18 Threats and Conservation Needs for North American Tortoises

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Since the 1500s, at least ten species of tortoises and freshwater turtles have become extinct (Turtle Conservation Coalition 2011), and many more are critically endangered with extinction. All five extant species of *Gopherus* face serious threats to well-being and continued existence. Threats facing populations at local, regional, and range-wide levels are time-sensitive and have the potential to change rapidly in type and severity.

In this chapter, we summarize the degree of endangerment as assessed internationally through the Red List of Threatened Species, nationally by country, and more locally by state or population segment. We report species by species on threats facing populations and habitat, conservation efforts undertaken by governments and nonprofit organizations, and prospects for the future.

THREATENED AND ENDANGERED RANKINGS INTERNATIONALLY, NATIONALLY, AND BY STATE OR POPULATION SEGMENT IN 2012

IUCN and the Red List of Threatened Species

Government and other agencies assign rankings of rarity and endangerment to plant and animal species at international and national levels and regionally within countries by states. The International Union for Conservation of Nature's (IUCN) Species Programme and Species Survival Commission (www.iucn.org/redlist.org) are the best known. The IUCN assesses conservation status of species, subspecies, varieties, and selected subpopulations on a global scale and publishes the findings online (IUCN 2010). Species are categorized on risk of global extinction as critically endangered, endangered, and vulnerable, as well as extinct or extinct in the wild. As of 2012, only one *Gopherus* species, *G. flavomarginatus,* had been assessed recently (van Dijk and Flores-Villela 2007), and it was assigned a vulnerable rating. *Gopherus agassizii* and *G. polyphemus* also have vulnerable ratings, and *G. berlandieri* is categorized as lower risk / least concern. Reevaluation is overdue, and will need to include the newly described *G. morafkai* (Murphy et al. 2011). All *Gopherus* species are likely to be upgraded. In 2011, a coalition of international and national conservation organizations listed *G. flavomarginatus* among the top 40 tortoises and freshwater turtles at very high risk of extinction globally (Turtle Conservation Coalition 2011).

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2011)

A second international form of protection, CITES (www.cites.org), provides a framework for domestic legislation on import and export of species. Both the United States and Mexico are parties to CITES. Covered species are listed in two appendices. Appendix I (*G. flavomarginatus*) includes species threatened with extinction; trade is permitted only in exceptional circumstances. Appendix II (*G. agassizii, G. polyphemus, G. berlandieri, G. morafkai*) includes species not necessarily threatened with extinction but for which trade must be controlled.

Federal Legislation in the United States and Mexico

All *Gopherus* species described prior to 2011 are protected in whole or in part through federal legislation within the U.S. or Mexico. *Gopherus flavomarginatus* was federally listed as endangered by the U.S under the Endangered Species Act of 1973, as amended, and by Mexico in 2000 under Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (U.S. Dept. of the Interior, Fish and Wildlife Service [USFWS] 1979, SEMARNAT 2000). Listings for *G. polyphemus* and *G. agassizii* have occurred by limited area or population segment, often following years between petitions for listing and final rules. For *G. polyphemus,* populations west of the Tombigbee and Mobile rivers in southwest Alabama, Mississippi, and Louisiana were listed as threatened in 1987, and a recovery plan was approved in 1990, but with no critical habitat designation (USFWS 1987, 1990a). Eastern populations in Alabama, Georgia, Florida, and South Carolina were petitioned for federal listing as threat-

ened in 2006. In July 2011, the USFWS determined that listing was warranted but precluded by higher priority actions (USFWS 2011a). Federal listing protects *G. polyphemus* from both direct and incidental take, which includes destroying tortoise burrows.

For *G. agassizii,* the first population listed as threatened in 1980 was the historic site described by Woodbury and Hardy (1948) on the Beaver Dam Slope of Utah (USFWS 1980). Four years later, a petition was submitted to list populations within the U.S. as threatened; the USFWS determined that federal listing was warranted but precluded because of other, higher priorities (USFWS 1985). In 1990, the Mojave population, defined as occurring west and north of the Colorado River in California, Nevada, Utah, and Arizona in both the Mojave and western Sonoran Deserts, was finally listed as threatened (USFWS 1990b). Critical habitat designations and a recovery plan for the Mojave population were published in 1994 (USFWS 1994a, 1994b). A revised recovery plan was published in 2011 (USFWS 2011b). The desert tortoise population in Mexico was listed as threatened in 1994 (SEMARNAT 1994). In 2010, after receiving a petition to list the Sonoran population of desert tortoise as threatened, the USFWS published a finding of warranted but precluded by other, higher priorities (USFWS 2010a); this finding does not include the Sinaloan population segment. To complicate the situation further, populations occurring east and south of the Colorado River were described as a new species, *G. morafkai,* in 2011, and thus Sonoran and Sinaloan population segments were subsumed under the new species (Murphy et al. 2011). *Gopherus berlandieri,* although not federally listed in the U.S., was listed as threatened by Mexico in 2002 (SEMARNAT 2002).

Protections Provided by State Laws and Regulations

State laws and regulations provide some protection for *G. polyphemus, G. agassizii, G. morafkai,* and *G. berlandieri* within the U.S. These laws or regulations, available on the World Wide Web by state for U.S. tortoise populations, are designed to protect wild populations and to manage captive tortoises. They cover such topics as harm, collecting, possession, registration, propagation, imports and exports, and adoption of captives, but are inconsistent from one state to another for the same species. The primary gap in regulatory protections is the protection of habitat on private land even where a species is federally listed.

