A New Approach to Conservation of the Mojave Desert Tortoise

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The Mojave desert tortoise was listed as threatened *under the US Endangered Species Act (ESA) because of local population declines and an array of threats. Challenges to the recovery of this species include an incomplete understanding of the threats most responsible for its decline, insufficient information on the effectiveness of management actions, and the intractability of threats across a large geographical range and multiple jurisdictions. Recognition that these challenges require long-term conservation efforts to ensure the species' persistence—with or without the protections of the ESA—necessitates a more structured approach to recovery, including broad stakeholder participation. A conservation-reliant perspective will probably be increasingly relevant for additional species and for adapting land management in the face of climate change by improving regional coordination of management activities, broadening spatial and temporal points of view in management, and increasing the emphasis on addressing multiple threats simultaneously.*

Keywords: conservation-reliant species, Endangered Species Act, Gopherus agassizii*, recovery, threatened species*

The Mojave desert tortoise (*Gopherus agassizii*; figure 1) occurs in the United States 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 (Murphy et al. 2011). Adults typically range from 18 to 27 centimeters in carapace length (Germano 1994), reach sexual maturity in 13–20 years (Germano 1994, Curtin et al. 2009), and can live up to approximately 50 years in the wild (Germano 1992, Curtin et al. 2009). Low reproductive rates during a long period of reproductive potential, with the concomitant risk of mortality before successful reproduction, result in slow potential rates of population growth (Doak et al. 1994). Mojave desert tortoises inhabit both valley bottoms and more rugged upland terrain (Germano et al. 1994, Rautenstrauch and O'Farrell 1998), where, in either case, they spend much of their lives avoiding inhospitable desert conditions in self-constructed burrows or in existing caves and rocky shelters (Nagy and Medica 1986, Bury et al. 1994). Approximately 80% of the species' habitat occurs on federally managed land (USFWS 2010).

Historically, population densities in some areas exceeded 150 tortoises per square kilometer, but most of the species' range was occupied by more diffuse, low-density populations (e.g., less than 40 tortoises per square kilometer; Luckenbach 1982, Berry and Medica 1995, Krzysik 2002). Declines in abundance exceeding 20% within local populations across the species' distribution (losses of up to 90% of the adult females in some populations; see Berry and Medica 1995) led to the decision in 1990 to list the species as *threatened* under the Endangered Species Act (ESA; USFWS 1990). Although the ultimate goal is to enable the recovery of desert tortoise populations such that they are once again self-sustaining, it will be a slow process, given the tortoise's life history and the nature of the threats to its persistence.

In this article, we describe how the Mojave desert tortoise's persistence in the wild is threatened and the obstacles that hinder the abatement of those threats in perpetuity. If these obstacles can be overcome, the Mojave desert tortoise will no longer need the legal protection of the ESA but will instead be reliant on conservation actions that far outlast the ESA's formal process of directing efforts that allow the species to recover. In light of this, the present article serves as a case study of one approach to identifying, prioritizing, and addressing the needs of a conservation-reliant species (Scott et al. 2005, 2010). Recognition that the Mojave desert tortoise is conservation reliant led us to a new approach to pursuing the recovery and continued conservation of the species than had been historically implemented.

Threats to the Mojave desert tortoise

The observed declines in Mojave desert tortoise populations throughout the past century are believed to result from numerous, diverse threats (USFWS 1990). These perceived

BioScience 62: 893–899. ISSN 0006-3568, electronic ISSN 1525-3244. doi:10.1525/bio.2012.62.10.9

*Figure 1. Mojave desert tortoise (***Gopherus agassizii***). Photograph: Kimberleigh J. Field.*

Figure 2. Wildfire in the Mojave Desert fueled by the invasive exotic grass **Bromus rubens**, *in the foreground. Photograph: Kimberleigh J. Field.*

threats vary across the desert tortoise's range; not all individuals or even all populations are affected by every threat. However, most populations are probably affected by several of these threats simultaneously, and these threats may interact with one another synergistically (USFWS 2011). Although some of the threats result in direct mortality of individuals, many affect the habitat on which the species depends.

Impacts to tortoise habitat result from many human activities (Lovich and Bainbridge 1999). For example, habitat conversion occurs as a result of urban development, mining, waste disposal, energy development, and road construction. Habitat modification is caused by military training, off-highway vehicle use, utility corridors, livestock grazing, and the proliferation of invasive plants. Although direct mortality can be caused by many of the factors listed above, direct losses of tortoises also occur through predation (Boarman 1993, Esque et al. 2010), disease (Brown MB et al. 1994), collection from the wild (USFWS 2011), and recreational killing (Berry 1986).

