem areas or offending individuals are identified. For example, we are implementing with several cooperating agencies a phased-approach, integrated predator management plan to reduce predation by the common raven in the California desert (USFWS *et al.* 2008). Control methods can include targeted removal of known tortoise predators by shooting or trapping (live or lethal), as well as nest removal, directed at specific problem areas within tortoise conservation areas or where predation is affecting specific recovery-related research. We consider lethal predator control to be a short-term, temporary solution to predation problems, and we do not consider general, widespread predator control to be an appropriate recovery action.

2.15. Minimize impacts to tortoises from horses and burros. Wild horses and burros alter desert tortoise habitat through soil compaction and vegetation change (Boarman 2002). Tortoises and horses and burros may also compete for the same food. The California Desert Managers Group has been coordinating among member agencies since 1998 to substantially remove horses and burros from outside herd management areas. Herds have been eliminated in most critical habitat, and efforts are continuing to reduce their numbers. Within the Las Vegas District of the Bureau of Land Management, all herd management areas are at appropriate management levels, and herds outside of herd management areas have been eliminated.

This action entails continued exclusion of horses and burros from desert tortoise conservation areas by fencing and/or removal. Managing for zero population levels and gathering animals to maintain this goal inside desert tortoise conservation areas is consistent with existing land use plans and the Wild Free Roaming Horses and Burros Act of 1971.

2.16. **Minimize impacts to tortoises from livestock grazing.** Grazing by livestock (cattle and sheep) affects desert tortoises through crushing animals or their burrows, destroying or altering vegetation (which may introduce weeds and change the fire regime), altering soil, and competing for food (Boarman 2002). There is currently no evidence that cattle grazing will restore habitat or prevent fire in Mojave Desert environments. Cattle grazing may help create and maintain habitat for natives where: 1) the grassland ecosystem is highly productive; and 2) disturbance was previously caused by native grazers and browsers (*e.g.*, Brooks 1995; Marty 2005). The Mojave Desert is neither highly productive, nor is it an environment which historically supported native cattle-sized grazers.

The Service should work to assist grazing managers to develop experimental application of more flexible grazing practices, such as allowing or reducing grazing during specific times of the year (*e.g.*, after ephemeral forage is gone or winter only) or under certain environmental conditions (*e.g.*, following a specified minimum amount of winter rain), in order to investigate the compatibility of grazing with desert tortoise populations. Collaboration with grazing managers to identify appropriate experimental applications would facilitate this process. Experimental applications would be most appropriate outside desert tortoise conservation areas to collect data to determine whether specific grazing regimes can be compatible with tortoise recovery.

Until research determines grazing compatibility with tortoise populations, this recovery action entails continuing to minimize the impacts to tortoises from livestock grazing within tortoise conservation areas. Appropriate site-specific management actions would vary for any given site, but some of these management actions might include reducing impacts by fencing, removing trespass cattle, retiring allotments through acquisitions from willing sellers or allotment exchanges to locations outside tortoise conservation areas, or prohibiting supplemental feeding.

3. Augment Depleted Populations through a Strategic Program

3.1. **Develop protocols and guidelines for the population augmentation program, including those specific to head-starting and translocation.** Specific guidelines and protocols will be developed by the Desert Tortoise Recovery Office, with advice and input from the Science Advisory Committee, topical experts, and representatives from pertinent regulatory and land management agencies. Guidelines will draw from knowledge gained through recent research into head-starting and translocation and from recommendations made by the Science Advisory Committee relative to controlling disease (Hudson *et al*. 2009). Within the first year after publication of the revised recovery plan, draft guidelines and protocols for the strategic population augmentation program will be developed. We expect the documents to be continually updated as new information is evaluated.

3.2. Identify sites at which to implement population augmentation efforts. Populations to be augmented should be identified based upon knowledge of population trends, habitat, and threats in the area, unique opportunities to learn about augmentation techniques or threats through a research-based program, and feasibility. Data from previous population monitoring efforts, including a spatial analysis, and recent advances in genetics will facilitate selection of the target areas.

3.3. Secure facilities and obtain tortoises for use in augmentation efforts.

- Secure facilities for head-starting tortoises. Several groups in California have begun research into head-starting techniques. Currently, facilities exist at Edwards Air Force Base, Marine Corps Air Ground Combat Center at Twentynine Palms, and Mojave National Preserve. These facilities may be used, and additional facilities will need to be constructed. For example, the addition of facilities in the Las Vegas area could serve surrounding recovery units. The existing Desert Tortoise Conservation Center could be renovated to house such facilities in a secure location. See also Science Advisory Committee recommendations related to desert tortoise holding facilities and the control of disease (Hudson *et al*. 2009).

- Obtain adult tortoises for generation of progeny. Tortoises used in the head-starting program will be of known origin and of the genotype (genetic makeup) that inhabits the specific areas to be augmented. Depending on several factors, breeding colonies may be maintained in captivity, or wild females may be periodically captured and released after collection of eggs.

- Head-start progeny. Maintain progeny in captivity as specified in guidelines developed under 3.1.

- Obtain adult tortoises for translocation. Some adult tortoises removed from construction sites or other disturbed areas may be suitable for translocation to target areas. Refer to guidelines developed under 3.1.

3.4. Implement translocations in target areas to augment populations using a scientifically rigorous, research-based approach. Translocation and head-starting efforts should be implemented in conjunction with directed research on the factors affecting success of the augmentation, including methodological factors, but especially including factors related to management of habitat and threats. Refer to guidelines developed under 3.1 for information on target areas.

4. Monitor Progress toward Recovery

The ability to describe range-wide trends depends on reliable, adequate, and consistent funding. A key recommendation of the General Accounting Office's audit of the desert tortoise recovery program was that the Departments of the Interior and Defense work with other agencies and organizations "to identify and assess options for securing continued funding for range-wide population monitoring" (GAO 2002). Rather than developing monitoring based on individual-agency annual budgeting considerations, the Desert Tortoise Management Oversight Group should implement the GAO's recommendation (for example, through five-year time frames) to allow effective planning, contracting, and hiring to be implemented under a long-term study plan. The following recovery actions parallel the recovery criteria described earlier, helping ensure that progress toward recovery is measured effectively.

4.1. Monitor desert tortoise population growth. Trends in tortoise populations should be assessed both by directly enumerating the number of tortoises and by estimating the rate of births, deaths, and related recruitment into each age or size class so that the resulting trend in population growth can be determined.

- <u>Monitor the number of tortoises in each recovery unit</u>. We will estimate population change (λ) on a recovery-unit-wide scale through measures of population size, density, and/or occupancy. Refinement of range-wide monitoring techniques should continue, as recommended by USFWS (2006a).

- <u>Use demographic rates in key areas of each recovery unit (*i.e.*, demographic study areas) to independently estimate population growth in each recovery unit</u>. Surveys of demographic study areas should document age distributions sufficiently to characterize age distributions that distinguish stable or increasing populations from decreasing ones, especially including the proportion of juveniles represented. Dynamic vital-rate models should be used to provide an independent estimate of the population growth rate λ. Some existing or prior study plots may be appropriate for inclusion in the set of demographic study areas to make use of long-term datasets.

4.2. Monitor the extent of tortoise distribution in each recovery unit. Monitoring changes in desert tortoise distribution by estimating occupancy of tortoises entails investigating the most feasible scale at which occupancy would be evaluated, as well as the number of visits to a given site that would be needed to estimate detection probability if tortoises are present. Taken together and repeated over the years of the recovery program, occupancy estimation would provide a description of the rates at which tortoises are being locally extirpated from occupied habitat as well as recolonizing currently unoccupied habitat across the range. Occupancy estimation, if feasible, would also provide another estimate of population growth rate λ. In addition, historical study-plot and sign-count data should be compared with current patterns of live and dead tortoise concentrations to provide insights into recent larger scale declines relative to those reported from some plots (USFWS 2006).

4.3. Track changes in the quantity and quality of desert tortoise habitat. A baseline for tracking habitat quantity across each recovery unit exists with the newly developed habitat model (Nussear *et al*. 2009). Trends in habitat quality over time should be integrated into the recovery database/decision support system (6.1) as conditions affecting habitat quality are identified (5.1). Remote sensing and GIS data, validated by ground truthing as necessary, can be used to quantify the loss or restoration of habitat against the baseline (for instance, habitat completely lost to urbanization, degraded by wildfires, or authorized for use as rights-of-way or energy projects; the number and average size of habitat fragment polygons created by roaded boundaries).

4.4. Quantify the presence and intensity of threats to the desert tortoise across the landscape. Remote sensing, GIS data, ground truthing, and other surveys should be used to update and refine information on threats presented in the background of this recovery plan and used in the initial decision support system (6.1, Appendix B), including disease and other threats that may be related to habitat quality discussed above. This information will allow recovery efforts to be better tailored to specific areas while being incorporated with additional information gained through research and monitoring.

5. Conduct applied research and modeling in support of recovery efforts within a strategic framework

5.1. Determine factors that influence the distribution of desert tortoises.

- Validate and refine the desert tortoise habitat model (Nussear *et al*. 2009). The habitat model should be expanded to model potential effects of global climate change on existing desert tortoise habitat. Data collected from the range-wide monitoring program or other surveys, especially those outside currently designated critical habitat, may also be used to refine the model.

- Determine characteristics that contribute to the relative condition (*e.g.*, high, medium, or low quality) of desert tortoise habitat. Variation in desert tortoise habitat quality likely contributes to habitat-specific demographic rates (*e.g.*, higher recruitment in habitats with nutritious forage and few ravens; see Pulliam 1996) and occupancy. Some environmental factors, such as water available from rainfall, may be beyond the scope of management, but identifying specific, measurable characteristics of habitat that contribute to high rates of survival, reproduction, and recruitment is important to inform effective recovery efforts. Information from this recovery action is essential to meeting Recovery Criterion 3 relative to ensuring that habitat quality increases over at least the next 25 years. Research in this area should identify:

    - factors that affect how desert tortoises function within altered landscapes or habitat affected by climate change;

    - landscape attributes, if any, that cause clumping of desert tortoises; and

    - minimum conditions for potential desert tortoise occupancy.

5.2. Conduct research on the restoration of desert tortoise habitat.

- Evaluate the effectiveness of different restoration methods. While a body of research exists on the science of restoration and revegetation of desert ecosystems (Lovich and Bainbridge 1999; Ostler *et al*. 2002; Warren and Ostler 2002; Ostler and Hansen 2003; Webb 2002), managers lack a comprehensive source of information on methods, techniques, and results of past restoration projects in the Mojave Desert (Weigand and Rodgers 2009). More work is necessary to identify effective restoration methods in order to successfully implement Recovery Action 2.6.

- Identify methods to eradicate non-native, invasive plants within desert tortoise habitat. Invasive plants are a significant threat to desert tortoise habitat and populations across the species' range. Research is needed to identify methods for weed suppression or eradication in order to successfully implement Recovery Action 2.6.

- Assess the ecological consequences of climate change on future vegetation communities within the range of the desert tortoise. Integrated modeling, monitoring, and experimentation is needed to assess restoration opportunities relative to changes in vegetation communities and in the face of potential retreat of some invasive species (Bradley *et al*. 2009).

- Correlate habitat restoration with desert tortoise population status. The response of tortoise populations to restoration efforts should be evaluated, especially as habitat-specific demography is clarified (5.3). This action may also be implemented in coordination with population augmentation (3.1-3.4) and monitoring demographic study areas (4.1).

5.3. Improve models of threats, threat mitigation, and desert tortoise demographics. The decision support system (6.1) requires information on how threats affect desert tortoise populations and how management actions abate those threats. This information has currently been incorporated in the decision support system in a very rudimentary way.

- Develop conceptual and quantitative models of threats. Models of desert tortoise threats are needed to clarify interactive relationships between threats and to identify critical synergies that contribute to population declines. In addition, the demographic effects of individual threats and suites of threats on desert tortoise populations should be determined experimentally whenever possible.

- Develop and test models of the effectiveness of management actions. The corollary of modeling and experimentally investigating threats is determining the effectiveness of threat mitigation by specific management actions (for example, developing effective grazing-related mitigation practices outside of tortoise conservation areas to determine whether specific grazing regimes can be compatible with tortoise recovery). Recovery Implementation Teams should identify and secure funding for applied research on the effectiveness of recovery actions based on local priorities. Conceptual models should be developed for all recovery actions, and these models should be quantified with new research and monitoring information, as it becomes available.

- Model desert tortoise demography relative to habitat condition to determine the proportion of habitat that needs to be occupied (or is available to be occupied) for recovery. As habitat-specific demography is clarified, population models should be developed to refine estimates of habitat quantity and tortoise occupancy necessary to sustain populations into the future. Models should incorporate predicted effects of climate change on desert tortoise demography as well as on the current composition of tortoise habitat. Information from this recovery action is essential to refining Recovery Criterion 3 relative to the amount of habitat needed to meet the conditions for delisting.

- Update previous population viability analyses (USFWS 1994a). New demographic data should be used to conduct population viability analyses with an emphasis on exploring the impact of environmental catastrophes and spatio-temporal variation (variation in space and time) on long-term persistence within tortoise conservation areas.

5.4. **Conduct research on desert tortoise diseases and their effects on tortoise populations.** While the precise role of disease in desert tortoise population declines relative to other threats is unclear, disease has been a high-profile and controversial topic. Therefore, we provide specific recommendations to better understand the nature and relative importance of disease to desert tortoise populations. The first three recommendations below arise from the working hypothesis that mycoplasmosis-induced die-offs are initiated by environmental stressors.

- Determine whether population declines through environmental stress are less severe when *Mycoplasma* is absent.

- Determine if desert tortoises exposed to simulated drought conditions become more susceptible to infection and more infectious.

- Determine whether diets high in plants of low nutritional value increase susceptibility to disease, as well as infectiousness.

- Identify the virulent and less virulent strains of *Mycoplasma* circulating in wild and captive populations and monitor temporal and spatial change in prevalence in relation to host genetic status and environmental stressors. Identification of genes expressing toxin production and the circumstances when these genes are expressed could be a fruitful area of research. Studies examining the level of cross immunity between strains and variation in resistance in relation to the plane of nutrition and availability of water would be of great assistance. This research aims to examine the presence and variation in *Mycoplasma* strains with the aim of containing virulent strains.

- Identify which individual tortoises are shedding, how they shed (*i.e.*, transmit), when they shed, and for how long they shed infectious *Mycoplasma* particles. Identify whether individuals removed from drought-stressed areas or areas with severely deteriorated habitats continue to shed *Mycoplasma* and for how long. This research will identify in more detail seasonal forces of infection, the period of infectiousness, and how infectiousness varies under different circumstances.

- Undertake trials to determine if it is possible to cure individuals with *Mycoplasma* infections, even if only feasible in captive individuals. Preliminary veterinary trials with mixed antibiotics and anti-inflammatory steroids have met with some success and could be extended.

- Examine the behavior of infectious tortoises in comparison to uninfected tortoises in the wild. Obtain estimates of contact rate according to sex, age, and season. This research will help us understand the most critical epidemiological parameters associated with transmission and, with other data, allow us to produce a predictive model of outbreak.

- Examine the implications of releasing sick tortoises into uninfected populations. Such studies should occur within enclosures at captive holding facilities.

- Further explore natural antibodies in desert tortoises.

- Create a comprehensive disease-tortoise population model that incorporates the above information. A disease-tortoise population model could be used to anticipate outbreaks and patterns of spread.

- Evaluate other known or emerging diseases for effects on desert tortoise populations. Less is known about other diseases that have been identified in the desert tortoise (*e.g.*, herpesvirus, cutaneous dyskeratosis). Continued study of *Mycoplasma* will help facilitate investigations of other diseases. In the meantime, surveys or pathological study of other diseases should be conducted within the context of other threats (*e.g.*, 5.4).

5.5. **Determine the importance of corridors and physical barriers to desert tortoise distribution and gene flow.** Determining the importance of corridors and barriers will allow population models to be made spatially explicit relative to current land management (*e.g.*, population and habitat fragmentation due to roads, urbanization, and energy development) and potential distributional shifts resulting from climate change.

6. Implement an Adaptive Management Program

Recovery Implementation Teams (established under Strategic Element 1; *Partnerships* in Figure 4) will be the driving force, in coordination with the Desert Tortoise Recovery Office, behind implementation of the adaptive management program. Here, we describe the specific steps that the Recovery Implementation Teams and Desert Tortoise Recovery Office must apply in order to fully implement the program. We refer to these steps, depicted in Figure 4, with italicized labels in the text below.

6.1. Revise and continue development of a recovery decision support system. The Recovery Implementation Teams begin the adaptive management process by *Assessing the Problem.* Toward that end, a spatial decision support system is being developed (Appendix B) to identify and prioritize recovery actions relative to managing desert tortoise populations and habitat. Due to the lack of data on the effects of individual threats on tortoise demography, the initial decision support system has been based largely on information collected from workgroups convened during the recovery planning process or other sources, simple preliminary models, and expert opinion. Initial application of the decision support system is not an attempt to represent certainties about the relationship between tortoise populations, habitat, threats, and management, but instead to establish a "rapid prototype" that will identify key assumptions and allow evaluation of the relative importance of different assumptions, components, or gaps in the model (Starfield 1997; Nicolson *et al.* 2002).

The models contained within this rapid-prototype decision support system, including any new monitoring or research results, should be regularly *Evaluated* (at least biennially) by independent reviewers, including the Science Advisory Committee. The decision support system should be then be *Adjusted* to achieve goals that a) ensure the overall decision support system is clearly partitioned into a suite of models with clear purposes, b) ensure all models or components are transparent and comprehensible, and c) the sensitivity of model output to different parameter values and assumptions is adequately tested. It is especially critical to continue to update the underlying data in the decision support system with a range-wide, geospatial database of current management activities, landscape information on threats, habitat quality and quantity, and tortoise populations. In addition to contributing to models, maintaining an up-to-date database will facilitate reporting of implementation progress.

Specific tasks and timelines relative to this action include:

- Within the first year after publication of the final, revised recovery plan, the Recovery Implementation Teams, Desert Tortoise Recovery Office, and other partners, should update the underlying data in the decision support system for at least two recovery units, including data on threats and current recovery-action implementation. This stage should be completed for the remaining recovery units within the second year, and regular updates to all recovery units should occur on an ongoing basis thereafter.

- Within the second year after publication of the revised recovery plan, the Desert Tortoise Recovery Office, Science Advisory Committee, and other independent reviewers should evaluate the underlying models in the decision supports system. Re-evaluation should occur at least biennially, although it is likely that different models will be in different stages of evaluation or revision within each biennium.

- Refinement of the decision support system should continue to clarify and operationalize recovery action terminology. One of the challenges in developing the prototype decision support system was making the list of recovery actions more operational. For example, not all actions are mutually exclusive of one another; several are complementary and can be implemented in tandem. Several actions listed in the 1994 Recovery Plan overlap with one another, and it was clear from the recovery planning workshops that various actions meant different things to different people.

6.2. Develop/revise recovery action plans. Recovery Implementation Teams should use the decision support system to tier off the recovery plan by developing five-year action plans and budget needs with priorities for management scaled down to local or jurisdictional levels (*i.e.*, participation plans, as described in USFWS and National Oceanic and Atmospheric Adminstration [NOAA] 1994). Five-year action plans should be coordinated with the Management Oversight Group and completed within the first year of publication of the revised recovery plan. Initial application of the decision support system for prioritizing actions at the local or regional level will vary among recovery units according to the timeline for updating the system, as described above.

- The first step in each adaptive-management iteration includes prioritizing general actions, followed by identification of spatially and temporally explicit actions, specific enough that the action plans can be reviewed, critiqued, and adopted without confusion in relevant planning documents of the participating land management agencies. For instance, if "roads" are identified as a priority threat in a particular Recovery Implementation Team area, the general action recommended might be "road closures." The Recovery Implementation Team would then proceed to recommend specific roads for closure, so that the appropriateness of this action can be evaluated, and the action agencies have clear understanding of the Recovery Implementation Teams' recommendations.

- In conjunction with prioritizing recovery actions, the Recovery Implementation Teams must prioritize needs for effectiveness *Monitoring* or other *Research*. In order to rank monitoring priorities, a further step from the decision support system is required. Recovery Implementation Teams will need to describe conceptual models that link each threat to each of the pathways that impact tortoise health, survival, movement, population structure, recruitment, or fecundity. These models are part of *Assessing the Problem* and are the first step in describing the linkages that will be affected by management activities, so they also point to the type of *Monitoring* or *Research* that will capture the effectiveness of these activities in breaking the links. Population augmentation in conjunction with other land management, effectiveness monitoring, or research activities may also be recommended through the procedures described under Recovery Action 3. These 4 elements (Strategic Elements 2-5) will be reviewed by the Desert Tortoise Recovery Office and placed within the larger range-wide strategy.

- Once the recovery action plans, including prioritized actions, monitoring, and research, have been developed by the Recovery Implementation Teams and Desert Tortoise Recovery Office and approved by the Management Oversight Group, the relevant land management agencies will use their own processes to *Design* and *Implement* actions. By *Design*, we mean that the necessary planning processes will be engaged to formalize each agency's commitments to the adopted actions. Because all Recovery Implementation Team members should remain fully engaged, it is important that all represented land management agencies have clear tasks for each Recovery Implementation Team cycle.

- All Recovery Implementation Teams will have access to the data and models in the system, via one or more of the following capabilities: 1) a desktop application in which land managers and stakeholders spatially define and prioritize recovery actions and enter implementation metrics; 2) an online web application where land managers and stakeholders can register, update, and edit implementation metrics, and review progress; and 3) an online web application where land managers and stakeholders can create monitoring programs, adding and editing effectiveness metrics, updating results, and reviewing progress.

- The Recovery Implementation Teams and Desert Tortoise Recovery Office should report progress on recovery implementation to the Management Oversight Group on an annual basis and revise the recovery action plans accordingly.

6.3. Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions. Federal, State, County, and City land managers should *Adjust* recovery efforts based on outcomes of the processes described above by amending planning documents as needed. Broad land-use plans, such as Bureau of Land Management resource management plans, may not need revision, as they often include language stipulating that agencies will strive to implement recovery for federally listed species. Program-level or area-specific plans, such as habitat management plans, wilderness plans, and Area of Critical Environmental Concern plans, are an opportunity to work with stakeholders to build in detailed planning at local levels.

6.4. Incorporate scientific advice for recovery through the Science Advisory Committee. The Desert Tortoise Recovery Office should continue to work directly with the Science Advisory Committee and other independent experts, meeting at least annually to *Evaluate* progress in *Research* and *Monitoring* and other recovery plan accomplishments. The Science Advisory Committee should make new recommendations, as needed, based on progress in implementing the recovery plan. A particular need exists for vigilance in focusing on large-scale, range-wide tortoise recovery, maintaining connection to *Recovery Criteria* in the 25-year horizon, through at least five-year evaluations of the range-wide monitoring program. Annual Science Advisory Committee meetings should include an opportunity for stakeholder and manager interaction, in association with Management Oversight Group meetings, to provide direct feedback and information exchange.

Table 4. Comparison of recovery actions between the 1994 and 2011 recovery plans. Acronyms are defined at the end of the table.

Recovery Action	1994	2011	Comments
Establish DWMAs and implement management plans	D.1.a-b, d	6.2	1994: DWMAs designated and are now managed as ACECs on BLM lands, where critical habitat generally coincides. 2011: Expands "tortoise conservation areas" to include desert tortoise habitats within critical habitat, DWMAs/ACECs, and other areas managed for the desert tortoise. Recovery action plans are recommended for each area.
Develop, support, and build partnerships to facilitate recovery		1	Specifically, establish regional Recovery Implementation Teams to prioritize and coordinate implementation of recovery actions.
Secure habitat	D.1.c	2.9	Emphasis is placed on DWMAs/tortoise conservation areas. 2011: 2.11 also emphasizes connecting functional habitat.
Environmental education	D.2, E.2.h	2.3	2011: Includes using the Desert Tortoise Conservation Center as education/research facility.
Exclude from DWMAs/tortoise conservation areas			1994: Recovery action E.1 includes a list of activities recommended for prohibition throughout all DWMAs.
All vehicle activity off of designated roads; all competitive and organized events on designated roads	E.1	2.4,10	
Habitat destruction and other surface-disturbing activities	E.1	2.1	
Mining		2.12	1994: Mining acceptable on a case-by-case basis, provided that cumulative impacts 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.
Domestic livestock grazing	E.1	2.16	Action recommended until research finds grazing regimes compatible with tortoise recovery.
Grazing by feral ("wild") burros and horses	E.1	2.15	
Vegetation harvest, except by permit	E.1		2011: Not considered to be an action that warrants focus above existing land management plans.
Collection of biological specimens, except by permit	E.1	2.4	2011: Enforcing prohibitions on collection of desert tortoises is inherent to the law enforcement action.
Dumping and littering	E.1	2.4	2011: Included under law enforcement action.
Deposition of captive or displaced desert tortoises or other animals, except under authorized translocation research projects	E.1	2.4	2011: Included under law enforcement action.
Uncontrolled dogs out of vehicles	E.1	2.4	2011: Included under law enforcement action.
Discharge of firearms, except for hunting of big game or upland game birds from September through February	E.1	2.4	2011: Included under law enforcement action.
Restrict establishment of new roads	E.2.a.1	2.5	

Table 4. Continued.

Recovery Action	1994	2011	Comments
Implement closure to vehicular access with exception of designated routes	E.2.a.2	2.5	2011: Existing roads should be designated as open, closed, or limited. Non-essential or redundant routes should be closed.
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	E.2.a.3	2.5	2011: Existing roads should be designated as open, closed, or limited. Non-essential or redundant routes should be closed.
Fence or otherwise establish effective barriers to tortoises along heavily-traveled roads; install culverts that allow underpass of tortoises to alleviate habitat fragmentation	E.2.a.4	2.5,2.11	
25mph speed limits on appropriate rural roads		2.5	1994: Not included in the 1994 plan.
Maintain berms along dirt roads such that tortoises do not get trapped in the roadbed		2.5	1994: Not included in the 1994 plan.
Enforce regulations	E.2.b	2.4	2011: Increase law enforcement.
Restore disturbed areas	E.2.c	2.6	2011: The revised plan expands on and provides additional specific recommendations from the 1994 plan.
Eradicate or suppress invasive weeds		2.6	1994: Not included in the 1994 plan.
Revegetate degraded areas with native plants of high nutritive quality to desert tortoises, as well as shrubs needed for cover		2.6	1994: Not included in the 1994 plan.
Remove toxicants and unexploded ordnance		2.6	1994: Not included in the 1994 plan.
Sign and fence DWMA/protected area boundaries	E.2.d	2.8	2011: Also specifies signing boundaries of heavily impacted areas
Install and maintain urban and other barriers		2.7	1994: Not included in the 1994 plan. 2011: Several specific locations are described in the plan.
Implement appropriate administration	E.2.e	1	2011: The actions described by the 1994 plan are functionally covered by Recovery Implementation Teams.
Modify ongoing and planned activities so they are consistent with desert tortoise recovery	E.2.f	6.2,6.3	2011: This is covered in detail in the adaptive management strategic element.
Control use of landfills and sewage ponds by desert tortoise predators (no new landfills in DWMAs; address unauthorized dumping)	E.2.g	2.13	
Minimize factors contributing to disease		2.2	1994: Not included in the 1994 plan. 2011: Several specific actions are described in the plan.
Minimize excessive predation on desert tortoises in identified problem areas		2.14	1994: Not included in the 1994 plan.

Table 4. Continued.

Recovery Action	1994	2011	Comments
Continue development of recovery decision support system		6.1	1994: Not included in the 1994 plan.
Incorporate scientific advice for recovery through the Science Advisory Committee		6.4	1994: Not included in the 1994 plan.
<u>Population Augmentation</u> Develop protocols and guidelines		3.1	1994: Not included in the 1994 plan.
Identify sites at which to implement population augmentation		3.2	1994: Not included in the 1994 plan.
Secure facilities and obtain tortoises for use in augmentation		3.3	1994: Not included in the 1994 plan.
Implement translocations in target areas to augment populations using a scientifically rigorous, research-based approach		3.4	1994: Not included in the 1994 plan.
<u>Monitoring</u> Monitor population growth	D.1.f	4.1	
Monitor tortoise distribution		4.2	1994: Not included in the 1994 plan.
Monitor tortoise habitat		4.3	1994: Not included in the 1994 plan.
Quantify threats		4.4	1994: Not included in the 1994 plan.
<u>Research</u> Densities inside and outside DWMAs	D.3.a	5.3	2011: While not specific to comparisons inside and outside of DWMAs, the basic concepts of the 1994 action are subsumed under research recommendations relative to threats, management, and tortoise demographics in the revised plan.
Model desert tortoise demography	D.3.b	5.3, 5.2	2011: Includes modeling demography relative to habitat condition, including predicted effects of climate change, to determine the proportion of habitat that needs to be occupied for recovery, as well as updated population viability analyses. Also correlate habitat restoration with desert tortoise population status.
Epidemiology of URTD and other diseases	D.3.b.1	5.4	2011: The revised plan expands on and provides additional specific recommendations from the 1994 plan.
Determine whether population declines through environmental stress are less severe when *Mycoplasma* is absent		5.4	
Determine if desert tortoises exposed to simulated drought conditions become more susceptible to infections and more infectious		5.4	
Determine whether diets high in plants of low nutritional value increase susceptibility to disease, as well as infectiousness		5.4	

Table 4. Continued.

Recovery Action	1994	2011	Comments
Identify virulent and less virulent strains of *Mycoplasma* circulating in wild and captive populations and monitor temporal and spatial change in prevalence in relation to host genetic status and environmental stressors		5.4	
Identify which individual tortoises are shedding, how they shed (*i.e.*, transmit), when they shed and, for how long they shed infectious *Mycoplasma* particles		5.4	
Undertake trials to determine if it is possible to cure individuals with *Mycoplasma* infections, even if only feasible in captive individuals		5.4	
Examine behavior of infectious tortoises in comparison to uninfected tortoises in the wild		5.4	
Examine implications of releasing sick tortoises into uninfected populations		5.4	
Further explore natural antibodies in desert tortoises		5.4	
Create a comprehensive disease-tortoise population model that incorporates the above information		5.4	
Evaluate other known or emerging diseases for effects on desert tortoise populations		5.4	
Sources and relative contribution of mortality	D.3.b.2	5.3	2011: Develop conceptual and quantitative models of threats.
Recruitment & survivorship of young age classes	D.3.b.3	5.1+	2011: The basic concepts of the 1994 action are subsumed within the research recommendation to determine factors that influence the distribution of desert tortoises, among others, in the revised plan.
Population structure	D.3.b.4		2011: Not included in the revised plan.
Long-term research on impacts of grazing, road density, barriers, human-use levels, restoration, augmentation, and translocation on desert tortoise populations	D.3.c	5.3	2011: Develop conceptual and quantitative models of threats.
Effectiveness of protective measures	D.3.d	5.2,3	2011: Specifically includes effectiveness of different habitat restoration methods.
Spatial variability of climate and plant productivity, correlated with population parameters	D.3.e	5.1	2011: More specifically, determine characteristics that contribute to the relative condition of desert tortoise habitat.
Nutritional and physiological ecology	D.3.f	5.4	2011: See nutrition/disease research recommendation above.
Reproductive behavior and physiology	D.3.g	5.1	2011: This is integral to the demography research recommendation.

