DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R2–ES–2009–0032; MO 92210–0–008]

Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List the Sonoran Population of the Desert Tortoise as Endangered or Threatened

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of 12-month petition finding.

SUMMARY: We, the U.S. Fish and Wildlife Service, announce a 12-month finding on a petition to list the Sonoran population of the desert tortoise (*Gopherus agassizii*) as endangered or threatened and to designate critical habitat under the Endangered Species Act of 1973, as amended (Act). After review of all available scientific and commercial information, we find that listing the Sonoran population of the desert tortoise is warranted. Currently, however, listing the Sonoran population of the desert tortoise is precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. Upon publication of this 12-month petition finding, we will add the Sonoran population of the desert tortoise to our candidate species list. We will develop a proposed rule to list the Sonoran population of the desert tortoise as our priorities allow. We will make any determination on critical habitat during development of the proposed listing rule. In any interim period we will address the status of the candidate taxon through our annual Candidate Notice of Review (CNOR).

DATES: The finding announced in this document was made on December 14, 2010.

ADDRESSES: This finding is available on the Internet at *http://www.regulations.gov* at Docket Number FWS–R2–ES–2009–0032. Supporting documentation we used in preparing this finding is available for public inspection, by appointment, during normal business hours at the U.S. Fish and Wildlife Service, Arizona Ecological Services Office, 2321 West Royal Palm Road, Suite 103, Phoenix, Arizona 85021. Please submit any new information, materials, comments, or questions concerning this finding to the above address.

FOR FURTHER INFORMATION CONTACT: Steven L. Spangle, Field Supervisor Arizona Ecological Services Office (see **ADDRESSES**); by telephone at (602) 242–0210; or by facsimile at (602) 242–2513. If you use a telecommunications device for the deaf (TDD), please call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Background

Section 4(b)(3)(B) of the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 *et seq.*), requires that, for any petition to revise the Federal Lists of Endangered and Threatened Wildlife and Plants that contains substantial scientific or commercial information that listing the species may be warranted, we make a finding within 12 months of the date of receipt of the petition. In this finding, we determine that the petitioned action is: (a) Not warranted, (b) warranted, or (c) warranted, but the immediate proposal of a regulation implementing the petitioned action is precluded by other pending proposals to determine whether species are threatened or endangered, and expeditious progress is being made to add or remove qualified species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Section 4(b)(3)(C) of the Act requires that we treat a petition for which the requested action is found to be warranted but precluded as though resubmitted on the date of such finding, that is, requiring a subsequent finding to be made within 12 months. We must publish these 12-month findings in the **Federal Register.**

Previous Federal Actions

On October 15, 2008, we received a petition dated October 9, 2008, from WildEarth Guardians and Western Watersheds Project (petitioners) requesting that the Sonoran population of the desert tortoise be listed under the Act as a distinct population segment (DPS), as threatened or endangered rangewide (in the United States and Mexico), and critical habitat be designated. The petition contained detailed information on the natural history, biology, current status, and distribution of the Sonoran population of the desert tortoise. It also contained information on what the petitioners reported as potential threats to the Sonoran population of the desert tortoise, such as livestock grazing, urbanization and development, mining, international border patrol activities, illegal collection, inadequacy of existing regulations, altered fire regimes, off-highway vehicle use, drought, and climate change. We acknowledged the receipt of the petition in a letter to the WildEarth Guardians and Western Watersheds Project, dated November 26, 2008. In that letter we also stated that we had reviewed the information presented in the petition and determined that issuing an emergency regulation temporarily listing the species as per section 4(b)(7) of the Act was not warranted. We also stated that we intended to make our finding on whether the petition presented substantial information that the requested action may be warranted, to the maximum extent practicable within 90 days of receipt of the petition, according to the provisions of section 4(b)(3) of the Act.

On August 28, 2009, we made our 90-day finding that the petition presented substantial scientific information indicating that listing the Sonoran population of the desert tortoise (*Gopherus agassizii*) may be warranted. The finding and notice of our initiation of a status review was published in the **Federal Register** on August 28, 2009 (74 FR 44335).

On April 10, 2010, a stipulated settlement agreement (*WildEarth Guardians and Western Watersheds Project* v. *Salazar,* 10–cv–86–ACT–RHS (D. NM)) was filed. In this agreement, we agreed to submit a 12-month finding to the **Federal Register** on or before December 5, 2010. The stipulated settlement agreement was signed and adopted by the District Court of New Mexico on April 15, 2010.

This notice constitutes our 12-month finding for the petition to list the Sonoran population of the desert tortoise as threatened or endangered.

Other Federal Actions

Throughout this finding, we use “Mojave” to describe desert tortoise populations north and west of the Colorado River, as well as any reference to the biotic community known as the “Mojave Desert” or “Mojave desertscrub.” These uses are consistent with the previous and current spelling of the common name in Federal actions that have addressed this population. We use “Mohave” in the geographic context to remain consistent with its reference by the U.S. Board of Geographic Names (*e.g.,* Mohave County). In addition, while the Sonoran population of the desert tortoise is not currently formally recognized as a unique taxonomic entity, for ease of reference, we refer to the Sonoran population of the desert tortoise as the “Sonoran desert tortoise” in this finding.

On December 30, 1982, we published a notice of review which determined the desert tortoise throughout its range in the United States and Mexico to be a Category 2 Candidate species (47 FR

58454); this was reaffirmed on September 18, 1985 (50 FR 37958). Category-2 status was granted to species for which information in our possession indicated that a proposed listing as threatened or endangered was possibly appropriate, but for which sufficient data were not available to make a determination of listing status under the Act.

On April 2, 1990, we issued a final rule designating the Mojave population of the desert tortoise (occurring north and west of the Colorado River) as a threatened species under the Act (55 FR 12178; see final rule for a summary of previous actions regarding the Mojave population of the desert tortoise). Currently, the Mojave population of the desert tortoise is recognized as a distinct population segment under the Act. As part of that rulemaking, we designated any desert tortoise from the Sonoran population as threatened when observed outside of its known range, due to similarity of appearance under section 4(a) of the Act.

On December 5, 1996, we published a rule that discontinued the practice of keeping a list of Category 2 Candidate species (61 FR 64481). Since that time, the Sonoran desert tortoise observed inside its known range has had no Federal Endangered Species Act status.

For a detailed account of previous Federal actions that pertained to the desert tortoise in the United States, please review the following **Federal Register** documents: "Proposed Endangered Status and Critical Habitat for the Beaver Dam Slope Population of the Desert Tortoise" (43 FR 37662, August 23, 1978); "Requirement to withdraw or supplement proposals to determine various U.S. taxa of plants and wildlife as Endangered or Threatened or to determine Critical Habitat for such species" (44 FR 12382, March 6, 1979); "Reproposal of Critical Habitat for the Illinois mud turtle and Beaver Dam Slope population of the desert tortoise" (44 FR 70680, December 7, 1979); "Listing as Threatened With Critical Habitat for the Beaver Dam Slope Population of the Desert Tortoise in Utah" (45 FR 55654, August 20, 1980); "Review of Vertebrate Wildlife for Listing as Endangered or Threatened Species" (47 FR 58454, December 30, 1982); "Notice of Findings on Four Petitions, and Review of One Species" (50 FR 13054, April 2, 1985); "Review of Vertebrate Wildlife" (50 FR 37958, September 15, 1985); "Finding on Desert Tortoise Petition" (50 FR 49868, December 5, 1985); "Findings on Pending Petitions and Description of Progress of Listing Actions" (53 FR 25511, July 7, 1988); "Findings on Pending Petitions and Description of Progress of Listing Actions" (53 FR 52746, December 29, 1988); "Emergency Determination of Endangered Status for the Mojave Population of the Desert Tortoise" (54 FR 32326, August 4, 1989); "Desert Tortoise" (54 FR 42270, October 13, 1989); "Determination of Threatened Status for the Mojave Population of the Desert Tortoise" (55 FR 12178, April 2, 1990); "Finding on a Petition to List the Sonoran Desert Tortoise as Threatened or Endangered" (56 FR 29453, June 27, 1991); "Proposed Determination of Critical Habitat for the Mojave Population of the Desert Tortoise" (58 FR 45748, August 30, 1993); "Determination of Critical Habitat for the Mojave Population of the Desert Tortoise" (59 FR 5820, February 8, 1994); "Determination of Critical Habitat for the Mojave Population of the Desert Tortoise" (59 FR 9032, February 24, 1994); "Notice of Final Decision on Identification of Candidates for Listing as Endangered or Threatened" (61 FR 64481, December 5, 1996); and "90–Day Finding on a Petition To List the Sonoran Population of the Desert Tortoise (*Gopherus agassizii*) as a Distinct Population Segment (DPS) with Critical Habitat" (74 FR 44335, August 28, 2009).

Species Information

Taxonomy

The desert tortoise is in the genus *Gopherus* (Rafinesque 1832), or gopher tortoises, and is a member of the Testudinidae family, or terrestrial tortoises. The North American tortoises formerly comprised two genera, *Gopherus* and *Xerobates,* with the latter including *X. agassizii,* the desert tortoise (Crumly 1994, pp. 7–8). Scientific nomenclature assigned to the desert tortoise has undergone a series of changes since its initial description by Cooper (1863) as *X. agassizii* (Barrett and Johnson 1990, p. 5); the currently recognized scientific name for the desert tortoise is *Gopherus agassizii.* Further information is available in Barrett and Johnson (1990, p. 5) or in the detailed account of desert tortoise phylogeny (evolutionary development) and systematics (taxonomic classification) by Crumly (1994, pp. 7–32). The desert tortoise is known in Mexico with the common names of "tortuga del monte," "Galápago de desierto," or the "xtamóosni" (Rorabaugh 2008, p. 35).

Physical Description of Sonoran Desert Tortoises

Adult Sonoran desert tortoises range in total carapace (straight-line top shell) length from 8 to 15 inches (in) (20 to 38 centimeters (cm)), with a relatively high domed shell (AGFD 2001, p. 1; Brennan and Holycross 2006, p. 54). The record length for a Sonoran desert tortoise is 19.4 in (49 cm) total carapace length (Jackson and Wilkinson-Trotter 1980, p. 430). The carapace is usually brownish with a definite pattern and prominent growth lines (AGFD 2001, p. 1). The plastron (bottom shell) is yellowish and is not hinged (AGFD 2001, p. 1; Brennan and Holycross 2006, p. 54). The hind limbs are very stocky and elephantine; forelimbs are flattened for digging and covered with large conical scales (AGFD 2001, p. 1; Brennan and Holycross 2006, p. 54). Male Sonoran desert tortoises are differentiated from females by having elongated gular (throat) shields, chin glands visible on each side of the lower jaw (most evident during the breeding season), a concave plastron, and larger overall size (AGFD 2001, p. 1).

Distribution

The desert tortoise includes portions of southern California, southern Nevada, southwestern Utah, and the western, northwestern, and southern portions of Arizona in the United States, and also includes the Mexican State of Sonora into the northern portion of Sinaloa. One-third of the geographic range of the desert tortoise occurs in northwestern Mexico (Bury *et al.* 2002, p. 86). The specific distribution of desert tortoise is influenced by habitat and climatic characteristics (vegetation community for food), soil and substrate characteristics (for shelter), and precipitation pattern (for water availability) within the appropriate elevation range.

The distribution of the Sonoran desert tortoise in the United States is considered to be entirely within Arizona and comprises approximately 26.8 million acres (ac) (10.8 million hectares (ha)); east and south of the Colorado River (Barrett and Johnson 1990, pp. 4–5; Lamb *et al.* 1989, p. 84). Sonoran desert tortoise distribution in Arizona is limited to the northeast by the limits of the Sonoran Desert. The Arizona portion of their range constitutes approximately 52 percent of their total distribution. In Arizona, the Sonoran desert tortoise occurs primarily on Federal land but also occurs on a variety of non-federal lands as well as on ten Native American reservations: (1) Fort Mojave Indian Tribe; (2) Colorado River Indian Tribe; (3) Hualapai Tribe; (4) Fort McDowell Yavapai Nation; (5) Salt River Pima-Maricopa Indian Community; (6) Gila River Indian Community; (7) Ak Chin; (8) Tohono O'odham Nation; (9) Pasqua Yaqui Tribe; and, (10) San Carlos Apache Tribe (AIDTT 2000, p. 40).

In Mexico, where 48 percent of their range occurs, the distribution of the Sonoran desert tortoise extends from the international border of Sonora and Arizona, south to the vicinity of Guaymas, and north of the Río Yaqui (the southern and southeastern-most border of their distribution), in southern Sonora (Germano *et al.* 1994, p. 77; Fritts and Jennings 1994, p. 51; Bury *et al.* 2002, p. 88; Van Devender 2002a, p. 5; Edwards *et al.* 2009, pp. 7–8). This includes approximately the western half of the State of Sonora from the Gulf of California coast east roughly to the transition to unsuitable woodland and conifer forest areas in the higher elevations of the Sierra Madre Occidental. In 30 timed searches conducted August to September 1983, and beyond the known distribution of Sonoran desert tortoises in Sonora, Mexico, Fritts and Jennings (1994, p. 52) found several patterns in Sonoran desert tortoise distribution. First, most Sonoran desert tortoises in the eastern and northern extent of their distribution in Mexico occur below the 2,600 foot (ft) (790 meters (m)) elevation contour (Fritts and Jennings 1994, p. 52). Second, populations may be the densest and the least patchy between elevations of 900 and 1,600 ft (270 and 490 m) (Fritts and Jennings 1994, p. 52). They were also not found in habitat in Mexico that received an average of 3.9 in (10 cm) or less of rain annually (Fritts and Jennings 1994, p. 53).

One question about the distribution of the Sonoran desert tortoise concerns the origin of a small number of tortoises that have been found in far southeastern Cochise County, Arizona, an area generally considered well east of the known distribution. There is some evidence that these tortoises may represent a naturally occurring population based on the presence of suitable habitat (Rorabaugh 2009, pers. comm.), similar animal communities (Rosen 2009, pers. comm.), and historic and current observations of tortoises in the area (Hulse and Middendorf 1979, p. 546; Radke 2009, pers. comm.; Van Devender *et al.* 1976, pp. 300–303). However, these observations have traditionally been discounted as released pets rather than a natural population (AIDTT 2000, p. 3; Germano *et al.* 1994, p. 81). Also, recent genetic analysis of a Sonoran desert tortoise collected from this area in 2009 indicated it was most closely related to tortoises in the Phoenix, Arizona, area and is likely, therefore, a "released or escaped captive" tortoise (Edwards 2010, pers. comm.). We recognize there is a fair amount of uncertainty regarding the origin of this population. However, because Sonoran desert tortoises are infrequently documented from this area and recent genetic testing indicated that observations represent released captives, we conclude that desert tortoises from this area do not represent a naturally-occurring, disjunct population. Consequently, we will not evaluate potential threats to the tortoises in this area of Cochise County in this finding.

Habitat

Sonoran desert tortoises are most closely associated with the Arizona Upland and Lower Colorado River subdivisions of Sonoran desertscrub and Mojave desertscrub vegetation types. They occur most commonly on rocky (predominantly granitic rock), steep slopes and bajadas (lower mountain slopes often formed by the coalescing of several alluvial fans (fan-shaped deposits at the ends of canyons formed when fast flowing streams slow and widen)) and in paloverde-mixed cacti associations (Ortenburger and Ortenburger 1927, p. 120; Burge 1979, p. 49; 1980, p. 48). Sonoran desert tortoise density has been observed to be higher in the Arizona Upland subdivision of the Sonoran desertscrub than in the Lower Colorado subdivision of the Sonoran desertscrub or in Mojave desertscrub (Berry 1984, p. 434; AIDTT 2000, p. 4; Boarman and Kristan 2008, p. 19). In addition to the use of vegetation to meet energy and nutritional needs, the Sonoran desert tortoise uses vegetation for predator avoidance, thermal protection, and in social behaviors (Avery and Neibergs 1997, p. 13; Grandmaison *et al.* in press, p. 3). An important attribute of Sonoran desert tortoise habitat is the presence of cryptogamic crusts (soil crusts with unique, microscopic association of flora and fauna) (Bowker *et al.* 2008, p. 2309). These occur on the surface of Sonoran Desert soils and assist with nitrogen-fixing to enhance soil fertility, improve water infiltration into soils, and prevent or lessen effects from wind and water erosion, all of which help to sustain vegetation vital to the Sonoran desert tortoise (DeFalco 1995, p. 22; DeFalco *et al.* 2001, pp. 1, 9).

Sonoran desert tortoises rarely occur in oak woodland habitat. However, one such population occurs at approximately 5,000-ft (1,500-m) elevation in Chiminea Canyon in the Rincon Mountains of Pima County, Arizona (Van Devender 2002a, p. 23), and they are also known from similar elevation in the Atascosa and Pajarito Mountains in south-central Arizona. Zylstra and Steidl (2008, p. 747) found that habitat selection by Sonoran desert tortoises was most closely associated with topographic (degree of steepness of slope) and geomorphologic (rock type and structure) influences rather than by vegetation type. Specifically, Zylstra and Steidl (2008, p. 747) found that the likelihood of observing Sonoran desert tortoises increased with increasing slope, with a strong association to aspect (the direction to which a slope faces), with east-facing slopes preferred over north-facing slopes. However, the season of use may affect which slope-aspects (the direction a particular slope faces) Sonoran desert tortoises are likely to use based on their needs at that time (Zylstra and Steidl 2008, p. 752). Specifically, Sonoran desert tortoises have different thermoregulatory and physiological needs based upon their seasonal behaviors, such as hibernation or seeking temporary shelter during the tortoise's surface-active seasons.

In addition to steep, rocky slopes and bajadas, Sonoran desert tortoises also use inter-mountain valleys as part of their home ranges and for dispersal at all age classes (Averill-Murray and Averill-Murray 2002, p. 16). In the Ironwood National Forest, Averill-Murray and Averill-Murray (2005, p. 65) found tortoises or their signs (such as scat (droppings) and burrows) on 92 percent of transects in boulder habitat, on 71 percent of transects that included incised washes (dry stream beds that flow in response to precipitation), and on 25 percent of transects that had neither boulder habitat nor incised washes. Sonoran desert tortoises were found up to one mile (mi) (1.6 kilometers (km)) away from the nearest slope, indicating that they occur in low densities in inter-mountain valleys. Averill-Murray and Averill-Murray (2005, p. 65) stated that maintaining these areas "may be important for long-term population viability." Washes might also be selectively chosen by reproductive female Sonoran desert tortoises as all eggs and hatchling desert tortoises observed by Barrett (1990, p. 205) occurred there. Sonoran desert tortoises on the 40-square-mile (sq mi) (64-square-kilometer (sq km)) Florence Military Reservation in Pinal County, Arizona, primarily use xeroriparian habitat (a habitat association with plant species tolerant to hyper-arid conditions) along washes, with caliche caves (caves formed along steep banks of washes within cemented, sedimentary rock formations of calcium carbonate) within washes being an important component to occupied habitat (Lutz *et al.* 2005, p. 22; Riedle *et al.* 2008, p. 418). Another frequently used habitat type on the Florence Military Reservation included gently rolling alluvial fans dominated by creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) during all periods of the year; somewhat atypical for Sonoran desert tortoises in other portions of its range (Lutz *et al.* 2005; p. 22; Grandmaison *et al.* in press, p. 4). In this habitat, Sonoran desert tortoises often used packrat middens (organic debris piles constructed for nesting purposes which often are comprised of wood material, cactus pads, etc.) as shelter sites, especially those with suitable canopy cover, an absence of cattle activity, and proximity to roads and washes (Lutz *et al.* 2005, p. 22; Grandmaison *et al.* in press, p. 2).

Sonoran desert tortoises in Arizona generally occur within elevations from 510 to 5,300 ft (155 to 1,615 m) (Barrett and Johnson 1990, p. 7; AGFD 2001, p. 4). According to the AGFD's Heritage Data Management system, 95 percent of Sonoran desert tortoise observations in Arizona have occurred at an elevation of 904 to 4,198 ft (275 to 1279 m) (Zylstra and Steidl 2009, p. 8). However, one example of an extreme exception was a Sonoran desert tortoise observed at 7,808 ft (2,379 m) in a ponderosa pine-dominated coniferous community in the Rincon Mountain District of Saguaro National Park in Pima County, Arizona (Aslan *et al.* 2003, p. 57). The nearest road was 8.6 mi (13.9 km) away by trail and nearly 2,000 ft (610 m) lower in elevation from the observed location of the tortoise, which strongly dismisses any notion that human activity was responsible for its location at such a high elevation (Aslan *et al.* 2003, p. 57).

Sonoran desert tortoises in Mexico are generally found at lower elevations, ranging from approximately 1,000 to 1,640 ft (305 to 500 m) in elevation in rocky outcrops in desertscrub and foothills thornscrub habitat (Bury *et al.* 2002, p. 89). As in Sonoran desertscrub habitat in Arizona, Sonoran desert tortoises in Mexico often use shrubs as temporary shelter sites, and species such as mesquite (*Prosopis* spp.) and ironwood (*Olneya tesota*) may play important roles in the natural history of Sonoran desert tortoises in Mexico (Bury *et al.* 2002, p. 100). Sonoran desert tortoises in Mexico have not been documented in flatter areas between mountain ranges (Bury *et al.* 2002, p. 89), although we presume they use these areas to some extent for dispersal much like they do in similar inter-mountain basins of Arizona. With the exception of the El Pinacate Desert Bioreserve in northwestern Sonora, Sonoran desert tortoises have not been documented using the extremely arid Lower Colorado subdivision of the Sonoran Desert in Mexico (Bury *et al.* 2002, p. 89). However, based on their presence in El Pinacate and the general lack of surveys in Mexico, the Sonoran desert tortoise may potentially be found in this habitat in northwestern Sonora in low densities. The extent of Sonoran desert tortoise distribution in northeastern Sonora, an area characterized as a transitional zone of foothills thornscrub, tropical deciduous forest, and Madrean oak woodland, is poorly understood (Bury *et al.* 2002, p. 89).

Burrow Use

Adequate shelter, often in the form of constructed burrows, is one of the most important habitat features for the Sonoran desert tortoise. Burrows are constructed under rocks and boulders, beneath vegetation, on semi-open slopes, within the sidewalls of washes, or by using rocky crevices which may or may not be altered by the tortoise (Burge 1979, p. 44; 1980, pp. 44–45; Barrett 1990, p. 205; Averill-Murray *et al.* 2002a, pp. 136–137, Grandmaison *et al.* in press, p. 14). Sonoran desert tortoises construct burrows in a variety of soil types including silt, silt with loose gravel, diatomite (a light-colored porous rock composed of the shells of diatoms) and diatomaceous marl (a crumbly mixture of clays, calcium and magnesium carbonates, with remnants of shells), and well-lithified (process whereby loose particles are converted into rock) volcanic ash, as observed in the lower San Pedro River Valley of Arizona (Bailey *et al.* 1995, pp. 363–364). Burrows are used for thermoregulation, nesting, and protection from predators, and the lack of suitable conditions for constructing burrows may be a limiting factor in Sonoran desert tortoise populations (Barrett and Humphrey 1986, p. 262; Bailey *et al.* 1995, p. 366; Zylstra and Steidl 2008, p. 752). In fact, Sonoran desert tortoise population densities appear to be highly correlated with available burrows, or potential burrow sites (Averill-Murray and Klug 2000, p. 69; Averill-Murray *et al.* 2002b, p. 126). Sonoran desert tortoises often use a group of relatively closely-located burrows as focal areas of activity in their home range. In doing so, they establish circular or slightly linear movement patterns, and may temporarily move on to another such cluster of burrows within the same active season (Bulova 1994, p. 140; Averill-Murray and Klug 2000, p. 62; Lutz *et al.* 2005, p. 21).

Burrows influence a variety of Sonoran desert tortoise behaviors and physiological characteristics. During the winter dormancy period (colder, winter months of inactivity), female Sonoran desert tortoises typically use more shallow burrows that are more susceptible to variation in ambient temperatures and consequently females emerge earlier in the spring (as early as late February) than do males, who often remain dormant until the commencement of the summer monsoon (AIDTT 2000, p. 7; Ernst and Lovich 2009, p. 547). Averill-Murray and Klug (2000, p. 66) and Bailey *et al.* (1995, p. 367) suggest that shallow burrows may account for responsiveness of females to warming periods in early spring for additional foraging opportunities to increase energy reserves for egg development, as shallower burrows are more reflective of ground-surface temperatures. Alternatively, cool, less variable temperatures in deeper burrows selected by male Sonoran desert tortoises may enhance sperm development and viability, as cooler temperatures allow more sperm production (Bailey *et al.* 1995, p. 367).

The season may influence the locations and dimensions of burrows used by Sonoran desert tortoises in order to meet their behavioral and physiological needs (Barrett 1990, p. 205; Bailey *et al.* 1995, pp. 363, 366). Finally, particularly in hatchling and juvenile size classes, the burrow microclimate can affect the rate of water loss in desert tortoises, which results in behaviors (drinking pooled rain, withdrawing into their shell, seeking long, deep burrows) to avoid lethal dehydration in relatively hot, dry seasons (Wilson *et al.* 2001, p. 158; Bulova 2002, pp. 184–186).

Other forms of shelter used by Sonoran desert tortoise include packrat middens, which are often shared with other native reptiles, including other tortoises (Averill-Murray *et al.* 2002a, pp. 136–137; Lutz *et al.* 2005, p. 22; Grandmaison *et al.* in press, p. 2). These shelter types provide less insulation than earthen burrows and are therefore used for shorter duration, especially during the months with extremely hot or cold temperatures. This was the most commonly used shelter site at Florence Military Reservation.

Seasonal Behavior and Long-Distance Movements

The Sonoran desert tortoise is diurnal (active during daylight hours) but sometimes emerge at night in response to rainfall (Ernst and Lovich 2009, p. 544). Sonoran desert tortoises may be surface-active every month of the year, but in the winter, surface activity is likely a response to thermoregulatory needs or movements between burrows (Averill-Murray and Klug 2000, p. 66).

Temperature and precipitation are important predictors of Sonoran desert tortoise activity (Meyer *et al.* 2010, p. 11). Precipitation amounts and timing vary among the populations of desert tortoise. The lowest amount of rainfall (usually during the winter) occurs in the northwestern-most portion of the species' range, and gradually increases and becomes seasonally bimodal pattern (rains in winter and summer) to the south into the southern-most extent of the species range in northern Sinaloa, Mexico (Germano *et al.* 1994, p. 76). Sonoran desert tortoise surface activity largely mimics the warm-season precipitation pattern (Averill-Murray *et al.* 2002a, p. 139; Van Devender 2002a, p. 7). Like the Arizona populations, Sonoran desert tortoises in Mexico seem to be most active in late summer (Ernst and Lovich 2009, p. 544). Sonoran desert tortoises are approximately half as active during the spring as they are in the summer, with females typically becoming surface active to forage in late March, while males typically emerge (but are not necessarily active) in late April (Averill-Murray *et al.* 2002a, p. 138).

The summer monsoon (occurring typically from late June through September), characterized by both excessive heat and frequent thunderstorms, is the peak activity season for the Sonoran desert tortoise (Averill-Murray *et al.* 2002a, pp. 139–140). During this period, new growth of perennial plants is initiated and annual plants germinate, providing forage for tortoises (Averill-Murray *et al.* 2002a, p. 140). The onset of the summer monsoon triggers Sonoran desert tortoises to drink, flush their bladders, and rehydrate, establishing a positive water and energy balance, and spurring reproductive behaviors (AIDTT 2000, p. 7). Sonoran desert tortoises have been observed to seek out rocks with surface depressions during summer months to drink puddled water from monsoon storm events (Oftedal 2007, p. 23). Surface activity in Sonoran desert tortoises begins to wane as early as late September and ends by mid-December as they prepare for hibernation. Temperature and photoperiod (the duration of daylight) are likely the cues used by Sonoran desert tortoises to commence hibernation (Bailey *et al.* 1995, p. 367; Averill-Murray *et al.* 2002a, p. 147). Periods of hibernation (typically from mid-November through mid-February) in Sonoran desert tortoises appear to vary greatly among populations and among years but appear to correlate with seasonal temperatures (Bailey *et al.* 1995, p. 367; Averill-Murray and Klug 2000, p. 66).

The behavior and ecology of hatchling Sonoran desert tortoises is poorly understood because their small size makes them very difficult to observe in the wild. Their scat is small, inconspicuous, and ephemeral, and burrows used by individuals in this size class resemble those of other terrestrial vertebrates in Sonoran desert tortoise habitat (Germano *et al.* 2002, pp. 271–272). This size class is thought to be the most vulnerable, experiencing the highest mortality rates (Morafka 1994, p. 161).

Home range sizes of Sonoran desert tortoises vary with precipitation levels, contracting during wet years and expanding during dry years in response to the availability of forage plants (Averill-Murray and Klug 2000, p. 67). The home range of Sonoran desert tortoises may be as small as 6.4 ac (2.6 ha) but can vary widely, with males having larger home ranges than females (Barrett 1990, p. 203; Averill-Murray and Klug 2000, pp. 55–61; Averill-Murray *et al.* 2002a, pp. 150–151). In the lower San Pedro River Valley, Meyer (1993, p. 99) found Sonoran desert tortoise home ranges varied between 45 and 640 ac (18 and 258 ha) in size. Sonoran desert tortoises are known to exhibit high fidelity to their home ranges, with exception to dispersal movements when they move to new areas (Zylstra and Swann 2009, p. vi). They likely habituate to specific attributes of their home range, including the location of mates, water catchments, mineral licks, and burrow sites (Berry 1986a, p. 113).

Sonoran desert tortoises are known to make long-distance movements between populations in adjacent mountain ranges. In an extreme example, Edwards *et al.* (2004, p. 494) tracked an adult female Sonoran desert tortoise moving 20 mi (32 km) between the Rincon and Santa Rita mountains of southern Arizona (also see Zylstra and Swann 2009, p. 10). During this long-distance movement, this tortoise encountered several barriers to movement that required human intervention to overcome such as fence lines, railroad tracks, an interstate highway, and several captures (including a temporary adoption) by humans (Edwards *et al.* 2004, p. 494). In another example, in the San Pedro Valley of southern Arizona, a sub-adult Sonoran desert tortoise was captured and marked in 1992. It was recaptured in 2005 approximately 14 mi (23 km) from its original point of capture (Meyer *et al.* 2010, p. 18). Dispersal distances of hatchling Sonoran desert tortoises are not well understood, but are likely shorter than those of adults because of the complex habitat of boulders and vegetation (where they occur) may inhibit long-distance movements (Van Devender 2002a, p. 14).

Gibbons (1986, p. 104) suspected that long-distance movements by turtles can be explained by: (1) Nest site selection; (2) seasonal migration; (3) departure from unfavorable habitat conditions; or (4) movement by males in search of females. Averill-Murray and Klug (2000, p. 68) suggested that long-distance movements may be interpreted as random wanderings, infrequent travels to known sources of biological needs, explorations, adaptations for genetic exchange, or for dispersal to other suitable areas. Precipitation may influence the likelihood of long-distance movements, especially in individuals approaching reproductive age in populations that experience above-average precipitation for a 2- to 3-year period (AIDTT 2000, p. 8). Averill-Murray and Klug (2000, p. ii) stated, "A large cohort of young tortoises that experiences a relatively wet and productive environment, with high survival, may provide the stock for dispersal between populations as they approach sexual maturity, in addition to replacing aging adults within the local population." Long-distance movements by Sonoran desert tortoises observed by Averill-Murray and Klug (2000, p. 69) suggest the potential for metapopulation (interrelated population dynamics between regionally proximal populations) relationships between local populations inhabiting regional hillsides. Habitat features may also influence the Sonoran desert tortoises' ability to make long-distance movements. Dispersal of Sonoran desert tortoises between populations might be less likely through sparse desertscrub in very hot, dry river valleys in the Lower Colorado River subdivision of Sonoran desertscrub. Van Devender (2002a, p. 16) suggested that populations occurring in the Eagletail, Maricopa, Sand Tank, and similarly situated mountain ranges might have existed in isolation for decades, if not centuries.

There are no data to evaluate long-distance movements in populations that occur in Mexico. Although Sonoran desert tortoises in Mexico are known to occupy slopes, arroyos, and bajadas, they are infrequently observed using valley bottoms (Fritts and Jennings 1994, p. 52). Sonoran desert tortoise populations in Mexico have been poorly studied, but we presume individuals make similar long-distance movements between populations.

Longevity

Estimates of longevity in wild Sonoran desert tortoises vary considerably from 30 years to over 100 years (Germano 1992, pp. 369–370; 1994, p. 176; Zylstra and Swann 2009, p. vii). Using a growth equation to extrapolate longevity in Sonoran desert tortoises, Germano *et al.* (2002, p. 271) estimated that the average oldest ages attained for Sonoran desert tortoises is 62.2 years in females and 64.4 years in males; however, they admitted that correlating age with size is problematic in turtles. Zylstra and Swann (2009, p. vii) suspected that Sonoran desert tortoises may reach 80 to 100 years of age in the wild. Sonoran desert tortoises have been shown to live longer in the wild than those from the Mojave population.

Bladder Physiology

The bladder in the Sonoran desert tortoise is unique and serves an important function in its survival. Sonoran desert tortoises are capable of drinking large amounts of water when it is available, and may even construct water catchments by digging earthen depressions, likely as an adaptation to the infrequent and unpredictable nature of rainfall events throughout their range (Ernst and Lovich 2009, p. 546). The bladder of Sonoran desert tortoises is a large and bilobed (divided into two lobes) organ critical for withstanding the effects of seasonal and short-term drought because of its ability to store water, dilute excess dietary salts and metabolic wastes, and reabsorb water into the bloodstream (Averill-Murray *et al.* 2002a, p. 146; Ernst and Lovich 2009, p. 545). In seasonal or short-term drought conditions, the concentration of urine in Sonoran desert tortoises allows them to forage on dried vegetation by reducing the dehydration effects of such forage types (Averill-Murray *et al.* 2002a, p. 146; Ernst and Lovich 2009, p. 545). Water serves an important role in flushing salts from the body of Sonoran desert tortoises and resetting the electrolytic balance, preparing the Sonoran desert tortoise for the next dry period (Averill-Murray *et al.* 2002a, pp. 140, 146).

Diet, Foraging Behavior, and Potassium Excretion Potential

The Sonoran desert tortoise is an herbivore, and has been documented to eat 199 different species of plants, including herbs (55.3 percent), grasses (17.6 percent), woody plants (22.1 percent), and succulents (5 percent) (Ogden 1993, pp. 1–8; Van Devender *et al.* 2002; pp. 175–176; Brennan and Holycross 2006, p. 54; Oftedal 2007, p. 21; Ernst and Lovich 2009, p. 562; Meyer *et al.* 2010, pp. 28–29, 44–48). Of the numerous nonnative plant species that have become established throughout the range of the Sonoran desert tortoise, only red brome (*Bromus rubens*) and redstem filaree (*Erodium cicutarium*) are frequently eaten and considered relatively important nonnative species in the diets of Sonoran desert tortoises (Van Devender *et al.* 2002, p. 183). However, physical injury to Mojave desert tortoises resulting from consuming nonnative grass species (i.e., red brome and cheatgrass (*Bromus tectorum*)) has been documented, and sharp seeds have been found lodged between the tortoises' upper and lower jaw. This injury may adversely affect their foraging ability or become a source for infection (Medica and Eckert 2007, p. 447). Though this study focused on Mojave desert tortoises, this may affect all desert tortoises wherever these plant species occur (i.e., within the Sonoran Desert in Arizona).

Significant differences in the nutritional quality of native versus nonnative forage for desert tortoises were not found by Hazard *et al.* (2010, pp. 139–145). Nagy *et al.* (1998, pp. 260, 263) compared the nutritional values of native and nonnative grasses (native: Indian ricegrass (*Achnatherum* (*Oryzopsis*) *hymenoides*); nonnative: Mediterrean grass (*Schismus barbatus*)) and forbs (native: desert dandilion (*Malacothrix glabrata*); nonnative: redstem filaree), finding that the two grasses possessed similar nutritional value. The dry matter and energy digestibility of the two grasses were much lower than those of the forbs, providing little nitrogen, and tortoises lost more water than they gained while processing grasses. The native forb was more readily digestible than the nonnative forb as dried mass, but the inverse was true as fresh mass (Nagy *et al.* 1998, p. 263). However, the native forbs provide significantly more nitrogen and water than the nonnative forbs, which is important in maintaining a positive water balance. Results of these feeding trials suggest that the proliferation of nonnative grasses leading to the exclusion of forbs places desert tortoises at a nutritional disadvantage. 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 the best nutrition. Nagy *et al.* (1998, p. 260) concluded that the life stage of the plant and the plant type (forb or grass) were important predictors of nutritional quality versus a plant being native or nonnative to a particular region. In summary, research has shown that forbs are more valuable to Sonoran desert tortoise nutrition than grasses, and that native forbs are more valuable than nonnative forbs in a dried state, which may be important in periods of drought.

Diets of Sonoran desert tortoises vary among populations in response to seasonal availability of plant species and in response to precipitation amounts (Martin and Van Devender 2002, p. 31). In years of low winter rainfall, Sonoran desert tortoises are less selective in plant species consumed because there are fewer options, but in years of high winter rainfall, Sonoran desert tortoises have exhibited highly selective foraging habits (Oftedal 2002, pp. 205–206). During years when monsoon rains are light or irregular, Sonoran desert tortoises consume dried plant material (Averill-Murray *et al.* 2002a, p. 140). Within Saguaro National Park in southern Arizona, Sonoran desert tortoises frequently ate annual legumes in the spring (high in water content, low in potassium), and annual and perennial grasses (supplemented by prickly pear fruit (*Opuntia engelmannii*)) during the monsoon when ponding water can replenish water reserves (Oftedal 2007, p. 17). In most years, Sonoran desert tortoises consume enough calories during the summer monsoon to fuel growth and store fat for the next year (Van Devender 2002a, p. 10).

Desert tortoises are uniquely vulnerable to changes in their potassium levels (Oftedal 2002, p. 208). Because potassium cannot be easily stored in the body, excess potassium must be excreted to avoid toxicological effects (Oftedal 2002, p. 208). Therefore, Sonoran desert tortoises that must forage on plants with high potassium content must also flush their bladders more frequently and therefore risk a net loss in metabolic water levels and subsequent dehydration (Oftedal 2002, p. 209).

The potassium excretion potential (PEP) is an index of water, nitrogen, and potassium levels in a plant that relates to a desert tortoise's ability to efficiently excrete potassium. PEP is a critical consideration for determining the value or risk of particular forage species during times of drought or major perturbations to habitat, and for comparing potential effects of forage competition between tortoises and livestock. A positive PEP value for a plant species (preferred by tortoises) means there is more water and nitrogen in the food than is needed to excrete potassium, and vice-versa for a negative PEP value (Oftedal 2002, p. 215; Ernst and Lovich 2009, p. 545). Sonoran desert tortoises have been documented to selectively forage on high PEP plant species to minimize water loss associated with metabolizing potassium (Oftedal 2002, p. 214; Ernst and Lovich 2009, p. 545). High PEP values can be found in certain species of primroses, filaree, legumes, mustards, and spurges (Ernst and Lovich 2009, p. 545). Sonoran desert tortoises have been found to be seasonally selective for high PEP forage species, based on the abundance and diversity of plants and precipitation (Oftedal 2002, p. 223; 2007, pp. 3, 22).

In addition to herbivory, Sonoran desert tortoises are also geophagous; in other words, they consume bones, stones, and soil for additional nutrient and mineral supplements, for mechanical assistance in grinding plant matter in the stomach, or to expel parasites in the intestinal tract (Sokol 1971, p. 70; Marlow and Tollestrup 1982, p. 475; Esque and Peters 1994, pp. 108–109; Stitt and Davis 2003, p. 57; Walde *et al.* 2007b, p. 148). Sonoran desert tortoises are highly attracted to sites with exposed calcium carbonate and have been observed congregating at these sites year after year eating these soils (Meyer *et al.* 2010, p. 11). Soil condition and quality are important to the Sonoran desert tortoise, not only for nutrients derived from eating soil, but also production and maintenance of vegetation that is consumed by tortoises (Avery and Neibergs 1997, p. 13).

Desert tortoises have been observed eating scat from black-tailed jack rabbits, wood rats, collared peccaries, and even desert tortoises. This behavior could possibly aid in the transfer of gut microflora such as bacteria or fungi or it could be used as a source of additional nutrients (Walde *et al.* 2005, p. 77–78). Bostick (1990, p. 149) asserted that desert tortoises feed “primarily on dung” although this claim was refuted in the literature (Boarman 2002, pp. 27, 35, 38). Infrequent observations of sand, bird feathers, arthropod parts, and snake and lizard skins have also been made during fecal analyses of desert tortoises (Ernst and Lovich 2009, p. 560).

