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Gopherus agassizii, Mojave Desert Tortoise

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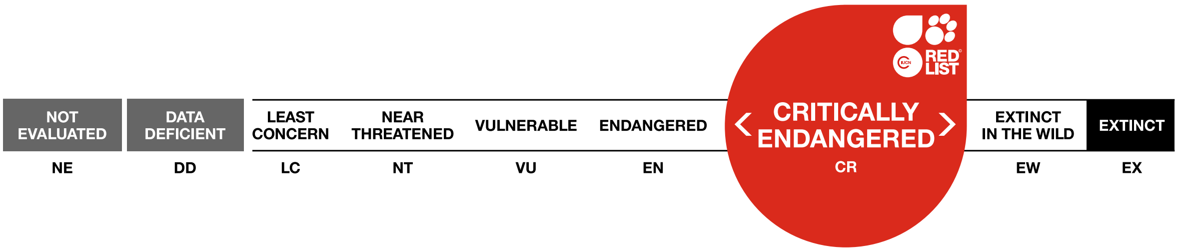

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Taxonomy

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Reptilia	Testudines	Testudinidae

Scientific Name: *Gopherus agassizii* (Cooper, 1861)

Synonym(s):

- *Xerobates agassizii* Cooper, 1861
- *Xerobates lepidocephalus* Ottley & Velázquez-Solis, 1989

Common Name(s):

- English: Mojave Desert Tortoise, Agassiz's Desert Tortoise
- French: Gophère d'Agassiz, Tortue d'Agassiz
- Spanish; Castilian: Tortuga del Desierto

Taxonomic Source(s):

TTWG (Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Bour, R. Fritz, U., Georges, A., Shaffer, H.B. and van Dijk, P.P.). 2017. Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (8th Ed.). In: Rhodin, A.G.J., Iverson, J.B., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Pritchard, P.C.H., and Mittermeier, R.A. (eds), *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*, pp. 1-292. Chelonian Research Monographs.

Taxonomic Notes:

The Desert Tortoise was previously considered to be a single wide-ranging species, *Gopherus agassizii* (*sensu lato*), inhabiting the Mojave and Sonoran Desert regions of the southwestern USA and northwestern Mexico (Iverson 1992). The species was eventually found to be polytypic, and Murphy *et al*. (2011) split out the morphologically and genetically distinct Sonoran Desert subpopulations as *Gopherus morafkai,* the Sonoran Desert Tortoise. Further analysis demonstrated that *G. morafkai* was also polytypic and therefore split further to separate and describe the Sinaloan Thornscrub Tortoise further to the south as *G. evgoodei* (Edwards *et al*. 2016). This taxonomy of three species of desert tortoises has been accepted by TTWG (2017) and Berry and Murphy (2019).

Assessment Information

Red List Category & Criteria: Critically Endangered A2abce+4abce ver 3.1

Year Published: 2021

Date Assessed: October 1, 2020

Justification:

A provisional Red List Assessment of the widespread Desert Tortoise, *Gopherus agassizii* (*sensu lato*), was performed at a Desert Tortoise Council workshop in 2010 and updated by the IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG) in 2011, at which time the Mojave Desert subpopulation, now considered *G. agassizii* (*sensu stricto*) following taxonomic analysis and splitting into three separate species (*G. agassizii, G. morafkai,* and *G. evgoodei*), was assessed as Critically Endangered A2bce+A4bce based on population reduction (decreasing density), habit loss of over 80% over three generations (90 years), including past reductions and predicted future declines, as well as the effects of disease (upper respiratory tract disease / mycoplasmosis). *Gopherus agassizii* (*sensu stricto*) comprises tortoises in the most well-studied 30% of the larger range; this portion of the original range has seen the most human impacts and is where the largest past population losses had been documented. A recent rigorous range-wide population reassessment of *G. agassizii* (*sensu stricto*) has demonstrated continued adult population and density declines of about 90% over three generations (two in the past and one ongoing) in four of the five *G. agassizii* recovery units and inadequate recruitment with decreasing percentages of juveniles in all five recovery units. As such, we reaffirm the prior assessment of the taxonomically restricted Mojave Desert Tortoise, *G. agassizii*, as Critically Endangered, and add criterion "a" for direct population observations: CR A2abce+A4abce. The previously defined widespread species *G. agassizii* (*sensu lato*) was last assessed as Vulnerable on the IUCN Red List in 1996; a separate assessment currently in progress by the TFTSG for the Sonoran Desert Tortoise, *G. morafkai* (previously considered part of *G. agassizii*) has provisionally assessed that species as Vulnerable.

Geographic Range

Range Description:

The Desert Tortoise was previously considered to be a single wide-ranging species, *Gopherus agassizii*, inhabiting the Mojave and Sonoran Desert regions of the southwestern United States and northwestern Mexico from southern California and Arizona through Sonora and into northern Sinaloa (Stebbins 1966, 2003; Iverson 1992). The species was found to be polytypic by Murphy *et al*. (2011), who split the morphologically and genetically distinct Sonoran Desert populations as *Gopherus morafkai*, the Sonoran Desert Tortoise. Further analysis demonstrated that *G. morafkai* was also polytypic and split further to separate and describe the Sinaloan Thornscrub Tortoise further to the south as *Gopherus evgoodei* (Edwards *et al*. 2016).