One example of how threats act synergistically is illustrated by the relationship among invasive plants, tortoise nutritional needs, and the proliferation of wildfires. Invasive plant abundance is increasing in the Mojave Desert, largely as a result of human disturbance (Brooks 2009). Invasion by nonnative plants can affect the quality and quantity of plant foods available to tortoises and can thereby affect their intake of important nutrients (Nagy et al. 1998, Oftedal et al. 2002, Hazard et al. 2010). Many of these nonnative plants are fire adapted and contribute to increases in fire frequency (figure 2; Brown DE and Minnich 1986, Brooks and Esque 2002), which further enhances their establishment, thereby exacerbating the cycle.

Previous conservation efforts

Since the Mojave desert tortoise was given protections under the ESA in 1990, numerous actions have been taken to conserve the species. Desert wildlife management areas (DWMAs) were successfully established in all four states, formalized through agency (largely US Bureau of Land Management) land-use planning processes. The establishment of these special management areas, with functional habitat connecting them and with conservation actions implemented within them, was intended to allow for the persistence of viable tortoise populations (USFWS 1994). The DWMAs, together with National Park Service lands and other lands allocated for resource conservation, provide an extensive network that is managed either directly or indirectly for desert tortoise conservation (USFWS 2011).

Administrative land-management designations alone, however, do little to conserve desert tortoise populations. Although few data existed on which threats had the greatest impacts on specific desert tortoise populations (see below), conservation actions aimed at improving the status of populations and eventually helping the species to recover were implemented. Governmental agencies acquired land, installed protective fencing, retired grazing allotments, limited off-highway vehicle access, and restored habitat at an expense of over $100 million (USGAO 2002, USFWS 2011). From 2005 through 2009, expenditure reports show that federal and state agencies spent a cumulative average of over $18 million per year on Mojave desert tortoise management activities (*www.fws.gov/endangered/esa-library/index.html*). However, demonstrable increases in tortoise populations are not yet apparent, whereas declines have continued in some areas (USFWS 2011).

Obstacles to the recovery of the Mojave desert tortoise

In evaluating whether the Mojave desert tortoise no longer needs the protections of the ESA, recovery will be determined through three criteria: Population trends must be

increasing over at least 25 years (approximately one tortoise generation), the populations must be well distributed across the range, and there must be no net loss of the habitat needed to support viable populations (USFWS 2011). To meet these criteria, threats to the species' persistence must be reduced so that self-sustaining populations can be maintained into the future.

Perhaps the greatest obstacle to the recovery of the Mojave desert tortoise is identifying from among the diverse suite of potential threats those most responsible for site-specific population declines and implementing effective management actions that address those threats. Although extensive research shows that all of the documented threats directly kill or indirectly affect individual tortoises, there are few data available with which to evaluate or quantify the relative population-level effects (Boarman 2002, USFWS 2011). For example, although numerous desert tortoises can die in individual wildfires (Esque et al. 2003), population-level effects of decreased nutritional food value are harder to document. On the other end of the spectrum, individual tortoises have been killed by shooters (Berry 1986), but the population-level impacts of this threat are similarly difficult to determine. With such diverse impacts, establishing the relative importance of threats has been difficult, even at local scales. Desert tortoises may be subjected to various nonlethal threats over their long life spans, which complicates determining precise causes of death or population decline. This uncertainty is particularly true for indirect, habitat-based threats, which constitute the majority of those identified for the Mojave desert tortoise (USFWS 1990, 2011).

Even assuming knowledge of which threats were most responsible for declines within specific populations, determining the effectiveness of management actions still presents a challenge. For many potential threats to Mojave desert tortoise populations, effective management actions have not been identified or implemented sufficiently. The diffuse distribution of individuals and the low population-growth rate of the species, even under optimal conditions, make trend detection and the effects of management on tortoise populations difficult to evaluate over the short term (see Tinkle 1979, Gibbons et al. 2000). Given the long life span of desert tortoises, a number of different threats and management actions can affect populations over a given generation—a period that is also beyond most agency planning horizons. To further complicate assessments of management effectiveness, in most cases, surrogate indicators of effectiveness (e.g., the availability or biomass of food plants following habitat restoration, the number of juvenile tortoise carcasses beneath raven nests following raven control) must be used to detect results within management time frames rather than waiting for demonstrable increases in tortoise populations (e.g., over the 25 years specified in the recovery criteria). These indicators have largely gone unmonitored since the tortoise was listed under the ESA, and the effectiveness of most recovery actions is therefore unknown (USGAO 2002). Despite extensive management and research expenditures over the years, there has been no overall coordination of research to ensure that questions about management-action effectiveness are answered (USGAO 2002)—a problem not limited to desert tortoises (Doremus 2006).