Reproduction

The Sonoran desert tortoise breeding season begins with the summer monsoon when male-male combat over receptive females can be observed, such as at sites with exposed calcium carbonate soils, where tortoise densities may be higher (discussed above) (Meyer *et al.* 2010, p. 11). Sexual maturity and first reproduction in female Sonoran desert tortoises occurs from 12 to 22 years of age, or at 8.7 in (22 cm) in midline carapace length, and reproductive activity is highly influenced by winter and spring precipitation (Averill-Murray and Klug 2000, p. 69; Averill-Murray *et al.* 2002b, p. 119; Bury *et al.* 2002, p. 100; Germano *et al.* 2002, p. 265). Females may store sperm for up to two years, meaning that one season’s mating produces the following season’s clutch of eggs (Palmer *et al.* 1998, pp. 704–705; Averill-Murray *et al.* 2002a, p. 141). Female Sonoran desert tortoises may lay one clutch of 1–12 eggs per year, usually around the onset of the summer rainy season, although they may not produce a clutch every year (Averill-Murray 2002b, p. 295). Eggs hatch in September and October (Van Devender 2002a, pp. 10–11; Averill-Murray 2002b, p. 295). The average clutch size is 3.8 to 5.7 eggs, and in contrast to Mojave Desert tortoises, clutch size is not positively correlated with female body size (Mueller *et al.* 1998, p. 313; Averill-Murray 2002b, p. 299; Averill-Murray *et al.* 2002b, p. 119). Late oviposition (deposition of eggs) dates recorded on the Sugarloaf study site in central Arizona in 1998 and 1999 suggest that eggs and hatchlings may occasionally overwinter in nests (Averill-Murray 2002b, p. 299). Female desert tortoises have been known to urinate on their nest sites before and after nesting; this may be to aid in digging the nest, and might make it more difficult to dig up the nest after the soil dries, or possibly to hydrate soils in contact with eggs as the rigid-shelled eggs of desert tortoises have been shown to uptake moisture from the soil faster than it evaporates from the shell exposed to air (Patterson 1971, p. 199; Spotila *et al.* 1994, p. 112). Female Sonoran desert tortoises that survive to reproductive age are believed to produce as many as 85 eggs over the course of their lives, with perhaps two or three of those hatchlings surviving to reproductive age (Van Devender 2002a, p. 11).

Desert tortoises exhibit environmental sex determination, which means that incubation temperatures during embryonic development determine the sex of the tortoises. Higher incubation temperatures produce more females and lower temperatures produce more males (Spotila *et al.* 1994, pp. 109–111; Rostal *et al.* 2002, p. 313). Incubation temperatures at or below 86.9 degrees Fahrenheit (° F) (30.5 degrees Celsius (° C)) result in the production of all male desert tortoises, whereas temperatures of 90.5 °F (32.5 °C) result in all females, and eggs incubated at the “pivotal” temperature of 88.3 °F (31.3 ° C) develop a 1:1 sex ratio (Rostal *et al.* 2002, p. 313).

Predation

As adults, Sonoran desert tortoises are relatively protected from natural predation because of their hard shells. Mountain lions (*Felis concolor*) appear to be the only natural predator in the Sonoran Desert with the jaw strength required to puncture or crack the shells of adult Sonoran desert tortoises. However, mountain lion predation is not known to contribute to elevated mortality rates within monitored Sonoran desert tortoise populations (AIDTT 2000, p. 8; Meyer *et al.* 2010, p. 18; Riedle *et al.* 2010, p. 165). Dickenson *et al.* (2001, p. 254) recorded 14 Sonoran desert tortoise mortalities in the Little Shipp Wash and Harcuvar monitoring plots from 1990–1994, five of which were attributed to mountain lion predation. Javelina (*Tayassu tajacu*) predation on Sonoran desert tortoises was suspected in the San Pedro Valley of southern Arizona (Meyer *et al.* 2010, p. 18). Other mammalian predators may include badgers (*Taxidea taxus*), ring-tailed cats (*Bassiriscus astutus*), bobcats (*Felis rufus*), skunks (*Spilogale gracilis, Mephitis mephitis, M. macroura, Conepatus mesoleucus*), kit foxes (*Vulpes macrotis*), gray foxes (*Urocyon cinereoargenteus*), coyotes (*Canis latrans*), and domestic dogs (*Canis familiaris*) (Boarman 2002, p. 17; Ernst and Lovich 2009, p. 563).

Both golden eagles (*Aquila chrysaetos*) and common ravens (*Corvus corvax*) have been documented to prey upon all size classes of Mojave desert tortoises in California (Berry 1985, pp. 1, 6–10). Such predation might also occur on Sonoran desert tortoises. The greater roadrunner (*Geococcyx californianus*) is also a suspected predator on juvenile Mojave desert tortoises, based upon one field observation of roadrunner tracks next to a freshly killed individual (Berry 1985, p. 11); such predation might also occur on Sonoran desert tortoises. However, because avian predators rely exclusively on their vision to detect prey, we expect lower rates of avian predation on Sonoran desert tortoises occupying Arizona upland Sonoran desertscrub because the dense, complex habitat structure likely limits birds’ ability to detect tortoises. Habitat-associated protection from avian predation may be less pronounced where Sonoran desert tortoises occur in the sparser vegetation of the Lower Colorado River subdivision of Sonoran desertscrub.

Sonoran desert tortoises are most vulnerable to predation while in their eggs or as hatchlings and juveniles predominantly because of their size and undeveloped, softened shells (which do not adequately harden until approximately 7 years of age) which provide little protection and are easily compromised. Higher mortality rates in the hatchling and juvenile age classes may also be partially due to their higher metabolic rates, which necessitates longer periods of surface activity to obtain suitable amounts of forage. Longer surface activity may cause greater risk of detection by predators (Morafka 1994, p. 163). Nest predation levels may be high in some populations. Seventy-five percent of Sonoran desert tortoise nests suffered predation over a two-year period at the Sugarloaf study plot in Maricopa County, Arizona (Averill-Murray 2002b, p. 298). Gila monsters (*Heloderma suspectum*) are a primary predator on tortoise eggs, and female Sonoran desert tortoises in the process of oviposition will actively defend the burrow and aggressively pursue Gila monsters in attempting to drive them away (Barrett and Humphrey 1986, p. 262). Coachwhips (*Coluber flagellum*) and gophersnakes (*Pituophis catenifer*) have been reported consuming juvenile Sonoran desert tortoises (Amarello *et al.* 2004, p. 178; Ernst and Lovich 2009, p. 563). Presumably, other snake species such as common kingsnakes (*Lampropeltis getula*) with generalized prey preferences consume eggs or hatchling Sonoran desert tortoises, but we did not find other examples in the literature.

For more detailed information on all aspects of Sonoran desert tortoise biology, see Barrett and Johnson (1990, pp. 1–95) and Bury and Germano (1994, pp. 1–212).

Monitoring and Population Status

Monitoring and Statistical Analyses

We are unaware of any structured, long-term monitoring program for Sonoran desert tortoises in Mexico; therefore, we are unable to assess the current status or population trends in that part of the range. Therefore, we discuss only Arizona studies in this section.

Twenty-eight individual Sonoran desert tortoise populations in Arizona have been studied since the mid-1970s but few populations have been studied for more than a few years (Averill-Murray 2000, p. 1; Averill-Murray *et al.* 2002b, p. 109). Monitoring plots (also referred to as "plots") have varied from 0.2 to 1.5 sq mi (0.3 to 2.4 sq km) in size (Averill-Murray 2000, p. 4). Beginning in 1987, AGFD and the U.S. Bureau of Land Management (BLM) have established and maintained 17 plots in Arizona as long-term monitoring plots and have surveyed them in a somewhat irregular, but repeated fashion. Each plot has been surveyed between two and nine times during this timeframe, with 11 to 86 person-days (cumulative days spent by researchers working on plots) spent during each survey (AGFD 2010, p. 1). These long-term monitoring plots are located in six counties within Arizona, and their locations were chosen to represent Sonoran desert tortoise distribution in the State.

General monitoring objectives for the 17 plots are to document abundance, density, and changes of Sonoran desert tortoise populations across the State using capture-recapture methods (Averill-Murray 2000, p. 3). Records of demographic characteristics of each population, including sex ratios and age/size structure as well as individual health and signs of disease within each population were also recorded during monitoring activities (Averill-Murray 2000, p. 3). Monitoring protocols used from 1987 to 2000 are summarized in Averill-Murray (2000, pp. 3–7).

The Sonoran desert tortoise is a difficult species to monitor in the wild because of its slow movement and camouflaged appearance, especially in the smaller hatchling and juvenile age classes. These factors can significantly hamper a surveyor's ability to detect them in the field (Zylstra *et al.* 2010, p. 1311). In addition, Arizona Upland subdivision of Sonoran desertscrub (where Sonoran desert tortoise population densities are the highest) is complex, often with many large boulders, somewhat dense vegetation, and challenging topographic relief. Drought and emigration also affect the reliability of data from Sonoran desert tortoise population monitoring because the tortoises may be inactive (in their burrows) or have left the population (dispersed). In these cases the absence of observations might be mistaken as mortality. Also, Sonoran desert tortoises can occur in low densities with little surface activity both seasonally and daily (Zylstra *et al.* 2010, p. 1311). Alone or in combination, these factors, in addition to a relatively short sampling period for such a long-lived species, make subtle population trends difficult to distinguish and overall population trend analysis problematic.

Low detectability may have been responsible for long periods between recaptures of marked desert tortoises in an 18-year desert tortoise study from 1980 to 1997 in the San Pedro Valley, Arizona. For example, a sub-adult Sonoran desert tortoise was captured and marked in 1992, and was not encountered again until 2005, when it was incidentally observed approximately 14 mi (22.5 km) from its original point of capture, 8 years after the conclusion of the study (Meyer *et al.* 2010, p. 18). Within the entire duration of this study, approximately 30 percent of 577 marked Sonoran desert tortoises were never recaptured, with only 15 total carcasses found, indicating potential emigration, long-term burrow use, or difficulties in detecting individuals in complex landscapes (Meyer *et al.* 2010, p. 20). The amount of time between recaptures of Sonoran desert tortoises can be significant; durations between recaptures of some individuals in the San Pedro Valley study were as high as 18 years (Meyer *et al.* 2010, p. 20).

Several authors have investigated how detectability may bias results of Mojave desert tortoise monitoring. For example, Anderson *et al.* (2001, p. 583) studied the degree to which field observers can meet the assumptions underlying line-transect sampling to monitor populations of desert tortoises in Mojave desertscrub. They found that when all Mojave desert tortoises are not detected along the centerline of the transect route (which routinely occurs), biases in sampling data result (Anderson *et al.* 2001, p. 583). Anderson *et al.* (2001, p. 593–596) noted that surveyor numbers and level of experience contribute to the reliability of line transect methods. Freilich and LaRue (1998, p. 594) experimentally tested the effect of personnel experience on Mojave desert tortoise survey outcomes in Mojave desertscrub. They found that observers consistently overestimated the number of desert tortoise burrows (falsely assigning other animal burrows as those made by desert tortoises), and found fewer desert tortoises and scat than were actually placed on test plots. Their results indicated that experience played a relatively small role in detecting Mojave desert tortoises (Freilich and LaRue 1998, pp. 593–594). In an effort to increase detections, some investigators have tested the use of tortoise detection dogs in Mojave desert tortoise monitoring projects (Cablk and Heaton 2006, p. 1926; Heaton *et al.* 2008, pp. 476–477; Nussear *et al.* 2008, pp. 109–111). Because Sonoran desertscrub is more dense and complex than Mojave desertscrub, detection is even more difficult in Sonoran desert tortoise monitoring. Zylstra and Steidl (2009, p. 16) found that line transect methods are not an efficient means with which to monitor Sonoran desert tortoises.

The seasonal timing of surveys and fluctuating influence of precipitation on Sonoran desert tortoise surface activity also create problems with monitoring populations and interpreting results. Sonoran desert tortoises often become inactive, residing in their burrows, during periods of seasonal or short-term drought. For example, in a multi-year mark and recapture study of Mojave desert tortoises in Joshua Tree National Park, Freilich *et al.* (2000, pp. 1487–1488) found that in years of below-normal precipitation, desert tortoise home ranges decreased, individual captures decreased, and the effort required to find each tortoise nearly doubled; indicating the significant influence of precipitation on the possible discrepancy between the number of tortoises that can be observed versus the number of tortoises that actually occur within a monitoring plot.

In an attempt to improve monitoring protocols to account for such complicating factors described above, Averill-Murray (2000, pp. 7–13) critiqued the original protocols used for long-term monitoring plots of Sonoran desert tortoise populations in Arizona. This work became the basis for several changes in monitoring protocols, beginning in 2000. Although line transect methods have not been implemented on Arizona's Sonoran desert tortoise long-term monitoring plots, the capture-recapture methods currently used likely violate assumptions about equal detection probability (all animals having the same probability of being captured during every sampling occasion) (Zylstra and Steidl 2009, p. 9).

While monitoring of Sonoran desert tortoise populations in Arizona has been ongoing for several decades, attempts to quantify temporal trends in abundance have been hampered by the data limitations discussed above (Zylstra and Steidl 2009, p. 5; Zylstra *et al.* 2010, pp. 1311–1317). Effective monitoring is largely dictated by the objective of the monitoring, whether that objective is to detect changes in distribution, abundance, density, or survival. In addition, using existing plot data to establish rangewide trends in Sonoran desert tortoise populations is generally problematic because the current set of monitoring plots does not represent a random sample from the species' entire range in Arizona (Averill-Murray and Klug 2000, p. 25). Despite the history and effort dedicated to monitoring Sonoran desert tortoise populations in Arizona since 1987, there are limitations of these data with respect to interpreting rangewide trends of the Sonoran desert tortoise. Averill-Murray (2000, pp. 12–13) identified problems with extrapolating the results of the plot monitoring data to making range-wide assessments outside of the plots. We elaborate on these problems in our assessment of Boarman and Kristan (2008) below.

Boarman and Kristan (2008, pp. 3–12) analyzed mark and recapture data from the 17 Sonoran desert tortoise long-term monitoring plots throughout Arizona that were surveyed on the average of once every 4 years from 1987 to 2006. Boarman and Kristan (2008, p. ii) concluded that the Sonoran population of the desert tortoise in Arizona experienced statistically significant declines, at an annual rate of 3.52 percent over the 20-year period; equating to a cumulative 51 percent decline in overall numbers during this timeframe.

We received several comments from the public in response to our 90-day finding that addressed the Boarman and Kristan (2008) report (AGFD 2010, pp. 4–6; Carothers *et al.* 2010, pp. 5, 8–12; Ogden 2009, pp. 3–12, Smith 2010, pp. 4–5). Commenters criticized the method and manner with which Boarman and Kristan (2008) used statistical tests, as well as the conclusions they made. Significant concerns were noted with respect to the type of statistical tests used by Boarman and Kristan (2008) because data were extrapolated beyond the statistical tests' ability to avoid inherent biases (AGFD 2010, p. 4). Problems associated with the statistical confidence intervals for monitoring plot data used by Boarman and Kristan (2008) were also identified (Ogden 2009, pp. 2–3). Also, monitoring plot data used in Boarman and Kristan (2008, p. 20) were not designed to compare population trends among individual plots (Ogden 2009, p. 2). Carothers *et al.* (2010, pp. 8–12) identified numerous additional problems with the statistical analysis provided by Boarman and Kristan (2008). Collectively, based upon comments received from the public as well as our internal review, the number and magnitude of potential problems associated with Boarman and Kristan's (2008) statistical analysis call into question the validity of their conclusions. After careful review of the report and the questions raised by reviewers of the report, we decided that the conclusions pertaining to overall Sonoran desert tortoise population trends do not represent the best available information and, therefore, we did not use the report in this finding. However, other information in the Boarman and Kristan (2008) report was used in our analysis of the status of and threats to the Sonoran desert tortoise and is cited in this finding. For a more detailed analysis of the Boarman and Kristan (2008) report, see our "Review of Boarman and Kristan (2008)" provided at *http://www.regulations.gov* (Docket Number FWS–R2–ES–2009–0032).

Survivorship and Population Densities in Arizona

Viable populations in turtles usually require that both juvenile and adult size classes have high survivorship (Averill-Murray and Klug 2000, p. 70). Data on the recruitment of juveniles into Sonoran desert tortoise populations, and their survivorship, are generally lacking due to the difficulty detecting juveniles in the field (AGFD 2010, p. 3). Data on juvenile and adult survivorship in Sonoran desert tortoises require long-term, repeated population monitoring, which in turn, requires long-term, reliable funding sources. Consequently, these data are conspicuously rare or absent for most Sonoran desert tortoise monitoring plots making population viability estimates for Sonoran desert tortoise populations within Arizona problematic at best. As expected for a long-lived species, survivorship in Sonoran desert tortoises (using data generated from a few long-term monitoring plots in Arizona) is generally high for adults but potentially lower for juveniles and hatchlings (Zylstra and Steidl 2009, p. 7). Where enough data from long-term monitoring plots or independent studies exist, survivorship has been calculated for adults in the following plots or study areas: Sugarloaf Mountain (96–98 percent), Florence Military Reservation (88–97 percent), Little Shipp Wash (94–97 percent), Granite Hills (94–97 percent), and Eagletail Mountains (94–97 percent) (AGFD 2010, p. 2; Riedle *et al.* 2010, p. 165).

Densities of Sonoran desert tortoises among populations vary considerably. In 2000, the density of Sonoran desert tortoises, as determined by surveys on long-term monitoring plots and other monitoring plots during the 1990s, varied from 15 to 150 individuals per square mile (2.6 sq km) (AIDTT 2000, pp. 5–6; Averill-Murray and Klug 2000, p. i). In the San Pedro Valley of southern Arizona, the average density of the Sonoran desert tortoise population was 38 individuals per square mile (Meyer *et al.* 2010, p. 17). Stager *et al.* (2010, p. 37) suspect that Sonoran desert tortoise populations in Mohave County, Arizona may be naturally lower due to limited burrowing habitat available to them to survive cold winters and hot summers.

Periodic, Localized Declines in Arizona Populations

There are no records of actual extirpations of Sonoran desert tortoises from any of the monitored populations. However, periodic, localized, and sometimes substantial declines have been documented in at least five of 17 monitored populations (Hart *et al.* 1992, p. 60; Averill-Murray *et al.* 2002b, p. 124; AGFD 2010, p. 4). Because of their life history, Sonoran desert tortoise populations may be slow to rebound from declines (Howland and Rorabaugh 2002, p. 340). The AGFD (2010, p. 4) suggested that observed declines in certain plots demonstrate localized, stochastic events and are not indicative of population trends as a whole across the distribution of the Sonoran desert tortoise. Sonoran desert tortoise populations are particularly vulnerable to elevated mortality of adults. Sustaining the adult, reproductive age class within Sonoran desert tortoise populations is important because mortality rates of juveniles are high and because it takes a long time for a Sonoran desert tortoise to reach sexual maturity (Howland and Rorabaugh 2002, p. 339). The relatively higher visibility of adult Sonoran desert tortoises leaves them more vulnerable to human impacts like collecting or shooting, and their tendency to move longer distances make them more susceptible to road mortality (Howland and Rorabaugh 2002, p. 340).

The largest population decline noted at any Sonoran desert tortoise monitoring plot was observed on the Maricopa Mountains plot, where substantially more tortoise carcasses were found than live tortoises in successive years from 1987 through 1991 (Hart *et al.* 1992, p. 54; Averill-Murray *et al.* 2002b, p. 124). Regional drought from 1984–1992 was a suspected cause of the die-off of Sonoran desert tortoises in the Maricopa Mountains (Hart *et al.* 1992, p. 60; Averill-Murray *et al.* 2002b, p. 124). However, in 1987, the estimated density of Sonoran desert tortoises on the Maricopa Mountains plot was uncharacteristically high at 146 tortoises per square mile (2.6 sq km), suggesting that the population may have been in the process of naturally correcting to carrying capacity (the state at which a population level is commensurate with available resources) (AGFD 2010, p. 3). Since 1991, the Sonoran desert tortoise population on the Maricopa Mountains plot has experienced relatively high survivorship and shown evidence of reproduction. No additional carcasses have been documented, indicating the population may be stable, if not returning to the previous 1987 level (AGFD 2010, p. 3).

The AGFD (2010, p. 3) and Hart *et al.* (1992, p. 120) confirm Sonoran desert tortoise populations declined from initial population estimates (as demonstrated by density estimates and relative carcass numbers) on three additional plots (Hualapai Foothills, San Pedro Valley, and East Bajada), suspecting that drought conditions may have played a role in the observed declines on these plots (Ogden 2009, pp. 12–13). An observed decline on the Tortilla Mountains plot in 2001 may have been an artifact of low surface activity in response to below-average precipitation, because an increase in carcasses was not detected (AGFD 2010, p. 3).

For detailed information on monitoring and survey results from the previous three decades for the Sonoran desert tortoise in Arizona, see the following reports: Schneider (1981), Shields and Woodman (1987), Wirt (1988), Woodman and Shields (1988), Holm (1989), Shields *et al.* (1990), SWCA (1990a; 1990b; 1990c), Hart *et al.* (1992), Murray and Schwalbe (1993; 1997), Woodman *et al.* (1993; 1994; 1995; 1996; 1998; 1999a; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009), AIDTT (2000, pp. 5–6), Averill-Murray (2000, pp. 3–7), Averill-Murray and Klug (2000, pp. 3–25), Averill-Murray *et al.* (2002b, pp. 110–112), Walker and Wood (2002), Young *et al.* (2002), and Zylstra and Swann (2009).

It should be noted that an average generation time for a Sonoran desert tortoise is 12–15 years and that monitoring of Sonoran desert tortoise populations has only occurred for about 30 years, representing approximately two generations. Many threats described below have been potentially acting on Sonoran desert tortoise populations for many decades, longer than populations have been studied. Below, we discuss the effects of various threats to individual Sonoran desert tortoises. However, due to limitations in monitoring data, we are unable to discern how Sonoran desert tortoise populations may have responded to these threats over time, or identify any long-term, historical trends in tortoise populations. We have not observed any extirpations among monitored populations.

Distinct Population Segment

We consider a species for listing under the Act if available information indicates such an action might be warranted. “Species” is defined by the Act as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate fish or wildlife that interbreeds when mature (16 U.S.C. 1532(16)). We, along with the National Marine Fisheries Service (now the National Oceanic and Atmospheric Administration—Fisheries), developed the Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4722; February 7, 1996), to help us in determining what constitutes a DPS. The policy identifies three elements that are to be considered regarding the status of a possible DPS. These elements include: (1) The discreteness of the population segment in relation to the remainder of the taxon (group of similar biological organisms); (2) the significance of the population segment to the taxon to which it belongs; and (3) the population segment’s conservation status in relation to the Act’s standards for listing (*i.e.,* whether the population segment, when treated as if it were a species, is endangered or threatened) (61 FR 4722, February 7, 1996). The first two elements are used to determine if a population segment constitutes a valid DPS. If it does, then the third element is used to consider whether such DPS warrants listing. In this section, we will consider the first two criteria (discreteness and significance) to determine if the Sonoran desert tortoise is a valid DPS (*i.e.,* a valid listable entity). Our policy further recognizes it may be appropriate to assign different classifications (*i.e.,* threatened or endangered) to different DPSs of the same vertebrate taxon (61 FR 4722).

Discreteness

Under the DPS policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following two conditions:

(1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity (separation based on genetic or morphological characters) may provide evidence of this separation.

(2) It is delimited by international governmental boundaries within which significant differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Based upon available information, the international boundary between Mexico and the United States is not considered for delineation of discreteness because the edge of the DPS is not located at the International Border and, therefore, will not be addressed further.

The Colorado River and Río Yaqui are two perennial rivers that form biogeographical barriers (a natural barrier that prevents the migration of species) to movement of tortoises between the Mojave and Sonoran desert tortoise populations, and between the Sonoran and Sinaloan desert tortoise populations, respectively. The Colorado River, separating California and Arizona, comprises the northern and western boundaries of the Sonoran desert tortoise population as identified in the April 2, 1990, final rule designating the Mojave population of the desert tortoise (occurring north and west of the Colorado River) as a threatened species under the Act (55 FR 12178; see final rule for a summary of previous actions regarding the Mojave population of the desert tortoise). The eastern boundary is the extent of the range of the Sonoran desert tortoise where desert habitats end and grassland, chaparral, and mountain habitats begin, which are areas that do not contain desert tortoises. The southern boundary of the Sonoran desert tortoise DPS, as considered in this finding, is the Río Yaqui in southern Sonora, Mexico; south and east of there, desert tortoises are considered Sinaloan populations. Potential threats to the Sinoloan desert tortoise are not evaluated as part of this finding.

In view of this biogeographical isolation, significant ecological divergence has occurred between the Mojave and Sonoran populations of desert tortoise, largely due to significant differences in geology, vegetation types, and precipitation cycles where the populations are distributed. Desert tortoises in the Mojave population are most dense in the intermountain valleys that have soil types favorable to the construction of large, deep burrows (Bury *et al.* 1994, pp. 66–70). However, Sonoran desert tortoises reach maximum densities in the rocky bajadas and hillsides of higher slopes, with reduced densities in the intermountain valleys (Berry 1984, p. 434; AIDTT 2000; p. 4; Van Devender 2002a, p. 7; Brennan and Holycross 2006, p. 54; Zylstra and Steidl 2008, p. 747). At the southern end of the DPS, Edwards *et al.* (2009, pp. 7–8) suggested that Sinaloan population of desert tortoise uses Sinaloan thornscrub and tropical deciduous forest habitats. These different habitat types with differing soils and vegetation communities are created by higher precipitation levels. However, some level of gradation may occur in the vegetative transition zone between Plains of Sonora subdivision of Sonoran desertscrub and Sinaloan thornscrub habitats of central Sonora such as in the vicinity of the Río Yaqui (Edwards *et al.* 2009, p. 8).

In addition to habitat differences, morphological differences have also been documented among the three populations of desert tortoise. Several morphological differences in carapace size and shape have been documented between the Mojave, Sonoran, and Sinaloan populations of desert tortoise: The carapace of the Mojave desert tortoise is the widest and tallest of the three, the Sinaloan desert tortoise carapace is the most narrow and least domed, and the carapace of the Sonoran desert tortoise is intermediate between the two in those dimensions (Germano 1993, pp. 324–325; AGFD 2001, p. 1). Using eight independent shell measurements, Weinstein and Berry (1987, pp. 26–28) documented three distinct phenotypes (physical appearances) in desert tortoise populations within the United States based on morphometric (body measurement) analyses: The "California" phenotype (Mojave population), "Beaver Dam Slope" phenotype (Mojave form in Arizona), and the "Sonoran type" (Sonoran population). Desert tortoises from southern Sonora and northern Sinaloa in Mexico were not studied as part of this effort.

Differences in reproduction strategies between the Sonoran and Mojave populations of desert tortoises also occur. Mojave desert tortoises lay up to three clutches of eggs per year with larger clutch sizes (more eggs), earlier in the year (April to mid-July) (Wallis *et al.* 1999, p. 405) while those in the Sonoran population lay one clutch per year of smaller size, later in the year (June through August) (Averill-Murray *et al.* 2002a, p. 141). These differences led Averill-Murray (2002b, pp. 119–122) to the conclusion that Sonoran desert tortoises invest all reproductive effort into a single clutch which hatches at the peak of forage and water availability and abundance owing to late-summer rainfall. Whereas desert tortoises in the Mojave population (maturing at smaller body sizes) (Berry *et al.* 2002a, p. 259) have higher clutch numbers to offset higher mortality from greater variability in environmental conditions.

The Mojave, Sonoran, and Sinaloan populations of the desert tortoise have been found to have significantly differentiated genotypes (genetic characteristics) (Lamb and McLuckie 2002, p. 74; Van Devender 2002a, p. 24). Genetic distances, expressed as percent sequence divergence (an estimate of percent difference in the genetic code), are substantial among the three populations of desert tortoise. Divergence is 5.1–5.6 percent between the Sonoran and Mojave populations, 4.2 percent between the Sonoran and Sinaloan populations, and 5.1 percent between the Sinaloan and Mojave populations (Lamb and McLuckie 2002, pp. 74, 77). Considering geographic distribution, genealogical depth, and a suite of other characteristics, the Mojave, Sonoran, and Sinaloan populations of desert tortoise are considered to be ecologically significant units (populations or groups of populations historically isolated from one another, and thus representing deep phylogenetic (evolutionary development of species over time) subdivisions within species) (Lamb and McLuckie 2002, pp. 81–82). According to mitochondrial DNA markers, the Sonoran and Mojave populations appear to have diverged some 5 million years ago (Lamb *et al.* 1989, p. 83; Lamb and McLuckie 2002, p. 76).

McCord (2002, p. 62) presented three possible causes of the significant genetic differentiation between Sonoran and Mojave desert tortoises. First, genetic differentiation between Sonoran and Mojave desert tortoises may have been the result of differences in rainfall patterns between the winter-dominated rainfall pattern of the Mojave Desert and the summer-dominated rainfall pattern of the Sonoran desert. Second, genetic differentiation between Sonoran and Mojave desert tortoises may have occurred because the Sonoran desert tortoises may be represented as a relict population (remnant survivor from the past) of the tropical deciduous forest-evolved population of the Sinaloan population (based upon their general absence in valley bottoms due to heavy flooding during summer rains, a phenomenon generally absent in the Mojave Desert). Last, genetic differences between Sonoran and Mojave desert tortoises may have resulted from their mutual competition with the Bolson tortoise (*Gopherus flavomarginatus*), another desert tortoise species which was widely distributed throughout Arizona in the Pleistocene, but which never occurred in California. The competing Bolson tortoise population may have acted as a wedge between the Sonoran and Mojave populations, driving them even farther apart, in a process known as competitive displacement.

To explore the evolutionary track the three desert tortoise populations may have taken and the extent of their current genetic differentiation on the landscape, Edwards *et al.* (2009, p. 8) collected genetic samples from desert tortoises within three regions of Sonora, Mexico: Twenty-two samples from near Alamos, Sonora (tropical deciduous forest in extreme southern Sonora), 19 samples from near Ciudad Obregón (foothill thornscrub in south-central Sonora, south of the Río Yaqui), and 14 samples from two sites north of Hermosillo (Sonoran desertscrub in central Sonora). When they compared genetic data with previously collected samples from Arizona, they found a "continuum of genetic similarity" in genetic samples taken from desert tortoises from the Hermosillo area of Sonora, Mexico, 528 mi (850 km) northwest to the Kingman, Arizona area when they compared genetic data with previously collected samples from Arizona (Edwards *et al.* 2009, p. 8). This confirms the similar genetic relationships of Sonoran desert tortoises throughout the DPS. Genetic samples from the Ciudad Obregón region, southward, showed clear genetic distinction and supported prior evidence for a third distinct population of desert tortoise, referred to as the Sinaloan population (Edwards *et al.* 2009, p. 8). The southern limits of desert tortoise distribution in northern Sinaloa are likely influenced by the growth of disease-causing bacteria and fungi present in the soil of burrows, exacerbated by the hot, humid, and wet conditions during tropical summer rainy seasons (Van Devender 2002b, p. 43).

Evaluation of Discreteness

Some biological similarities do exist among the three populations of desert tortoise (Mojave, Sonoran, and Sinaloan). For example, some overlap in habitat use occurs. It is well known that Sonoran desert tortoises generally occur on steep, rocky slopes and bajadas in contrast to the Mojave desert tortoise, which occurs primarily along the valley bottoms. But to a lesser extent, Sonoran desert tortoises also use valley bottoms and Mojave desert tortoises also use steep slopes and mountain bajadas (Gardner and Brodie 2000, p. 51; Averill-Murray and Averill-Murray 2002, p. 16; Lutz *et al.* 2005, p. 22; Grandmaison *et al.* in press, p. 4; Riedle *et al.* 2008, p. 418). However, there are many more numerous and convincing data in the scientific literature to support the discreteness of the three recognized populations of *Gopherus agassizii,* including differences in their ecology, behavior, morphology, physiology, and genetics (Weinstein and Berry 1987, pp. 26–28; Germano 1993, pp. 324–325; Germano *et al.* 1994, p. 82; AGFD 2001, p. 1; Averill-Murray 2002b, pp. 299–300; Berry *et al.* 2002a, p. 259; Lamb and McLuckie 2002, pp. 74, 77; McCord 2002, p. 62; Van Devender 2002a, pp. 24–25; Van Devender 2002b, p. 45; Zylstra and Steidl 2008, p. 747; Edwards *et al.* 2009, p. 8).

We have reviewed the best available commercial and scientific information and find that the Sonoran population of the desert tortoise as it occurs east and south of the Colorado River, south to the Río Yaqui, in Sonora, Mexico, is discrete, under the Service's DPS policy, from the Mojave and Sinaloan desert tortoise populations. We base this conclusion on ecological (habitat use), physiological (reproductive characteristics), morphological (shell dimensions), and behavioral (seasonal activity patterns) differences that are further supported by analysis of genetic differences that concluded significant divergence has occurred among the three populations.

Significance

If a population segment is considered discrete under one or more of the conditions described in the Service's DPS policy, its biological and ecological significance will be considered in light of Congressional guidance that the authority to list DPSs be used "sparingly" while encouraging the conservation of genetic diversity. In making this determination, we consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. Since precise circumstances are likely to vary considerably from case to case, the DPS policy does not describe all the classes of information that might be used in determining the biological and ecological importance of a discrete population. However, the DPS policy describes four possible classes of information that provide evidence of a population segment's biological and ecological importance to the taxon to which it belongs. As specified in the DPS policy (61 FR 4722), this consideration of the population segment's significance may include, but is not limited to, the following:

(1) Persistence of the discrete population segment in an ecological setting unusual or unique to the taxon;

(2) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon;

(3) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or

(4) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

A population segment needs to satisfy only one of these conditions to be considered significant. Furthermore, other information may be used as appropriate to provide evidence for significance.

The current range of the Sonoran desert tortoise, as described in the discussion above pertaining to discreteness, represents several hundred miles of occupied habitat spanning across an international border. This population segment is confined by two large perennial rivers: The Colorado River in its northern periphery (separating the Mojave and Sonoran populations), and the Río Yaqui at its southern periphery (separating the Sonoran and Sinaloan populations). These two rivers represent significant biogeographical barriers to genetic exchange between adjacent population segments and, therefore, preclude recolonization of this expanse of habitat from adjacent populations, should the Sonoran population of the desert tortoise become extirpated. Thus, the loss of the Sonoran desert tortoise would constitute a significant gap of several hundred miles in the range between the Mojave and Sinaloan populations of desert tortoises, and may constitute as much as 40 percent of the total range occupied by desert tortoises as a whole, rangewide, which affirms its significance to the entire species.

In addition, our evaluation of discreetness above found extensive scientific support concluding that the Sonoran desert tortoise differs significantly in its behavior (reproduction, seasonal activity), ecology (habitat use and burrow construction), morphology (physical characteristics), and genetics from either the Sinaloan or the Mojave populations. Because of these distinctions, the loss of the Sonoran desert tortoise population would result in the permanent loss of a unique biological entity and would diminish the natural variation within the species as a whole.

Evaluation of Significance

We have reviewed the best available commercial and scientific data, and based on that review, we find that the Sonoran desert tortoise is significant to the continued existence of the taxon. We base this conclusion on: (1) The large geographic range of the Sonoran population, which is significant (approximately 40 percent) to the taxon as a whole; (2) a gap of several hundred miles that would result from the loss of the Sonoran population, which would effectively bisect the species' range; and

(3) the behavioral, ecological, physical, and genetic distinctions among the three desert tortoise populations.

Determination of Distinct Population Segment

Based on our review of the best commercial and scientific information available, the Sonoran population of desert tortoise is discrete from the Mojave and Sinaloan populations and significant to the species as a whole. As a result, we have determined that the Sonoran population of desert tortoise qualifies as a DPS and a listable entity under the Act.

In the August 23, 2009, 90-day finding (74 FR 44335), we discussed a local population of Mojave-genotype (genotype: genetic code) desert tortoises (that also share Mojave phenotype (the physically-expressed genetic code) and habitat-use characteristics with the Mojave desert tortoise population) occurring within the delineated Sonoran population in the Black Mountains area of western Mohave County, Arizona. This population is isolated from the threatened Mojave DPS that occurs north and west of the Colorado River. The exact geographic extent of this Mojave-genotype in Arizona is currently undefined and we expect there is interbreeding between desert tortoises with the Mojave and Sonoran genotype along the periphery of this population in the Black Mountains. Therefore, we include this population of desert tortoises as part of our status assessment for the Sonoran desert tortoise in this finding.

Distinct Population Segment Five-Factor Analysis

Section 4 of the Act (16 U.S.C. 1533) and implementing regulations (50 CFR part 424) set forth procedures for adding species to, removing species from, or reclassifying species on the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, a species may be determined to be endangered or threatened based on any of the following five 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; or

(E) Other natural or manmade factors affecting its continued existence.

In making this finding, information pertaining to the Sonoran desert tortoise in relation to the five factors provided in section 4(a)(1) of the Act is discussed below.

In considering what factors might constitute threats to a species, we must look beyond the exposure of the species to a particular factor to evaluate whether the species may respond to that factor in a way that causes actual impacts to the species. If there is exposure to a factor and the species responds negatively, the factor may be a threat and, during the status review, we attempt to determine how significant a threat it is. The threat is significant if it drives, or contributes to, the risk of extinction of the species such that the species warrants listing as endangered or threatened as those terms are defined in the Act. However, the identification of factors that could impact a species negatively may not be sufficient to compel a finding that the species warrants listing. The information must include evidence sufficient to suggest that these factors are operative threats that act on the species to the point that the species may meet the definition of endangered or threatened under the Act.

In our review of the best scientific and commercial data available, we found numerous threats are impacting Sonoran desert tortoises or their habitat throughout their range. Some of these threats occurred historically, some are current, and some will continue into the foreseeable future. As described in detail below, these threats include nonnative plant species and altered fire regimes, urban and agricultural development, barriers to dispersal and genetic exchange, off-highway vehicles, roads and highways, ironwood and mesquite tree harvest, improper livestock grazing, undocumented human immigration, illegal collection, effects from field research and manipulation, predation from feral dogs, human depredation and vandalism, drought, and climate change. The effect of habitat disturbances on Sonoran desert tortoises may differ among age classes, but may be most significant to hatchlings or juveniles (Tracy *et al.* 2006b, pp. 271–272).

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

Nonnative Plant Species and Altered Fire Regimes

The most significant modification to Sonoran desert tortoise habitat is associated with the ongoing invasion of nonnative plants in Mojave and Sonoran desertscrub habitats, permanently altering these ecosystems and causing a change in the frequency, duration, intensity, and magnitude of wildfires in a region that largely evolved in the absence of invasive nonnative plants. These ecosystem-level changes cause both direct and indirect effects on the Sonoran desert tortoise and its habitat.

Much of the available research on the effects of nonnative plant species invasions and wildfire used in our analysis has focused on Mojave desertscrub habitats, largely due to the presence of the Mojave desert tortoise, which is already listed as endangered. However, Brooks and Matchett (2006, p. 158) suggest that research from the Mojave Desert is applicable to the Sonoran Desert when stating, “Both (Mojave and Sonoran deserts) occur at elevations above the hyperarid shrublands, are often positioned on the lower slopes of mountain ranges, and possess moderate woody plant cover.” Therefore, we used the information available from research on Mojave Desert habitats in our assessment of the effects of nonnative plants in the Sonoran Desert.

Nonnative perennial plants like buffelgrass, fountain grass, and Lehmann lovegrass were historically introduced to the Sonoran Desert of Arizona as livestock forage and to prevent soil erosion. For example, buffelgrass was included in the nonnative plant species recommended for release by the Tucson Plant Materials Center of the Soil Conservation Service until at least 1987 (Bahr 1991, p. 156). These nonnative plant species subsequently became common and widespread in Sonoran desertscrub in Arizona (Brooks and Pyke 2001, p. 5). They have since colonized new areas, often taking advantage of disturbed soils, such as those resulting from construction associated with roadways, power lines, and railroad tracks (Bahre 1991, p. 155; D'Antonio and Vitousek 1992, p. 65). Construction and maintenance of roads and highways can also significantly enhance the likelihood of nonnative plant invasions by increasing nitrogen deposition in the soil, the dispersal potential of nonnative seeds, and adjacent soil moisture (Brooks 2007, pp. 153–154). Roadside ditches along highways are particularly important dispersal corridors for nonnative plant species such as red brome and buffelgrass (Esque *et al.* 2002, p. 313).