Table 4. Continued.

Recovery Action	**1994**	**2011**	**Comments**
Validate and refine the desert tortoise habitat model		5.1	1994: Not included in the 1994 plan.
Identify methods to eradicate non-native, invasive plants within desert tortoise habitat		5.2	1994: Not included in the 1994 plan.
Determine importance of corridors and physical barriers to desert tortoise distribution and gene flow		5.5	1994: Not included in the 1994 plan.

ACEC: Area of Critical Environmental Concern
BLM: U.S. Bureau of Land Management
DWMA: Desert Wildlife Management Area
URTD: upper respiratory tract disease

Table 5. Reference table connecting major recovery actions to listing factors and recovery objectives. Recovery actions are categorized according to each strategic element of the recovery program. Subactions for each major recovery action are not listed (see the recovery narrative).

	Recovery Action	Listing Factor	Recovery Objective
1.	**Develop, support, and build partnerships to facilitate recovery**		
1.1	Establish regional, inter−organizational Recovery Implementation Teams to prioritize and coordinate implementation of recovery actions.	All	All
2.	**Protect existing populations and habitat**		
2.1	Conserve intact desert tortoise habitat.	A,E	3
2.2	Minimize factors contributing to disease.	C	1,2
2.3	Establish/continue environmental education programs.	All	All
2.4	Increase law enforcement.	A-D	All
2.5	Restrict, designate, close, and fence roads.	A-D	All
2.6	Restore desert tortoise habitat.	A,E	3
2.7	Install and maintain urban or other barriers.	A-C	All
2.8	Sign and fence boundaries of sensitive or impacted areas.	A,B	3
2.9	Secure lands/habitat for conservation.	A	3
2.10	Restrict off-highway vehicle events within desert tortoise habitat.	A,B	All
2.11	Connect functional habitat.	A	2
2.12	Limit mining and minimize its effects.	A,C	All
2.13	Limit landfills and their effects.	A,C	1,3
2.14	Minimize excessive predation on tortoises.	C	1
2.15	Minimize impacts to tortoises from horses and burros.	A	3
2.16	Minimize impacts to tortoises from livestock grazing.	A	3
3.	**Augment depleted populations through a strategic program**		
3.1	Develop protocols and guidelines for the augmentation program.	All	1-2
3.2	Identify sites at which to implement population augmentation efforts.	All	1-2
3.3	Secure facilities and obtain tortoises for use in augmentation efforts.	All	1-2
3.4	Implement translocations in target areas to augment populations.	All	All
4.	**Monitor progress toward recovery**		
4.1	Monitor desert tortoise population growth.	All	1
4.2	Monitor the extent of tortoise distribution in each recovery unit.	All	2
4.3	Track changes in the quantity and quality of desert tortoise habitat.	A,D,E	3

Table 5. Continued.

	Recovery Action	Listing Factor	Recovery Objective
4.4	Quantify the presence and intensity of threats to the desert tortoise across the landscape.	All	All
5.	**Conduct applied research and modeling in support of recovery efforts within a strategic framework**		
5.1	Determine factors that influence the distribution of desert tortoises.	All	2,3
5.2	Conduct research on the restoration of desert tortoise habitat.	A,E	3
5.3	Improve models of threats, threat mitigation, and desert tortoise demographics.	All	1,3
5.4	Conduct research on desert tortoise diseases and their effects on tortoise populations.	C	1,2
5.5	Determine the importance of corridors and physical barriers to desert tortoise distribution and gene flow.	All	1,2
6.	**Implement an adaptive management program**		
6.1	Revise and continue development of a recovery decision support system.	All	All
6.2	Develop/revise recovery action plans.	All	All
6.3	Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions.	All	All
6.4	Incorporate scientific advice for recovery through the Science Advisory Committee.	All	All

Listing Factors:
A. The present or threatened destruction, modification, or curtailment of its habitat or range
B. Overutilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or manmade factors affecting its continued existence

Recovery Objectives:
1. Maintain self-sustaining populations of desert tortoises within each recovery unit into the future.
2. Maintain well-distributed populations of desert tortoises throughout each recovery unit.
3. Ensure that habitat within each recovery unit is protected and managed to support long-term viability of desert tortoise populations.

III. IMPLEMENTATION SCHEDULE

The implementation schedule outlines the recovery actions discussed in the Recovery Program chapter and indicates action numbers, priorities, durations, estimated costs, and partners that may be involved in implementing the action. When accomplished, these actions should result in improved habitat conditions and favorable population responses that would enable the desert tortoise to be delisted. The costs for each actions are rough estimates, and actual budgets will have to be determined when each action is undertaken (TBD = to be determined). Cost estimates are unavailable for several actions, such as research, due to uncertainties in the scope and magnitude of the specific action. Recovery plans are non-regulatory documents, and as such, identified partners are not obligated to implement recovery actions. Cost estimates do not commit funding by any agency.

Action priorities in the implementation schedule are assigned as follows:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. *Note that no recovery actions have been assigned at the Priority 1 level based on the judgment that the desert tortoise is not on the verge of extinction or declining irreversibly at this time (reflected by its status as Threatened, rather than Endangered).*

Priority 2: An action that must be taken to prevent a significant decline in species population numbers or habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

We have attempted to provide an overall priority for each recovery action that applies across recovery units. However, threats, and therefore the importance of recovery actions that ameliorate those threats, vary by recovery unit. Recovery Implementation Teams need to be established upon publication of the final revised recovery plan (Recovery Action 1.1), and they should guide recovery action priorities and develop updated budget projections within each recovery unit through the use of an updated/improved decision support system (6.1-6.2).

Task duration in Column 4 indicates the number of years estimated to complete the task. A *Continuing* task will continue to be conducted once implemented. Many tasks are listed as *Ongoing*; these are already being conducted and should continue. The Responsible Party indicates the lead agency or agencies identified for a particular task and includes the full suite of local, State, and Federal land and wildlife management agencies within the desert tortoise's range (= Land Managers). Other stakeholders or organizations (included in "All") may also contribute to particular recovery actions. However, other parties may also have significant roles in different tasks, and (as mentioned above) the listing of a party does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

Abbreviations of the responsible parties identified in the Implementation Table are defined as follows:

BLM – Bureau of Land Management
CC MSHCP – Clark County, Nevada, Multiple Species Habitat Conservation Plan
CS MSHCP – Coyote Springs, Nevada, Multiple Species Habitat Conservation Plan
DOD – Department of Defense
MNP – Mojave National Preserve
NPS – National Park Service
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
WC HCP – Washington County, Utah, HCP

Implementation Schedule | **Costs (thousands of dollars)**

	Recovery Action	Priority	Duration (years)	Responsible Party	FY 1	FY 2	FY 3	FY 4	FY 5	Total
1.	**Develop, support, and build partnerships to facilitate recovery**									
1.1	Establish regional, inter-organizational RITs to coordinate implementation activities of recovery actions.	2	Continuing	USFWS (All)	500	500	500	500	500	12,500
2.	**Protect and manage existing populations and habitat**									
2.1	Conserve intact desert tortoise habitat.	2	Ongoing	Land Managers	Negligible additional costs above normal activities.					
2.2	Minimize factors contributing to disease.	2	Continuing	All	10	10	10	10	10	250
2.3	Establish/continue environmental education programs.	2	Ongoing	All	100	100	100	100	100	2,500
2.4	Increase law enforcement.	2	Ongoing	Land Managers	1000	1000	1000	1000	1000	25,000
2.5	Restrict, designate, close, and fence roads.	2	Ongoing	BLM, NPS	1000	1000	1000	1000	1000	10,000
2.6	Restore desert tortoise habitat.	2	Continuing	Land Managers	TBD	TBD	TBD	TBD	TBD	TBD
2.7	Install and maintain urban or other barriers.									
	Upper Virgin River Recovery Unit	2	2	WC HCP, BLM	0	0				0[1]
	Eastern/Northeastern Mojave recovery units	2	5	CC MSHCP CS MSHCP	0	0	0	0	0	0[1]
	Western Mojave Recovery Unit	2	5	Land Managers	200	200	200	200	200	1,000
	Remainder of desert tortoise range	3	5	Land Managers	500	500	500	500	500	2,500
2.8	Sign and fence boundaries of sensitive or impacted areas.									
	Upper Virgin River Recovery Unit	2	2	WC HCP, BLM	0	0				0[1]
	Remainder of desert tortoise range	3	Ongoing	Land Managers	600	600	600	600	600	3,500
2.9	Secure lands/habitat for conservation.									
	Upper Virgin River, Colorado Desert, and Western Mojave recovery units	2	Ongoing	Land Managers	TBD	TBD	TBD	TBD	TBD	TBD
	Remainder of desert tortoise range	3	Ongoing	Land Managers	TBD	TBD	TBD	TBD	TBD	TBD
2.10	Restrict off-highway vehicle events within desert tortoise habitat.	3	Ongoing	BLM	50	50	50	50	50	1,250
2.11	Connect functional habitat.	3	Ongoing	Land Managers	TBD	TBD	TBD	TBD	TBD	TBD

	Recovery Action	Priority	Duration (years)	Responsible Party	FY 1	FY 2	FY 3	FY 4	FY 5	Total
					Costs (thousands of dollars)					
2.12	Limit mining and minimize its effects.	3	Ongoing	BLM	100	100	100	100	100	1,000
2.13	Limit landfills and their effects.	3	Ongoing	Counties	100	100	100	100	100	2,500
2.14	Minimize excessive predation on tortoises.	3	10	Land Managers	100	100	100	100	100	1,000
2.15	Minimize impacts to tortoises from horses and burros.	3	Ongoing	BLM, NPS	500	500	500	500	500	12,500
2.16	Minimize impacts to tortoises from livestock grazing.	3	Ongoing	BLM, MNP	100	100	100	100	100	2,500
3.	**Augment depleted populations through a strategic program**									
3.1	Develop protocols and guidelines for the augmentation program.	2	1	USFWS	50					50
3.2	Identify sites at which to implement population augmentation efforts.	2	1	USFWS	50					50
3.3	Secure facilities and obtain tortoises for use in augmentation efforts.	2	10	USFWS, DOD, MNP	500	500	500	500	500	5,000
3.4	Implement translocations in target areas to augment populations using a scientifically rigorous, research-based approach.	2	15	USFWS, Land Managers			TBD	TBD	TBD	TBD
4.	**Monitor progress toward recovery**									
4.1	Monitor desert tortoise population growth.	3	Ongoing	USFWS (All)	1,500	1,500	1,500	1,500	1,500	37,500
4.2	Monitor the extent of tortoise distribution in each recovery unit.	3	Continuing	USFWS (All)	1,500	1,500	1,500	1,500	1,500	37,500
4.3	Track changes in the quantity and quality of desert tortoise habitat.	3	Continuing	USFWS (All)	TBD	TBD	TBD	TBD	TBD	TBD
4.4	Quantify the presence and intensity of threats to the desert tortoise across the landscape.	3	Continuing	USFWS (All)	TBD	TBD	TBD	TBD	TBD	TBD
5.	**Conduct applied research and modeling in support of recovery efforts within a strategic framework**									
5.1	Determine factors that influence the distribution of desert tortoises.	3	TBD	USFWS, USGS (other research institutions)	TBD	TBD	TBD	TBD	TBD	TBD

Implementation Schedule Continued | **Costs (thousands of dollars)**

	Recovery Action	Priority	Duration (years)	Responsible Party	FY 1	FY 2	FY 3	FY 4	FY 5	Total
5.2	Conduct research on the restoration of desert tortoise habitat.	3	TBD	All, research institutions	TBD	TBD	TBD	TBD	TBD	TBD
5.3	Improve models of threats, threat mitigation, and desert tortoise demographics.	3	TBD	USFWS (All; research institutions)	TBD	TBD	TBD	TBD	TBD	TBD
5.4	Conduct research on desert tortoise diseases and their effects on tortoise populations.	3	TBD	USFWS (research institutions)	TBD	TBD	TBD	TBD	TBD	TBD
5.5	Determine the importance of corridors and physical barriers to desert tortoise distribution and gene flow.	3	3	Research institutions	TBD	TBD	TBD			TBD
6.	**Implement an adaptive management program**									
6.1	Revise and continue development of a recovery decision support system.	2	Ongoing	USFWS (All)	50	10	5	5	5	175
6.2	Develop/revise recovery action plans.	2	Continuing	All	Costs included under Action 1.1					
6.3	Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions.	3	Continuing	Land Managers	TBD	TBD	TBD	TBD	TBD	TBD
6.4	Incorporate scientific advice for recovery through the Science Advisory Committee.	3	Ongoing	USFWS (All)	5	5	5	5	5	125
FY Totals (These totals are minimum cost estimates that do not include TBD costs.)					8615	8475	8470	8470	8470	

[1]Costs for minimizing mortality and Habitat Conservation Plan activities are not included because these costs are typically required by regulatory processes, rather than as proactive recovery actions.

Total cost of recovery through 2025: $159,000,000 plus additional costs that cannot be estimated at this time.

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APPENDIX A

THREATS TO THE MOJAVE POPULATION OF THE DESERT TORTOISE AND ITS HABITAT SINCE THE TIME OF LISTING

Below is a synopsis of the threats that formed the basis for listing the desert tortoise as a threatened species (USFWS 1990), were further discussed in the 1994 Recovery Plan (USFWS 1994), and continue to affect the species. A substantive body of data has been accumulated since 1994 for some of the threats, but others remain relatively unstudied. New information is provided where available, and all of the threats warrant continued attention and data collection that will inform management actions and recovery implementation through the use of a range-wide database and decision support system.

The vast majority of threats to the desert tortoise or its habitat are associated with human land uses. Extensive research shows that all of these individual threats directly kill or indirectly affect tortoises. Research has also clarified many mechanisms by which these threats act on tortoises. However, despite the clear demonstration that these threats impact individual tortoises, there are few data available to evaluate or quantify the effects of threats on desert tortoise populations (Boarman 2002; Tracy *et al*. 2004). While current research results can lead to predictions about how local tortoise abundance should be affected by the presence of threats, quantitative estimates of the magnitude of these threats, or of their relative importance, have not yet been developed. Thus, a particular threat or subset of threats with discernable solutions that could be targeted to the exclusion of other threats has not been identified for the desert tortoise.

The assessment of the 1994 Recovery Plan emphasized the need for a greater appreciation of the implications of multiple, simultaneous threats facing tortoise populations and a better understanding of the relative contribution of multiple threats on demographic factors (*i.e.*, birth rate, survivorship, fecundity, and death rate; Tracy *et al.* 2004). The approach of focusing on individual threats may not have produced expected gains toward desert tortoise recovery since 1994 because multiple threats act simultaneously to suppress tortoise populations at any given location within the species' range. Therefore, this revised recovery plan focuses on expanding our knowledge of individual threats and places emphasis on understanding their multiple and combined effects on tortoise populations.

A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

1. Urbanization

Urban development directly affects desert tortoise populations through fragmentation and permanent loss of habitat. Areas of the desert southwest occupied by desert tortoises have been subject to episodic human settlements and associated impacts since the mid to late 1800s (USFWS 1994). Urbanization and associated infrastructure within desert ecosystems continues to take place at a rapid pace (Table A-1), and currently more than 30 million people live in close proximity to the desert, which is popular with recreationists (Berry *et al.* 2006a; Hughson 2009). Between the years 2000 and 2005, the West experienced an 8.1 percent change in population, compared to 7.3 percent in the South, 2.4 percent in the Midwest, and 2.0 percent in the Northeast (U.S. Census Bureau 2005). During this same time period, Nevada saw a 20.8 percent increase, Arizona a 15.8 percent increase, Utah a 10.6 increase, and California a 6.7 percent increase in population growth (U.S. Census Bureau 2005).

Table A-1. Human population growth in the states and counties within the range of the Mojave population of the desert tortoise between 1994 (when the Recovery Plan was published) and 2006.

State/Counties	1994 Population Estimate[1]	2006 Population Estimate[2]	Percent Change
Arizona	4,147,561	6,166,318	48.7
Mohave	116,320	193,035	66.0[3]
California	31,317,179	36,457,549	16.4
Imperial	136,248	160,301	17.7
Inyo	18,450	17,980	-2.5
Kern	608,858	780,117	28.1
Los Angeles	9,048,129	9,948,081	9.9
Riverside	1,354,966	2,026,803	49.6
San Bernardino	1,553,732	1,999,332	28.7
Nevada	1,456,388	2,495,529	71.4
Clark	938,611	1,777,539	89.4
Esmeralda	1143	790	-30.9
Lincoln	3849	4738	23.1
Nye	21,648	42,693	97.2
Utah	1,930,436	2,550,063	32.1
Washington	65,520	126,312	92.8

[1] Byerly and Deardorff 1995
[2] U.S. Census Bureau 2007b
[3] Most population increase has been outside the Arizona Strip and the range of the Mojave population of the desert tortoise.

Population growth and urban development in the desert region of the Southwest continue to expand into previously undisturbed areas, putting intense pressures on the natural resources. St. George, Utah, was the fastest-growing metropolitan area in the U.S. between 2000 and 2006, with growth of 39.8 percent. Las Vegas, Nevada, grew 29.2 percent, making it one of the top five fastest-growing areas during this time period (U.S. Census Bureau 2007a). In fact, the population of the Las Vegas metropolitan area nearly doubled between 1995 and 2005, as more than 5,000 newcomers continue to move to the Las Vegas area every month. The growth rate is projected to slow to approximately 7 percent per year in the longer term (2020 through 2025) as the economy matures and fewer new hotels are added (Clark County Department of Aviation 2006).

Rapid growth is not limited to metropolitan areas. Mohave County, Arizona, grew 66 percent between 1994 and 2006, and Nye County, Nevada, grew 97 percent during the same time period (Table A-1). The Beaver Dam/Littlefield community (within the Virgin River Basin) on the Arizona Strip supported some 1,580 persons in 2000. This area saw more than 200 percent growth between 1990 and 2000. Given this rapid growth rate, the population for the basin will be between 3,000 and 4,000 persons in 2010 (S. Donahue, Mohave County, pers. comm. 2007).

Related to population growth, the border with Mexico in both California and Arizona has experienced a high level of illegal immigration activity. Illegal immigration traffic can degrade habitat for desert tortoises through surface disturbance and dumping. Law enforcement efforts to address illegal crossings, such as construction of new roads and the use of off-road vehicles, have intensified environmental damage (Sancho 2008).

Increasing human populations result in corresponding increases in impacts to desert tortoise habitat not only through direct habitat loss. Impacts to desert tortoise habitat also occur as more people recreate in or otherwise spread into the desert and as greater infrastructure is needed to support growing communities and increased desire for access. Lovich and Bainbridge (1999) identified various types of anthropogenic impacts from which desert ecosystems may take 50 to 300 years to recover to pre-disturbance plant cover levels. However, areas that have experienced permanent, direct habitat loss due to intense urbanization will never be restored or recovered. In addition, urban environments have indirect impacts on desert tortoise populations and habitat at their interface with the desert (Berry and Burge 1984; Berry and Nicholson 1984). Unconfined pets may kill or wound tortoises (see section C(3), Predation), and unauthorized collecting of desert tortoises may affect populations (see section B(1), Collection by Humans). Human populations subsidize (*i.e.*, provide food for) increasing predator populations, which then apply greater pressure on desert tortoise populations near the urban-wildland interface (see section C(3), Predation). Indiscriminate use of firearms and off-highway vehicles, dumping of trash, and removal of vegetation or unimproved road proliferation are activities that occur in and beyond the urban-desert interface that may result in injury and mortality to tortoises and degradation of their habitats (see section E, Other Natural or Manmade Factors). Pollution from increasing human populations leads to nitrogen deposition within the desert which can lead to increased biomass of non-native grasses and associated impacts (Allen *et al.* 2009). Habitat fragmentation resulting from infrastructure associated with urbanization such as residential fencing, roads, and railroad tracks, can greatly inhibit desert tortoise movements (Edwards *et al.* 2004; Brooks and Lair 2005). These barriers to movement and population connectivity have implications to exchange of genetic material, which can lead to inbreeding, and may result in mortality of individuals (Boarman and Sazaki 1996) (see section A(2), Roads).

2. Paved and Unpaved Roads, Routes, Trails, and Railroads.

Vehicular roads, routes, and trails are the most common type of human disturbance observed in desert ecosystems, and much emphasis has been placed on understanding the impacts these linear features have on arid environments (Brooks and Lair 2005). Brooks and Lair (2005) cite vehicular routes as one of the biggest challenges to land managers in the desert southwest, especially as they relate to the conservation status of the desert tortoise.

Direct and indirect impacts of roads and railroads on desert tortoise populations are well documented and include habitat and population fragmentation and degradation as well as mortality of individual tortoises (USFWS 1994, Boarman 2002). Paved and unpaved roads serve as corridors for urbanization and dispersal of invasive species and provide access to recreation; railroads also facilitate urbanization and the spread of non-native plants. Roads and railroads also act as barriers to movement. Railroads are similar to roads as sources of mortality for desert tortoises, as tortoises can become caught between the tracks causing them to overheat and die or be crushed by trains (U.S. Ecology 1989).

Direct effects to desert tortoise habitat from roads, routes, trails, and railroads also occur during initial stages of construction or off-highway vehicle route/trail establishment when vegetation and soils are lost or severely degraded. Construction of these features can result in physical and chemical changes to soils within unpaved roadways as well as in adjacent areas (Brooks and Lair 2005). In addition, roadside vegetation is often more robust and diverse because water that becomes concentrated along roadside berms promotes germination, which attracts tortoises and puts them at higher risk of mortality as road-kill (Boarman *et al.* 1997). Raised roadbeds or other types of linear human infrastructure also affect water runoff patterns across the landscape, decreasing soil moisture on upland areas between channels downslope of the linear structure and resulting in lower shrub density and biomass (Schlesinger and Jones 1984; Brooks and Lair 2009).

Hoff and Marlow (2002) demonstrated that there is a detectable impact on the abundance of desert tortoise sign adjacent to roads and highways with traffic levels from 220 to over 5,000 vehicles per day. The extent of the detectable impact was positively correlated with the measured traffic level; the higher the traffic counts, the greater the distance from the road reduced tortoise sign was observed (Hoff and Marlow 2002). This supports LaRue (1993) and Boarman *et al.* (1997), wherein depauperate desert tortoise populations were observed along highways. Subsequent research shows that populations may be depressed in a zone at least as far as 0.4 kilometers (0.25 miles) from the roadway (Boarman and Sazaki 2006). Hoff and Marlow (2002) also surmised that unpaved access roads with lower traffic levels may have significant effects on tortoises. Desert tortoise populations may also be indirectly affected by road corridors that fragment habitat and limit an animal's ability to migrate and disperse (Boarman *et al.* 1997). Subsequently, populations may become isolated and at higher risk of localized extirpation from stochastic events or from inbreeding depression (Boarman *et al.* 1997; Boarman and Sazaki 2006). Data suggest fences may reduce mortality of desert tortoises as well as other wildlife species (Boarman *et al.* 1997), and tortoises have been documented to use culverts to cross beneath roadways (Boarman *et al.* 1998), although the degree to which this use mitigates population-fragmenting effects has not been investigated.

(a) Spread of Invasive Plants. Construction and maintenance of roadways facilitates changes in plant species composition and diversity. Non-native, invasive species and edge-associated species often become dominant along these linear features, which serve as corridors for weed dispersal (Boarman and Sazaki 2006; Brooks 2009). Vegetation removal and manipulation and addition of soils in preparation for road construction, as well as grading of unpaved roads, create areas of disturbance that allow weedy species to become established and proliferate (Gelbard and Belnap 2003). Brooks and Berry (2006) found that the density of dirt roads was the best predictor of non-native plant proliferation as measured by non-native species richness and biomass of *Erodium cicutarium*. Vehicles serve as a major vector in dispersal of non-native species along roadways (Brooks and Lair 2005).

Near Canyonlands National Park in Utah, cover of the non-native grass *Bromus tectorum* (cheatgrass) was three times greater along paved roads than four-wheel-drive tracks, and richness (the number of species) and cover of non-native species were more than 50 percent greater and native species richness 30 percent lower at interior sites along paved roads than four-wheel-drive tracks (Gelbard and Belnap 2003). There also appears to be a correlation between the level of road improvement (*i.e.*, paved, improved, unpaved) and the level of invasion by non-natives (Gelbard and Belnap 2003). As previous studies show (LaRue 1993; Boarman *et al.* 1997; Hoff and Marlow 2002; Boarman and Sazaki 2006), the greater the distance from the road, the more desert tortoise sign is observed. Similarly, the cover and richness of non-native species decreases as distance from the road increases (Boarman and Sazaki 2006).

As natural areas are impacted by linear features such as roads, routes, trails, and railroads, previously intact, contiguous habitats become degraded and fragmented, and non-native invasive species play a more dominant role in ecosystem dynamics. For instance, increases in plant cover due to the proliferation of non-natives have altered fire regimes throughout the Mojave Desert region (Brooks 1999; Brooks and Esque 2002; Esque *et al.* 2003; Brooks *et al.* 2004) (see sections A(4)(b) and A(5) on Invasive Species and Increasing Fuel Load and Fire).

(b) Predator Subsidies. In the desert southwest, common raven populations have increased over the past 25 years (greater than 1000 percent), probably in response to increased human populations and anthropogenic changes to the landscape, including roads, utility corridors, landfills, and sewage ponds (Knight and Kawashima 1993; Boarman and Berry 1995; Boarman *et al.* 1995; Knight *et al.* 1999; Boarman *et al.* 2006). See section C(3), Predation, for a detailed description of the effects of predator subsidies on the desert tortoise.

3. Off-Highway Vehicles

Off-highway vehicle activities take many forms, from organized events, small- or large-scale competitive races involving up to thousands of motorcycles, to casual family activities. Organized events and off-highway vehicle tours are now reviewed and permitted by land managers. Generally, an education component and speed limitations are requirements of the permit. Nonetheless, unauthorized off-highway vehicle use continues to be of concern, for instance south of Interstate 10 in the Colorado Desert and adjacent to the Johnson Valley Open Area in the Western Mojave Recovery Unit, and present a variety of threats to the desert tortoise. Repeated off-highway vehicle trail use leads to new routes that are not included in road databases (Brooks and Lair 2009), a difficulty we found in trying to compile these data for the spatial decision support system described elsewhere in this plan.

Impacts from off-highway vehicle use include mortality of tortoises on the surface and below ground, collapsing of desert tortoise burrows, damage or destruction of annual and perennial plants and soil crusts, soil erosion and compaction, proliferation of weeds, and increases in numbers and locations of wildfires (Brooks 2009; Lei 2009). Despite the many observations that have been documented and reported, statistical correlation between off-highway vehicle impacts and reduced desert tortoise densities continues to be lacking (Boarman 2002). However, it is evident that off-highway vehicle activities remain an important source of habitat degradation and could result in reductions in desert tortoise densities (Boarman 2002).

Damage to or destruction of shrubs and burrows can lead to disruption of desert tortoises' water balance, thermoregulation, and energy requirements, and the loss of annual plants reduces the availability of food (USFWS 1994). One of the most significant ecological implications of off-highway vehicle routes is the exacerbation of erosion and changes in drainage patterns (Brooks and Lair 2005).

Bury and Luckenbach (2002) compared habitat, abundance, and life history features of desert tortoises on one unused, natural area and a nearby area used heavily by off-highway vehicles. The unused, natural area had 1.7 times the number of live plants, 3.9 times the plant cover, 3.9 times the number of desert tortoises, and 4 times the number of active tortoise burrows than the area used by off-highway vehicles. The two largest tortoises in the off-highway vehicle use area weighed less than would be expected based on what is known about season-to-season fluctuations. Despite the lack of pre-disturbance data for the off-highway vehicle area and the patchy distribution of tortoises, the areas furthest from concentrated off-highway vehicle activity (pit areas) still reflected the least amount of habitat impact and supported more tortoises (Bury and Luckenbach 2002).

Jennings (1997) found that desert tortoises are vulnerable to negative effects from off-highway vehicles because of their habitat preferences. Tortoises in a study at the Desert Tortoise Natural Area spent significantly more time traveling and foraging in hills and washes than on the flats. Tortoises use washes for travel, excavation of burrows, and foraging, and at least 25 percent of their forage plants were found to occur within washes. Hills and washes are also favored by users of motorcycles, trail bikes, all-terrain vehicles, and other four-wheel vehicles. Because tortoises prefer washes and hills, they are more vulnerable to direct mortality from off-highway vehicles. Additionally, off-highway vehicle use in these habitats causes degradation of vegetation and loss of forage species important in the desert tortoise diet (Jennings 1997).

Surface disturbance from off-highway vehicle activity can cause erosion and large amounts of dust to be discharged into the air. Recent studies on surface dust impacts on gas exchanges in Mojave Desert shrubs showed that plants encrusted by dust have reduced photosynthesis and decreased water-use efficiency, which may decrease primary production during seasons when photosynthesis occurs (Sharifi *et al.* 1997). Sharifi *et al.* (1997) also showed reduction in maximum leaf conductance, transpiration, and water-use efficiency due to dust. Leaf and stem temperatures were also shown to be higher in plants with leaf-surface dust. These effects may also impact desert annuals, an important food source for tortoises.

Off-highway vehicle activity can also disturb fragile cyanobacterial-lichen soil crusts, a dominant source of nitrogen in desert ecosystems (Belnap 1996). Belnap (1996) showed that anthropogenic surface disturbances may have serious implications for nitrogen budgets in cold-desert ecosystems, and this may also hold true for the hot deserts that tortoises occupy. Soil crusts also appear to be an important source of water for plants, as crusts were shown to have 53 percent greater volumetric water content than bare soils during the late fall when winter annuals are becoming established (DeFalco *et al.* 2001). DeFalco *et al.* (2001) found that non-native plant species comprised greater shoot biomass on crusted soils than native species, which demonstrates their ability to exploit available nutrient and water resources. Once the soil crusts are disturbed, non-native plants may colonize, become established, and out-compete native perennial and annual plant species (D'Antonio and Vitousek 1992; DeFalco *et al.* 2001). Invasion of non-native plants can affect the quality and quantity of plant foods available to desert tortoises (see section A(4)(a), Invasive Plants and Nutrition) and can contribute to increased fire frequency (see sections A(4)(b) and A(5), Increasing Fuel Load and Fire). Brooks and Lair (2009) provide a comprehensive overview of the ecological effects of various types of vehicular routes in the Mojave Desert.

4. Invasive Plants

Proliferation of invasive plants is increasing in the Mojave and Sonoran deserts, largely as a result of human disturbance, and is recognized as a significant threat to desert tortoise habitat (Brooks 2009). Many species of non-native plants from Europe and Asia have become common to abundant in some areas, particularly where disturbance has occurred and is ongoing. As non-native plant species become established, native perennial and annual plant species may decrease, diminish, or die out (D'Antonio and Vitousek 1992).