Whereas other threatened species are often characterized by small population sizes and local or regional ecosystem threats, threats to the Mojave desert tortoise are also difficult to resolve because of the large landscapes and multiple jurisdictional units involved and because of the numerous potentially affected members of the public in the surrounding desert communities. A difficulty in managing habitat at such a scale has been termed the *tragedy of fragmentation*, in which numerous jurisdictional units produce shortsighted, local decisions that can aggregate into a large "decision" that is never explicitly acknowledged (Goble 2009). This situation is evident through the 26 programmatic-level, federal land-management plans currently in place or in preparation within the range of the Mojave desert tortoise (USFWS 2011). Multiple-use land-management agencies are challenged to maintain active conservation of desert tortoises at regional scales where recreation, infrastructure (roads, utilities, rights of way), and resource extraction (mining, livestock grazing) continue to be proposed at local scales. For example, recent approval of solar-energy development projects on public lands across the Mojave and Colorado deserts have included little assessment of larger-scale and cumulative ecosystem impacts beyond individual project boundaries (Lovich and Ennen 2011).

Even if we can overcome these barriers to recovery, such that population- and habitat-based delisting criteria are met and the species is ultimately delisted, continued long-term conservation efforts to ensure the species' persistence still will be required. Ongoing efforts to address the most important threats through the implementation of effective conservation actions and coordination at the landscape scale will be required to maintain self-sustaining populations in the long term and to prevent a recurrence of the threats that originally led to the species' listing under the ESA. Many threats to Mojave desert tortoise populations cannot be completely eliminated because of their relationship to human population growth and activities. Without explicit post-ESA safeguards, the Mojave desert tortoise is likely to be among those species that require permanent protection under the ESA (see Doremus and Pagel 2001).

A long-held assumption for species that have been delisted under the ESA is that they share two characteristics: (1) Their decline was primarily the result of a specific, remediable threat, and (2) the risk-management structure necessary to prevent a recurrence of the threat was minimal and could be provided through existing regulatory mechanisms (Goble 2009). Neither of these currently characterize the Mojave desert tortoise. Furthermore, many of the threats to the desert tortoise's persistence ultimately result in a degradation of habitat, which is particularly hard to address in the long term and which requires the continued implementation of conservation management actions. Of the

species recovered and delisted to date, habitat degradation rarely played a significant role in their population declines (Doremus and Pagel 2001, Scott et al. 2006). Many of the significant threats to desert tortoises will return if there is not a sustained management effort—to control invasive plants, for example—and if human activities are not limited in large areas of the species' distribution. These types of recovery strategies—relying on control of other species, control of human access, and active habitat management—are characteristic of other conservation-reliant species (Scott et al. 2010).

The keys to truly recovering a conservation-reliant species are knowing the important threats causing the species' endangerment and implementing evidence-based management actions to mitigate those threats at scales that are conservation relevant (Scott et al. 2005). As was described above, however, both of these keys to recovery have proven difficult for Mojave desert tortoise management in the past. Species-specific approaches to conservation that include diligent long-term monitoring are also important when multiple interacting threats are involved and when there is no apparent primary cause of population declines. This is particularly important when species are declining within designated conservation areas (Brashares 2010).

A new approach to conserving the Mojave desert tortoise

The magnitude, complexity, and uncertainty that have thwarted the recovery progress of the Mojave desert tortoise to date illustrate that a new approach to recovery is necessary to allow delisting under the ESA and to ensure continued threat abatement. This new approach includes two important components: (1) organization of a coordinated, structured recovery program and (2) broad and active participation in the recovery program.