Mechanisms that allow the spread of nonnative species generally pertain to ground disturbance, but the plants may also be spread by other mechanisms. For example, Smith *et al.* (2000, pp. 79–80), and Brooks and Esque (2002, p. 337) both found that elevated atmospheric carbon dioxide levels, predicted as a result of climate change (discussed in

Factor E below), are likely to favor nonnative plant species, such as red brome, over native species in desertscrub habitats. Increases in atmospheric nitrogen deposition may also be advantageous to nonnative plant species. Brooks (2003, pp. 344–345) suspected that increasing human populations will lead to increased levels of atmospheric pollution and nitrogen deposition and stated, "Increased levels of soil nitrogen caused by atmospheric nitrogen deposition may increase the dominance of invasive alien plants and decrease the diversity of (native) plant communities in desert regions, as it has in other ecosystems." Sonoran desert tortoise habitat may be particularly vulnerable to even minor increases in soil nitrogen levels, because the ratio of increased nitrogen to plant biomass is higher compared with that of most other ecosystems (Brooks 2003, p. 344). This suggests that even small changes in nitrogen levels could result in substantial changes in the plant community that supports Sonoran desert tortoise habitat.

The prevalence of nonnative grasses in many areas of Sonoran desertscrub habitats has resulted in high amounts of flammable fuels in interspaces between native plants that would otherwise be free of vegetation. This situation serves to promote the ignition and carrying of wildfire (Brooks 1999, p. 13). In our review of the best scientific data available, red brome, splitgrass (or Mediterranean grass, *Schismus* spp.), and buffelgrass were considered the nonnative plant species that pose the greatest concern to the Sonoran desert tortoise and its habitat, because they are thoroughly integrated into some areas of the desertscrub communities, and serve to promote and carry wildfire (Bahre 1991, p. 155; D'Antonio and Vitousek 1992, pp. 65, 75; Brooks 1999, p. 13; Brooks and Pyke 2001, p. 5; Brooks and Esque 2002, p. 337; Esque *et al.* 2002, p. 313; Van Devender 2002a, p. 16; Brooks and Matchett 2006, p. 148; DeFalco 2007a, p. 1; Zouhar *et al.* 2008, p. 157; Abella 2010, p. 1249; AGFD 2010, p. 13). Red brome is known to carry wildfire in Sonoran desertscrub habitat north of Tucson, natal grass is known to carry wildfire in desert grassland habitat south of Tucson to Nogales, Arizona, and buffelgrass is known to carry wildfire in Sonoran desertscrub and foothills thornscrub south of the international border to central Sonora (Esque *et al.* 2002, p. 316). Other nonnative plant species identified in the literature as present in Sonoran and Mojave desertscrub communities include Saharan (or Asian) mustard (*Brassica tournefortii*), thistles (genera *Centaurea* and *Cirsium*), crimson fountaingrass (*Pennisetum setaceum*), natal grass (*Melinus repens*), and Lehmann lovegrass (*Eragrostis lehmanniana*) (Brooks 2001, p. 4; Brooks and Pyke 2001, pp. 3, 5).

We are not aware of any good estimates of the number of acres of desertscrub that have been invaded by nonnative plant species, but Thomas and Guertin (2007, Appendices I and II) calculated the number of records by county for many known invasive, nonnative plants in Arizona that are harmful to Sonoran desert tortoise habitat. These data illustrate general locations where certain nonnative species are most common and describe which nonnative species are the most reported in each area. Thomas and Guertin (2007, Appendices I and II) reported the following for Arizona as of 2007 (relative number of reports of densities being "extremely high," "high," "moderate," and "occurs," all within the distribution of the Sonoran desert tortoise):

(1) Buffelgrass is the most-reported nonnative plant species in Arizona, at 16.3 percent of total reports with 6,287 reports (p. 3); it reaches extremely high densities in Maricopa and Pima Counties, with high densities in Pinal and Yuma Counties and moderate densities in Santa Cruz and La Paz Counties, but it also occurs in Yavapai, Gila, and Cochise Counties (A–I, p. 60);

(2) *Schismus* spp. is one of the top 20 invasive plant species, at 2.4 percent of total reports, with 919 reports (p. 3); it reaches high densities in Maricopa, Pinal, and Pima Counties, with moderate densities in Mohave, Yavapai, Gila, La Paz, and Yuma Counties, but it also occurs in Santa Cruz County (A–I, p. 69);

(3) Red brome is one of the top 20 invasive plant species, at 3 percent of total reports, with 1,152 reports (p. 3); it reaches high densities in Yavapai, Gila, Pinal, and Pima Counties, with moderate densities in Mohave and Maricopa Counties, but it also occurs in La Paz and Yuma Counties (A–I, p. 24);

(4) Saharan mustard is one of the top 20 invasive plant species, at 3.3 percent of total reports, with 1,261 reports (p. 3); it reaches high densities in Maricopa, Pinal, Pima, La Paz, and Yuma Counties, with moderate densities in Mohave, Yavapai, and Gila Counties, but it also occurs in Cochise County (A–I, p. 21);

(5) *Centaurea* spp. had a total of 3–318 reports (depending on species) (p. 9) and reaches high densities in Pima County, with moderate densities in Mohave, Yavapai, Gila, Pinal, and Cochise Counties (A–I, pp. 15, 28–30);

(6) Bull thistle (*Cirsium vulgare*) is one of the top 20 invasive plant species, at 3.1 percent of total reports, with 1,195 reports (p. 3); it reaches moderate densities in Yavapai and Gila Counties (A–I, p. 35);

(7) Crimson fountaingrass is one of the top 20 invasive plant species, at 2.6 percent of total reports, with 999 reports (p. 3); it reaches high densities in Pima County, with moderate densities in Yavapai, Gila, La Paz, Santa Cruz, and Maricopa Counties (A–I, p. 61); and

(8) Lehman lovegrass is one of the top 20 invasive plant species, at 2.5 percent of total reports, with 980 reports (p. 3); it reaches high densities in Pima and Cochise Counties, with moderate densities in Yavapai, Gila, Santa Cruz, Maricopa, and Pinal Counties, but also occurs in La Paz County (A–I, p. 45).

No spatial data were provided for natal grass, but there were 191 observations (Thomas and Guertin 2007, p. 10).

Buffelgrass has widely invaded Arizona and northern Mexico since its introduction in 1939 (Stevens and Fehmi 2009, p. 379). While buffelgrass invasions are occurring and are poised to seriously impact the southwestern United States, the species has already exacted significant tolls on Sonoran desertscrub communities in Sonora, Mexico, because its expansion continues to be facilitated through intentional plantings and cultivation. Consequently, the clearing of Sonoran desertscrub and Sinaloan thornscrub in Sonora to plant pastures of buffelgrass for livestock grazing creates a near monoculture (area covered by a single plant species) that is highly prone to wildfires, and therefore represents a substantial threat to the Sonoran desert tortoise in Mexico (Bury *et al.* 2002, p. 104; Walker and Pavlakovich-Kochi 2003, p. 14; Van Devender and Reina 2005, pp. 160–161; University of Arizona 2010, p. 2). Buffelgrass has been planted in Sonora's desertscrub lands since the 1950s and at least 5.5 million ac (2.2 million ha) of potential Sonoran desert tortoise habitat has already been converted into a near monoculture of buffelgrass (Stoleson *et al.* 2005, p. 62). Buffelgrass has become established in both the lower valley habitats and into the granite boulder-strewn areas of adjacent foothills, and has altered historical fire regimes, regionally converting large areas of Sonoran desertscrub into habitat resembling the African savannah (Bury *et al.* 2002, p. 104).

In Arizona, the Southern Arizona Buffelgrass Coordination Center

(SABCC, a coalition of non-profit organizations, Federal, State, and local governments, conservation organizations, private businesses, and individual citizens) reports dense stands of buffelgrass on public reserves, State and local lands, and private property, including Saguaro National Park, Coronado National Forest, Bureau of Land Management's (BLM) Ironwood Forest National Monument, neighborhoods of Tucson, Sahuarita, Marana and Oro Valley, and along roadsides throughout this region of Arizona (SABCC 2010, p. 1) These areas are all within the distribution of the Sonoran desert tortoise in Arizona.

Brooks and Minnich (2006, p. 9) stated that southwestern desert ecosystems likely evolved in a fire regime best described by "low intensity, patchy burns and long fire return intervals." Wildfire capable of carrying itself in Sonoran desertscrub is a recent phenomenon in evolutionary and geological contexts and only became apparent recently in the Sonoran Desert (Brooks and Pyke 2001, p. 5; Esque *et al.* 2002, p. 312; Zouhar *et al.* 2008, pp. 155, 160). From 1937 to 1986, only 1 percent of all lightning-caused fires in the Rincon Mountains area of southern Arizona occurred in desertscrub habitat; 5.6 percent occurred in desert grassland habitat (Bahre 1991, p. 126). While historical wildfires in desertscrub habitat were exceptionally rare, after successive years of above-average levels of precipitation, enough native fuels can develop to carry wildfire in desertscrub communities, such as happened south of Florence, Arizona in 1979 (Bahre 1991, p. 141; Brooks and Esque 2002, p. 336; Brooks and Minnich 2006, p. 9). While increased precipitation enhances plant growth and subsequently increases the likelihood for wildfire starts in desertscrub habitat, drought can have an inverse effect with respect to certain nonnative plant species. Red brome, for example, is sensitive to drought conditions and, therefore, might contribute to reduced fuel loads and decreased fire frequency during long-term drought (Brooks and Esque 2002, p. 337), which might help to minimize the likelihood of wildfires in areas where red brome has formed a monoculture. Smith *et al.* (2000, p. 79) noted, "This shift in species composition in favor of exotic annual grasses, driven by global [climate] change, has the potential to accelerate the fire cycle, reduce biodiversity and alter ecosystem function in the deserts of western North America."

Wildfire ignitions in the Sonoran Desert region historically resulted from lightning but ignitions are now more common from human sources such as burning trash, parking vehicles over dry vegetation, fireworks, discarded cigarettes, and accidental starts from backcountry recreationists (Esque *et al.* 2002, p. 313). Human-caused wildfires in desertscrub habitat are most common near urban developments, major roadways, and in areas where off-highway vehicle use is unregulated, while lightning-caused wildfire in desertscrub is typically located in more remote wilderness areas (Brooks 1999, p. 13). In central Sonora, ranchers intentionally set fires to maintain the vigor of buffelgrass for livestock forage (Esque *et al.* 2002, p. 313).

Numerous wildfires, varying in size, have occurred in recent times in many areas throughout the Sonoran Desert including the: (1) Pusch Ridge Fire of 1987 on the southern slopes of the Santa Catalina Mountains; (2) Skyline (1992) and Rock Peak (1993) fires in the San Tan Mountains; (3) Mother's Day Fire of 1994 on the eastern slope of the Rincon Mountains (Esque *et al.* 2002, p. 323; 2003, p. 104); and (4) Cave Creek Complex fire of 2005 northeast of Cave Creek, Arizona, which burned 248,310 ac (100,487 ha) of Sonoran desert tortoise habitat; the largest wildfire ever recorded in Sonoran desertscrub in the United States.

The BLM has kept records of wildfire in Sonoran desert tortoise habitat. From 1990 to 2008, there have been 61 wildfires, affecting 21,977 ac (8,894 ha) in Category I Sonoran desert tortoise habitat; 285 wildfires, affecting 33,364 ac (13,502 ha) in Category II Sonoran desert tortoise habitat; and 508 wildfires, affecting 109,460 ac (44, 297 ha) in Category III Sonoran desert tortoise habitat (USBLM 2010, p. 9). In total, during the 1990–2008 period, 164,801 ac (66,693 ha) of categorized and uncategorized Sonoran desert tortoise habitat has burned on BLM lands (USBLM 2010, p. 9). Combining the known area of habitat affected by fire on both BLM and other lands, an estimated 1.5 percent of habitat in Arizona has been adversely affected due to wildfire in recent years; rangewide this is estimated to be 0.8 percent, although total acreage data on wildfires in Mexico are unknown and the total percentage of affected habitat is likely higher because of the higher incidence of buffelgrass and lessened capacity to fight wildfire in Sonora, Mexico. The total area reported as burned is a relatively small proportion of BLM lands and has not likely been a significant impact to most Sonoran desert tortoise populations in Arizona so far. As the invasion of nonnative plants continues to expand, the high number of fire starts has a greater potential of creating larger and more destructive wildfires, especially where they occur in remote, inaccessible areas as a result of lightning strikes.

Indirect effects of wildfires on Sonoran desert tortoises are variable and can be significant, including habitat changes such as altered nutrient availability and quality, loss of perennial plant species that are important as temporary cover from predators, loss of thermal refugia, altered tortoise behavior, shifts in biotic community, pronounced desert tortoise emigration from burned habitat, and lower growth and reproductive output (Esque *et al.* 2003, p. 107; DeFalco 2006, p. 5; McLuckie *et al.* 2007, p. 8). While a single fire in an area may or may not produce long-term reductions in plant cover or biomass, repeated wildfires in a given area are capable of ecosystem type-conversion from native desertscrub to nonnative annual grassland, and render the area unsuitable for desert tortoises (Brooks and Esque 2002, p. 336). Increased frequency in wildfires caused by nonnative plant species invasion increases light intensity at ground level and soil nutrient availability, and reduces competition from native perennial plants. These changes further promote dominance by nonnative plant species (Brooks and D'Antonio 2003, p. 29). Wildfire in desertscrub habitats can reduce native and nonnative seed banks (Brooks and Draper 2006, p. 2). In Mojave desertscrub, the effects of fire are most pronounced under shrubs, where fire can kill seed banks and reduce annual grass diversity, due to higher burn intensity (Brooks 2002a, p. 1; 2002b, p. 1088). Microhabitat associated with shrubs in Sonoran desert tortoise habitat is an important source of temporary shelter and provides foraging opportunities while tortoises are thermoregulating.

Fires associated with nonnative plant species have already affected Sonoran desert tortoise populations in Arizona. The AGFD (2010, p. 13) reported results from an unpublished study after the Edge Complex Fire of 2005 in the Four Peaks area on the Tonto National Forest, which indicated higher numbers of Sonoran desert tortoises (or their scat were observed in unburned versus burned habitat), but they acknowledged that the study was preliminary and very limited in scope (AGFD 2010, p. 13).

In Sonora, Mexico, 5.5 million ac (2.2 million ha), representing an estimated 22 percent of Sonoran desert habitat in Mexico, or 11 percent rangewide, has been planted to bufflegrass. This figure still does not account for the land area where buffelgrass has become naturally established or the 11.9 million ac (4.8 million ha) (or one-third of the land area of the state of Sonora) that are suitable for future natural establishment of buffelgrass (Stoleson *et al.* 2005, p. 62). Combining the current and predicted number of acres converted to buffelgrass in Mexico, 34 percent of the Sonoran desert tortoises' habitat is lost or at risk across its range. In the area of El Batamote, 29 mi (47 km) north of Hermosillo, Sonora, buffelgrass has invaded Sonoran desert tortoise habitat in the adjacent foothills, which has led to wildfires that burned so hot that the soil was scorched and the bedrock cracked (Esque *et al.* 2002, p. 321).

In addition to impacts from fire, Franklin and Molina-Freaner (in press, p. 1) found that these large-scale conversions from desertscrub to grasslands in Sonora have reduced plant species richness by half, and reduced tree and shrub cover by 78 percent, vastly affecting the ability of Sonoran desert habitat to meet the species' thermoregulatory needs (that is, using vegetation as cover to regulate body temperature). These changes have resulted in substantial changes in primary productivity (creation of organic nutrients and the lowest level of the food chain, the plant community) and vegetation structure (the physical structure of plant sizes and shapes as a mosaic on the landscape) which can affect the forage base and habitat suitability for Sonoran desert tortoises, as well as lessened the feasibility of restoring native plant communities in Sonora without aggressive land management (Franklin and Molina-Freaner, in press, p. 1). Dense stands of buffelgrass have also been shown to physically disrupt tortoise movements in the closely related Texas tortoises (*Gopherus berlandieri*) (Fujii and Forstner 2010, p. 61), so this may also be true for Sonoran desert tortoises. The grass can become so thick that the tortoises cannot walk through it, and the grass may be too tall for the tortoises to walk on top of it.

In addition to damaging Mojave and Sonoran desertscrub habitat, wildfires can directly injure and kill Sonoran desert tortoises. Wildfire may kill a desert tortoise by incineration, by elevating body temperature, by poisoning from smoke inhalation, or by asphyxiation (Brooks *et al.* 1999, p. 40; Brooks and Esque 2002, p. 335; McLuckie *et al.* 2007, p. 7). Survival rates of Sonoran desert tortoises may be contingent upon several factors, including soil type, substrate, vegetation, tortoise activity during fire, whether tortoises are active and above ground or in shelter during a fire, weather, fire behavior, and shelter depth (McLuckie *et al.* 2007, p. 8). The desert tortoise is most vulnerable to the direct effects of wildfire when they are surface active and away from primary cover sites such as burrows, caliche caves, and rock shelters, because these structures reduce direct exposure to heat and smoke (Brooks and Esque 2002, p. 335). Gravid (with fertilized eggs) female Sonoran desert tortoises may be more likely to perish from wildfire than other tortoises because peak wildfire season in Sonoran desertscrub occurs during the months of May and June. This is when reproductive females are actively foraging on spring growth to compensate for energy used in egg development; (Esque *et al.* 2002, pp. 323–324; 2003, p. 106).

Sonoran desert tortoises that survive the wildfire itself may struggle to survive in post-burned Sonoran desertscrub habitat due to: (1) A reduction in forage and shade structure, such as packrat (*Neotoma* sp.) middens and shrubs; and (2) increased visibility to predators (which may be further increased in intermountain valleys where temporary shade, predator avoidance, and available forage are particularly important in long-distance movements in these dispersal corridors) (Esque *et al.* 2002, pp. 325–326).

The effects on Sonoran desert tortoises of one particular fire were studied in some detail. Within Saguaro National Park, the Mother's Day Fire of 1994 burned 340 ac (138 ha) of Arizona Upland Sonoran desertscrub habitat that was occupied by Sonoran desert tortoises, killing an estimated 11 percent of the tortoise population (Esque *et al.* 2003, p. 105). To assess how Sonoran desert tortoises used burned versus unburned habitat following this fire, transmitters were attached to 12 tortoises, 6 each in burned and unburned habitat within or adjacent to the Mother's Day Fire footprint. Surprisingly, no differences were observed in movement or activity patterns between tortoises in burned and unburned areas, nor were long-term effects of the fire on surviving tortoises noted over the 6-year study period (Zylstra and Swann 2009, p. 7). These results indicate that different tortoise populations may respond differently to wildfires and that numerous variables and factors are at work.

One of the principal reasons that nonnative plants pose a significant impact to Sonoran desert tortoise habitat is because few, if any, reasonable methods currently exist to control the ongoing invasion of these plants or to remediate areas where they have become established. Mechanical removal is one option that has been implemented on a small scale in some areas, but is extremely labor intensive and not practical for treating large areas. Prescribed fire has been proposed as an alternative means to control nonnative plant species invasions, but also carries obvious inherent risks to habitat and to Sonoran desert tortoises (Brooks 2006, p. 31).

It is also important to note the limitations of Sonoran desert habitat with respect to post-disturbance (for example, after fires) regeneration (ability for native vegetation to recover). Desertscrub regions receive low annual precipitation totals, and the plant communities have correspondingly low growth rates. Based on the type of disturbance, recovery time estimates range from 40 years to centuries (Abella 2010, pp. 1271, 1273). Combined, these factors result in slow, post-disturbance recovery periods and it may take a long time before any area becomes suitable for Sonoran desert tortoises to recolonize, if at all. The presence of nonnative species such as buffelgrass, cheatgrass, or red brome in disturbed Mojave or Sonoran desertscrub may further limit post-disturbance recovery, delay recovery, or prevent recovery altogether (Brown and Minnich 1986, p. 411; Brooks 1999, p. 18).

In our review of the best available information, we have documented that nonnative plant species pose a significant threat to the Sonoran desert tortoise and its habitat, both in Arizona and Sonora, by promoting and carrying wildfire in an ecosystem that evolved in its absence. Wildfires that are facilitated by nonnative plant species invasions may have direct and indirect adverse effects on tortoises and tortoise populations. The threat from nonnative plant species to the Sonoran desert tortoise occurs throughout the species' range and is expected to increase over time with the expansion of nonnative plants. There is currently no viable solution to curbing this continued expansion across the landscape. This threat also acts synergistically with other threats discussed in this finding.

Urban Development and Agriculture

Human population growth results in the disturbance or loss of Sonoran desertscrub or the conversion of land for urban and agricultural development. Arizona increased its population by 394 percent from 1960 to 2000, and was second only to Nevada as the fastest growing State during this timeframe (Social Science Data Analysis Network (SSDAN) 2000, p. 1). Since 1990, Arizona's population has grown by 44 percent. From 1960 to 2000, population growth rates in Arizona counties where the Sonoran desert tortoise occurs have varied by county but are no less remarkable, and all are increasing: Maricopa (463 percent); Pima (318 percent); Pinal (54 percent); Santa Cruz (355 percent); Cochise (214 percent); Yavapai (579 percent); Gila (199 percent); Graham (238 percent); Yuma (346 percent); LaPaz (142 percent); and Mohave (2,004 percent) (see SSDAN 2000). The population of Phoenix, Arizona, grew 67 percent from 1980 to 2000 (Berry *et al.* 2006, p. 7).

Urban expansion and human population growth trends in Arizona are expected to continue into the future. Maricopa-Pima-Pinal county areas of Arizona are expected to grow by as much as 71 percent in the next 15 years, creating rural-urban edge effects across millions of acres of public lands currently supporting Sonoran desert tortoise populations (AIDTT 2000, p. 10; BLM files—Lands Livability Initiative). In another projection, the population in Arizona is expected to more than double within the next 20 years compared to the 2000 population estimate (U.S. Census Bureau 2005, p. 1). Many cities and towns within the distribution of the Sonoran desert tortoise have already experienced substantial growth during the 8-year time span, 2000–2008: City of Avondale (118.3 percent); City of Buckeye (392.5 percent); Bullhead City (20.3 percent), Town of Carefree (30.5 percent); Casa Grande (56 percent); Town of Cave Creek (44.2 percent); City of Chandler (37.5 percent); City of Coolidge (24.9 percent); City of El Mirage (195.6 percent); City of Eloy (22.3 percent); City of Florence (20.3 percent); Town of Fountain Hills (23.2 percent); City of Gilbert (84.5 percent); City of Goodyear (203 percent); City of Kingman (32.2 percent); Lake Havasu City (33.3 percent); City of Litchfield Park (34.2 percent); City of Mammoth (45 percent); Town of Marana (139.9 percent); City of Maricopa (2,508 percent); Town of Oro Valley (32.5 percent); Town of Queen Creek (544.5 percent); Town of Saguarita (507.3 percent); City of San Luis (58.5 percent); City of Somerton (63.2 percent); City of Surprise (187.3 percent); City of Tolleson (43.2 percent); and, Town of Youngtown (62.2 percent) (U.S. Census Bureau 2008, pp. 1–4).

This population growth has spurred a significant increase in urbanization and development in these areas. Regional development is predicted to be extreme in certain areas within the distribution of the Sonoran desert tortoise in Arizona. In particular, a wide swath from the international border in Nogales, through Tucson, Phoenix, and north into Yavapai County (called the Sun Corridor "Megapolitan") is predicted to have 8 million people by 2030, an 82.5 percent increase from 2000 (Gammage *et al.* 2008, pp. 15, 22–23). If build-out occurs as expected, it will encompass a significant proportion of the Sonoran desert tortoise distribution in Arizona, and will in effect permanently isolate Sonoran desert tortoise populations that occur on either side of the Interstate 19, Interstate 10, and Interstate 17 corridors.

The land area permanently altered by human activities from urban development and agriculture has grown to 13 percent of all land in the western United States, Lue *et al.* (2008, p. 1130). Lue *et al.* (2008, p. 1133) concluded that in low-productivity habitat, such as desertscrub habitats, slight human disturbances can have pronounced effects. Significant urban development occurs within intermountain valleys, within or adjacent to occupied Sonoran desert tortoise habitat, which increases the likelihood of effects along the rural-urban interface, and may also inhibit movement of individuals between populations on nearby hillsides or mountain ranges. Disturbances to Sonoran desert tortoise habitat on the landscape can take many forms and cover extreme distances. Roads, canals, pipelines, and railroad tracks are examples of linear habitat destruction. We discuss the potential effects of linear disturbances below in the section titled, "Development as a Barrier."

Development pressure across Arizona has slowed due to the recent economic downturn and decline in the housing market. However, development will likely continue in the future, although perhaps at a slower pace than in the earlier part of this century. We also recognize that economic trends are difficult to predict into the future. The most recent draft Pinal County Comprehensive Plan (February 2009) acknowledges that the county is in the middle of the Sun Corridor Megapolitan and proposes four shorter-term growth areas in defining where development will likely occur, or be encouraged to develop, over the next decade, but does not discourage growth outside of these areas (Pinal County Comprehensive Plan 2009, p. 109). These four growth areas (Gateway/Superstition Vistas, West Pinal, Red Rock, and Tri-Communities) fall completely within the range of the Sonoran desert tortoise. The Gateway/Superstition Vistas growth area alone encompasses 176,000 ac (71,225 ha), or 275 sq mi (712 sq km), of State Trust land, and it is anticipated that 800,000 to more than 1 million people will one day live in this development (Pinal County Comprehensive Plan 2009, p. 115). The loss of 176,000 ac (71,225 ha) constitutes a loss of 0.7 percent of Sonoran desert tortoise habitat in Arizona; rangewide, 0.34 percent. The Pinal County Comprehensive Plan (2009, p. 117) identifies many miles of new freeways and principal arterials in the analysis area at build-out, which the plan acknowledges may take over a half century to realize (Pinal County Comprehensive Plan 2009, p. 115). The effect of roads on Sonoran desert tortoises is discussed below.

Additionally, the Maricopa County Comprehensive Plan calls for growth areas to the south and east of Chandler and Mesa, Arizona, which are within the range of the Sonoran desert tortoise (Maricopa County Comprehensive Plan 2002 (revised), p. 92). City comprehensive plans within the range of the Sonoran desert tortoise also call for future growth areas. For example, the City of Eloy has designated six such areas encompassing 15,520 ac (6,281 ha), mostly along the Interstate 10 corridor (City of Eloy General Plan 2004, pp. 7–6 through 7–10). The loss of 15,520 ac (6,281 ha) constitutes a loss of 0.06 percent of their habitat in Arizona; rangewide, 0.03 percent. While much of this area has already been impacted by development or irrigated agriculture, any remaining dispersal habitat for the Sonoran desert tortoise will likely be negatively affected as development and its associated infrastructure progress into these areas.

Much of the past and projected development within the range of the Sonoran desert tortoise in central and southwestern Arizona has occurred and is expected to continue as a conversion from agricultural uses to municipal uses. Land traditionally used for agriculture is not occupied by Sonoran desert tortoises, but has a comparatively minor effect on adjacent Sonoran desert tortoises. When these lands are converted to municipal uses, the effect to adjacent Sonoran desert tortoise populations increases human access, and use of adjacent undeveloped land increases as a result of development of these former agricultural areas.

The human population of Sonora, Mexico, doubled in size from 1970 (1.1 million) to 2000 (2.2 million) (Stoleson *et al.* 2005, p. 54). The population of Sonora is expected to increase by 23 percent, to 2.7 million people, in 2020 (Stoleson *et al.* 2005, p. 54). In discussing threats to Sonoran desert tortoise populations adjacent to, and stemming from, urbanization in Sonora, Mexico, Fritts and Jennings (1994, p. 53) stated, "Tortoise populations adjacent to large population centers such as Hermosillo, Guaymas, and Caborca probably have experienced long-term harm, including direct human exploitation, habitat degradation, road kills, predation by domestic dogs, and use as pets. However, we found evidence of tortoise populations on hillsides and mountain slopes near each of these cities, which suggests that some tortoise populations have survived despite perturbations by humans." Therefore, Sonoran desert tortoises may persist as depressed populations adjacent to urban development, but without long-term population trend data for these areas, we are unable to know for how long.

Urban development has been identified as a concern for Sonoran desert tortoise conservation in several areas within Arizona because of the associated increase in human-based threats to populations in close proximity. Averill-Murray and Swann (2002, p. 1) stated that urban development adjacent to the Saguaro National Park in Pima County threatens the Sonoran desert tortoise via several mechanisms including harassment and predation by feral or off-leash domestic dogs, illegal releases of captive Sonoran desert tortoises and exotic species that may transmit diseases to wild Sonoran desert tortoises, elevated mortality on roads, and illegal collection for pets. Averill-Murray and Swann (2002, p. 7) stated that mid- to large-scale development projects on the bajadas and foothills of the Rincon, Santa Rita, Santa Catalina, Tortolita, and Tucson Mountains has likely led to area-wide decreases in Sonoran desert tortoise populations. However, no population estimates for Sonoran desert tortoises before development of these areas exist, and, therefore, population responses to development of these areas cannot be ascertained.

In addition to the Tucson metropolitan area, urban encroachment on Sonoran desert tortoise habitat occurs adjacent to the greater Phoenix metropolitan area, in the area around South Mountain and adjacent to the Superstition Mountains (AGFD 2010, p. 7). Sonoran desert tortoises are known or suspected to still occur in 12 of the 16 Maricopa County and City of Phoenix urban mountain parks and reserves. The four parks where no tortoise sign has been found in recent years are completely surrounded by urban development (AGFD 2010, p. 7). Urban development has occurred adjacent to five monitoring plots, but only the Hualapai Foothills plot is completely surrounded by developed lands (AGFD 2010, p. 7). A development consisting of 48,000 single family homes, south of the Colorado River in western Mohave County, is also currently being planned (THS 2009, p. 4; Mardian 2010, p. 1).

Because less area is being used currently for agriculture in the United States, habitat loss due to agricultural development is more of a historical issue. However, impacts to Sonoran desert tortoise dispersal habitat within valley floors from historical agricultural use and wood harvesting are still evident. The vegetation and soils of many valleys in the Sonoran Desert were shaped by the periodic flooding of dynamic wash systems, which partially recharged a shallow, fluctuating groundwater table. Because of agricultural development, these valleys no longer experience these defining processes and there has been a permanent loss of meso- and xeroriparian habitat which are known to be corridors for movement by Sonoran desert tortoises (Jackson and Comus 1999, pp. 233, 249; Lutz *et al.* 2005, p. 22; Riedle *et al.* 2008, p. 418).

Agriculture in Sonora, Mexico, has shifted from small-scale, local markets toward large-scale agro-industry, with Sonora producing 40 percent of the country's total wheat crop (Stoleson *et al.* 2005, p. 59). While agriculture in Sonora is largely constrained to valleys (along the Rio Sonora), many types of habitat used by Sonoran desert tortoises have been cleared for agriculture, including Sonoran desertscrub, thornscrub, and tropical deciduous forest (Stoleson *et al.* 2005, p. 60). In 1994, the total irrigated acreage in Sonora was 128,000 ac; in 2004 that figure rose to 530,509 ac (214,689 ha), an increase of 314 percent (AQUASTAT 2007, p. 2). This constitutes an estimated loss of 2 percent of Sonoran desert tortoise habitat in Mexico; rangewide, 1 percent.

The projected growth of the human population in Arizona and northern Mexico and subsequent urbanization discussed above is expected to place onerous demands on lands where the Sonoran desert tortoise occurs, increasing the need for infrastructure associated with development, such as power lines, power plants, pipelines, landfills, roads, sand and gravel mines, and removal of boulders for landscaping (AIDTT 2000, p. 10). In addition, these growth projections will increase human visitation to formerly remote Sonoran desert tortoise habitat as urban-rural interface expands, whereby increasing human-associated threats discussed in detail below (AIDTT 2000, p. 10). The AGFD (2010, p. 7) concluded that "* * * as urbanization continues to expand, (Sonoran desert tortoise) habitat will continue to be lost." In a Global Information System exercise, we calculated that currently, 75 percent of potentially occupied Sonoran desert tortoise habitat within Arizona occurs within 30 mi (48 km) (a reasonable distance a person might travel to recreate outdoors on public land) or less of a city or town with a population of 1,000 or more. As the human population of Arizona grows and development expands as expected, we assume that 100 percent of Sonoran desert tortoise populations will occur within 30 mi (48 km) or less of a city or town with a population of 1,000 or more, in the foreseeable future. Tortoise populations are being increasingly exposed to humans and human activities, and therefore to numerous threats that would otherwise be minimized or nonexistent. We discuss these types of threats and how they affect Sonoran desert tortoises and their habitat below in Factors B, C, D, and E.

Some forms of development are likely to increase. The interest in renewable energy projects is expected to increase significantly in the future. Solar radiation levels in the southwestern United States, including Arizona, are some of the highest in the world, and interest in tapping into this source of potential energy is growing. Potentially significant tracts of BLM lands in southwestern Arizona have been identified for possible solar energy development, encompassing large percentages of Arizona's valley bottomland in La Paz and Yuma Counties and adjacent to or within the foothills of the Black Mountains of western Mohave County, which could isolate Sonoran desert tortoise populations and affect genetic exchange among regional populations in those areas (USDOE 2009, p. 1). Since most solar projects are in the early planning stages and have yet to be officially approved by the BLM, we are unable to ascertain the amount of Sonoran desert tortoise habitat likely to be impacted. However, we acknowledge that large areas within the distribution of the Sonoran desert tortoise in Arizona are being considered for solar projects.

In one example, 12,100–15,100 ac (4,897–6,110 ha) of BLM, State, and private land containing Sonoran desert tortoise habitat along the southern bajada of the Black Mountains in western Mohave County, Arizona, has been identified for development of the Sterling Solar Generating Facility within the next 4 to 6 years (Needle Mountain Power, LLC 2010, pp. 4, 8, 11). At build-out, the Sterling Solar Generating

Facility will consist of solar fields, power blocks, buildings, retention ponds, rainwater catch basins, evaporation ponds, wastewater and water treatment facilities, water storage tanks, on-site housing, a substation, a visitors center, a substation and switching station interconnection with the Western Area Power Administration power lines, and septic tanks (Needle Mountain Power, LLC 2010, p. 11). We expect the construction of this facility to render at least 13,100 ac (5,300 ha) of Sonoran desert tortoise habitat as unusable because this type of construction requires the complete grading (removal of vegetation) of the project footprint. It could, therefore, significantly affect the Black Mountains desert tortoise population, especially in consideration of other effects acting in combination with those poised from the proposed housing development and highway construction in the immediate area (THS 2009, p. 4; ADOT 2010, p. 3; Mardian 2010, p. 1). The estimated loss of 13,100 ac (5,300 ha) constitutes an estimated loss of 0.05 percent of their habitat in Arizona; rangewide, 0.025 percent.

Other solar energy development and transmission corridors pose similar threats to the Sonoran desert tortoise as development and roadway projects (see discussion below). An average utility-scale solar facility to generate 250 megawatts of electricity would occupy about 1,250 ac (500 ha) of land (BLM 2009a, p. 1), and would involve removal of all vegetation within its footprint. Additionally, concentrating solar power facilities requires liquids such as oils or molten salts to create steam to power conventional turbines and generators, as well as various industrial fluids, such as hydraulic fluids, coolants, and lubricants, all of which may present a contaminant risk should these fluids leak onto the ground (Scott 2009, p. 12). New transmission lines would need to be built for these facilities, as well as roads to maintain the facilities, posing additional threats to the Sonoran desert tortoise through the destruction or contamination of remaining habitat and increased potential for road-kill mortality.

In conclusion, the literature documents that urban development and population growth in Arizona and Sonora has been remarkable, and no information is available to suggest these trends will not continue into the foreseeable future. Sonoran desert tortoise habitat is permanently lost where urban development occurs. Sonoran desert tortoises and their habitats that occur adjacent to developed areas are also threatened by the increased incidence of an array of human activities or influences such as off-highway vehicle use, facilitation of the spread of nonnative plant species via soil disturbances, and increased wildfire ignitions. These threats act in combination with other threats discussed elsewhere in this finding, including ironwood and mesquite tree harvest, livestock grazing, nonnative plants and altered fire regimes, roads and highways, and undocumented human immigration and interdiction.

Development as a Barrier

Urban development, canals, and transportation infrastructure, such as roads and railroads, disrupt ecological processes, increase mortality in animals, promote the degradation, loss, and isolation of wildlife habitat, and cause fragmentation of populations (Spang *et al.* 1988, p. 9; Saunders *et al.* 1991, pp. 23–24; Averill-Murray and Klug 2000, p. 68; Seiler 2001, p. 3; Howland and Rorabaugh 2002, p. 335; Edwards *et al.* 2004, p. 496). Sonoran desert tortoise populations are island-like in their distribution, meaning they are generally concentrated on the bajadas and hillsides of mountains, and less-distributed within the valleys between these areas. As a result, they may be particularly vulnerable to large-scale disturbances that affect the suitability of intervening habitat (Spang *et al.* 1988, p. 9). Factors that affect inter-population dynamics in Sonoran desert tortoises include distance between populations, physical size of habitat areas, sizes of source populations, and the ease of which intervening areas can be crossed by dispersing individuals (Howland and Rorabaugh 2002, p. 335).

The effect of potential barriers to inter-population movements of Sonoran desert tortoises (discussed above in the *Species Information* section) is not equal across their range. The ability for the Sonoran desert tortoise to move among populations is also important for allowing shifts in their range in response to climate change, and to promote recolonization after fire or other regional disturbances (Beier and Majka 2006, p. 2). Dispersal of Sonoran desert tortoises between populations through sparse desertscrub is less likely in very hot, dry valleys in the Lower Colorado subdivision of Sonoran desertscrub and populations in mountain ranges, such as the Eagletails, Maricopas, and Sand Tanks, have likely been existing in isolation for a long time (Van Devender 2002a, p. 16).

Genetic analysis of blood samples collected from Sonoran desert tortoises in Saguaro National Park in Pima County, Arizona, suggest that intermediate gene flow still occurs, or occurred recently, among isolated populations at the rate of at least 1 migrant per generation (12–15 years) (Edwards *et al.* 2004, p. 485). However, thousands of acres of tortoise habitat have been recently lost to large residential developments in the foothills of the Santa Catalina, Tortolita, Rincon, and Tucson Mountains in the greater Tucson metropolitan area (Edwards *et al.* 2004, p. 485).

The importance of allowing movement of individual tortoises between populations is observable by evaluating historical gene flow. Edwards *et al.* (2004, p. 485) used seven microsatellite DNA markers to examine the genetic relationships of tortoises in eight populations in southern and central Arizona, in the vicinity of Tucson and Phoenix. They also calculated migration rates among these populations to estimate historical rates of gene flow, and, therefore, the importance of individuals moving between populations (Edwards *et al.* 2004, p. 485). Edwards *et al.* (2004, p. 496) found no evidence of recent loss of genetic diversity that would indicate genetic bottlenecking that could occur from lack of mixing among Sonoran desert tortoise populations in southern Arizona. However, the authors acknowledged that a small sample size and small number of genetic markers (alleles) used in their analyses would likely not detect this genetic effect. Despite reduced mixing among populations, Sonoran desert tortoises may be capable of maintaining small effective population sizes (still viable populations, despite small size), even with a low degree of genetic diversity (Edwards *et al.* 2004, p. 496). However, Edwards *et al.* (2004, p. 496) also stated, "Because effective population sizes of Sonoran desert tortoises are small, dispersal events probably play an important role in the long-term maintenance of these populations." This suggests that while dispersal and movement of tortoises may be rare, they may be important events. Therefore, barriers that prevent this movement could result in significant genetic impacts, by preventing mixing of populations over the long term.

The effect of urban barriers limits inter-population movements of Sonoran desert tortoises resulting in "closed" populations. Experts believe that an isolated population of Sonoran desert tortoises that experiences significant declines in population size could not overcome losses simply through an increase in reproduction, based on evidence of past gene flow (Edwards *et al.* 2004, p. 496). Therefore, if a population were to experience a catastrophic decline as a result of a stochastic event such as drought, the immigration of new tortoises from adjacent populations would be necessary for population recovery (Edwards *et al.* 2004, p. 496). Urban barriers effectively prevent this immigration of new tortoises, resulting in closed, or isolated, Sonoran desert tortoise populations, which are now evident within the metropolitan areas of Phoenix and Tucson. Mountains and associated foothills with Sonoran desertscrub habitat occur in these urban areas, and although development within this habitat has been restricted by zoning laws, development is still allowed to virtually surround the bases of the mountains, isolating tortoise populations. Examples of this development include the Union Hills, White Tank Mountains, McDowell Mountains, Black Mountains, and South Mountain Park in the Phoenix metropolitan area and Tumamoc Hill, Tucson Mountains, and Saguaro National Park West in the Tucson metropolitan area (Edwards *et al.* 2004, p. 496). Zylstra and Swann (2009, pp. 10–11) remarked that the increasing negative effect of human-made barriers on Sonoran desert tortoise movements between populations may require translocation (moving animals out of harm's way into more secured areas of suitable habitat), or occasional augmentation of populations with tortoises from other populations, to remain viable.