Land managers and field scientists identified 116 species of non-native plants in the Mojave and Colorado deserts, including *Erodium cicutarium* (redstem filaree), *Bassia hyssopifolia* (bassia), *Ambrosia acanthicarpa* (sand bur), *Ambrosia psilostachya* var. *californica* (western ragweed), *Hemizonia pungens* (common spikeweed), *Matricaria matricarioides* (pineapple weed), *Amsinckia intermedia* (fiddleneck), *A. tessellata* (bristly fiddleneck), *Descurainia sophia* (flixweed), *Sisymbrium altissimum* (tumble mustard), *S. irio* (London rocket), *Salsola iberica* (Russian thistle), *Eremocarpus setigerus* (turkey mullein), and *Marrubium vulgare* (horehound) (Tierra Madre Consultants, Inc.1991; Brooks and Esque 2002). Annual grasses include: *Bromus rubens* (red brome), *B. tectorum*, *Hordeum glaucum* (smooth barley), *H. jubatum* (foxtail barley), *H. leporinum* (hare barley), *Schismus barbatus* (split grass), and *S. arabicus* (Arab grass). *Brassica tournefortii* (Sahara mustard) and *Hirschfeldia incana* (Mediterranean mustard) are rapidly spreading, non-native winter annuals invading the desert southwest, especially in sandy soils (LaBerteaux 2006).

Brooks and Berry (2006) found that while non-native plant species comprised only a small fraction of the total annual plant flora (*i.e.*, a small fraction of the total number of plant species), they were the dominant component of the annual plant community biomass. For instance, in 1995, a high rainfall year in the Mojave Desert, non-native species comprised 6 percent of the flora and 66 percent of the biomass; in 1999, a low rainfall year, non-natives comprised 27 percent of the flora and 91 percent of the biomass. Annual species dominate the non-native flora, with *Bromus rubens*, *Schismus barbatus*, and *Erodium cicutarium* comprising up to 99 percent of the non-native biomass.

Increased levels of atmospheric pollution and nitrogen deposition related to increased human presence and combustion of fossil fuels can cause increased levels of soil nitrogen, which in turn may result in significant changes in plant communities (Aber *et al.* 1989; Allen *et al*. 2009). Many of the non-native annual plant taxa in the Mojave region evolved in more fertile Mediterranean regions and benefit from increased levels of soil nitrogen, which gives them a competitive edge over native annuals. Studies at three sites within the central, southern, and western Mojave Desert indicated that increased levels of soil nitrogen can increase the dominance of non-native annual plants and promote the invasion of new species in desert regions. Furthermore, increased dominance by non-native annuals may decrease the diversity of native annual plants, and increased biomass of non-native annual grasses may increase fire frequency (Brooks 2003).

(a) Nutrition. Nutritional intake affects growth rates in juvenile desert tortoises (Medica *et al.* 1975) and female reproductive output (Turner *et al.* 1986, 1987; Henen 1992). Invasion of non-native plants can affect the quality and quantity of plant foods available to desert tortoises, and thereby affect nutritional intake. Desert tortoises are generally quite selective in their choices of foods (Burge 1977; Nagy and Medica 1986; Turner *et al.* 1987; Avery 1992; Henen 1992; Jennings 1992, 1993; Esque 1992, 1994), and in some areas the preferences are clearly for native plants over the weedy non-natives.

As native plants are displaced by non-native invasive species in some areas of the Mojave Desert, non-native plants can be a necessary food source for some desert tortoises. However, non-native plants may not be as nutritious as native plants. Recent studies have shown that calcium and phosphorus availability are higher in forbs than in grasses and that desert tortoises lose phosphorus when feeding on grasses but gain phosphorus when eating forbs (Hazard *et al.* 2010). Nagy *et al.* (1998) conducted feeding trails on four plant species (native and non-native grasses *Achnatherum hymenoides* [Indian ricegrass] and *Schismus barbatus* [split grass] and native and non-native forbs *Malacothrix glabrata* [desert dandelion] and *Erodium cicutarium* [red-stemmed filaree]) to compare the nutritional qualities for the desert tortoise. The digestibility of the nutrients in the two forbs were similar. The dry matter and energy digestibility of the two grasses were much lower than the forbs, providing little nitrogen, and tortoises lost more water than they gained while processing grasses. Results of these feeding trials suggest that the proliferation of non-native grasses such as *Schismus* to the exclusion of forbs (D'Antonio and Vitousek 1992) places desert tortoises at a nutritional disadvantage. Furthermore, if, instead of eating to obtain a given volume of food, tortoises consume just enough food to satisfy their energy needs (as commonly noted in other vertebrate groups), then the native forbs provide significantly more nitrogen and water than the non-native forbs (Nagy *et al.* 1998).

Changes in the abundance and distribution of native plants also may affect desert tortoises in more subtle ways. In the Mojave Desert, many food plants are high in potassium (Minnich 1979), which is difficult for desert tortoises to excrete due to the lack of salt glands that are found in other reptilian herbivores such as chuckwallas (*Sauromalus obesus*) and desert iguanas (*Dipsosaurus dorsalis*) (Minnich 1970; Nagy 1972). Reptiles are also unable to produce concentrated urine, which further complicates the ability for desert tortoises to expel excess potassium (Oftedal and Allen 1996). Oftedal (2002) suggested that desert tortoises may be vulnerable to disease as a result of physiological stress associated with foraging on food plants with insufficient water and nitrogen to counteract the negative effects of dietary potassium. Only high quality food plants (as expressed by the Potassium Excretion Potential, or PEP, index) allow substantial storage of protein (nitrogen) that is used for growth and reproduction, or to sustain the animals during drought. Non-native, annual grasses have lower PEP indices than most native forbs (Oftedal 2002; Oftedal *et al.* 2002). Oftedal *et al.* (2002) found that foraging juvenile tortoises favored water-rich, high-PEP, native forbs. Much of the nutritional difference between available and selected forage was attributable to avoidance of abundant, non-native split grass

(*Schismus* spp.) with mature fruit, which is very low in water, protein, and PEP. Of the species eaten, *Camissonia claviformis*, a native Mojave desert primrose, accounted for nearly 50 percent of all bites, even though it accounted for less than 5 percent of the biomass encountered, and was largely responsible for the high PEP of the overall diet. Impacts to vegetation (such as livestock grazing, invasion of non-native plants, and soil disturbance) that reduce the abundance and distribution of high PEP plants may result in additional challenges for foraging desert tortoises (Oftedal *et al.* 2002).

Tracy *et al.* (2006) also quantified the rates of passage of digesta (food in the stomach) in young desert tortoises in relation to body size and diet quality. They observed that, compared to adults, young, growing tortoises need higher rates of nutrient assimilation to support their higher metabolic rates. Juvenile desert tortoises also forage selectively by consuming plant species and plant parts of higher quality (Oftedal *et al.* 2002) and pass food through the gut more quickly (Tracy *et al.* 2006). Hence, these findings of differential passage rates suggest that it is beneficial for young tortoises to specialize on low-fiber diets, as this would allow for more efficient uptake of nutrients. In addition, habitat disturbances (*e.g.*, invasion of annual grasses) that favor species with little nutritional value and preclude access to low-fiber foods may negatively impact the physiological and behavioral ecology of young desert tortoises. Adults, on the other hand, may be better adapted to tolerate low-quality foods for a longer period of time because of their lower metabolism, more voluminous guts compared to subadults, and consequent longer retention times (Tracy *et al.* 2006).

(b) Increasing Fuel Load. The proliferation of non-native plant species has contributed to an increase in fire frequency in tortoise habitat by providing sufficient fuel to carry fires, especially in the inter-shrub spaces that are mostly devoid of native vegetation (Brown and Minnich 1986; USFWS 1994; Brooks 1998; Brooks and Esque 2002). Invasive, non-native annual grasses and forbs increasingly spread over the desert floor, resist decomposition, and provide flash fuel for fires. Brooks (1999) found that non-native annual grasses contributed most to the continuity and biomass of dead annual plants and to the spread of summer fires compared to native forbs. Red brome in particular has contributed to significant increases in fire frequency since the 1970s (Kemp and Brooks 1998; Brooks *et al.* 2003).

Fire also appears to affect the spread of non-native plants. Brooks and Berry (2006) found that proliferation of non-native plants was best predicted by disturbance, specifically frequency and size of recent fires for biomass of *Bromus rubens*. Once fires occur, opportunities for invasion and proliferation of non natives increase because they regenerate on burned areas more quickly than native plants (Brown and Minnich 1986). Changes in plant communities caused by non-native plants and recurrent fire negatively affect the desert tortoise by altering habitat structure and species composition of their food plants (Brooks and Esque 2002) (see also section A(5), Fire).

5. Fire

Fire has the potential to be an important force governing habitat quality and persistence of desert tortoises. Tortoises can be killed or seriously injured by burning and smoke inhalation during fire events. The extent of the direct impacts experienced by tortoises is influenced by tortoise activity at the time of fire (whether inside or outside burrow), depth of burrow (to afford protection), fire intensity (amount of heat generated), speed of fire (how quickly it moves through an area), and patchiness (extent of an area burned) (Esque *et al.* 2003). Early-season fires may be more threatening than summer fires because desert tortoises are active above ground and more vulnerable to direct effects of fire at that time. Fire can also compromise the quality of tortoise habitat by reducing the vegetation that provides shelter, cover, and nutrition (key forage plants) for tortoises (Brooks and Esque 2002; Esque *et al.* 2003).

Natural fire regimes have been altered due to profuse invasions of non-native grasses throughout much of the range of the desert tortoise. The biomass of weedy species has increased remarkably in the desert Southwest as a result of disturbance from vehicles, grazing, agriculture, urbanization, and other human land uses (Brooks and Berry 1999; Brooks and Esque 2002; Brooks *et al.* 2003; Brooks and Berry 2006; Brooks and Matchett 2006). Fuel loads that consist of dense annual grasses rather than sparse cover of native species make it more likely for fire to become hot enough to damage native shrubs, which are poorly adapted to survive and/or regenerate quickly after fire and are poor colonizers (Tratz and Vogl 1977; Tratz 1978). Ultimately, recurrent fire can result in conversion of shrublands to annual grasslands, which can be devastating for desert tortoises that depend upon shrubs for cover (Brooks and Esque 2002). Conversion to grassland also tends to create a self-perpetuating grass/fire cycle as fuels continuously reestablish in burned areas (D'Antonio and Vitousek 1992).

Years of high rainfall promote the growth of invasive annuals that increase the fine fuel loads, but high rainfall also increases food and water availability for desert tortoises. Desert tortoise reproduction also increases in high rainfall years. Small hatchlings are more vulnerable to fire than larger tortoises, and tortoises in general are more vulnerable to fire when they are above ground foraging. Thus, the high rainfall episodes that are important to maintaining healthy desert tortoise populations may also create the highest fire risk (Brooks and Esque 2002).

Plant litter produced by non-native annual grasses decomposes more slowly than native annuals and accumulates during successive years, thus providing an excess of fine fuels that sustains and spreads fires throughout the desert ecosystem (Brooks 1999). Historical fire intervals of 30 to greater than 100 years have been shortened to an average of 5 years in some areas of the Mojave Desert, due to the invasion of non-native grasses. Additionally, fires can increase the frequency and cover of non-native annual grasses within 3 to 5 years of a fire event, thus promoting the continuity of this grass/fire cycle that shortens the fire interval (Brooks *et al.* 1999; Brooks and Esque 2002; Brooks and Minnich 2006). Increased levels of surface-disturbing activities, rainfall, and atmospheric nitrogen and carbon dioxide may also increase the dominance of non-native plants and frequency of fires in the future (Brooks and Esque 2002; Brooks *et al.* 2003).

The most striking changes in fire frequency in the Mojave Desert have been observed in the middle elevations dominated by *Larrea tridentata* (creosote bush), *Yucca brevifolia* (Joshua tree), and *Coleogyne ramosissima* (blackbrush), at the upper limits of desert tortoise distribution, where most of the fires occurred between 1980 and 2004 (Brooks and Matchett 2006). The combination of enough cover of native vegetation to carry a fire and the accumulation of fuels from non-native annual grasses following years of above average rainfall may result in significantly larger fires at shorter return intervals than normally expected in this zone. Lower elevations are less susceptible to larger fires because of the natural lack of native plant cover, whereas upper elevations may experience larger fires as they generally support enough native fuels to carry large fires (Brooks and Matchett 2006). Brooks and Matchett (2006) advise, however, that additional research is necessary to confirm their results due to a limited dataset, and that longitude, elevation, and regional climatic conditions may cause substantial variation in observations.

The year 2005 was a particularly bad fire year in the Mojave Desert. According to the Bureau of Land Management, U.S. Forest Service, and California Department of Forestry geospatial data of the extent of fires in 2005, the wildfires burned over 58,208 hectares (140,000 acres) of critical habitat that year (Table A-2). The Bureau of Land Management's geospatial fire data depict slightly different acreages than have been reported elsewhere. According to McLuckie *et al*. (2007), 3,191 hectares (7,885 acres) burned within the Red Cliffs Desert Preserve, which emcompasses the majority of the Critical Habitat within the Upper Virgin River Recovery Unit.

Table A-2. Area (hectares) of desert tortoise critical habitat burned during 2005.*

Critical Habitat Unit	Area Burned (hectares)	Percent of CHU area burned
Beaver Dam Slope	21,662	26
Chemehuevi	23	<1
Fenner	12	<1
Fremont-Kramer	11	<1
Gold Butte-Pakoon	26,442	13
Ivanpah	397	<1
Mormon Mesa	5,241	3
Ord-Rodman	11	<1
Superior-Cronese	137	<1
Upper Virgin River	4,272	19

*Complete data sources: CA fire data from California Department of Forestry and Fire Protection's Fire and Resource Assessment Program: http://frap.cdf.ca.gov/data/frapgisdata/download.asp?rec=fire; NV fire data from BLM as a single 2005 file: http://www.blm.gov/nv/st/en/prog/more_programs/geographic_sciences/gis/geospatial_data.html; AZ fire data from Forest Service, part of historic files [cross referenced against BLM ADSO fire data]: http://www.fs.fed.us/r3/gis/datasets.shtml; UT fire data from BLM, as part of historic fires file: http://www.blm.gov/ut/st/en/prog/more/geographic_information/gis_data_and_maps.print.html.

Studies were conducted in five burned areas within the range of the desert tortoise to determine immediate effects of the fire and fire suppression tactics and to monitor the recovery of habitats (Esque *et al.* 1994, 2003). Between 16 to 81 hectares (40 and 200 acres) were surveyed for wildlife remains on each fire via walking transects 9 to 15 meters (30 to 50 feet) apart. Desert tortoise mortality was documented at 0 to 7 per transect, but live tortoises were also observed. There were statistically significant losses of perennial cover, but some fires left unburned patches of vegetation that can serve as refugia for tortoises and plants. These refugia may be important to the long-term recovery of burned desert ecosystems. No destroyed burrows or desert tortoise mortalities were observed in surveys of routes used for off-road fire suppression activities in Utah, indicating that carefully planned and monitored fire suppression maneuvers can help stop the spread of damaging wildfires while reducing immediate and long-term tortoise mortality (Esque *et al.* 1994, 2003).

In general, as fire becomes more prevalent throughout the range of the desert tortoise, the threats to the species from mortality or injury by burning and smoke inhalation during fire events and impacts to desert habitats will also increase. Changes in habitat structure from shrub-dominated communities to non-native annual grasslands would limit the availability of cover sites for tortoises as well as alter species composition of food plants.

6. Grazing

Impacts of grazing on arid lands are well documented (Fleischner 1994; Jones 2000). Recovery from these impacts is variable, but can take decades, will likely require significant management effort beyond excluding livestock, and will be affected by other factors such as drought (GAO 1991; Friedel 1991; Laycock 1991). Livestock grazing (sheep and cattle as well as horses and burros) is known to have direct and indirect impacts on desert tortoises and their habitats through trampling that results in direct mortality, either while above ground or in burrows, and degradation of vegetation and soils, including the spread of non-native plants or the displacement of native plants (Brooks 1995; Avery 1998; Boarman 2002). The magnitude of the threat on desert tortoise populations remains unclear, and the degree of impact depends on a number of factors including, but not limited to, resiliency of soil and vegetation types, type of livestock, stocking rates, season of use, and years of use with and without rest (USFWS 1994). Other factors can interact with livestock grazing and can affect the degree and extent of impacts to desert tortoises (*e.g.*, introduction and spread of weeds [Brooks 2009], changes in vegetation due to grazing, fire, drought, and other land uses [USFWS 1994]).

Oldemeyer (1994) suggests that the primary evidence that grazing adversely affects desert tortoises relates to an overlap in food habits of livestock and tortoises. Grazing is thought to reduce cover of shrubs and annual forbs. Studies in the eastern Mojave Desert on foraging behavior and food preferences of range cattle and desert tortoises showed that a dietary overlap (spatial and temporal) exists and that this overlap is greatest in the spring when fresh annual plants preferred by both desert tortoises and livestock are at their peak biomass and densities. Competition for these food plants is expected to be greatest when annual plants start to dry in the spring, before cattle and tortoises switch to other forage plants (Avery and Neibergs 1997).

Avery and Neibergs (1997) observed direct and indirect interactions between cattle and tortoises. Their study indicates that grazing during winter may destroy a large percentage of active tortoise burrows. They noted that tortoises outside an ungrazed cattle exclosure spent more nights outside of burrows than tortoises within the exclusion area, because more burrows were destroyed in the grazed area than in the ungrazed area. Almost 200 tortoise burrows were recorded as trampled during a survey of the 2.6-square-kilometer (1-square-mile) East Bajada (of the Black Mountains), Arizona, study plot in 1997 (Woodman *et al*. 1998). The presence of cattle dung, tracks, and trails suggested that most trampled burrows were caused by livestock, but some may have been due to horses or burros. In a study on translocated tortoises in the northwest Mojave Desert, one tortoise was found alive in its hibernation burrow even though the burrow had been crushed by cattle. It had skin lesions and had been parasitized by fly larvae. The tortoise was removed from the study because it was assumed that it would have died if it had been left in the crushed burrow (Nussear 2004). Tortoises with home ranges located in areas of poorly-managed cattle grazing may experience increased risk of mortality, increased energetic costs, and changes in activity time budgets (caused by additional time and effort required to build new burrows).

Comparative studies of historically grazed and never-grazed grasslands in southeast Utah (Neff *et al.* 2005) showed that grazing can continue to impact soil biogeochemical characteristics three decades after grazing had been removed. Reduced soil nutrient levels in the historically grazed site compared to the never-grazed site were attributed to erosion of nutrient-rich fine soil materials due to disturbance caused by grazing practices. Soil organic matter, carbon and nitrogen content, and microbial biomass were also lower in the grazed site. The decline of organic matter content may be attributed to the destruction of biological soil crusts or long-term changes in vegetation cover/composition resulting from grazing. This study illustrates the sensitivity of arid land biogeochemical processes to land use change and the need for a better understanding of potential long-term impacts from grazing practices in the southwestern United States. Furthermore, wind erosion may contribute significantly to loss of soil nutrient content and should be considered in management of arid land ecosystems (Neff *et al.* 2005).

Unmanaged livestock grazing, especially where plants are not adapted to large herbivorous mammals or where the non-native species are less palatable than the natives, can preferentially remove native vegitation, leaving non-native plants to grow under reduced competition (Wittenberg and Cock 2005:228). Studies at the Desert Tortoise Natural Area showed that both abundance and diversity of native plants and animals is higher inside than outside of the protected desert tortoise habitat (Brooks 2000). It should be noted that the Desert Tortoise Natural Area has received limited protection since 1973, but has been effectively protected from sheep grazing and off-highway vehicle use through the installation of exclusion fencing for the last 10 years (Brooks 2000). Similarly, grazing (and simulated grazing treatments) negatively impacted native plant species, while non-native species were unaffected and demonstrated superior competitive abilities, at Carrizo Plain National Monument, California (Kimball and Schiffman 2003).

7. Agriculture

Lands in the Mojave Desert have been used for agricultural purposes since the early nineteenth century when peoples of the Mohave Tribe planted crops within the floodplain of the Colorado River to sustain their populations (Mojave Desert.net 2007). The 1994 Recovery Plan stated that the most significant effect agriculture has on desert tortoises is loss of habitat. Since the 1950s, losses of tortoise populations have been attributed to urbanization and agriculture in the western Mojave Desert in the Indian Wells, Antelope, Victor, Apple, Lucerne, and Johnson valleys (Berry and Nicholson 1984). Once converted to agricultural fields, the habitat becomes unsuitable to tortoises for foraging or burrowing. Agricultural activities may also result in drawdown of the water table, introduction of invasive plants, production of fugitive dust, and possible introduction of toxic chemicals (Koehler 1977; Wilshire 1980; Berry and Nicholson 1984). Additionally, agricultural fields can support ravens, which prey upon juvenile tortoises (Knowles *et al.* 1989; Camp *et al.* 1993; Knight *et al.* 1999). Old agricultural fields are often invaded by non-native, invasive species, which compete with native plants for resources and may reduce the abundance and diversity of the native species that provide shelter and food for desert tortoises (Hobbs 1989; USFWS 1994).

8. Energy and Mineral Development

Exploration for and development of energy and mineral resources, as well as sand and gravel extraction, result in habitat fragmentation and permanent habitat loss due to haul roads, development of facilities necessary to support large mining operations, ancillary facilities, leachate ponds, and mine tailings. Additional impacts to the desert tortoise may result from soil erosion, establishment of invasive plant species in disturbance zones (see section C(4), Invasive Plants), and fugitive dust and introduction of toxins (see section C(1), Disease). Tortoises may be killed during exploration, construction and ongoing operations, and maintenance activities (USFWS 1994; Boarman 2002).

At the time the 1994 Recovery Plan was approved, it was estimated that 41 percent of high-density tortoise habitat throughout the species' range was leased or partially leased for oil or gas, and 2 percent was directly impacted by mining operations or leased for geothermal development (Luke *et al.* 1991; USFWS 1994). The extent of impacts to desert tortoise habitat and effects to tortoise populations from energy and mineral development are still not well documented. Cumulative habitat loss from mining-related disturbances combined with increased development to support those operations may pose the most significant impact resulting from mining (Lovich and Bainbridge 1999; Boarman 2002).

In 2005, the Federal Energy Security Policy Act established a mandate to approve 10,000 megawatts (MW) of non-hydropower, renewable-energy generation on public lands by 2015, a five-fold increase from the current level of approximately 1,900 MW. In 2008, California Governor Schwarzenegger signed Executive Order S-14-08, which increased the target for California's renewable-energy portfolio to 33 percent by 2020. Nevada has mandated a 20-percent renewable-energy portfolio by 2015, Arizona requires 15 percent by 2015, and Utah has a voluntary portfolio of 20 percent by 2015. The President established broader goals of generating 10 percent of the nation's electricity from renewable sources by 2012 and 25 percent by 2025. To achieve these goals, the Secretary of Interior issued a Secretarial Order in March 2009 that makes the development, production, and delivery of renewable energy top priorities of the Department of the Interior. The U.S. Congress underscored the need for accelerated development of renewable-energy projects with the passage of the American Recovery and Reinvestment Act (ARRA), which confers economic benefits to developers of renewable-energy projects that begin construction before the end of 2010.

By April 2009, the Bureau of Land Management had received approximately 160 applications for solar energy, mostly in California and Nevada; these applications comprised approximately 728,000 hectares (1.8 million acres) of public land and proposed a combined generating capacity of approximately 97,000 MW. In order to facilitate project permitting and approval to meet ARRA deadlines, several projects were categorized as "fast track" and became the top priority of local field and regional office staffs in both Federal and State wildlife and resource agencies. As of November 2010, within the range of the desert tortoise, six fast-track solar projects in California and one in Nevada were approved on public lands, constituting 3,037.5 MW on 9,683 hectares (23,926 acres) and 430 MW on 3,173 hectares (7,840 acres), respectively. Three additional solar projects on private lands in California have been approved, totaling 1,063 MW on 1,686 hectares (4,165 acres). Seven fast-track solar projects on public lands are still pending, totaling 1,450 MW on 4,314 hectares (10,659 acres) in California and 900 MW on 6,955 hectares (17,186 acres) in Nevada. Three fast-track wind projects within the range of the desert tortoise are also pending, totaling 536.5 MW on 11,775 hectares (29,096 acres) of public and private rights-of-way; one of the California projects is proposed within designated critical habitat. No applications have been submitted for solar or wind projects on public lands within the range of the Mojave population of the desert tortoise in Arizona or Utah. As of November 2010, 31 solar and wind-energy right-of-way applications were for example, pending within the Bureau of Land Management's California Desert District, totaling 16,979 MW on 85,210 hectares (210,558 acres). The area of approved and pending solar and wind-energy applications on public lands in California exceeds 100,000 hectares (247,000 acres).

At this time, we do not have information on renewable-energy projects proposed on private lands within the range of the Mojave population of the desert tortoise outside California, but according to the California Energy Commission, more than 51 solar projects, totaling 5,475 MW, had been proposed on private lands. Depending on the technology used, projects may require 2-3.6 hectares (5-9 acres) per MW; therefore, approximately 15,500 hectares (38,300 acres) would be developed by these projects, assuming an average need of 2.8 hectares (7 acres) per MW. At least 10 wind projects had been proposed on private lands in southern California, totaling about 2,700 MW.

Conflicts between energy development and the desert tortoise have been recognized at least since 1986 (Pearson 1986). A typical 250-400MW solar energy project requires about 1,200 hectares (3,000 acres). The land is typically contoured and fenced, resulting in habitat loss and availability for other public land uses. While developing utility-scale solar projects on public lands could help achieve the national and regional energy goals, it would also require large reallocations of land and water resources and have significant environmental impacts. Many of these impacts will directly affect the desert tortoise and desert ecosystems. The BLM has committed to excluding these projects from designated critical habitat for the desert tortoise and Desert Wildlife Management Areas; however, potential long-term effects of utility-scale energy development fragmenting or isolating desert tortoise conservation areas and restricting gene flow between these areas have not been evaluated. The energy development process on Bureau of Land Management lands has been constantly changing, with applicants submitting multiple requests to modify their projects or withdrawing their applications altogether (J. Crisp, Bureau of Land Management, pers. comm. 2007).

9. Landfills

There are more than 50 authorized sanitary landfills and waste disposal facilities known in the California and Nevada deserts (Boarman 2002). In urban areas throughout the range of the tortoise, all communities produce solid waste that must be transported to appropriate facilities. Landfills and other waste disposal facilities potentially affect desert tortoises and their habitat through fragmentation and permanent loss of habitat, spread of garbage that attracts predators, introduction of toxic chemicals, increased road kill of tortoises on access roads, and increased predator populations (Boarman 2002) (see also section C(3), Disease and Predation). With the exception of raven predation, which is considered one of the most important consequences of landfills, negative effects on tortoises associated with the presence of landfills have not been quantified (Boarman 2002).

10. Military Operations

Military operations in the Mojave Desert have taken place since as early as 1859 (USFWS 1994; Boarman 2002). Military activities that impact desert tortoises and their habitats can be categorized as: (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, and abandonment of unexploded ordnance, shell casings, and ration cans; and (4) distribution of chemicals. These activities result in degradation and permanent loss of desert tortoise habitat and are often coupled with other impacts associated with large human settlements in the desert (*i.e.*, collection of tortoises, trash dumping, increased raven populations, domestic pets as predators, off-highway vehicle use, increased exposure to disease, and increased road-kill mortality) (USFWS 1994).

The military bases and test ranges in the Mojave Desert include the Nevada Test and Training Range and Nellis Air Force Range in Nevada, and Edwards Air Force Base, Twentynine Palms Marine Corps Air Ground Combat Center, Barstow Marine Corps Logistics Bases (includes the Yermo Annex, Main Base at Nebo, and the Marine Corps Rifle Range), Fort Irwin National Training Center, China Lake Naval Air Weapons Station, and the Mojave B and Randsburg Wash Test Ranges in California. The Chocolate Mountains Aerial Gunnery Range in California is the primary base affecting desert tortoise habitat in the Colorado Desert (USFWS 1994). All of these military facilities encompass desert tortoise habitat.

All of the threats associated with military activities described above continue to affect desert tortoises and their habitat. For example, in a study of tortoise populations at several sites on the Fort Irwin National Training Center, tortoises living in historically or recently used military maneuver areas had significantly higher frequencies of shell disease than a site where military activities had not taken place (Berry *et al*. 2006b). The expansion of military bases and activities into previously unused areas occupied by desert tortoises also threatens the species. In 2004, we issued a biological opinion to the Department of the Army for the use of additional training lands at the Fort Irwin National Training Center in California. This action will result in the loss or degradation of approximately 76,081 hectares (188,000 acres) of desert tortoise habitat, including approximately 30,351 hectares (75,000 acres) within the Superior-Cronese critical habitat unit, and the translocation of several hundred desert tortoises from harm's way. To date, the Department of the Army has purchased approximately 40,104 hectares (99,100 acres) of lands formerly owned by the Catellus Development Corporation and portions of cattle allotments in the western Mojave Desert to minimize impacts associated with the expanded training areas (R. Bransfield, U.S. Fish and Wildlife Service, pers. comm. 2007). The Bureau of Land Management subsequently retired these allotments and removed grazing on over 129,499 hectares (320,000 acres). A plan has also been developed to guide the translocation of tortoises in the expansion area (Esque *et al.* 2005).

11. Utility Corridors

By 1994, most critical habitat units had one or more power lines, natural gas pipelines, fiber optic cables, and/or communication sites within their proposed boundaries (USFWS 1994). Disturbances associated with these corridors are usually linear in nature, and the zone of disturbance can vary in width from 15.2 to 30.5 meters (50 to 100 feet) to several hundred meters/yards, depending on the number of transmission lines (USFWS 1994). Impacts to desert tortoise habitat and individuals occur both during initial construction as well as during long-term maintenance activities (Boarman 2002). Additionally, utility corridors are often used by the public for off-highway vehicle and recreational access. LaRue and Dougherty (1999) evaluated results of over 230 biological opinions issued by our southern California and Nevada offices and found that 80 percent of the tortoises reported killed in these two states were found along utility corridors. Most of these mortalities resulted from a few large projects during the construction phases, and very few tortoises have been killed during utility maintenance projects (R. Bransfield, U.S. Fish and Wildlife Service, pers. comm. 2007). While tortoises may be observed within these corridors, continual vehicular use along access roads may alter use by tortoises both for foraging and movement and may result in road-kills (Boarman 2002). Utility towers also provide nesting substrate and hunting perches to avian predators, such as ravens and red-tailed hawks.

12. Vandalism and Harvest of Vegetation

Vandalism and harvest of vegetation, particularly cacti and yuccas, were identified as potential threats to desert tortoises and their habitats in the 1994 Recovery Plan. Harvest of vegetation includes the removal of vegetation for personal or economic purposes (*i.e.*, use in landscaping or sale for profit). Vandalism of vegetation is considered to be the deliberate destruction of vegetation (*i.e.*, shooting, crushing). While these activities may still occur on a relatively small scale and may pose some threat on a localized level, there is no recent documentation that indicates this activity poses a significant or widespread threat to tortoise populations throughout their range.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

1. Collection by Humans

Some of the threats to the desert tortoise identified in the 1994 Recovery Plan include the deliberate removal of desert tortoises by humans for use as food (Berry and Nicholson 1984; Swingland and Klemens 1989; Schneider and Everson 1989; Ditzler 1991; BLM files 2006), and collection and commercial trade for pets (Berry and Burge 1984; Berry and Nicholson 1984; St. Amant 1984). Collection of desert tortoises for personal or commercial purposes was evidently significant in the past (Grant 1936; Berry and Burge 1984; Berry and Nicholson 1984; Ditzler 1991; Berry *et al.* 1996; USFWS 1994). Desert tortoises are protected from collection under both Federal and State law in all states where it occurs; however, the legal status has not always served as a deterrent to this activity (Boarman 2002). For example, nine cases of illegal collection were documented from the Red Cliffs Desert Reserve, Washington County, Utah, between May 2003 and May 2006, including four cases within 5 weeks during 2006 (A. McLuckie, Utah Division of Wildlife Resources, pers. comm. 2006). While illegal collection of desert tortoises still occurs and could possibly impact local populations, little quantitative evidence exists to support it as a significant threat causing declines in the Mojave populations (Boarman 2002). Also, information specific to this threat is limited owing to the wide distribution of the species coupled with the need for additional law enforcement officers and wardens on the ground (see section D, Inadequacy of Existing Regulatory Mechanisms).