THREATS TO WELL-BEING OF SPECIES AND POPULATIONS

The type and severity of threats vary by species and population segment, land ownership or land administrator, and whether habitat has been designated critical habitat (tables 18.1–18.4). Some general patterns exist across species (high mortality rates among adults and/or juveniles, habitat loss and deterioration, inadequate regulations and/or enforcement of existing regulations to protect the species and habitats), but specifics vary. We ranked threats as high, medium, or low as of 2012 (tables 18.1–18.4). Many anthropogenic activities have cumulative and synergistic effects that increase the severity of an activity or combinations of activities on tortoises and their habitats (USFWS 2010a, 2010b, 2011b; Leu et al. 2008). Urban and exurban development, for example, not only results in habitat loss but also in deterioration of adjacent lands from associated infrastructures, dumping of trash, recreational activities, invasion and establishment of exotic plants, predation by subsidized predators (dogs, ravens, coyotes, raccoons, opossums), increased fires, collecting, and vandalism. The most pressing issue for all five species is sufficient protection of viable and representative populations and habitat.

The species with the fewest identified threats, *Gopherus flavomarginatus,* has the smallest geographic range, is remote from major urban areas, and the least studied. Populations are reported to be in a precarious situation (Traphagen et al. 2007; M Traphagen, personal communication; E Goode, personal communication). The greatest threats are lack of recovery or management plans and protected habitats. The species has no advocate, government agency, or nongovernment organization (NGO) actively monitoring and reporting on status of populations and habitat. Other high- to moderate-level threats are from government resettlement programs of agriculturists in ejidos; subsequent clearing of habitat for plantings of corn, cactus, and other crops; deterioration of habitat from livestock grazing; fragmentation of habitat from roads and railroads; and loss of individual tortoises from road kills and take by humans (Aguirre et al. 1997, Trevino et al. 1997, Traphagen et al. 2007, van Dijk and Flores-Villela 2007).

Two themes predominate in threats to *G. polyphemus:* human predation and habitat loss (table 18.1). Human predation throughout most of the 20th century caused significant population declines or extirpation in southern Alabama, southwestern Georgia, and the Panhandle and northern peninsula of Florida (Auffenberg and Franz 1982, Mushinsky et al. 2006). Habitat loss remains the greatest range-wide threat (Enge et al. 2006, Florida Fish and Wildlife Commission [FWC] 2007, USFWS 2009a). For example, in Florida, since the 1960s, an estimated 50 to 80% population decline was inferred from habitat reduction caused by urbanization (residential and commercial development, roads, infrastructure), agriculture (row crops and citrus groves), and phosphate mining (FWC 2001a, 2006; Mushinsky et al. 2006). An estimated 690,000 ha of former habitat is now classified as urban, representing a 15.7% loss (FWC 2006). In Florida and elsewhere, populations are also threatened by habitat loss, degradation, fragmentation, and modification caused by common agricultural and silvicultural practices and lack of management (i.e., prescribed fire, essential for maintaining habitat quality). The potential threat of mycoplasmal upper respiratory tract disease (URTD) to wild populations has been debated extensively in recent years. Although the disease can cause mortality of individual tortoises, little is known of population-level effects and the contribution to overall population declines, however

Table 18.1 Threats to *Gopherus polyphemus*, with estimated level of importance

Threats	Threat Level	References
Direct mortality		
Illegal collection and human predation	Medium	Taylor 1982b; Berish 2001; Enge et al. 2006; Mushinsky et al. 2006; FWC 2007; USFWS 2009a; Aresco, pers. obs.; D. Johnson, FWC Law Enforcement
Gassing of burrows (rattlesnake roundups)	Low	Speake and Mount 1973; Smith et al. 2006
Disease		
upper respiratory tract disease	Medium	Smith et al. 1998; Brown et al 2002; Seigel et al. 2003; McCoy et al. 2005; Mushinsky et al. 2006; Smith et al. 2006; Berish et al. 2010
herpesvirus, ranavirus, iridovirus	Unknown	FWC 2007
Pesticides/herbicides	Unknown	Lohoefener and Lohmeier 1984; Diemer 1986
Subsidized predators		
birds	Low	FWC 2007
dogs	Medium	Causey and Cude 1978; Hawkins and Burke 1989
coyotes	Medium	Mushinsky et al. 2006; Aresco et al. 2010
imported fire ants	Medium	Epperson and Heise 2003; Smith et al. 2006; FWC 2007
Vehicle kills	High	Landers and Buckner 1981; Diemer 1987; Enge et al. 2006; Mushinsky et al. 2006; Aresco, pers. obs.
Illegal relocations	High	Ashton and Ashton 2008
Permitted translocations, improperly conducted	High	Burke 1989b; Berish 2001; Mushinsky et al. 2006; Ashton and Ashton 2008
Entombment under incidental take permits issued before August 2007 (Florida only)	High	FWC 2001b; Fleshler 2005; FWC 2007
Entombment from unpermitted land clearing and development activities	High	Diemer 1989; Aresco pers. obs.
Habitat		
Habitat loss		
urbanization, human population growth, new roads, infrastructure	Very High	Auffenberg and Franz 1982; Diemer 1986; McCoy et al 2002; Enge et al. 2006; FWC 2001a, 2006, 2007; Mushinsky et al. 2006; Smith et al. 2006; USFWS 2009a
rural, exurban	High	Enge et al. 2006; Mushinsky et al. 2006
agriculture	High	Hermann et al 2002; Mushinsky et al. 2006
phosphate mining, sand and clay extraction	High	Diemer 1986; Mushinsky et al. 2006
Habitat modification, conversion, alteration, fragmentation		
silviculture	High	Landers and Buckner 1981; Lohoefener and Lohmeier 1981; Auffenberg and Franz 1982; Kautz 1998; Aresco and Guyer 1999a, b; Conner and Hartsell 2002; Hermann et al. 2002; USFWS 2009a
agriculture	High	Hermann et al. 2002; Mushinsky et al. 2006
fire exclusion / lack of habitat management	High	Landers and Speake 1980; McCoy and Mushinsky 1992b; Mushinsky and McCoy 1994; Aresco and Guyer 1999a; Enge et al. 2006; McCoy et al. 2006
livestock grazing	Low	Auffenberg and Franz 1982; Diemer 1986
invasive exotic plants	Medium	Cogongrass, *Imperata cylindrica* (Shilling et al. 1997; Mushinsky et al. 2006; Smith et al. 2006; FWC 2007)
Adequacy of population and habitat management by government agencies	Varies by state, low to high	Mushinsky et al. 2006; Smith et al. 2006; USFWS 2009a; FWC 2011

(Mushinsky et al. 2006, USFWS 2009a). Mycoplasmal URTD may be a chronic disease with high morbidity but low mortality (Berish et al. 2010).