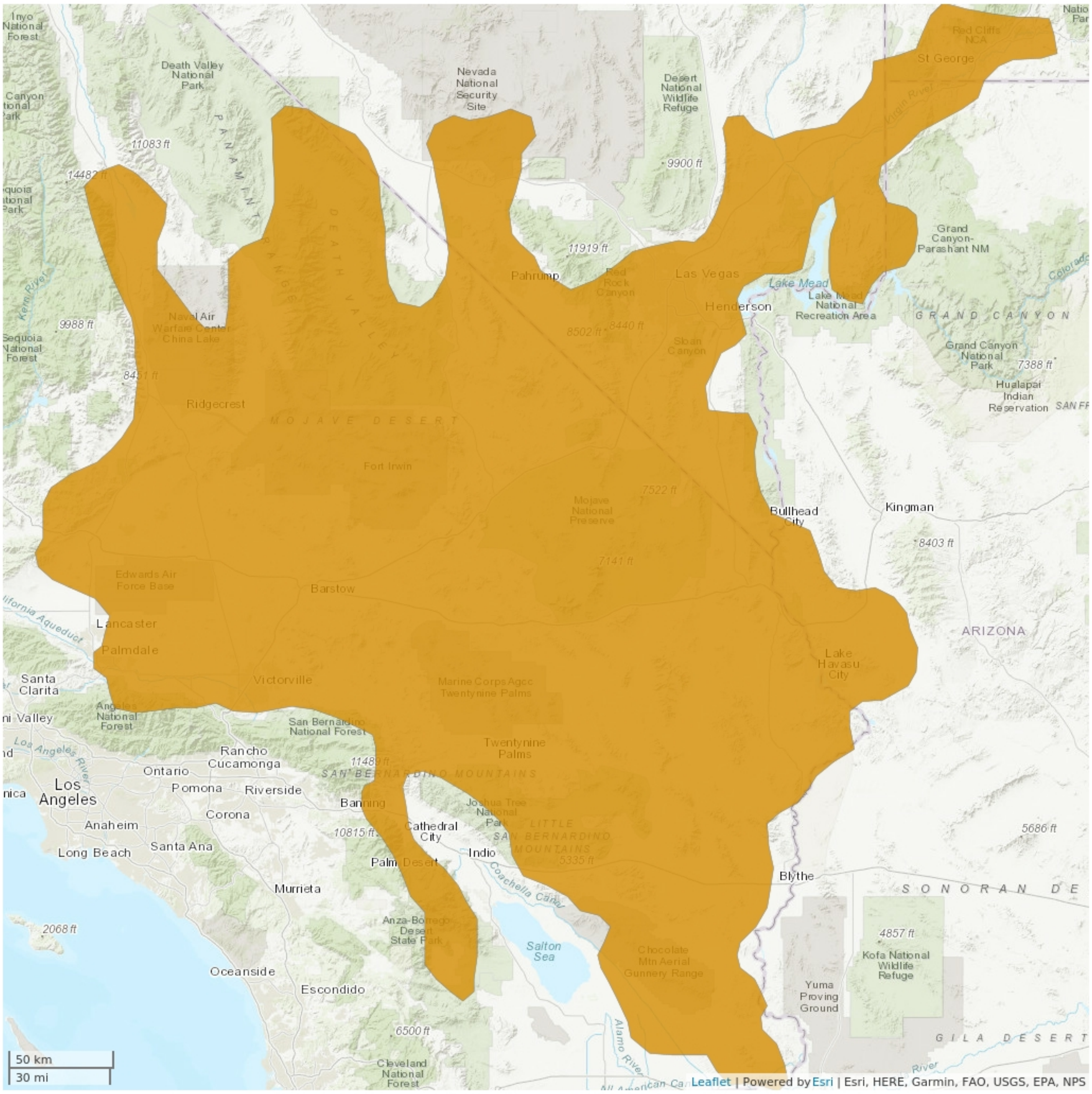
Geographically restricted *G. agassizii*, the Mojave or Agassiz's Desert Tortoise, is endemic to the United States, inhabiting southeastern California, southern Nevada, southwestern Utah, and extreme northwestern Arizona west and north of the Colorado River (TTWG 2017, Berry and Murphy 2019). The Sonoran Desert Tortoise, *G. morafkai*, occurs in both the United States and Mexico, inhabiting Arizona south and east of the Colorado River, Sonora (including Isla Tiburón), and extreme northern Sinaloa (Murphy *et al.* 2011, TTWG 2017). The Sinaloan Thornscrub Tortoise, *G. evgoodei*, is endemic to Mexico and occurs in southern Sonora, northern Sinaloa, and extreme southwestern Chihuahua (Edwards *et al.* 2016, TTWG 2017).

Within its geographic range, *G. agassizii* occurs in the Mojave Desert, the western Sonoran or Colorado Desert, the ecotone of the Mojave with the Great Basin Desert, and ecotones with vegetation types typical of higher elevations on the lower slopes of the Sierra Nevada, Transverse, Peninsular and desert mountain ranges (USFWS 1994). McLuckie *et al*. (1999) identified a subpopulation of *G. agassizii* east of the Colorado River in the Black Mountains of northwestern Arizona in which morphometric and mtDNA characteristics of the majority of the subpopulation were typically Mojavean; however, elements typical of tortoises in the Sonoran Desert were also evident. Edwards *et al.* (2015), using new genetic techniques, examined this and other nearby tortoise subpopulations, and identified hybrids (F2) in three mountain ranges near the Colorado River in Arizona. The two *Gopherus* species come in contact in limited places where Mojave Desert habitats meet Sonoran Desert habitats. The two species likely maintain largely independent taxonomic identities due to ecological niche partitioning (Inman *et al*. 2019). The species has been recorded at elevations of up to 1,570 m asl (Rautenstrauch and O'Farrell 1998); however, tortoises may be found in unusual places, often transported by humans or other animals (e.g., the type specimen of *Xerobates lepidocephalus* [Ottley and Velázquez-Solis 1989] from southern Baja California, Mexico, is actually an introduced *Gopherus agassizii* [Murphy *et al*. 2011]).

Country Occurrence:

Native, Extant (resident): United States (Arizona, California, Nevada, Utah)

Distribution Map

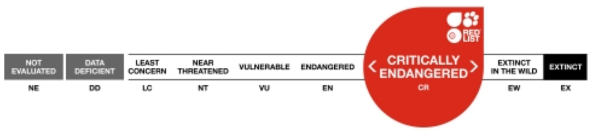


Legend

EXTANT (RESIDENT)

Compiled by:

Chelonian Research Foundation 2021



The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN.

Population

Population estimates and trends have previously been difficult to obtain with certainty for large segments of *Gopherus agassizii* populations due to their patchy distribution, difficulty of detection, and associated statistical weaknesses of population estimates. Population data have been variously documented or reviewed by Woodbury and Hardy (1948), Hardy (1976), Berry (1984, 1986, 1989), Bury and Corn (1995), Freilich *et al*. (2000), Ernst and Lovich (2009), and Berry and Murphy (2019). A recent rigorous range-wide population reassessment of *G. agassizii* by Allison and McLuckie (2018) has demonstrated continued adult population declines in four of the five *G. agassizii* recovery units and inadequate recruitment with decreasing percentages of juveniles in all five recovery units and low densities in nearly all subpopulations near the minimum required to remain viable (3.9 adult tortoises/km^2).

Between the 1930s and early 2000s, estimates of density and trends in populations were based on demographic data, habitat condition, and anthropogenic threats from both long- and short-term study plots of varying sizes, as well as reports by government agency personnel and expert observers (e.g., Woodbury and Hardy 1948; Hardy 1976; Berry 1984, 1989). The study plots were limited in number and did not represent the entirety of subpopulations across the geographic range (e.g., Berry 1984). The subpopulation on the Beaver Dam Slope, Utah, was federally listed as threatened in 1980 (USFWS 1980). A petition submitted by the Desert Tortoise Council in 1984 to list all wild populations in the United States was denied; the USFWS determined that listing of U.S. populations was warranted but precluded because of other higher priorities (USFWS 1985). In 1989 and 1990, the State of California and USFWS listed the tortoise as threatened (USFWS 1989, 1990; California Department of Fish and Wildlife 2016). The appearance of upper respiratory tract disease and rapidly declining populations in the western Mojave and a major decline in tortoises in parts of the western Sonoran (Colorado Desert, California) associated with appearance of shell disease were additional threats to the many causes of declines (USFWS 1990, 1994, and references therein). Reflecting its concern over these declines, USFWS (1994:3) stated that: “The most serious problem facing the remaining desert tortoise population is the cumulative load of human and disease-related mortality accompanied by habitat destruction, degradation, and fragmentation. Virtually every extant desert tortoise subpopulation has been affected by one or more of these factors.” As a result, the U.S. Department of the Interior (USFWS 1994) also designated federal critical habitat units for desert tortoises at that time. In October 2020, the California Fish and Wildlife Commission accepted a petition from Defenders of Wildlife to up-list wild desert tortoises from threatened to endangered status; California has the largest subpopulation and geographic range of the species. The petition is currently under consideration by the agency with a response estimated in 2021.

To better measure trends in densities of adult populations in the threatened subpopulations, the Recovery Team proposed development of a landscape scale program (USFWS 1994). At the same time, the Recovery Team also noted the importance of study plot data, because more population attributes were provided than density of adults. After experimenting with different techniques, the USFWS decided to use distance sampling and initiated a formal, range-wide program for estimating densities of adult populations in critical habitat units (USFWS 2015, and references therein).