Translocation has been considered an option, and implemented to some degree for Mojave desert tortoise conservation and recovery. In assessing the viability of translocation as a recovery and conservation tool for the Mojave population, concern has been expressed for potentially moving tortoises into areas where threats to desert tortoise populations remain, which could negate any conservation value associated with the action. Our (Mojave) Desert Tortoise Recovery Office stresses that translocation of tortoises should not occur under such circumstances, emphasizing the need to address threats which impact all tortoises regardless of origin.

Translocation of desert tortoises has received mixed reviews in the scientific literature and, as noted, may not be a viable option for the Sonoran desert tortoise. There are several factors that must be considered in deciding whether or not to translocate tortoises into new areas, including temporary or longer-term holding conditions of tortoises; the propensity for post-release, long-distance movements; drought; the status of receiving population; and disease screening, among other factors (Berry 1986a, p. 113; Field *et al.* 2007, pp. 232, 237, 240, 242; Martel *et al.* 2009, p. 218). Translocated Mojave desert tortoises have been shown to settle at release sites, travel in straight lines for substantial distances, or disperse up to approximately 4 miles (6.4 km) (Berry 1986a, p. 113). Translocated desert tortoises may disrupt social hierarchies in receiving populations by displacing residents or they may be displaced themselves (Berry 1986a, p. 113). Howland and Rorabaugh (2002, p. 341) suggest that translocation of Sonoran desert tortoises may not be a viable tool for conservation because most intact Sonoran desert tortoise populations in Arizona are currently considered relatively healthy, and likely occur at or near carrying capacity. Mullen and Ross (1997, pp. 145–146) found that translocated Mojave desert tortoises have a lower survivorship than resident individuals (especially when moved during the summer versus during the spring), but that negative effects commonly associated with translocations are generally short-lived (1–2 years).

A 2004 population viability analysis for the Mojave desert tortoise recommended that a minimum of 50,000 individuals are required for a 50 percent chance of persistence for 500 years, yet extrapolation of Sonoran desert tortoise population data from southern Arizona suggest that most populations number less than 20,000 individuals, with some as low as several hundred (Edwards *et al.* 2004, p. 496). Because the average generation time of a Sonoran desert tortoise is approximately 12–15 years and much of the urban development is relatively recent, the full effect of developments as barriers to genetic exchange among Sonoran desert tortoise populations cannot be fully assessed at this time (Edwards *et al.* 2004, p. 486). Edwards *et al.* (2004, p. 495) further cautioned that their estimates of gene flow are contingent on what occurred pre-settlement, and should not be taken as evidence that natural immigration or emigration still occurs.

In conclusion, the literature documents that urban development and population growth, roads and highways, canals, railroad tracks, and other types of development threaten the Sonoran desert tortoise by creating barriers to movement in Arizona and, perhaps to a lesser extent, in Sonora, Mexico. The creation of barriers affects the tortoises' genetic exchange capacity within and between populations, which in turn affects their ability to recolonize habitat in the event of population declines or extirpations, and may lead to isolation and eventual genetic bottlenecking. This threat acts synergistically with other factors as discussed above.

Off-Highway Vehicles

Off-highway vehicle use may pose a variety of threats to the suitability of habitat within the range of the Sonoran desert tortoise. Off-highway vehicle use in Sonoran desert tortoise habitat can result in damage to soil, riparian areas, wetlands, water quality, and air quality. This damage occurs due to reduced vegetation cover and growth rates, soil compaction, diminished water infiltration, diminished presence and impaired function of soil stabilizers (biotic and abiotic soil crusts), noise, wildlife habitat fragmentation, spread of invasive plant species, and accelerated erosion rates (Boarman 2002, pp. 43–51; Ouren *et al.* 2007, pp. 5, 11; USGAO 2009, pp. 10, 13; Vega 2010, p. 3). Off-highway vehicle use in Sonoran desert tortoise habitat can also potentially affect Sonoran desert tortoises directly by crushing individuals or their burrows (Boarman 2002, pp. 43–51).

Off-highway vehicle use has grown considerably in Arizona. Between 21 and 56 percent of Arizona residents (depending on the county in Arizona) consider themselves off-highway vehicle users as of 1999, and projected increases in population growth are expected to increase recreation on public lands, in particular off-highway vehicle use (AIDTT 2000, p. 10). As of 2007, 385,000 off-highway vehicles were registered in Arizona (a 350 percent increase since 1998), and 1.7 million people (29 percent of the Arizona's public) engaged in off-road activity from 2005–2007 (Sacco, pers. comm., 2007). Over half of off-highway vehicle users reported that merely driving off-road was their primary activity, versus using the off-highway vehicle for the purpose of hunting, fishing, or hiking (Sacco, pers. comm., 2007). The BLM (USBLM 2001, p. 1) stated that interest in off-highway vehicle use has increased substantially in recent years and cited several reasons, such as urban growth in the west, improved capabilities of off-highway vehicles in accessing previously inaccessible areas, and greater public interest in unconfined outdoor recreational opportunities.

The Forest Service stated that "the number of off-highway vehicle users has climbed sevenfold in the past 28 years, from approximately 5 million in 1972 to 36 million in 2000" (USFS 2009, p. 2). The Tonto National Forest, which encompasses a considerable amount of

Sonoran desert tortoise habitat, receives the highest off-highway vehicle use of any national forest nationwide, partially due to its close proximity to the Phoenix metropolitan area. The Arizona State Land Department recently closed to off-highway vehicle use many of their lands in Maricopa County (which includes Phoenix), to control dust pollution, which appears to have shifted off-highway vehicle access to the nearby Tonto National Forest (USFS 2009, p. 2; USGAO 2009, p. 11). The Tonto National Forest has indicated that soil erosion appears to be the most significant result from off-highway vehicle use on their lands and identified "unmanaged recreation" (off-highway vehicle use) as one of four key threats to soil, water, and wildlife habitat (USFS 2009, p. 1; USGAO 2009, pp. 10, 13).

Off-highway vehicle use is widespread across Arizona, occurring on Forest Service, BLM, private, tribal, and State Trust lands, and has been documented on all 17 Sonoran desert tortoise monitoring plots. Pronounced effects are found on the Four Peaks and Wickenburg Mountains plots, which are near urbanized areas (greater Phoenix and Wickenburg, respectively) (AGFD 2010, p. 13).

The Tonto National Forest has proposed to designate approximately 800 mi (1,287 km) of roads as open for use, and close 280 mi (451 km) of roads which are currently open (due to significant resource damage). This is a net increase of 520 mi (837 km) of off-highway vehicle trails and roads on the Tonto National Forest (USFS 2009, p. 3). In addition, the Tonto National Forest has proposed the designation of five more off-highway vehicle areas (representing 2,799 ac (1,132 ha) collectively, or 0.01 percent of its habitat in Arizona) within Sonoran desert tortoise habitat on the Mesa and Globe Ranger Districts (USFS 2009, p. 3). All other motorized travel not specifically designated will be prohibited by the Tonto National Forest except as authorized for dispersed camping access and big game retrieval (USFS 2009, p. 4). Because of the increase in off-highway vehicle access and subsequent use anticipated to occur on the Tonto National Forest, associated threats to the Sonoran desert tortoise and its habitat on the Forest are expected to increase in scope and magnitude in the immediate future.

BLM regulations require their lands be designated as open, limited, or closed to off-highway vehicle use (USGAO 2009, p. 7). As of March 2009, the BLM has nationally designated approximately 32 percent of its lands as open to off-highway vehicle use, 48 percent as limited-use, 4 percent as closed, and 16 percent of lands have yet to be designated (USGAO 2009, p. 7). These figures indicate that at least 80 percent of BLM lands allow for off-highway vehicle use in some capacity. However, we do not have specific information for BLM off-highway vehicle use in Arizona. The BLM is taking actions to help manage off-highway vehicle use on their lands.

Historically, competitive off-highway vehicle racing events have occurred on a comparatively infrequent basis in Arizona. On BLM lands in Arizona, these activities are generally restricted from March 31 to October 15, in consideration of potential surface activity of Sonoran desert tortoises (USBLM 2010, p. 4). However, similar considerations may not occur with respect to these events on lands managed by other agencies, thus making their lands more desirable for planning such events. For example, a Special Land Use Permit application was recently submitted to the Arizona State Land Department for the establishment of a semiannual competitive off-highway vehicle race within Sonoran desert tortoise habitat, slightly north of Tucson near Mammoth, Arizona (Vega 2010, pp. 1–16).

Competitive off-highway vehicle events can have a variety of detrimental effects on Sonoran desert tortoises or their habitat. Event courses have been found to create new destinations for increased, year-long use, and correspondingly greater impacts to local Sonoran desert tortoise habitats and higher incidence of illegal route proliferation (Vega 2010, p. 3). The high rates of speed associated with competitive off-highway vehicle events significantly increase the likelihood for damage to burrows or other habitat features (Vega 2010, p. 4). Lastly, event spectators seeking good views have been found to park their vehicles indiscriminately along the race course without regard to vegetation and may crush Sonoran desert tortoises and their burrows, or start wildfires if parked over dry vegetation (Vega 2010, p. 5).

In his literature review, Boarman (2002a, p. 50) found that, as of 2002, most research on the effect of off-highway vehicles had been performed in areas of high off-highway vehicle use within the Mojave desert tortoise distribution. As a result, there are fewer available data for lightly-traveled areas (Boarman 2002, p. 50).

On the Florence Military Reservation, Grandmaison *et al.* (in prep., p. 16) found that Sonoran desert tortoises use infrequently traveled gravel roads as movement corridors within their home ranges, placing individuals at greater risk of mortality from collisions with off-highway vehicles. Populations that occur in similar areas throughout their distribution may also be vulnerable to mortality associated with collisions, or previously discussed indirect effects to their habitat from off-highway vehicle use.

Effects of off-highway vehicle use on Sonoran desert tortoises are likely to be more significant within washes that separate steep slopes and rocky bajadas used by Sonoran desert tortoises, where tortoises are known to frequent and off-highway vehicle use often occurs (AGFD 2010, p. 13). For example, "rock crawling" (technical off-roading usually with highly-modified, high clearance, four-wheel drive vehicles), generally occurs in boulder-strewn washes where Sonoran desert tortoises are most likely to inhabit. This activity may be uniquely destructive to Sonoran desert tortoise habitat because: (1) It occurs on steep slopes and rocky bajadas within Arizona Upland Sonoran desertscrub where populations reach their highest densities; and, (2) the intent of rock crawling is to aggressively challenge aspects of a given landscape that would otherwise clearly represent barriers to overland travel, which places habitat and tortoises at greater risk. However, rock crawling activity is presumed to be less popular an activity than more conventional off-highway vehicle use and, therefore, likely affects a much smaller percentage of Sonoran desert tortoise habitat.

Bury (1987, p. 1) studied the effects of off-highway vehicle use on Mojave desert tortoises in Mojave desertscrub habitat. Some of his findings included a 60 percent reduction in perennial plant cover, 1.3 desert tortoises per hectare (2.47 ac) in a control plot in which off-highway vehicles were excluded, versus 0.3 desert tortoises in an area used by off-highway vehicles, and four times the number of active burrows in the control plot versus the off-highway vehicle area (Bury 1987, p. 1). Bury and Luckenbach (2002, p. 257) found that there were 1.3 times more live plants, 3.9 times more plant cover, 3.9 times the number of Mojave desert tortoises, and four times the number of active burrows in undisturbed Mojave desertscrub as compared to areas where off-highway vehicles were used. We are not certain whether the areas studied by Bury (1987, p. 1) and Bury and Luckenbach (2002, p. 257) were unregulated, or regulated areas with designated routes, but similar effects to Sonoran desert tortoises and their habitat can be expected in areas of high off-road vehicle use in Sonoran and Mojave desertscrub habitat within Arizona, particularly in areas of higher accessibility (such as valley bottoms and lower foothills), such as the Florence Military Reservation in Pinal County (AIDTT 2000, p. 34; Lutz *et al.* 2005; p. 22; AGFD 2010, p. 7; Grandmaison *et al.* in press, p. 4).

Brooks and Lair (2005, pp. 7–8) found that, in Mojave desertscrub, off-highway vehicle routes can cause a myriad of effects including: (1) Altering precipitation runoff patterns which promote increased erosion; (2) producing air-borne pollutants laden with heavy metals that affect habitat at distances ranging from 65 to 650 feet (20 to 200 m) from the road; (3) increasing nitrogen deposition in soils, thereby favoring nonnative plant invasions; and (4) providing a pathway for nonnative plant species invasions. These impacts degrade Sonoran desert tortoise habitat as well as their forage base.

Soil disturbance from off-highway vehicle use, development projects, and other activities can facilitate the invasion of nonnative plant species by eliminating competition and creating a rougher soil surface for seeds to lodge and germinate (Hobbs and Huenneke 1992, pp. 329–330). Motorized and mechanical vehicles aid in the dispersal of plants by transporting seeds of both native and nonnative plant species. Rew and Pollnac (2010, p. 2) found that trucks and sport utility vehicles driven off road in dry conditions can pick up as many as 176 seeds from 50 mi (80 km) of driving, and recreational off-highway vehicles can pick up as many as 200,000 seeds in 48 mi (77 km) of off-road driving. Off-highway vehicles are generally transported via trailer from site to site and may spread nonnative plant species in subsequent uses. Off-highway vehicle use has also been shown to create edge effects along trails that generate dust, blanketing adjacent vegetation, and inhibiting plant growth rates, size, and survivorship, all of which affect the forage base and available cover for Sonoran desert tortoises (Ouren *et al.* 2007, p. 11).

We have documented that off-highway vehicle use poses a threat to the Sonoran desert tortoise and its habitat in Arizona because it damages soil, reduces vegetation cover and growth rates, leads to soil compaction, diminishes water infiltration, diminishes the presence and impairs the function of soil stabilizers (biotic and abiotic soil crusts), fragments habitat, facilitates the spread of nonnative plant species, ignites wildfire, accelerates soil erosion, enhances the potential for illegal collection (discussed below), and may crush or injure Sonoran desert tortoises (also discussed below). In addition, we have documented the tremendous growth in popularity of off-highway vehicle use in Arizona, as well as compliance deficiencies in off-highway vehicle licensing programs (and therefore deficient fees collected that are intended to fund enforcement and environmental mitigation) and enforcement programs (discussed above and below). This threat acts synergistically with other threats discussed herein. Considering the population growth estimates we have documented above for Arizona, we believe that the popularity of off-highway vehicle use will continue to grow, leading to an increase in severity and geographic extent of impacts across the distribution of the Sonoran desert tortoise in Arizona over time.

Roads and Highways

Foreman (2002, p. 35) estimated that at least 20 percent of land in the United States has been ecologically affected by roads. Roads and highways might also adversely affect Sonoran desert tortoises as they do Mojave desert tortoises. Studies of Mojave desert tortoises suggest that effects include providing human access to occupied habitat, facilitating the spread of nonnative plant species, altering movement patterns, enhancing the genetic fragmentation effect between populations of Sonoran desert tortoises by acting as barriers, and contaminating adjacent habitat (Boarman and Sazaki 1996, p. 1; Forman and Alexander 1998, p. 207; Boarman 2002, pp. 54–55; Edwards *et al.* 2004, pp. 495, 497; Boarman and Sazaki 2006, p. 95; Andrews *et al.* 2008, pp. 127, 129–130; Rew and Pollnac 2010, p. 2). Roads that act as barriers to genetic exchange between Sonoran desert tortoise populations may increase the risk of inbreeding depression and population extirpation (Boarman and Sazaki 2006, p. 95). In one example, biological connectivity between Sonoran desert tortoise populations of the Harquahala and Wickenburg Mountains is significantly limited due to several barriers to tortoise movement including highways U.S. 60 and U.S. 93, the Burlington Northern Santa Fe Railroad, and urban development, and would be further limited by the proposed Wickenburg bypass highways which are in the planning phase (Beier *et al.* 2006d, p. vi).

The use of dirt or gravel roads by vehicles generates dust which may adversely affect physiological processes of adjacent plants and reduce overall primary productivity, whereby affecting the amount and quality of available forage vegetation for Sonoran desert tortoises (Sharifi *et al.* 1997, pp. 844–845).

Construction of major highways planned in Arizona has the potential to greatly affect certain Sonoran desert tortoise populations. For example, the Arizona Department of Transportation (ADOT) has proposed rerouting State Route 95 through the southern and eastern bajada of the Black Mountains in Mohave County, Arizona (Jacobs Engineering Group, Inc. 2009, pp. 24, 33; ADOT 2010, p. 3; Goodman 2010, pp. 3–4). The proposed realignment of State Route 95 is expected to pass directly through 30 mi (48 km) of a Sonoran desert tortoise population (THS 2009, p. 4; Goodman 2010, pp. 3–4). We expect this new four-lane highway to eliminate considerable amounts of Sonoran desert tortoise habitat, become a significant source of mortality, and threaten the continued viability of the Black Mountains habitat to support the population of the Sonoran desert tortoise there, if appropriate mitigation measures are not enacted or are ineffective.

Both the ADOT and the Federal Highways Administration participate in the BLM's tortoise mitigation program and provide funding for the acquisition of Sonoran desert tortoise habitat using compensation rates prescribed for in the BLM's mitigation policy (ADOT 2010, p. 3). Compensation rates for disturbances in Category I or II habitat are 3–6:1 and 2–5:1, respectively (USBLM 2009, p. 18). To date, 584 ac (236 ha) of Sonoran desert tortoise habitat have been acquired through this program with ADOT and Federal Highways Administration. Another 98 ac (40 ha) are scheduled to be acquired as a result of the proposed rerouting of U.S. Highway 95 through the Black Mountains of Mohave County (ADOT 2010, p. 3).

Considerable planning efforts for future road and highway development in Arizona have been afforded to the preservation of wildlife corridors, or "linkages." Linkage design plans have been completed for several biological corridor areas in Arizona where Sonoran desert tortoises may be threatened by construction and development activities that could become barriers to movement between populations (Beier and Majka 2006, pp. 1–81; Beier *et al.* 2006a, pp. 1–189; 2006b, pp. 1–151; 2006c, pp. 1–88; 2006d, pp. 1–97; 2006e, pp. 1–135). These linkage design plans are specific to both individual corridors that may be affected throughout Arizona, and to species (including the Sonoran desert tortoise) chosen as representative "focal species" in each individual assessment (Beier and Majka 2006, pp. 1–81; Beier *et al.* 2006a, pp. 1–189; 2006b, pp. 1–151; 2006c, pp. 1–88; 2006d, pp. 1–97; 2006e, pp. 1–135).

In one example, a series of voluntary conservation recommendations were proposed in Beier *et al.* (2006c, pp. 15–16; 2006e, pp. 14–15) to mitigate effects of major roadways, such as U.S. Highway 60 which traverses Sonoran desert tortoise habitat in Pinal and Gila Counties, Arizona. However, the Sonoran desert tortoise was not afforded consideration in all projects. For example, Sonoran desert tortoise populations in Rincon and Santa Rita mountains in eastern Pima County, Arizona, are adversely affected by Interstate 10 and State Highway 83 (known barriers to tortoise movement), yet were not addressed in the Rincon-Santa Rita-Whetstone linkage design plan (Beier *et al.* 2006a, pp. i–ii). In another example, the Sonoran desert tortoise was not afforded any consideration in the Santa Rita-Tumacacori linkage design plan, despite the likely adverse effects by Interstate 19, a known barrier to movement between populations located in the Santa Rita and the Atascosa-Pajarito-Tumacacori mountains complex in southern Santa Cruz County, Arizona (Beier *et al.* 2006b, pp. i–ii). While some highways have associated structures that prevent or funnel tortoises to underground crossings, several populations are still affected by barriers to movement from major roads and highways that have no such structures.

In our review of the literature, we have documented that roads and highways pose a threat to Sonoran desert tortoises in Arizona because they form barriers to movement, whether through direct mortality from vehicles or from avoidance of roads by tortoises. The effects associated with barriers are described in detail in the "Development as a Barrier" section above. While several roads or highways have associated tortoise fencing and or culverts to prevent road-kill of tortoises and facilitate safe movement, studies have shown that these devices are often not maintained and, therefore, become ineffective over time in achieving their desired goal. This threat also acts synergistically with other influences discussed herein.

Ironwood and Mesquite Harvest

The harvest of mesquite and ironwood trees for charcoal production and use in wood carvings adversely affects Sonoran desertscrub habitat in Mexico, both historically and more recently (Bahre 1991, pp. 143–146). The harvest of mature mesquites from Mexico's Sonoran desertscrub habitat permanently alters desert ecosystems because these leguminous (bearing seed pods similar to pea or bean plants) trees are important anchors for these systems and their associated flora and fauna (Taylor 2006, p. 8). More than 200 plant and animal species depend on mesquite trees in northern Mexico for survival and reproduction (American University Database 2010, p. 1). Mesquite and ironwood trees are ecologically important to Sonoran desert habitat as they serve as nursery plants (i.e., aiding in dispersal, germination, seedling development, and survival) for other plant species used as forage for desert tortoises, and provide valuable shade for temporary shelter sites for Sonoran desert tortoises (American University Database 2010, p. 2). In areas where harvest has been concentrated, the loss of mesquite trees results in the loss of organic matter, fixed nitrogen, and sulfur and soluble salts, affecting overall habitat quality and quantity (Rodriguez Franco and Maldonado Aguirre 1996, p. 47).

The demand for mesquite wood, used for cooking, has increased in the Sonoran Desert region of northern Mexico; one million ac (400,000 ha) have been cleared of mesquite to meet these growing demands (American University Database 2010, p. 1). The modification of one million ac contributes to the degradation or possible loss of 4 percent of tortoise habitat in Mexico; rangewide, 2 percent. Ironwood trees are also being harvested in the Sonoran desert of northern Mexico, where it is cherished for its hardness and carving potential in Seri Indian artwork (American University Database 2010, p. 2). The accelerated rate of legume tree depletion for charcoal and carvings in Sonora has affected the health of ironwood populations and associated communities (Suzan *et al.* 1997, p. 955). This is evidenced by an increased number of damaged and dying trees, as well as generally small size classes for sampled areas (Suzan *et al.* 1997, pp. 950–955). In the Sonoyta region of northern Sonora, more than 478,000 ac (193,000 ha) have been affected by deforestation related to charcoal production, brick foundries, tourist crafts, and pasture conversion (Nabhan and Suzan 1994, p. 64). The modification of 478,000 ac (193,000 ha) contributes to the degradation or possible loss of an estimated 2 percent of their habitat in Mexico; rangewide, 1 percent.

Pressure for fuel wood and crafts materials has been so intense in Mexico south of Organ Pipe Cactus National Monument that wood harvest, especially ironwood, has been detected more than a third of a mile inside the boundary of the Monument, as supplies have been decimated south of the border (Suzan *et al.* 1999, p. 1499). The structure of Sonoran desert tortoise habitat in both washes and upland habitats in the Monument boundary has been affected by this harvest (Suzan *et al.* 1999, p. 1499).

In conclusion, the literature documents that harvest of ironwood and mesquite trees has degraded Sonoran desert tortoise habitat in Mexico, primarily, by the loss of organic matter, fixed nitrogen, and sulfur and soluble salts, affecting overall habitat quality and quantity, which collectively and indirectly affect the forage base and protective cover for Sonoran desert tortoises in as much as 4 percent of its range in Mexico. This threat acts in combination with other threats that affect Sonoran desert tortoise populations in Mexico discussed in this finding.

Livestock Grazing

Sonoran desert tortoises, livestock, and wild burros potentially share habitat throughout their distribution in Arizona, with the exception of lands managed by the U.S. Fish and Wildlife Service or National Park Service. Wild burro herds range across millions of acres of Sonoran desert tortoise habitat in Arizona, predominantly on BLM lands northwest of Phoenix, although the literature is generally lacking in analysis of potential effects of wild burros on Sonoran desert tortoise populations or habitat (AIDTT 2000, p. 21).

The Mexican government has designated over 5 million ac (2 million ha) of Sonoran desertscrub for conversion into grasslands for livestock production (American University Database 2010, p. 1). Sonoran desert tortoises are not found in grasslands, and this habitat type is not considered suitable for the species. The loss of 5 million ac (2 million ha) would constitute an estimated loss of 20 percent of their habitat in Mexico; rangewide, 10 percent. Livestock grazing began to expand and modernize in its extent and distribution in Sonora, Mexico, in 1950, when land considered unsuitable for agriculture was subsequently used for livestock grazing (Hawks 2003, p. 3). During this time, new bulls were introduced throughout ranching operations to improve herd genetics, and artificial seeding of pastures also commenced at this time (Hawks 2003, p. 3). By 1970, buffelgrass was the chosen seed for artificial range supplementation for a growing rural livestock industry, and pastures were seeded with the species throughout Sonora, Mexico. In Sonora, buffelgrass has trended towards a monoculture in many areas, and changed the fire regime to the detriment of native vegetation (Hawks 2003, p. 4). We discuss the threat of nonnative plant species such as buffelgrass in the "Nonnative Plant Species and Altered Fire Regimes" section above.

Livestock stocking rates in Sonora have been documented at 2–5 times the recommended rate for resource sustainability (Walker and Pavlakovich-Kochi 2003, p. 14; University of Arizona 2010, p. 2). Rorabaugh (2008, p. 25) found that livestock grazing "* * * is probably the most widespread human use of Sonora's landscapes" and that rangelands in Sonora are often heavily grazed, with effects most apparent during periods of drought. Livestock production in Mexico is concentrated in the northern states, and the numbers of livestock have grown from 10 million in 1940, to 37.5 million in 1983, largely due to the proximity to the United States, the major importer of Mexican cattle and beef (Stoleson *et al.* 2005, p. 60). In Sonora, 79 percent of agricultural and rangelands are devoted to livestock production (Stoleson *et al.* 2005, p. 60). Effects of poorly-managed livestock grazing observed in Sonora include changes in plant species composition and vegetation cover and structure, soil compaction, erosion, altered fire regimes, and nonnative plant species introductions and invasions (Stoleson *et al.* 2005, pp. 61–62).

In the United States, however, permitted levels of livestock grazing have been reduced to 10 percent of historical levels (Bostick 1990, p. 149). Potential effects of livestock grazing in desertscrub habitat received significant treatment in the literature, with varied scientific conclusions. Fleischner (1994, p. 631) listed specific attributes of ecosystems, such as composition, function, and structure, as vulnerable to the effects of livestock management through a variety of mechanisms including: (1) Decreasing the density and biomass of individual species, reducing species richness, and changing biological community organization; (2) interfering with nutrient cycling and ecological succession; and (3) changing vegetation stratification, contributing to soil erosion, and decreasing availability of water to biotic communities (Waser and Price 1981, pp. 409–410). In Mojave desertscrub, livestock grazing can increase soil compaction and decrease water absorption, thereby reducing water availability to potential Sonoran desert tortoise forage species and subsequently reducing available forage (Boarman 2002, p. 30). Oldemeyer (1994, pp. 100–101) commented that there remains much uncertainty on the exact effects of livestock grazing on desert tortoises. Meyer *et al.* (2010, p. 42) suggested that the effects of livestock grazing on Sonoran desert tortoises should be placed in the context of a grazing regime, effective precipitation, habitat type, topography, Sonoran desert tortoise behavior, and habitat requirements. Loeser *et al.* (2007, pp. 93–96) suggested that climatic variation is key in determining the ecological effects of grazing practices in arid rangelands.

The effects of soil compaction on desertscrub vegetation have been analyzed. In Mojave desertscrub where Sonoran desert tortoises also occur, Adams *et al.* (1982, p. 167) found that soil strength of drying compacted soils increased at a greater rate than non-compacted soils, and that even minor compaction produced similar effects to soil strength. Soil strength was found to be inversely proportionate to production of summer annual grass species (Adams *et al.* 1982, p. 167). Plant species with taproots appeared more vulnerable to the effects of soil compaction whereas fibrous root systems common in nonnative species such as *Schismus* spp. appeared less vulnerable, which indicates that root structure affects the response of plant species and that plant species respond differently to soil compaction, potentially favoring nonnative species in compacted soils (Adams *et al.* 1982, p. 174).

While the Mojave and Sonoran desert tortoises differ to some degree in their biology and behavior, research on livestock grazing effects on Mojave desert tortoises or their habitat does have applicability to Sonoran desert tortoises (especially where Sonoran desert tortoises occupy Mojave desertscrub habitat and by virtue of the arid-land commonality), representing the best scientific information available. However, because Mojave desert tortoises typically occur in flat or gently-sloped terrain and construct earthen burrows in soil, they may be more susceptible to direct effects from livestock grazing. In comparison, Sonoran desert tortoises typically occur on steeper slopes and often construct burrows that are reinforced by boulders and, consequently, less susceptible to direct effects from livestock grazing.

Observed effects of livestock grazing within Mojave desert tortoise habitat include dietary overlap and competition for food resources, destruction of vegetation structure used as temporary shelter sites, trampling of tortoises, collapsing of tortoise burrows, altering plant species composition by facilitating the invasion of nonnative plant species, and compaction of soil which may inhibit the construction of burrows (Avery and Neibergs 1997, p. 13). Boarman (2002a, p. 32) as well as Hobbs and Huenneke (1992, p. 329) found that livestock grazing can import nonnative plant propagules (seeds and other plant parts that may propagate) into native vegetation and subsequent physical alterations in vegetation structure and soil disturbance, such as trampling by livestock hoof-action, may increase germination rates of seeds through burying and compaction and provide microsites for establishment of nonnative plant species.

Avery and Neibergs (1997, p. 13) compared Mojave desert tortoise habitat in both grazed and ungrazed areas (where buffelgrass was not intentionally planted), and found no significant differences in annual plant cover, biomass, or density between study areas. The densities and individual volumes of big galleta (*Hilaria rigida*), a perennial grass species, were greater in grazed habitat than within the grazing exclosure (Avery and Neibergs 1997, p. 13). There was no significant difference in total cover of perennial plant species within study plots (Avery and Neibergs 1997, p. 13). Avery and Neibergs (1997, p. 13) documented livestock nudging and rubbing Mojave desert tortoises, collapsing (potentially occupied) desert tortoise burrows, and destroying vegetation shading actively used burrows. The number of damaged and undamaged burrows in grazed habitat was equal, whereas the number of undamaged burrows in ungrazed habitat was significantly higher (Avery and Neibergs 1997, p. 18). Winter grazing appears to affect a higher proportion of actively used Mojave desert tortoise burrows. Indirect effects from burrow damage include increased risk of tortoise mortality, increased energy costs, and altered activity time budgets as a result of the need to construct new burrows (Avery and Neibergs 1997, p. 19). The potential for livestock to damage Sonoran desert tortoise burrows on lower slopes not reinforced with granite boulders may be similar to the findings of Avery and Neibergs (1997, p. 18), as almost 200 Sonoran desert tortoise burrows were recorded as trampled during a survey of the East Bajada plot in the Black Mountains of

Arizona in 1997 (Woodman *et al.* 1998, pp. 74–75).

Some degree of overlap was observed in the forage plant preferences between Mojave desert tortoises and livestock, with both preferring green annual species when available, and most overlap occurring during the spring (Avery and Neibergs 1997, pp. 18–19). However, preferences began to diverge as spring and summer ensued, with Mojave desert tortoises preferring dried annuals, beavertail cactus (*Opuntia basilaris*), and stems and dried flowers of silver cholla (*Opuntia echinocarpa*), and livestock preferring California jointfir (*Ephedra californica*) and big galleta grass (Avery and Neibergs 1997, p. 18). We presume similar relationships between preferred forage species of livestock and Sonoran desert tortoises exist, because of their highly varied, and often opportunistic, foraging behavior as they take advantage of both summer and winter rainy seasons characteristic of the Sonoran desert. This precipitation pattern affords Sonoran desert tortoises greater access to standing water and, therefore, the ability to forage on a more varied forage base, compared to the Mojave desert tortoise.

Studies have shown that livestock grazing may result in varying effects on plant species richness, composition, and density of the Sonoran desert tortoise forage base. Blydenstein *et al.* (1957, pp. 523, 525) found that vegetation density in some perennial species can be affected by livestock grazing in Sonoran desertscrub, while species composition and annual plant species density were unaffected. Sixteen years of rest from livestock grazing in the desert grassland and oak woodlands in southeastern Pima County in Arizona (at the extreme periphery of the Sonoran desert tortoise range) showed increases in plant species richness and significant increases in canopy cover for midgrass, shortgrass, shrubs, and forbs (Brady *et al.* 1989, pp. 285–287). However, there was no statistical difference in total vegetation cover between grazed land and rested land (Brady *et al.* 1989, pp. 285–287).

Features that attract livestock to certain locations within an allotment may have pronounced effects on desert tortoises and their habitat. Livestock watering, supplemental feeding, or salt-lick sites in desertscrub attract higher use by greater densities of livestock in arid environments. Effects to desertscrub habitat are commensurate with livestock use of these areas and decrease with increasing distance from these sources (Avery and Neibergs 1997, p. 19; Boarman 2002, p. 34). The density of certain nonnative plant species, such as *Schismus* spp., has also been positively correlated to distance to watering sites, while others, such as red brome, are negatively correlated (Brooks *et al.* 2006, p. 139). Native plant species cover and richness has been shown to decrease with increasing proximity to livestock waters (Brooks *et al.* 2006, pp. 140–141). Brooks *et al.* (2006, p. 138) state that these effects can be anticipated from 164 to 656 ft (50 to 200 m) from the edge of the watering site. Juvenile and adult Sonoran desert tortoises were frequently observed by Meyer (1993, pp. 101–102) using salt licks provided for livestock. Frequenting salt licks may benefit desert tortoises (especially hatchlings and small juveniles), but likely increases risk of being trampled by livestock because the salt licks can attract higher concentrations of both livestock and tortoises in actively grazed pastures. Based on the results of a study conducted by Balph and Malecheck (1985, p. 227), cattle avoid stepping on uneven surfaces. Desert tortoises will likely be perceived as an uneven ground surface, therefore, cattle may intentionally avoid stepping on them.

Neff *et al.* (2005, p. 87) compared the effects to soil geology, geomorphology, and geochemical characteristics of biological soil crusts that had been disturbed, and the subsequent wind erosion due to livestock grazing, to an ungrazed area in arid lands of southeastern Utah. They found that "* * * despite almost 30 years without livestock grazing, surface soils in the historically grazed sites have 38–43 percent less silt, as well as 14–51 percent less total elemental soil magnesium, sodium, phosphorus, and magnesium content relative to soils never exposed to livestock disturbances" and 60–70 percent declines in surface soil carbon and nitrogen reserves (Neff *et al.* 2005, p. 87). We are not certain to what extent the loss of these surface soil nutrients may affect the forage quality or quantity for Sonoran desert tortoises in arid habitat. Approximately 46 livestock grazing allotments on the Tonto National Forest partially or wholly overlap the potential range of the Sonoran desert tortoise, with several rated as having impaired or unsatisfactory soil conditions (AIDTT 2000, p. 37).

We observed several instances in the literature that discussed an inherent partitioning of land used by livestock and that used by Sonoran desert tortoises. Livestock often take the paths of least resistance and are unlikely to venture great distances from water. These behavioral traits of domestic livestock limit, to some degree, the potential effects from livestock grazing in Sonoran desert habitat, as livestock are less likely to travel into rough, steep terrain, instead favoring valley bottoms and water sources (AIDTT 2000, pp. 9, 21). Effects from livestock grazing are expected to be attenuated due to the relatively steep slopes and rugged terrain often preferred by Sonoran desert tortoises, but quantitative studies have not been conducted to confirm this assumption (AIDTT 2000, p. 9; Oftedal 2007, p. 26). Because of the generalized differences in habitat usage by livestock (flats, ridge tops, and drainage bottoms) and Sonoran desert tortoises (steep slopes and rocky bajadas), ecological and dietary overlap is uncommon, but does occur to some degree (AGFD 2010, p. 6). Where such overlap is significant, in particular in periods of drought, the effect of livestock use on Sonoran desert tortoise habitat may be considerable (AGFD 2010, p. 7). Sonoran desert tortoises may also selectively avoid grazed areas. While Sonoran desert tortoises are generally known to use steep rocky slopes and bajadas as their primary habitat areas, they occasionally occur in more flat terrain, such as the Florence Military Reservation, where they are 35 percent less likely to use habitat where livestock grazing occurs (AGFD 2010, p. 7). Grandmaison *et al.* (in press, p. 2) examined microhabitat selection by the Sonoran desert tortoise on the Florence Military Reservation in south-central Arizona, and found that tortoises most strongly selected for canopy cover, followed by an absence of cattle activity and proximity to roads and washes.

Of the 17 long-term monitoring plots, evidence of some degree of habitat usage overlap with livestock has been observed on 12 plots. On several plots (Arrastra Mountains, Bonanza Wash, West Silverbell Mountain, and Tortilla Mountains) extensive overlap with livestock use has been documented in each year they were surveyed (AGFD 2010, p. 7). Heavy trampling and destruction of Sonoran desert tortoise burrows has been documented on the Bonanza Wash plot. One Sonoran desert tortoise was crushed by livestock trampling on the West Silverbell Mountain plot, although such extreme reports of livestock-related direct effects on Sonoran desert tortoises are uncommon in the literature (AGFD 2010, p. 7).

Sonoran desert tortoises might compete with livestock for high-PEP plants (for review, see discussion of diet in the *Species Information* section above) and therefore may place unique competitive pressure on Sonoran desert tortoise populations (Oftedal 2002, pp. 235–236). Many high-PEP plant species are found primarily in the transition zone between areas where livestock and Sonoran desert tortoises compete directly for these plant species, as noted in several Arizona long-term monitoring plots (East Bajada of the Black Mountains, Hualapai Foothills, Little Shipp Wash, New Water Mountains, San Pedro Valley), in addition to similar observations from studies performed at Ragged Top, Saguaro National Park, and Sugarloaf Mountain (Oftedal 2007, p. 26). However, Oftedal (2007, p. 25) hypothesized that in situations where winter precipitation is modest, high-PEP plant species are in low abundance, and nonnative annual grass species are in high abundance, "the immediate effect of grazing (forage competition with Sonoran desert tortoise) would be [a] reduction of overall forage biomass, not [a] change in the quality of tortoise diets. This suggests that cattle grazing may be less damaging to tortoises in years of modest rainfall." In conclusion, Oftedal (2007, p. 26) found that "the high degree of diet selection that occurs during spring leaves (Sonoran) desert tortoises susceptible to influences that may alter the abundance of the somewhat scarce high-PEP plants, and thus that may reduce the overall quality of the diet. Tortoises foraging in summer appear less susceptible to the impacts of livestock grazing." Thus, seasonality and precipitation levels appear to affect the likelihood of grazing to adversely affect the forage base of Sonoran desert tortoises, with spring being a period of elevated sensitivity of Sonoran desert tortoises to livestock grazing where tortoises and livestock spatially overlap.

Livestock grazing can influence the microclimate at the ground surface. Grazing may positively affect soil temperature and, therefore, benefit desert tortoise burrow temperatures where burrows are not associated with boulders, but instead constructed in more open habitat such as underneath shrubs (Boarman 2002, p. 31). Field research in Mojave desertscrub indicates that when the undergrowth beneath shrubs is grazed, and the shrub itself is minimally browsed or unaffected by grazing, underlying soils may cool from effects from wind and shade. Heavily vegetated undergrowth traps heat and increases soil temperature (Boarman 2002, p. 31). Alternately, heavily browsed shrubs can increase soil temperatures (Boarman 2002, p. 31). Lower vegetative ground cover in northern Sonora, as a response to livestock overgrazing, was found to increase soil and air temperatures above the levels found in adjacent grazed lands within the United States (Bryant *et al.* 1990, p. 243). Increased soil temperatures may impact the Sonoran desert tortoise in a variety of ways, such as influencing changes in behavior, lowering survivorship, and skewing the sex ratios of hatchlings (which are determined by incubation temperatures; *see Species Information,* above).