Gopherus agassizii, despite 22 years of federal protection as a threatened species (USFWS 1990b) and designation of 13 critical habitats (USFWS 1994b), has not recovered. Numerous threats contribute to the status, and severity varies by region (table 18:2). High on the list of threats are rapidly growing human populations, cities and towns, exurban areas and associated infrastructures, all of which result in new habitat loss and deterioration and high mortality rates (USFWS 1994a, 2010b). Within critical habitats, the density of highways and paved roads averages 0.5 km/km^2 (range = 0.14–1.14; USFWS 2010b); few roads have exclusion fencing to protect tortoises from road kills. Utility and transportation corridors affect 8 to 20% of eight critical habitats (USFWS 2010b). Most critical habitats have deteriorated from decades of livestock grazing, and from 33 to 95% of seven critical habitats are still grazed. Unauthorized off-highway (OHV) recreation and military-related activities are major concerns in several critical habitats (U.S. District Court 2009, 2011). Invasive alien plants (*Schismus* spp., *Bromus* spp., and *Brassica tournefortii*) have altered the food supply for tortoises in many areas (e.g., Oftedal 2002, Brooks and Berry 2006). The alien plants are primary

Table 18.2 Estimated level of threats to *Gopherus agassizii* in 13 critical habitats and other noncritical habitats (inclusive of the "Mojave" population occurring north and west of the Colorado River)

Threats	Threat Level	References
Direct Mortality		
Illegal collection and release of captive or exotic tortoises	Medium in Mojave Desert, potentially lower in Colorado Desert	Johnson et al. 2006; summary of releases in Murphy et al. 2007; Berry et al. 2008
Vandalism	Low to Medium, depending on area	Berry 1986b; Berry et al. 2006a, 2008
Disease	High	Jacobson et al. 2009
upper respiratory tract disease	High	Jacobson et al. 1991, 1995; Brown et al. 1999a; Christopher et al. 2003; Jacobson and Berry 2012
herpesvirus	Present but little information on prevalence	Christopher et al. 2003; Johnson et al. 2006; Jacobson et al. 2012
shell disease	Medium to high in Colorado Desert, eastern Mojave Desert, CA	Jacobson et al. 1994; Christopher et al. 2003; Berry et al. 2006a
Subsidized predators	High	Especially high near urban and exurban areas and, for coyotes, also during drought (Fedriani et al. 2001; Esque et al. 2010b)
avian	High	Boarman 1993; Boarman and Berry 1995; Kristan and Boarman 2003
dogs	High	Lenth et al. 2008; Young et al. 2011
coyotes	High	Esque et al. 2010b
Vehicle kills	Low to high, depending on critical habitat and presence of exclusion fencing	USFWS 1994a, 2010b; Von Seckendorff Hoff and Marlow 2002; Boarman and Sazaki 2006
Translocation	High	See text
Habitat		
Habitat loss		
human population growth, urbanization, and infrastructure	High	USFWS 1994a, 2010b; Berry et al. 2006b; Esque et al. 2010b
rural, exurban	Medium	USFWS 1994a, 2010b
agriculture	New direct losses are low in terms of km^2	USFWS 1994a, 2010b; impacts include subsidies for predators, invasive species, and fugitive dust
military maneuvers	High in CA; low elsewhere	Esque et al. 2005; Berry et al. 2006a; USFWS 2010b; 13–26% of 3 critical habitats are in military installations
solar energy	High	USFWS 2010b; L. LaPré pers. comm.
Habitat fragmentation, creation of barriers	High	
paved roads, canals, railroads, power lines, utility corridors	High; most roads have no exclusion fencing to protect tortoises	Boarman and Sazaki 2006; Brooks and Lair 2009; USFWS 2010b
unpaved roads	Low to medium	See above
routes, trails	High	Routes and trails from OHVs, often unauthorized USFWS 1994a, 2010b; USDC 2009, 2011
Habitat modification, conversion, deterioration	Medium to high	
ranching, livestock grazing	Medium to Low, depending on area	Brooks et al. 2006; USFWS 2010b
mining	Low to medium	Chaffee and Berry 2006
recreation	From low to high depending on region; high in the Mojave Desert, CA	Jennings 1997; Bury and Luckenbach 2002; Berry et al. 2008; Brooks 2009; USFWS 2010b. Unauthorized vehicle use is high in several critical habitats (USDC 2009, 2011).
invasive plants	High	Brooks and Pyke 2001; Oftedal 2002; Brooks and Berry 2006; Brooks 2009; USFWS 2010b
fire	UT, AZ, and NV: very high; CA: medium	Brooks and Esque 2002; Brooks and Matchett 2006; Brooks and Minnich 2006; McLuckie et al. 2007; USFWS 2010b
Other factors		
climate change and drought	Ongoing and future threat	Henen et al. 1998; Berry et al. 2002b; Duda et al. 1999; Seager et al. 2007; Hunter 2007; IPCC 2007; McLachlan et al. 2007; Esque et al. 2010b
contaminants	Low now, higher later in more arid conditions	Jacobson et al. 1991; Seltzer and Berry 2005; Chaffee and Berry 2006; Rowe 2008
Adequacy of population and habitat management by government agencies	High	
human immigration and interdiction	Low	Locally, impacts from border patrol and immigrants have been observed in Chuckwalla critical habitat