A coordinated, structured recovery program. Despite good intentions, past conservation efforts for the Mojave desert tortoise were disjunct, were untracked, and did little to illuminate the species' most critical needs. Research and monitoring were used to revise management efforts on an ad hoc basis, which was inefficient and which contributed to slow progress in the recovery of the species (USFWS 2011). In 2004, the US Fish and Wildlife Service established the Desert Tortoise Recovery Office to focus solely on the conservation needs of the species. For the first time, conservation planning, implementation of actions, research, and monitoring for the Mojave desert tortoise could be coordinated and structured.

Making well-informed, prioritized decisions 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 action relative to the objectives, described through conceptual models (Lyons et al. 2008). Accordingly, greater emphasis must be placed on management and policy-relevant research and on the evaluation of the effectiveness of management actions through a structured decisionmaking and adaptive-management process (Ralls and Starfield 1995, Rauscher 1999). Such an approach has recently been incorporated into the recovery program for the Mojave desert tortoise, including the development of an interactive decision-support system that computes the output of a set of models (e.g., the effects of a threat on a tortoise population) on the basis of underlying databases that capture information on the spatial extent and overlap of each threat, of habitat potential to support tortoise populations, and of management actions (USFWS 2011). This structured approach will finally allow the risk of various threats to be assessed, conservation actions to be prioritized, implementation to be tracked, and effectiveness to be determined.

Broad participation in the recovery program. In addition to the treatment of conservation actions as closely monitored experiments, the involvement of participants who can directly influence the implementation of these actions is important in species conservation (Ruckelshaus and Darm 2006). The management of conservation-reliant species generally requires the participation of a broad community of individuals and entities to reach and to sustain recovery goals (Scott et al. 2010). This is certainly true for a species with a distribution as wide ranging and spanning as many jurisdictional boundaries as that of the Mojave desert tortoise. Of 24 broad recovery actions that are related to on-the-ground habitat or population management and associated monitoring, 63% require implementation by the collective group of land and wildlife management agencies across the species' range (USFWS 2011). Multijurisdictional responsibility is apparent across classifications of conservation management strategies, especially active habitat management and the control of direct human impacts (figure 3).

In order to facilitate the active participation of a broad, recovery-focused community (as well as to overcome the tragedy of fragmentation), the new recovery program established cross-jurisdictional recovery implementation teams composed of land and wildlife managers from federal, state, and local agencies; nongovernmental stakeholders; and scientists to prioritize, coordinate, and track the implementation of recovery actions in an adaptive-management framework at manageable spatial scales (USFWS 2011). Even though approximately 80% of the species' range occurs on federally managed public or US Department of Defense land, the participation of private and other nonfederal partners (e.g., states, tribes) is necessary to fully implement the recovery plan. Such participation is critical to secure buy-in for, compliance with, and assistance in the implementation of conservation actions on public lands. These partnerships are particularly critical in some situations, such as that in Washington County, Utah, where the Washington County Habitat Conservation Plan, through its Red Cliffs Desert Reserve and associated management actions, essentially guides the conservation