2. Deliberate Maiming and Killing by Humans

Little additional information regarding maiming and killing of desert tortoises has been obtained since the 1994 Recovery Plan. Postmortem forensic analysis determined that 14.3 percent of 635 carcasses collected at 11 of 27 California desert sites between 1976 and 1982 showed evidence of gunshots (Berry 1986). Evidence of gunshot was significantly higher in carcasses from the west Mojave than from the east Mojave or Colorado Desert (Berry 1986), which may be a function of the proximity of human populations in the west Mojave region compared to that in the east Mojave or Colorado Desert.

3. Research Activities

We permit various research activities that will inform management and recovery of the desert tortoise but that may result in infrequent injury or mortality. Potential stress to desert tortoises from handling may vary depending on the time, frequency, and activity involved. Invasive procedures associated with obtaining physiological data can cause significant stress to individuals (Berry *et al.* 2002a). For example, female tortoises that void their bladders during handling may be at a reproductive disadvantage since the loss of fluid may negatively affect egg production, which requires higher total body water in reproductive females than non-reproductive females. In one analysis, tortoises that urinated when handled during repeated surveys of three sites in Arizona had lower survival than those that did not (Averill-Murray 2002).

Despite the inherent low-level risk associated with activities covered under recovery permits, incidental injury or mortality of desert tortoises is not expected. However, if injury or mortality should occur, the permit is suspended until the circumstances surrounding the incident are reviewed and appropriate procedures are in place to prevent further injury or mortality. In any given year, we generally issue fewer than 15 recovery permits for desert tortoise research. Because of the emphasis that we, through the Desert Tortoise Recovery Office, intend to place on recovery-related research activities pertaining to the desert tortoise, the number of permits issued may increase over the next few years.

C. Disease or Predation

1. Disease

Disease is a natural phenomenon within wild animal populations, and epidemic outbreaks can have catastrophic effects on small or declining populations. To date, the available evidence indicates that upper respiratory tract disease is probably the most important infectious disease for desert tortoises (Hudson *et al*. 2009). Less is known about other diseases that have been identified in the desert tortoise (*e.g.*, herpesvirus, cutaneous dyskeratosis or shell disease, shell necrosis, bacterial and fungal infections, and urolithiasis or bladder stones) (Jacobson *et al.* 1994, 1995; Homer *et al.* 1998; Berry *et al.* 2002b; Origgi *et al.* 2002). Additional research is needed to clarify the role of disease in desert tortoise population dynamics relative to other threats and the level of effort we should expend in disease control as compared to other threats.

Upper respiratory tract disease. At least two pathogenic species of *Mycoplasma* known to cause upper respiratory tract disease in desert and gopher tortoises have been identified (*M. agassizii* and *M. testudineum*) (Brown *et al.* 1994, 1999, 2001; Brown *et al*. 2002). The pathogens are likely transmitted by contact with an infected individual or aerosols (airborne liquid droplets or solid particles). Once infected, tortoises may develop lesions in the nasal cavity, excessive nasal discharge, swollen eyelids, sunken eyes, lethargy, and possible death (Jacobson *et al.* 1991; Schumacher *et al.* 1997; Homer *et al.* 1998; Berry and Christopher 2001). However, these clinical signs, which may not always be evident in an infected individual, may also be symptomatic of other conditions, such as dehydration, or pathogens (Brown *et al*. 2002). Various tests have been developed to detect the presence of antibodies to *M. agassizii* or help determine active infection (Schumacher *et al.* 1993; Brown *et al.* 1995; Wendland *et al.* 2007; Hunter *et al*. 2008). Johnson *et al.* (2006) uncovered a positive link between tortoises with anti-*Mycoplasma* antibodies and the severity of clinical signs of upper respiratory tract disease, as well as with age class, with adults being more likely to test positive for presence of antibodies. However, in-depth study of the desert tortoise's immune system and epidemiological study of disease dynamics across space and time is necessary to more thoroughly understand the factors involved in the spread and virulence of the disease in the wild (Boarman 2002; Sandmeier *et al*. 2009).

Because the release or escape of infected captive tortoises has been implicated as a potential cause of outbreaks of upper respiratory tract disease in natural populations in the Mojave Desert, Johnson *et al.* (2006) evaluated captive tortoises in Barstow, California, to investigate pathogen exposure. Anti-*Mycoplasma* antibodies (indicating exposure to the pathogen) were present in 82.7 percent of the tortoises tested (sample size of 179), and anti-herpesvirus antibodies were observed in 26.6 percent of the animals (sample size of 109). Jones (2008) also found captive tortoises to be 1.8 to 5.4 times more likely to test positive for anti-*Mycoplasma* antibodies than free-ranging Sonoran desert tortoises around Tucson, Arizona. Further, a higher incidence of disease was found in suburban areas around Tucson, suggesting that habitat degradation associated with urbanization may be a stressor that contributes to disease outbreaks (Jones 2008). These studies, however, were completed prior to Hunter *et al*.'s (2008) work that indicates some tortoises may carry innate anti-*Mycoplasma* antibodies. Reasons for the susceptibility of tortoises to upper respiratory tract disease remain speculative and require further study (Boarman 2002).

Shell disease. The most commonly described shell disease in desert tortoises is cutaneous dyskeratosis, which manifests itself as lesions along scute sutures of the plastron and sometimes on the carapace, which then spread to the scutes themselves (Jacobson *et al*. 1994; Homer *et al*. 1998). Shell diseases have been seen in tortoise populations in the eastern Mojave and Colorado deserts of California but less so in the western Mojave Desert (Jacobson *et al*. 1994; Christopher *et al*. 2003). Shell diseases occur in all sizes and ages of desert tortoises but are usually more common in adults (Jacobson *et al*. 1994; Homer *et al*. 1998). It appears that shell diseases reflect metabolic and physiological changes that involve more than the shell itself (Homer *et al*. 1998, 2001). Little is known about the causes of shell disease; no evidence indicates a bacterial or viral origin, despite directed research efforts by pathologists to find one (Jacobson *et al*. 1994; Homer *et al*. 1998). Five-years of health profiles at three sites in the California Mojave Desert (Desert Tortoise Research Natural Area, Ivanpah Valley, Goffs) found that the numbers of tortoises with moderate to severe plastron disease and active carapace lesions increased significantly between 1990 and 1995, especially at Goffs (Christopher *et al*. 2003). Shell disease was also found to be significantly more severe with increasing tortoise age, suggesting a chronic, cumulative problem (Christopher *et al*. 2003). Cutaneous dyskeratosis has been associated with mortality on the Chuckwalla Bench in California (Berry 1997). However, the extent to which shell diseases contribute to population declines in desert tortoises remains unclear (Jacobson *et al*. 1994).

Herpesvirus. In tortoises with herpesvirus infection, clinical signs range from a mild conjunctivitis (inflammation of the membrane surrounding the eye) to a severe lesions and plaques on the tongue and hard palate (Johnson *et al*. 2006). Plaques (small growths) typical of herpesvirus were reported in tortoises in Goffs and Ivanpah (Christopher *et al*. 2003). Herpesvirus infections have also been reported in other species of turtles and tortoises, especially in those associated with the exotic trade (Martel *et al*. 2009).

The contribution of herpesvirus to population declines in desert tortoise is unknown. However, herpesvirus infections have been reported in captive desert tortoises and have been associated with illness and mortality (Johnson *et al*. 2006). Clinical herpesvirus infections can be rapid and progressive, resulting in large die-offs in other species of vertebrate animals as well (Johnson *et al*. 2006). Therefore, at least in theory, herpesvirus could become a serious threat to desert tortoise populations, especially for those living near the urban-desert interface where wild individuals are more likely to encounter infected captive tortoises or turtles.

Effects of one disease on susceptibility to other diseases. There is evidence that any one disease may predispose desert tortoises to other diseases (Christopher *et al*. 2003). However, it is not known whether this is a cause or effect. That is, it is not known whether disease in an individual increases susceptibility to other diseases in that individual or whether an individual's baseline susceptibility to disease causes that individual to get more diseases. Nevertheless, positive nasal cultures for *Mycoplasma agassizii* had relatively high positive predictive values for tortoises with moderate to severe shell disease (Christopher *et al*. 2003). Pathologists also report that the location and histologic (structural) appearance of lesions seen in tortoises with cutaneous dyskeratosis are suggestive of either a deficiency disease or toxicosis or both (Jacobson *et al*. 1994, Homer *et al*. 1998).

2. Toxicants and Disease Susceptibility

Some have suggested that a significant source of mortality is direct induction of toxicosis-related diseases (*e.g.*, liver diseases) and in increasing susceptibility to infectious diseases by environmental contaminants (Homer *et al.* 1994, 1996; Berry 1997; Christopher *et al*. 2003). Elevated mercury and arsenic levels have been associated with diseased tortoises in the wild (Jacobson *et al*. 1991; Homer *et al*. 1998; Seltzer and Berry 2005; Chaffee and Berry 2006). Necropsy and analyses of kidney, liver, and scute tissues suggested that tortoises from California with a variety of diseases (upper respiratory tract infection, urolithiasis, metabolic disease, and shell diseases) had statistically significantly higher levels of potentially toxic elements as compared to healthy tortoises (Berry *et al*. 1997). No one single element or group of known or potentially toxic elements was found at elevated levels in the tissues of diseased and dying tortoises. It has been postulated that elemental toxicity may compromise the immune system of desert tortoises or otherwise detrimentally affect physiological function, rendering them more susceptible to disease, but further investigation is needed.

Illegal dumping of hazardous wastes that occurs in the California deserts may expose tortoises to increased levels and possible consumption of toxic substances. Garbage, litter, and toxic spills may affect tortoises on a localized level where these activities are concentrated (Boarman 2002). Toxicant load in the environment may also be a factor that induces diseases related to toxicosis (*e.g.*, liver disease) and influences the susceptibility of tortoises to infectious diseases and mortality. For example, tortoises that died of mycoplasmosis at the Desert Tortoise Natural Area in 1989 through 1990 had 11 times the mercury content in their livers than tortoises from a control area (Jacobson *et al.* 1991). Some necropsies showed elevated levels of arsenic in scutes (Seltzer and Berry 2005).

Fugitive dust containing toxicants that affect tortoises may be released from anthropogenic sites such as mines, roads, construction, and other disturbances. Chaffee and Berry (2006) collected soil, stream sediment, and plant samples at six tortoise habitat study areas in the Mojave and Colorado deserts. They analyzed samples for up to 66 different elements to determine their distribution and abundance at a regional and local level, to identify potential sources of toxicants in desert tortoise habitats. Some measurements of high concentrations of arsenic, mercury, and lead, were attributed to mining and vehicle exhaust. High levels of soil and plant arsenic extended more than 14 kilometers (9 miles) from some existing mine sites, and mercury was detected more than 5 kilometers (3 miles) from some mine tailings. Traces of lead were found more than 21 kilometers (13 miles) from a paved road and likely had been redistributed by vehicle exhaust, wind, and rain events. Elevated levels of these elements have been observed in ill tortoises found in these areas; however, additional research is necessary to ascertain the direct effects of elemental toxicants on desert tortoise health and their susceptibility to disease (Chaffee and Berry 2006).

3. Predation

Desert tortoises are preyed upon by several native species of mammals, reptiles, and birds; however, the contribution of mammalian or avian predation to overall desert tortoise mortality has not been quantified. Natural predation in undisturbed, healthy ecosystems is generally not considered a threat, but under some circumstances predation comes to the forefront as a management concern, especially where landscapes have been altered and intensive human use occurs. In addition, during times of drought when typical prey species are limited, food habits of predators may shift and tortoises become more frequent components of their diets (USFWS 1994).

The best-documented predator of small tortoises is the common raven (*Corvus corax*). For example, Campbell (1986) found 136 carcasses of juvenile desert tortoises with evidence of raven predation at the base of fence posts on the perimeter of the Desert Tortoise Natural Area. Berry *et al*. (1990) reported that 30 and 45 percent, respectively, of all desert tortoise deaths at two study plots during a 6-year period were probably caused by raven predation; up to 75 percent of deaths of tortoises ≤103 mm (4.1 in) carapace length were attributed to raven predation at these plots.

In the desert southwest, common raven populations have increased over the past 25 years (greater than 1000 percent), probably in response to increased human populations, associated food and water subsidies, and anthropogenic changes to the landscape (Boarman and Berry 1995; Boarman *et al.* 1995; Boarman *et al.* 2006). For instance, ravens obtain food in the form of organic garbage from landfills and trash containers, water from sewage ponds and municipal areas, and nesting substrates on billboards, utility towers, bridges, and buildings (Boarman *et al.* 2006). Particularly in the west Mojave and Coachella Valley, linear features such as roads and utility corridors and other urban sites such as landfills and sewage ponds have been shown to attract common ravens, red-tailed hawks (*Buteo jamaicensis*), and turkey vultures (*Cathartes aura*) (Knight and Kawashima 1993; Boarman *et al.* 1995; Knight *et al.* 1999). The use of anthropogenic nesting substrates facilitates increased predation of juvenile tortoises, especially within about 0.4 kilometers (0.25 miles) of the raven nest (Boarman 2002; Kristan and Boarman 2003). The presence of roads may encourage such opportunistic species because road-killed animals are a reliable food source (Camp *et al.* 1993; Boarman and Sazaki 2006).

Raven numbers were shown to decrease with distance from urban sites in the west Mojave, placing tortoises that occur in the urban-desert interface at higher risk of predation (Kristan and Boarman 2003). This risk also increases with the numbers of ravens in the vicinity, and the distribution of breeding and non-breeding ravens is likely to influence patterns of predation across the landscape. Breeding ravens tend to disperse more evenly across suitable habitats, whereas non-breeding birds are concentrated around anthropogenic sites. This suggests that occupied desert tortoise habitats distant from population centers and the urban-desert interface experience reduced predation pressures from ravens (Kristan and Boarman 2003).

Determining precise demographic impacts of (increased) raven predation on desert tortoise populations is complicated because of the difficulty of monitoring small, hard to find juvenile tortoises (Boarman 2002). Nevertheless, the potential impact to desert tortoise populations from raven predation is a conservation concern, especially where subsidized predators are able to persist in large numbers despite declines in their prey base. Populations of long-lived animals like the desert tortoise can sustain moderate levels of annual juvenile mortality (*e.g.*, 25 percent), but in the face of depressed adult survival, juvenile mortality must be reduced to approximately 5 percent to ensure recruitment into the breeding population (Congdon *et al*. 1993). Human-subsidized predators thus put at great disadvantage any prey species such as the desert tortoise that is unable to rebound from predation pressures (Kristan and Boarman 2003).

Desert tortoise predation by coyotes (*Canis latrans*) was documented by Woodbury and Hardy (1948) who found tortoise remains in coyote scat. Berry (1990) reported that over 50 percent of deaths at 4 study plots in California were attributable to mammalian predators. During a drought, coyotes killed most of the study tortoises at the Desert Tortoise Natural Area and killed 21–28 percent of a study population near Ridgecrest, California, in a 12-month period (Berry 1974). Peterson (1994a) reported high mortality in two western Mojave desert tortoise populations, resulting from both disease and predation attributable to 'natural' effects of drought and functional responses of predators to a diminished prey base. Predators were also a suspected source of mortality near Fort Irwin, California, with over 50 percent of remains showing signs of mammalian predation in some cases (Berry *et al*. 2006b). Tortoise mortality attributed to coyote predation exceeded 30 percent at several sites across the Mojave Desert in spring 2008 (Esque *et al*. 2010; USFWS, unpublished data).

Red-tailed hawks, golden eagles (*Aquila chrysaetos*), loggerhead shrikes (*Lanius ludovicianus*), American kestrels (*Falco sparverius*), burrowing owls (*Athene cunicularia*), and greater roadrunners (*Geococcyx californianus*) have also been implicated in tortoise predation, although available data are minimal (Boarman 1993). Kit foxes (*Vulpes macrotis*), mountain lions (*Felis concolor*), ground squirrels (*Citellus* spp.), and free-roaming dogs are known mammalian predators of desert tortoise (Boarman 2002; M. McDermott, Southern Nevada Environmental, Inc., pers. comm. 2006; Medica and Greger 2009; Riedle *et al*., 2010). Invertebrate predators of eggs and hatchling tortoises include native fire ants (Nagy *et al*. 2007).

D. Inadequacy of Existing Regulatory Mechanisms

1. Law Enforcement

The final listing rule acknowledged that all four states within the range of the Mojave population of the desert tortoise have laws in place to protect the species. However, State wildlife or endangered species permitting requirements do not specifically cover habitat and generally do not require mitigation of impacts to suitable, potentially occupied habitat. In addition, a great deal of effort has been dedicated to planning by the various Federal and State land management agencies whose jurisdictions include desert tortoise habitat. While many of the existing plans include language specific to protection of the species, such as limiting off-highway vehicle use and competitive/organized events, grazing, vegetation harvest, and collection of desert tortoises, agency multiple-use mandates require a complex balancing of tortoise conservation and public use of Federal and State lands. Also, land management agencies frequently do not have sufficient funding to enforce their land use regulations (Table A-3). The number of law enforcement officers or game wardens on the ground does not necessarily translate into protection of the species, as personnel are often spread across vast landscapes and have multiple resource responsibilities. As calculated from the data in Table A-3, current information indicates that each law enforcement officer is responsible for an average of more than 89,000 hectares (220,000 acres).

Table A-3. Law enforcement (LE) resources within desert tortoise habitat by agency.

Responsible Agency/Unit[1]	**Number of LE Officers**	**Number of Vacancies** **(if applicable)**	**Number of Acres** **(approx.)**
BLM-California Desert District[2]	43	4	10,400,000
Barstow Field Office	8	0	3,000,000
El Centro Field Office	12	0	1,400,000
Needles Field Office	6	2	3,300,000
Palm Springs – South Coast Field Office	9	2	1,700,000
Ridgecrest Field Office	8	0	1,800,000
BLM-Arizona Strip Field Office[3]	3	1	2,000,000
BLM-NPS Grand Canyon-Parashant National Monument[4]	3 BLM 2 NPS	0	1,100,000
BLM-Las Vegas and Ely Field Offices[5]	14 (Vegas) 1 (Ely)	?	3,000,000 726,000
BLM-St. George Field Office[6]	1	0	630,000
NPS-Mojave National Preserve[7]	9	4	1,400,000
NPS-Joshua Tree National Park[8]	10	4	790,000
NPS-Death Valley National Park[9]	14	?	3,300,000
NPS-Lake Mead National Recreation Area[10]	16	?	1,500,000
USFWS-Desert National Wildlife Refuge Complex[11]	5	2	1,600,000
US Forest Service-Spring Mountains National Recreation Area[12]	3	2	317,000
Arizona Game and Fish Department[13]	2	?	
California Department of Fish and Game[14]	16	3	
Nevada Department of Wildlife[15]	16	3	
Utah Division of Wildlife Resources[16]	4	0	
Clark County MSHCP-Boulder City Conservation Easement[17]	1	0	86,000
Total	**163**	**23**	**>36,249,000**

[1] Information provided via electronic mail or personal communication (July, August 2007) from the following:
[2] Jim Abbott, Bureau of Land Management California State Office
[3] Scott Florence, Bureau of Land Management Arizona Strip District
[4] Kathleen Harcksen, Bureau of Land Management Grand Canyon-Parashant National Monument
[5] Elroy Masters, Bureau of Land Management Nevada State Office
[6]Jim Crisp, Bureau of Land Management St. George Field Office
[7] Debra Hughson, Kirk Gebicke, National Park Service, Mojave National Preserve
[8] Paul DePrey, Curt Sauer, National Park Service Joshua Tree National Park
[9] David Ek, National Park Service Death Valley National Park
[10] Bill Dickinson, National Park Service Lake Mead National Recreation Area
[11] Cynthia Martinez, USFWS Desert National Wildlife Refuge Complex
[12] David Leveille, USFS Humboldt-Toiyabe National Forest
[13] Cristina Jones, Luke Thompson, Arizona Game and Fish Department
[14] Rebecca Jones, Mike McBride, California Department of Fish and Game
[15] Polly Conrad, Fred Henson, Nevada Department of Wildlife
[16] Ann McLuckie, Utah Division of Wildlife Resources
[17] Sue Wainscott, Clark County
? Information not provided or not available.

2. Land Acquisitions, Exchanges, and Transfers

Land exchanges and transfers may result in loss of desert tortoise habitat, increased fragmentation, and displacement of resident desert tortoises. Tortoise habitat that is exchanged out of Federal ownership is at greater risk of development, resulting in loss of habitat on the new private holdings (Sievers *et al.* 1988). Transactions may also be executed in the interest of securing additional lands targeted for conservation of the desert tortoise and other sensitive species or habitats (see Conservation Efforts).

In 1988, the Bureau of Land Management exchanged 11,758 hectares (29,055 acres) of public land in the Coyote Springs Valley in southern Nevada to Aerojet-General Corporation for private wetlands in Florida for wildlife conservation under the Nevada-Florida Land Exchange Authorization Act. An additional 5,571 hectares (13,767 acres), which are surrounded by the 11,758 hectares (29,055 acres), were leased to Aerojet for an initial term of 99 years with a 99-year extension. The Coyote Springs Investment (CSI) HCP was developed to address urban development and tortoise conservation on CSI lands in Lincoln County. The plan permits development over 8,682 hectares (21,454 acres) in Lincoln County, most of which is desert tortoise habitat (Mormon Mesa critical habitat unit). The plan also establishes a desert tortoise reserve on 5,571 hectares (13,767 acres) of the CSI leased land.

Under the Bureau of Land Management's Western Mojave Land Tenure Adjustment Program, which provides a mechanism pursuant to the Federal Land Policy and Management Act of 1976 to acquire lands within and dispose of Federal lands outside of DWMAs, approximately 21,044 hectares (52,000 acres) of land within desert tortoise critical habitat have been acquired and approximately 6,880 hectares (17,000 acres) outside of designated critical habitat have been transferred out of Federal management since 1990. The overall ratio of acquired to disposed habitat of the desert tortoise is expected to be approximately 2.3:1 at the completion of the Western Mojave Land Tenure Adjustment Program, for a net benefit to the amount of desert tortoise habitat protected on Federal lands (BLM *et al*. 2005).

The Southern Nevada Public Lands Management Act of 1998, as amended (Public Law [PL]-105-263), provides for the "disposal of certain Federal lands in Clark County, Nevada, and for the acquisition of environmentally sensitive lands in the State of Nevada." The law was enacted partly to address the Bureau of Land Management's extensive and complicated land management responsibilities for disjunct parcels that are interspersed with or adjacent to private land in the Las Vegas Valley and the rapid urbanization taking place in the valley. In order to "promote responsible and orderly development in the Las Vegas Valley, certain of those Federal lands should be sold by the Federal Government based on recommendations made by local government and the public" (PL-105-263). This legislation provided the mechanism for significant changes to take place in the Las Vegas area of the Mojave Desert relative to human occupation in the Mojave Desert wherein over 58,600 hectares (145,000 acres) of Federal land are identified for disposal and urban development.

A series of other related public laws have connections to the Southern Nevada Public Lands Management Act and facilitate the transfer or disposal of public lands. These laws include the Lincoln County Conservation, Recreation, and Development Act of 2004 (PL-108-424); the

Lincoln County Land Act of 2000 (PL-106-298); the Clark County Conservation of Public Land and Natural Resource Act of 2002 (PL-107-282); the Fiscal Year 2004 Appropriations Act amending the Southern Nevada Public Lands Management Act (PL -105-263); the Lake Tahoe Restoration Act; the Mesquite Lands Act of 1986 (PL-99-548) and 1988 and PL-104-208 (1996 amendment to the Mesquite Lands Act of 1988); the Ivanpah Valley Airport Public Lands Transfer Act of 2000; and the Federal Land Transaction Facilitation Act of 2000.

E. Other Natural or Manmade Factors Affecting its Continued Existence

1. Climate Change

Climate change and drought were not regarded as threats to the desert tortoise in the 1994 Recovery Plan. Since that time it has become apparent that the combined effects of global climate change (*i.e.*, increased ambient temperatures and altered precipitation patterns) and drought may become significant factors in the long-term persistence of the species. The Earth's climate has warmed by nearly 1.5 degrees Fahrenheit over the past 100 years (Walther *et al.* 2002), and anthropogenic emissions of greenhouse gases play a major role in this process (Weltzin *et al.* 2003). Warming in the Mojave Desert region began approximately in the late 1970s, and recent average temperatures have climbed well above prior values (Redmond 2009). While warming, as well as changes in precipitation patterns, is not uniform with regard to time and space, the rate of warming during the last 30 years has generally been greater than at any other time during the last 1,000 years, and this variation in warming and precipitation is likely to contribute also to variation in ecological dynamics across ecosystems.

There is now evidence that recent climatic changes have affected a broad range of organisms with diverse geographical distributions (Walther *et al.* 2002). Interactions between altered precipitation patterns and other aspects of global change are likely to affect natural and managed terrestrial ecosystems. For example, climate models predict that Joshua trees would likely no longer be able to persist within Joshua Tree National Park through the 21st century (Cole *et al.* 2005). Human responses to climate change (*e.g.*, increased infrastructure for the capture and use of water) may also negatively affect desert ecosystems. While little is known regarding direct effects of climate change on the desert tortoise and its habitat, predictions can be made about how global and regional precipitation regimes may be altered and the consequences of these changes (Weltzin *et al.* 2003; Seager *et al.* 2007). Similar to the Joshua tree example above, climate models also predict a reduction of 9-49 percent in suitable habitat, along with increasing fragmentation, for the desert tortoise within Joshua Tree National Park (Barrows 2009).

The Intergovernmental Panel on Climate Change has suggested that increasingly reliable climate change projections are now available as the result of improved modeling capabilities and advanced understanding of climate systems (Christensen *et al*. 2007). The Intergovernmental Panel on Climate Change's 2007 report discussed the results of 21 Atmosphere-Ocean General Circulation Models that were run to predict regional changes in temperature and precipitation in 2080 to 2099 compared to conditions that occurred between 1980 and 1999. Generally, predictions for the geographic range of the desert tortoise's listed population suggest more frequent and/or prolonged droughts. For example, annual mean temperature is likely to increase by 3.5 to 4.0 degrees Celsius (6.3 to 7.2 degrees Fahrenheit), with the greatest increases occurring in summer (June-July-August mean up to 5 degrees Celsius [9 degrees Fahrenheit] increase) (Christensen *et al*. 2007). In summer, the highest temperatures will likely increase even more than the average temperatures. Precipitation will likely decrease by 5 to 15 percent annually in the region with winter precipitation decreasing in the range of 5 to 20 percent. More than half of the models predict that changes in summer precipitation may be more moderate (decrease by as much as 10 percent) with the possibility for a 5 percent increase (Christensen *et al*. 2007). This prediction for more drying in winter than in summer within the range of the desert tortoise's listed population differs from predictions for much of the United States. However, variation in the results among models suggests that specific future precipitation regimes are problematic to predict confidently (Smith *et al.* 2009). Because germination of the tortoise's food plants is highly dependent on cool-season rains, the forage base could be reduced due to increasing temperatures and decreasing precipitation in winter. Drought is a normal phenomenon in the Mojave Desert (Peterson 1994a; Hereford *et al.* 2006). Extended periods of drought, however, have the potential to affect desert tortoises and their habitats through physiological effects to individuals (*i.e.*, stress) and limited forage availability.

Recent findings demonstrate that the Mojave Desert shrub ecosystem is a significant sink for carbon dioxide (CO_2) on an annual basis, suggesting that desert ecosystems may be vital contributors to counteracting global and local climate change (Wohlfahrt *et al*. 2008). In particular, expansion and growth of cryptobiotic crust organisms (lichens, mosses, and cyanobacteria) may account for a significant portion of the carbon accretion in the Mojave Desert system, but further investigation into cryptobiotic crust productivity is needed. Experiments in Nevada at the Free-Air CO_2 Enrichment Facility to predict the possible complex ecological and biogeochemical changes in semidesert ecosystems caused by increasing atmospheric CO_2 have been ongoing since 1997 (Hamerlynck *et al.* 2000; Smith *et al.* 2000; Huxman and Smith 2001). Because deserts are both water- and nutrient-limited systems and many native desert plants are slow-growing, it is still too early to say with any confidence how even the most intensively studied desert shrub communities of the southwestern United States will respond to rising CO_2 (Lioubimtseva and Adams 2004). However, results from the Free-Air CO_2 Enrichment Facility site demonstrate that the non-native grass *Bromus tectorum* responds to increases in CO_2 (a component required for photosynthesis) with far greater productivity than that of native plants during wet years (Smith *et al.* 2000). As discussed in sections A(4)(b) and A(5), Increasing Fuel Load and Fire, colonization by non-native annual grasses is known to increase the frequency and intensity of fires, both of which have dramatic negative effects on desert water cycles and wildlife habitat (Hamerlynck *et al.* 2000). The overall response of non-native grasses to increased CO_2 is uncertain, though, given expected reductions in precipitation.

Climatic regimes are believed to influence the distribution of plants and animals through species-specific physiological thresholds of temperature and precipitation tolerance. Warming temperatures and altered precipitation patterns may result in distributions shifting northward and/or to higher elevations, depending on resource availability (Walther *et al.* 2002). We may expect this response in the desert tortoise to reduce the viability of lands currently identified as "refuges" or critical habitat for the species (Barrows 2009). Seager *et al.* (2007) ran a series of climate models and simulations on the precipitation history and future of the southwestern United States and parts of northern Mexico that consistently showed a severe drying trend in this region throughout the 21st century, especially in areas where evapotranspiration exceeds precipitation (such as most desert regions). *Bromus tectorum* is expected to retreat with climate change, however, from the northern portion of the desert tortoise's range (Bradley *et al*. 2009). How the closely related invasive grass *Bromus rubens* responds and whether it replaces *B. tectorum* in the absence of active restoration efforts is uncertain.

Some evidence suggests that desert tortoises may be capable of adapting to changes in the environment through modification of their behavior, periods of activity, and diet (Morafka and Berry 2002). The desert tortoise evolved millions of years before the formation of the North American deserts, and the species experienced both more mesic and more xeric conditions within the last several thousand years (Morafka and Berry 2002). Paleoclimate indicators show that severe, multi-year droughts, some lasting up to a decade or two, occur at least once or twice a century (Redmond 2009). Perhaps as the habitats they occupied changed and became more arid, the tortoise was able to adapt and succeed in desert climes and exploit a broad ecological range. The probability that the desert tortoise will be able to survive ongoing changes in vegetation and food sources or temperature and precipitation patterns remains to be seen, especially in light of continued anthropogenic alterations of the environment (Morafka and Berry 2002). Models demonstrate large shifts in plant distributions that over a long period of time may allow opportunities for migration and adaptation. Under the current scenario, however, where change may occur within a few decades, it cannot be predicted whether or not plants and animals would be able to readily migrate into new habitats (Thompson *et al.* 2003).