drivers for wildfires that severely damaged from 13 to 26% of three critical habitats between 2005 and 2010 (Brooks and Matchett 2006, McLuckie et al. 2007, USFWS 2010b). Solar energy development, a new threat, will consume substantial habitat bordering critical and other protected habitats, will cause further losses with new transmission corridors, and degrade habitats in natural areas, parks, and wilderness (Desert Renewable Energy Conservation Plan, Independent Science Panel 2012; LaPré 2010). Sources of direct mortality to the tortoises include subsidized predators (coyotes, ravens, and dogs), vehicle kills on and off paved highways, illegal collections, and translocations. Diseases, particularly URTD caused by *Mycoplasma agassizii,* and the shell disease cutaneous dyskeratosis have contributed to declines of some populations (Jacobson et al. 1991, 1994; Brown et al. 1999a; Christopher et al. 2003).

Populations of *G. morafkai* in the U.S. face threats similar to those of *G. agassizii:* habitat loss, conversion, fragmentation, and deterioration (table 18.3). Although many positive actions have been taken (USFWS 2010a), deficiencies remain for controlling invasive nonnative plant species, wildfires, vandalism, dog predation, OHV use, releases of captive tortoises and exotic species, military use, and management to counter climate change. The nonnative and invasive buffelgrass (*Pennisetum ciliare*), which disrupts Sonoran ecosystems and contributes to wildfires, is an increasing threat (USFWS 2010a). Threats to *G. morafkai* in Mexico are even more severe. Existing laws to protect tortoises and habitat are not enforced, e.g., an estimated 22% of Sonoran habitat is planted to buffelgrass with an estimated 98% likely to be adversely modified in the near future (Stoleson et al. 2005, USFWS 2010a).

Historically, populations of *G. berlandieri* were impacted by intensive brush clearing that converted natural thornscrub-grassland habitat to agricultural or range land (table 18.4). More recently, establishment of the exotic buffelgrass has contributed to habitat deterioration. Droughts and wildfires have caused significant losses to some tortoise population and habitat, e.g., the tortoise population on the Chaparral Wildlife Management Area (WMA) declined by ~95% following drought and a catastrophic wildfire fueled by buffelgrass in 2008, and the population on Las Palomas WMA declined by >90% from the combined effects of prolonged drought and intense heat (Kazmaier et al. 2012; R Kazmaier, personal communication). Fracking and mineral extraction are important new threats, because mineral rights are not owned by the government on state and federal "protected" lands (R Kazmaier, personal communication). The fracking zone affects nearly 50% of the species' range in Texas with the heaviest impacts in the interior Rio Grande Plains, an area formerly considered secure (R. Kazmaier, personal communication). New roads, increased vehicle traffic, and habitat fragmentation are associated with fracking. The combined threats of fracking, climate change (extreme drought and fires), and the spread of exotic grasses may result in catastrophic declines of this species.

For *Gopherus* species living in arid habitats, climate warming is a threat (Intergovernmental Panel on Climate Change [IPCC] 2007, Seager et al. 2007, McAuliffe and Hamerlynck 2010). Droughts affect almost every aspect of the well-being and activities of *G. agassizii* (e.g., Henen et al. 1998, Christopher et al. 1999, Duda et al. 1999, Berry et al. 2002b, Esque et al. 2010b). Drought has been implicated in deaths of *G. berlandieri* in Texas (Kazmaier et al. 2012). More frequent and prolonged droughts are likely to lead to drying and desertification of habitats, local extinctions, and further fragmentation of remaining populations. Some populations may require rescue and translocation to more mesic sites (Hunter 2007, McLachlan et al. 2007).

CONSERVATION EFFORTS

The Importance of Legal Status as Threatened and Endangered Species

In most cases, actions to protect the *Gopherus* species at international, national (federal), state, and local levels have come slowly and have been insufficient to stem population declines, habitat loss, fragmentation, and deterioration. As of 2012, no federally or state-listed population or species merits de-listing or can be treated as "recovered."

Legal status, especially as a federally threatened or endangered species, has provided some measure of protection. The federal endangered status of *G. flavomarginatus* contributed to the establishment of the Mapimí Biosphere Reserve in Mexico (Comisión Nacional de Áreas Naturales Protegidas 2006); however, development of land has continued to occur in the species' habitat inside Reserve boundaries, and status of populations and habitat within the Rancho Sombretillo are unknown (Traphagen et al. 2007; M. Traphagen, personal communication). Within the U.S., federal listings often require years, and then may only occur after scientists or NGOs petition the USFWS, threaten court action, or take the USFWS to court. The next phases of protection for a federally listed species within the U.S. are designation of critical habitat, preparation of a recovery plan, and implementation of the recovery plan. Of the five species of *Gopherus,* only two, *G. polyphemus* and *G. agassizii,* are federally listed; one, *G. morafkai,* has designated critical habitat. Only *G. agassizii* and western populations of *G. polyphemus* have signed recovery plans (USFWS 1990a, 1994a, 2011b). Many recommendations described in each of these recovery plans have not been implemented. For example, soon after the federal listing of *G. polyphemus* in 1990, federal and state agencies prepared several new land-use plans or revised existing plans, a process essential for changing directions in uses on federal and private land (Berry 1997, USFWS 2010b). That process required 10 to 15 years. In 2011, another new land-use planning process for the species was initiated to speed development of renewable energy on federal lands (Desert Renewable Energy Conservation Plan Independent Science Panel 2012).