In the first Recovery Plan (USFWS 1994), population size, viability, and sizes of protected areas were discussed. Assuming the minimum density of adults in a population was “approximately 10 adults per square mile” (equivalent to 3.9 adults/km^2), the target size for protected areas (then called Desert Wildlife Management Areas) was approximately 1,000 mi^2 (ca. 2,590 km^2). This would ensure that even at such low densities and assuming half of such large areas might support no or few tortoises, each protected area would support enough adults for a genetically minimum viable population. The Recovery Team recommended six Recovery units with 12 different populations. The updated Recovery Plan (USFWS 2011) is based on the same number of populations but configured into five revised Recovery units with 17 different monitored subpopulations.

Most demographic data from study plots collected from the 1930s on the Beaver Dam Slope and between 1979–1980 in California and Nevada during the spring season indicated counts of 5–64 adult tortoises/km^2 (Berry and Murphy 2019). In describing trends between 1978 and 1990 in California, the USFWS summarized data from 10 study plots in the Mojave and Colorado deserts and reported a highly significant downward trend (USFWS 1994). Additional data for the period showed some populations with low but potentially stable densities in Nevada (Berry and Medica 1995). A review of population status (Tracy *et al*. 2004) considered updated information from the permanent study plots in California and found that population declines in the western part of the range in California continued and declines were perhaps beginning in the eastern part of the California range.

The current population trends are based on landscape-level assessment using distance sampling for the 11-year period between 2004 and 2014 (USFWS 2015, Allison and McLuckie 2018). The sampling represented all five recovery units with 16 subpopulations in critical habitat units of from 115 to 3,763 km^2 described in the original Recovery Plan (USFWS 1994). Joshua Tree National Park is treated as a protected area and monitored as a 17th subpopulation although not designated as critical habitat. Consistent downward trends have continued in four of the five recovery units, with 11 of the 17 subpopulations registering declines in adult tortoises ranging from 26.6 to 64.7% during the 11 years. Most of the increasing subpopulations were in Nevada. Population densities for adults ranged from 1.5 to 7.2/km^2 in declining populations as of 2014; the exceptions were adult densities in the Red Cliffs Desert Reserve (15.3/km^2) and the Desert Tortoise Research Natural Area (10.2/km^2) (Berry et al. 2014, 2020). Unfortunately, in July 2020, a significant part of the Red Cliffs Desert Reserve burned and tortoises were found injured and dead. The Red Cliffs subpopulation declined from 2005 wildfires and with the recent 2020 fires, there will likely be further depression in densities. The six subpopulations with increasing densities had 2.7 to 6.4 adults/km^2 in 2014. However, most of the 17 populations were near or below the 3.9 /km^2 density of adults considered as a minimum for viable populations (USFWS 1994, 2015).

Current Population Trend: Decreasing

Habitat and Ecology (see Appendix for additional information)

The life history of *Gopherus agassizii* is typical of long-lived chelonians and has been reviewed by Berry and Murphy (2019). Tortoises require 17–20 years to reach sexual maturity at a straight-line carapace length (CL) of 18 cm or more (Woodbury and Hardy 1948, Turner *et al*. 1987, Medica *et al*. 2012). Variation in years is dependent on desert region, frequency of droughts, and quality of available forage. In the northern part of the geographic range, females smaller than 20.9 cm were not reproducing (Mueller *et al*. 1998). Maximum lifespan was estimated by Turner *et al*. (1987) at 75 years, but few live beyond 50 yrs in the wild (Germano 1992). Generation time was estimated to be 20–32 years (Turner *et al*. 1987, USFWS 1994). Based on data from three desert regions, mean sizes of females ranges from

21.4 to 23.1 cm, whereas the mean sizes of males ranged from 24.3 to 24.9 cm; the largest desert tortoises on record, a male, reached 38.1 cm carapace length (Stebbins 2003), whereas a female was 37.4 cm, but these animals were exceptions (Berry and Murphy 2019).

Mature females may lay clutches of one to 10 eggs in up to three clutches per year in spring and early summer; in some years, some females do not lay eggs (Rostal *et al*. 1994, Henen 1997, Mueller *et al*. 1998, Wallis *et al*. 1999, McLuckie and Fridell 2002, Ennen *et al*. 2012, Lovich *et al.* 2015). Annual fecundity ranges from 0 to 16 eggs (Mueller *et al*. 1998, Lovich *et al*. 2015). Several factors may affect egg production: site, year, size of female, size and number of eggs, and available water and protein from precipitation and forage in the year preceding egg laying, as well as the year eggs are laid (Henen 1997).

Incubation times for eggs range from 67 to 104 days (Burge 1977, McLuckie and Fridell 2002, Ennen *et al*. 2012). Hatching success varies and appears to depend on year, location of the nest, and whether it is the first or second clutch. Eggs may be infertile or broken during laying (e.g., 12%; Turner *et al*. 1987). Many nests are destroyed by predators before hatching and the loss of eggs (and nests) varies by year (Turner et al. 1987); they estimated an average loss of 37.1% of nests in a multi-year study. Hatching success in intact nests, undisturbed by predators, has been shown to vary from 73 to 100% (McLuckie and Fridell 2002, Rostal *et al*. 2002, Bjurlin and Bissonette 2004, Ennen *et al*. 2012).

Desert tortoises inhabit desert scrub habitats, including saltbush, creosote bush, Joshua Trees and Mojave yuccas, and microphyll woodlands with ironwood, palo verde, desert willow, and smoke trees (Berry and Murphy 2019). In the northeastern part of their geographic range, they occur in an ecotone between the Mojave and Great Basin deserts with sand sagebrush and junipers. Actual occurrences tend to be in valleys, alluvial fans, bajadas, and ephemeral stream channels, although tortoises can be found in low sand dunes and on steep slopes of mesas and cliffs (Berry and Murphy 2019).

Desert tortoises are herbivorous and selective in their choice of plant species (Jennings 1993, Oftedal 2002, Oftedal *et al*. 2002, Jennings and Berry 2015). They primarily eat forbs when available. In years of abundant precipitation, they are selective feeders and prefer specific species of annuals and herbaceous perennials in the legume, mallow, borage, aster, four o'clock, and cactus families (as well as other families). Although they eat grasses, a diet solely of grasses is deficient in nutrients and is likely to inhibit growth and survival, especially in neonate, juveniles, and immature tortoises (Hazard *et al*. 2009, 2010; Drake *et al*. 2016). The quality and quantity of preferred plant foods has diminished because of continuing invasion of non-native annual grasses and forbs and increased fire associated with the highly combustible non-native grasses (D'Antonio and Vitousek 1992, Brooks and Berry 2006, Brooks and Matchett 2006, Berry *et al*. 2014b).

Annual survival and mortality of adults is dependent on sex, size of the tortoise, frequency and severity of droughts, numbers and types of anthropogenic uses, location, and decade of study. In a multi-year study in the eastern Mojave Desert, annual survivorship of juveniles increased with size, ranging from 0.767 when <6.0 cm to 0.861 when 6.0 to 17.9 cm (Turner *et al*. 1987). When tortoises reach breeding age at an estimated 18.0 cm, survival rates were 0.87 to 0.944. Freilich *et al*. (2000) reported an annual survival of 0.883 for adults at Joshua Tree National Park. In a study in the Colorado Desert, Agha *et al.* (2015) estimated adult survival at a wind-turbine energy site (0.96) and an adjacent area (0.92). At two sites in the eastern Mojave Desert, Longshore *et al*. (2003) reported annual survival of adults of 0.985 and 0.829, with the lower survival rate at a site affected by drought.