Direct climatic effects on growth and development, spatial distribution, and species interactions are apparent in amphibians and reptiles, which, in common with other ectotherms, are heavily influenced by environmental conditions. Both seasonal temperature and humidity affect their reproductive physiology and population dynamics (Walther *et al.* 2002). In addition, desert tortoises have temperature-dependent sex determination (*i.e.*, the sex of the hatchlings is determined by the temperatures in the nest), with 1:1 sex ratios produced at approximately 31.3 degrees Celsius (88.3 degrees Fahrenheit), all males produced at 30.5 degrees Celsius (86.9 degrees Fahrenheit) and below, and all females produced at 32.5 degrees Celsius (90.5 degrees Fahrenheit) and above (Rostal *et al*. 2002). Although there has been some speculation that global temperature increases may skew sex ratios or eliminate male offspring altogether for some turtles (Janzen 1994), there is also evidence that temperature-dependent sex determination systems may be able to evolve through maternal nesting behavior if gradual changes in climate result in skewed sex ratios (Janzen and Morjan 2002). Sex ratios of reptiles may be robust to moderate temperature increases as long as eggs experience daily fluctuating temperatures (Booth 2006). The varying environments in which tortoises nest provide opportunities among diverse potential nest sites for exposure to a variety of temperature regimes, and nest placement within the burrow is an important determinant of what temperature regime the nest experiences during incubation and the resultant hatchling sex ratios (Baxter *et al*. 2008). The survival of reptile species with temperature-dependent sex determination through cycles of warming and cooling over the last 100,000 years suggests that changes in climate were such that species were capable of shifting the time of nesting, choice of nest sites, the range occupied, or even temperature at which the sexes were produced (Booth 2006). Rapid changes in climate may challenge the ability of the desert tortoise to make such shifts.

Smith *et al.* (2009) review various types of global change relative to expected effects in the Mojave Desert, such as elevated carbon dioxide and altered precipitation regimes facilitating invasive plant species, thereby increasing fire frequency. Effects of altered nitrogen dynamics on the Mojave Desert are less clear. For example, increased nitrogen deposition from dust in the vicinity of metropolitan areas could result in higher plant production, exacerbating the effects from carbon dioxide noted above (Smith *et al*. 2009). Alternatively, increased temperatures may release nitrogen gases from Mojave Desert soils, reducing fertility of those soils and the ability to support plant life (McCalley and Sparks 2009). While it is unclear how global and regional changes in climate may affect the desert tortoise, continued research and monitoring relative to behavioral and life history traits of the species under climate change will inform conservation and management decisions regarding recovery of the species in the Mojave Desert.

(a) Drought. Data exist on some of the effects of drought on the desert tortoise. Drought is a normal phenomenon in the Mojave Desert; desert tortoises have been inhabitants of this region for over 10,000 years and have adapted to variable conditions (Nagy and Medica 1986; Peterson 1994a,b; 1996a; Henen 1997; Hereford *et al.* 2006). As noted above, extended periods of drought may affect desert tortoises through physiological effects to individuals (*i.e.*, stress) and through limited forage availability. Energy acquisition and expenditure in desert tortoises are strongly constrained by the contingencies of rainfall, both indirectly through effects on availability and quality of food, and directly through reliance on free-standing water for drinking (Peterson 1996a,b; Wilson *et al*. 2001).

The effect of drought on demographic parameters of tortoise populations (*i.e.*, birth, death, recruitment, and growth rates) is not well understood (Avery *et al.* 2002; Boarman 2002). However, studies have attributed many adverse effects to periods of drought, including dehydration, malnutrition, and starvation; reduced reproductive output of females; altered behavior such as failure to seek shelter, reduced movement, and surface activity (O'Connor *et al.* 1994; Homer *et al.* 1996; Duda *et al.* 1999; Berry *et al.* 2002b); and increased susceptibility to predation and disease (Peterson 1994a,b).

Since 1975, a tortoise population on the Beaver Dam Slope in Arizona and Utah experienced high mortality; malnutrition caused by reduced nutrient availability was considered responsible for osteoporosis and subsequent mortality (Jacobson 1994). Increased mortality in the Ivanpah Valley in 1981 and 1982 was attributed to drought conditions (Turner *et al.* 1984), and abnormally high levels of mortality were recorded in the east and west Mojave Desert during a three-year drought period (1988 through 1990). Deaths in the Ivanpah Valley study site were attributed to drought-induced starvation and dehydration (Turner *et al.* 1984). Peterson (1994a) found that high mortality in two desert tortoise populations in 1988-1990 was attributable to drought, directly in the eastern Mojave population through starvation and dehydration, and indirectly in the western Mojave population through functional responses of predators to a diminished prey base and, possibly, increased susceptibility of tortoises to disease.

Research conducted in the early 1980s indicated a strong correlation between clutch frequency (the number of clutches produced by a female in one reproductive season) and biomass of annual plants used by tortoises for food (Turner *et al.* 1986, 1987). Studies conducted at five sites (Joshua Tree National Park, Mojave National Preserve, Palm Springs, Piute Valley, and St. George) supported the results of Turner *et al.* These studies indicated that in high-rainfall years with corresponding abundant food-plant availability, more females reproduced and reproducing females laid more clutches per reproductive season, compared with low-rainfall years (Lovich *et al.* 1999). Clutch size (number of eggs per clutch) was relatively constant regardless of conditions; however, Avery *et al.* (2002) noted that females at higher elevations with greater annual rainfall had a larger mean clutch size.

Recent studies also indicate that even a relatively short-term drought combined with little or no biomass of annual plants can cause a severe reduction in adult tortoise survival. A study of adult tortoise survival rates at two sites in the eastern Mojave desert (near or adjacent to Piute-Eldorado critical habitat unit) attributed die-offs in 1996 to a period of drought that began in the summer of 1995, coupled with failure of annual vegetation production in 1996 (Longshore *et al.* 2003). During three years of no or minimal biomass production of annual plants (1996, 1997, and 1999), the survival of adult tortoises decreased. In 1996, 30 percent (15 individuals) of radio-monitored adults died following a drought that began in the summer of 1995. Although the researchers obtained no physiological evidence, they believed these deaths likely resulted from dehydration, as there was no substantial evidence of other mortality mechanisms, such as disease or predation (Longshore *et al.* 2003).

2. Garbage, Trash, and Balloons

Turtles and tortoises are known to eat non-food objects, such as rocks, balloons, plastic, and other garbage. Such objects can become lodged in the gastrointestinal tract or entangle heads and legs, causing injury or death (Burge 1989; USFWS 1994; Walde *et al*. 2007). Unauthorized deposition and dumping of refuse is most prevalent near towns, cities, and settlements in remote areas as well as at the urban-desert interface. Such garbage not only contributes to direct mortality and habitat degradation, trash also attracts ravens and other desert tortoise predators, as discussed in section C(3), Predation. Some trash, such as balloons, may also be found in more remote areas. Walde *et al*. (2007) counted the number of balloons encountered during field work approximately 40 kilometers northeast of Barstow, California. They found that in 8 months, 178 new balloons arrived at the remote site, and they observed a tortoise partially ingesting a balloon. Their work suggests that the prevalence of at least some types of garbage in the desert may not be as localized as previously thought (Boarman 2002). Likewise, Averill-Murray and Averill-Murray (2002) estimated that 11,207 balloons were distributed across the 76,800-hectare (189,776-acre) Ironwood Forest National Monument, Arizona, in 2001.

3. Noise and Vibration

The 1994 Recovery Plan cited noise and vibration as having potentially significant effects on the desert tortoise's behavior, communication, and hearing apparatus (USFWS 1994). Very limited additional data have been obtained specific to this potential. Studies on the effects of flight noise from jet aircraft and sonic booms on hearing, behavior, heart rate, and oxygen consumption of desert tortoises concluded that hearing loss and physiological changes are not likely to be dangerous during occasional short-term exposures; however, those results cannot be extrapolated to chronic exposures over a tortoise's lifetime. The authors advise that their results are "best viewed as a first-order effort to determine the effects of subsonic and supersonic aircraft noise on a desert reptile." They recommend that changes in tortoise activity with repeated exposure to aircraft noise should be investigated under natural conditions, including during food and water deprivation, torpor, or exposure to dangers such as rivals and predators (Bowles *et al.* 1999).

4. Non-motorized Recreation and Miscellaneous Human Activities

Non-motorized recreation includes activities such as camping, hunting, target practice, rock collecting, hiking, horseback riding, biking, and sight-seeing. While there are no data correlating these activities with impacts to the desert tortoise, it may be surmised based on information on visitor-use days that these activities bring with them many of the threats associated with increased human presence, such as loss of habitat from development of recreational facilities and guzzlers; handling and disturbance of tortoises; increased collection, road kill, and vandalism of tortoises; and increased raven populations (USFWS 1994; Boarman 2002). Off-trail use can degrade habitat by damaging vegetation and soil crusts (Belnap 1996) and by compacting soils (Lei 2009).

Very few studies have been conducted to document the effects of non-motorized activities to desert tortoises. One study measured the effect of surface disturbance from foot, bike, and vehicle tracks on the nitrogenase activity in cyanobacterial-lichen soil crusts, a dominant source of nitrogen for cold-desert ecosystems (Belnap 1996). Results showed that the levels of nitrogenase activity were reduced by 30 to 100 percent, depending on the degree of soil disruption and the microbiotic composition of the soils (Belnap 1996). This study demonstrated that anthropogenic surface disturbances may have serious implications for the nitrogen budgets of cold-desert ecosystems, which may be confounded by increased levels of atmospheric pollution and nitrogen deposition associated with increased human populations (see Brooks 2003). However, soil crusts retain greater water content than bare soils, and non-native plants colonize and out-compete native species on disturbed soils (DeFalco *et al.* 2001).

5. Unauthorized Release or Escape of Captive Tortoises to the Wild

Implications of infectious disease spread by the release of captive-bred animals and relocation of wild animals are a major concern in conservation biology (Wolff and Seal 1993). Captive releases have the potential to introduce disease into wild populations of desert tortoises (Johnson *et al*. 2006; Martel *et al*. 2009). Tomlinson and Hardenbrook (1993) reported that the highest prevalence of clinical signs of upper respiratory tract disease was observed in tortoises removed from areas where previous releases of captive animals had occurred. Release or escape of captive tortoises genetically different from the resident population can also lead to disrupted local adaptation (Tallmon *et al*. 2004).

A large captive population of desert tortoises, dating prior to listing under the Endangered Species Act and enactment of State regulations, magnifies these risks associated with disease and genetics. Unauthorized breeding of pet tortoises further exacerbates these risks and can lead to pressures on management agencies that must direct resources toward managing the captive population rather than focusing resources on recovering wild populations.

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APPENDIX B

A DECISION SUPPORT SYSTEM FOR DESERT TORTOISE RECOVERY: A TOOL FOR EVALUATING RECOVERY ACTION EFFECTIVENESS

A. INTRODUCTION

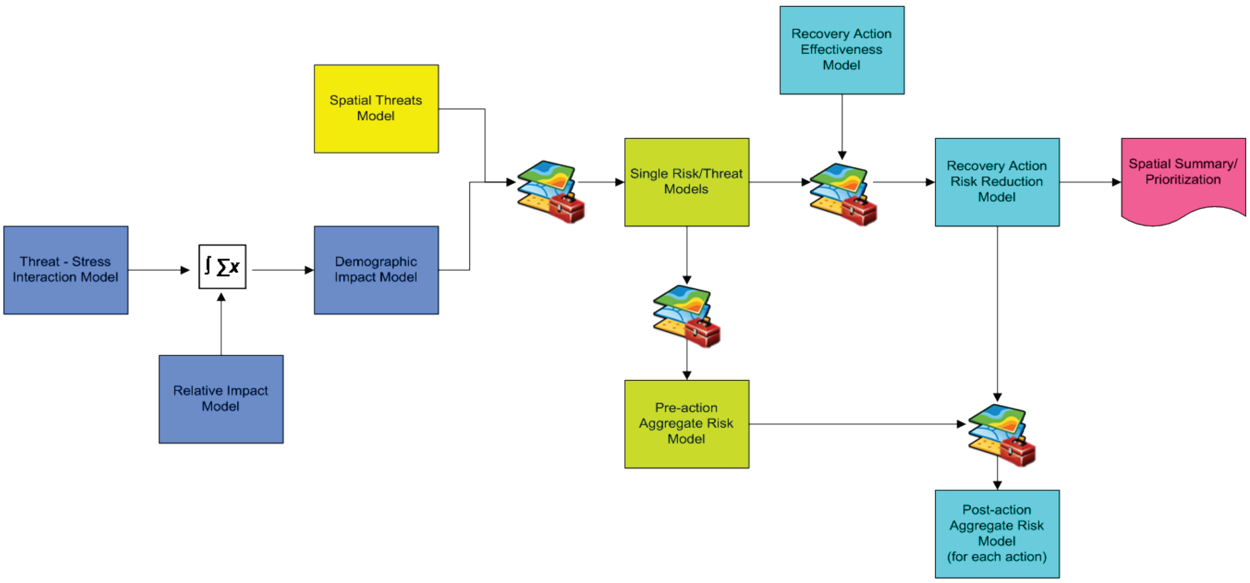
This appendix summarizes the processing steps, data inputs, and outputs of a spatial decision support system developed for the Fish and Wildlife Service's Desert Tortoise Recovery Office (DTRO) to aid in the implementation of the Recovery Plan for the desert tortoise. The current decision support system is a refinement of a prototype system developed in consultation with land managers with jurisdiction over desert tortoise habitat through a series of recovery planning workshops. These workshops were conducted during March-May 2007 at which managers provided information on geographic distribution of threats, management actions, and other information described below. Additional data collection, modeling, and input by land managers and scientists subsequent to the publication of the Draft Revised Recovery Plan contributed to the current system.

The DTRO spatial decision support system estimates the impacts of threats to tortoise populations and identifies and prioritizes recovery actions that are most likely to ameliorate those threats. The decision support system models the inter-relationships among threats and tortoise population changes (*i.e.*, which threats cause other threats, and how do these threats effect tortoise population numbers) and recovery action-population stress relationships (*i.e.*, what are the most appropriate actions given a set of population stresses faced by the species?). The system relies primarily on GIS data of the spatial extent of threats (*i.e.*, where threats occur geographically) to calculate how changes in threats contribute to changes in tortoise population numbers at any geographic extent (>1 square kilometer).

The decision support system models the relationships between threats, population stresses, and demographic change factors. The relationships within the model are weighted using expert assessments of the strengths of:1) inter-threat links, 2) threat to population stress links, and 3) population stress to demographic change links using the standard lexicon for biodiversity conservation as in Salafsky *et al.* (2008). The GIS data of the spatial extent of threats are then geoprocessed with these weights to calculate how changes in threats contribute to changes in tortoise population numbers and how recovery action implementation is predicted to effect threat to population stress linkages. All data and underlying models will be updated and evaluated on a regular basis as described by recovery action 6.1.

B. DECISION SUPPORT SYSTEM ROAD MAP

The flow chart diagram below illustrates the overall modeling process within the decision support system. Each model is leveraged on the previous to produce the overall assessment of risk to desert tortoise populations and management priorities to mitigate that risk. It is important to note that what is described here is a prototype system, which we are continually improving (Starfield and Bleloch 1991; Starfield 1997; Murphy et al. 2008). Each model is transparent and can be evaluated and revised independently of the others as new information or better models become available. For example, several simple models describing the distribution of particular threats are being updated based on those published by Leu *et al*. (2008). In addition, sensitivity analyses still need to be conducted to determine the relative importance of different assumptions (*e.g.*, relative impacts of threats to tortoise demography or relative effectiveness of recovery actions on abating threats) and to identify priorities for model improvement (Freick and Hall 2004; Malczewski 2006).



The steps and component models currently in the system can be summarized as follows:

- *Spatial Threats*: uses geospatial data to represent where threats occur geographically and with what relative intensity

- *Stress to Population Models*
  - Threat-Stress Interaction Model: estimates the contribution of each threat to stress to the population
  - Relative Stress Model: estimates the contribution of each stress to demographic change factor
  - Demographic Impact Model: estimates contributions of each demographic impacts to overall population change

- *Models of the Risk to Tortoise Populations on the Ground*
  - Single Risk/Threat Model: combines degrees of threat with stress/demographic impact to estimate severity of each threat to the population
  - Pre-action Aggregate Risk Model: estimates the aggregate measure of the risk/severity posed to the population by all threats

- *Recovery Action Models*
  - Recovery Action Effectiveness Model: estimates the effectiveness of recovery actions in mitigating threat-stress links
  - Recovery Action Risk Reduction Model: combines the estimated risk to populations with recovery action effectiveness to estimate the reduction in risk/threat severity

- Post-action Aggregate Risk Model: estimates the aggregate measure of the risk/threat severity posed to the population by all threats after management actions are applied

- *Spatial Prioritization*: prioritizes recovery actions by their estimated effectiveness in risk reduction

C. COMPONENTS OF SUPPORT SYSTEM CALCULATIONS

1. Compile and Evaluate Spatial Threats Data

The Spatial Threats Model utilizes GIS data of the spatial extent of threats. For each threat, GIS layers from multiple sources illustrating where threats occur geographically are integrated into a single layer. Initial sources of threat data include previously published datasets and outputs of published models and mosaic datasets verified by local biologists and managers. Threats for which no data exist can be derived using the best available data and inter-threat relationships within the conceptual model. These data will be updated by Recovery Implementation Teams as new information becomes available.

2. Estimate Contribution of Each Threat to Overall Demographic Impact

Even though very little is known about the demographic impacts of individual threats on desert tortoise populations or the relative contributions each threat makes to population numbers (Boarman 2002; Tracy *et al.* 2004), we must still estimate the relative impact of the various threats to tortoise populations. This involves rating the 'severity' or contribution of each threat with regard to tortoise demography and is accomplished by combining two submodels: 1) the Threat-Stress Interaction Model, which estimates the contribution of each threat to population stresses, and 2) the Relative Stress Model, which estimates the contribution of each population stress to overall change in tortoise population numbers.

2.1 Estimate the contribution of each threat to stress

The Threat-Stress Interaction Model uses conceptual models of the interrelationships of threats and stresses (Figure B-1). The language used in the conceptual model is based on Salafsky *et al.* (2008). The relationship among threats, between threats and population stresses, and between stresses and demographic change factors were weighed using expert on-line assessments. Assessment responses relate to range-wide, relative contributions of: 1) threats to threats; 2) threats to populations stresses; and 3) population stresses to demographic change parameters. Using the conceptual models and assessments, an average contribution of each threat to overall population change can be calculated. When determining a threat's contribution to a stress, both direct and indirect threat contributions are considered. Indirect contributions are links between one and another threat that itself has a link to a stress.

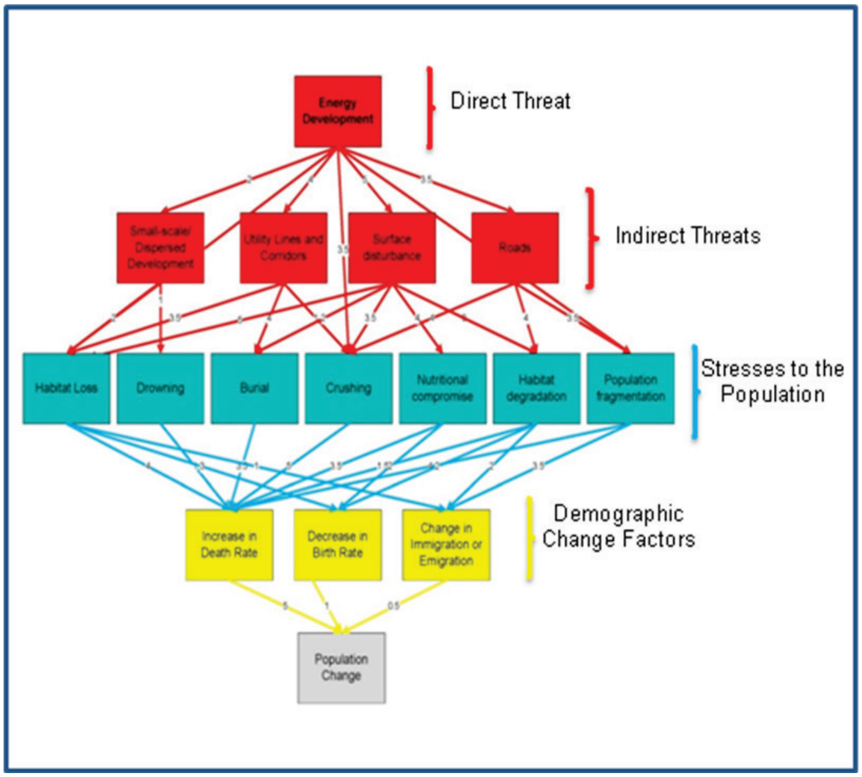


Figure B-1. An example of how the relationship between a single threat and overall population change is represented within the conceptual model. In this example, the relationships among one focal threat, Energy Development, and its indirect threats, stresses to the population, and demographic change parameters are depicted. The numbers on the linkages represent the relative contribution weights from expert on-line assessments.

2.2 Estimate the contribution of stresses to overall change in population

In the Relative Stress Model, each stress is assigned a weight that described its relative contribution to demographic change parameters, as per our conceptual models of threat-stress relationships. For this iteration of the system, we consider only two age classes (pre-reproductive, juvenile and reproductive, adult), and we consider only two demographic change factors (death rate and birth rate [reproductive output]). Immigration and emigration rates will be considered in future versions of the system. To generate these weights, the contribution of each stress to the demographic impact is weighted on a significance scale, which resulted in an overall set of relative weights for each stress to the populations. Note that these same weights could be replaced with quantitative data from future research to provide more reliable results. The relative contribution of each demographic factor to overall population change is determined by assessing outputs of population viability analyses (Doak *et al.* 1994; Wisdom *et al.* 2000; Reed *et al.* 2009).

2.3 Estimate threat contribution to overall change

Combining 2.1 and 2.1 gives the threat contribution to overall population change – the relative contribution, over the entire range, of that threat to overall population change across the range.

3. Spatial Risk to Populations

3.1 Combine degree of threat with population change factor to estimate threat severity

This step creates a Single Risk Model for each stress by combining the spatial distribution of each threat with the threat contribution to population change. This step yields a severity rating for each threat to desert tortoise populations within a geographic area of interest (*e.g.*, recovery unit, recovery implementation team workgroup area, etc). The rating represents both degree of threat (intensity and frequency) and the risk to population associated with that threat, as calculated in the previous step.

3.2 Estimate Aggregate Threat Severity

This step provides a synopsis of threats across the tortoises' range. It is a GIS processing step that involves summing each threat layer using the severity ratings developed in the previous step (3.1). The output is an aggregate rating of threat severity (risk) posed to the desert tortoise, reported at the spatial unit of 1 square kilometer (Figure B-2).

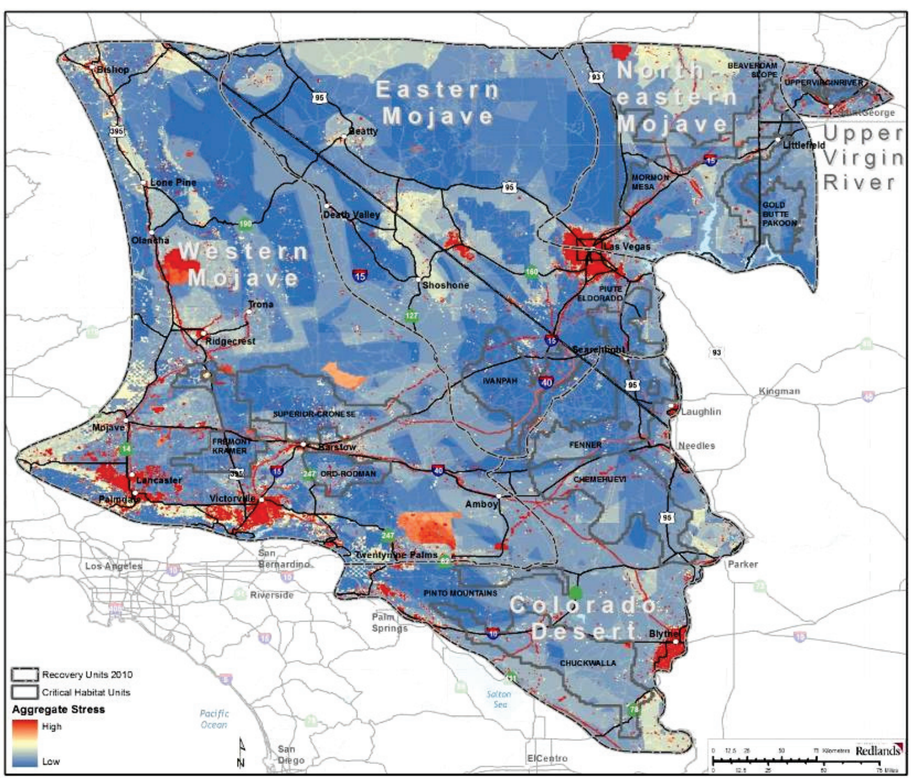


Figure B-2. Example of aggregated risk or population stress severity across the range of the Mojave population of the desert tortoise. Warmer colors indicate greater risk to the tortoise.

4. Estimate Effects of Recovery Actions

The Recovery Action Effectiveness Model relates recovery actions to the threat-population stress relationships they address. For example, the recovery action "install tortoise fencing" addresses crushing of tortoises (population stress) by motor vehicles on paved roads (threat). Relationships between recovery actions and threat-stress links are rated on a scale of 0-5 (0 = no effect; 5 = 100% effectiveness at eliminating the population stress due to a particular threat). A more thorough quantification of these relationships will provide more reliable results as the model-assessment process proceeds. The Recovery Action Risk Reduction Model then combines the risk to the tortoise before an action with the effectiveness of that action on a given threat. The result of this calculation yields an estimated reduction of the risk posed by a threat as a result of an action or suite of actions. Individual recovery actions can then be prioritized based on their overall predicted risk reduction score (Figure B-3).

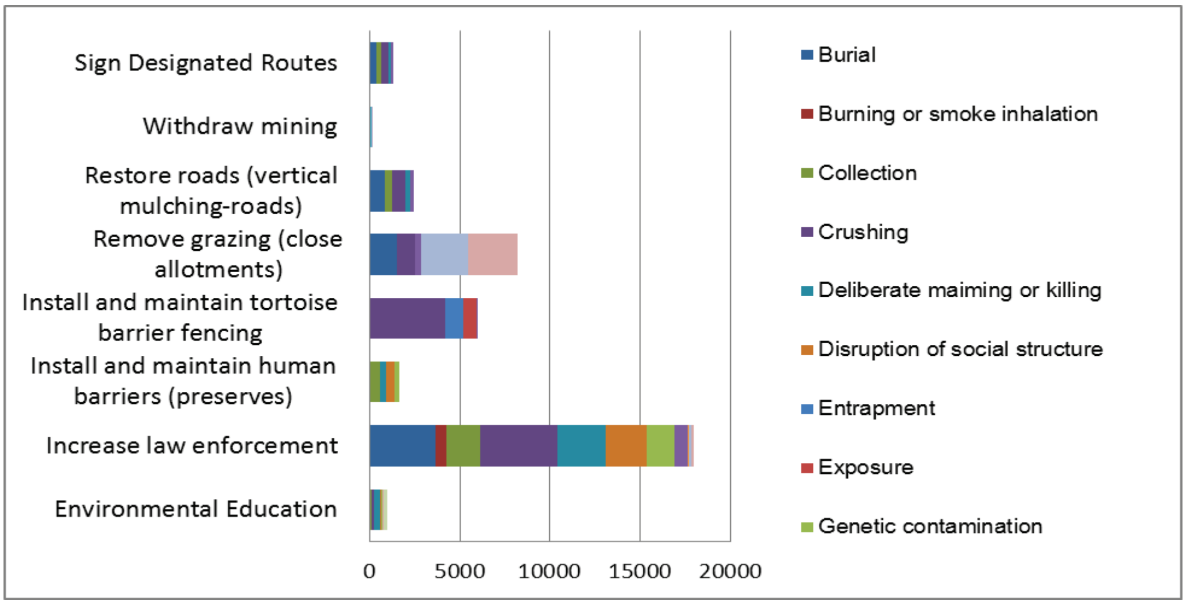


Figure B-3. Example of estimated risk reduction to a desert tortoise population for a proposed subset of recovery actions within a particular geographic area.

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APPENDIX C

RECOMMENDED SPECIFICATIONS FOR DESERT TORTOISE EXCLUSION FENCING (SEPTEMBER 2005)

These specifications were developed to standardize fence materials and construction procedures to confine tortoises or exclude them from harmful situations, primarily roads and highways. Prior to commencing any field work, all field workers should comply with all stipulations and measures developed by the jurisdictional land manager and the U.S. Fish and Wildlife Service for conducting such activities in desert tortoise habitat, which will include, at a minimum, completing a desert tortoise education program.

Fence Construction

Materials

Fences should be constructed with durable materials (*i.e.,* 16 gauge or heavier) suitable to resist desert environments, alkaline and acidic soils, wind, and erosion. Fence material should consist of 1-inch horizontal by 2-inch vertical, galvanized welded wire, 36 inches in width. Other materials include: Hog rings, steel T-posts, and smooth or barbed livestock wire. Hog rings should be used to attach the fence material to existing strand fence. Steel T-posts (5 to 6-foot) are used for new fence construction. If fence is constructed within the range of bighorn sheep, 6-foot T-posts should be used (see New Fence Construction below). Standard smooth livestock wire fencing should be used for new fence construction, on which tortoise-proof fencing would be attached.

Retrofitting Existing Livestock Fence

Option 1 (see drawing). Fence material should be buried a minimum of 12 inches below the ground surface, leaving 22-24 inches above ground. A trench should be dug or a cut made with a blade on heavy equipment to allow 12 inches of fence to be buried below the natural level of the ground. The top end of the tortoise fence should be secured to the livestock wire with hog rings at 12 to 18-inch intervals. Distances between T-posts should not exceed 10 feet, unless the tortoise fence is being attached to an existing right-of-way fence that has larger interspaces between posts. The fence must be perpendicular to the ground surface, or slightly angled away from the road, towards the side encountered by tortoises. After the fence has been installed and secured to the top wire and T-posts, excavated soil will be replaced and compacted to minimize soil erosion.

Option 2 (see drawing). In situations where burying the fence is not practical because of rocky or undigable substrate, the fence material should be bent at a 90E angle to produce a lower section approximately 14 inches wide which will be placed parallel to, and in direct contact with, the ground surface; the remaining 22-inch wide upper section should be placed vertically against the existing fence, perpendicular to the ground and attached to the existing fence with hog rings at 12 to18-inch intervals. The lower section in contact with the ground should be placed within the enclosure in the direction of potential tortoise encounters and level with the ground surface. Soil and cobble (approximately 2 to 4 inches in diameter; can use larger rocks where soil is shallow) should be placed on top of the lower section of fence material on the ground covering it with up to 4 inches of material, leaving a minimum of 18 inches of open space between the cobble surface and the top of the tortoise-proof fence. Care should be taken to ensure that the fence material parallel to the ground surface is adequately covered and is flush with the ground surface.