Bostick (1990, pp. 150–151) suggested that high desert tortoise densities are correlated with high livestock use, citing health examinations of Mojave desert tortoises that existed in grazing exclosures in northwestern Arizona. Bostick (1990, p. 149) also asserted that desert tortoises feed "primarily on dung," inferring that with more livestock, there would be an abundance of available tortoise forage. Bostick (1990, p. 151) summarized his conclusions on the relationship between livestock grazing and desert tortoises with the following: (1) Desert tortoises have coexisted with cattle for 300 years in California and Mexico and at least 100 years elsewhere; (2) the highest tortoise densities known occurred at a time when overgrazing by livestock was the most severe ever known; (3) the fewer the cattle on a range, the fewer the number of tortoises; and, (4) excluding cattle for many years endangers the tortoise population. Boarman (2002, pp. 27, 35, 38) refuted the conclusions made by Bostick (1990, pp. 149–151) that grazing benefits the desert tortoise. In addition, we found no information in the scientific literature that supported the findings of Bostick (1990, pp. 149–151).

Some research has examined the effects of various livestock grazing regimes to Sonoran desert tortoise populations. Meyer *et al.* (2010, pp. 20–26) compared the number and density of Sonoran desert tortoises in study plots exposed to four different livestock grazing regimes: Yearlong light grazing (plot size 2,279 ac (922 ha)), yearlong moderate grazing (plot size 3,254 ac (1,317 ha)), yearlong heavy grazing (plot size 4,634 ac (1,875 ha)), and rest-rotation (plot size 4,758 ac (1,925 ha)). They found that the highest number and density of Sonoran desert tortoises (266 total individuals; 36.89 individuals per square mile) was observed in the pastures with yearlong heavy grazing as compared to rest-rotation (215 total individuals; 28.94 individuals per square mile), yearlong light grazing (52 total individuals; 14.61 individuals per square mile), and yearlong moderate grazing (47 total individuals; 9.23 individuals per square mile) (Meyer *et al.* 2010, p. 23). The study plots used for this comparison between the number and density of Sonoran desert tortoises and various livestock grazing regimes were of unequal size, with the yearlong light and moderate plots being the smallest. This could affect the number of tortoises observed but not likely the density of tortoises. Other variables that likely affected the analysis of Sonoran desert tortoise densities were differences in vegetation, topography, soil types, and the location of tortoise populations among study plots (Meyer *et al.* 2010, p. 38). In addition, the ability to detect Sonoran desert tortoises is likely to increase with intensity of livestock use and a subsequent decrease in ground cover, which could have further biased the number of observations in the yearlong moderate and heavy grazing study plots. Given the results of these analyses, Meyer *et al.* (2010, p. 42) surmised that "tortoise densities were affected by soil, topography and vegetation and had little or no relationship to livestock grazing or grazing systems."

Additional research examined effects of grazing regimes on fire behavior and wildlife and vegetation communities, citing beneficial effects. Bahre (1991, p. 141) compared the relative frequency of wildfires that occurred in the mid-1900s (carried by nonnative plants), to fires in more recent times, and suggested that mechanical fuel reduction by livestock grazing might assist in reducing the propensity of wildfires in Sonoran desertscrub habitat. Loeser *et al.* (2007, p. 97) found that in Arizona grasslands "* * * some intermediate level of cattle grazing may maintain greater levels of native plant diversity than the alternatives of cattle removal or high-density, short-duration grazing practices."

In an unpublished review of livestock grazing literature, Holecheck (undated, p. 2) found that "* * * controlled livestock grazing may enhance rangeland vegetation by accelerating plant succession, increasing plant diversity, increasing plant productivity, and reducing plant mortality during drought. These positive impacts of livestock grazing are most likely to occur when grazing intensities are light to conservative." Holecheck (undated, p. 2) countered the unanimous findings of over 30 independent livestock grazing impact studies that documented that controlled grazing increases compaction, reduces infiltration, and increases erosion by claiming that "these impacts are generally of small magnitude and are ameliorated by natural processes that cause soil formation, soil deposition, and soil loosening."

Some local land management organizations are currently working on proactive conservations efforts to reduce potential impacts of ranching and other activities on the Sonoran desert tortoise. For example, the Winkelman Natural Resource Conservation District (WNRCD, a coalition of local livestock ranchers and grazing lease permittees in the Winkelman area of the lower San Pedro River in Arizona) has prepared a draft conservation plan for the desert tortoise within their area (WNRCD 2010, pp. 1–13). This draft plan proposes conservation and land management prescriptions for land managers in their area as recommended by the Arizona Interagency Desert Tortoise Team. However, presently the draft plan has not secured specific agreements with land managers responsible for Sonoran desert tortoise habitat, and it lacks financial commitments to carry out the recommended conservation actions. For example, Pinal County was identified as having responsibilities for conservation actions but has since indicated that they are unable to participate in the draft plan (Pinal County 2010, p. 1). While this draft conservation plan could further Sonoran desert tortoise conservation in this area once all the necessary management and financial agreements are in place and the plan is finalized, it currently provides limited conservation benefit to the Sonoran desert tortoise.

In consideration of the literature presented above, we conclude that grazing effects to the Sonoran desert tortoise may occur but are likely limited in severity and scope in Arizona, because habitat shared by livestock and Sonoran desert tortoises is not a significant proportion in most areas in Arizona, and because livestock grazing in Arizona is actively managed by land management agencies (see Factor D). We also acknowledge that data generated from research on grazing effects to tortoises and their habitat are variable, making it difficult to accurately assess the risk of livestock grazing to the Sonoran desert tortoise. However, due to limited regulations affecting livestock management in Mexico, and the information we have examined on its extent in Sonora, we conclude that livestock grazing likely poses a threat to the Sonoran desert tortoise in Mexico. We also acknowledge the potential for livestock grazing effects to act synergistically with other influences discussed herein.

Undocumented Human Immigration

United States border-enforcement efforts have significantly increased along the United States-Mexico international border in Arizona in recent years. Sonoran desert tortoise habitat occurs along approximately 140 mi (225 km) of the border, from approximately Nogales west to the California State line. International border fencing structures and barriers (especially the impenetrable pedestrian fencing) along the Arizona-Sonoran border pose population-connectivity problems for the Sonoran desert tortoise, which depends on emigration and immigration for genetic fitness of regional populations. However, along most of the border, just vehicle barriers occur, which allow tortoises to pass through them, and do not pose a barrier to movement (Cohn 2007, p. 96; Flesch *et al.* 2010, p. 179; Audsley 2010, p. 5; Sferra 2010, pers. comm.). The two primary types of barrier devices that have been constructed, or are planned for construction, are vehicle barriers and pedestrian fences, the latter of which may be impenetrable to Sonoran desert tortoises where the fence is buried into the ground (Audsley 2010, p. 5; Sferra 2010, pers. comm.). Where pedestrian fences are not buried completely and bollard fences (barriers formed by a series of vertical posts) are installed, Sonoran desert tortoises less than 4 in (10 cm) in width may be able to get through (Audsley 2010, p. 5; Sferra 2010, pers. comm.).

Undocumented immigrants affect Sonoran desert tortoise habitat by trampling vegetation along well-used routes and cutting wood for campfires, which affects the quality and amount of forage and also reduces the number of temporary shelter sites for Sonoran desert tortoises (Averill-Murray and Averill-Murray 2002, p. 29). Other human activities along the international border (off-road driving, high-speed driving, accidentally setting fires from cooking or purposefully for distraction of law enforcement personnel, and interdiction activities by the U.S. Border Patrol, U.S. Immigration and Customs Enforcement, and other enforcement agencies) also impact Sonoran desert tortoises and their habitat (AIDTT 2000, p. 27; Marris 2006, pp. 338–339; Sayre and Knight 2010, p. 347).

Historically, border enforcement policies and associated structures have indirectly channeled undocumented immigration pressure onto the Cabeza Prieta National Wildlife Refuge (Marris 2006, pp. 338–339; Cohn 2007, p. 96). Analysis has shown there are about 8,000 mi (12,875 km) of unauthorized routes on the approximate 1,000 sq mi (2,600 sq km) refuge, mostly in designated wilderness (McCasland 2010, pers. comm.). These routes are most likely attributable to illegal cross-border traffic and associated law enforcement response by Border Patrol (McCasland 2010, pers. comm.). Recently, 33.5 mi (54 km) of permanent vehicle barriers were installed along the international border within the Cabeza Prieta National Wildlife Refuge, which has likely reduced illegal vehicular access to the Refuge (SBBI Incorporated 2010, p. 1).

Along the entire southern boundary of the Buenos Aires National Wildlife Refuge, a 7-mi- (11.3-km-) long pedestrian barrier has been constructed (USDHS 2007, pp. 4, Figure 2–1). Because pedestrian barriers on the border are generally well-fortified, complete barriers to terrestrial movement, we assume that Sonoran desert tortoises in the larger juvenile and adult size classes are now prevented from making trans-border dispersal movements as a result of the barrier construction in this area.

The border region associated with the Tohono O'odham Nation in Pima County, Arizona, was recently considered to have one of the highest rates of attempted crossings, because it is relatively remote (Sferra 2010, pers. comm.). Currently, all but 3 mi (4.8 km) of the 70-mi (113-km) section of border between the Tohono O'odham Nation and Mexico is reinforced with a vehicle barrier (Lackner 2010b, pers. comm.). Vehicle barriers are not constructed where terrain is too steep or rocky, or where vehicular access is considered impossible (Lackner 2010b, pers. comm.). The lands of the Tohono O'odham Nation are predominantly classified as Arizona Upland Sonoran desertscrub. The lands presumably have significant numbers of Sonoran desert tortoises, although survey data are generally scarce from that area.

Along the Organ Pipe Cactus National Monument border with Mexico, vehicle barriers exist across most of the monument, and a potentially impenetrable pedestrian fence has been erected in Arizona Upland Sonoran desertscrub on Monument Hill and along 4 mi (6.4 km) of the border at the Lukeville Port of Entry (Sferra 2010, pers. comm.).

The comparison of 2009 and 2010 apprehension rates of undocumented immigrants reflects both the number of attempted illegal crossings and the intensity of enforcement activities within various regions of the Arizona-Mexico border, as well as areas north of the border (Lackner 2010a, pers. comm.). Within Sonoran desert tortoise habitat, significant increases in apprehension rates have occurred in the following areas (percentage denotes change from 2009 to June 2010): Tohono O'odham Nation (18.37 percent); Organ Pipe Cactus National Monument (63.8 percent), and the Sonoran Desert

National Monument (70.69 percent) (U.S. Border Patrol 2010, pers. comm.). In other areas, the apprehension rates have substantially decreased over the same time period: Ironwood Forest National Monument (−47.18 percent), Barry M. Goldwater Air Force Range (−32.02 percent), and the Cabeza Prieta National Wildlife Refuge (−13.19 percent) (U.S. Border Patrol 2010, pers. comm.). Over the same time period, and in total, there have been 79,307 apprehensions made, compared to 71,775 apprehensions in 2009, which represents a 10 percent increase (Lackner 2010a, pers. comm.).

New border- and access-road construction has connected previously remote and undisturbed habitat to the existing network of Arizona roads, providing vehicular access to areas previously only accessible by foot or on horseback (Sayre and Knight 2010, pp. 346–347; Sferra 2010, pers. comm.). An unintended consequence of these new roads is that they are used not only by U.S. Border Patrol, but by the public and illegal traffic, increasing the risk of wildfires, invasions of nonnative plant species, alteration of erosion and water movement patterns (affecting infiltration and soil stability), and mechanical damage to vegetation (Sayre and Knight 2010, p. 347; Sferra 2010, pers. comm.). Many new roads along the border have included cattle guards built with enclosed concrete pits that have the unintended consequence of acting as lethal pit-fall traps for reptiles, such as smaller size class Sonoran desert tortoises (Sayre and Knight 2010, p. 347).

Based on our review of the literature and communications with resource experts and enforcement personnel, we conclude that Sonoran desert tortoises and their habitat, both near the international border and within corridors of heavy undocumented immigrant travel and enforcement interdiction, are threatened by these activities. Specifically, off-road route proliferation, high-speed driving, road construction (providing new access to formerly inaccessible areas), human depredation of tortoises as food sources, and barriers to tortoise movement created by pedestrian fencing are recognized as having serious impacts to Sonoran desert tortoise habitat. The geographic scope of these threats is relatively small on the landscape, restricted to the immediate border region, and to undocumented immigrant migration corridors, such as that recognized through the Tohono O'odham Nation, extending through Ironwood Forest National Monument. However, these impacts are significant where they occur.

Summary of Factor A

Our analysis under Factor A identified an array of threats to Sonoran desert tortoise habitat. The documented invasion and purposeful cultivation of nonnative plant species within the distribution of the Sonoran desert tortoise in the United States and Mexico significantly increases the threat of wildfire in an ecosystem that evolved in the absence of wildfire. This threat is widespread and, although currently and comparatively less significant in Arizona, is substantial in Mexico, and is expected to increase in the future. When including the total land area adversely modified by ironwood and mesquite harvesting, an estimated 98 percent of the Sonoran desert tortoises' habitat will be lost or adversely modified in Mexico in the near future, or 47 percent of the Sonoran desert tortoise's habitat rangewide. It is important to recognize that while nonnative plant species are expanding their distribution on the landscape, Sonoran desert tortoise populations have persisted in affected areas that remain unburned, for decades. The effect of nonnative plants on Sonoran desert tortoise populations is most significant after a wildfire has occurred; effectively giving nonnative species a distinct competitive advantage over native vegetation, and threatening a type-conversion in habitat. While we have found evidence of numerous wildfires in occupied desertscrub, the majority of occupied habitat that has been invaded by nonnative plants has not yet burned and remains suitable habitat for the tortoise.

In addition, projections for human population growth and urban development throughout the species' range are likely to both pose significant problems for genetic exchange among Sonoran desert tortoise populations as well as increase the degree and scope of human interactions with tortoises and occupied habitat, which threatens the tortoise in a variety of ways. Currently in Arizona, 75 percent of potentially occupied Sonoran desert tortoise habitat occurs within 30 mi or less of a city or town with a population of 1,000 or more, and considering future growth projections, it is likely that 100 percent of occupied tortoise habitat will be affected in the future. Livestock grazing in Mexico poses significant threats to the Sonoran desert tortoise habitat there due to ineffective livestock management and continued overgrazing. Lastly, desertscrub habitat that has been disturbed takes a very long time to recover, on the order of decades or centuries, which hinders remediation projects with respect to their ability to prevent population declines in Sonoran desert tortoises in the short- or medium-term. Each of these impacts results in significant cumulative threats to the species' habitat and, based upon our review of the best commercial and scientific data available, we conclude that the present or threatened destruction, modification, or curtailment of its habitat or range is an immediate threat of high magnitude to the Sonoran desert tortoise, both now and in the foreseeable future.

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

Illegal Collection

In urban areas of Sonora, Mexico, such as Hermosillo, desert tortoises have become increasingly common as household pets. They have been mostly obtained from the wild in adjacent areas (Bury *et al.* 2002, p. 103). The sale of desert tortoises in Mexican pet stores ended when the tortoise was listed as threatened in that country in 1994 (Bury *et al.* 2002, p. 103).

Sonoran desert tortoises are a closed season species in Arizona (Commission Order 43), and therefore cannot be legally taken from the wild or possessed without special license. In Arizona, the current possession limit for Sonoran desert tortoises legally held in captivity, *i.e.,* either obtained prior to season closure or obtained through the tortoise adoption program, is one per person per household (AGFD 2010, p. 12). The AGFD allows for disposition of lawfully possessed tortoises by gift to another person in Arizona, or as directed by the AGFD (AIDTT 2000, p. 14). Despite collection prohibitions in Arizona, the Sonoran desert tortoise is a very common reptile pet in Arizona households and has been so for decades. The actual number of Sonoran desert tortoises in captivity is unclear because there are no special licenses or permits required to possess Sonoran desert tortoises, or laws that prohibit their propagation in captivity (Jarchow *et al.* 2002, p. 289; Jones 2008, p. 69). Jarchow *et al.* (2002, p. 289) state that the number of captive Sonoran desert tortoises in Arizona is so large that an outright prohibition of their possession is both impossible and impractical.

The popularity of Sonoran desert tortoises in captivity, as well as the various adoption programs around the State, may unintentionally mislead the public into thinking that Sonoran desert tortoises are not protected, and may, therefore, be collected from the wild

(Grandmaison in press, p. 6). For example, the area surrounding the Hualapai Foothills plot experienced increased development in 2001, which may have increased human-tortoise interactions and possibly illegal collection. Declines in tortoise encounters at this plot in 2001 and 2005 may have, in part, resulted from illegal collection due to that plot's proximity to developed land (AGFD 2010, p. 7).

Arizona's regulations have no provisions requiring permits for possession of Sonoran desert tortoises, which would aid in identification of those tortoises that were in lawful possession before January 1, 1988. In addition, there may be incentive created for the illegal release of captive tortoises into the wild because of the number of tortoises breeding in captivity, and the difficulty associated with finding recipients of offspring within the legal 24-month window (under Arizona's Commission Order 42). This could result in a higher number of illegal and indiscriminant releases into the wild (AIDTT 2000, p. 14). Edwards *et al.* (2010, pp. 801–807) conducted genetic testing of 180 captive tortoises from Arizona to discern their genetic origin (as Sonoran, Mojave, or a hybrid). They found that 45 percent of sampled captive tortoises were not of strictly Sonoran origin, but rather either pure Mojave, Sonoran-Mojave cross, or Texas tortoise (*Gopherus berlandieri*)—Sonoran desert tortoise hybrids (Edwards *et al.* 2010, p. 804). These data indicate there may be a risk of genetic contamination of wild populations when captives are released. Genetic contamination can weaken the genetic fitness of a population and render it vulnerable to extirpation. In addition, as documented in Factor C below, captive Sonoran desert tortoises have been shown to have a higher incidence of disease, and their release can place wild populations at risk.

Opportunities to collect Sonoran desert tortoises often result from incidental observations by motorists while using dirt, gravel, or paved roads. In a recent study, out of a total of 561 opportunities for motorist-Sonoran desert tortoise interaction, 1.43 percent resulted in attempted collection of a live decoy, and 7.4 percent attempted the collection of an artificial Sonoran desert tortoise decoy (Grandmaison in press, pp. 8–9). Combining the data, Grandmaison (in press, p. 11–12) found that collection attempts varied with road type and approximately 1 in 12 (8 percent) motorists that detect a Sonoran desert tortoise in the wild may attempt to illegally collect it. Adult tortoises are the most conspicuous and are likely the most-frequently collected age class, which could be detrimental to populations, especially when reproductive females are collected. Grandmaison (2010a, pers. comm.) stated, "Illegal collection of desert tortoises is a form of additive mortality resulting from the impacts of roadways in tortoise habitat. Given that adult tortoises are the most likely demographic to be collected (i.e., they are easier to detect than juveniles or hatchlings), and the sensitivity of tortoise population growth rates to even small increases in adult mortality, illegal collection really needs to be considered when discussing the cumulative impacts of roads."

While the actual collection of Sonoran desert tortoises detected on roadways is one form of interaction, a higher percentage of motorists attempt to move Sonoran desert tortoises off the roadway when they are detected. Grandmaison (2010a, pers. comm.) found that 28 percent of all motorists passing a desert tortoise will move the tortoise off of the road. While moving a Sonoran desert tortoise off the roadway may be considered well-intended, the stress to a Sonoran desert tortoise that is created when it is handled may result in intestinal torsion (which can cause intestinal obstructions), or lead to the tortoise voiding its bladder. As discussed below, bladder voiding has serious implications, potentially resulting in decreased survival, especially during late spring and early summer in the Sonoran Desert, when precipitation is usually rare or non-existent (Grandmaison 2010a, pers. comm.; in press, p. 11).

Although removal of Sonoran desert tortoises from the wild has clear negative effects on wild populations, their popularity as household pets may provide some educational benefits to the public. Jarchow *et al.* (2002, p. 310) provided evidence for potential conservation benefits from Sonoran desert tortoises that are already in captivity by stating, "The captive population of desert tortoises provides not only enjoyment to their custodians but, more importantly, opportunities for education of the public and increased awareness of the species among those who may never see a desert tortoise in nature. Thus, the captive population may play an important role in mustering public support for conservation of their wild relatives."

In conclusion, research suggests that about 1 in 12 motorists in Arizona who detect a Sonoran desert tortoise will attempt to collect it, and that the highest incidence of collection is within the adult age class. The removal of an adult Sonoran desert tortoise from a population poses a higher threat to that population, because the survivorship of tortoises in this size class is the highest, and the odds of a given Sonoran desert tortoise reaching this size class is believed to be comparatively low, further adding importance to the maintenance of adults within a population. The removal of an adult female from a population also removes the opportunity for numerous clutches of eggs. In addition, nearly one-third of all motorists who encounter a Sonoran desert tortoise will attempt to move it off the roadway, which increases the risk of bladder-voiding, which may place additional physiological stress on moved tortoises and may decrease their survivorship. We also found data on collection and sale of Sonoran desert tortoises in Mexico, which is likely less of a threat in current times, due to the prohibition of commercial sale and to the demographic trend associated with more people moving to urban areas, reducing the number of wild encounters with tortoises in Mexico.

Field Research and Physical Manipulation

Field research and monitoring of wild Sonoran desert tortoise populations has been ongoing since the 1970s, producing invaluable information for wildlife and habitat managers to make reasoned decisions with respect to conservation planning. However, some level of harassment or potential harm from disease transmission or dehydration is inherent to hands-on manipulation (such as collecting blood samples, affixing radio transmitters, and conducting health assessments).

One of the more significant risks to Sonoran desert tortoises from the handling of wild tortoises by researchers is the increased potential for them to void water reserves stored in their bladder. As a defense mechanism when threatened, Sonoran desert tortoises may occasionally evacuate their bladders, releasing valuable water stores important for survival in their arid habitat, especially during drought years. Averill-Murray (2002a, p. 430) noted, "This water loss could result in serious health threats or compromise normal behavior or physiology, especially during hot, dry summer months." Water loss in Sonoran desert tortoises can also result in reductions of reproductive output and survivorship (Averill-Murray 2002a, pp. 430, 433–434). Averill-Murray (2002a, pp. 430, 434) found that Sonoran desert tortoises that urinated during field research handling had a 5–13 percent lower survival rate.

Any kind of handling of tortoises during field research or monitoring of Sonoran desert tortoise populations during periods of excessive drought may be stressful to the tortoises (Berry *et al.* 2002b, p. 436). Berry *et al.* (2006b, p. 436) recommended that scientists working with wild desert tortoises recognize abnormalities in behavior and laboratory data as early warning signs of stress to modify, delay, or terminate specific field protocols on stressed populations.

Use of radio telemetry technology on desert tortoises may affect their behavior, survival, and reproductive success, but available literature is largely inconclusive (Boarman *et al.* 1998, p. 26). There is little doubt that radio telemetry studies have provided many insightful data on the biology and behavior of Sonoran desert tortoises, and are therefore more of a benefit than a potential threat.

Jacobson *et al.* (1992, pp. 238–239) reviewed the recommended procedures for obtaining blood samples from desert tortoises, including collection from the heart, jugular vein, brachial vein, ventral coccygeal vein, orbital sinus, and trimmed toenails, and assessed the potential risks associated with each collection site. At a minimum, the collection of blood samples from desert tortoises is considered relatively invasive and is likely a source of temporary stress to the animal, potentially leading to bladder voiding and subsequent dehydration if fluid levels are not replenished before release. However, we believe the majority of field researchers exercise appropriate caution when collecting blood samples from Sonoran desert tortoises, and the literature does not indicate these procedures are an appreciable source of mortality for wild Sonoran desert tortoises.

Over the years, field protocols have been developed and standardized to minimize risks to Sonoran desert tortoises while they are being physically handled. These protocols are outlined in Averill-Murray (2000, p. 17) and Berry and Christopher (2001a, pp. 433–434). We believe these field protocols have minimized potential risks to individual tortoises posed by researchers during their field work.

Summary of Factor B

We identified two possible mechanisms for which the potential overutilization of Sonoran desert tortoises for commercial, recreational, scientific, or educational purposes could occur: Illegal collection and field research. Many desert tortoises exist in captivity, and are generally available to those who want one as a household pet, through several channels within the captive population (discussed further in Factor D). In addition, efforts are being made to educate the public about the Sonoran desert tortoise, with an emphasis on leaving Sonoran desert tortoises in the wild when they are observed. We believe these factors may reduce the likelihood of illegal collection. However, a recent scientific study found that one in 12 tortoises that is detected by a motorist (mostly adult tortoises) is illegally collected. We expect that in the foreseeable future, incidence of collection will likely increase as the human population grows and more people will use off-road trails, with higher frequency, within occupied tortoise habitat. Scientists who conduct field research on and monitoring of wild Sonoran desert populations have identified the potential risk for bladder voiding and disease transmission during field manipulation of tortoises, and have now built appropriate protocols in their field methodology to minimize these risks. Based on this information, we find that overutilization for commercial, recreational, scientific, or educational purposes, in the form of illegal collection, is likely to threaten the Sonoran desert tortoise now or in the foreseeable future.

Factor C. Disease or Predation

Natural predation of Sonoran desert tortoises occurs as discussed previously in the *Species Information* section above. Unnatural sources of predation, such as from feral, or off-leash dogs, human depredation for recreation or as food, and as an indirect result of human land uses (referred to as subsidized predation) also occur. A subsidized predator is one whose survival in a particular area is facilitated by the availability of food, water, or other potentially limiting resources made available by the presence of human activities in that area (Boarman 1993, p. 192). Common examples of subsidized predators are coyotes and ravens. Human activity-related resources that provide basic biological needs for subsidized predators include such things as roads, landfills, sewage and septic ponds, open dumpsters, agricultural fields, feedlots, parks, picnic areas, livestock waters, utility poles, building sites, and overpasses (Boarman 1993, p. 193; Rosentstock *et al.* 2004, p. 3; Boarman *et al.* 2006, p. 259; Webb *et al.* 2009, p. 72).

For example, Averill-Murray and Swann (2002, p. 1) stated that urban development adjacent to the Saguaro National Park in Pima County threatens the Sonoran desert tortoise via several mechanisms, including harassment and predation by feral or off-leash domestic dogs, and illegal releases of captive Sonoran desert tortoises and exotic species that may transmit diseases to wild Sonoran desert tortoises.

Predation by Ravens

Ravens and coyotes are known predators on Mojave desert tortoises, and possibly on Sonoran desert tortoises, and are most likely to benefit from anthropogenic subsidization (Boarman 1993, p. 192; Boarman *et al.* 2006, p. 259). Ravens turn over hatchling desert tortoises and pierce through their soft plastrons, or pierce directly through their carapace, to access their meat and organs. Ravens are often less likely to emigrate long distances to colonize would-be suitable areas, but subsidization from human activities on the landscape create opportunities for rapid population growth of ravens where they formerly did not occur (Boarman *et al.* 1995, p. 1; Fleischner *et al.* 2008, p. 472). Ravens, in particular, have been identified as subsidized predators on juvenile Mojave desert tortoises, and possibly on juvenile Sonoran desert tortoises (Boarman 1993, p. 192). Roads and power line rights of way attract potential avian predators of Sonoran desert tortoises, such as ravens and red-tailed hawks that use power lines as nesting and perching sites, and roads can serve as sources of carrion (Knight and Kawashima 1993, p. 266). Raven populations, and potential risk of predation of Sonoran desert tortoises by ravens, are both higher with increasing proximity to human development (Kristan and Boarman 2003, p. 2432).

Documented reports of raven predation on Sonoran desert tortoises are rare in the literature, however. One local rancher in southeastern Mohave County, Arizona, reported an observation of raven predation on a Sonoran desert tortoise (Dieringer 2010, p. 1). Ravens have also been observed on the Four Peak monitoring plot on several occasions, but their predation on Sonoran desert tortoises within this plot has never been documented (Murray and Schwalbe 1997, p. 33). Mojave desert tortoises are most commonly associated with valley bottomlands characterized by relatively open, sparse vegetation communities which may be advantageous to a purely visual-based predator such as the raven. In Arizona Upland Sonoran desertscrub, where Sonoran desert tortoises reach their peak population densities, habitat is a more complex mosaic of boulders and denser vegetation, which would hamper the ability of such predators to locate prey, in particular, small hatchlings. Some exceptions include habitat within sparsely vegetated valley bottoms that are used for dispersal between populations on adjacent mountains or foothills, or similar, uncharacteristic areas that maintain Sonoran desert tortoise populations, such as the Florence Military Reservation. The best scientific and commercial data available indicates that predation by ravens is significantly less of a concern for Sonoran desert tortoises than it is for Mojave desert tortoises.

In conclusion, although raven predation has been identified as a substantial threat to the Mojave desert tortoise, largely because of the relatively open, valley bottomland where they occur, the risk to Sonoran desert tortoise populations is relatively low. Very few observations of raven predation of Sonoran desert tortoises in Arizona or Sonora have been documented in the literature, leading us to conclude that raven predation on the Sonoran desert tortoise is not a concern.

Predation From Feral or Off-Leash Dogs

Feral dogs are known to interact with numerous species of animals, including desert tortoises and related species, and they may force Sonoran desert tortoises to use their habitat in an unnatural manner (Causey and Cude 1978, pp. 94–95; Lenth *et al.* 2008, pp. 222–223). The risk of feral or off-leash dog predation on Sonoran desert tortoises is expected to be highest within the urban-rural interface (a likely source of domesticated, feral dogs).

Jones (2008, p. 66) documented 35 separate incidences of harassment by wild or domestic dogs in surveys conducted in high-use public lands adjacent to the urban centers of Tucson, Phoenix, and Kingman, Arizona (Pima, Maricopa, and Mohave Counties, respectively), based upon observed shell damage. These incidences were positively correlated with increasing proximity to urban centers. Also, three to five packs of presumably feral dogs were observed in both the East Bajada monitoring plot in Mohave County and in Saguaro National Park West in Pima County (Jones 2008, p. 66). Researchers of Sonoran desert tortoises within the Tucson Mountain District of Saguaro National Park noted a high number of tortoises with injuries consistent with dog attacks, attributing these observations to the close proximity of this district to urban development (Zylstra and Swann 2009, pp. 14–15). The AGFD (2010, pp. 11–12) reported that domestic dogs, their scat, and chew marks on, or trauma to, Sonoran desert tortoises have been reported in 47 percent of the monitoring plots. Three such plots occur within 1 mi (1.6 km) of developed areas. Domestic dogs have been observed attacking and chewing on Sonoran desert tortoises in the Hualapai Foothills and Bonanza Wash plots (AGFD 2010, p. 12). Domestic dogs appear to be a significant problem, which may be worsening, in the East Bajada plot, where in 1997, 53 percent of live tortoises, and in 2002, 78 percent of live tortoises, exhibited injuries associated with domestic dogs (AGFD 2010, p. 12). One citizen commented that in 1997 a purebred Rottweiler was observed roaming freely on the Ironwood Forest National Monument with an adult Sonoran desert tortoise in its jaws. The tortoise was mortally wounded from a punctured carapace, suggesting that large, powerful domestic dog breeds may be able to penetrate the carapace of adult tortoises and kill them (Coping 2009, p. 7).

Numerous signs of attempted predation (consistent with those from feral dogs), ranging from mild to severe, were observed in wild Sonoran desert tortoises examined in Sonora, Mexico (Brown *et al.* 2006, p. 6). We are unaware of the locations where these wild Sonoran desert tortoises were captured by Brown *et al.,* but the proximity to human settlements, and free-ranging domestic dogs (a common sight in Mexico) may have been responsible.

In conclusion, the threat of feral dog predation exists in both Arizona and Sonora, Mexico, and has been shown to be strongly correlated with distance to urbanized areas in most cases. We found numerous reports of observed or suspected feral dog predation in the literature, most in immediate proximity to urban areas. Feral dog predation has been documented in approximately half of the long-term monitoring plots in Arizona, and may be a significant cause of population decline in one plot. As urbanization and human population growth continues into the future, as described in Factor A, the incidence of feral dog predation of Sonoran desert tortoises is expected to also increase.

Human Depredation and Vandalism

Human depredation (intentional killing) of Sonoran desert tortoises has been documented to occur either as a result of vandalism (most commonly via gunshot) or as a source of food. The intentional shooting of Mojave desert tortoises in southern California was reported to be relatively common, at least before the Mojave population was Federally listed. Berry (1986b, p. 127) found that 14 percent of 635 carcasses taken from 11 sites in the Mojave Desert over a 6-year time period exhibited signs of gunshots. Many of these observations occurred before the listing of the Mojave desert tortoise, indicating that tortoises may have been shot simply for misdirected recreational sport or entertainment, not from politically-driven motives (people disliking the protections of the Act). Bury and Marlow (1973, p. 11) described examples of Mojave desert tortoise mortalities in California as a result of shooting, including eight independent observations of shot Mojave desert tortoises along two miles (3.2 km) of dirt road; an individual's confession of using juvenile desert tortoises as skeet (aerial shotgun) targets; and a report of an individual lining up a total of 47 desert tortoises and shooting each of them with a shotgun.

Recreational firearms target practice occurs in dispersed fashion throughout Federal and State lands in Arizona within the distribution of Sonoran desert tortoises. Some reports of gunshot deaths of Sonoran desert tortoises on these lands have been made (Hart *et al.* 1992, p. 120; AGFD 2010, p. 9; Jones 2010, pers. comm.). In some locations, recreational firearms target practice is highly conspicuous (as evidenced by large amounts of debris used as targets and left behind) in densely occupied Sonoran desert tortoise habitat, most notably in areas near urban population centers, such as at Sugarloaf Mountain on the Cave Creek Ranger District of the Tonto National Forest. In this location, two incidences of shot Sonoran desert tortoises have been reported, although it could not be determined whether these wounds occurred pre- or post-mortem (Jones 2010, pers. comm.). Another incidence of shooting was reported in the Hualapai Foothills monitoring plot (Hart *et al.* 1992, p. 120). The AGFD (2010, p. 9) reported 13 separate incidences of vandalism on Sonoran desert tortoises on or adjacent to 7 different monitoring plots; several of the Sonoran desert tortoises appeared to have been killed by gunshot.

When studying Mojave desert tortoises, Berry (1986b, p. 129) found that the incidence of gunshot deaths is likely to be higher in areas of greater vehicular access and in proximity to urban areas. The potential effect of gunshot deaths on Sonoran desert tortoise populations is not entirely known, but is likely most significant on the adult size class, which is the most conspicuous, and this effect may act synergistically with other threats we have identified. Combined with the relatively low recruitment rate of juvenile desert tortoises into adult size classes, adverse effects to survivorship of populations adjacent to urban areas might be expected (Berry 1986b, p. 130).

Sonoran desert tortoises are sometimes used as a food source in Sonora, and likely experience population declines where they occur adjacent to moderately sized settlements (Fritts and Jennings 1994, p. 52). Bury *et al.* (2002, p. 102) reported several historical incidences of Sonoran desert tortoises being used as a source of food by native peoples in Sonora, but less frequently in current times. According to 12 interviews at 6 ranches in central Sonora, 67 percent of local people described Sonoran desert tortoises as declining. All but one interviewee stated they have eaten Sonoran desert tortoise meat at some point in their lives (Bury *et al.* 2002, p. 102). However, demographic trends in Sonora indicate the number of people living on ranches and ejidos (commonly owned lands used for agriculture and livestock grazing) have declined, while city populations have increased, potentially reducing the likelihood of Sonoran desert tortoises being used for food (Bury *et al.* 2002, pp. 102–103).

Sonoran desert tortoises have also been documented as a food source for undocumented immigrants on their journey through the Sonoran Desert of Arizona, specifically in the Ironwood Forest National Monument. Coping (2009, p. 4) claims that by the time undocumented immigrants reach the Ironwood Forest National Monument, many have been abandoned by their guides and left without food, water, or a sense of direction, leaving them in intense desperation (Coping 2009, p. 4). In one instance on June 2, 1997, a small group of undocumented immigrants approached a resident living within the Ironwood Forest National Monument. The immigrants had a live Sonoran desert tortoise they had captured along the way that had a rope tethered to its front leg. They told this resident that if they did not receive food from him, they planned to eat the tortoise (Coping 2009, p. 5). In another reported observation, a livestock grazing permittee on the Ironwood Forest National Monument stated that he had seen immigrants carrying tortoises, “presumably with the intent to consume” (Averill-Murray and Averill-Murray 2002, p. 29). Indigenous communities of the Sonoran Desert historically used Sonoran desert tortoises for food and medicine, and their shells for ladles, dippers, bowls, and shovels (Nabhan 2002, p. 356). However, we have no information to suggest these uses have continued into modern times.

In conclusion, direct human depredation on Sonoran desert tortoises is most likely to occur via vandalism (*i.e.,* shooting) and utilization as a source of food. While the deliberate shooting of Sonoran desert tortoises has been documented in Arizona, reports are comparatively rare, especially considering the amount of monitoring and survey effort that has been afforded to wild populations over the past several decades. However, as the human population continues to grow and urbanization expands, we expect the incidence of human depredation to increase. Sonoran desert tortoises have been used for food in Mexico historically, but these occurrences are suspected to be comparatively rare in current times. Sonoran desert tortoises may also be captured by undocumented immigrants as they pass through remote areas of Arizona, but increasing border-enforcement activities are expected to reduce the number of undocumented immigrants entering Arizona in the foreseeable future, reducing this risk.

Upper Respiratory Tract Disease

The threats of mycoplasmosis (or upper respiratory tract disease (URTD)), and cutaneous dyskeratosis (shell disease) were major factors in the listing of the Mojave desert tortoise (Berry 1997, p. 91). Genetic analyses were performed by Brown *et al.* (1994, p. 4580) on seven *Mycoplasma* organisms that were recovered from the upper respiratory tract of clinically ill desert tortoises. These laboratory tests led to the discovery and subsequent species description of *Mycoplasma agassizii,* the species of bacteria that causes upper respiratory tract disease in infected tortoises (Berry and Christopher 2001b, p. 413). Although *M. agassizii* has been studied in Mojave and Sonoran desert tortoises, as well as gopher tortoises (*G. polyphemus*), since the 1980s, its origins are unknown. It may be a naturally occurring or an exotic pathogen. There are several potential routes of inoculation of vertebrates by microbiota such as *Mycoplasma* spp., including horizontal (transmission between individuals), vertical (passed down from parent to offspring), and environmental (passed from environment to individual) (Belden and Harris 2007, p. 536). Brown (2002, p. 1340) states that direct contact with infected individuals is the most likely route of transmission. Brown (2003, p. 1) stated that *M. agassizii* is not known to be transferred through the eggshell.

Disease may be spread to wild populations as a result of the release of captive native or nonnative tortoise species, which can be carriers of diseases that could affect wild Sonoran desert tortoises (Howland and Rorabaugh 2002, p. 343). The release of any captive reptile or amphibian is strictly prohibited by the AGFD. In a study investigating the relationship between exposure to *M. agassizii* and an urban gradient of Greater Tucson, Arizona, Jones (2008, p. 36–37) found evidence to suggest a positive correlation between the likelihood of testing seropositive for antibodies to *M. agassizii* (meaning a tortoise has been exposed to URTD), and proximity to urban centers. These results suggest that there may be a relationship between urbanization and this pathogen. Tortoises from suburban sites are 2.3 times more likely to test seropositive for antibodies to *M. agassizii* than tortoises from other sites in the greater Tucson area. In fact, Sonoran desert tortoise populations in the Rincon Mountains (adjacent to Tucson, Arizona) had the highest prevalence of exposure to URTD of any sites tested in Arizona, with 72.7 percent of sampled Sonoran desert tortoises identified as seropositive (Jones 2008, p. 93).

Jones (2008, p. 60) also explored the relationship between URTD and captive and wild desert tortoises from high-use public lands in Maricopa, Mohave and Pima counties, and found that captive desert tortoises are 1.8 times more likely to test seropositive for exposure to *M. agassizii* than wild tortoises (p. 65). Sonoran desert tortoises from Pima County (wild and captive) had the highest incidence of exposure to URTD and were 5.4 times more likely to be seropositive for antibodies to *M. agassizii* than those from Mohave or Maricopa Counties (Jones 2008, p. 65). While clinical signs of URTD are infrequently observed in wild Sonoran desert tortoises in Arizona, Jones (2008, pp. 37, 74) found that *M. agassizii* is widespread among captive desert tortoises in Arizona, suggesting that the captive population may be an important reservoir of URTD-infected tortoises that can spread the disease to wild populations if unlawfully released or allowed to escape.