In the U.S., *G. morafkai* benefitted from the federal listing of the closely related *G. agassizii* in 1990 (USFWS 1990b). As a preemptive measure, government agencies formed the Arizona Interagency Desert Tortoise Team (AIDTT), and developed a management plan for the Sonoran Desert

Table 18.3. Threats experienced by *Gopherus morafkai* (Sonoran and Sinaloan populations in U.S. and Mexico), with estimated level of importance

Threats	Threat Level	References
Direct Mortality		
Collection for pets or release of captive or exotic tortoises	AZ, MX: medium	AZ: Jarchow et al. 2002; Edwards et al. 2010; Grandmaison and Frary 2012; C. Jones pers. comm. MX: Bury et al. 2002; M. Vaughn pers. comm.
Collection for food	MX: medium (Sonora) to high (Sinaloa)	MX: Bury et al. 2002, M. Vaughn pers. comm.
Vandalism	Probably medium	AZ and MX: documented, associated with proximity to human populations, illegal immigration, food (USFWS 2010a; Bury et al. 2002)
Disease	Probably low in 2011	MX: a risk if captives are released; disease documented on coast at Punta Tepopa (M. Vaughn pers. comm.)
upper respiratory tract disease	Probably low	AZ: Jones 2008; Edwards et al. 2010; USFWS 2010a MX: Dickinson et al. 2005
herpesvirus	Unknown	
shell disease	Probably low	
Predators		
birds	Low to none	USFWS 2010a
dogs	Medium	AZ and MX: USFWS 2010a
Vehicle strikes	Medium	USFWS 2010a; M. Vaughn pers. comm.
Habitat		
Habitat loss	High currently and in the near future	
urbanization, human population growth, and infrastructure	High	AZ: USFWS 2010a MX: Bury et al. 2002; M. Vaughn pers. comm.
rural, exurban	AZ: high in the future because of close proximity to human populations	AZ: USFWS 2010a MX: Bury et al. 2002
agriculture	Very high to high	AZ: USFWS 2010a MX: Bury et al. 2002; USFWS 2010a; Stoleson et al. 2005; planting for food crops or illegal drug crops also high
solar energy	Regionally a threat to specific populations	AZ: proposed project in Black Mountains affects 0.05% of habitat
Habitat fragmentation, creation of barriers	High	AZ: Sun Corridor "Megapolitan"
paved roads, canals, railroads, power lines		AZ: Boarman and Sazaki 2006; Andrews et al. 2008; USFWS 2010a MX: P. Rosen pers. comm.
unpaved roads		Grandmaison and Frary 2012
routes, trails (OHV)	High	USFWS 2010a
Habitat modification, conversion, deterioration	High currently and in the near future	
ranching, livestock grazing	AZ: low MX: high due to ineffective management and continued overgrazing	AZ: Oftedal 2002; Brooks et al. 2006; Grandmaison et al. 2010 MX: designation of 2 mil ha of Sonoran Desert habitat to grasslands for livestock production, loss of 20% of tortoise habitat; stocking rates at 2 to 5 times recommended rates
ironwood and mesquite tree harvest	MX: high	MX: loss of 4% and 2% of Sonoran Desert habitat to mesquite clearing and ironwood harvest (Suzan et al. 1999; USFWS 2010a; P. Rosen pers. comm.)
mining and gas exploration	MX: high AZ: also see contaminants	MX: M. Vaughn pers. comm.
recreation	AZ: high	AZ: OHV use an increasing threat (USFWS 2010a; Brooks and Lair 2009; Grandmaison et al. 2010) (see also collecting)
invasive plants	Very high, most severe threat to mod, curtailment of habitat & range (FWS 2010b)	Summary in USFWS 2010a; Brooks 2009; Bury et al. 2002; Esque et al. 2002, 2003; Thomas and Guertin 2007; Stevens and Fehmi 2009
fire	High potential, coupled with invasion and establishment of invasive species (above)	USFWS 2010a: Bury et al. 2002; Esque et al. 2002; Brooks and Matchett 2006; Brooks and Minnich 2006
Other factors		
climate change and drought	Potential threat in the near future in concert with other factors (USFWS 2010b)	AZ: IPCC 2007; Seager et al 2007; McAuliffe and Hamerlynck 2010 MX: high (P. Rosen pers. comm.); drought probably responsible for die-off of tortoises on Tiburon Island and coast of Sonora (M. Vaughn pers. comm.)
contaminants	Potential threat but not documented	AZ: USFWS 2010a; Seltzer and Berry 2005
Adequacy of population and habitat management by government agencies	High	
human immigration and interdiction	AZ: impacts limited, but severe locally	USFWS 2010a

Table 18.4 Threats experienced by *Gopherus berlandieri*, with estimated level of importance