<u>New Fence Construction</u>

Options 1 or 2 should be followed except in areas that require special construction and engineering such as wash-out sections (see below). T-posts should be driven approximately 24 inches below the ground surface spaced approximately 10 feet apart. Livestock wire should be stretched between the T-posts, 18 to 24 inches above the ground to match the top edge of the fence material; desert tortoise-proof fencing should be attached to this wire with hog rings placed at 12 to 18-inch intervals. Smooth (barb-less) livestock wire should be used except where grazing occurs.

If fence is constructed within the range of bighorn sheep, two smooth-strand wires are required at the top of the T-post, approximately 4 inches apart, to make the wire(s) more visible to sheep. A 20 to 24-inch gap must exist between the top of the fence material and the lowest smooth-strand wire at the top of the T-post. The lower of the top two smooth-strand wires must be at least 43 inches above the ground surface.

(72-inch T-posts: 24 inches below ground + 18 inches of tortoise fence above ground + 20 to 24-inch gap to lower top wire + 4 inches to upper top wire = 66 to 70 inches).

Inspection of Desert Tortoise Barriers

The risk level for a desert tortoise encountering a breach in the fence is greatest in the spring and fall, particularly around the time of precipitation including the period during which precipitation occurs and at least several days afterward. All desert tortoise fences and cattle guards should be inspected on a regular basis sufficient to maintain an effective barrier to tortoise movement. Inspections should be documented in writing and include any observations of entrapped animals; repairs needed including bent T-posts, leaning or non-perpendicular fencing, cuts, breaks, and gaps; cattle guards without escape paths for tortoises or needed maintenance; tortoises and tortoise burrows including carcasses; and recommendations for supplies and equipment needed to complete repairs and maintenance.

All fence and cattle guard inventories should be inspected at least twice per year. However, during the first 2 to 3 years all inspections will be conducted quarterly at a minimum, to identify and document breaches, and problem areas such as wash-outs, vandalism, and cattle guards that fill-in with soil or gravel. GPS coordinates and mileages from existing highway markers should be recorded in order to pinpoint problem locations and build a database of problem locations that may require more frequent checking. Following 2 to 3 years of initial inspection, subsequent inspections should focus on known problem areas which will be inspected more frequently than twice per year. In addition to semi-annual inspections, problem areas prone to wash-outs should be inspected following precipitation that produces potentially fence-damaging water flow. A database of problem areas will be established whereby checking fences in such areas can be done efficiently.

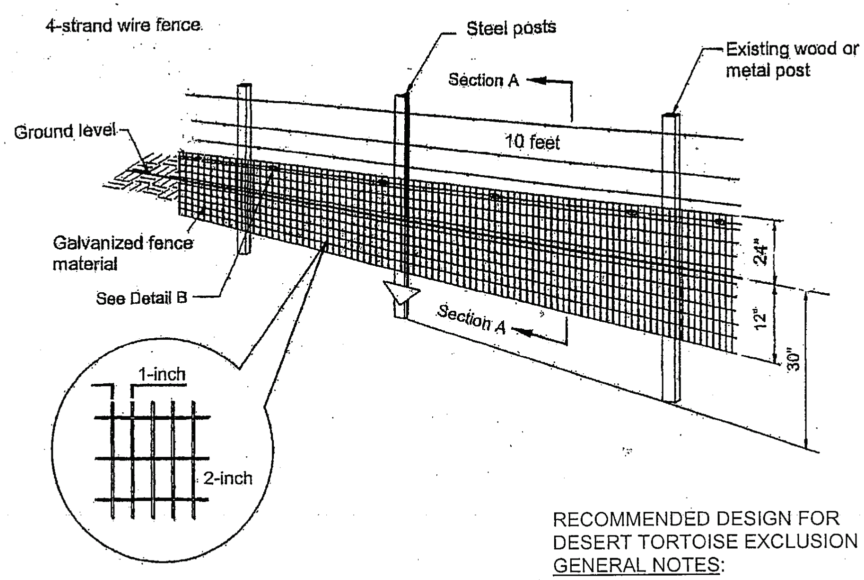
Repair and Maintenance of Desert Tortoise Barriers

Repairs of fence wash-outs: (1) realign the fence out of the wash if possible to avoid the problem area, or (2) re-construct tortoise-proof fencing using techniques that will ensure that an effective desert tortoise barrier is established that will not require frequent repairs and maintenance.

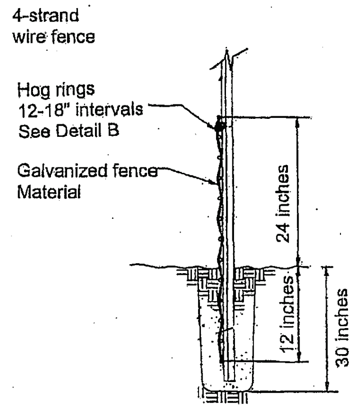
Gaps and breaks will require either: (a) repairs to the existing fence in place, with similar diameter and composition of original material, (b) replacement of the damaged section to the nearest T-post, with new fence material that original fence standards, (c) burying fence, and/or (d) restoring zero ground clearance by filling in gaps or holes under the fence and replacing cobble over fence constructed under Option 2. Tortoise-proof fencing should be constructed and maintained at cattle guards to ensure that a desert tortoise barrier exists at all times.

All fence damage should be repaired in a timely manner to ensure that tortoises do not travel through damaged sections. Similarly, cattle guards will be cleaned out of deposited material underneath them in a timely manner. In addition to periodic inspections, debris that accumulates along the fence should be removed. All cattle guards that serve as tortoise barriers should be installed and maintained to ensure that any tortoise that falls underneath has a path of escape without crossing the intended barrier.

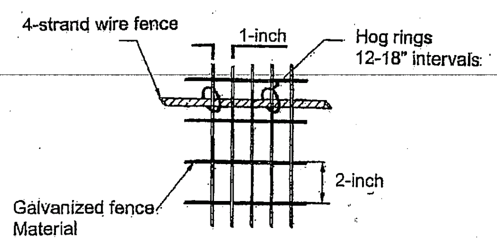
DESERT TORTOISE EXCLUSION FENCE (2005)



DETAIL A



SECTION A



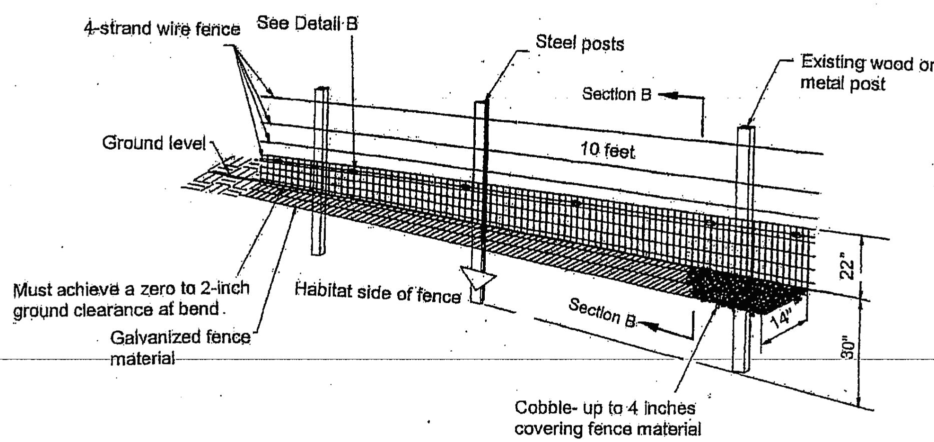
DETAIL B

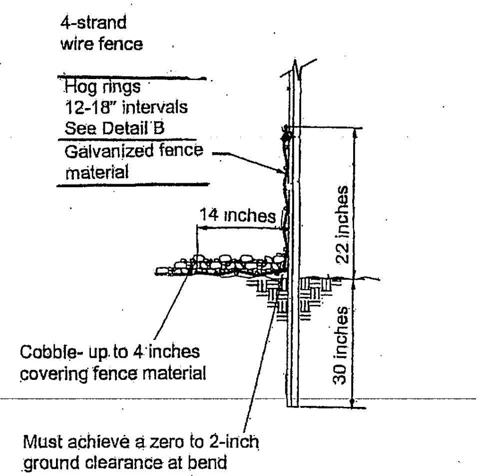
RECOMMENDED DESIGN FOR
DESERT TORTOISE EXCLUSION FENCE
GENERAL NOTES:

1. Ensure that fence posts and materials conform to the standards approved by the U.S. Fish and Wildlife Service.
2. Ensure that the height above ground level is no less than 18 inches and no higher than 24 inches.
3. Ensure that the depth of fence material below ground level is about 12 inches but no less than 6 inches. (See SECTION A above)
4. Install additional steel posts when span between existing fence posts exceed 10 feet.
5. Attach fence material to existing fence or wire using hog rings at 12-inch intervals.
6. Fasten fence material to posts with 3 tie wires with a wire near the top, bottom, and center of the fence material.
7. Backfill trenches with excavated material and compact the material.
8. Attach fence material to all gates. Ensure that clearance at base of gate achieves zero ground clearance.
9. Substitute smooth wire for barbed wire if additional support wires are necessary.
10. The number and placement of support wires may be modified to allow sheep and deer to pass safely.
11. Erosion at the edge of the fence material where the fence crosses washes may occur and requires appropriate and timely monitoring and repair.
12. Tie the fence into existing culverts and cattleguards when determined necessary to allow desert tortoise passage underneath roadways.

FOR BEDROCK OR CALICHE SUBSTRATE

1. Use this fence design (see below) only for that portion of the fence where fence material cannot be placed 6 inches below existing ground level due to presence of bedrock, large rocks or caliche substrate.
2. Ensure that the fence height above ground level is no less than 22 inches.
3. Ensure that there is a zero to 2-inch ground clearance at the bend.
4. Ensure that the bent portion of the fence is lying on the ground and pointed in the direction of desert tortoise habitat.
5. Cover the portion of the fence that is flush with the ground with cobble (rocks placed on top of the fence material to a vertical thickness up to 4 inches).
6. When substrate no longer is composed of bedrock or caliche, install fence using design shown above.





SECTION B

APPENDIX D

COMMENTS RECEIVED ON THE DRAFT PLAN

A. Overview of Public Comment Period

In August 2008, we released the Draft Revised Recovery Plan for the Mojave Population of the Desert Tortoise (*Gopherus agassizii*) (draft plan) and initiated a 90-day comment period. We received comments from Federal agencies, State and local governments, and members of the public. Among six scientists asked to provide peer review of the draft plan, we received comments from Drs. J. Whitfield Gibbons, Ken Nagy, H. Bradley Shaffer, and Anthony Starfield.

This section provides a summary of general information including the total number of letters received from various affiliations. It also provides a summary of the major comments. All letters of comment on the draft plan are kept on file in the Nevada Fish and Wildlife Office at 1340 Financial Boulevard, Suite 234, Reno, Nevada 89502.

We received 49 letters and over 6000 internet-generated form letters during the comment period. The email form letters voiced opposition to aspects of the recovery plan with only general reasoning provided, which was also reflected in various of the 49 more substantive letters. Some letters included new information or suggestions for clarity. In these cases, the information has been incorporated into the final version of the recovery plan. Many comments resulted in revisions to the draft plan. Information and comments not incorporated into the final version of the recovery plan were considered, noted, and are on file with the entire package of agency and public comments. Major comments that were not incorporated or that require clarification in addition to their incorporation are addressed in the summary below.

The following is a breakdown of the number of letters received from various affiliations:

Federal agencies	3
State agencies	5
Local governments	8
Environmental/conservation organizations	10
Academia/professional (including 4 peer reviews)	9
Individual citizens	13
Recreation groups	1

B. Summary of Comments and Our Responses

1. General Comments

Comment: One commenter stated that the recovery plan does not establish a useful baseline from which to assess recovery and that the data used to justify the listing should be used to inform effectiveness of recovery.

Response: Reasons for not using existing data as range-wide population baseline are articulated in the Population Trends and Distribution section. Existing data, including observed local population declines from across the range of the desert tortoise, are used to support assumptions of downward trends. In addition, effectiveness of actions to benefit desert tortoises has not been monitored adequately and remains largely unknown. Clarifications have been made to text.

Comment: Several commenters stated the revised recovery plan is either unchanged from the 1994 recovery plan, is insufficient, focuses too much or not enough on the 1994 plan, or that the 1994 plan was founded in science and should be fully implemented before being revised.

Response: Because the threats to desert tortoises remain largely unchanged from 1994, previous management and recovery actions remain appropriate. Both the GAO report (2002) and the assessment of the 1994 recovery plan (Tracy *et al*. 2004) found that plan and its recommendations to be fundamentally sound based on the best available science. Therefore, the revised recovery plan uses the 1994 plan as a foundation on which to build and integrate new criteria, focus on effectiveness monitoring, and develop a spatial decision support system. Some clarifications have been made in the Executive Summary and under the Recovery Strategy section.

Comment: One commenter stated the desert tortoise should be listed as endangered.

Response: The listing status of the desert tortoise is evaluated through a process separate from recovery planning. Under section 4(c)(2) of the Act, we conduct 5-year reviews to determine if a federally listed species should be delisted, reclassified from endangered to threatened status or from threatened to endangered status, or if the status of the species should remain the same. The most recent 5-year review for the desert tortoise found that the threats to the species did not warrant changing its status from threatened (USFWS 2010).

Comment: One commenter stated that the revision should simply update the 1994 recovery plan with accomplishments over the past 14 years, outstanding actions, and new actions needed to provide greater protection of populations and critical habitat (including suggestions for site- and area-specific actions).

Response: The revised recovery plan builds upon the 1994 Recovery Plan. As such, accomplishments, outstanding actions and new actions needed are discussed in the revised plan. The revised recovery plan updates the 1994 plan with new criteria, and additional strategies for recovery. Recovery actions are enumerated for the recovery units and tortoise conservation areas; many of these actions further specify priority needs within individual tortoise conservation areas. Additional site-specific actions will be identified and implemented through the Recovery Implementation Teams, as necessary.

Comment: One commenter suggested that a change in the recovery priority number should include additional discussion about the timeline for improving the situation for the species and the immediate need to have certain actions funded. Based on the discussion of the measures that have been implemented, the species should be in a better position to recover today than it was in

1990. The plan as written does not clearly present what changed on the ground since the original recovery plan was issued that resulted in this change in classification.

> Response: While a change in recovery priority number is not typically associated with a specific list of action items or a timeline for ameliorating threats, recovery plans are designed to identify and prioritize actions needed to advance recovery. Recovery plans also identify timelines for particular actions to the extent that they can be predicted (in the Implementation Schedule), and recovery plans often project a timeline to recovery (often in the Executive Summary). These items are all found in the revised desert tortoise plan. The revised plan for the desert tortoise further outlines uncertainties about various threats and our ability to manage them, reflected in the changed recovery priority number, and discusses at some length the ineffective approach to recovery to date. The revised plan also discusses the problems arising from the lack of a centralized recovery database, which would help us better track the effectiveness of measures that have been implemented since 1994. For example, it was not possible during the recovery planning process to obtain accurate data from all the various land management agency offices on how threats or management actions have changed since the original listing and recovery plan publication. Efforts continue in this area in the development of the decision support system and recovery database, however. We anticipate that implementation of the revised plan will resolve key uncertainties about threats and management and improve recovery potential for the desert tortoise by the next recovery plan assessment.

2. Process

Comment: One commenter stated that we failed to follow statutory and policy requirements in the development of the revised plan.

> Response: We believe that we have followed applicable laws, policies and guidance in this recovery planning process. The Science Advisory Committee is a recovery team and as such is exempt from FACA pursuant to section 4(f)(2) of the Act. The workgroups/ workshops were information-gathering sessions to which the public as well as invitees were welcome. These sessions focused on gathering individual opinion, best professional judgement, and information about threats to and recovery actions for the desert tortoise. We used the information gathered in developing both the decision support system and recovery actions identified in the plan.

Comment: One commenter criticized the location of recovery planning working groups in Nevada, which were difficult for interested parties from California to attend.

> Response: Two recovery planning workshops were held in Redlands, California, in addition to two in Las Vegas, Nevada, in an effort to foster broad participation in the planning process. We recognize that wherever workshops are held, they will be difficult for some parties to attend. We made our best effort to pick locations that would be feasible for many potential participants. Desert Tortoise Management Oversight Group meetings are held in Las Vegas, which is most centrally located for managers and stakeholders across the range.

3. Introduction – Population Trends

Comment: One commenter suggested that the revised plan ignores an abundant amount of existing information about the status and trends of the desert tortoise. Another suggested that tools to accurately measure regional or range-wide trends do not yet exist; therefore, statements about population trends should be made with disclaimers.

> Response: The revised plan summarizes the state of rangewide information; *i.e*., local declines have been confirmed, and these local areas are across the range, supporting the conclusion of broader and perhaps continuing declines. The Population Trends and Distribution section has been revised. In the revised section, we briefly describe previous efforts to quantify tortoise populations, explain the weaknesses of the older desert tortoise status data for assessing population trends, and describe more recent monitoring efforts and our ability to detect trends using them.

Comment: One commenter suggested that it was unclear if population declines have been offset by increases elsewhere, as no baseline exists and no consistent range-wide surveys have been done.

> Response: Past surveys that detected local declines were not randomly placed nor were they placed specifically to observe declines or increases. The Recovery Plan states that local declines, noted opportunistically, do not happen to be matched by local population increases that might also have been noted opportunistically.

Comment: One commenter indicated that even though the draft recovery plan states that "historic estimates of desert tortoise density or abundance do not exist at the range-wide or regional level for use as a baseline" and does not acknowledge the historic triangle-transect data going back as far as 1980 in Nevada, these surveys did identify estimates of tortoises across the landscape and are still used as historical presence/absence data in daily land management decisions.

> Response: In the late 1970s and early 1980s, the Bureau of Land Management implemented "corrected sign" transects to assess general and relative abundance of tortoises across larger management areas, particularly in the California Desert District. These transects were placed regularly on the landscape, and in suspected tortoise habitat, to map relative densities of tortoises for planning purposes (Berry and Nicholson 1984a). The same authors note some limitations with the technique, feeling that it generally underestimated by a moderate amount the true number of tortoises in most areas. Since the 1990s, based on difficulties and inaccuracies noted with the technique, it has not been considered a reliable way to estimate tortoise numbers. While it is true that these surveys for sign can be used in a presence/absence context, this is different from using the data for comparative purposes or for trend estimation. See also revised text in the Population Trends and Distribution section.

4. Introduction – Reasons for Listing and Appendix A (Threats)

Comment: One commenter stated that the recovery plan translates the agency's own failure to document recovery actions, the paucity of effectiveness-monitoring data, and the obviously inadequate timeframe over which impacts of threat reduction could be manifest, into the notion that not only is the effectiveness of recovery actions unclear but that the threats are uncertain.

> Response: The GAO report (2002) found that despite considerable efforts by land managers to conserve the desert tortoise, the effectiveness of their actions was not the focus of any research or monitoring activities; therefore, the ability to determine the effectiveness of a given action was limited. With the establishment of the Desert Tortoise Recovery Office in 2004, the Fish and Wildlife Service is better equipped to track implementation of recovery actions, as well as focus efforts on methods to evaluate effectiveness of management actions. Additional considerations are the biological constraints and cryptic nature of the species that confound our ability to design meaningful studies to evaluate effectiveness as it relates to population responses.

Comment: Several commenters criticized discussion of synergistic threats as either inadequate or without merit.

> Response: Little, if any, direct research has been conducted to quantify synergisms between various threats. However, Tracy *et al*. (2004) provided a conceptual model that illustrates how multiple individual threats act on the same mortality mechanisms, justifying a renewed focus on understanding how different threats interact. The spatial decision support system refines this conceptual model to predict effects of multiple threats on tortoise populations and the effects of management actions to reduce those threats.

Comment: One commenter claimed that "potential" threats are treated as "real" without justification and stated that the fact that few data exist to evaluate or quantify effects of individual threats on desert tortoise populations is a weakness of the revised plan.

> Response: The revised plan documents that all the identified threats are harmful to individual tortoises. Inclusion of these threats in the recovery plan is supported by the GAO (2002) audit of the recovery program and subsequent scientific reviews. Quantifying the magnitude and importance of individual threats and groups of threats on desert tortoise populations is a major goal of the spatial decision support system recommended by this plan.

Comment: Several commenters criticized the lack of description of the extent of threats in each recovery unit, including specific impacts to critical habitat.

> Response: Many of the threats to the desert tortoise exist across broad portions of the species' range. In several cases, more local or recovery-unit based threats are highlighted by location-specific recovery action recommendations. The prototype decision support system uses the best data that could be obtained within the planning process and provides a guide as to what additional data are most needed. The initial datasets provide a structure and way to prioritize the next round of data gathering, particularly including impacts to critical habitat. These data, including future updates, will be made publicly available through the Recovery Implementation Team (RIT) process.

Comment: One commenter noted that Table A-1 does not reflect growth in desert areas of Kern County, but rather for the greater-Bakersfield area. Another was concerned that the revised plan implies that all private lands will convert to urban uses, which is not supported by California SB375 or California AB32 which will encourage more compact land uses and potentially reduce threats to the desert tortoise.

> Response: The data in Table A-1 are from Byerly and Deardorff (1995) and the 2007 U.S. Census Bureau estimates for the states and counties within the range of the Mojave population of the desert tortoise between 1994 and 2006. Data for both entire counties and entire states are included. We do not mean to imply, nor do we expect, that all private lands will convert to urban uses. However, increasing human populations in areas peripheral to the range of the desert tortoise do lead to pressures on desert tortoise habitat and populations through recreation and other impacts.

Comment: One commenter felt that the revised plan presents little evidence to support the statements regarding off-highway vehicle (OHV) impacts, such as crushed tortoise burrows, and asked that the number of acres of critical habitat that have been degraded by OHVs be provided.

> Response: Despite many observations of off-highway vehicle impacts to tortoise burrows (Berry and Nicholson 1984b, Bury and Marlow 1973, Bury and Luckenbach 1986, Berry 1990), no statistical correlation between off-highway vehicle impacts and crushed tortoise burrows has been found (Boarman 2002). The revised plan describes several impacts to desert tortoise habitat and individuals from OHV use. Data are not readily available to quantify the number of acres of critical habitat degraded by OHV use; however, we are currently in the process of assembling various spatial data layers, such as aerial photography and satellite-derived land cover data, to complete these sorts of analyses as part of the RITs' prioritization and evaluation of recovery actions.

Comment: One commenter asked if the draft desert tortoise habitat model includes predictions under climate change scenarios.

> Response: The current version of the habitat model (Nussear *et al*. 2009), finalized since publication of the draft plan, does not include climate change scenarios. The revised plan includes a research recommendation to model the predicted effects of climate change on desert tortoise demography and habitat (Recovery Action 5.1).

Comment: One commenter suggested that the Intergovernmental Panel on Climate Change (IPCC) report provides sufficient detail to predict population consequences that climate change will have on the desert tortoise and that these predictions should be included in the revised plan.

> Response: The models and conclusions published in the 2007 IPPC report provide general information on how climate may change in the desert southwest, but they do not model regional or local ecological responses or effects on individual species. The revised plan describes many of these general effects and potential consequences to desert tortoises, but additional research and modeling, as recommended in Recovery Action 5.1, is necessary to determine specific consequences and develop actions that may be necessary to mitigate effects of changing climate.

5. Introduction – Conservation Efforts

Comment: One reviewer suggested a section called "Progress and Failures to Date" to answer questions about population trends, actions taken, and effectiveness of those actions since listing.

> Response: We agree that such a section would be valuable. Unfortunately, despite clear demonstration that threats to the desert tortoise impact individual tortoises, there are few data available to evaluate or quantify the effects of these threats on desert tortoise populations. Likewise, effectiveness of actions to benefit desert tortoises has not been monitored adequately and remains largely unknown, especially since historic estimates of desert tortoise abundance do not exist at the range-wide or regional level for use as a baseline. Therefore, the information for the section the reviewer recommends is not readily available. The prototype decision support system recommended in the revised plan uses the best data that could be obtained within the planning timeframe and provides a guide as to what data are most needed.

Comment: One commenter stated that the role of the Clark County Multi-Species Habitat Conservation Plan's (HCP) Conservation Management Strategies (CMSs) in desert tortoise recovery is unclear. What is the implementation schedule/strategy and what is the Fish and Wildlife Service's role?

> Response: The CMSs for Desert Wildlife Management Areas in Nevada were finalized in February 2007 and implementation has not yet begun. They were drafted to fulfill a requirement under the Clark County Multi-Species HCP (RECON 2000) to guide the prioritization, mitigation, and funding needs relative to desert tortoise in each of the Desert Wildlife Management Areas. The County has not yet indicated how it intends to implement the CMSs; however, the information gathered and recommendations contained in the strategies can serve as a baseline for each of the Desert Wildlife Management Areas and should inform the Recovery Implementation Teams in their efforts to implement prioritized regional recovery actions.

Comment: One commenter asked if the lands purchased under the California Desert land acquisition project were within critical habitat, did the lands support desert tortoises, and was there any study of the desert tortoises there?

> Response: The majority of lands purchased by the Department of Defense and Wildlands Conservancy are within designated critical habitat. No specific desert tortoise studies have been conducted on these lands.

Comment: One commenter stated the recovery plan fails to acknowledge loss of recreational lands due to the conservation of the desert tortoise and that this acreage should be quantified.

> Response: We added text under the Conservation Efforts section relative to the California Desert Conservation Area Plan. Some recreational activities (*e.g.*, off-highway vehicle use) have been displaced due to conservation efforts for various resources including the desert tortoise, but overall, recreational opportunities still exist within the same geographic areas. The route designation process within the California Desert Conservation Area resulted in closure of some routes and restricted use of open washes;

however, alternative routes still exist, and unauthorized routes continue to be established. The Bureau of Land Management does not track the number of acres of recreation that has been displaced.

6. Recovery Strategic Element 1 – Partnerships

Comment: One reviewer asked whether or not the Recovery Implementation Teams (RITs) will be effective.

Response: The primary goal of the RITs is to coordinate recovery action implementation to reduce threats to the desert tortoise. We will be implementing a formal process to track and assess effectiveness of recovery efforts. The effectiveness of the RITs should be demonstrated by the effectiveness of regional/local recovery efforts as tracked in the spatial decision support system and evidenced by range-wide monitoring.

Comment: One commenter suggested that the recovery plan is required to be a binding document and that we may not delegate our authority to implement the plan to RITs.

Response: Recovery plans are non-regulatory documents, and as such, identified partners are not obligated to implement recovery tasks. The revised plan recommends the formation of RITs to facilitate cross-jurisdictional implementation of the actions recommended in the plan.

Comment: Two commenters asked for clarification of the link between the RIT process and existing land use plans, such as the Bureau of Land Management's resource management plans (RMPs) and the existing Conservation Management Strategies (CMSs) in Clark County, Nevada.

Response: Existing RMPs within the range of the desert tortoise include language specific to the protection and conservation of natural resources, including desert tortoises and their habitat. RMPs are often supplemented by more specific guiding documents, such as habitat management plans or wilderness management plans. The CMSs have also identified actions for specific areas that are important to desert tortoise recovery. The regional RIT action plans are intended to be supplements which prioritize recovery actions within an RMP jurisdictional or CMS area for the next five years.

Comment: One commenter claimed that the recovery plan is based on a flawed management structure. Since we cannot ensure participation by land management agencies, nor can we influence budget allocations or commitment of resources to recovery, the commenter recommended that we assert and enforce the obligations of the federal agencies under section 7(a)(1) of the Endangered Species Act (ESA).

Response: Recovery plans are guidance documents, not regulatory documents. No agency or entity is required by the ESA to implement the recovery strategy or specific actions in a recovery plan. However, the ESA envisions recovery plans as the central organizing tool for guiding each species' recovery. Recovery plans should also guide Federal agencies in fulfilling their obligations under section 7(a)(1) of the ESA, which calls on all Federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species

... .” In addition to outlining strictly proactive measures to achieve species’ recovery, recovery plans provide context and a framework for implementation of other provisions of the ESA with respect to a particular species, such as section 7(a)(2) consultations on Federal agency activities, development of Habitat Conservation Plans (HCPs) or Safe Harbor agreements under section 10, special rules for threatened species under section 4(d), or the creation of experimental populations in accordance with section 10(j).

Comment: Two commenters questioned the role of public input into the RIT process, including a process to appeal the recommendations of the RITs.

Response: Members of the RITs will be appointed by our Regional Director based on demonstrated interest and participation in the recovery planning process. Others will be considered upon request. Five-year action plans developed by the RITs will be completed and submitted to appropriate regional groups (*e.g.*, Desert Managers Group in California) and the Management Oversight Group for review within the first year of publication of the revised recovery plan. Meetings of both regional groups and the Management Oversight Group are open to the public and will provide a forum for further public input into the RIT recommendations.

Comment: Several commenters asked for further clarification on the RIT structure, organization, composition, and function. In particular, commenters asked for the number and jurisdictional area of the individual RITs and emphasized the need for integration with the other standing groups, such as groups involved in HCP processes.

Response: RITs will either coordinate directly with the California Desert Manager’s Group, the Southern Nevada Agency Partnership, and the Washington County HCP’s Adaptive Management Team, as appropriate. Desert tortoise experts will be encouraged to be part of the RITs, as either agency representatives or stakeholder representatives. Team members will be appointed by our Regional Director and will be representative of both agencies (land management, wildlife management, county government, and tribal resource agency) and stakeholders (natural resources use group, recreation group, conservation organization, and the scientific community). Additional detail has been added to the revised plan.

Comment: Several commenters recommended that the development of five-year action plans and budget needs with priorities for management should be undertaken by the Fish and Wildlife Service itself and not be left to regional stakeholder groups. They worried that because the RITs will be composed of a broad base of managers, stakeholders, and scientists, it appears that we are delegating guidance and implementation of recovery to the RITs, which the commenters did not believe are required to make decisions based on science. One did not agree that the RITs should be included within the Federal Advisory Committee Act (FACA) exemption because they are not intended to be science-based recovery teams but rather include numerous types of stakeholders.

Response: The RITs will serve as advisory groups to the Fish and Wildlife Service through the Desert Tortoise Recovery Office and Region 8. The RITs will develop five-year recovery action plans within the scientific framework of the spatial decision support system. However, a plan is just that, a plan. For results, the plan must be implemented.

We have neither the resources nor the authority to implement many, if not most, recovery actions. Communication, coordination, and collaboration with a wide variety of potential stakeholders are essential to the acceptance and implementation of recovery plans. Involving stakeholders early and throughout the process may help achieve necessary understanding of the species' biology, threats and recovery needs, identify and resolve implementation issues and concerns at the planning stage, increase buy-in, and facilitate more effective implementation.

We note that the Act, our policies, and applicable guidance do not specify that a recovery team must include only scientists. Instead, the section 4(f)(2) of the Act indicates that we "may procure the services of appropriate public and private agencies and institutions, and other qualified persons" to serve on recovery teams. We find that stakeholders are not only qualified, but also valuable additions, to recovery teams. For example, they help us assess the feasibility of recovery actions. Appointed recovery teams are exempt from FACA per section (4)(f)(2) of the Act.