Woodbury and Hardy (1948) estimated that 1% of adults died per year in a population mostly comprised of adults. In the northeastern Mojave Desert, Turner *et al*. (1984) reported mortality rates of 18.4% in a year of drought and 4.4% in a normal year. In the western Mojave Desert, death rates were lowest at a protected Research Natural Area (2.8%/yr) and highest in critical habitat (20.4%/yr). At Joshua Tree National Park, the mortality rate was 11.7% (Freilich *et al.* 2000), and in Red Rock State Park, 67% (Berry et al. 2008). In a demographic study of tortoises at 21 sites in the central Mojave Desert, mortality rates of adults ranged from 1.9 to 95.2% (Berry *et al*. 2006).

Turner *et al*. (1987) predicted an annual rate of population increase of *ca*. 2% in a model based on a tortoise subpopulation in the eastern Mojave Desert between 1977 and 1985. By 2000, this subpopulation had declined precipitously, apparently due to disease (see Christopher *et al*. 2003). Freilich *et al*. (2002) estimated the recruitment rate of young tortoises into the adult subpopulation at 0.092 in a plot in Joshua Tree National Park. This number of tortoises on this plot was thought to be stable between 1991 and 1995, but later declined (Lovich *et al*. 2014).

Systems: Terrestrial

Use and Trade **(see Appendix for additional information)**

Commercial take or use of *Gopherus agassizii* is prohibited by law, and few animals have been documented in (illegal) trade in recent decades. The evaluation of conservation status, conservation and monitoring actions for the species have generated significant financial investments in the species, supporting a range of local and visiting livelihoods. The approximate cost to develop and implement the 25-year recovery program for the Mojave Desert Tortoise was USD 100 million (USGAO 2002, Ernst and Lovich 2009, USFWS 2011, Averill-Murray *et al*. 2012). Thirty years have passed since the federal listing of *G. agassizii* as threatened in 1989–1990, declines of breeding adults continue, and many tasks to reduce deaths, described first in 1994 (USFWS 1994), remain to be implemented (see also USFWS 2011, Reports from the Recovery Implementation Teams). If fully implemented, the recommended actions could exceed 159 million USD plus additional costs that could not be estimated in the 2011 Recovery Plan (USFWS 2011). As one of the keystone species of the Mojave Desert, *G. agassizii* plays an unquantified but substantial role in generating tourism income to regional protected areas (see Joshua Tree National Park, Mojave National Preserve, and Lake Mead National Recreation Area (https://irma.nps.gov/STAT/).

Threats **(see Appendix for additional information)**

Gopherus agassizii faces multiple threats to individuals, populations, and habitat (for annotated bibliographies of reports and published papers, see Hohman *et al*. 1980; Berry 1984; USFWS 1990, 1994, 2010, 2011; Grover and DeFalco 1995; Bury and Luckenbach 2002; von Senckendorff Hoff and Marlow 2002; Lovich *et al*. 2011; Lovich and Ennen 2013a; Berry *et al*. 2015; Berry and Murphy 2019). Recent articles document further examples of threats (Tuma *et al*. 2016; Berry *et al*. 2020a,b,c). Much of the information with numerous references are contained in Berry and Murphy (2019). Substantial tortoise habitat was already lost to cities, towns, settlements, agriculture, energy developments, and military bases in the 20th century, and continuing habitat loss and degradation, combined with high mortality rates in dwindling low-density populations due to disease (upper respiratory tract disease / mycoplasmosis), road and off-road vehicle-induced mortality, subsidized predators (e.g., ravens), poaching for pets, and mortality from increasing droughts associated with climate change, are threatening most remaining populations of Desert Tortoises (summarized in Berry and Murphy 2019). The majority of desert tortoise populations are currently considered non-viable because of the low density of adults and their existence in isolated and fragmented pieces of habitat (Berry 1984, USFWS 2010, Allison and McLuckie 2018, Berry *et al*. 2020a,b).

Many threats are cumulative in nature and interact synergistically with others. By rating them separately in the Standard Threats Classification Scheme below, the severity of threats and their negative impacts are not described in full measure. One of the limitations of the classification scheme for threats are the ratings for severity. Severity is associated with declines (or not) by percent over 10 years or three generations, whichever is longer. For species such as desert tortoises with long generation times (*ca*. 20–30 years), this may be 60 to 90 or more years. Here we provide a detailed and expanded Threats Classification Scheme for *G. agassizii*.

Detailed Threats Classification Scheme

Classification Level

a. Examples
b. Timing and Scope

1.1 Housing & urban areas, towns, settlements, ranches
a. Desert cities, towns, settlements, scattered homes in rural areas, desert land entry, e.g., Inyokern, Ridgecrest, Red Mountain, Trona, Boron, Lancaster, Palmdale, Victorville, Lucerne Valley, Ft. Irwin, Barstow, Daggett, Mountain Pass, Joshua Tree, Twentynine Palms, Vidal Junction, Ludlow, Amboy, Needles, Las Vegas, St. George, Palm Springs, Borrego Springs, Parker, Blythe, El Centro, Stateline, Las Vegas, Mesquite, St. George.
b. Ongoing. Severe impacts, disappearance of tortoises and habitat; 20% of geographic range. Loss of habitat from widespread and rapidly growing and expanding cities, towns, and settlements associated with high levels of human population growth in the Mojave and western Sonoran deserts and loss and degradation of adjacent habitat (Hughson 2009, U.S. Census Bureau 2010). In the northwest and southwest portions of the geographic range, tortoise populations are locally extinct, absent from valleys and fans and in low densities on military bases.

1.2 Commercial & Industrial
a. Airports and landing strips, military bases, solar and wind farms.
b. Ongoing. Severe impacts, loss of tortoises and habitat; 8% of geographic range. Development and use of multiple airports, landing strips, several large military bases with ground disturbing activities (military manoeuvres), and solar and wind farms (with associated transmission lines and roads) result in degradation and loss of substantial habitat in both the Mojave and western Sonoran deserts.

1.3 Residential & commercial; golf courses, tourism, recreation
a. Golf courses are associated with cities and towns that currently exist or are expanding within or near Desert Tortoise habitat (e.g., Las Vegas, Henderson). Vehicle-oriented recreation and visitation are very high in many parts of both deserts including what is now critical habitat, several State Parks and National Parks, Lake Mead National Recreation Area, Red Cliffs National Conservation Area, museums,

and other points of interest.

b. Ongoing. Loss and degradation of habitat, illegal collecting of tortoises: 30%. The high levels of visitor use pose severe threats to *G. agassizii* throughout remaining habitat as well as in critical habitat. For example, at Lake Mead National Recreation, annual records of visitors from 1946 was >1 million visitors per year; by 2018 more than 7.5 million visits occurred (https://irma.nps.gov/Stats/Reports/Park/). In parts of critical habitat in the western Mojave Desert, visitor use is very high, e.g., visits and visitor days recorded annually from 2008–2018 ranged from 55,874 to 94,474 visits and 26,218 to 90,445 visitor days per year (USBLM 2019). Visitor use, particularly vehicle-oriented use, is very difficult to control; a substantial portion occurs off-highway and designated trails. Off-road vehicle recreational uses are associated with higher rates of deaths from gunshots in tortoises occurring in areas with high visitor use days (Berry 1986, 2020a).