Even though URTD appears to occur widely and has been documented in Sonoran desert tortoise populations, no die-offs have been attributed to URTD in Arizona. Currently, URTD does not appear to be a source of mortality for Sonoran desert tortoise populations (Hart *et al.* 1992, p. 120; AIDTT 2000, p. 9; Averill-Murray and Klug 2000, p. 69; Dickinson *et al.* 2002, p. 256; Howland and Rorabaugh 2002, p. 343; Jones 2008, p. 22; AGFD 2010, p. 9). Howland and Rorabaugh (2002, p. 343) hypothesized that if disease does become a significant threat to Sonoran desert tortoise populations in the future, their patchy distribution may limit the spread of disease. However, because the captive population of desert tortoises may serve as a reservoir of disease and because captives are unlawfully released into the wild by the public, monitoring wild tortoise populations that occur near urban areas will continue to be important (Howland and Rorabaugh 2002, p. 343; Jones 2008, pp. 6–7, 41, and 72–73).

An indirect effect of disease is that it may also subject individuals to increased predation. Sonoran desert tortoises that are exhibiting clinical signs of URTD may be more active during winter months, in order to increase their metabolism and elevate their body temperatures. This increase in surface activity might result in a greater chance of predation or human detection (Jones 2008; p. 105). Jones (2008, p.103) found that periods of surface activity may increase in clinically ill Sonoran desert tortoises; however, home range size did not differ between seropostive and seronegative tortoises (p. 103), so seropositive tortoises which are more active in winter months do not appear to be increasing the areas over which they move.

Wild Sonoran desert tortoises in Sonora, Mexico, were tested for the presence of antibodies to two *Mycoplasma* species, *M. agassizii* and *M. testudineum,* and were found to be generally unexposed (Brown *et al.* 2006, p. 5). Twenty-seven of 28 wild Sonoran desert tortoises were found to be seronegative, indicating they had not been exposed to *Mycoplasma* spp.; and one individual was serosuspect (a result indicating that the antibody level is intermediate between positive and negative, and is considered inconclusive) for *M. testudineum* (Brown *et al.* 2006, p. 5). However, 11 of 21 captive Sonoran desert tortoises in Sonora, Mexico, tested seropositive for antibodies, indicating exposure to *M. agassizii;* and four were serosuspect for exposure to *M. testudineum.* Ten captive desert tortoises had *M. agassizii* isolated from nasal flushes, indicating a current infection, suggesting that disease may be more prevalent in the Sonora captive population (Brown *et al.* 2006, pp. 5–6). Nearly all of the captive desert tortoises exhibited mild to severe clinical signs of URTD. Of the captive tortoises, six had swollen or draining chin glands and four had evidence of nasal discharge (Brown *et al.* 2006, p. 5–6). Once infected by URTD, tortoises may ultimately die from the disease.

Cutaneous Dyskeratosis

Cutaneous dyskeratosis, a shell disease, was also a major factor considered in the listing of Mojave desert tortoises. In populations of Mojave desert tortoises exhibiting clinical signs of this disease, significant die-offs have been documented, some as high as 70 percent mortality rate (Jacobson *et al.* 1994, p. 69). Cutaneous dyskeratosis may appear on the carapace, plastron, and thickened scales of the forelimbs, but is most often apparent on the plastron (Jacobson *et al.* 1994, pp. 70–74). Potential causes of cutaneous dyskeratosis have not been confirmed, but may be related to deficiency diseases and environmental contamination (Berry 1997, p. 91).

Cutaneous dyskeratosis has been reported as more prevalent than URTD within Sonoran desert tortoise populations across Arizona. As of 2000, Sonoran desert tortoises infected with cutaneous dyskeratosis had been observed in every monitored population, with the exception of the Wickenburg Mountains plot (AIDTT 2000, p. 9; Averill-Murray and Klug 2000, p. 69). However, noticeable population-level effects have not been reported in any of the monitoring plots (AIDTT 2000, p. 9; Averill-Murray and Klug 2000, p. 69; AGFD 2010, p. 9). Of the 36 individual Sonoran desert tortoises sampled from the Little Shipp Wash and the Harcuvar Mountains from 1990 to 1994, only 5 (all females presumed to be at least 30 years old) had signs of cutaneous dyskeratosis, and all lived through the end of the field study. This prompted Dickinson *et al.* (2002, p. 258) to suspect that Sonoran desert tortoises might not be affected by this disease, although they acknowledged that more research was necessary. As of 2000, the highest incidence of cutaneous dyskeratosis (62 percent of individuals) was reported from the East Bajada plot (AIDTT 2000, p. 9). In Sonora, Mexico, 14 of the 28 wild Sonoran desert tortoises examined exhibited clinical signs of cutaneous dyskeratosis (Brown *et al.* 2006, p. 6).

In conclusion, disease has been documented as a serious threat to the Mojave desert tortoise, and was a primary cause for its listing under the Act. The two most prevalent diseases that could affect Sonoran desert tortoise populations are URTD and cutaneous dyskeratosis. Researchers have speculated that Sonoran desert tortoises may be able to clear infections of *M. agassizii,* and no wild Sonoran desert tortoises have been found to have died from URTD in Arizona, although it is nearly impossible to document the precise cause of death in many situations. The literature documents that Sonoran desert tortoise populations in proximity to urbanized areas are most at risk of disease (as a result of released captives), because the captive population (both in Arizona and Mexico) has a significantly higher percentage of seropositive tortoises and tortoises that have acquired URTD. Cutaneous dyskeratosis has been documented in virtually all Sonoran desert tortoise long-term monitoring plots in Arizona, although no Sonoran desert tortoises have been documented to have succumbed to this disease, and we conclude that cutaneous dyskeratosis is not a substantial threat to populations. Disease screening has been a regular component to field research and monitoring of wild Sonoran desert tortoise populations throughout their range for many years, and has not indicated that either URTD or cutaneous dyskeratosis pose a current threat to the Sonoran desert tortoise.

For additional information on disease in desert tortoises, or specific disease data from monitored Sonoran desert tortoise populations, see Hart *et al.* (1992, p. 120); Berry (1997, p. 91); Brown *et al.* (1994, p. 4580; 1995, p. 350; 2002, p. 497; 2006, pp. 5–6); Jacobson *et al.* (1994, pp. 69, 70–74); Schumacher *et al.* (1999, pp. 829–830); AIDTT (2000, p. 9); Averill-Murray and Klug (2000, p. 69); Berry and Christopher (2001b, p. 413); Averill-Murray and Averill-Murray (2002, pp. 16, 19, 26); Brown (2002, pp. 1340, 1343; 2003, p. 1); Dickinson *et al.* (2001, pp. 254–256; 2002, pp. 256, 258, 260–261; 2005, p. 841); Howland and Rorabaugh (2002, p. 343); Tracy *et al.* (2006a, p. 1191); Belden and Harris (2007, pp. 536, 538); Wendland *et al.* (2007, p. 1190); Jones *et al.* (2005, p. 1); Boarman and Kristan (2008, p. 19); Jones (2008, pp. 6–7, 70, 93, 103, 105); Zylstra and Swann (2009, pp. ix–x); and AGFD (2010, p. 9).

Summary of Factor C

In review of the information presented above, we conclude that predation from feral domestic dogs and, to a lesser extent, human depredation and vandalism, in combination with other threats, threaten Sonoran desert tortoise populations, most notably as a result of the expansion of urbanization and associated increases in human activity in remote areas. We conclude this threat to be of moderate magnitude. Based upon our review of the available literature, disease does not appear to be significantly affecting the status of wild Sonoran desert tortoise populations. Therefore, we conclude that disease does not pose a significant threat to the Sonoran desert tortoise now or in the foreseeable future.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

Within its distribution in the United States, the Sonoran desert tortoise occurs on lands managed by a myriad of Federal and State agencies and Native American tribes, and on private lands. State agencies, such as the Arizona Game and Fish Department (AGFD) or the Arizona Department of Transportation (ADOT), have either direct management authority over the Sonoran desert tortoise, or could potentially impact Sonoran desert tortoise populations or habitat directly or indirectly in carrying out their intended missions. Internationally, the Sonoran desert tortoise is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (commonly referred as to CITES), which requires permits to transport individuals between member nations (Bury *et al.* 2002, p. 86; Howland and Rorabaugh 2002, p. 348). Under the International Union for Conservation of Nature's "Red List," the desert tortoise (rangewide) is considered "vulnerable"—meaning it faces a high risk of extinction in the medium-term (Rorabaugh 2008, p. 27). In our review, we found that the Sonoran desert tortoise is commonly considered in conservation planning where it occurs on public or tribal lands in Arizona. Below we discuss how each agency or entity manages their land, or otherwise considers the Sonoran desert tortoise in their planning activities.

U.S. Bureau of Land Management

BLM is very proactive in their conservation management, directly and indirectly, through three main mechanisms: (1) Sonoran desert tortoise habitat categorization and compensation (monies derived from adverse effects to Sonoran desert tortoise habitat for the acquisition of new habitat, funding research, etc.); (2) resource management planning; and (3) land designation. The BLM has developed numerous documents that outline how Sonoran desert tortoise habitat management goals and objectives are to be achieved and accounted for in their land use planning.

The BLM developed the document titled "Desert Tortoise Management on the Public Lands: A Rangewide Plan" (authored by Spang *et al.* 1988), and created the designation of three categories of desert tortoise habitat throughout the species' range, using four main criteria to indicate the importance of the habitat: (1) Maintaining viable populations, (2) resolvability of conflicts, (3) desert tortoise density, and (4) population status (stable, increasing, or decreasing) (AIDTT 2000, p. 16; USBLM 2010, p. 1). The BLM categorized habitat based upon its suitability for the desert tortoise, with Category I being the most suited, and Category III the least, with the goals of maintaining viable desert tortoise populations in Category I and II habitat, and limiting population declines in Category III habitat to the extent possible (AIDTT 2000, p. 16). However, not all Sonoran desert tortoise habitat was included in this categorization process.

AIDTT (2000, p. 19) depicts the distribution of the categorized habitat included in Arizona. In Arizona, there are 723,769 ac (292,899 ha) of Category I Sonoran desert tortoise habitat, 2.6 million ac (1.1 million ha) of Category II habitat, and 3.8 million ac (1.5 million ha) of Category III habitat, totaling 7.1 million ac (2.9 million ha) of categorized habitat (AIDTT 2000, p. 18). The 1988 Rangewide Plan also indentified 14 different management objectives the BLM has defined specifically for desert tortoise management, each with its own itemized management action plan. These management objectives include the following categories: (1) Increased awareness; (2) inventory and monitoring; (3) cumulative impacts; (4) identification of endangered populations; (5) coordination and cooperation; (6) research and studies; (7) management of tortoise habitat; (8) regulation of lands and realty actions; (9) regulation of off-highway vehicles; (10) regulation of livestock use; (11) regulation of wild horses and burros; (12) wildlife habitat management; (13) predator control; and (14) management of energy and minerals research and extraction (Spang *et al.* 1988, pp. 14–23; AIDTT 2000, p. 18).

In 1990, BLM's Arizona State Office issued the policy titled Strategy for Desert Tortoise Habitat Management on Public Lands in Arizona, Instruction Memorandum No. AZ–91–16. It outlined objectives and management actions to be implemented, and also established the BLM Desert Tortoise Mitigation Policy, which was later reissued in 1999 (USBLM 2010, p. 2). In 2009, the BLM finalized the Desert Tortoise Mitigation Policy, in order "to articulate mitigation policy including off-site compensation for the Sonoran desert tortoise and its habitat on public lands managed by (BLM) in Arizona, in a consistent manner between District and Field Offices" (USBLM 2009b, p. 1). The BLM's Desert Tortoise Mitigation Policy "establishes policy to mitigate for impacts to desert tortoises and their habitats including compensation for residual impacts that cannot otherwise be mitigated. Mitigation, including compensation must be designed to meet the purposes of the Rangewide Plan, including maintaining viable populations as well as maintaining the quantity and quality of Category I and II desert tortoise habitat" (USBLM 2009b, p. 1). Compensatory funds derived from BLM's compensation policy are then used for a variety of conservation activities to lessen impacts to Sonoran desert tortoises including protective tortoise fencing, culverts for crossing, land acquisition, and research (AIDTT 2000, p. 19). Details of this policy can be found in USBLM (2009b, pp. 1–45).

The BLM implements various objectives and management actions through resource management plans unique to certain geographic regions of BLM-managed lands (USBLM 2010, p. 3). Currently, there are eight individual resource management plans, some recently issued and others up to 22 years old, representing the areas with potential Sonoran desert tortoise habitat (USBLM 2010, p. 3). The Phoenix Resource Management Plan, which directs the management of approximately 440,000 ac (178,000 ha) of Sonoran desert tortoise habitat, does not contain district-specific management actions, but incorporates management actions described in the Strategy for Desert Tortoise Habitat Management on Public Lands in Arizona (USBLM 2010, p. 3). Approximately 1.1 million ac (455,000 ha) in the Yuma, Lake Havasu, Bradshaw-Harquahala, and Kingman resource management planning areas that were considered Sonoran desert tortoise habitat have been designated as "priority habitats," meaning that the BLM prioritizes management of wildlife habitat over other multiple-use activities (USBLM 2010, p. 3).

The BLM can directly or indirectly manage for the Sonoran desert tortoise through the process of land designation, such as Areas of Critical Environmental Concern (ACEC) and Wilderness Areas. In the case of ACECs, those values may pertain to specific species or habitats, or cultural or scenic values (AIDTT 2000, p. 22). Sonoran desert tortoises were the impetus for the Poachie and McCracken ACECs, while other ACECs benefit the Sonoran desert tortoise through broad protections, such as in the Agua Fria and Ironwood Forest National Monuments (AIDTT 2000, p. 22). Sixteen Arizona ACECs contain Sonoran desert tortoise habitat (AIDTT 2000, p. 22). ACEC designations facilitate the minimization of surface-disturbing activities, such as vehicular travel, camping, fire use, mineral extraction activities, and grazing (AIDTT 2000, p. 22). There are also 48 wilderness areas managed by the BLM in Arizona, including approximately 850,000 ac (344,000 ha) of Sonoran desert tortoise habitat, through "reclaiming damaged areas, reclaiming old vehicle ways and routes, establishing campfire and camping policies to avoid resource impacts, establishing livestock grazing use objectives with respect to desired vegetation, setting objectives for wildlife habitat including the desert tortoise, and setting prescriptions for wildfire" (AIDTT 2000, pp. 22–23). In addition, the BLM manages Sonoran desert tortoise habitat in Wilderness Areas and National Monuments with an emphasis on maintaining natural conditions and biological function of these areas (USBLM 2010, p. 10). Approximately 22 percent of categorized Sonoran desert tortoise habitat falls under these management prescriptions on BLM lands in Arizona (USBLM 2010, p. 10).

Livestock grazing is the most widespread land-use activity permitted on BLM lands, with 273 individual allotments covering approximately 6 million ac (2.4 million ha), and 74 percent of Sonoran desert tortoise habitat in the U.S. on their lands (Rosmarino and Connor 2008, p. 49). A policy was developed by the BLM's Arizona State Office in 1994, addressing livestock use of upland vegetation growth in response to significant winter precipitation, ensuring adequate amounts of forage remained for the Sonoran desert tortoise (and other species) before and after livestock use. These "ephemeral" pastures or allotments are permitted for 30 days of livestock grazing, with additional 30-day extensions if monitoring concludes adequate forage capacity exists (AIDTT 2000, p. 22). AIDTT (2000, p. 22) viewed this grazing policy as a "significant protective change that ensured forage for other animals, such as desert tortoises, and also ensured that perennial plants would not be damaged due to insufficient ephemeral growth." In 1997, the BLM (USBLM 1997, pp. 1–18) further developed standards and guidelines for livestock grazing and rangeland health. In upland sites, the BLM standard is "Upland soils exhibit infiltration, permeability, and erosion rates that are appropriate to soil type, climate and landform (ecological site)" (USBLM 1997, p. 5). To assess whether an allotment is meeting this standard, the BLM uses descriptive criteria that pertain to soil conditions, ground cover, and erosion rates (USBLM 1997, p. 5).

The BLM generally prohibits mineral material sales (mining activities) in Category I and II Sonoran desert tortoise habitat, but requests are evaluated on a case-by-case basis (USBLM 2010, p. 3). For example, in the Phoenix District, the BLM has denied 11 such mineral material sales, while others have been denied in the Tucson District, to prevent potential impacts to Sonoran desert tortoises and their habitat (USBLM 2010, p. 4).

In summary, the BLM considers the Sonoran desert tortoise in its land management planning and has denied or altered projects which could adversely affect the Sonoran desert tortoise or its habitat, specifically with respect to mining and livestock-grazing activities. However, we are not aware of specific actions the BLM is taking with respect to invading nonnative plant species and subsequent wildfire concerns, vandalism of tortoises, feral dog predation, or management to counter anticipated climate change. In addition and as discussed below, BLM management of off-highway vehicle use on their lands is not protective of Sonoran desert tortoise populations. Therefore, we conclude that BLM management of the Sonoran desert tortoise and its habitat is currently inadequate.

U.S. Forest Service

The Sonoran desert tortoise is included on the U.S. Forest Service's Regional Forester's Sensitive Species List, which means it is evaluated in all biological evaluations for activities and projects proposed within its habitat (AIDTT 2000, p. 35). Sonoran desert tortoises occur on the Prescott (Bradshaw Ranger District), Coronado (Santa Catalina and Nogales Ranger Districts), and Tonto National Forests in Arizona (Murray and Schwalbe 1993, p. 39). The Tonto National Forest manages the most Sonoran desert tortoise habitat of the three National Forests in Arizona, where they occur in the Cave Creek, Mesa, Globe, and Tonto Basin Ranger Districts.

Multiple land uses occur on these National Forests, including recreation, camping, livestock grazing, and off-highway vehicle use. Approximately 46 livestock grazing allotments on the Tonto National Forest partially or wholly overlap the potential range of the Sonoran desert tortoise, with several rated as having impaired or unsatisfactory soil conditions (AIDTT 2000, p. 37). We are not aware of the exact number of livestock grazing allotments that overlap Sonoran desert tortoise habitat on the Coronado or Prescott National Forests. With the exception of livestock grazing, the majority of land uses that have the highest potential to affect the Sonoran desert tortoise occur in districts adjacent to urbanized areas, such as the Santa Catalina Ranger District on the Coronado National Forest (adjacent to the Tucson metropolitan area) and the Cave Creek and Mesa Ranger Districts on the Tonto National Forest (adjacent to the Phoenix metropolitan area). While the Coronado National Forest does not have specific management policies for the Sonoran desert tortoise, two policies may serve its benefit: (1) "Provide habitat for wildlife populations consistent with the goals outlined in the Arizona and New Mexico Department of Game and Fish Comprehensive Plans and consistent with other resource values;" and, (2) "Provide for ecosystem diversity by at least maintaining viable populations of all native and desirable nonnative wildlife, fish, and plant species through improved habitat management" (AIDTT 2000, p. 36).

In September 2005, Region 3 of the U.S. Forest Service adopted a new policy for rangeland adaptive management (USFS 2007, pp. 1–34), called the Chapter 90 policy. Under this policy, limits on timing, intensity, frequency, and duration of livestock grazing are set in Allotment Management Plans. Monitoring and adaptive management are key attributes of the Chapter 90 policy and are intended to ensure livestock grazing outcomes meet desired resource conditions which include the needs of wildlife such as the Sonoran desert tortoise. The term "conservative use" in this policy is defined as forage utilization on key forage species between 30 and 40 percent or less of annual forage production by weight for herbaceous perennials, and 50 percent or less on woody browse species (USFS 2007, pp. 26, 30). It is inherent in the term "conservative use" that watershed conditions and vegetative ground cover will be optimized as appropriate to various range sites. At no time is excessive use considered acceptable. The goal is to achieve conservative use in the uplands over successive years. This strategy recognizes the importance of adaptive management, and may include adjustments of timing, intensity, frequency, and duration of grazing to reach resource objectives (USFS 2007, pp. 13–14).

Implementation monitoring of livestock grazing under conservative use practices can be done using a variety of methods, and is designed to provide information that will enable decision-makers to practice adaptive management by making necessary changes needed for plant development and recovery, and to assess physical improvements to allotments (USFS 2007, pp. 16–17). Effectiveness monitoring of conservative use practices documents whether management actions are having the expected progress toward achieving resource-management objectives, and is used to track upland vegetative and soil condition over the long term (USFS 2007, pp. 16–17). From a short-term (within-year) perspective, wildlife habitat and watershed conditions are gauged by monitoring seasonal utilization on key forage species during the grazing period. Due to a warmer climate, variable precipitation, and mild winters, seasonal-utilization monitoring is important because the end of a particular growing season is not well-defined for all plant communities in Sonoran desert tortoise habitat on Forest Service lands. In review of this policy, we conclude that implementation of the Forest Service's rangeland management strategy is likely to retain physical characteristics necessary to provide for the necessary forage and shelter requirements for Sonoran desert tortoise.

In summary, the USFS considers the Sonoran desert tortoise in all biological evaluations for activities and projects proposed within its habitat. The USFS has developed a system of adaptive management for livestock grazing on their lands, using resource monitoring to indicate when changes in land conditions occur or prescribed use levels are unsustainable, preventing excessive harm to sensitive Sonoran desert tortoise habitat. However, we are not aware of specific actions the USFS is taking with respect to management of invasive, nonnative plant species and subsequent wildfire concerns, vandalism of tortoises, feral dog predation, or efforts to counter anticipated climate change. In addition, and as discussed below, USFS management of off-highway vehicle on their lands is not protective of Sonoran desert tortoise populations. Therefore, we conclude that USFS management of the Sonoran desert tortoise and its habitat is currently inadequate.

Off-Highway Vehicle Management and Enforcement on Public Lands

While both the USFS and BLM have developed broad, strategic plans to manage off-highway vehicle use, these plans have been found to be missing some key elements that could improve off-highway vehicle management, such as results-oriented goals, strategies to achieve the goals, timeframes for implementing strategies, or performance measures to monitor incremental progress (USGAO 2009, p. 16). Limitations of the USFS's strategic plan have resulted from a general failure to address motorized travel designations on the ground, communicate with the public, monitor off-highway vehicle trail systems, or enforce off-highway vehicle regulations (USGAO 2009, p. 16).

In response to public concerns, the BLM developed the "National Management Strategy for Motorized Off-Highway Vehicle Use on Public Lands" (USBLM 2001, p. 9). This strategy outlines action items that are to be implemented "as soon as practical" (USBLM 2001, pp. 10–21). However, the U.S. Government Accountability Office (2009, pp. 17–18) found that "[d]espite identifying numerous goals and strategies to achieve the goals, BLM's recreation plan does not identify any timeframes for implementing the strategies or any performance measures for monitoring incremental progress * * *. Without performance measures and timeframes, the BLM cannot ensure that it is making progress on achieving its goals in a timely manner."

The BLM generally prohibits competitive off-highway vehicle events that could adversely affect Sonoran desert tortoises, from March 31 through October 15, but noncompetitive off-highway vehicle activities are evaluated on a case-by-case basis, and mitigation measures are implemented to reduce potential impacts to Sonoran desert tortoises (USBLM 2010, p. 4). Although requests to permit rock crawling events (defined in *Factor A,* above) have been denied where they were proposed in Sonoran desert tortoise habitat (USBLM 2010, p. 4), this activity still occurs outside of organized "events." Rock crawling is allowed where it might adversely affect the Sonoran desert tortoise or its habitat (USBLM 2010, p. 4).

Both the USFS and BLM acknowledge limited staff and financial resources for off-highway vehicle management (USGAO 2009, p. 37). Off-highway vehicles that pass over undisturbed desertscrub habitat may leave tracks which are then noticed by others and subsequently used until the trail is mistakenly recognized as a designated route; this process is known as "route proliferation" (Brooks and Lair 2005, p. 5). Illegal proliferation of roads and unauthorized use of off-highway vehicles has left persistent scars in the Sonoran Desert (Abella 2010, p. 1249). In the Kingman area, between 1994 to 1999, the BLM tracked an increase of greater than 20 percent of off-highway vehicle use within the range of the Sonoran desert tortoise, and reported 124 and 123 violations of improper vehicle use Statewide in 1998 and 1999, respectively (AIDTT 2000, p. 10). The BLM has only 195 law enforcement officers nation-wide, which means that on average, each officer is responsible for overseeing approximately 1.2 million ac (490,000 ha) of land, or 1,875 sq mi (4,856 sq km) (USGAO 2009, p. 38). Law enforcement of off-highway vehicle use in the Arizona-Mexico border region is further complicated by increasing demands to address drug smuggling and other border-related issues (USGAO 2009, p. 39). To address an inadequate law enforcement presence, the BLM's Phoenix District has initiated an "ambassador program" which recruits volunteers to "educate users and promote safe, sustainable off-highway vehicle use in the area" (USGAO 2009, p. 38). The use of signs is a common method to enforce off-highway vehicle regulations on Federal lands, but signs are often vandalized (sometimes within 48 hours of their installation), and must be frequently replaced (USGAO 2009, p. 40).

In addition to wildlife management (described below), the AGFD also licenses, promulgates rules for, and assists with regulatory enforcement of off-highway vehicles use on public lands. In January 2009, the AGFD created an off-highway vehicle decal program, designed to increase revenues for off-highway vehicle enforcement, education, and signage on public lands (AGFD 2009, p. 1). However, as of November 2009, only 21 percent of all eligible off-highway vehicles and off-highway vehicle owners in Arizona were participating in the off-highway vehicle decal program (AGFD 2009, p. 1).

In review of off-highway vehicle management on USFS and BLM lands in Arizona, we conclude that the current status of law enforcement is inadequate to protect Sonoran desert tortoises and their habitat. We considered the following in making this conclusion: (1) The documented adverse effects of off-highway vehicle use on Sonoran desert tortoise habitat (see *Factor A*); (2) the propensity for off-highway vehicle users to illegally collect Sonoran desert tortoises in the wild (discussed in *Factor B*); (3) the significant, and growing, use of off-highway vehicles in Arizona (discussed above in *Factor A*); and (4) the deficient level of law enforcement staff responsible for regulating the use of off-highway vehicles on these lands discussed above.

In addition, we accept the U.S. Government Accountability Office finding that the USFS and BLM goals and objectives, intended to protect trust resources from damage associated with off-highway vehicle use, miss some key elements that could improve off-highway vehicle management.

Ironwood and Mesquite Harvest

To address ecological problems stemming from wide-ranging mesquite and ironwood harvesting in northern Mexico (discussed above in *Factor A*), the Arizona-Mexico Commission, and state government in Sonora, Mexico, made it illegal to cut and export these species (American University Database 2010, p. 4). Additionally, Mexico's Federal government has protected the ironwood tree, adding additional monitoring and enforcement to protect remaining ironwood trees (American University Database 2010, p. 4). Finally, non-profit, bi-national groups are raising awareness and funds to help stop these practices in Mexico (American University Database 2010, p. 4). We consider these regulations effective in reducing the harvest of ironwood and mesquite in the future, but the land area already adversely modified by ironwood and mesquite harvesting, as discussed in *Factor A* above, constitutes a current threat to Sonoran desert tortoise habitat.

U.S. Department of Defense

Three prominent Department of Defense-administered lands maintain populations of Sonoran desert tortoise: The Yuma Proving Ground, Barry M. Goldwater Range, and Florence Military Reservation. The Yuma Proving Ground, administered by the Department of the Army, encompasses 840,000 ac (340,000 ha) in LaPaz and Yuma Counties of southwestern Arizona (AIDTT 2000, p. 32). The majority of land on the Yuma Proving Ground is closed to public access year-round with the exception of 133,000 ac (54,000 ha) that are open to hunting access for 6 months per year. The relative inaccessibility of these lands results in little disturbance to the Sonoran desert tortoise and its habitat (AIDTT 2000, p. 33). In addition, the Yuma Proving Ground developed a management plan for the Sonoran desert tortoise in 1996 (AIDTT 2000, pp. 33–34). We are uncertain whether or not this management plan is effective in Sonoran desert tortoise conservation on the Yuma Proving Ground.

The Barry M. Goldwater Range, used for aerial training exercises, is the largest contiguous portion of Department of Defense lands in Arizona (1.7 million ac, 690,000 ha), and is jointly administered by the Luke Air Force Base and Marine Corps Air Station—Yuma, and is located in portions of Maricopa, Yuma, and Pima Counties (AIDTT 2000, pp. 32–33). The majority of military training exercises occur over the valleys where Sonoran desert tortoise densities are low, leaving the majority of Sonoran desert tortoise populations unexposed to potential threats from these exercises (AIDTT 2000, p. 34). Outside of training exercises, the public may access the Barry M. Goldwater Range with a permit, via designated routes (AIDTT 2000, p. 34).

The Florence Military Reservation encompasses 25,752 ac (10,421 ha), and is jointly administered by the Arizona Army National Guard, the Arizona State Land Department, and the BLM (AIDTT 2000, p. 34). As stated previously, the Sonoran desert tortoise population on the Florence Military Reservation is unique among other populations across their range, because of the conspicuous absence of boulder outcrops and use by tortoises of broad alluvial fans and incised washes (Riedle *et al.* 2008, p. 418; Grandmaison *et al.* in press, p. 4). There is significant public access and multiple land uses allowed on the Florence Military Reservation, with no specific protections afforded to the Sonoran desert tortoise (AIDTT 2000, p. 34). Sonoran desert tortoise home ranges overlap with concentrated military training areas on the Florence Military Reservation (Grandmaison *et al.* in press, p. 1). When not used for military training, these areas serve as recreational areas for camping, hunting, and off-highway vehicle use, which cumulatively have degraded Sonoran desert tortoise habitat by removing vegetative cover, which in turn may have led to reduced use of these areas by Sonoran desert tortoises (Grandmaison *et al.* in press, p. 4).

There are few data on the potential effects of military operations to Sonoran desert tortoises on U.S. Department of Defense lands, specifically with respect to aircraft operations. However, Bowles *et al.* (1999, pp. 19–26) tested the response of Mojave desert tortoises to simulated aircraft sound and to sonic booms associated with aircraft, in an attempt to ascertain potential effects to wild desert tortoises that are exposed to such auditory stimuli within and adjacent to aircraft flight paths and military training areas. They found that Mojave desert tortoises could detect these sounds and had somewhat subdued reactions ranging from "freezing" all movements, to bladder voiding (Bowles *et al.* 1999, pp. xxii-xxiv). We are not certain whether Sonoran desert tortoise populations on U.S. Department of Defense lands are subjected to aircraft noise at similar sound pressure levels, but we presume they are, because aircraft training occurs on these lands in Arizona.

In summary, the Barry M. Goldwater Range and Yuma Proving Ground provide for considerable protection of Sonoran desert tortoise habitat on their installations as a result of access restrictions or through a permitting program. The Barry M. Goldwater Range also created a management plan specifically for the Sonoran desert tortoise in 1996. In addition, since these lands are unlikely to be developed in the future, these areas will likely be important in future Sonoran desert tortoise conservation planning. However, the literature has documented that current management on the Florence Military Reservation is not adequate for protecting Sonoran desert tortoises or their habitat. In discussion under *Factors A* and *B,* we discussed several activities that occur in this area which adversely affect the Sonoran desert tortoise and its habitat.

U.S. Fish and Wildlife Service National Wildlife Refuges

Sonoran desert tortoises occur on several National Wildlife Refuges in Arizona. Sonoran desert tortoise populations are highest on the Kofa, Buenos Aires, and Cabeza Prieta National Wildlife Refuges, although they also may occur in low densities within the Cibola, Imperial, and Lake Havasu National Wildlife Refuges along the Colorado River (AIDTT 2000, p. 31). The mission of the National Wildlife Refuge System is " * * * to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (AIDTT 2000, p. 31). Management on these National Wildlife Refuges is largely protective of Sonoran desert tortoises, as multiple use activities such as livestock grazing and off-highway vehicle use are prohibited (AIDTT 2000, p. 31). However, the U.S. Border Patrol uses administrative roads, which are closed to public use in these areas, along the border region of the Buenos Aires and Cabeza Prieta National Wildlife Refuges, which may affect Sonoran desert tortoises or their habitat in these areas. For further discussion of the effect of U.S. Border Patrol operations on Sonoran desert tortoises or their habitat, see the section on Undocumented Immigration in *Factor A* of this finding.

In summary, we conclude that the regulations establishing the mission and management of the National Wildlife Refuge system are consistent with Sonoran desert tortoise habitat management, and are therefore adequate to protect the tortoise where it occurs on our lands.

National Park Service

Sonoran desert tortoise habitat occurs on Organ Pipe Cactus National Monument, Saguaro National Park, and the Lake Mead National Recreation Area (AIDTT 2000, p. 27). The National Park Service is mandated by law to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (AIDTT 2000, p. 26). The resource-management goals on National Park Service lands are broad in scope, and include reducing ground disturbance, developing and implementing inventory and monitoring programs, assessing and mitigating resource disturbance, and developing environmental restoration and research programs (AIDTT 2000, p. 26). Livestock grazing and off-highway vehicle use are not permitted on National Park Service lands. While the National Park Service has no specific provision for Sonoran desert tortoise conservation on their lands, all wildlife inhabiting National Park Service lands in Arizona, including the Sonoran desert tortoise, are protected, and possession or removal of wildlife is prohibited (AIDTT 2000, p. 26).

However, where National Park Service lands are adjacent to urban areas, such as Saguaro National Park outside of the Tucson metropolitan area, threats to Sonoran desert tortoises have been documented. Averill-Murray and Swann (2002, p. 1) and Jones (2008, p. 66) documented threats such as harassment and predation by feral domestic dogs, releases of captive Sonoran desert tortoises and exotic species (that may transmit diseases), road mortality, and illegal collection of tortoises, as affecting the Sonoran desert tortoise population on Saguaro National Park land.

In summary, we acknowledge that the mission and management of the National Park Service and their lands is consistent with Sonoran desert tortoise habitat management, but where Park Service land is affected by adjacent urbanized areas, adequate regulatory protections for the tortoise have not been realized.

Arizona State Land Department

Arizona State Trust Land, managed to derive revenues for trust beneficiaries including educational, health, and penal institutions, comprises 13 percent of all land in Arizona, much of which contains Sonoran desert tortoise habitat (AIDTT 2000, p. 15). In general, the mission of the Arizona State Land Department is to maximize economic return (AIDTT 2000, p. 16). The Arizona State Land Department has no broad management practices, policies, or directives that pertain to Sonoran desert tortoise management, but does coordinate with the AGFD on some projects to reduce potential impacts to the Sonoran desert tortoise (AIDTT 2000, p. 16). Four Sonoran desert tortoise monitoring sites occur partially or fully on Arizona State Trust Lands: Granite Hills, Little Shipp Wash, Tortolita Mountains, and Picacho Mountains; two of these sites, Granite Hills (Pinal County) and Little Shipp Wash (Yavapai County) are long-term monitoring plots (AIDTT 2000, pp. 5–6, 15). Other blocks of Sonoran desert tortoise habitat on Arizona State Trust Lands occur west of the Upper Burro Creek, Arrastra Mountain, and Tres Alamos wilderness areas in Yavapai County and from the Tortolita to the Tortilla Mountains in Pinal County (AIDTT 2000, p. 15). Recreation on State Trust Lands is generally not monitored and therefore may not be protective of Sonoran desert tortoises or their habitat.

The Arizona State Land Department is considering restricting access to its lands for purposes of conducting wildlife studies. These access restrictions may prohibit further research due to numerous permit requirements. These new policies are not yet in place and could be changed prior to final issuance (Jody Latimer, ASLD, 2010, pers. comm.). If implemented as described by Latimer (ASLD, 2010, pers. comm.), these proposed procedures and fees have the potential to limit Sonoran desert tortoise monitoring and research on Arizona State Trust lands in the future through new monetary and procedural requirements. While these new policies and regulations are not yet in effect, even if they are implemented it appears they will not address conservation and management of the Sonoran desert tortoise and its habitat, and further, may have a negative effect by potentially restricting important research needed for conservation of the tortoise. Furthermore, we are not aware of specific actions the Arizona State Land Department is taking with respect to management of invasive, nonnative plant species and subsequent wildfire concerns, vandalism of tortoises, feral dog predation, or efforts to counter anticipated climate change. Therefore, we conclude that Arizona State Land Department management of the Sonoran desert tortoise and its habitat is currently inadequate.

Arizona Game and Fish Department

The Arizona Game and Fish Department (AGFD) currently classifies the Sonoran desert tortoise as a Tier 1b "Species of Greatest Conservation Need" AGFD (2006, p. 485). A Tier 1b species is one that requires immediate conservation actions aimed at improving conditions through intervention at the population or habitat level. Before April 28, 1989, the AGFD allowed the collection and possession of one lawfully captured Sonoran desert tortoise per person (AIDTT 2000, p. 14). After this date, under Commission Order 43, the AGFD closed the season on Sonoran desert tortoises, which prohibited the take of desert tortoises from the wild, except under special permit (for example, scientific or educational) (AIDTT 2000, p. 14). Unless otherwise prescribed in title 17, it is unlawful to [t]ake, possess, transport, buy, sell or offer or expose for sale wildlife except as expressly permitted by this title" (ARS 17–309). It is also unlawful to release wildlife into the wild except as authorized by the Arizona Game and Fish Commission or as defined in title 3 (see ARS 17–306). As a closed-season species, the desert tortoise cannot be taken from the wild or possessed without special permit (Commission Order 43). As restricted live wildlife (R12–4–406), they cannot be imported, exported, or possessed without special license or lawful exemption.

Enforcement of the State closure on collection of Sonoran desert tortoises occurs when directly observed by law enforcement personnel, but the remoteness of many Sonoran desert tortoise populations makes enforcement strategies and techniques problematic (AIDTT 2000, p. 14). Furthermore, regulations regarding the collection or possession of Sonoran desert tortoises are poorly known to the public, emphasizing the importance of education efforts (AIDTT 2000, p. 14). The effect of illegal collection of Sonoran desert tortoises on wild populations in Mexico is largely unknown (see *Factor B*).

The AGFD has led Sonoran desert tortoise conservation in Arizona through research, guidance provided to the public and other agencies, and cooperative conservation management on public lands. For example, the AGFD (2007a, p. 1) provides construction and development contractors with guidance, should a Sonoran desert tortoise be encountered within an area of a development. In addition, the AGFD (2007b, p. 1) also provides environmental consultants guidance on proper survey techniques and considerations when surveying for Sonoran desert tortoises. AGFD (2006, pp. 485–487) described numerous management priorities with respect to mitigating potential threats facing the tortoise in Arizona. The recommendations outlined in these documents are recommended guidance, voluntary in nature, and no reporting requirements are mandated. Therefore, we are uncertain whether project proponents implement these recommendations.

Arizona Interagency Desert Tortoise Team

As part of a multi-agency collaborative project, the Arizona Interagency Desert Tortoise Team (AIDTT) was formed in 1985 to coordinate research and management of Sonoran desert tortoise populations in Arizona. Participating agencies in the AIDTT manage habitat, manage the species, or conduct research, and include the AGFD, Arizona State Lands Department, U.S. Forest Service, BLM, U.S. Bureau of Reclamation, U.S. Bureau of Indian Affairs, U.S. Fish and Wildlife Service, National Park Service, U.S. Geological Survey, and several U.S. Department of Defense military reservations (AIDTT 1996, Preface; AIDTT 2000, p. 2). The AIDTT is co-chaired by representatives from the U.S. Fish and Wildlife Service (Arizona Ecological Services Office) and the AGFD. Since its inception, the AIDTT has collaborated in the development of numerous documents addressing conservation of the Sonoran desert tortoise including "Survey Protocol for Sonoran Desert Tortoise Monitoring Plots: Reviewed and Revised" (Averill-Murray 2000a), "Status of the Sonoran Population of the Desert Tortoise in Arizona: An Update" (Averill-Murray 2000b), "Guidelines for Handling Sonoran Desert Tortoises Encountered on Development Projects" (AGFD 2007a), "Desert Tortoise Survey Guidelines for Environmental Consultants" (AGFD 2007b), and "Recommended Standard Mitigation Measures for Projects in Sonoran Desert Tortoise Habitat" (AIDTT 2008). Available online, the AIDTT (2008, pp. 1–7) offers guidance on standard types of mitigation for projects that may affect Sonoran desert tortoises; these measures are voluntary.