Comment: Two commenters were concerned that the revised plan further delays the recovery of the desert tortoise, given that it will be at least six months after the publication of the final plan that the RITs are established and several more months before the five-year action plans are completed. Commenters worried that action will be delayed by the planning process prescribed under the Adaptive Management element, specifically the two-year deadline for updating the underlying data in the decision support system.

Response: All on-the-ground recovery recommendations, especially those under Strategic Element 2, apply during RIT establishment and the planning process. For future recovery implementation, a more strategic, well-coordinated recovery effort (as detailed in the revised plan) will encourage cross-jurisdictional, landscape-level action that promises to increase effectiveness and efficiency. Unlike past desert tortoise recovery efforts, this coordinated approach will be tracked, monitored, and evaluated.

Comment: One commenter asked why the RITs aren't being formed immediately.

Response: We will be appointing the RITs once the revised recovery plan is finalized. Per Section 4(f)(4) of the ESA, we must ". . . provide public notice and an opportunity for public review and comment. . ." and ". . . consider all information presented during the public comment period prior to approval of the plan." Once all public comments have been considered and the plan is final, we will form the RITs.

Comment: One commenter asked that the revised plan clarify how communication among stakeholders will be established and maintained.

Response: Stakeholder representatives on the RITs will be encouraged to coordinate among their interest groups. In addition, five-year action plans developed by the RITs will be completed and submitted to appropriate regional groups (*e.g.*, Desert Managers Group in California) and the Management Oversight Group for review, and the RITs will report to these groups annually. Both regional group and Management Oversight Group meetings are open to the public and will provide a forum for further public input into the RIT recommendations.

Comment: One commenter noted that the draft recovery plan provides for additional stepped-down recovery planning at the recovery unit level, but that this scale of planning may yet be too large for some recovery units and additional teams may need to be created at the individual recovery unit level. The plan should provide for this level of flexibility.

Response: RITs will have the flexibility to focus their efforts on the most appropriate geographic scales in their respective regions.

7. Strategic Element 2 – Protect Populations and Habitat

Comment: One commenter stated that intervention (means of providing elements for survival) should be a tool available to the Recovery Implementation Teams (RITs), especially in light of drought and suboptimal forage conditions.

Response: Actions proposed in the recovery plan do not constitute an exhaustive list, so additional ideas may be proposed, particularly as recovery action plans are developed by the RITs. We added text in the Recovery Strategy section to clarify that this is the case.

Comment: Two commenters stated that populations, habitats, and actions outside tortoise conservation areas are also important to recovery, while another commenter expressed concern that recovery efforts might be applied outside tortoise conservation areas.

Response: We explicitly state under Strategic Element 2 and Recovery Objective/ Criterion 3 that while recovery efforts are prioritized within existing desert tortoise conservation areas, habitats, populations, and actions outside these areas may also either impact or contribute to recovery of the species, are subject to the section 7 and 10 provisions of the Endangered Species Act, and their importance is in no way diminished.

Comment: Several commenters stated that the recovery plan does not identify any meaningful site-specific management actions. The recovery plan focuses on the need for coordination, monitoring, and research on the myriad of unanswered questions instead of focusing on implementing what is known.

Response: Under the Recovery Action section, actions that should be implemented within tortoise conservation areas are identified. Similar actions were included in the 1994 recovery plan, which focused implementation within Desert Wildlife Management Areas. Additional site-specific actions will be determined by the RITs and will be based on what is known about the status of recovery action implementation and current conditions within the respective recovery units.

Comment: One commenter stated that the inclusion of the habitat model and discussion of RITs identifying important habitats outside tortoise conservation areas leads the reader to believe the Fish and Wildlife Service's goal is to recover the desert tortoise throughout its entire range. Maps of occupied habitat should be included in recovery plan, and hard-line boundaries should depict where recovery will be focused.

Response: The habitat model provides "a range-wide quantification of desert tortoise habitat that can help direct where management actions should be implemented as well as provide a basis for documenting trends in habitat impacts or loss." The recovery plan states that habitats and populations outside tortoise conservation areas may also be important for recovery; therefore, the recovery plan does not restrict RITs to focusing solely on these areas, especially in light of potential connectivity issues and the fact that all desert tortoises are protected under the Endangered Species Act. However, the current strategy as stated in the recovery plan focuses management/recovery action priority within the tortoise conservation areas.

Comment: Several commenters stated that the recovery plan fails to specify adequate implementable actions, how those actions are to be implemented, and a timeline for implementation.

Response: The Recovery Actions section includes a series of actions, many of which were initially identified in the 1994 recovery plan. On-the-ground activities and implementation coordination will be assessed and prioritized by the RITs through recovery action plans that will be evaluated every five years.

Comment: One commenter stated that the recovery plan failed to address previously stated concerns about the apparent decision that data inadequacies are an excuse for inaction.

Response: As with many listed species, a lack of substantive data is often an ongoing issue; however, we do not view this as an excuse for inaction. In fact, a tremendous amount of effort and money have been spent on desert tortoise conservation, management, recovery, and mitigation. We acknowledge that there are gaps in the data relative to direct correlations between threats and population numbers and the effectiveness of various actions; however, the recovery plan includes numerous on-the-ground recovery actions based on the best available information. The revised plan establishes a framework for resolving data gaps through a robust research and monitoring program and spatial decision support system. These elements of the recovery program will enable us to better assess actions and their effectiveness, ensuring funds are spent most effectively.

Comment: Two commenters stated that the tortoise conservation areas appear to have none of the important management prescriptions set forth for Desert Wildlife Management Areas and urged that the recovery plan clarify that the Desert Wildlife Management Areas and their existing management prescriptions are essential for tortoise recovery and are incorporated into the final recovery plan update.

Response: The revised plan states that recovery efforts will be focused within tortoise conservation areas, which include various existing conservation-oriented designations and related prescriptions by land-management agencies. Recovery actions include the Desert Wildlife Management Area-specific actions contained in the 1994 plan. Desert Wildlife Management Areas and Areas of Critical Environmental Concern are mentioned throughout the plan, especially in the Conservation Efforts section. The new Table 4 in the revised plan illustrates how recovery actions in this plan compare to those in the 1994 Recovery Plan.

Comment: One commenter stated that there is a need for bold changes in public lands management to decrease known or suspected causes of adult tortoise mortality while increasing or preserving soil integrity.

Response: Public land management is challenging in the face of multiple-use mandates and conservation requirements. The recovery plan strives to achieve balance by discouraging future land disturbances within tortoise conservation areas as prescribed by the actions described therein and monitored under Recovery Criterion 3. These actions should also protect soil integrity in these areas.

Comment: One commenter stated that one tortoise conservation area in each recovery unit should be set aside with the most restrictive management and access possible under federal land management guidelines (including a possible change in the lead management agency or institution of new designations). Another stated that all critical habitat should be protected against all human uses.

Response: Wilderness is the most restrictive land use allocation, requiring Congressional and Presidential approval, and still does not provide for total exclusion of human uses. Currently, there are no land designations that would restrict all human uses on public lands, and private land management is at the discretion of the landowner. Land designations are legislative or management decisions outside our purview, but the recovery plan recommends specific actions to minimize or eliminate human impacts to desert tortoises and their habitat.

Critical habitat receives protection under section 7 of the Endangered Species Act through prohibition against Federal agencies carrying out, funding, or authorizing activities that are likely to result in the destruction or adverse modification of critical habitat. Section 7(a)(2) of the Endangered Species Act requires consultation on Federal actions that may affect critical habitat. The designation of critical habitat does not affect land ownership or establish a refuge, wilderness, reserve, preserve, or other conservation area.

Comment: Several commenters suggested that disposal of public lands in or adjacent to desert tortoise habitat should be mitigated at 1:1, and other lands used as mitigation or compensation for project impacts should be managed as reserves/preserves by a conservation entity. Certain areas should be identified as "experimental management zones."

Response: The recovery plan suggests that "mitigation of activities harmful to the desert tortoise should draw on a suite of opportunities provided by" the strategic elements contained in the document. Acquisition and placement of lands into conservation status are included among these opportunities. With the emphasis on conservation efforts within tortoise conservation areas, experimental management would be most appropriate in habitat outside the tortoise conservation areas, for example, as suggested for alternative grazing practices in Recovery Action 2.16.

Comment: One commenter stated that sufficient information exists on current threats to justify taking immediate, corrective action (including, for example, specific areas where off-highway vehicle use should be controlled) and that we have disregarded threats analyses contained in various California Desert Conservation Area Plan amendments.

> Response: The recovery plan includes equivalent information from literature as is in the West Mojave Plan amendment to the California Desert Conservation Area. Specific recovery actions are included in the revised plan, including those from the 1994 Recovery Plan, and additional priority actions/areas will be identified and funding opportunities for implementation sought by the RITs. The priorities will be established according to actions already implemented, as well as pending actions or remaining threats, under existing land management plans.

Comment: One commenter stated that conservation recommendations contained in biological opinions should be binding requirements, or the desert tortoise will continue its demise.

> Response: Under section 7 of the Endangered Species Act implementing regulations, 50 CFR §402.02 *Definitions*, conservation recommendations are suggestions of the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information. Binding requirements by the Service are pursuant to 50 CFR §402.14(i)(2) *Formal Consultations, Incidental Take, Reasonable and Prudent Measures.* Per this section of the regulations, the Service provides nondiscretionary measures that are necessary and appropriate to minimize the impact of incidental take.

Comment: One commenter stated that compatible activities in Desert Wildlife Management Areas from the 1994 plan are not included.

> Response: Including a list of compatible uses in the recovery plan would imply that we know how each of these activities affects or does not affect desert tortoise populations. As stated in the recovery plan, our understanding of specific and/or synergistic threats as they relate to tortoise populations and mortality are evolving, and data gaps will continue to be filled as our research program is focused and developed. Therefore, instead of offering what could be interpreted as an exhaustive list of compatible activities, we encourage avoidance and minimization of surface disturbing activities.

Comment: Two commenters felt that the fire discussion is inadequate. They stated that the plan should be promoting prevention rather than rapid response for suppression given the distances many first responders must travel and that fuels management should be a priority, including a carefully managed grazing component. Other comments suggested that a fuels management component where grazing is used as a reduction method should be added to the revised plan.

> Response: Fire prevention is addressed by the recommendation to conserve intact desert tortoise habitat (Recovery Action 2.1) and indirectly by the recommendation to eradicate or suppress invasive plants in the habitat restoration section (Recovery Action 2.6). It has been demonstrated that cattle grazing may help create and maintain habitat for native plants where: 1) the grassland ecosystem is highly productive; and 2) disturbance was

previously caused by native grazers and browsers (*e.g*., Brooks 1995; Marty 2005). The Mojave Desert is neither highly productive, nor is it an environment which historically supported native grazers. There is no evidence that cattle grazing will restore habitat or prevent fire in Mojave Desert environments. Such a proposal is therefore experimental and is included under Recovery Action 5.3 and directed to occur outside tortoise conservation areas under Recovery Action 2.16.

Comment: One commenter stated that the Recovery Plan should include a protocol for handling desert tortoises in the field; who can remove shedding animals and to what disposition; and how to mark seropositive, non-symptomatic tortoises. The commenter also stated that we and our contractors will never have sufficient field workers to undertake the needed removal and that several quarantine facilities will be required.

Response: Appropriate management of disease within desert tortoise populations is an evolving field of inquiry. Protocols based on the Science Advisory Committee's and other expert recommendations for managing disease, including facilities management, will be developed separate from the recovery plan.

Comment: One commenter stated that there must be an actual dollar commitment reflecting estimated costs of implementing the disease research recommendations.

Response: All costs shown in the implementation schedule are estimates. Some costs are noted as TBD (to be determined); this is the case for disease research because it is difficult to accurately estimate costs for research projects which have not yet been designed.

Comment: One commenter stated that Section 2.2 has no discussion of Brown’s environmental stressor hypothesis in relation to disease and fails to call out proactive and administrative measures, such as quarantines and translocation moratoriums, in order to localize disease outbreaks.

Response: Hypotheses related to disease and environmental stress are addressed under Recovery Action 5.5 (conduct research on desert tortoise diseases and their effects on tortoise populations) and were discussed in Appendices A and B of the draft revised Recovery Plan. Although the Science Advisory Committee's disease recommendations white paper (formerly Appendix B) is not included in the final revised Recovery Plan, an updated June 2009 version (Hudson *et al.* 2009) was used by the Desert Tortoise Recovery Office in writing the final revised Recovery Plan. Text was added to section 2.2 related to site quarantines and the implementation of actions based upon results of research conducted under Recovery Action 5.5.

Comment: Two commenters felt that there is no means of gauging effectiveness of the identified outreach efforts or what corrective action is necessary if such efforts are deemed ineffective.

Response: Environmental education has been shown to effectively change learned behavior (Hungerford and Volk 1990). Monitoring the effectiveness of environmental education efforts will be as difficult as any monitoring for the effectiveness of specific actions and will depend largely on the indicator (or metric) chosen to be monitored. For example, a random survey regarding the attitudes of residents towards desert tortoise recovery, or human impacts affecting recovery, could be assessed as a metric for the effectiveness of the education effort (*e.g.*, Vaske and Donnelly 2007).

Comment: One commenter stated that the section on Unauthorized Off-road Vehicle Travel, within the Law Enforcement section (Recovery Action 2.4), describes the problems off-highway vehicle activity poses for tortoises, yet the strategy only acknowledges that more law enforcement is needed and provides no strategy or set of strategies to lessen the impact of such activity on the species or habitat. The plan should also suggest other strategies, such as simply closing critical habitat and other essential habitat for the desert tortoise to all off-highway vehicle use.

Response: Recovery Action 2.4 addresses *unauthorized* off-highway vehicle use. Recovery Action 2.5 addresses route designations, closures, and related actions that would minimize vehicle impacts to desert tortoises and habitat. In addition, Recovery Action 2.10 addresses organized off-highway vehicle events.

Comment: One commenter stated that before we simply call for more law enforcement we should be explicit in what we are asking them to do and what the expected outcomes should be in terms of connection to tortoise population recovery.

Response: Regional and site-specific law enforcement needs will be evaluated and prioritized by the RITs, and through this process we will be able to make more explicit recommendations than those listed under Recovery Action 2.4.

Comment: One commenter asked that the revised plan make state transportation agencies aware of connectivity and fragmentation issues when fencing roadsides.

Response: No study has been done to identify how many underpasses are needed, from either a genetic or demographic standpoint, to effectively prevent population fragmentation. Recovery Action 5.6 calls for the determination of the importance of corridors and physical barriers to desert tortoise distribution and gene flow. Transportation agencies will be included in coordinating recovery actions dealing with highway fencing and culvert installation.

Comment: One commenter recommended that we should determine the usefulness and effectiveness of highway underpasses designed to ensure connectivity and suggested that perhaps human intervention is required to move males from one tortoise conservation area to another. Several recommended that road fencing (Recovery Action 2.5) be considered only for those locations identified in the revised plan, raised concern about the cost of fencing construction and maintenance, or asked that Recovery Action 2.7 be rewritten to explicitly reflect actual needs based on the most current information. One commenter also noted that costs of such barriers must be borne by the agencies, not by property owners and residents. The commenter pointed out that costs of connecting isolated populations should be borne by the agencies, not property owners and residents.

Response: No study has been done to identify how many underpasses are needed, from either a genetic or demographic standpoint, to connect populations. Recovery Action 5.5

involves determining the importance of corridors and physical barriers to desert tortoise distribution and gene flow. Fencing efforts will be prioritized by the RITs, but will not be limited to the locations identified within Recovery Action 2.5 or 2.7. We cannot predict how various developments will change usage and traffic density patterns, and thus fencing needs, for the life of the revised recovery plan. The priorities for installation and maintenance of urban and other barriers are based on the most currently available information. The Implementation Schedule currently states that land managers and funds from appropriate Habitat Conservation Plans should support the installation and maintenance of urban and other barriers and culverts.

Comment: One commenter noted that the recovery plan recommendation of no net gain of roads may relate to other infrastructure associated with projects such as wind energy development. The commenter suggested that the recovery plan does not recognize that the potential impacts of road construction on desert tortoise conservation are variable based on the nature of the road and that if this concept in retained in the final plan, it must recognize the inherent differences among various types of roads as well as the extensive road planning which has previously been approved for Areas of Critical Environmental Concern by us through the section 7 consultation process.

Response: Proposed new roads within tortoise conservation areas should be considered by the RITs and will continue to be evaluated by the Fish and Wildlife Service through the section 7 and 10 processes.

Comment: One commenter suggested that additional critical habitat should be designated in the El Paso Mountains and northern Searles Valley.

Response: Critical habitat cannot be designated through the recovery planning process. However, as indicated in Recovery Action 1.1, RITs should identify areas not included within existing tortoise conservation areas that may warrant focused management efforts.

Comment: Three commenters suggested that the revised plan recommend the removal of all off-highway vehicle events within tortoise habitat, including recovery units and tortoise conservation areas, and restrict casual off-highway vehicle use within desert tortoise habitat to existing and designated roads and trails.

Response: Recommending exclusion of off-highway vehicle events or restricting casual use within desert tortoise habitat throughout the recovery units and tortoise conservation areas would essentially close the entire Mojave Desert to off-highway vehicle users. The revised plan recommends continued effort to identify, designate, and close off-highway vehicle routes within desert tortoise habitat, as well as excluding off-highway vehicle events specifically within tortoise conservation areas. We will continue to work through the RITs to identify and prioritize areas where tortoises may benefit from more restricted access to off-highway vehicles in order to achieve sustainability of the desert tortoise where other, more protective designations are lacking.

Comment: One commenter stated that the decision support system should consider both competitive and non-competitive off-highway vehicle events within desert tortoise habitat.

Response: The decision support system will incorporate as much data as are available regarding the threats facing the species, including from off-highway vehicle use. Our ability to obtain data on non-competitive off-highway vehicle events is limited; competitive events generally go through a permitting and consultation process and, therefore, data are available. Non-competitive events fall under landscape-level resource management plans, which generally do not have data gathering requirements. However, we continue to assemble spatial data layers, such as aerial photography and satellite-derived land cover data, in an attempt to quantify impacts from all off-highway vehicle and other land uses as part of the RIT's prioritization and evaluation of recovery actions.

Comment: One commenter asked where does the recommendation of restricting off-highway vehicle events apply - all habitats or just critical habitat?

Response: The recovery plan states that recovery actions will be focused within tortoise conservation areas; however, because all desert tortoises are protected under the Endangered Species Act, avoidance and minimization measures may be required in areas outside tortoise conservation areas pursuant to any consultations with the resource agencies.

Comment: One commenter indicated that there is no analysis framework provided to help managers determine the appropriate number of off highway vehicle events and/or participants per event. Similarly, there is also no prioritization of areas where this issue should be addressed. Offices that have limitations currently in place cannot tell if further restrictions are needed.

Response: The revised plan states that off highway vehicle events should avoid tortoise conservation areas to the extent practicable. Beyond this, the RITs will identify areas or events in particular need of attention relative to desert tortoise recovery.

Comment: One commenter stated that data are lacking to show that modern mining poses a threat to desert tortoises, and thus withdrawing mining from tortoise conservation areas and including mining as a threat are unsupported.

Response: Reducing the potential for negative impacts to desert tortoises and their habitat are fundamental for tortoise conservation areas to be successful. As stated under Recovery Action 2.12, activities associated with mining can degrade habitat and result in direct take. Boarman and Kristan (2006) found that there was strong evidence that energy and mineral developments can be a threat to desert tortoises by way of habitat loss and direct take. Should limited mining continue to occur within tortoise conservation areas, we expect monitoring of the effects and appropriate minimization measures to be applied.

Comment: One commenter requested an additional Recovery Action specifically calling for the relocation of sand and gravel leases outside of tortoise conservation areas and recovery units be added to the Implementation Schedule as a priority 1.

Response: Recovery Action 2.12 already states that mining (including sand and gravel extraction) should be withdrawn from tortoise conservation areas, if feasible, or otherwise limited if they cannot be withdrawn. While we do not call this a priority 1 action (because we do not expect lack of implementation of this action alone to result in the extinction or irreversible decline of the species), the RITs have the ability to prioritize recovery actions and make recommendations about specific mining activities in their implementation areas.

Comment: Several commenters stated that the recovery plan overemphasizes grazing as a threat, ignores all that has been done to reduce grazing, and it does not make any conclusions as to whether or not any positive responses in terms of recovery have been measured; the recovery plan needs to document the degree to which grazing remains a threat within tortoise conservation areas and recognize its utility as a management tool. They further state that no data have been presented on the effectiveness of efforts to remove grazing.

Response: The Conservation Efforts section identifies the extensive efforts that have been undertaken to improve grazing management within desert tortoise habitats, especially within critical habitat. The recovery plan cites several reports that acknowledge the lack of effectiveness information on the recovery actions that have been implemented to date; therefore, the plan emphasizes the development and refinement of the spatial decision support system, which will enable us to better track implementation and effectiveness of recovery actions. References cited in Appendix A note, however, that recovery from grazing-related impacts can take decades within desert landscapes.

Comment: Several commenters stated that no justification for relaxing the standards on grazing is presented, despite strong scientific evidence to the contrary; grazing should be curtailed not only in drought years but also in good rainfall years after drought so that the desert tortoise can recover and need not compete with cattle or other livestock for their preferred forage of native annuals.

Response: Recovery Action 2.16 carries forth recommendations in the 1994 recovery plan to exclude grazing within tortoise conservation areas. The revised plan acknowledges that more flexible grazing practices may be implemented experimentally outside tortoise conservation areas to help fill data gaps relative to the magnitude and intensity of impacts from grazing to the desert tortoise and its habitats as well as gaps regarding the effectiveness of grazing as a fuels-reduction tool.

8. Strategic Element 3 - Population Augmentation

Comment: One reviewer recommended that population augmentation be strategic with respect to habitat and demographics of the target populations. A warning was included that urged assessment of how other aspects of the program might suffer from dilution of funding given uncertainties associated with population augmentation.

Response: We agree with the comment and plan to address these concerns in the research-based population augmentation strategy recommended by Recovery Action 3.1. In addition, we anticipate that much of any translocation effort will be funded directly by project proponents who are disturbing habitat to the extent that resident tortoises must be cleared from the project area, thereby minimizing dilution of funding that would otherwise be directed to on-the-ground management actions.

Comment: One commenter stated that in conjunction with head-starting there is a need to understand reasons for local population declines, and that due to predation on adult tortoises during drought, broader application of predator control in localized areas may be necessary after thorough evaluation by the Recovery Implementation Teams (RITs).

> Response: We agree that there is a need to understand local population declines, which is why we call for augmentation to be approached experimentally in conjunction with threats management and restoration activities such that causes of declines can be better elucidated. As stated in Recovery Action 2.14, we do not view widespread predator control as a recovery action; however the RITs may propose specific measures in localized areas for further consideration.

Comment: One commenter suggested that translocation and augmentation are proven successful, thus we should take a strong position to implement translocation/augmentation in areas where RITs determine the method viable, regardless of legal challenges.

> Response: While some studies have shown initial success in translocation to be high, we will not know how much population augmentation will increase population numbers for the long-term until we implement experimental augmentations in conjunction with threats management. Defining success on the population level (as opposed to defining success based on concern over each individual's fate) will be important as we proceed with translocation and/or augmentation.

Comment: One commenter stated that the draft recovery plan fails to cite scientific studies (published or otherwise) on headstarting in support of using this unproven strategy for desert tortoise recovery.

> Response: The statement by the commenter is incorrect. The draft Recovery Plan cites several studies pertaining to head-starting of desert tortoises and indicates that these studies lay a foundation from which to build. The plan also states that augmentation will be approached experimentally, in terms of the continued development and evaluation of techniques (including head-starting).

Comment: Two commenters state that augmentation of desert tortoise populations should not replace or reduce efforts to tackle critical decisions that need to be made regarding public lands management and that reducing or eliminating known or suspected causes of breeding adult tortoise mortality should remain the primary emphasis of the recovery plan.

> Response: We agree that augmentation actions should not detract from efforts to implement key land management actions to reduce threats. In the plan we state that it is important to understand that increasing numbers through augmentation alone will not result in recovery. The causes of population declines must be addressed and augmentation is only an intermediate strategy to gain insight into causes of declines and to attempt to increase population numbers more rapidly than possible through natural processes.

Comment: Several commenters stated that threats must be minimized or eliminated at sites prior to augmentation attempts or the effort will be defeated. One commenter further suggested that discussion about population augmentation be expanded to include consideration of habitat quality and carrying capacity.

> Response: We agree that ideally all existing threats would be minimized at sites where population augmentation is to be implemented in order to realize the greatest increase in tortoise numbers. In fact, when threats are known, we state that augmentation will be used in conjunction with elevated threats management and/or habitat restoration. Unfortunately, in some cases the original causes of declines at sites are unknown and too few tortoises remain at those sites to investigate the causes of declines and effectiveness of recovery actions. For these reasons, Strategic Element 3 and particularly Recovery Action 3.4 call for implementing augmentations using a scientifically rigorous, research-based approach, including considerations of habitat quality that may affect carrying capacity. In addition to habitat considerations, Recovery Action 3.2 (identification of sites for population augmentation) emphasizes knowledge about the population existing at the recipient site when identifying sites for augmentation. Such an approach will allow us not only to evaluate the factors that affect the success of augmentations, but also to learn more about threats that continue to act on those populations and evaluate the effectiveness of targeted recovery actions.

Comment: One commenter asked if population augmentation would result in greater chance for spread of upper respiratory tract disease due to high densities of animals.

> Response: The population augmentation strategy will take into consideration current knowledge of disease in desert tortoise populations to avoid spreading upper respiratory tract or other diseases.

9. Strategic Element 4 – Monitoring

Comment: One reviewer suggested that the monitoring program should be linked to the adaptive management program. The reviewer expressed concern that, as currently proposed, the monitoring program will not have the power or specificity to be useful in an adaptive management or decision-support framework.

> Response: The range-wide monitoring program described in the revised plan targets estimation of population trends at the recovery unit scale, which will provide indirect evidence of the effectiveness of the overall recovery program over time (*e.g.*, 25 years). The monitoring component of the adaptive management five-year action plans will proceed primarily through directed effectiveness monitoring and effectiveness research (*e.g.*, Recovery Action 5.4). Effectiveness monitoring will require the Recovery Implementation Teams (RITs) to identify specific impacts that will be affected by management activities and to develop indicators or metrics for whether or not the management action is affecting the threat. Recovery Action 5.3 also specifically recommends that models of recovery action effectiveness be developed and tested and that conceptual models that explicitly define expected outcomes be developed for all recovery actions.

Comment: Two commenters suggested that the current method of monitoring trends in desert tortoise populations (line distance sampling) may be statistically inadequate.

Response: Improvements to the range-wide monitoring program continue to be made, and we are confident that the program will be sufficient to detect trends in desert tortoise populations over a period of approximately 25 years.

Comment: One commenter suggested that monitoring protocols or methodologies be consistent across recovery units and not be left to stakeholder-driven RITs for development.

Response: Range-wide protocols currently exist for monitoring Recovery Criterion 1a and are consistent across recovery units. Specific protocols for monitoring the remaining recovery criteria will be developed by the Fish and Wildlife Service. We will consider suggestions made by the Science Advisory Committee and other outside experts as we develop the protocols.

Comment: One commenter suggested that we develop a suite of indicator species that could be monitored to provide more timely responses to changes in management actions or threat severity.

Response: We are unaware of any evidence that there are true indicator species for the desert tortoise; *i.e*., there is no reason to believe that side-blotched lizards, kangaroo rats, or other recommended species will respond to environmental conditions in the same way as tortoises or help us to better understand the status of the tortoise.

Comment: One commenter suggested that monitoring should be continued as part of a comprehensive adaptive management strategy, but it should not be as emphasized in the Implementation Schedule as activities that will accomplish recovery.

Response: Monitoring is included in the Implementation Schedule as a necessary activity through which progress toward recovery will be measured.

Comment: One commenter noted that it was not obvious how occupancy estimates would estimate population growth rate.

Response: Applying occupancy to abundance estimation is an active area of research (Royle *et al*. 2005; MacKenzie *et al*. 2006, Chapter 10). While the revised plan does not specifically rely on occupancy estimation to assess trends in rates of population change, this approach may provide an additional measure in the future.

10. Strategic Element 5 – Research

Comment: One commenter suggested the recovery plan should be proposing testable hypotheses that can provide the basis for expanding our understanding.

Response: While the recovery plan does not identify specific hypotheses, we will work with the Management Oversight Group, Science Advisory Committee, and Recovery Implementation Teams (RITs) in establishing research priorities within the broad recommendations contained herein. The spatial decision support system will also aid in targeting research within the recovery units.

Comment: One commenter noted that, despite the amount of research on disease that has been conducted to date, little research has investigated the role disease has played in tortoise population declines relative to other threats and that the revised plan fails to commit meaningfully to disease research.

Response: We specifically considered this topic in developing the recovery plan. Detailed research recommendations are included in Recovery Action 5.4 to specifically focus research on disease.

Comment: One commenter criticized the lack of research on habitat quality to date and asserted that the lack of research quantifying specific characteristics that contribute to habitat quality relegates statements in the revised plan about the effect of habitat degradation on tortoises to mere assumptions without evidentiary support.

Response: It is well known in the ecological literature that habitat quality can affect wildlife demography (see Pulliam 1996, for example), and the revised plan documents numerous specific direct and indirect impacts to desert tortoise habitat that can, in turn, impact individual tortoises. The revised plan specifically recommends research to more directly quantify factors affecting tortoise habitat quality relative to demographics and population-level effects.

Comment: One commenter suggested that effectiveness monitoring needs to demonstrate recovery value prior to requiring significant investments from partners least able to bear the cost.

Response: As noted previously, recommended recovery actions are based on justifiable information. Recovery Actions 5.3 and 6.2 specify that the RITs should be directly involved in identifying priorities for effectiveness monitoring. The development of conceptual models and implementation of the spatial decision support system will assist in ensuring that effectiveness monitoring is targeted toward projects with the highest estimated recovery value or greatest degree of controversy or uncertainty. Recovery Implementation Teams should also identify funding opportunities to implement effectiveness monitoring projects.

Comment: Some commenters recommended that disease research be continued, particularly with respect to determining the feasibility of using diseased females in headstarting, and that diseases other than upper respiratory tract disease be investigated. One commenter indicated that disease research should be reduced in priority relative to other actions.

Response: Clarifying the role of disease and identifying effective management actions to alleviate it is an important task for recovery. Recovery Action 5.4 specifically recommends, among other topics, that other known or emerging diseases be evaluated for effects on desert tortoise populations.

11. Strategic Element 6 – Adaptive Management

Comment: One reviewer recommended that clearly stated hypotheses about tortoises and effects of recovery actions be developed. Then, modeling should be used to estimate power of monitoring and to simulate how best to test hypotheses.

> Response: This is a primary goal of the spatial decision support system (SDSS) and Recovery Implementation Teams (RITs). However, most of modeling the effects of recovery actions will likely not include tortoise responses, rather surrogate or indicator responses to actions, such as an increase in habitat or reduction in threat.

Comment: One reviewer urged that an explicit link between the SDSS and recovery objectives be made.

> Response: Given the lack of quantitative information on the relationships between threats, management actions, and tortoise populations, it is difficult to explicitly link the SDSS directly to the recovery objectives. Instead, we expect the SDSS to help strengthen our understanding of these relationships so that more direct links between management actions and recovery targets can be made in the future.