Threats	Threat Level	References and Personal Communications
Direct Mortality		
Collecting	Medium	For pets: Auffenberg and Weaver 1969; Luckenbach 1982; Judd and Rose 2000. For food: Rose and Judd 1982; Judd and Rose 2000. MX: tourist market curios: Judd and Rose 2000
Release of captive tortoises	Probably medium	Fujii and Forstner 2010; R. Kazmaier pers. comm.
Vandalism	Probably medium	Ernst and Barbour 1972; Judd and Rose 2000
Disease	Probably medium	
upper respiratory tract disease	Probably medium	Documented in captives, Judd and Rose 2000; and in wild tortoises, Lower Rio Grande Valley R. Kazmaier pers. comm.
herpesvirus	Unknown	
shell disease	Low	High incidence but apparently not fatal (Judd and Rose 2000)
Predators		
birds	Low	Rose et al. 2011; R. Kazmaier pers. comm. (Crested caracaras)
dogs	Probably medium	Rose et al 2011
other subsidized predators	Probably medium	Judd and Rose 2000; Rose et al. 2011; raccoons, skunks, opossums, coyotes
introduced fire ants	Probably medium	Eggs and hatchlings, Judd and Rose 2000
wood rats	Medium	Auffenberg and Weaver 1969; Judd and Rose 2000
Texas indigo snakes	Low	R. Kazmaier pers. comm.
Vehicle strikes	High	Bury and Smith 1986, Judd and Rose 2000, Engeman et al. 2004
Habitat		
Habitat loss	High currently and in the near future	
urbanization, human population growth, residential development and infrastructure	High	Rose and Judd 1982; Judd and Rose 2000, especially lower Rio Grande Valley
rural, exurban	High	Judd and Rose 2000
agriculture	High	Rose and Judd 1982; Judd and Rose 2000; Kazmaier 2000; Kazmaier et al. 2001a
Habitat fragmentation, creation of barriers	High	
agriculture	High	Rose and Judd 1982; Judd and Rose 2000; Kazmaier et al. 2002
paved roads	High	Fujii and Forstner 2010
unpaved roads	High	Engeman et al. 2004
one-lane tracks	High	Engeman et al. 2004
Habitat modification, conversion, deterioration	High currently and in the near future	
large-scale clearing of native thornscrub habitat by chaining, chopping, herbicide	High	Historically caused very high mortality (Judd and Rose 2000) and currently continues to create unsuitable habitat (Kazmaier et al. 2001a)
livestock grazing	TX: low to high depending on grazing intensity MX: high due to ineffective management and continued overgrazing	Auffenberg and Weaver 1969; Kazmaier 2000; Kazmaier et al. 2001b
mineral development / fracking	Very high within the Eagle Ford Shale region	R. Kazmaier pers. comm.
recreation	Unknown	
invasive plants	High	MX and TX: large areas now dominated by exotic grasses, particularly buffelgrass (Judd and Rose 2000; R. Kazmaier pers. comm.)
wildfire	Low naturally; high when coupled with invasion and establishment of invasive grasses and drought	Bury and Smith 1986; R. Kazmaier pers. comm.
Other factors		
climate change and drought	High, particularly in concert with other factors	Drought: Rose and Judd 1982; Rose et al. 2011
woven wire fencing	High	Engeman et al. 2004; Judd and Rose 2000
Adequacy of population and habitat management by government agencies	High	Existing government measures to protect populations and habitat are inadequate and enforcement is weak (Judd and Rose 2000)

population within the state (AIDTT 1996, Arizona Game and Fish Department 2011). In Mexico, *G. morafkai* and *G. berlandieri* received protection on paper from take, import, and export, but enforcement and protection of habitat have not been priorities.

Protected Lands, Reserves, Refuges, and Natural Areas for the *Gopherus* Species

Habitats and populations may be protected or partially protected in wilderness, national parks and monuments, national wildlife refuges, national forests, military reservations, areas of critical environmental concern, reserves, preserves, and natural areas. Few sites have been designated specifically to protect and conserve a *Gopherus* species, or the species may receive benefits from being on land designated for other purposes. Highly desirable are substantial blocks of land that support viable and undisturbed populations, are interconnected, and that taken as a whole, preserve genetic, morphologic, physiologic, and ecological diversity. In many cases, the existing protected areas are insufficient to support viable populations and have anthropogenic activities that threaten the integrity within or adjacent to the boundaries. Further, many habitats on protected lands are fragments that support few animals, for example, *G. flavomarginatus, G. polyphemus,* and *G. berlandieri*. In recent years, some sites have been established for release of captives or translocated tortoises. Some examples illustrate these points. *Gopherus polyphemus* occurs within numerous national forests, military reservations, state wildlife management areas, state protected areas, and mitigation parks; few of these sites support viable populations. *Gopherus agassizii,* which has >28,000 km² of critical habitat in 13 blocks, as well as a Research Natural Area and habitat within four National Park Service holdings, is a case in point. Critical habitat designation has not ensured protection: the loss of 303.5 km² of critical habitat and displacement of ~1000 animals for expansion of the Ft. Irwin military installation in the central Mojave Desert is just one of many examples (USFWS 2010b). Although a recovery plan was published in 1994 (USFWS 1994a), implementation of measures to facilitate recovery has been slow. Deterioration of critical habitat is ongoing from wildfires, livestock grazing, and unauthorized OHV use (e.g., USFWS 2010b). The Mapimí Biosphere Reserve for *G. flavomarginatus* provides another, similar example: biologists observed that land was being cleared for agriculture (Traphagen et al. 2007), cattle grazing is causing habitat deterioration, and tortoises are depleted from take for food in rural areas (Traphagen et al. 2007; M Traphagen, personal communication; E Goode, personal communication).

The presence of a federally- or state-listed species on federal or state lands alone does not ensure protection. For example, within the U.S., 85% of populations and habitat for *G. morafkai* occur on federal and state lands. The federal lands, where 60% of habitat occurs, are on public lands managed by the Bureau of Land Management, three national forests, three Department of Defense facilities, four National Park Service properties, and six National Wildlife Refuges (Jeff Servoss, personal communication). An additional 25% of habitat exists on Arizona State lands, 10% on Indian Tribal lands, and 5% in private holdings. In spite of the high percentage of habitat on government lands, *G. morafkai* still qualifies for threatened status (USFWS 2010a). The objectives for managing the federal and state lands are frequently incompatible with maintaining viable populations of this chelonian. In Mexico, where an estimated 50% of the geographic range of *G. morafkai* occurs, no protected habitats have been established (USFWS 2010a), and data are unavailable on demographic attributes of the tortoises and amounts and condition of habitat.

Most *G. berlandieri* populations occur on private land where they are only protected by state regulations. The only populations in the U.S. on federally protected lands occur on the southeast coast of Texas on three national wildlife refuges (Laguna Atascosa, Lower Rio Grande Valley, and Padre Island National Seashore). Three Texas wildlife management areas (WMA)—Chaparral, James E. Daughtrey, and The Las Palomas—also provide protection; two of these, Chaparral and Las Palomas, have sustained ≥90% losses to populations and habitat from recent fires and drought.