The AIDTT's Memorandum of Understanding, signed in 1995, established specific objectives for the team including: (1) Ensuring the survival of the species; (2) preventing loss of the species; and (3) improving the quality of Sonoran desert tortoise habitat in Arizona, with the team to function as an advocate for the Sonoran desert tortoise (AIDTT 1996, Preface; AIDTT 2000, p. 2). A management plan for the Sonoran desert tortoise completed in 1996 called for improved monitoring protocols, the implementation of threat-minimization activities, and the creation of Sonoran Desert Management Areas (AIDTT 1996, pp. 20–26). However, common criticisms of the 1996 plan include: (1) Lack of meaningful goals and objectives; (2) lack of political willpower without legal protection for the Sonoran desert tortoise; (3) failure to designate Sonoran Desert Management Areas; and (4) poor funding (AIDTT 2000, p. 2). Collectively, these recognized shortcomings hampered the implementation of threat-minimization activities. In recognition of these shortcomings, the AIDTT is currently in the process of developing a State Conservation Agreement, Assessment and Strategy with the goal of identifying reasonable, obtainable conservation goals and objectives that will contribute to Sonoran desert tortoise conservation on public lands in a meaningful capacity.

Mexican Government (Secretaria de Medio Ambiente y Recursos Naturales)

Throughout Mexico, the desert tortoise is listed as "Amenazadas," or Threatened, by the Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) (Bury *et al.* 2002, p. 86; Howland and Rorabaugh 2002, p. 348; SEDESOL 2008, p. 99). Threatened species are "those species, or populations of the same, likely to be in danger of disappearing in a short or medium timeframe, if the factors that negatively impact their viability, cause the deterioration or modification of their habitat or directly diminish the size of their populations continue to operate" (SEDESOL 2008 (NOM–059–ECOL–2008), p. 5). This designation prohibits taking of the species, unless specifically permitted, and also prohibits any activity that intentionally destroys or adversely modifies its habitat (SEDESOL 2000 and 2001 (NOM–059–ECOL–2001). However, activities that unintentionally destroy or adversely modify their habitat do not appear to be specifically prohibited (*e.g.,* cultivation of buffelgrass for livestock grazing). In 1988, the Mexican Government passed a regulation that is similar to the National Environmental Policy Act of the United States (42 U.S.C. 4321 *et seq.*). This Mexican regulation requires an environmental assessment of private or government actions that may affect wildlife or their habitat (SEDESOL 1988 (LGEEPA)).

The Mexican Federal agency known as the Instituto Nacional de Ecología (INE) is generally considered the Mexican counterpart to the U.S. Fish and Wildlife Service. INE is responsible for the analysis of the status and threats that pertain to species that are proposed for listing in the Norma Oficial Mexicana NOM–059 (the Mexican equivalent to a threatened and endangered species list), and if appropriate, the nomination of species to the list. INE developed the Method of Evaluation of the Risk of Extinction of the Wild Species in Mexico (MER), which unifies the criteria of decisions on the categories of risk, and permits the use of specific information fundamental to listing decisions. The MER is based on four independent, quantitative criteria: (1) Size of the distribution of the taxon in Mexico, (2) state (quality) of the habitat with respect to natural development of the taxon, (3) intrinsic biological vulnerability of the taxon, and (4) impacts of human activity on the taxon. INE implemented use of the MER in 2006; therefore, all species previously listed in the NOM–059 were, in many cases, based solely on expert review and opinion. Specifically, until 2006, the listing process under INE consisted of a panel of scientific experts who convened as necessary for the purpose of defining and assessing the status and threats that affect Mexico's native species that are considered to be at risk, and for applying those factors to the definitions of the various listing categories.

In summary, while the desert tortoise is federally listed in Mexico, we have documented significant threats to its persistence in that country (see *Factors A* and *C*) that are not controlled by the listing, and therefore conclude that regulations establishing management of the Sonoran desert tortoise in Mexico do not provide adequate assurances of its continued existence in that country.

Summary of Factor D

Numerous State and Federal entities have regulations or policies which implement management of either the Sonoran desert tortoise or its habitat throughout the species' range in Arizona. In Mexico, the species is currently listed as threatened. In our review of the available information on each entity's management policies and regulations, we found numerous examples where the Sonoran desert tortoise is considered in management actions and tortoise-specific mitigation measures are mandated, or where land activities that could appreciably threaten Sonoran desert tortoise populations are prohibited. While several land managers and agencies in Arizona actively consider the Sonoran desert tortoise in their resource planning, we found deficiencies in management of off-highway vehicle use, policies and procedures inconsistent with Sonoran desert tortoise conservation, and some threats such as invasive, nonnative plant species and subsequent wildfire concerns, vandalism of tortoises, feral dog predation, or efforts to counter anticipated climate change were not addressed by land management control. Lastly, significant threats we discuss above in *Factors A* and *C* are not being adequately addressed by land managers, including invasive, nonnative plant species and associated wildfire concerns, vandalism of tortoises, feral dog predation, and management to counter anticipated climate change.

Although the Sonoran desert tortoise is considered a threatened species in Mexico, we are not aware of conservation planning or enforcement of regulations that has occurred because of this status. Based upon our review of the information pertaining to threats in Mexico, it is unlikely that protections afforded to the Sonoran desert tortoise are adequate to ensure conservation for the foreseeable future in Mexico. As a result, we conclude that the Sonoran desert tortoise is threatened due the inadequacy of existing regulatory mechanisms, in combination with the other threats identified in this finding, both now and in the foreseeable future.

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

Environmental Contaminants

Many sources of potential contamination presently occur throughout the distribution of the Sonoran desert tortoise. Copper mining in the Sonoran Desert has occurred in Arizona and adjacent Mexico for centuries, and many of these sites have smelters (now decommissioned), which are former sources of airborne contaminants. In Arizona, historical or current large-scale copper mining operations exist in Pima, Pinal, Yavapai, Gila, and Mohave Counties, which are sources of low-level, persistent contaminants in surrounding areas as a result of fugitive dust, contaminated surface runoff, and other mechanisms consistent with contaminant fate and transport. Soil contamination within ephemeral washes from leaching operations associated with mining activities has occurred throughout the Sonoran Desert, and will likely continue to occur where these activities take place. Sonoran desert tortoises that forage in contaminated ephemeral washes may ingest toxic constituents through soil or contaminated plant matter, but we are not aware of any specific reports of tortoises that became sick or deceased from this risk. The mining industry in Mexico is largely concentrated in the northern tier of that country, with Sonora as the leader for generating copper, gold, graphite, molybdenum, and wollastonite, as well as the leader among Mexican States with the most surface area dedicated to mining (Stoleson *et al.* 2005, p. 56). The three largest mines (all copper) are found in Sonora (Stoleson *et al.* 2005, p. 57). The sizes of mines in Sonora vary considerably, as do the known environmental effects from mining-related activities (from exploration to long after closure), which include contamination and drawdown of groundwater aquifers, erosion, acid mine drainage, fugitive dust, pollution from smelter emissions, and landscape clearing (Stoleson *et al.* 2005, p. 57).

Rowe (2008, p. 623) investigated potential effects of persistent, low-level contaminants (*e.g.,* heavy metals, polychlorinated biphenols, organochlorides) on long-lived vertebrates (such as the Sonoran desert tortoise). Cadmium and lead are of special concern due to their toxicity, and because they are persistent, common environmental contaminants (Martínez-López *et al.* 2010, p. 671). Cadmium may affect turtle gonadal development, and lead may affect an individual tortoise's susceptibility to infections and disease, because it may suppress its immune capacity. The latter can potentially affect the spread of known diseases such as herpesvirus, cutaneous dyskeratosis, and URTD within and among affected populations (Martínez-López *et al.* 2010, p. 671). As stated previously, cutaneous dyskeratosis is prevalent within most populations of Sonoran desert tortoise throughout their distribution in Arizona, but this disease has not been determined to currently be a significant threat to Sonoran desert tortoise populations. Another common environmental contaminant is the heavy metal arsenic, which is carcinogenic (cancer-causing) and may also already occur in naturally-high levels in some areas of the American Southwest (Seltzer and Berry 2005, p. 263).

Because the Sonoran desert tortoise is characterized as having a delayed sexual maturation and a long generation time, potential effects from persistent, low-level contaminants in the environment include: (1) Mortality before reproduction, (2) chronic accumulation of contaminants that may be transferred to offspring upon maturation, (3) reduced size at maturity reducing offspring quantity or quality, (4) delayed expression of fitness effects at the population level, and (5) delayed recovery of populations following abatement of fitness effects (Rowe 2008, p. 626). In several areas of the Sonoran Desert in Arizona and Sonora, Mexico, mining operations and other human-related activities can result in remobilization and concentration of elemental toxicants in the air, on the soil surface, and on the surfaces of forage plants, both from ground disturbance and from long-range atmospheric deposition associated with old copper smelter sites, coal-fired power plants, and fugitive dust from abandoned and active mining sites (Seltzer and Berry 2005, p. 263; Rowe 2008, p. 628). The most likely routes for exposure of Sonoran desert tortoises to these types of contaminants are through ingestion of contaminated soil or plant matter, or through inhalation of contaminated dust or particles, especially when a tortoise constructs or modifies a burrow (Seltzer and Berry 2005, p. 263; Hinck *et al.* 2010, p. 287). We have no specific records of Sonoran desert tortoises becoming sick or dying from this type of contamination; effects from these contaminants can be significantly delayed and slow to manifest. Also, few field researchers are sampling wild tortoises to test for contaminant exposure.

Conversion of habitat to large-scale agriculture has been concentrated in Sonora, Mexico, which has provided sources of surface and groundwater pollution such as salt intrusion due to agricultural water use extraction; municipal and agricultural discharges; and solid waste, including cast-off agrochemical containers, winery residues, and hog farm muck (Nauman 2007, p. 1). The extent to which Sonoran desert tortoises drink freely from perennial or intermittent streams is not known, but since tortoises are opportunistic drinkers, we presume they use streams as a source of water in addition to ephemeral pools generated by precipitation events, and that they may subsequently ingest such toxins.

In conclusion and based upon our review of the best available scientific or commercial data, little is known of the potential effect of low-level environmental contamination on Sonoran desert tortoises. We did ascertain that the risk of environmental contaminants affecting Sonoran desert tortoise populations is most likely from the presence of persistent, low-level toxicants such as heavy metals, polychlorinated biphenols, and organochlorides. However, potential effects of this type of environmental contamination are often delayed and difficult to observe in long-lived species such as the Sonoran desert tortoise, largely because of delayed sexual maturation and long generation times. We did not find documentation of population-level effects in Sonoran desert tortoises as a result of environmental contamination. Therefore, we conclude that environmental contamination of Sonoran desert tortoise habitat is not currently threatening populations; however, we acknowledge that further study is warranted to identify whether there is a risk for population-level impacts, and we recommend that land managers consider collecting baseline soil data in areas that may be vulnerable.

Vehicle Strike Mortalities

We expect that the increased use of off-highway vehicles within Sonoran desert tortoise habitat will increase the likelihood of encounters with Sonoran desert tortoises which can result in a variety of potential outcomes for tortoises. According to the Arizona Interagency Desert Tortoise Team (AIDTT 2000, p. 10), "[a]n abundance of anecdotal knowledge indicates that contacts between people and wild tortoises usually end to the detriment of tortoises (*e.g.,* collection, handling, vandalism, crushing under vehicle tires, and shooting)."

Averill-Murray and Swann (2002, p. 1) stated that urban development adjacent to the Saguaro National Park in Pima County threatens the Sonoran desert tortoise via several mechanisms, including elevated mortality on roads. The high rates of speed associated with competitive off-highway vehicle events significantly increase the risk of direct mortality of Sonoran desert tortoises from vehicle collisions (Vega 2010, p. 4).

Reptiles, including the Sonoran desert tortoise, may be particularly vulnerable to roads due to the higher risk of mortality as a result of vehicle strikes (Boarman and Sazaki 1996, p. 1; Boarman *et al.* 1997, p. 57; Forman and Alexander 1998, p. 213; Boarman 2002, pp. 54–55; Boarman and Sazaki 2006, p. 98; Dieringer 2010, p. 1). Anticipated adverse effects of roads on Sonoran desert tortoise populations are likely related to the level of their use. For example, Hoff and Marlow (2002, pp. 451–454) found that the impact of roads on the prevalence of Mojave desert tortoise signs (tracks, scat, etc.) was commensurate with traffic volume—with the impacts more significant adjacent to heavily traveled roads. Mojave desert tortoise populations showed depressed numbers within 1,300 feet (400 m) of highways in the Mojave Desert (Boarman and Sazaki 2006, p. 98). Similar effects to Sonoran desert tortoise populations might be expected when heavily used roads are adjacent to, or are routed through, core Sonoran desert tortoise habitat such as steep, boulder-strewn slopes within Arizona Upland Sonoran desertscrub (Dieringer 2010, p. 1; Grandmaison 2010b, p. 3).

Sonoran desert tortoises move slowly and take a relatively long time to cross roads and highways, which may place them at elevated risk (Andrews *et al.* 2008, p. 124). However, we suspect that, due to their size and shape (particularly in the sub-adult and adult size classes), drivers may instinctively avoid striking a crossing tortoise because of their similarity to rocks, and the subsequent damage that hitting a "rock" could do to a vehicle. However, intentional vehicle strikes of Mojave desert tortoises have been reported (Bury and Marlow 1973, p. 11). While unpaved roads traverse 16 of the 17 Sonoran desert tortoise monitoring plots, the AGFD is only aware of one instance of direct mortality of a Sonoran desert tortoise from a vehicle on a long-term monitoring plot, on the East Bajada Plot (AGFD 2010, p. 14).

Increased vegetation adjacent to paved or heavily compacted roads resulting from increased water runoff may be beneficial to Sonoran desert tortoises, serving as a means to rehydrate them, but it may also attract them to these areas, indirectly increasing the likelihood of adverse interactions from: (1) Tortoises wandering onto the road, (2) vehicles pulling onto the vegetated shoulder of the road and crushing tortoises, (3) injury from grading or mowing activities, (4) exposure to herbicides applied to control growth of weeds along the road shoulder, and (5) increased potential for observation and collection by passers-by (Boarman 2002, p. 55). As stated previously, Sonoran desert tortoises may use infrequently traveled gravel roads as travel routes within their home ranges (Grandmaison *et al.* in press, p. 16). This suggests that low density Sonoran desert tortoise populations observed adjacent to heavily traveled roads may be the result of mortality from vehicle collisions and illegal collection rather than road avoidance behavior (Grandmaison *et al.* in press, p. 16).

There appears to be a concerted effort to mitigate the potential effect of several roads and highways on Sonoran desert tortoise populations and their habitat. Barrier fencing (or tortoise fencing) and culverts along roads and highways are recognized methods employed throughout Arizona to reduce potential mortality through vehicle strikes of Sonoran desert tortoises. Installing tortoise fencing along roads and highways minimizes the risk of road mortality of tortoises but may also enhance the barrier effect between populations by restricting long-distance movements (Boarman and Sazaki 1996, p. 3). Culverts that pass under roads and highways may provide opportunities for Sonoran desert tortoises to safely cross roads and highways (Boarman and Sazaki 1996, pp. 3–4).

The ADOT constructs and maintains roads and highways that comprise Arizona's transportation system. It routinely implements varied conservation and mitigation actions with respect to Sonoran desert tortoise populations that may be affected by these activities. The ADOT (ADOT 2010, pp. 2–5) listed numerous conservation measures including those which address standard (voluntary and involuntary) mitigation measures, education, new construction design, habitat acquisition, native plant restoration, nonnative plant control, establishment of wildlife corridors, and research that have been integrated into their road system planning, construction, and improvement activities. Tortoise-proof fencing adjacent to highways has been installed along numerous routes throughout Arizona including 27.6 mi (44.4 km) along U.S. Highway 93 and 10.8 mi (17.4 km) along State Route 85 (ADOT 2010, p. 3). Numerous, additional structures that assist Sonoran desert tortoises to cross roads safely, such as pathways, ramps, and culverts, have been installed along the U.S. Highway 93 corridor and along a segment of the U.S. Highway 60 through the Tonto National Forest (ADOT 2010, p. 3).

The ability of tortoise fencing to prevent road mortality of Sonoran desert tortoises is highly contingent on inspections and maintenance. Sonoran desert tortoise fencing along 10 mi (16 km) of U.S. Highway 93 in Mohave and

Yavapai Counties in Arizona, between mile markers 144 and 155, was shown to have major deficiencies, including 567 individual fencing breaches and instances of culvert undercutting, which diminish the effectiveness of these mitigation techniques (Grandmaison 2010b, p. 3). Five Sonoran desert tortoise road-mortalities were documented in 2008 in this stretch of highway, though none was documented in 2009 (Grandmaison 2010b, p. 5). A rancher in southeastern Mohave County, Arizona, reported observations of Sonoran desert tortoises being killed on U.S. Highway 93, particularly after heavy rains, when adjacent tortoise barrier fencing along the highway gets washed out, allowing access of tortoises to the highway surface (Dieringer 2010, p. 1). Using radio-telemetry, Grandmaison (2010b, p. 6) found that Sonoran desert tortoises with home ranges within 0.62 mi (1 km) adjacent to this stretch of Highway 93 did not cross the highway. However, additional instances of Sonoran desert tortoise mortality on this and other major routes within the distribution of Sonoran desert tortoises undoubtedly occurs but is rarely reported.

Many activities undertaken by the ADOT minimize the effect of roads and highways on tortoise populations. However, we have concern regarding the lack of ongoing maintenance of protection structures such as tortoise barrier fencing. Therefore, we conclude that maintenance of tortoise protection structures is not adequate to meet the desired objective of these structures in many areas, or to protect Sonoran desert tortoise populations affected by heavily used roads and highways in Arizona.

Balloons and Trash

Helium-filled balloons are capable of dispersing great distances (greater than 164 mi (264 km)) from their release points, and have been shown to make up the largest percentage of litter types encountered in desert tortoise field studies (Walde *et al.* 2007a, p. 148). Desert tortoises are known to eat trash, such as balloons, plastic, and other garbage, which may kill them by becoming lodged in the gastrointestinal tract or by entangling the tortoise (Averill-Murray and Averill-Murray 2002, p. 27; Walde *et al.* 2007a, p. 148). Balloons and balloon string can also entangle the tortoise, sometimes leading to induced amputation of an appendage (Burge 1989, p. 7). Averill-Murray and Averill-Murray (2002, p. 27) reported 36 balloons found on Ironwood Forest National Monument in Pima County, Arizona, indicating that opportunities for a Sonoran desert tortoise to consume, or become entangled with balloons, exist. However, Averill-Murray and Averill-Murray (2002, p. 29) posited that while balloons may affect individuals, they are unlikely to cause population-level impacts to Sonoran desert tortoises.

Illegal dumping in Arizona is ubiquitous throughout the Sonoran Desert, but most concentrated in areas adjacent to human settlements. These relatively small but widely dispersed piles of solid and potentially hazardous waste may also serve as sources of toxicological contamination of Sonoran desert tortoises in areas where ingestion of contaminated soils or plant matter can occur.

In conclusion, balloons and trash occur throughout the range of the desert tortoise. Trash piles are most concentrated adjacent to human settlements but helium-filled balloons can travel many miles away from cities or towns and be deposited in remote habitat as they fall from the sky. We have documented that balloons in particular may pose health risks to Sonoran desert tortoises and are encountered in monitoring plots although specific reports of tortoises directly affected by balloons are rare in the literature. While effects can occur to individual tortoises, the literature did not indicate that population-level effects can be expected from such exposure.

Climate Change

There is unequivocal evidence that the earth's climate is warming based on observations of increases in average global air and ocean temperatures, widespread melting of glaciers and polar ice caps, and rising sea levels (IPCC 2007, p. 4). Furthermore, the Intergovernmental Panel on Climate Change (IPCC 2007, p. 7) summarized the likelihood of general future trends in several climatic variables, predicting: (1) Warmer and fewer cold days and nights over most land areas, (2) warmer and more frequent hot days and nights over most land areas, (3) more frequent warm spells/heat waves over most land areas, (4) changes in precipitation patterns favoring an increased frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) over most areas, and (5) an increase in the area affected by droughts. All of these changes are caused by alterations in the energy balance within the atmosphere and the Earth's surface. The primary factors that affect this balance are concentrations of greenhouse gases (mainly carbon dioxide), aerosols, land surface properties, and solar radiation. These global climate changes will influence climatic patterns at regional and local scales.

At a regional scale, there is a broad consensus among climate models that the area encompassing the southwestern United States and northern Mexico will get drier in the twenty-first century and that the trend towards a more arid climate is already under way (Seager *et al.* 2007). Evidence to support such changes in temperature and rainfall in the southwest deserts is abundant. For example, maximum summer temperatures in the southwestern United States are expected to increase over time in response to changes in the climate system (Christensen *et al.* 2007, p. 887). Weiss and Overpeck (2005, p. 2075) examined low-temperature data over a 40-year timeframe from numerous weather stations in the Sonoran Desert ecoregion of Arizona and California, as well as the Mexican States of Baja California, Baja California Sur, and Sonora. They found: (1) Widespread warming trends in winter and spring, (2) decreased frequency of freezing temperatures, (3) lengthening of the freeze-free season, and (4) increased minimum temperatures per winter year. Such changes are likely to have widespread impacts on Southwestern ecosystems.

While temperatures in the Southwest are predicted to increase, rainfall patterns will also be affected. The current, multi-year drought in the western United States, including most of the Southwest, is the most severe drought recorded since 1900 (Overpeck and Udall, 2010, p. 1642). Numerous models predict a decrease in annual precipitation in the southwestern United States and northern Mexico. Solomon *et al.* (2009, p. 1707) predict precipitation amounts in the southwestern United States and northern Mexico will decrease by as much as 9 to 12 percent (measured as percentage of change in precipitation per degree of warming, relative to 1900 to 1950 as the baseline period). Christensen *et al.* (2007, p. 888) state, "The projection of smaller warming over the Pacific Ocean than over the continent, * * * is likely to induce a decrease in annual precipitation in the southwestern USA and northern Mexico." In addition, Seager *et al.* (2007, pp. 1181–1184) analyzed 19 models of differing variables to estimate the future climate of the southwestern United States and northern Mexico in response to predictions of changing climatic patterns. All but one of the 19 models predicted a drying trend within the southwest (Seager *et al.* 2007, p. 1181). A total of 49 projections were created using the 19 models and all but 3 predicted a shift to increasing aridity (dryness) in the southwest as early as 2021 to 2040 (Seager *et al.* 2007, p. 1181). While most climate change models predict less precipitation in the southwestern United States, a model produced by the Hadley Centre for Climate Prediction and Research (HadCM2) predicted increased precipitation throughout most of the United States, and particularly in the southwest (Weltzin *et al.* 2003, p. 942). While there may be some uncertainty associated with the predictions of decreased rainfall in the arid deserts, there is broad agreement that the overall trend will be reduced precipitation.

In addition to increasing trends in aridity, the timing of precipitation may also be altered as a result of climate change, which would result in important changes in the vegetation community within habitat of the Sonoran desert tortoise. The IPCC (2007, p. 20) found that winter precipitation in the southwestern United States is predicted to decline by as much as 20 percent as a result of climate change, while summer precipitation may increase slightly. Precipitation in Mojave desertscrub occurs predominantly during the cool-season (winter) months but, depending on location, it may also occur during the warm-summer months (Hereford *et al.* 2006, p. 29). Perennial plant species in Mojave desertscrub are most affected by changes in winter precipitation, as increases in winter precipitation increases germination and the establishment of new plants (Hereford *et al.* 2006, p. 25). In contrast, decreases in winter precipitation substantially increase mortality in perennial plants, most notably in short-lived species (Hereford *et al.* 2006, p. 25). In addition, decreasing winter precipitation has been linked with a high mortality of drought-resistant shrubs in parts of the Sonoran and Mojave deserts (McAuliffe and Hamerlynck 2010, p. 885). A reduction in winter precipitation could significantly alter the plant communities of the Sonoran and Mojave deserts.

Arid environments are especially sensitive to climate change, because the plants and animals that inhabit these areas are near their physical tolerances for temperature and water stress. Slight changes in temperature and rainfall, along with increases in the magnitude and frequency of extreme climatic events, can significantly alter species distributions and abundance (Archer and Predick 2008, p. 23). In fact, warming effects may be particularly severe for reptiles and amphibians. For instance, Walther *et al.* (2002, pp. 393–394) found that because of their physiology, reptiles and amphibians are sensitive to climatic changes, which may result in effects to their development, spatial distribution, and interactions with other species. Specifically, egg development, sperm development, and sex ratios may be affected by climatic changes in temperatures. Increased temperatures may influence sex ratios within clutches to favor females over males, which may benefit populations as one male can fertilize several females. However, if temperatures rise too much, the effect could strongly select for female-only clutches, significantly skewing the sex ratio within populations, and posing long-term problems for reptiles such as Sonoran desert tortoise populations (Walther *et al.* 2002, pp. 393–394). But as stated earlier, Sonoran desert tortoises build their nests in burrows underground, thereby tempering the effects of rising surface temperatures.

Sonoran desert tortoises may be affected directly by regional climate change. For example, increasing temperatures may cause desert tortoises to overheat (Ernst and Lovich 2009, p. 544). Sonoran desert tortoises are vulnerable to overheating because they heat up 10 times faster than they can cool down, making them potentially sensitive to temperature extremes associated with anticipated climate change (Ernst and Lovich 2009, p. 544). While climate change may directly affect the Sonoran desert tortoise, most of the impacts of climate change are anticipated to be indirect effects to the tortoise caused by other changes in the ecosystem that supports them. The following discussion describes anticipated indirect effects to the tortoise in response to predicted climate change effects.

Changes in atmospheric carbon dioxide and soil nitrogen levels are anticipated to affect the Sonoran desert tortoise through responses observed in their forage base. The desert ecosystems inhabited by the Sonoran desert tortoise are also expected to be sensitive to increased levels of carbon dioxide in the atmosphere. Desert shrub cover may increase with increasing carbon dioxide, but nonnative species may also respond positively, out-competing native vegetation (Smith *et al.* 2000, p. 79; Loubimsteva and Adams 2004, p. 401), thereby increasing the risk of fire. In addition, water and nitrogen are the biggest constraints that influence biological productivity in desert ecosystems (Ramanujan 2009, p. 1). Predicted higher temperatures are expected to cause higher levels of nitrogen to escape as a gas from desert soils, leading to a decrease in soil fertility (Ramanujan 2009, p. 1). Murphy *et al.* (in prep., p. ii) expect these responses in the vegetation community to adversely affect the quality of forage for Sonoran desert tortoises, leading to dietary nitrogen deficiencies.

Desert tortoises are likely to be affected by decreases in precipitation due to climate change. Rain is the single most important climatic factor that drives desert ecosystems because it ultimately determines recruitment rates, growth and reproduction rates, nutrient cycling, and net ecosystem productivity, resulting in these ecosystems being the most vulnerable to changes in precipitation levels (Weltzin *et al.* 2003, p. 944; Huxman *et al.* 2004, p. 254; Hereford *et al.* 2006, p. 25). Peterson (1996a, p. 1831) highlights the importance of rain for desert tortoises: "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 freestanding water for drinking, which is apparently necessary for achieving a net annual energy profit." Desert tortoises evolved in arid conditions, and possess numerous physiological and behavioral adaptations to survive some degree of drought (Schmidt-Nelson and Bently 1966, p. 911; Peterson 1996b, p. 1325; Christopher 1999, p. 365; Duda *et al.* 1999, p. 1188; AIDTT 2000, p. 4; Berry *et al.* 2002b, pp. 443–446; Dickinson *et al.* 2002, pp. 251–252). Peterson (1996a, p. 1831) found desert tortoises have a very low field metabolic rate when compared to other desert reptiles, which may provide them an advantage in drought conditions. However, a decrease in winter precipitation may disproportionately affect reproductive females because they are highly dependent upon springtime forage. A decrease in winter precipitation is expected to adversely affect the quantity and quality of their forage. This, in turn, is likely to directly affect reproductive output of Sonoran desert tortoise populations (Hereford *et al.* 2006, p. 25). Persistent drought, and subsequent changes in the tortoise forage base, can affect blood chemistry and water metabolism, reduce or eliminate the thymus and fat stores, and result in skeletal muscle and liver atrophy in desert tortoises (Berry *et al.* 2002b, pp. 443–446; Dickinson *et al.* 2002, pp. 251–252).

Seasonal changes in rainfall may contribute to the spread of invasive species, such as Sahara mustard and exotic grasses, which are capable of explosive growth, and able to quickly out-compete native species (Barrows *et al.* 2009, p. 673). As explained in *Factor A,* invasive species displace the native vegetation, reducing forage for tortoises, and increasing the threat of wildfires in desert ecosystems, resulting in further reduction of forage plants for the tortoise.

Droughts, which are likely to be more frequent and severe as a result of climate change, have been suggested to have caused in declines in local Sonoran desert tortoise populations. Periodic times of drought are not uncommon in the Southwest, and tortoises have evolved with drought. However, future drought conditions may be more severe and long-lasting than previously recorded droughts (Cook *et al.* 2004, p. 1016). The effects of drought have been shown to have significant population-level impacts on Mojave desert tortoises, as exhibited by the observed declines in their populations during years of drought-induced reductions in annual plants (Longshore *et al.* 2003, p. 169). As stated previously, Sonoran desert tortoises strongly benefit from the bimodal precipitation pattern characteristic of the Sonoran Desert region, specifically from precipitation received during the summer monsoon. However, the monsoon is characterized by highly-localized rainfall events of short duration and high magnitude, and can be spatially unpredictable. Therefore, while some Sonoran desert tortoise populations may receive satisfactory amounts of summer precipitation, others may be exposed to reduced monsoon precipitation totals, and potentially zero precipitation in a given year. This seems to have been the case during the late 1980s in the Maricopa Mountains near Phoenix, Arizona. The precipitous loss of 226 Sonoran desert tortoises in the Maricopa Mountains plot, which occurred between 1987 and 1990, is believed to have resulted from severe, localized drought, when no measurable rainfall occurred in that area in 1989. This indicates that even Sonoran desert tortoises may succumb to excessive drought conditions (Schwalbe 2010, p. 2). Subsequent surveys have shown that survivorship within this population has improved, and there is evidence that reproduction has resumed in this population. Also, a lack of additional carcasses found on the plot indicates that population declines have stabilized, and the population might be rebounding (AGFD 2010, p. 4). Drought conditions also apparently played a significant role in a decline of new Sonoran desert tortoise captures between 1988 and 1990 in the San Pedro Valley (Meyer *et al.* 2010, p. 11). Localized cases of population declines as a result of drought could be more common in the future, due to decreasing rainfall caused by climate change.

Another way to evaluate the threats to a species is the use of vulnerability assessments. The results of one assessment, conducted by Galbraith and Price (2009, p. ii) concluded that the desert tortoise within the United States was "highly vulnerable" to extinction as a result of climate change. The framework used by Galbraith and Price (2009, pp. 80–82) considered numerous factors including: (1) Current population size and trends, (2) range trends, (3) likely future stressor trends, (4) individual replacement time, (5) likely future vulnerability to stochastic events, (6) future vulnerability to policy/management change, (7) likely future vulnerability to natural stressors, (7) physiological sensitivity to temperature and precipitation change and to extreme weather events, (8) dispersive capability and potential rate of increase, (9) habitat specialization, (10) likely event of future habitat loss due to climate change, (11) ability of habitats to shift in response to climate change, and (12) dependence on temporal inter-relations and other species. They summarized: "Over the last three or four decades, these populations (Mohave and Sonoran) have come under high degrees of stress due largely to human activity (particularly urbanization and recreational intrusion) * * * Climate change may be a significant new stressor, causing even more habitat loss and exacerbating an already difficult situation. Together, existing stressors and the direct and indirect effects of climate change could result in desert tortoises being put at even greater risk of population reduction and extinction in their U.S. range."

Galbraith and Price (2009, pp. 79–80) estimate that at least 20 to 50 percent of habitat today will not be available to desert tortoises by 2020 as a result of climate change and, to a much lesser extent, anticipated development. However, in their analysis, Galbraith and Price (2009, pp. 74–84) largely disregarded the fact that the Sonoran desert tortoise ranges into Mexico (which represents approximately half of its total distribution), which should be factored into their vulnerability analysis. They also often misapplied or gave disproportionate influence to specific research on the Mojave desert tortoise in addressing the desert tortoise in the U.S. as a whole. While we found certain attributes of Galbraith and Price (2009, pp. 74–84) to be accurate, these identified shortcomings provide an incomplete picture of the status of the desert tortoise and its vulnerability to the effects of climate change.

Weiss and Overpeck (2005, p. 2074) disagreed with Galbraith and Price (2009, pp. 74–84). Accelerated increases in temperature projected as a result of climate change will potentially result in changes to the current geographical boundaries of the Sonoran Desert, as well as the distribution of associated plant species (Weiss and Overpeck 2005, p. 2074). Specifically, Weiss and Overpeck (2005, p. 2074) predicted that the current geographic boundary of the Sonoran Desert will contract in its southeast portion and expand in distribution and rise in elevation in the eastern and northern portions, thus potentially expanding areas of suitable habitat for the Sonoran desert tortoise. Weiss and Overpeck (2005, p. 2075) and Galbraith and Price (2009, p. 80) agreed that observed changes to the fire regime of the Sonoran Desert favor nonnative plant species, and may impede the trajectory or degree of potential expansion of the Sonoran Desert.

With the differences in predicted climate change under different scenarios, and the uncertainty of those effects on the tortoise, it is difficult to come to a definitive conclusion as to the potential impacts of climate change on the Sonoran desert tortoise. All, none, or a combination of these predictions may actually be realized in the future within the distribution of the Sonoran desert tortoise, which adds uncertainty to how the tortoise may respond to any given combination of these predictions. For example, warmer average temperatures may affect the Sonoran desert tortoise positively by lengthening annual surface-activity periods which may enhance reproduction potential and survivorship. Increased frequencies in heavy precipitation may provide more opportunities for rehydration of Sonoran desert tortoises and promote the production of forage species, whereby reducing daily foraging periods to both avoid excessive high temperatures and, as a consequence, lessen predation risks. However, higher temperatures coupled with drought conditions could also negatively affect the Sonoran desert tortoise by increasing metabolism rates, foraging needs, and associated foraging time, therefore increasing predation risk. Higher temperatures coupled with drought conditions could also reduce forage availability of plant species that depend on higher frequencies of precipitation events for growth (annual plant species that respond to monsoon storms).

The temporal aspect of anticipated changes in climate and their effects on the Sonoran desert tortoise and its habitat must be considered in context with the rate of evolutionary adaptation of the species. Skelly *et al.* (2007, pp. 1353–1355) examined preferred temperature ranges and thermal maxima, and suggested that some species with short generation times might evolve to meet the demands of a changing climate. The Sonoran desert tortoise has much longer generation times (approximately 12 to 15 years) and may therefore be more vulnerable to the effects of climate change, because they are unlikely to be able to rapidly adapt to environmental changes. Specifically, we do not expect their evolutionary processes to keep pace with the relatively fast-paced changes predicted as a result of climate change in the near- or mid-term.

Perhaps the most important aspect of projected changes in climate is the relative irreversibility of these changes into the future. Solomon *et al.* (2009, p. 1704) state that the effects of climate change will be irreversible for approximately 1,000 years, even if carbon emissions dropped to zero in current times, as a result of the longevity of atmospheric carbon dioxide and feedbacks associated with ocean warming (Solomon *et al.* 2009, p. 1709).

Summary of Factor E

Our review of the best scientific and commercial data available indicated that Sonoran desert tortoises may be vulnerable to the effects of environmental contamination: Ingestion of trash, including balloons; and substances from illegal solid waste dumps. However the literature did not indicate these threats were currently affecting populations and specific reports of affected individual tortoises were rare. Vehicle strike mortalities have been documented, and may have some local sub-population effects in close proximity to more heavily traveled roads and highways, but again, these effects are more localized and not rangewide, and thus do not appear to have overall population-level effects. Further, while management and mitigation actions are being implemented, such as the construction of barrier fences and culverts, these devices are generally not maintained and appear to be ineffective in helping to reduce these individual mortalities.

Climate change may also affect Sonoran desert tortoises. The combined effects of global and regional climate change, along with the effects of long-term drought, will play a role in the long-term persistence of the species. However, we are not able to quantify, with certainty, how the direct and indirect effects of climate change will affect Sonoran desert tortoise populations. Tortoise habitat may shift, native vegetation may change depending on rainfall patterns, increasing temperatures may affect the growth of native vegetation, the quality and quantity of desert tortoise forage may be affected, precipitation patterns will likely affect desert vegetation, and tortoises may experience physiological effects that could result in changes in reproduction and overall survival. We conclude that climate change may be a significant stressor that exacerbates current threats, both directly (physiological effects to the tortoise) and indirectly (habitat loss and fragmentation). As such, climate change, in and of itself, may affect Sonoran desert tortoise populations, but the magnitude of the impacts to the Sonoran desert tortoise remains uncertain. Climate change is not currently a threat to the Sonoran desert tortoise, but it has the potential to be a threat in the foreseeable future. Impacts from climate change in the future will likely exacerbate the current and ongoing threat of habitat loss caused by other factors, as discussed above.

Finding

As required by the Act, we conducted a review of the status of the Sonoran desert tortoise DPS and considered the five factors in assessing whether the DPS is threatened or endangered throughout all or a significant portion of its range. We examined the best scientific and commercial information available regarding the past, present, and future threats faced by the Sonoran desert tortoise. We reviewed the petition, information available in our files, and other available published and unpublished information, and we consulted with species experts, land managers, and numerous stakeholders including Federal, State, and Tribal agencies.

In considering what factors might constitute threats, we must look beyond the mere exposure of the species to the factor to determine whether the species responds to the factor in a way that causes actual impacts to the species. If there is exposure to a factor, but no response, or only a positive response, that factor is not a threat. If there is exposure and the species responds negatively, the factor may be a threat and we then attempt to determine how significant a threat it is. If the threat is significant, it may drive or contribute to the risk of extinction of the species such that the species warrants listing as threatened or endangered as those terms are defined by the Act. This does not necessarily require empirical proof of a threat; however, reasonably strong data-based inferences are the minimum standard for considering a threat significant. The mere identification of factors that could impact a species negatively is not sufficient to compel a finding that listing is appropriate; we require evidence that these factors are operative threats that act on the species to the point that the species meets the definition of threatened or endangered under the Act.

Despite the history of conservation and management efforts afforded the Sonoran desert tortoise in Arizona, our review of the literature identified threats to the Sonoran desert tortoise attributable to all Threat Factors (*A–E*). The primary threats to the Sonoran desert tortoise from habitat modification and destruction (*Factor A*) include the: (1) Current and ongoing invasion of nonnative plant species resulting in an unnatural, destructive wildfire regime in portions of the species' distribution; (2) cumulative, anticipated indirect effects to habitat and individual tortoises from increased human activity tied to urbanization and human population growth; (3) current and anticipated creation of barriers to genetic exchange among populations from urbanization and associated infrastructure; (4) high and growing use and popularity of OHV use in Sonoran desert tortoise habitat; (5) mesquite and ironwood tree harvest in Mexico; (6) improper livestock grazing in Mexico; and (7) undocumented human immigration and interdiction activities. The primary threat to the Sonoran desert tortoise from overutilization for commercial, recreational, scientific, or educational purposes (*Factor B*) is illegal collection. The primary threat to the Sonoran desert tortoise from predation (*Factor C*) is the increase in feral or off-leash domestic dog predation and human depredation associated with anticipated increases in urbanization and human population growth. The Sonoran desert tortoise is also threatened by the inadequacy of regulatory mechanisms (*Factor D*). In our review of the available information, we found numerous examples where the Sonoran desert tortoise is considered in management actions and tortoise-specific mitigation measures are mandated, or where land activities that could appreciably threaten Sonoran desert tortoise populations are prohibited. However, significant threats we have identified in *Factors A, C,* and *E* (primarily invading nonnative plant species and subsequent wildfire concerns, vandalism of tortoises, feral dog predation, and climate change) are not being adequately addressed by land managers or other regulatory mechanisms. The primary threats to the Sonoran desert tortoise from other natural or manmade factors affecting its continued existence (*Factor E*) include the threats from vehicle strike mortality due to unmaintained structures intended to prevent tortoise mortality along heavily traveled routes through core Sonoran desert tortoise populations. In addition, anticipated effects from climate change are likely to exacerbate the ongoing threat of habitat loss and degradation by other factors, but we were unable to conclude that climate change, by itself, currently threatens the Sonoran desert tortoise. We have documented adverse effects of many of these threats on existing Sonoran desert tortoise populations, both historically and currently, and note that many threats act in synergistic combination in their effects to the tortoise. The factors that are the primary drivers of these threats, such as urbanization, human population growth, and drought, are predicted to increase in the foreseeable future.