Comment: Several commenters expressed concern about the revised plan's reliance on adaptive management. In particular, commenters felt that specific goals and objectives are lacking, which will lead to non-recovery and excessive paperwork and that the adaptive management portion of the plan is simply a poorly-veiled effort to continue with the failed policies of the last 20 years.

> Response: The emphasis on adaptive management in the revised plan is not to create excessive paperwork or to continue failed policies. Rather, this emphasis recognizes that a successful recovery program depends on clearly identifying objectives (*e.g.*, related to desert tortoise populations or habitat), a set of potential actions, and some expectation of the consequences of each action relative to the objectives, described through conceptual models. The SDSS provides a framework within which to prioritize and implement recovery actions and develop and evaluate the conceptual models, thereby providing more explicit measures of recovery progress than in the past.

Comment: One commenter asked how the monitoring component of adaptive management will actually work. Concern was expressed that because of the pace of the response, if measured by change in tortoise numbers, feedback will not likely to be a significant component of recovery management over the life of this recovery plan.

> Response: The monitoring component of the adaptive management five-year plans will proceed at three levels: 1) effectiveness monitoring, 2) population monitoring, and 3) effectiveness research. Effectiveness monitoring will require the RITs to identify the specific impacts that will be affected by management activities to develop indicators or metrics for whether or not the management action is affecting the threat. For example, if off-road vehicle use is linked to habitat degradation, and we postulate that closing roads and vertical mulching in a particular tortoise conservation area will decrease travel within the area, we can monitor the change in travel in that area with metrics such as "miles of open road" or "OHV track density" or "scarring" as viewed with satellite imagery.

Population monitoring will continue to be undertaken at the recovery unit scale to determine population trends through our range-wide monitoring program. Range-wide monitoring can assess the overall effectiveness of the recovery effort through time. Effectiveness research can begin to address questions such as: what is the effect of closing off-road vehicle routes, closing and vertical mulching off-road vehicle routes, and closing, mulching, and signing routes on the quality of tortoise forage? To answer these questions, several experimental and control plots would be created where specific qualities of tortoise forage could be monitored and statistically compared between control and experimental plots to determine the effectiveness of various recovery actions.

Comment: One reviewer recommended testing the SDSS with historical data.

Response: We hope that validation of the SDSS can take place within the RITs, by comparing model outputs conceptually or, best of all, by comparing outputs with data from the field. Historical data may play a role in these sensitivity analyses.

Comment: One commenter suggested that the Desert Tortoise Recovery Office retain the centralized tracking system capability of the SDSS that records implementation inputs and accounts for desert tortoise recovery that occurs either naturally or as the result of recovery actions, but cautioned that the SDSS should not rely on subjective judgments by biologists or managers.

Response: The "tracking" capacity of the SDSS is an important piece of the system, and the Desert Tortoise Recovery Office will be intimately involved in its management. To know where recovery actions are taking place on the ground is important in and of itself. The process of modeling the effects of individual threats on tortoises and the effectiveness of recovery actions to ameliorate these threats will be used in addition to the tracking capacity to assess the significance of data gaps and uncertainties and to predict the effects of alternative management actions. Subjective judgments by biologists or managers (expert opinions) that currently populate these models are simply the best information that we currently have to understand the relationship between particular threats and tortoise declines and how particular recovery actions will affect those threats. As management actions are implemented, "hard data" are collected, or better models developed regarding how particular management actions actually affect threats on the ground, then this information will take the place of subjective judgments in the SDSS, and management plans will be revised based on our improved understanding.

Comment: Several commenters expressed concern about the publication of a prototype SDSS which relies on incomplete data and subjective information in the form of survey responses; as such, the recovery plan fails to establish a broadly acceptable and scientifically credible base of information.

Response: Common misperceptions about modeling include that models cannot be built with incomplete understanding, with gaps in the data, or before they have been validated or “proven,” among others (Starfield 1997). In addition to the response above, we note that the prototype SDSS uses the best data that could be obtained within the planning timeframe and provides a guide as to what data are most needed. The initial datasets and prototype SDSS provide a baseline and a way to prioritize the next round of data gathering. The RITs will emphasize updating and improving the database. Sensitivity analyses will be conducted on the initial data to create a prioritized list of data needs, and the RITs will then work to deepen/edit/validate that prioritization using the SDSS and come up with a plan for the next round of data acquisition.

Comment: One commenter asked that we ensure that use of the SDSS as a tool to prioritize actions is not a black box.

Response: Within the first year after publication of the final, revised plan, the RITs, Desert Tortoise Recovery Office, and other partners will update the underlying data in the SDSS for at least two recovery units, including data on threats and current recovery action implementation. This stage should be completed for the remaining recovery units within the second year, and regular updates to all recovery units should occur on an ongoing basis thereafter. The process of updating the underlying data will provide an important opportunity for all components of the SDSS to be revisited by the RITs and other interested parties and for the framework of the system to be reviewed.

Comment: One commenter asked for clarification as to the compatibility of scales within the model and how the spatial extent of data layers may impact model input and output.

Response: Some datasets cover only part of the range. The model treats areas with no data for a particular threat as if the threat does not exist in that area. For all scales to be compatible, technically, all data should be re-sampled to the least accurate scale. As we move from the rapid prototype to a more detailed regional tool, the most current and accurate data will be obtained at as fine a resolution as possible.

Comment: Several commenters warned that the revised plan fails to confirm funding and resources to support the RITs and their development of action plans and that the costs of implementing the RIT process in both time and money is yet another set-back to tortoise recovery.

Response: Recovery plans are guidance documents that identify needed actions and approximate costs of those actions. Their purpose is not to identify resources to accomplish all actions. The RIT process will focus efforts on securing the necessary resources to implement recovery actions on the ground. We view the RIT process to be an important step forward from the 1994 Recovery Plan to maintain focus on coordinated implementation of the actions described in the revised plan.

Comment: One commenter asked what benchmarks will assure that the RIT action plans actually promote recovery.

Response: The structure of the adaptive management process requires agreed-upon objectives and provides feedback to ensure that actions are effective. Benchmarks to determine effectiveness will be identified in the planning process by following the adaptive management tenants: 1) appropriate monitoring of an action, 2) agreed upon criteria to determine whether an action is effective, and 3) agreed-upon actions to take as a necessary step for a research action or for a management action if the effectiveness threshold is not reached during the agreed upon timeframe.

Comment: Two commenters recommended that the Science Advisory Committee should be independent of the Desert Tortoise Recovery Office or should not receive financial benefits to conduct research or implement actions to accomplish recovery goals.

Response: The primary role of the committee is advisory to the Fish and Wildlife Service. The committee has assigned a chair from among its membership. The chair will coordinate with the Desert Tortoise Recovery Office on topics for the agenda. An important role of the Science Advisory Committee is to advise us on specific, priority topics which could be addressed by a variety of individuals or groups.

12. Recovery Units

Comment: One reviewer expressed that additional genetic data are not likely to contribute a great deal more to the current recovery planning; resources might be better used for field studies to determine why current efforts have not produced more positive results.

Response: Recovery Action 5.5 has been modified to de-emphasize research on population structure per se and to focus on determining the importance of corridors and barriers to desert tortoise distribution and gene flow.

Comment: One reviewer pointed out that the sampling for genetic analyses in Murphy *et al*. (2007) is a concern, leading one to wonder whether patterns observed are function of real breaks in genetic structure or artifacts of disjunct sampling. One commenter also suggested that given the isolation-by-distance character of desert tortoise population genetic structure and the discrete sampling of populations across large areas of continuous habitat by Murphy *et al*. (2007), assignment tests or other clustering methods should be used with caution as evidence for population differentiation. Violating assumptions of discrete populations can produce misleading interpretations.

Response: We agree and state in the revised plan, "To describe genetic relationships within species, particularly boundaries between divergent units, methods require analysis of many individuals sampled across relatively evenly spaced locations to avoid wrongly inferring genetic discontinuities between disjunct sampling locations (Pritchard *et al*. 2000; Allendorf and Luikart 2007:400)."

Comment: One commenter stated that identification of multiple recovery units amounts to an unlawful designation of distinct population segments (DPSs). The commenter also claimed that the draft plan is inconsistent in stating that recovery must be achieved in all recovery units before delisting can occur, but also that individual recovery units could be delisted through rule-making procedures.

Response: As stated in the revised plan, recovery units are tools used to identify geographic units that are individually necessary to conserve the diversity necessary for long-term sustainability of the entire listed population. They are not equivalent to DPSs which have been identified in a formal rule-making process. The recent 5-year review concluded that individual recovery units within the Mojave population do not qualify as DPSs (USFWS 2010). We have clarified the text of the revised plan accordingly.

Comment: One commenter suggested that identifying multiple tortoise conservation areas within multiple recovery units is unnecessary to conserve the single listed Mojave population of the desert tortoise. The commenter also recommended that reliance on multiple-use Bureau of Land Management lands be minimized for recovery relative to National Park Service, wilderness, and wildlife refuge designations, especially those areas that are isolated, likely disease-free, and have had conflicting land uses removed or mitigated. The commenter specifically recommended Red Cliffs, Utah; Piute Valley, Nevada; Mojave National Preserve, California; Chemehuevi, California; and Tassi-Pakoon, Arizona as areas for recovery emphasis.

> Response: The recovery emphasis areas suggested by the commenter fail to preserve the diversity necessary for long-term sustainability of the desert tortoise across its entire listed range. While tortoise conservation areas include all desert tortoise habitat within National Park Service, National Wildlife Refuge, and other lands designated for habitat or tortoise conservation, achieving sustainability of the desert tortoise across its range requires conservation on multiple-use lands in areas where other, more protective designations are lacking.

Comment: Several commenters claimed that the draft plan did not use the best scientific data in the delineation of recovery unit boundaries, especially with respect to not subdividing the Western Mojave Recovery Unit. In particular, these commenters felt that the draft plan placed too much reliance on an unpublished report by Hagerty and Tracy compared to the published paper by Murphy *et al*. (2007). Other commenters indicated that the recovery units make sense and are well supported by a combination of data.

> Response: We critically evaluated the published literature and additional data that were available when we identified recovery unit boundaries. Differences from recommendations made by Murphy *et al*. (2007) are described in the revised plan, justified by documented scientific literature, and supported by peer review. We clarified and added additional language to the section "Assessment of Revised Recovery Units." Claims that the draft plan over-emphasized the Hagerty and Tracy report are not supported by the fact that, of the 14 times the report was cited, 9 of those times it was cited with additional supporting references (including 7 times in which it was cited with Murphy *et al*. [2007]). Nevertheless, Hagerty's Ph.D. dissertation has been completed and papers published since publication of the draft plan, and citations of the report have been replaced with references to Hagerty (2008), Hagerty and Tracy (2010), and Hagerty *et al.* (2010) in the final plan.

Comment: One commenter disagreed with the combination of the original Northern Colorado and Eastern Colorado recovery units on the bases that Murphy *et al*. (2007) correctly assigned >70% of their samples to each unit; major differences in climate, forage availability, and seasonal activity occur across the region; the original recovery units are about 40 miles apart, separated by numerous natural and anthropogenic barriers; and different threats exist between the two original units.

Response: High gene flow across the range of the desert tortoise is supported by the fact that analysis of molecular variance revealed that over 88 percent of the variation occurs within, not among, populations (Murphy *et al*. 2007; Hagerty 2008). In addition, with the exception of the Upper Virgin River Recovery Unit, assignment tests incorrectly placed 11 to 45 percent of individuals (Murphy *et al*. 2007). Some incorrect assignments could be explained by human-mediated translocation, but incorrectly assigning 11 to 45 percent of individuals is unlikely to be explained by translocations alone, especially given the general failure of early translocations (Berry 1986). In contrast, greater than 90 percent of gopher tortoises were assigned to the correct genetic assemblage (with fewer molecular markers than used by Murphy *et al*.) from where they were sampled in Georgia and Florida, where relocations of tortoises have been extensive (Schwartz and Karl 2005). The revised plan clarifies the rationale for combining the Northern and Eastern Colorado recovery units, particularly on the basis of evidence of historic population connectivity and gene flow at the southern end of the Cadiz Valley; little genetic differentiation between populations sampled in the two former recovery units, as well as the likely influence of gaps in genetic sampling in this area (as noted by the second comment in this section); and the gradient of environmental variation between these units.

Comment: Several commenters claimed that the data provided in the Hagerty and Tracy report cited in the draft revised recovery plan are insufficient to accurately assess its findings.

Response: We agree with the comment. The Hagerty and Tracy report was not formatted for publication or drafted for peer review, but rather to provide a brief overview of the presentation to the Science Advisory Committee in March 2007. However, Hagerty's Ph.D. dissertation and related papers have been completed, and citations of the report have been replaced with references to Hagerty (2008), Hagerty and Tracy (2010), and Hagerty *et al.* (2010) in the final plan. We note that in most cases, this study provides complementary, rather than contradictory, support to other cited literature. As indicated in the response to previous comments, identification of recovery unit boundaries are fully described in the final plan, justified by documented scientific literature, and supported by peer review.

Comment: One commenter noted that the sample locations depicted in Fig. 1 of Murphy *et al*. (2007) appear to be broader than depicted in Fig. 7 in the draft plan.

Response: Murphy *et al*. were unable to provide a digitized map of their sampling locations, so we circumscribed the areas as described in Table 1 of their paper. As a result, the depiction was somewhat imprecise, but not so imprecise as to affect related inferences in the revised plan. Part of the apparent discrepancy is due to the smaller scale of Murphy *et al*., Fig. 1, relative to Fig. 7 in the draft revised plan. Note that, for clarity in the figures, the genetic sampling areas are not depicted in the maps in the final revised plan.

Comment: One commenter noted that neither Murphy *et al*. (2007) nor the Hagerty and Tracy report considered a recent paper by Evanno *et al*. (2005) on assessing population genetic structure, which could influence the results of each study, particularly in the Western Mojave.

Response: We agree with the comment (but note that the more recent analysis by Hagerty [2008] did consider this paper). As indicated in the revised plan, and supported by Berry *et al*. (2002) and Allendorf and Luikart (2007:400), other methodological issues with the Murphy *et al*. (2007) analysis make recommendations for recovery unit delineation based solely on that study problematic. As noted above, we generally used the Hagerty and Tracy report as support for recovery unit boundaries complementary to other evidence. We stressed identification of geographic discontinuities or barriers that coincide with any observed variation among tortoise populations in delineating recovery unit boundaries.

Comment: One commenter suggested that the Fenner and Chemehuevi valleys (in the Colorado Desert Recovery Unit) are fragmented by I-40; tortoise movement from one valley to the other can only be made functional by augmentation and installation of highway culverts with fencing.

Response: We agree with the comment. The revised plan describes the geographic, ecological, and genetic bases for including these valleys within the Colorado Desert Recovery Unit. Recovery Action 2.5 specifically addresses fencing I-40, and Recovery Action 2.11 addresses connecting functional habitat with culverts.

Comment: One commenter asked whether there is good evidence that the Providence and New York mountains actually form a barrier between designated recovery units.

Response: While these ranges may be somewhat permeable and may not form absolute barriers, landscape-genetic analysis conducted by Hagerty (2008) reveals a substantial break in gene flow here.

Comment: One commenter suggested that application of the recovery unit concept within the desert tortoise recovery plan increases the barriers to de-listing and recovery. The commenter recommended that DPSs be designated so that individual units can be delisted. Another commenter claimed that we failed to designate DPSs according to the 1996 *Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act*.

Response: As noted in the revised plan, DPSs must be designated through formal rule-making processes and cannot be done in a recovery plan. Under section 4(c)(2) of the Act, the Service conducts 5-year reviews to determine if a federally listed species should be delisted, reclassified from endangered to threatened status or from threatened to endangered status, or status of the species should remain the same. The recent 5-year review for the desert tortoise found that individual recovery units within the Mojave population did not qualify as DPSs under the 1996 policy (USFWS 2010).

13. Recovery Objectives and Criteria

Comment: One commenter requested that historical permanent study plot data be correlated to new range-wide monitoring data (2001-2008).

Response: A comparison of historical plot data and recent range-wide monitoring data is planned. As we make progress in identifying specific demographic study areas, which will draw heavily from the historical plots, increased emphasis will be placed on this analysis. This may help place local data in the context of the range-wide pattern.

Comment: Several commenters criticized the recovery criteria for lacking specific numerical baselines against which recovery will be measured.

> Response: The recovery criteria emphasize monitoring trends over a period of at least 25 years. For trend analysis, the baseline is represented by a parameter value at the earliest time represented by the regression. The population size at delisting can be estimated at that time because it will be the result of any increasing trend since that baseline. However, neither of these values - the starting population size nor the ending population size - was used to develop recovery criteria. Some comments expressed concern about the possibility that basing recovery on increasing trends beginning with reduced populations will result in the species being delisted at numbers well below historic levels. However, we will never be able to do more than speculate about how recovery population size compares to historical "baselines," because there are no historic data on landscape-level population numbers to make such a comparison. Note that there is no basis to presume that historic densities seen on localized plots (placed largely within higher-density areas) are necessary for long-term survival and recovery across entire conservation areas. On the other hand, if positive population growth trends are seen over the recovery period, we should have confidence that population densities are not limiting recovery. Interim evaluations during the monitoring period will provide periodic checks on the progress of recovery efforts.

Comment: One commenter suggested that threat-based criteria must be added to the recovery goals and objectives. On this topic, another commenter stated that we should eliminate all known or suspected sources of mortality to desert tortoises.

> Response: As indicated in the revised plan, even though a wide range of threats affect desert tortoises and their habitat, very little is known about their demographic impacts on tortoise populations or the relative contributions each threat makes to tortoise mortality. For example, we lack quantitative data on the specific contribution of raven predation, disease, or other individual threats on tortoise population declines, data which are needed to identify specific and meaningful threats-based recovery criteria. As quantitative information on threats and tortoise mortality is obtained, more specific threats-based recovery criteria may be defined during future recovery plan revisions. In the meantime, we have addressed all substantive identified threats (*i.e.*, sources of mortality) in the recovery actions outlined in the plan, and we assume that threat amelioration will have been successful if the current recovery criteria have been met.

Comment: One commenter criticized the lack of triggers for adaptive management if populations continue to decline.

> Response: Trends in population status will regularly be evaluated through Desert Tortoise Recovery Office oversight of the range-wide monitoring program. This evaluation, in conjunction with other threat- and implementation-status information, integrated into the spatial decision support system will provide the basis for redirecting recovery efforts through adaptive management.

Comment: Several commenters object to the recovery criterion (also included in the 1994 Recovery Plan) that the rate of population change is increasing ($\lambda > 1$), suggesting that this criterion fails to ensure recovery.

> Response: There are no historic data on landscape-level population numbers to make a comparison against a specific population size, and there is no basis to presume that historic densities seen on localized plots (placed largely within higher-density areas) are necessary for long-term survival and recovery across entire conservation areas. Further, recovery is not linked to "lambda greatly exceeding 1," as indicated by one commenter. For tortoises, with low intrinsic reproductive rate, lambda is expected to be only slightly positive during population growth and may well even be negative in areas at carrying capacity. In otherwise suitable habitat, this would reflect a healthy population.

Comment: Several commenters oppose the use of 90-percent confidence limits instead 95-percent.

> Response: While 95-percent confidence intervals may be more commonly used, they are no less arbitrary than 90-percent intervals. A 90-percent confidence interval describing trends of actual data will be narrower than a 95-percent interval. A 90-percent confidence interval could thus lead us to decide that a population trend really is increasing more often than would a 95-percent confidence interval (*i.e.*, more trends, whether apparently increasing or decreasing, will be indistinguishable from zero at 95-percent confidence). However, if the true trend in the population is actually zero or declining, the narrower 90-percent confidence interval will prevent us from describing that trend as a positive one. Therefore, the recommendation in the revised plan represents a more conservative conservation threshold in that it more effectively guards against an inaccurate conclusion that a declining population is actually increasing.

Comment: One commenter suggested that given the difficulties of sampling desert tortoises, it is unclear whether Recovery Objective 1 can be met on Bureau of Land Management lands.

> Response: Even though the Bureau of Land Management is the predominant management agency of desert tortoise habitat, Recovery Objective 1 will be assessed across tortoise conservation areas within each recovery unit, regardless of land management authority. Ability to detect trends of small magnitude across tortoise conservation areas can be examined with a power analysis, which was first conducted by Anderson and Burnham (1996) when the distance sampling approach was customized for monitoring desert tortoises. Although there are some unknowns remaining in our assessments, such as just how fast tortoise populations can increase and what sort of population fluctuations to expect as the populations increase, detecting a trend that exists is fairly straightforward, and it has been demonstrated that the existing range-wide monitoring approach can detect these trends with sufficient resources dedicated to the monitoring effort. Much of our confidence in the ability to detect any positive trend (if it occurs) is that trends send a stronger and more detectable signal the longer we monitor them.

Comment: One commenter suggested that achieving a well-distributed population throughout each recovery unit may be difficult due to variable habitat suitability and quality.

Response: Recovery Objective 2 does not seek an *evenly* distributed population within each recovery unit, but a well-distributed population within suitable habitat in the tortoise conservation areas.

Comment: Several commenters claimed that Recovery Objective/Criterion 2 "writes off" the full range of the desert tortoise by limiting its focus to tortoise conservation areas and ignoring habitat outside of those areas. The commenters suggested that the recovery plan should address the possibility that the desert tortoise's range may shift in response to climate change and must include recovery actions that monitor and model the effects of global warming on tortoise demographic parameters and population growth.

Response: The revised plan acknowledges that projects occurring both inside and outside these areas are subject to existing State laws and the Federal section 7 and 10 processes under the Endangered Species Act and that populations, habitat, and actions outside these areas may affect recovery of the desert tortoise. Recovery Action 1.1 directs Recovery Implementation Teams (RITs) to identify areas not included within existing tortoise conservation areas that may warrant focused management efforts to ensure recovery. Furthermore, Recovery Action 5.1 calls for modeling tortoise demography relative to habitat condition and a changing climate which may provide information on which to base new recovery actions or establishment of new, or expansion of existing, conservation areas.

Comment: One commenter suggested that more information is needed regarding the relationship of Recovery Objective 2 to species recovery, specific methods, and specific goals.

Response: Because habitat loss has been identified as one of the threats leading to decline of desert tortoises, the specific intent of this objective is to demonstrate recovery as measured by successful, increasing occupation of potential habitat. We agree that measurement of available habitat will reflect a shifting geographic area over this period of time, so the method described in the recovery plan (occupancy estimation) empirically determines directly whether tortoises are occupying the same, more, or less area. Occupancy estimation is an established monitoring technique (MacKenzie *et al*. 2006) that is based on sampling from larger areas. The ability to use a sampling approach with a species that is so wide-ranging makes this approach even more attractive.

Comment: One commenter indicated that Recovery Criterion 3 should include private lands because of the checkerboard nature of land ownership in some areas and the potential for fragmentation.

Response: We agree that checkerboard land ownership presents particular challenges to landscape-level recovery efforts. However, given the vast amount of desert tortoise habitat already under government management, we have excluded private lands from the "no net loss" standard of Recovery Criterion 3. We note that private lands are still subject to the "take" provisions of Section 9 of the Endangered Species Act and that Recovery Action 2.9 is directed toward acquiring, or otherwise securing for conservation benefit, sensitive private lands that would connect functional habitat or improve the management capability of surrounding land within tortoise conservation areas.

Comment: Several commenters suggested that habitat restoration is unproven in repairing all ecological functions of undisturbed habitat and that restoration (or the minimum conditions for such) needs to be specifically defined, particularly with respect to the length of time that degraded habitat may require to become suitable for desert tortoises.

> Response: We agree that it may take many years before particular parcels of “restored” habitat become suitable for desert tortoise occupancy, as reflected in the text describing Recovery Action 2.6. With respect to Recovery Objective/Criterion 3, the quantity of desert tortoise habitat will be measured over time against the threshold of complete loss of the elements necessary for desert tortoise occupation (see Box 5). Habitat restoration will have to provide sufficient resources for desert tortoises to reoccupy such lands, whether or not the habitat quality is sufficient for optimal or maximum reproductive output or survival. As specific habitat parameters are identified that correlate with desert tortoise demographic rates, restoration goals should be defined specifically according to those parameters.

Comment: Two commenters were critical of the statement in the revised plan that "the target for no net loss established by Recovery Criterion 3 may be relaxed on a limited, case-by-case basis, if we determine that greater recovery benefits can be achieved ... ."

> Response: This statement acknowledges the fact described in the introduction to the Recovery Goal, Objectives, and Criteria section that all recovery criteria are targets, rather than strict rules, by which progress toward recovery is measured. The statement further acknowledges that in some (limited) circumstances conservation measures may be identified that would provide greater recovery benefit than an acre-for-acre replacement of lost habitat. In these cases, we should strive to achieve the greatest recovery benefit while maintaining an eye toward achieving the no-net-loss of habitat standard as closely as possible.

Comment: One commenter suggested that we failed to provide an updated population viability analysis, which should be a necessary component of the revised plan.

> Response: The revised plan relies on the conclusions of population viability analyses included in the 1994 Recovery Plan by emphasizing protection and enhancement of desert tortoise populations within tortoise conservation areas, which coincide broadly with the Desert Wildlife Management Areas recommended in that plan. We recognize that as new demographic data become available (*e.g.*, through additional monitoring of demographic study areas pertinent to Recovery Criterion 1b), population viability analyses should be reinvestigated. More emphasis should be placed on exploring the impact of environmental catastrophes and long-term persistence within the tortoise conservation areas. Toward that end, we have recently initiated a project to conduct spatially-explicit population viability analyses.

Comment: One commenter noted that habitat loss, degradation, and fragmentation were not quantified in the revised plan and that it was therefore unclear whether habitat impacts were a serious threat to the desert tortoise.

Response: The revised plan provides numerous examples and references regarding habitat-related impacts to the desert tortoise. Unfortunately, as with most other threats, these impacts have not been systematically quantified or centrally compiled into a geospatial database. As a result, the revised plan emphasizes the development of a spatial decision support system in which such information will be compiled, reported, and used to help determine the relative magnitude of different threats and the local/regional priorities for managing those threats.

Comment: Several commenters noted that the no-net-loss standard in Recovery Criterion 3 and the 1 percent allowable disturbance under the Bureau of Land Management resource management plans in California do not mesh. One commenter further suggested that relying on the draft U.S. Geological Survey habitat model is premature and that it is unclear whether the no-net-loss objective is obtainable in light of global climate change, wildfires, and spread of invasive plants. Tracking this criterion will require a significant infrastructure mechanism.

Response: We note that the proposed Resource Management Plan and final Environmental Impact Statement for the Arizona Strip Field Office, Vermillion Cliffs National Monument, and Bureau of Land Management portion of the Grand Canyon-Parashant National Monument (BLM and NPS 2007) prescribes no net loss in the quality or quantity of desert tortoise habitat within Areas of Critical Environmental Concern (included in the revised plan as tortoise conservation areas). However, Recovery Criterion 3, like all recovery criteria, are targets, rather than strict rules, by which progress toward recovery is measured. If, after 25 years, 99 percent of current tortoise habitat has been conserved (rather than a net 100 percent) and tortoise populations and distribution have increased within that habitat as per Recovery Criteria 1 and 2, it would seem appropriate to evaluate whether or not delisting is warranted based on an analysis of the five listing factors identified in the Endangered Species Act. The habitat model has been finalized since publication of the draft plan, and its use should form the baseline for measuring changes in habitat quantity. We agree that this criterion requires a significant commitment to monitoring and that research into the effects of global climate change, invasive plants, and wildfires (as recommended in the revised plan) is essential to understand and mitigate effects to desert tortoise habitat.

Comment: One commenter suggested that the no-net-loss concept is impractical and that the recovery plan should contain language that provides for a reasonable amount of mitigated land uses within tortoise conservation areas that recognizes valid existing and appropriate uses.

Response: Given the current status of the desert tortoise, we do not believe that continued habitat loss within tortoise conservation areas is consistent with desert tortoise recovery, unless those losses are offset by habitat gains elsewhere or by other actions reasonably certain to enhance recovery more than habitat replacement would.

Comment: One commenter stated that the revised plan fails to identify the baseline areas where “no-net-loss” shall be measured, but instead relies on this to be determined by the RITs without guidance as to what constitutes disturbed lands.

Response: As described in the revised plan, no net loss under Recovery Criterion 3 will be measured across all potential desert tortoise habitat (based on the final U.S. Geological Survey habitat model) within tortoise conservation areas at the time of publication of the final plan. The RITs will use this information to clarify the baseline specifically in areas where critical habitat does not align with designated Desert Wildlife Management Areas or Areas of Critical Environmental Concern. Habitat subtracted from the baseline as of the publication date of the final plan, habitat loss as defined in Box 5, includes lands that have had complete removal of the elements necessary for desert tortoise occupation.

Comment: Two commenters questioned how mitigation acquisitions within conservation areas would be added to the baseline for calculating no net loss, particularly whether private lands were excluded from the initial baseline but could be added if acquired for conservation, thereby increasing the balance of conserved habitat on paper but not on the ground. One indicated that lands acquired as mitigation for existing projects cannot be used as grounds for allowing new development elsewhere.

Response: The goal of Recovery Criterion 3 is to focus efforts on maintaining at least the amount of desert tortoise habitat that currently exists under Federal or conservation management within the tortoise conservation areas into the future. While the revised plan recommends protecting desert tortoise habitat from land disturbance (Recovery Action 2.1), such projects will still occur on Federal and non-Federal lands, both inside and outside tortoise conservation areas. These projects must comply with sections 7 and 10 of the Endangered Species Act, and habitat acquisition is one tool that can be used to offset related impacts. Habitat acreage lost to such projects will be subtracted against the "ledger" of conserved habitat, and new acreage placed into conservation will be added.

14. Implementation Schedule

Comment: One commenter suggested that, due to the high anticipated cost of the recovery program, we should identify one to three actions that can be taken that will yield the biggest payoff at the most reasonable cost and that are likely to be funded. This approach, targeted toward a reduced number of recovery focal areas, would avoid the current "shotgun" approach of implementing only a few actions in many areas.

Response: As noted in previous comment responses, we believe that all of the tortoise conservation areas and recommended recovery actions (which have been broadly prioritized) are necessary for recovery of the desert tortoise. We agree with the comment and with the conclusions of Tracy *et al*. (2004) that the approach of implementing a few actions in a lot of places is inefficient and not likely to lead to recovery. Therefore, to the extent that full and immediate implementation is constrained by available resources, the revised plan emphasizes the use of a spatial decision support system by the Recovery Implementation Teams to identify which actions offer the biggest return on investment for each Team's respective areas, implement those actions, update the decision support system, and re-evaluate new priorities on a regular basis.

Comment: One commenter suggested that the statement that many tasks are already ongoing and should therefore continue conflicts with the premise of adaptive management and that it’s time to stop those management actions that are not contributing to recovery and forge a new path forward with efficient monitoring practices in place to detect future negative or positive results in the tortoise populations or their habitat condition and functionality.

> Response: We agree with the sentiment of the comment. Unfortunately, as indicated in the plan, data on the effectiveness of most recovery actions do not exist. Therefore, the revised plan recommends the use of a spatial decision support system to conduct such analyses and change the direction of the recovery program when it is indicated, as recommended by the commenter.

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