2.1.3 Agriculture: Agro-industry farming

a. Farms for cotton, alfalfa, pistachio, goat-nut, and other crops and dry farming in parts of the geographic range (e.g., Fremont, Antelope, Indian Wells, Victor, Apple, Lucerne, Mojave River, Chuckwalla and Virgin River valleys, bordering the Colorado River).

b. Severe, cleared land, local areas, often expansive, throughout the geographic range. Historic and ongoing. Habitat and tortoises lost, 10%. Farming began very early (late 1800s) and continues to the present. Farming has negatively affected the water table locally, causing subsidence and fissures to develop in at least one area (Berry 1984), as well as altering vegetation in the vicinity. Habitat cleared for farming generally is used for industrial purposes, e.g., solar or off-road vehicle recreation after abandonment. Both agricultural and industrial uses are associated with influx and proliferation of non-native plants onto adjacent, high quality desert tortoise habitat and protected areas.

2.3.2 and 2.3.3 Agriculture: livestock farming & ranching

a. Cattle ranching, sheep grazing and driveways, allotments, licenses, and leases (often on federal lands); growing herds of feral burros and expansion into critical habitat.

b. Moderate to severe, historic (from 1850s), ongoing; 80% of the geographic range affected. Grazing of livestock and use of driveways was widespread and often intensive throughout the geographic range until the Taylor Grazing Act in 1932. Livestock grazing was widespread after that time but managed as an important desert use (e.g., Berry 1984, USBLM 1980). In 1990, after the tortoise was listed as threatened, sheep grazing continued but was excluded from critical habitat. Cattle grazing continued throughout much of critical habitat and still occurs in an estimated 17% of critical habitat (USFWS 2010). Feral burros also graze in tortoise habitats and are encroaching into one critical habitat (USFWS 2010; Berry et al. 2020c). Livestock cause degradation and loss of habitat through development of piospheres, trampling, altering cover, composition of shrubs and forage plants available for tortoises to eat (Webb and Stielstra 1979, Fleischner 1994, Brooks *et al*. 2006, Abella 2008, Tuma *et al*. 2016). The disturbances created by grazing contributes to growth and proliferation of non-native, fire-prone, invasive grasses (D'Antonio and Vitousek 1992).

3.1 Energy production & mining: oil and gas

a. Oil and gas, drilling and exploration.

b. Medium severity, local areas, <1% of geographic range. Exploratory drilling has occurred in tortoise habitat and has left degraded and cleared areas of < 1-2 ha, with spoil piles, drilling waste, and trash from the drilling operations spread over the area. These sites became focal points for camping and vehicle-oriented recreation, enlarging over time (K.H. Berry pers. obs.).

3.2 Energy production & mining: mining and quarrying

a. Small and large mines, exploratory pits, bulldozed areas, shafts, and major mines; quarries.

b. Ongoing, severe degradation on a local or regional scale; 5%. Mining on small and large scales began in the late 1800s, killing tortoises and destroying habitat. Roads were constructed to access potential mining areas and districts (Mojave, Rand, Atolia, Goldstone, Calico, Mountain Pass). Tortoises fall into pits and shafts and were killed. Some mines cover 7.8 km^2 or more and their influence can expand beyond that. Gold mines are associated with spread of mercury and arsenic in soils and plants far beyond the source (e.g., >12 km), transported by wind and water (Chaffee and Berry 2006; Kim *et al*. 2012, 2014). Tortoises are negatively affected by these elemental toxicants with poor health; these toxicants were reported in livers, integument, lungs, etc. (Jacobson *et al*. 1991, Selzer and Berry 2005, Foster *et a*l. 2009).

3.3 Energy production & mining: renewable energy

a. Windfarms, photovoltaic, solar fields; new utility and transmission lines, power poles and towers with adjacent roads accompany these developments.

b. Ongoing, future. Severe degradation and loss locally over large areas, 5% over the geographic range. Windfarms occur in tortoise habitat, generally on slopes or on hills and small mountains. Solar panels have been constructed on abandoned agricultural fields or in low density or marginal habitat. However, some projects were built in prime habitat, causing loss of habitat and displacement of tortoises. Solar and wind energy is a growing industry with losses of >106 km^2 as of 2019 (Mark Massar, U.S. Bureau of Land Management, pers. comm.).

4.1 Transportation and service corridors: roads & railroads

a. Freeways, 2-lane highways, county gravel or dirt roads, and roads to points of interest; railroads (two major) and several spurs with associated dirt roads and tower lay-down areas for power towers and poles.

b. Ongoing, severe loss and degradation of habitat. 5% throughout the geographic range. Roads were developed in the late 1800s and have proliferated and widened into freeways since that time. Several major freeways and state highways cross the geographic range. Importantly many more dirt roads exist to points of interest (e.g., mines, mining areas, water troughs and water sources, outlying rural areas, recreation areas). Tortoise populations are depleted on either side of highways and well-used roads for distances of >4,000 m (von Seckendorff Hoff and Marlow 2002). A very small portion of these roads and highways have tortoise-proof fencing.

4.2 Transportation & service corridors: utility & service lines

a. Telephone and electric poles and lines; major transmission lines and corridors.

b. Ongoing, moderate to severe. Telephone poles and electric poles and lines usually parallel major or minor paved and dirt roads and extend from towns and cities into remote areas to provide service to agricultural developments, mines, wind and solar farms and individual residences or small settlements. Electric transmission lines cross many parts of the geographic range, including critical habitat (critical habitat alone: 1,634 km of lines in corridors, total area of corridors, 1,743.5 km^2) (USFWS 2010). These corridors are accompanied by dirt roads and spurs to the towers. Often corridors contain several sets of towers and electrical lines. Utility lines also include ground disturbance from fibre optic cables, aqueducts, and gas lines, all of which disturb tortoise habitat. Utility poles and transmission lines have allowed for spread of predators (Common Raven, Red-tailed Hawk) into remote parts of the desert, because they make use of the towers and poles for perching and nesting, leading to increased predation on tortoises (Knight and Kawashima 1993, Anderson and Berry 2019).

4.4 Transportation and service corridors: flight paths or military use a. Commercial, non-commercial, and Department of Defence flight paths.
b. Numerous, ongoing. Flight paths are minor or no impact if not associated with release of ordnance (bombing ranges). The noise may have effects on wildlife, including tortoises (e.g., Bowles *et al*. 1999).

5.1.1 Biological resource use: hunting & trapping terrestrial animals: intentional use (species is the target)
a. Illegal collecting of *Gopherus agassizii* for commercial sale, food, cultural purposes, and for international trade, etc.
b. Ongoing, severe. Tortoises have been and continue to be collected for pets, food, tourism, commercial sale, and cultural purposes, although such collection has been unlawful since 1939 (Berry 1984, Berry *et al*. 1996, Berry and Murphy 2019, Berry *et al*. 2020b).

6.1 Human intrusions & disturbance: recreational activities
a. Visits to State and National Parks and Preserves, National Recreation Areas, federal and state lands, private lands, and Open Recreation Use Areas (unrestricted vehicle play areas) by vehicle-oriented recreationists.
b. Ongoing, severe impacts regionally and locally, especially in the western, central, and southern Mojave Desert and growing in the western Sonoran Desert; associated with proximity to cities, towns, and settlements. Formerly populated with Desert Tortoises, several intensively used areas are now severely degraded and have few if any tortoises (e.g., Bury and Luckenbach 2002, Berry *et al*. 2014a, USFWS 2015, Berry and Murphy 2019). Vehicle-oriented visitation is exceptionally high, ranging from >50,000 to 86,550 between 2008 and 2018 annually in some regions of the Mojave Desert (USBLM 2019). Other parts of the desert and critical habitat are also experiencing growing numbers of visitors. Deaths of desert tortoises from road kills and shooting is higher in areas with high levels of vehicle-oriented visitation (Berry 1986, Berry *et al*. 2020b).