As a result of the numerous threats to the Sonoran desert tortoise identified above—which have occurred historically, continue today, and are predicted to continue in the foreseeable future—the tortoise has lost appreciable amounts of habitat to the collective footprint of urban development, agriculture, and infrastructure on the landscape. Collectively, these land changes have not only destroyed former Sonoran desert tortoise habitat, but have fragmented remaining populations, threatening long-term genetic fitness of the tortoise and precluding their recolonization ability in the event of population extirpations. In Mexico, significant areas of former Sonoran desert habitat have been significantly altered by the cultivation and natural colonization of invasive, nonnative plant species, and in combination with other threats, have likely greatly affected the viability of the Sonoran desert tortoise in that country.

Available monitoring data are not adequate to accurately determine how the Sonoran desert tortoise historically responded to the loss of habitat or how populations have individually responded to threats, but we are reasonably certain that there are fewer Sonoran desert tortoises currently than historically, and that populations have become significantly fragmented over time. Currently within Arizona, approximately 75 percent of potential Sonoran desert tortoise habitat is within 30 mi (48 km) or less of human populations of 1,000 people or more. The factors that have resulted in the loss or degradation of habitat, or threaten the tortoise directly, are predicted to worsen in the foreseeable future as the footprint of development and infrastructure grows and human population growth ensues. Some populations may disappear altogether, while others become smaller and more contracted; each of these scenarios exacerbates isolation and genetic and demographic exchange. Therefore, we reasonably anticipate that the Sonoran desert tortoise DPS is in danger of extinction in the foreseeable future throughout all or a significant portion of its range.

On the basis of the best scientific and commercial information available, we find that the petitioned action, to list the Sonoran desert tortoise is warranted. In making this finding, we gave significant deference to the irreversible effect of threats as they are anticipated to occur in the foreseeable future. We will make a determination on the status of the species as threatened or endangered when we do a proposed listing determination. However, as explained in more detail below, an immediate proposal of a regulation implementing this action is precluded by higher priority listing actions, and progress is being made to add or remove qualified species from the Lists of Endangered and Threatened Wildlife and Plants.

We reviewed the available information to determine if the existing and foreseeable threats render the species at risk of extinction at this time such that issuing an emergency regulation temporarily listing the DPS under section 4(b)(7) of the Act is warranted. We determined that issuing an emergency regulation temporarily listing the species is not warranted for this species at this time because we have not documented any significant population extirpations. However, if at any time we determine that issuing an emergency regulation temporarily listing the Sonoran desert tortoise is warranted, we will initiate this action at that time.

Listing Priority Number

The Service adopted guidelines on September 21, 1983 (48 FR 43098) to establish a rational system for utilizing available resources for the highest priority species when adding species to the Lists of Endangered and Threatened Wildlife and Plants or reclassifying species listed as threatened to endangered status. These guidelines, titled "Endangered and Threatened Species Listing and Recovery Priority Guidelines" address the immediacy and magnitude of threats, and the level of taxonomic distinctiveness. The system places greatest importance on the immediacy and magnitude of threats, but also factors in the level of taxonomic distinctiveness by assigning priority in descending order to monotypic genera (genus with one species), full species, and subspecies (or equivalently, distinct population segments of vertebrates). As a result of our analysis of the best available scientific and commercial information, we assigned the Sonoran desert tortoise a Listing Priority Number of 6, based on the high magnitude and non-imminence of threats. One or more of the threats discussed above are occurring in virtually every known population throughout its range. These threats are ongoing, and will continue to occur into the foreseeable future and, in some cases (such as nonnative plant species invasions and climate change effects), are considered irreversible. Our rationale for assigning the Sonoran desert tortoise an LPN of 6 is outlined below.

Under the Service's LPN Guidance, the magnitude of threat is the first criterion we look at when establishing a listing priority. The guidance indicates that species with the highest magnitude of threat are those species facing the greatest threats to their continued existence. These species receive the highest listing priority. Threats to the Sonoran desert tortoise vary in their magnitude. We found the most significant threats to the Sonoran desert tortoise to be the expansion of range and increase in number of nonnative plant species, urban development and associated human population growth in Arizona, and the highly popular and growing use of OHVs in Arizona. These threats have both direct and indirect effects to the Sonoran desert tortoise and its habitat. The area of land affected by nonnative species is widespread and, although currently and comparatively less significant in Arizona, it is substantial in Mexico. It is also expected to increase in the foreseeable future in both countries. When including the total land area adversely modified by ironwood and mesquite harvesting, it is projected that an estimated 98 percent of the Sonoran desert tortoises' habitat in Mexico (47 percent of habitat rangewide) will be lost or adversely modified in the foreseeable future. Additionally, there is currently no viable solution to the threat posed by the increase in nonnative plants on this landscape. The projected human population growth and urban development throughout this DPS are likely to both pose significant problems for genetic exchange among Sonoran desert tortoise populations. This will increase the degree and scope of human interactions with tortoises and occupied habitat, which threatens the tortoise in a variety of ways that we discuss in detail above. Currently in Arizona, 75 percent of potentially occupied Sonoran desert tortoise habitat occurs within 30 mi (48 km) or less of a city or town with a human population of 1,000 or more, and, considering future growth projections, it is likely that 100 percent of occupied tortoise habitat will be affected in the future. The ever-expanding human population in Arizona is also likely to lead to commensurate increases in OHV use. As of 2007, 385,000 off-highway vehicles were registered in Arizona (a 350 percent increase since 1998), and 1.7 million people (29 percent of the Arizona's public) engaged in off-road activity from 2005 to 2007. We identified significant threats from OHV use in Sonoran desert tortoise habitat, including habitat destruction, increased illegal collection of tortoises, and significant problems with law enforcement of OHV users. Despite problems associated with OHV management, several land management agencies responsible for Sonoran desert tortoise habitat have plans to expand OHV use on their lands. These three major threats operate in combination with other threats which, by themselves, might not be as serious, but acting together, cause a more serious cumulative impact. These threats include improper livestock management in Mexico, illegal collection and release of tortoises, undocumented human immigration and associated interdiction activities, predation from feral or off-leash dogs, vehicle strike mortality from unmaintained, roadside mitigation devices, and anticipated possible effects from climate change. In their totality, these threats are high in magnitude because of the amount of habitat that is likely to be affected and the irreversible nature of the effect of these threats in sensitive habitats that are slow to rebound.

Under our LPN Guidance, the second criterion we consider in assigning a listing priority is the immediacy of threats. This criterion is intended to ensure that the species that face actual, identifiable threats are given priority over those species for which threats are only potential or that are intrinsically vulnerable but are not known to be presently facing such threats. The threats are non-imminent because they are not ubiquitous throughout the range of the Sonoran desert tortoise where they occur. Some are acting currently in some areas, but not the whole DPS; some threats are likely to expand geographically over time; some are stabilized or even reducing in impact. Although we reviewed and discussed the numerous ways that individual Sonoran desert tortoises are affected by various threats, there is currently no evidence that any existing population is threatened with extirpation in the near future. So while some of the threats are happening now, impacts to tortoise populations are not likely to be evident in the immediate future.

For example, we have documented that the invasion of nonnative plants is most significant in Sonora, Mexico, because of active planting for livestock grazing purposes. However, while there were historic practices of planting nonnative plant species as forage for livestock in the United States, these activities have ceased, leaving only slower, natural mechanisms to facilitate the expansion of nonnative plant species in this country. Thus, comparatively less habitat area is significantly altered by nonnative plant distribution and abundance in Arizona, representing approximately half of the Sonoran desert tortoises' range. Additionally, monitoring data indicate that Sonoran desert tortoise populations persist in habitat that is unburned, but where nonnative species have become established. As stated in Factor A, wildfire is an important trigger, capable of making nonnative-invaded habitat unsuitable for Sonoran desert tortoises. The majority of nonnative-invaded Sonoran desert tortoise habitat remains unburned in the United States; however we are less certain about the occurrence of wildfire in nonnative-invaded habitat in Mexico. In both cases in Arizona and Mexico the ongoing conversion of habitats to nonnative grasses are not expected to impact tortoise populations in the very immediate future. Therefore, the actual impacts on tortoise populations from these and similar threats, such as climate change, are more likely to occur in the mid- to long-term future and are not considered imminent.

Also, many of the threats we discuss above are linked to urbanization and human population growth. In Arizona, we have observed significant development and human population growth over the past several decades, but a weakened economy has slowed growth in recent years. We documented that the Sun Corridor Megapolitan is expected to nearly double the human population of southern and central Arizona by 2030. However, much of the urbanization that has already occurred replaced agricultural land that was not usable Sonoran desert tortoise habitat. Additionally, our evaluation of Sonoran desert tortoise population monitoring data has not indicated that any monitored population has been extirpated and less than one-third of monitored populations have shown declines, indicating that impacts on Sonoran desert tortoise populations are not currently imminent. These actual, identifiable threats are covered in detail under the discussion of *Factors A* through *E* of this finding and currently include habitat destruction, modification, and fragmentation, overutilization, predation from unnatural sources, inadequate regulatory mechanisms, and other natural and manmade factors.

The third criterion in our LPN guidance is intended to devote resources to those species representing highly distinctive or isolated gene pools as reflected by taxonomy. The Sonoran desert tortoise is a valid taxon at the DPS level, and therefore receives a lower priority than species in a monotypic genus. The Sonoran desert tortoise faces high magnitude, non-imminent threats, and is a valid taxon at the DPS level. Thus, in accordance with our LPN guidance, we have assigned the Sonoran desert tortoise an LPN of 6.

We will continue to monitor the threats to the Sonoran desert tortoise, and the species' status on an annual basis, and should the magnitude or the imminence of the threats change, we will revisit our assessment of the LPN.

Work on a proposed listing determination for the Sonoran desert tortoise is precluded by work on higher priority listing actions with absolute statutory, court-ordered, or court-approved deadlines and final listing determinations for those species that were proposed for listing with funds from Fiscal Year 2011. This work includes all the actions listed in the tables below under expeditious progress.

Preclusion and Expeditious Progress

Preclusion is a function of the listing priority of a species in relation to the resources that are available and the cost and relative priority of competing demands for those resources. Thus, in any given fiscal year (FY), multiple factors dictate whether it will be possible to undertake work on a listing proposal regulation or whether promulgation of such a proposal is precluded by higher-priority listing actions.

The resources available for listing actions are determined through the annual Congressional appropriations process. The appropriation for the Listing Program is available to support work involving the following listing actions: Proposed and final listing rules; 90-day and 12-month findings on petitions to add species to the Lists of Endangered and Threatened Wildlife and Plants (Lists) or to change the status of a species from threatened to endangered; annual "resubmitted" petition findings on prior warranted-but-precluded petition findings as required under section 4(b)(3)(C)(i) of the Act; critical habitat petition findings; proposed and final rules designating critical habitat; and litigation-related, administrative, and program-management functions (including preparing and allocating budgets, responding to Congressional and public inquiries, and conducting public outreach regarding listing and critical habitat). The work involved in preparing various listing documents can be extensive and may include, but is not limited to: gathering and assessing the best scientific and commercial data available and conducting analyses used as the basis for our decisions; writing and publishing documents; and obtaining, reviewing, and evaluating public comments and peer review comments on proposed rules and incorporating relevant information into final rules. The number of listing actions that we can undertake in a given year also is influenced by the complexity of those listing actions; that is, more complex actions generally are more costly. The median cost for preparing and publishing a 90-day finding is $39,276; for a 12-month finding, $100,690; for a proposed rule with critical habitat, $345,000; and for a final listing rule with critical habitat, the median cost is $305,000.

We cannot spend more than is appropriated for the Listing Program without violating the Anti-Deficiency Act (see 31 U.S.C. 1341(a)(1)(A)). In addition, in FY 1998 and for each fiscal year since then, Congress has placed a statutory cap on funds which may be expended for the Listing Program, equal to the amount expressly appropriated for that purpose in that fiscal year. This cap was designed to prevent funds appropriated for other functions under the Act (for example, recovery funds for removing species from the Lists), or for other Service programs, from being used for Listing Program actions (see House Report 105–163, 105th Congress, 1st Session, July 1, 1997).

Since FY 2002, the Service's budget has included a critical habitat subcap to ensure that some funds are available for other work in the Listing Program ("The critical habitat designation subcap will ensure that some funding is available to address other listing activities" (House Report No. 107–103, 107th Congress, 1st Session, June 19, 2001)). In FY 2002 and each year until FY 2006, the Service has had to use virtually the entire critical habitat subcap to address court-mandated designations of critical habitat, and consequently none of the critical habitat subcap funds have been available for other listing activities. In some FYs since 2006, we have been able to use some of the critical habitat subcap funds to fund proposed listing determinations for high-priority candidate species. In other FYs, while we were unable to use any of the critical habitat subcap funds to fund proposed listing determinations, we did use some of this money to fund the critical habitat portion of some proposed listing determinations so that the proposed listing determination and proposed critical habitat designation could be combined into one rule, thereby being more efficient in our work. In FY 2011 we anticipate that we will be unable to use any of the critical habitat subcap funds to fund proposed listing determinations.

We make our determinations of preclusion on a nationwide basis to ensure that the species most in need of listing will be addressed first and also because we allocate our listing budget on a nationwide basis. Through the listing cap, the critical habitat subcap, and the amount of funds needed to address court-mandated critical habitat designations, Congress and the courts have, in effect, determined the amount of money available for other listing activities nationwide. Therefore, the funds in the listing cap, other than those needed to address court-mandated critical habitat for already listed species, set the limits on our determinations of preclusion and expeditious progress.

Congress identified the availability of resources as the only basis for deferring the initiation of a rulemaking that is warranted. The Conference Report accompanying P.L. 97–304, which established the current statutory deadlines and the warranted-but-precluded finding, states that the amendments were "not intended to allow the Secretary to delay commencing the rulemaking process for any reason other than that the existence of pending or imminent proposals to list species subject to a greater degree of threat would make allocation of resources to such a petition [that is, for a lower-ranking species] unwise." Although that statement appeared to refer specifically to the "to the maximum extent practicable" limitation on the 90-day deadline for making a "substantial information" finding, that finding is made at the point when the Service is deciding whether or not to commence a status review that will determine the degree of threats facing the species, and therefore the analysis underlying the statement is more relevant to the use of the warranted-but-precluded finding, which is made when the Service has already determined the degree of threats facing the species and is deciding whether or not to commence a rulemaking.

In FY 2010, $10,471,000 is the amount of money that Congress appropriated for the Listing Program (that is, the portion of the Listing Program funding not related to critical habitat designations for species that are already listed). Therefore, a proposed listing is precluded if pending proposals with higher priority will require expenditure of at least $10,471,000, and expeditious progress is the amount of work that can be achieved with $10,471,000. Since court orders requiring critical habitat work will not require use of all of the funds within the critical habitat subcap, we used $1,114,417 of our critical habitat subcap funds in order to work on as many of our required petition findings and listing determinations as possible. This brings the total amount of funds we had for listing actions in FY 2010 to $11,585,417.

The $11,585,417 was used to fund work in the following categories: compliance with court orders and court-approved settlement agreements requiring that petition findings or listing determinations be completed by a specific date; section 4 (of the Act) listing actions with absolute statutory deadlines; essential litigation-related, administrative, and listing program-management functions; and high-priority listing actions for some of our candidate species. For FY 2011, on September 29, 2010, Congress passed a continuing resolution which provides funding at the FY 2010 enacted level. In 2009, the responsibility for listing foreign species under the Act was transferred from the Division of Scientific Authority, International Affairs Program, to the Endangered Species Program. Therefore, starting in FY 2010, we use a portion of our funding to work on the actions described above as they apply to listing actions for foreign species. This has the potential to further reduce funding available for domestic listing actions. Although there are currently no foreign species issues included in our high-priority listing actions at this time, many actions have statutory or court-approved settlement deadlines, thus increasing their priority. The budget allocations for each specific listing action are identified in the Service's FY 2011 Allocation Table (part of our administrative record).

Based on our September 21, 1983, guidance for assigning an LPN for each candidate species (48 FR 43098), we have a significant number of species with an LPN of 2. Using this guidance, we assign each candidate an LPN of 1 to 12, depending on the magnitude of threats (high or moderate to low), immediacy of threats (imminent or nonimminent), and taxonomic status of the species (in order of priority: monotypic genus (a species that is the sole member of a genus); species, or part of a species (subspecies, distinct population segment, or significant portion of the range)). The lower the listing priority number, the higher the listing priority (that is, a species with an LPN of 1 would have the highest listing priority).

Because of the large number of high-priority species, we have further ranked the candidate species with an LPN of 2 by using the following extinction-risk type criteria: International Union for the Conservation of Nature and Natural Resources (IUCN) Red list status/rank, Heritage rank (provided by NatureServe), Heritage threat rank (provided by NatureServe), and species currently with fewer than 50 individuals, or 4 or fewer populations. Those species with the highest IUCN rank (critically endangered), the highest Heritage rank (G1), the highest Heritage threat rank (substantial, imminent threats), and currently with fewer than 50 individuals, or fewer than 4 populations, originally comprised a group of approximately 40 candidate species ("Top 40"). These 40 candidate species have had the highest priority to receive funding to work on a proposed listing determination. As we work on proposed and final listing rules for those 40 candidates, we apply the ranking criteria to the next group of candidates with an LPN of 2 and 3 to determine the next set of highest-priority candidate species. Finally, proposed rules for reclassification of threatened species to endangered are lower priority, since as listed species, they are already afforded the protection of the Act and implementing regulations. However, for efficiency reasons, we may choose to work on a proposed rule to reclassify a species to endangered if we can combine this with work that is subject to a court-determined deadline.

With our workload so much bigger than the amount of funds we have to accomplish it, it is important that we be as efficient as possible in our listing process. Therefore, as we work on proposed rules for the highest priority species in the next several years, we are preparing multi-species proposals when appropriate, and these may include species with lower priority if they overlap geographically or have the same threats as a species with an LPN of 2. In addition, we take into consideration the availability of staff resources when we determine which high-priority species will receive funding to minimize the amount of time and resources required to complete each listing action.

As explained above, a determination that listing is warranted but precluded must also demonstrate that expeditious progress is being made to add and remove qualified species to and from the Lists of Endangered and Threatened Wildlife and Plants. As with our "precluded" finding, the evaluation of whether progress in adding qualified species to the Lists has been expeditious is a function of the resources available for listing and the competing demands for those funds. Although we do not discuss it in detail here, we are also making expeditious progress in removing species from the list under the Recovery program in light of the resource available for delisting, which is funded by a separate line item in the budget of the Endangered Species Program. During FY 2010, we have completed two proposed delisting rules and two final delisting rules. Given the limited resources available for listing, we find that we made expeditious progress in FY 2010 in the Listing Program. This progress included preparing and publishing the following determinations:

FY 2010 AND FY 2011 COMPLETED LISTING ACTIONS

Publication date	Title	Actions	FR pages
10/08/2009	Listing *Lepidium papilliferum* (Slickspot Peppergrass) as a Threatened Species Throughout Its Range.	Final Listing Threatened	74 FR 52013–52064.
10/27/2009	90-day Finding on a Petition To List the American Dipper in the Black Hills of South Dakota as Threatened or Endangered.	Notice of 90-day Petition Finding, Not substantial.	74 FR 55177–55180.
10/28/2009	Status Review of Arctic Grayling (*Thymallus arcticus*) in the Upper Missouri River System.	Notice of Intent to Conduct Status Review for Listing Decision.	74 FR 55524–55525.
11/03/2009	Listing the British Columbia Distinct Population Segment of the Queen Charlotte Goshawk Under the Endangered Species Act: Proposed rule.	Proposed Listing Threatened	74 FR 56757–56770.
11/03/2009	Listing the Salmon-Crested Cockatoo as Threatened Throughout Its Range with Special Rule.	Proposed Listing Threatened	74 FR 56770–56791.
11/23/2009	Status Review of Gunnison sage-grouse (*Centrocercus minimus*)	Notice of Intent to Conduct Status Review for Listing Decision.	74 FR 61100–61102.
12/03/2009	12-Month Finding on a Petition to List the Black-tailed Prairie Dog as Threatened or Endangered.	Notice of 12-month petition finding, Not warranted.	74 FR 63343–63366.
12/03/2009	90-Day Finding on a Petition to List Sprague's Pipit as Threatened or Endangered.	Notice of 90-day Petition Finding, Substantial.	74 FR 63337–63343.
12/15/2009	90-Day Finding on Petitions To List Nine Species of Mussels From Texas as Threatened or Endangered With Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	74 FR 66260–66271.
12/16/2009	Partial 90-Day Finding on a Petition to List 475 Species in the Southwestern United States as Threatened or Endangered With Critical Habitat.	Notice of 90-day Petition Finding, Not substantial and Substantial.	74 FR 66865–66905.
12/17/2009	12-month Finding on a Petition To Change the Final Listing of the Distinct Population Segment of the Canada Lynx To Include New Mexico.	Notice of 12-month petition finding, Warranted but precluded.	74 FR 66937–66950.

FY 2010 AND FY 2011 COMPLETED LISTING ACTIONS—Continued

Publication date	Title	Actions	FR pages
1/05/2010	Listing Foreign Bird Species in Peru and Bolivia as Endangered Throughout Their Range.	Proposed Listing Endangered	75 FR 605–649.
1/05/2010	Listing Six Foreign Birds as Endangered Throughout Their Range	Proposed Listing Endangered	75 FR 286–310.
1/05/2010	Withdrawal of Proposed Rule to List Cook's Petrel	Proposed rule, withdrawal	75 FR 310–316.
1/05/2010	Final Rule to List the Galapagos Petrel and Heinroth's Shearwater as Threatened Throughout Their Ranges.	Final Listing Threatened	75 FR 235–250.
1/20/2010	Initiation of Status Review for *Agave eggersiana* and *Solanum conocarpum*.	Notice of Intent to Conduct Status Review for Listing Decision.	75 FR 3190–3191.
2/09/2010	12-month Finding on a Petition to List the American Pika as Threatened or Endangered.	Notice of 12-month petition finding, Not warranted.	75 FR 6437–6471.
2/25/2010	12-Month Finding on a Petition To List the Sonoran Desert Population of the Bald Eagle as a Threatened or Endangered Distinct Population Segment.	Notice of 12-month petition finding, Not warranted.	75 FR 8601–8621.
2/25/2010	Withdrawal of Proposed Rule To List the Southwestern Washington/Columbia River Distinct Population Segment of Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) as Threatened.	Withdrawal of Proposed Rule to List.	75 FR 8621–8644.
3/18/2010	90-Day Finding on a Petition to List the Berry Cave salamander as Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 13068–13071.
3/23/2010	90-Day Finding on a Petition to List the Southern Hickorynut Mussel (*Obovaria jacksoniana*) as Endangered or Threatened.	Notice of 90-day Petition Finding, Not substantial.	75 FR 13717–13720.
3/23/2010	90-Day Finding on a Petition to List the Striped Newt as Threatened.	Notice of 90-day Petition Finding, Substantial.	75 FR 13720–13726.
3/23/2010	12-Month Findings for Petitions to List the Greater Sage-Grouse (*Centrocercus urophasianus*) as Threatened or Endangered.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 13910–14014.
3/31/2010	12-Month Finding on a Petition to List the Tucson Shovel-Nosed Snake (*Chionactis occipitalis klauberi*) as Threatened or Endangered with Critical Habitat.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 16050–16065.
4/5/2010	90-Day Finding on a Petition To List Thorne's Hairstreak Butterfly as Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 17062–17070.
4/6/2010	12-month Finding on a Petition To List the Mountain Whitefish in the Big Lost River, Idaho, as Endangered or Threatened.	Notice of 12-month petition finding, Not warranted.	75 FR 17352–17363.
4/6/2010	90-Day Finding on a Petition to List a Stonefly (*Isoperla jewetti*) and a Mayfly (*Fallceon eatoni*) as Threatened or Endangered with Critical Habitat.	Notice of 90-day Petition Finding, Not substantial.	75 FR 17363–17367.
4/7/2010	12-Month Finding on a Petition to Reclassify the Delta Smelt From Threatened to Endangered Throughout Its Range.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 17667–17680.
4/13/2010	Determination of Endangered Status for 48 Species on Kauai and Designation of Critical Habitat.	Final Listing Endangered	75 FR 18959–19165.
4/15/2010	Initiation of Status Review of the North American Wolverine in the Contiguous United States.	Notice of Initiation of Status Review for Listing Decision.	75 FR 19591–19592.
4/15/2010	12-Month Finding on a Petition to List the Wyoming Pocket Gopher as Endangered or Threatened with Critical Habitat.	Notice of 12-month petition finding, Not warranted.	75 FR 19592–19607.
4/16/2010	90-Day Finding on a Petition to List a Distinct Population Segment of the Fisher in Its United States Northern Rocky Mountain Range as Endangered or Threatened with Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	75 FR 19925–19935.
4/20/2010	Initiation of Status Review for Sacramento splittail (*Pogonichthys macrolepidotus).*	Notice of Initiation of Status Review for Listing Decision.	75 FR 20547–20548.
4/26/2010	90-Day Finding on a Petition to List the Harlequin Butterfly as Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 21568–21571.
4/27/2010	12-Month Finding on a Petition to List Susan's Purse-making Caddisfly (*Ochrotrichia susanae*) as Threatened or Endangered.	Notice of 12-month petition finding, Not warranted.	75 FR 22012–22025.
4/27/2010	90-day Finding on a Petition to List the Mohave Ground Squirrel as Endangered with Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	75 FR 22063–22070.
5/4/2010	90-Day Finding on a Petition to List Hermes Copper Butterfly as Threatened or Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 23654–23663.
6/1/2010	90-Day Finding on a Petition To List *Castanea pumila* var. *ozarkensis*.	Notice of 90-day Petition Finding, Substantial.	75 FR 30313–30318.
6/1/2010	12-month Finding on a Petition to List the White-tailed Prairie Dog as Endangered or Threatened.	Notice of 12-month petition finding, Not warranted.	75 FR 30338–30363.
6/9/2010	90-Day Finding on a Petition To List van Rossem's Gull-billed Tern as Endangered or Threatened.	Notice of 90-day Petition Finding, Substantial.	75 FR 32728–32734.
6/16/2010	90-Day Finding on Five Petitions to List Seven Species of Hawaiian Yellow-faced Bees as Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 34077–34088.
6/22/2010	12-Month Finding on a Petition to List the Least Chub as Threatened or Endangered.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 35398–35424.
6/23/2010	90-Day Finding on a Petition to List the Honduran Emerald Hummingbird as Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 35746–35751.
6/23/2010	Listing *Ipomopsis polyantha* (Pagosa Skyrocket) as Endangered Throughout Its Range, and Listing *Penstemon debilis* (Parachute Beardtongue) and *Phacelia submutica* (DeBeque Phacelia) as Threatened Throughout Their Range.	Proposed Listing Endangered Proposed Listing Threatened.	75 FR 35721–35746.

FY 2010 AND FY 2011 COMPLETED LISTING ACTIONS—Continued

Publication date	Title	Actions	FR pages
6/24/2010	Listing the Flying Earwig Hawaiian Damselfly and Pacific Hawaiian Damselfly As Endangered Throughout Their Ranges.	Final Listing Endangered	75 FR 35990–36012.
6/24/2010	Listing the Cumberland Darter, Rush Darter, Yellowcheek Darter, Chucky Madtom, and Laurel Dace as Endangered Throughout Their Ranges.	Proposed Listing Endangered	75 FR 36035–36057.
6/29/2010	Listing the Mountain Plover as Threatened	Reinstatement of Proposed Listing Threatened.	75 FR 37353–37358.
7/20/2010	90-Day Finding on a Petition to List *Pinus albicaulis* (Whitebark Pine) as Endangered or Threatened with Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	75 FR 42033–42040.
7/20/2010	12-Month Finding on a Petition to List the Amargosa Toad as Threatened or Endangered.	Notice of 12-month petition finding, Not warranted.	75 FR 42040–42054.
7/20/2010	90-Day Finding on a Petition to List the Giant Palouse Earthworm (*Driloleirus americanus*) as Threatened or Endangered.	Notice of 90-day Petition Finding, Substantial.	75 FR 42059–42066.
7/27/2010	Determination on Listing the Black-Breasted Puffleg as Endangered Throughout its Range; Final Rule.	Final Listing Endangered	75 FR 43844–43853.
7/27/2010	Final Rule to List the Medium Tree-Finch (*Camarhynchus pauper*) as Endangered Throughout Its Range.	Final Listing Endangered	75 FR 43853–43864.
8/3/2010	Determination of Threatened Status for Five Penguin Species	Final Listing Threatened	75 FR 45497–45527.
8/4/2010	90-Day Finding on a Petition To List the Mexican Gray Wolf as an Endangered Subspecies With Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	75 FR 46894–46898.
8/10/2010	90-Day Finding on a Petition to List *Arctostaphylos franciscana* as Endangered with Critical Habitat.	Notice of 90-day Petition Finding, Substantial.	75 FR 48294–48298.
8/17/2010	Listing Three Foreign Bird Species from Latin America and the Caribbean as Endangered Throughout Their Range.	Final Listing Endangered	75 FR 50813–50842.
8/17/2010	90-Day Finding on a Petition to List Brian Head Mountainsnail as Endangered or Threatened with Critical Habitat.	Notice of 90-day Petition Finding, Not substantial.	75 FR 50739–50742.
8/24/2010	90-Day Finding on a Petition to List the Oklahoma Grass Pink Orchid as Endangered or Threatened.	Notice of 90-day Petition Finding, Substantial.	75 FR 51969–51974.
9/1/2010	12-Month Finding on a Petition to List the White-Sided Jackrabbit as Threatened or Endangered.	Notice of 12-month petition finding, Not warranted.	75 FR 53615–53629.
9/8/2010	Proposed Rule To List the Ozark Hellbender Salamander as Endangered.	Proposed Listing Endangered	75 FR 54561–54579.
9/8/2010	Revised 12–Month Finding to List the Upper Missouri River Distinct Population Segment of Arctic Grayling as Endangered or Threatened.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 54707–54753.
9/9/2010	12-Month Finding on a Petition to List the Jemez Mountains Salamander (*Plethodon neomexicanus*) as Endangered or Threatened with Critical Habitat.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 54822–54845.
9/15/2010	12-Month Finding on a Petition to List Sprague's Pipit as Endangered or Threatened Throughout Its Range.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 56028–56050.
9/22/2010	12-Month Finding on a Petition to List *Agave eggersiana* (no common name) as Endangered.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 57720–57734.
9/28/2010	Determination of Endangered Status for the African Penguin	Final Listing Endangered	75 FR 59645–59656.
9/28/2010	Determination for the Gunnison Sage-grouse as a Threatened or Endangered Species.	Notice of 12-month petition finding, Warranted but precluded.	75 FR 59803–59863.
9/30/2010	12-Month Finding on a Petition to List the Pygmy Rabbit as Endangered or Threatened.	Notice of 12-month petition finding, Not warranted.	75 FR 60515–60561.
10/6/2010	Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat.	Proposed Listing Endangered	75 FR 61664–61690.
10/7/2010	12-month Finding on a Petition to list the Sacramento Splittail as Endangered or Threatened.	Notice of 12-month petition finding, Not warranted.	75 FR 62070–62095.

Our expeditious progress also includes work on listing actions that we funded in FY 2010 and FY 2011, but have not yet been completed to date. These actions are listed below. Actions in the top section of the table are being conducted under a deadline set by a court. Actions in the middle section of the table are being conducted to meet statutory timelines, that is, timelines required under the Act. Actions in the bottom section of the table are high-priority listing actions. These actions include work primarily on species with an LPN of 2, and, as discussed above, selection of these species is partially based on available staff resources, and when appropriate, include species with a lower priority if they overlap geographically or have the same threats as the species with the high priority. Including these species together in the same proposed rule results in considerable savings in time and funding compared to preparing separate proposed rules for each of them in the future.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED

Species	Action
Actions Subject to Court Order/Settlement Agreement	
6 Birds from Eurasia	Final listing determination.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED—Continued

Species	Action
Flat-tailed horned lizard	Final listing determination.
Mountain plover [4]	Final listing determination.
6 Birds from Peru	Proposed listing determination.
Pacific walrus	12-month petition finding.
Wolverine	12-month petition finding.
Solanum conocarpum	*12-month petition finding*.
Desert tortoise—Sonoran population	12-month petition finding.
Thorne's Hairstreak butterfly [3]	12-month petition finding.
Hermes copper butterfly [3]	12-month petition finding.
Actions With Statutory Deadlines	
Casey's june beetle	Final listing determination.
Georgia pigtoe, interrupted rocksnail, and rough hornsnail	Final listing determination.
7 Bird species from Brazil	Final listing determination.
Southern rockhopper penguin—Campbell Plateau population	Final listing determination.
5 Bird species from Colombia and Ecuador	Final listing determination.
Queen Charlotte goshawk	Final listing determination.
5 species southeast fish (Cumberland darter, rush darter, yellowcheek darter, chucky madtom, and laurel dace) [4].	Final listing determination.
Altamaha spinymussel	Final listing determination.
Salmon crested cockatoo	Proposed listing determination.
CA golden trout	12-month petition finding.
Black-footed albatross	12-month petition finding.
Mount Charleston blue butterfly	12-month petition finding.
Mojave fringe-toed lizard [1]	12-month petition finding.
Kokanee—Lake Sammamish population [1]	12-month petition finding.
Cactus ferruginous pygmy-owl [1]	12-month petition finding.
Northern leopard frog	12-month petition finding.
Tehachapi slender salamander	12-month petition finding.
Coqui Llanero	12-month petition finding.
Dusky tree vole	12-month petition finding.
3 MT invertebrates (mist forestfly(*Lednia tumana*), *Oreohelix* sp.3, *Oreohelix* sp. 31) from 206 species petition.	12-month petition finding.
5 UT plants (*Astragalus hamiltonii, Eriogonum soredium, Lepidium ostleri, Penstemon flowersii, Trifolium friscanum*) from 206 species petition.	12-month petition finding.
2 CO plants (*Astragalus microcymbus, Astragalus schmolliae*) from 206 species petition	12-month petition finding.
5 WY plants (*Abronia ammophila, Agrostis rossiae, Astragalus proimanthus, Boechere* (*Arabis*) *pusilla, Penstemon gibbensii*) from 206 species petition.	12-month petition finding.
Leatherside chub (from 206 species petition)	12-month petition finding.
Frigid ambersnail (from 206 species petition)	12-month petition finding.
Gopher tortoise—eastern population	12-month petition finding.
Wrights marsh thistle	12-month petition finding.
67 of 475 southwest species	12-month petition finding.
Grand Canyon scorpion (from 475 species petition)	12-month petition finding.
Anacroneuria wipukupa (a stonefly from 475 species petition)	12-month petition finding.
Rattlesnake-master borer moth (from 475 species petition)	12-month petition finding.
3 Texas moths (*Ursia furtiva, Sphingicampa blanchardi, Agapema galbina*) (from 475 species petition)	12-month petition finding.
2 Texas shiners (*Cyprinella* sp., *Cyprinella lepida*) (from 475 species petition)	12-month petition finding.
3 South Arizona plants (*Erigeron piscaticus, Astragalus hypoxylus, Amoreuxia gonzalezii*) (from 475 species petition).	12-month petition finding.
5 Central Texas mussel species (3 from 475 species petition)	12-month petition finding.
14 parrots (foreign species)	12-month petition finding.
Berry Cave salamander [1]	12-month petition finding.
Striped Newt [1]	12-month petition finding.
Fisher—Northern Rocky Mountain Range [1]	12-month petition finding.
Mohave Ground Squirrel [1]	12-month petition finding.
Puerto Rico Harlequin Butterfly	12-month petition finding.
Western gull-billed tern	12-month petition finding.
Ozark chinquapin (*Castanea pumila* var. *ozarkensis*)	12-month petition finding.
HI yellow-faced bees	12-month petition finding.
Giant Palouse earthworm	12-month petition finding.
Whitebark pine	12-month petition finding.
OK grass pink (*Calopogon oklahomensis*) [1]	12-month petition finding.
Southeastern pop snowy plover & wintering pop. of piping plover [1]	90-day petition finding.
Eagle Lake trout [1]	90-day petition finding.
Smooth-billed ani [1]	90-day petition finding.
Bay Springs salamander [1]	90-day petition finding.
32 species of snails and slugs [1]	90-day petition finding.
42 snail species (Nevada & Utah)	90-day petition finding.
Red knot *roselaari* subspecies	90-day petition finding.
Peary caribou	90-day petition finding.

ACTIONS FUNDED IN FY 2010 AND FY 2011 BUT NOT YET COMPLETED—Continued

Species	Action
Plains bison	90-day petition finding.
Spring Mountains checkerspot butterfly	90-day petition finding.
Spring pygmy sunfish	90-day petition finding.
Bay skipper	90-day petition finding.
Unsilvered fritillary	90-day petition finding.
Texas kangaroo rat	90-day petition finding.
Spot-tailed earless lizard	90-day petition finding.
Eastern small-footed bat	90-day petition finding.
Northern long-eared bat	90-day petition finding.
Prairie chub	90-day petition finding.
10 species of Great Basin butterfly	90-day petition finding.
6 sand dune (scarab) beetles	90-day petition finding.
Golden-winged warbler [4]	90-day petition finding.
Sand-verbena moth	90-day petition finding.
404 Southeast species	90-day petition finding.
Franklin's bumble bee [4]	90-day petition finding.
2 Idaho snowflies (straight snowfly & Idaho snowfly) [4]	90-day petition finding.
American eel [4]	90-day petition finding.
Gila monster (Utah population) [4]	90-day petition finding.
Arapahoe snowfly [4]	90-day petition finding.
Leona's little blue [4]	90-day petition finding.
High-Priority Listing Actions [3]	
19 Oahu candidate species [2] (16 plants, 3 damselflies) (15 with LPN = 2, 3 with LPN = 3, 1 with LPN = 9)	Proposed listing.
19 Maui-Nui candidate species [2] (16 plants, 3 tree snails) (14 with LPN = 2, 2 with LPN = 3, 3 with LPN = 8)	Proposed listing.
Dune sagebrush lizard (formerly Sand dune lizard) [3] (LPN = 2)	Proposed listing.
2 Arizona springsnails [2] (*Pyrgulopsis bernadina* (LPN = 2), *Pyrgulopsis trivialis* (LPN = 2))	Proposed listing.
New Mexico springsnail [2] (*Pyrgulopsis chupaderae* (LPN = 2)	Proposed listing.
2 mussels [2] (rayed bean (LPN = 2), snuffbox No LPN)	Proposed listing.
2 mussels [2] (sheepnose (LPN = 2), spectaclecase (LPN = 4),)	Proposed listing.
8 Gulf Coast mussels (southern kidneyshell (LPN = 2), round ebonyshell (LPN = 2), Alabama pearlshell (LPN = 2), southern sandshell (LPN = 5), fuzzy pigtoe (LPN = 5), Choctaw bean (LPN = 5), narrow pigtoe (LPN = 5), and tapered pigtoe (LPN = 11)).	Proposed listing.
Umtanum buckwheat (LPN = 2) [4]	Proposed listing.
Grotto sculpin (LPN = 2) [4]	Proposed listing.
2 Arkansas mussels (Neosho mucket (LPN =2) & Rabbitsfoot (LPN = 9)) [4]	Proposed listing.
Diamond darter (LPN = 2) [4]	Proposed listing.
Gunnison sage-grouse (LPN = 2) [4]	Proposed listing.

[1] Funds for listing actions for these species were provided in previous FYs.
[2] Although funds for these high-priority listing actions were provided in FY 2008 or 2009, due to the complexity of these actions and competing priorities, these actions are still being developed.
[3] Partially funded with FY 2010 funds and FY 2011 funds.
[4] Funded with FY 2010 funds.
[5] Funded with FY 2011 funds.

We have endeavored to make our listing actions as efficient and timely as possible, given the requirements of the relevant law and regulations, and constraints relating to workload and personnel. We are continually considering ways to streamline processes or achieve economies of scale, such as by batching related actions together. Given our limited budget for implementing section 4 of the Act, these actions described above collectively constitute expeditious progress.

The Sonoran desert tortoise will be added to the list of candidate species upon publication of this 12-month finding. We will continue to monitor the status of this DPS as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures.

We intend that any proposed listing determination for the Sonoran desert tortoise will be as accurate as possible. Therefore, we will continue to accept additional information and comments from all concerned governmental agencies, the scientific community, industry, or any other interested party concerning this finding.

References Cited

A complete list of references cited is available on the Internet at *http://www.regulations.gov* and upon request from the Arizona Ecological Services Office (see **ADDRESSES** section).

Author(s)

The primary authors of this notice are the staff members of the Arizona Ecological Services Office.

Authority

The authority for this section is section 4 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: November 23, 2010.

Rowan W. Gould,

Acting Director, Fish and Wildlife Service.

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