Mitigation Measures

For the *Gopherus* species designated as threatened within the U.S. (*G. polyphemus* and *G. agassizii*), numerous conservation actions have been taken to minimize or mitigate loss of tortoises and habitat to development (e.g., see USFWS 2010b). Among the actions are land acquisition, tortoise exclusion fencing of highways and roads to reduce vehicle strikes and collecting, acquisition of grazing allotments and privileges, support of research projects, and translocation of tortoises. The concepts of mitigation and compensation for threatened and endangered species are relatively new and in transitional phases.

Gopherus polyphemus provides examples of mitigation measures typical for other members of the genus and a lesson that mitigation measures rarely compensate fully for losses to populations and habitat. Mitigation banks that preserve sandhill habitat and serve as translocation sites for tortoises moved from highway and public works projects and development sites have been established. Mitigations have changed since the early 1990s. From 1991 to 2007, developers had three options for dealing with tortoises: on-site relocation, off-site relocation, or an incidental take permit that allowed entombment of tortoises (FWC 2001b). Incidental take permits required developers to pay habitat mitigation fees that were used to purchase habitat elsewhere, but resulted in the loss of an estimated >100,000 tortoises and a net loss of 75–85% tortoise habitat (Fleshler 2005, Mushinsky et al. 2006). In contrast, the new FWC tortoise management plan clearly states that the conservation goal is to restore and maintain secure viable populations in Florida by addressing habitat loss, specifically by increasing the amount of protected habitat (increase total protected habitat to 7912 km² by 2022), managing habitat on public lands, restocking tortoise where densities are low on protected lands (60,000 tortoises by 2022), and decreasing tor-

toise mortality on development sites by ending incidental take permits and requiring translocation (180,000 tortoises by 2022 to protected, managed sites) (FWC 2007, 2011). Severe budget constraints and cuts have prevented Florida from attaining its annual land acquisition goals, however; funding for the Florida Forever land buying program was terminated in 2011 by the Florida Legislature with no new public lands added in 2009–2010 (FWC 2011). Furthermore, mitigation is not required for land conversion to agriculture or silviculture because agricultural interests are exempt from these regulations under the Florida Endangered Species Act. This exemption creates a regulatory loophole whereby converted lands can then be sold for development and tortoises legally removed prior to permits normally required for development activities (Mushinsky et al. 2006). Despite the best plans and intentions of regulatory agencies for *G. polyphemus,* significant challenges exist to achieving conservation goals: a lack of acquisition and management funds and low priority for such funding by most lawmakers.

The Role of Nongovernmental Organizations (NGOs)

Since the 1970s, NGOs and nonprofit organizations have been a driving force in protection, conservation, education, and research for *Gopherus* species. The World Wildlife Fund-U.S. and the Turtle Recovery Program financially support research on *G. flavomarginatus* (Aguirre et al. 1997), and members of the Turtle Conservancy, Behler Chelonian Center, have made efforts to acquire key parcels of habitat in recent years (E. Goode, personal communication). The Desert Tortoise Council in the Southwest and Gopher Tortoise Council in the Southeast are two focused nonprofit corporations dedicated to conservation, education, and preserving representative populations of *G. agassizii, G. morafkai,* and *G. polyphemus* throughout their respective geographic ranges (see www.deserttortoise.org, www.gophertortoisecouncil.org). The Desert Tortoise Council has also supported research and education for *G. flavomarginatus* and *G. berlandieri.* The Gopher Tortoise Conservation Initiative (GTCI) founded by Ray and Patricia Ashton is another focused nonprofit organization with similar objectives for *G. polyphemus* in Florida (www.ashtonbiodiversity.org/gtci.php). The GTCI (along with the Humane Society of the United States, Defenders of Wildlife, and other groups) was instrumental in securing a FWC policy change that ended the issuance of incidental take permits allowing entombment of *G. polyphemus* in 2007. In recent years, Southeastern Partners in Amphibian and Reptile Conservation, a consortium of government agencies, organizations, corporations, private individuals, and academic institutions, has also promoted *G. polyphemus* conservation and habitat management (Bailey et al. 2006).

Numerous NGOs have petitioned for federal listings of *G. polyphemus* and the desert tortoises. Save Our Big Scrub, Inc., and Wild South, two nonprofit environmental organizations, were the petitioners for Federal listing of *G. polyphemus* in the eastern part of its range in 2006. NGOs have lobbied Congress for funds to acquire land, litigated in court to gain protection, and to implement recovery actions for the two desert tortoise species, e.g., the Natural Resources Defense Council, Defenders of Wildlife, California Turtle and Tortoise Club, Center for Biological Diversity, WildEarth Guardians, Western Watersheds Council, and Public Employees for Environmental Responsibility.

On behalf of *G. agassizii,* government agencies and NGOs have acquired private inholdings in critical habitat, Natural Areas and other protected lands; they have also worked together and separately to acquire and retire livestock allotments in critical habitat and to erect vehicle and livestock exclusion fencing to protect tortoises and habitat. The Desert Tortoise Preserve Committee, a nonprofit corporation, is one such NGO with multipurposes: land acquisition and mitigation, preserve management and habitat restoration, and education (www.tortoise-tracks.org). This group has worked with the U.S. Department of the Interior's Bureau of Land Management and California Department of Fish and Wildlife to establish the Desert Tortoise Research Natural Area and other protected lands in California and to acquire a livestock allotment in critical habitat. The Wildlands Conservancy also acquires lands for protection of natural resources.

Neither *G. flavomarginatus* nor *G. berlandieri* has the broad-based support system of advocates and watchdogs enjoyed by the other three species of *Gopherus.* Traphagen (personal communication) noted that the greatest threat to *G. flavomarginatus* was lack of strong advocates within Mexico. Judd and Rose (2000) cited a lack of public awareness of the protected status of *G. berlandieri* and the need for public education as vital to conservation.