6.2 Human intrusions & disturbance: war, civil unrest & military exercises
a. World War II and subsequent. Military manoeuvres across substantial areas of habitat in the western Sonoran and eastern Mojave deserts to train troops using tanks and other vehicles for the war in North Africa. Since the 1960s, military manoeuvres with armoured vehicles in extensive areas in the western, southern, and central Mojave deserts; aerial bombing training in limited areas in the western Sonoran Desert.
b. Ongoing, severe. Military manoeuvres in 1942 resulted in severely degraded habitat (compacted soils, damaged desert pavements, altered vegetation, including forage available for desert tortoises. Lands disturbed in 1942 have not recovered after 60 years (Prose 1985, 1986; Prose and Wilshire 2000). Similar disturbances have occurred and continue to occur in tortoise populations and habitat at military installations in the southern and central Mojave Desert. In the early 2000s, expansion of the Fort Irwin military installation in the central Mojave Desert caused loss and degradation of 760 km^2 of tortoise habitat and *ca*. 304 km^2 of the lost habitat was part of critical habitat (USFWS 2010, Berry and Murphy 2019). An estimated *ca*. 300 km^2 will be lost with additional, ongoing expansion of the same base. The western expansion of the Marine Corps base at 29 Palms caused hundreds of tortoises to be translocated and habitat lost in the southern Mojave Desert (USDD 2017).

6.3 Work and other activities: law enforcement, illegal immigrants, species research, vandalism
a. Border patrol agents and illegal immigrants travel cross-country by foot and vehicle in tortoise habitat in the southern border range. Vandalism, specifically wanton shooting or killing of tortoises has affected some populations more than others, probably associated with higher visitor use and vehicle-oriented recreation.
b. Ongoing, moderate severity. Border patrol agents travel north from the border into tortoise habitat, including critical habitat, to apprehend illegal immigrants. Vehicle travel can occur off dirt roads, widen existing roads, and create new disturbances. Shooting tortoises, running over them deliberately with vehicles, or otherwise killing them has been documented in both the Mojave and western Sonoran deserts (Berry 1986, Berry *et al*. 2006, Berry *et al*. 2020a,b).

7.1.1 Fires & fire suppression
a. Caused by lightning, car fires on highways or roads, arson.
b. Ongoing, severe, with the severity dependent on the critical habitat unit or protected area. Mojave and Colorado Desert habitats did not evolve with fire (D'Antonio and Vitousek 1992). Fires increased in numbers, frequency, and amounts burned with the invasion and proliferation of non-native grasses which are highly combustible (Berry and Murphy 2019). Fires have occurred throughout the geographic range and have burned significant amounts of critical and other protected habitats in the southern, central, eastern and northeastern Mojave Desert regions. Once habitat burns, it is likely to burn again with higher frequencies and with potentially increased biomass of non-native annual grasses. Tortoises die in these fires or are injured, but some survive (Berry and Murphy 2019). Loss of cover of shrubs and food supply for the tortoises is severe in most burned areas. When fires are very hot, the seed bed may be damaged or destroyed. The most severely burned protected habitat is in the Red Cliffs Desert Reserve with >30% burned as of summer 2020 (McLuckie *et al*. 2021); the Mojave National Preserve also experienced a major fire and loss or degradation of 7% of the critical habitat unit in summer 2020 (Darby *et al*. 2021).

7.2.8 Abstraction of ground water
a. For agriculture, primarily, followed by urban and cities.
b. Ongoing, long-term degradation of habitat adjacent to cities, towns, industrial and agricultural developments. Depletion of the ground water table causing subsidence and formation of fissures has occurred in at least one part of the western Mojave Desert and in the northeastern Mojave Desert in the Las Vegas Valley in what was once desert tortoise habitat (Berry 1984, Burbey 2002). In the western Mojave Desert, the water table was depleted by agricultural uses (cotton, alfalfa) and now with solar energy development; and by cities in the Las Vegas Valley by depleted associated aquifers. Other regions have and continue to experience depletion of the water table in areas with agriculture and desert cities, e.g., adjacent to the Mojave, Colorado, and Virgin rivers (Stamos *et al*. 2001). Water is sought from sources and regions outside desert tortoise habitat (e.g., the Colorado River) to support cities and towns, as well as agriculture, because existing water tables are insufficient to support them.

8.1.2 Invasive and other problematic species, genes & diseases: Named species
a. *Bromus madritensis* ssp. *rubens, B. tectorum, Schismus* spp., *Erodium cicutarium, Hirschfeldia incana, Brassica tournefortii.*
b. Ongoing, severe degradation of the Mojave and western Sonoran ecosystems. Landscape conservation forecasting (Provencher *et al*. 2011) quantified the pervasive abundance of annual brome

grasses that foster destructive wildfires of a size and intensity far greater than the fire regime with which Mojave Desert habitats developed over the past millennia. In addition to supporting fires, the non-native grasses compete with native forage species of forbs required by tortoises to grow, reproduce, and remain healthy. Non-native grasses and forbs dominate the ecosystem in biomass in both wet and dry years in many tortoise habitats (Brooks and Berry 2006, Berry 2014b). Non-native grasses are not nutritious plants for tortoises to eat and cause weight loss and can cause death in juveniles (Hazard *et al.* 2009, 2010; Drake *et al*. 2016). The awns of *Bromus* also can injure tortoise mouths. The non-native *Hirschfeldia incana* and especially *Brassica tournefortii*, introduced through agricultural development, also compete with native forage species, changing the composition of the native flora (Berry *et al*. 2014b). They are not eaten by tortoises and can be high in oxalates, potentially a source of oxalosis in tortoises (Jacobson *et al*. 2009).

8.1.2 Diseases. Named species

a. Infectious diseases: *Mycoplasma agassizii, M. testudineum,* Testudinid herpesvirus 2 (TeHV2); Non-infectious diseases: oxalosis, gout, starvation, dehydration.

b. Infectious diseases: ongoing, severe in some areas. The two species of *Mycoplasma* are infectious pathogens. The first (*M. agassizii*) was discovered in wild populations in 1989 and the second (*M. testudineum*) a few years later (Jacobson *et al*. 1991, 2014). These pathogens are spread by contact between tortoises cause disease and death in some populations, and inhibit olfaction necessary for foraging (Jacobson and Berry 2012, Jacobson *et al*. 2014). *Mycoplasma agassizii* is common in captive desert tortoises, more so than in wild populations. Epidemiological studies indicate that the distribution of the two species differs, and that tortoises with antibody-positive tests for the diseases occur closer to human habitations rather than more distant (Berry *et al*. 2015). Mycoplasmosis has been implicated as a major contributor to a catastrophic die-off of tortoises at the Desert Tortoise Research Natural Area (Berry *et al.* 2020b). It is also associated with declines in other parts of the geographic range (Christopher *et al*. 2003). Non-infectious diseases of known etiology include oxalosis, gout, and starvation and dehydration (Homer *et al*. 1998, Berry *et al*. 2002, Jacobson *et al*. 2009). Some individuals and populations have been negatively affected by these diseases.