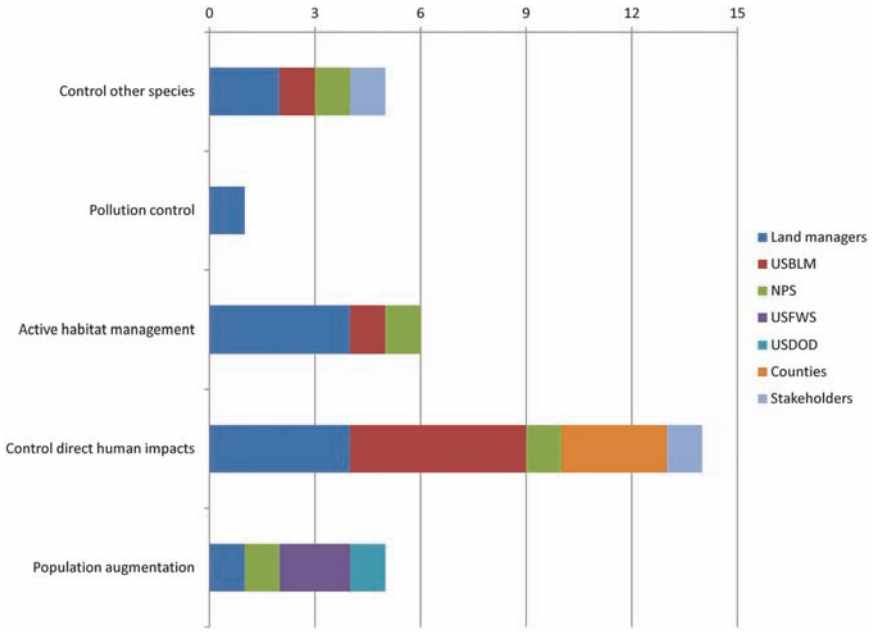

Figure 3. Frequency of on-the-ground recovery actions included in the Mojave desert tortoise recovery plan (USFWS 2011), grouped according to conservation management strategy as defined by Scott and colleagues (2010). Actions attributed to "Land managers" apply to all local, state, and federal land and wildlife management agencies across the Mojave desert tortoise's range in addition to actions relevant to particular agencies listed separately. Some actions are counted for multiple agencies. Abbreviations: NPS, National Park Service; USBLM, US Bureau of Land Management; USDOD, US Department of Defense; USFWS, US Fish and Wildlife Service.

of tortoises that constitute most of the Upper Virgin River Recovery Unit (see Owens 2000).

Prior to delisting, recovery implementation teams should establish regional recovery or conservation management agreements that ensure the continuation of those management actions that led to the biological recovery of the species and that ensure the implementation of those actions that will have important conservation benefits in the future (Scott et al. 2005, 2010, Bocetti et al. 2012 [in this issue]). A similar case, with habitat-based threats and a reliance on conservation management across multiple political jurisdictions, can be seen in the delisting of the Douglas County population of the Columbian white-tailed deer (Goble 2009). This species was delisted not only because its population and distribution had increased to the point that the risk of stochastic events had been reduced to an acceptable level but because the threats that require ongoing management were also reduced to a reasonable level through legal protections of the habitat. US Bureau of Land Management and county parks department management plans were dedicated to ensuring that the habitat would be managed in order to maintain the biological requirements of the species.

The success of recovery implementation teams in meeting the goals for species recovery and in advancing knowledge of management-action effectiveness will prime the implementation of effective postdelisting management plans for the Mojave desert tortoise. The recovery implementation teams will have already shared management responsibilities among agencies; state, local, and tribal governments; and private partners. The track record of recovery will be clearly documented in the decision support system and reflected in the long-term commitments made to reach the point of recovery.

Conservation implications

Given the complexities associated with the recovery of conservation-reliant species and the fact that limited funds mean that not all species can receive the same level of direct management focus, one might ask whether recovery efforts for less intractable species should be prioritized over those for species such as the Mojave desert tortoise. Effective recovery efforts for the Mojave desert tortoise require the conservation of a functioning desert ecosystem, which will also benefit other listed or sensitive species within the region. Notably, this is the primary purpose of the ESA, itself: "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (ESA § 2(b)). Indeed, many of the threats to and recommended recovery actions for the Mojave desert tortoise are broadly relevant to a functioning desert ecosystem. As a result, the incorporation of truly effective ecosystem-level conservation actions into land-management practices can help to lessen the challenges of sustaining the long-term funding of seemingly desert-tortoise-specific conservation actions.

However, even a concentrated focus on ecosystem management cannot avoid the specter of climate change that now looms over the conservation prospects of many species, whether they are currently recognized as *threatened* or not. Recent climatic changes have affected a broad range of organisms with diverse geographical distributions (Walther et al. 2002, Parmesan 2006), and interactions between altered precipitation patterns and other aspects of global change are likely to affect both natural and managed terrestrial ecosystems. For example, the amount of present-day Mojave desert tortoise habitat is projected to be substantially reduced in portions of the species' range under climate-change scenarios (Barrows 2011). Although it is yet unclear how global and regional changes in climate may precisely affect many species, highly coordinated long-term research, monitoring, and active management should be expected for

biodiversity conservation in general. Important elements in adapting land management in the face of climate change include improved regional coordination of management activities, broadened spatial and temporal perspectives in management, and an emphasis on simultaneously addressing multiple threats while being inclusive of diverse human communities (Heller and Zavaleta 2009, West et al. 2009). Each of these elements is inherent to the new approach for Mojave desert tortoise conservation described in this case study and is applicable to other conservation-reliant species, which probably number more than is currently recognized.

Acknowledgments

J. Michael Reed, J. Michael Scott, Dale D. Goble, Christine Mullen, and three anonymous reviewers provided valuable comments on earlier drafts of this manuscript. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the US Fish and Wildlife Service.

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