Headstarting Programs

Two species, *G. flavomarginatus* and *G. agassizii,* have had or currently have head starting programs. The first in situ head starting program for *G. flavomarginatus* was established at Instituto de Ecologia at Mapimí Biosphere Reserve, Mexico, to learn more about life history attributes and to enhance recruitment into local populations (Aguirre et al. 1997, Morafka et al. 1997). The program subsequently was abandoned. Ariel Appleton maintained an ex situ program for captive individuals at the Appleton Research Ranch, Arizona, for >20 years (Appleton 1978). Subsequently, the Appleton tortoises were transferred to the Living Desert Zoo and Gardens State Park and a ranch managed by the Turner Endangered Species Fund (TESF) in New Mexico (Truett and Phillips 2009). The TESF initiated a new head starting program with an objective of determining whether the species can persist in the wild in New Mexico (Truett and Phillips 2009).

The first head starting program for *G. agassizii,* initiated in 1990 for the Department of the Army, was designed to obtain information about life history attributes and survivorship of juveniles (Morafka et al. 1997). Three similar programs, with additional objectives, were established in 2002 by Edwards Air Force Base, in 2006 by the U.S. Marine Corps, and in 2011 by the Mojave National Preserve (Nagy et al. 2011; Buhlmann et al. 2013; B Henen, personal communication).

Vital rate studies of desert tortoises indicate that head-starting programs may have low relative value in recovery actions compared with eliminating threats to breeding females (Reed et al. 2009).

Translocation

Gopherus species have been moved from one place to another for decades and for numerous reasons. Captives have been released and wild tortoises have been moved short and long distances; some releases and translocations have been authorized by government agencies whereas others have not (see Murphy et al. 2007 for a summary for *G. agassizii*). Few releases and translocations have been studied, and most studies were conducted for only a few years—insufficient to determine long-term success (Berry 1986a, Field et al. 2007, Nussear et al. 2012). Translocation is a controversial technique because of valid concerns over negative effects on resident populations, potential spread of disease, genetic mixing, predation, moving tortoises to unprotected or unmanaged sites, and poor site fidelity (Burke 1989b, Dodd and Seigel 1991, Berish 2001, Mushinsky et al. 2006, Martel et al. 2009). Early releases often failed because of a lack of understanding and knowledge of the proper techniques required for success and, in some cases, tortoises were simply dumped on a tract of land with no follow-up monitoring or concern for fates of the tortoises. Translocation also can be time-consuming and costly when done correctly (Mushinsky et al. 2006, Ashton and Ashton 2008). Recent translocation studies of *G. polyphemus* have shown that soft release methods using long-duration enclosures (6–12 months duration) combined with frequent monitoring, attention to forage conditions, and habitat management significantly increase site fidelity and greatly improve the probability of augmenting or reestablishing populations (Tuberville et al. 2005, 2008, 2011; Ashton and Ashton 2008; Aresco et al. 2010).

Translocation of tortoises from lands that will be destroyed by development or committed to other activities has become an important tool for minimizing losses of individuals, especially for *G. agassizii* and *G. polyphemus*. The protocols for these two species differ, depend on legal protections and regulations in the states where they occur, and the outcomes may differ considerably because of behaviors and habitat types. For *G. polyphemus*, regulatory agencies that prohibit incidental take on private lands (e.g., USFWS where species are federally listed and FWC in Florida) attempt to prevent mortality by requiring translocation of all individuals on a development site to protected, managed land (USFWS: Conservation Banks; FWC: Recipient Sites) where tortoises were either extirpated or at unnaturally low densities (FWC 2009, USFWS 2009b).

For *G. agassizii* translocation projects, the types of mitigation and compensation required can be site-specific and may depend on whether habitat is designated critical habitat, federally managed or privately owned. Testing for URTD caused by *Mycoplasma agassizii* and *M. testudineum*, as well as herpesviruses may be required (USFWS 2011c), and may depend on such circumstances as size of the project and location (USFWS 2011c). No long-term studies have been undertaken on settling and survival of translocated individuals, although short-term studies have been published (e.g., Field et al. 2007, Nussear et al. 2012). Preliminary results of a multiyear translocation project in the central Mojave Desert have not been promising because of high death rates (e.g., Berry et al. 2011).

CONCLUSIONS

With the exception of the newly described *Gopherus morafkai*, the *Gopherus* species are protected in whole or in part by international, federal, and state regulations. Unfortunately, designation of a species as threatened, endangered, or fully protected by government agencies has not resulted in the regulations and enforcement essential to protecting individuals, populations, and habitats. General patterns for all species include high mortality rates among adults and/or juveniles, deterioration and fragmentation of habitat, and habitat loss. The list of threats to each species is numerous and continuing to grow. The status of all species can be considered as declining, with *G. flavomarginatus* at greatest risk. The most pressing issue for all *Gopherus* species is sufficient protection of viable and representative populations and habitat. Species with strong support from advocacy groups and NGOs are likely to fare better than those species without such support.

We anticipate that the threats to populations and habitats, described herein as of 2012, are likely to increase in scope and severity with the growing human populations and increasing socioeconomic pressures for use and development of land. Government agencies are making efforts to minimize and mitigate the negative impacts to federally listed species within the U.S. through such measures as land acquisition, establishment of protected areas, restoration of disturbed lands, limits on livestock grazing, highway exclusion fencing, head starting programs, and translocations of displaced wild and captive tortoises. Some measures are more effective than others. Restoration or natural recovery of disturbed habitats in the Southwest, for example, is likely to require centuries, if not longer, especially with climate change (e.g., Abella et al. 2010). Translocation and head starting of tortoises have yet to be demonstrated as effective tools to augment and enhance depleted populations for the genus, at least for *Gopherus agassizii*, on a long-term basis. In the meantime, we continue to observe declines in populations and losses to habitats. We encourage all concerned NGOs and government agencies to engage in vigorous efforts to tackle the complex and difficult problems facing this taxonomic group.

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