8.2.2 Problematic Native Species

a. The Common Raven (*Corvus corax)*, an uncommon to rare resident between the 1920s and 1940s in the Mojave and western Sonoran deserts, is now an abundant predator in ecosystems where the Desert Tortoise lives. Red-tailed Hawks (*Buteo jamaicensis*) is another similar predator, and Coyotes (*Canis latrans*) can also be a hyper-predator.

b. Ongoing, severe and negative effects on population structure; loss of juveniles and immature tortoises. Populations of the Common Raven have grown enormously, supported by subsidies of food, water, perch and nest sites available from humans (Boarman 1993, Boarman and Berry 1995). They have been able to access formerly remote parts of the desert by relying on settlements, road kills and trash along highways and roads, and utility poles and transmission lines for perching and nesting (Knight and Kawashima 1993). Common Ravens are very effective predators on hatchling, juvenile and immature tortoises, with dozens to hundreds of shells recorded beneath perch and nest sites. They are responsible for preventing recovery in many parts of the desert by depleting young tortoise cohorts in populations that can lead to local extinctions (Kristan and Boarman 2003). Red-tailed Hawks have expanded their use areas into remote parts of the desert ecosystems, using utility poles and towers as nest sites and juvenile tortoises for food (Anderson and Berry 2019). Similarly, Coyotes are subsidized predators found in increased numbers near cities, towns, and some military installations and at times have high predation rates on tortoises (Esque *et al*. 2010).

8.4.2 Problematic Species/ Diseases: Named Species

a. Several non-native species of tortoises and turtles carrying disease or potentially carrying disease have been released illegally into Desert Tortoise habitats, e.g., African Spurred Tortoise (*Centrochelys sulcata*; Nelson 2010; Anonymous 2018) and Central Asian Steppe Tortoise (*Testudo horsfieldii*; Jacobson *et al*. 2013, Winters *et al*. in prep.).

b. Ongoing, potentially severe. Releases of tortoises, whether native or non-native are illegal in large parts of the geographic range. Nevertheless, introduced, non-native turtles and tortoises such as the African Spurred Tortoise and Central Asian Steppe Tortoise have been found to carry new diseases that would negatively affect already declining *G. agassizii* populations (Nelson 2010; Anonymous 2018). The African Spurred Tortoise can do damage to habitat and to the native tortoise, *G. agassizii*, because of the large size and aggressive nature. One Central Asian Steppe Tortoise was captured in the Central Mojave Desert with a new herpesvirus not previously described in *G. agassizii* (Winters *et al*. in prep.). The concern is that this non-native tortoise may have transmitted the new herpesvirus to desert tortoises. New, non-native herpesviruses from other species and countries and continents are a threat to health in already declining *G. agassizii* populations.

8.5 Viral/Prion-induced Diseases

a. Herpesviruses are implicated in illness and mortality in tortoises.

b. Ongoing, potentially severe if coupled with other stressors. Herpesviruses are a threat to health and survival of desert tortoises, especially those herpesviruses introduced from other, non-native species to the desert. Tortoises with clinical signs of the disease were among populations that severely declined between the 1990s and 2000s; herpesvirus may have contributed in some areas (Christopher *et al*. 2003). Testudinid herpesvirus 2 was first identified in captive tortoises, then confirmed in wild *G. agassizii* (Jacobson *et al*. 2012). The estimated prevalence of this herpesvirus for captive and wild tortoises from the Mojave and western Sonoran deserts ranged from 15 to 56% (Jacobson *et al*. 2012).

8.6 Diseases of Unknown Cause

a. Shell diseases, i.e., cutaneous dyskeratosis, necrosis.

b. Ongoing, severe. A novel shell disease, cutaneous dyskeratosis and shell necrosis, was implicated in illness and deaths of Desert Tortoises (Jacobson *et al*. 1994; Homer *et al*. 1998, 2001) and a decline of ca. 80% in a once-robust population. Other populations in critical habitats appear to be affected similarly. This is a metabolic disease with lesions of the shell and integument as outward manifestations. The causes are suspected to be toxicants (e.g., elemental toxicants and/or nutritional deficiencies). The disease is implicated in elevated death rates in adult tortoises in the western Sonoran Desert and eastern Mojave Desert (Berry and Medica 1995, Christopher *et al*. 2003).

9.2.2 Industrial & military effluents

a. Seepage from mining.

b. Ongoing, unremediated regionally. There are links between some diseases in tortoises and toxicants from mining and other similar developments. Tortoises dying of upper respiratory tract disease caused by *Mycoplasma* spp. in the western Mojave Desert in close proximity to a mining district had high levels of mercury in livers compared to tortoises without the disease (Jacobson *et al*. 1991). Ill tortoises with high levels of arsenic occurred in an area mining district with high levels of mercury and arsenic (Selzer and Berry 2005). Waste from the mines was transported by wind and water to distances of 15 km

(Chaffee and Berry 2006; Kim et al. 2012, 2014). Mines in other tortoise habitat in different desert regions have yet to be examined.

9.4 Garbage & Solid Waste

a. Trash is a threat to tortoises because they can consume it or become entangled.

b. Ongoing, low to moderate. Consumption of trash can lead to illness and death (Donoghue 2006, Walde *et al*. 2007). Balloons and other trash are common throughout the desert and most abundant near human habitations, along roads, and recreation use areas (Berry *et al*. 2006, 2008, 2014a; Keith *et al*. 2008). Trash attracts predators—Common Ravens, Coyotes, and other canids—thus creating an additional risk to tortoises.

9.5 Air-borne Pollutants

a. Pollutants such as atmospheric nitrogen and increases in CO_2 enhance the growth of invasive grasses and thus fire.

b. Atmospheric nitrogen from urban or other areas is transported to deserts and tortoise habitat, and deposited on soils, thus enhancing growth of non-native grasses and plants prone to fire (Brooks 2003, Rao and Allen 2010).

11.1 Habitat Shifting & Alteration

a. Desertification; degradation of vegetation, soils, and topography

b. Ongoing, severe. Throughout the geographic range, most, if not all, tortoise habitats have received (and continue to receive) one or more anthropogenic uses and activities resulting in compacted or eroded soils and alteration of the natural structure and composition of annual and perennial vegetation (e.g., Lei 2009). Long-lived shrubs and native annual wildflowers and grasses have been replaced in part with short-lived colonizers (shrubs, non-native, fire-prone grasses) typical of disturbed areas. These changes have brought fewer places to dig burrows and a reduced supply of nutritious plants to eat (Brooks and Berry 2006, Webb and Wilshire 1983). In some areas, the rich diversity of shrubs and annual plants have been replaced by a few shrub species and the annuals replaced with primarily non-native annual species (Brooks and Berry 2006).

11.2 Droughts

a. Desert Tortoises require water from precipitation and a diverse diet of native annuals to grow, reproduce and survive.

b. Ongoing, increasingly severe with reduced survival throughout the geographic range, often associated with hyper-predation by coyotes. Although the Mojave and western Sonoran deserts are typified by droughts often lasting more than a year, tortoises have adaptations to cope. However, tortoises die of starvation and dehydration during prolonged droughts (Berry *et al.* 2002, Christopher *et al*. 2003, Longshore *et al*. 2003, Lovich *et al*. 2014). Juveniles are especially vulnerable. With climate change and warming, droughts, including megadroughts lasting 10 years or more, are predicted to occur in coming years (U.S. Global Change Research Program 2017, Steiger *et al*. 2019).

11.3 Temperature Extremes

a. Tortoises are able to withstand the extremes of temperature experienced in the desert; however, increases in warm temperatures coupled with drying and changes in precipitation patterns present high risks to the species.

b. Ongoing and a growing issue, with climate change having negative impacts throughout the geographic range. Tortoises cope with the extremes of summer and winter temperatures (and lack of water, see 11.2) by using deep burrows and restricting above-ground activities and reproduction during drought. As temperatures rise with the rise in CO_2 and other greenhouse gases, tortoises will need to find habitats where deeper burrows can be excavated. At the higher temperatures, the spring season for foraging on ephemeral annuals and egg laying is likely to be shortened, reducing the time for eating, growing, and egg production. Sex of tortoises is determined by temperature of incubation in nests, with females produced at the higher temperatures and males at the lower temperatures. Eggs laid in nest that will experience the high temperatures of summer may be predominantly female, and if temperatures are excessive, may not be viable. Although the species could survive at higher (and cooler) elevations, the habitat in mountain ranges will be more limited, steep, rocky, with exposed bedrock in places with inadequate forage.

12.1 Other Threats
a. Climate Change.
b. Ongoing, see 11.2 and 11.3. Change in timing and amounts of precipitation coupled with increasing temperatures are likely to have profound negative effects on the species, further reducing available habitat (e.g., Barrows 2011). Profound changes are predicted to cause deterioration in composition, structure, diversity and biomass of trees and shrubs (Munson et al. 2016) that provide shade and cover to the tortoises. Barrows (2011) predicted that tortoises may survive if they move from the western Colorado Desert to higher elevations. However, the long-lived tortoises have strong fidelity to existing home ranges.

Conservation Actions (see Appendix for additional information)

Conservation Measures taken:

The first legal conservation measures for *Gopherus agassizii* came from the State of California in 1939 (California Department of Fish and Game Code 1939–1981). Additional protective regulations followed until *G. agassizii* was listed as threatened under the California Endangered Species Act in 1989 (California Dept. of Fish and Wildlife 2016). Federal legislation to protect *G. agassizii* first occurred in 1980 and was restricted to the Beaver Dam Slope population in Utah (USFWS 1980). In 1989–1990, *G. agassizii* was federally listed as threatened (USDI 1990 and references therein). The only population of *G. agassizii* that is not protected by the Endangered Species Act of 1973, as amended, is in the northwest corner of Arizona (Edwards *et al*. 2015). Recovery efforts have been underway since 1990. The U.S. Fish and Wildlife Service (USFWS 1994) published the first Recovery Plan in 1994, coupled with designations of critical habitat units by the U.S. Department of the Interior (USFWS 1994); this was followed by a revised Recovery Plan in 2011 (USFWS 2011), and regional Recovery Implementation Teams established in 2012. These teams are chaired by an employee of the USFWS Desert Tortoise Recovery Office, and are composed of federal, state, and county employees from the range of the desert tortoise, including representatives from local and national conservation and other stakeholder organizations.

The species is included in CITES Appendix II as part of Testudinidae spp., requiring that any commercial international trade be documented not to be detrimental to the survival of wild populations. CITES Trade records generally show very low levels of international exports of live animals; the vast majority of live traded Desert Tortoises are personal pets moving in-country with their owners, and many of the records in fact concern seizures of illegally transported specimens (CITES UNEP-WCMC trade database).

Conservation and recovery efforts began in the early 1970s, long before efforts of the federal actions by the USFWS in 1989–90. The Desert Tortoise Council formed in 1974-75 out of an interim recovery effort involving the four Southwestern states. This non-profit corporation was and continues to be dedicated to preserving representative populations of desert tortoises; educating the public; holding annual introductory workshops; and annual symposia to bring together representatives from government agencies, academia, and the public to learn and discuss important topics aimed at recovery of tortoise populations. The Desert Tortoise Council was instrumental in providing critical materials for federal and state listings of the species. The Desert Tortoise Preserve Committee, Inc., was formed in 1974 to establish protected areas for *G. agassizii*. This non-profit organization is a land trust and mitigation bank, a source of education, and research. They were instrumental in establishing the Desert Tortoise Research Natural Area and increasing its size.

Two preserves or protected areas exist with moderately high degrees of protection. One is the 100 km^2 (and increasing) Desert Tortoise Research Natural Area, which was formally designated by the U.S. Congress in 1980. It is fenced, with no vehicle access, livestock grazing, mining, or surface disturbances other than a few limited natural trails and a kiosk. The Natural Area is for wild tortoises only and populations are allowed to fluctuate naturally with no augmentation. Population density of adults throughout the Natural Area in 2011-12 was 10.2/km^2 (Berry et al. 2014a). The second preserve is Red Cliffs Desert Reserve in Utah (251 km^2). The Red Cliffs National Conservation Area provides additional protection for federal lands within the Reserve. Several paved roads, fenced and unfenced, run through the Reserve and recreation occurs throughout (e.g., hiking, horseback riding, mountain biking). The next and lower level of protection could be described as occurring within National Parks, State Parks, and National Recreation Areas such as Joshua Tree and Death Valley National Parks, Mojave National Preserve, Red Rock Canyon, Anza-Borrego, and Red Rocks State Parks, Lake Mead National Recreation Area, and the Beaver Dam Wash National Conservation Area. These parks and recreation areas have very high visitor use, unfenced paved roads, and some illegal collecting and release of captive tortoises of one or more species.

Twelve critical habitat units, the basis for Tortoise Conservation Areas (term defined in USFWS 2011), were designated by the USFWS (1994), and have far less protection than either the Desert Tortoise Research Natural Area or the Red Cliffs Desert Reserve and are subject to multiple land uses that fragment and degrade habitat and create vulnerabilities and risks to the tortoises (e.g., invasive non-native grasses and other non-native species; highways; roads; utility poles, towers, and electrical transmission lines; gas lines and fibreoptic cables; recreational vehicle use; shooting; domestic and feral dogs; cattle grazing and feral burros; mining; military installations; fire that causes degradation of habitat).

Seventeen monitored subpopulations in the 12 critical habitat units are contained within five recovery units which cover a total of 25,678 km^2. The following information for each recovery unit and the 17 Tortoise Conservation Areas reports area (km^2), and density of breeding adults per km^2 in 2014. Western Mojave Recovery Unit: Fremont-Kramer (2,347 km^2, 2.6/km^2), Ord-Rodman (852 km^2, 3.6/km^2), Superior-Cronese (3,094 km^2, 2.4/km^2); Colorado Desert Recovery Unit: Chocolate Mountains Aerial Gunnery Range (713 km^2, 7.2/km^2), Chuckwalla (2,818 km^2, 3.3/km^2), Chemehuevi (3,763 km^2, 2.8/km^2), Fenner (1,782 km^2, 4.8/km^2), Joshua Tree (1,152 km^2, 3.7/km^2), Pinto Mountain (508 km^2, 3.4/km^2), Piute Valley (927 km^2, 5.3/km^2); Eastern Mojave Recovery Unit: El Dorado Valley (999 km^2, 1.5/km^2), Ivanpah Valley (2,447 km^2, 2.3/km^2); Northeastern Mojave Recovery Unit: Beaver Dam Slope (750 km^2, 6.2/km^2), Coyote Spring (960 km^2, 4.0/km^2), Gold Butte (1,607 km^2, 2.7/km^2), Mormon Mesa (844 km^2, 6.4/km^2); Upper Virgin River Recovery Unit: Red Cliffs Desert Reserve (115 km^2, 15.3/km^2) (USFWS 2015; Allison and McLuckie 2018). The overall decline in tortoise populations in critical habitats (Tortoise Conservation Areas) between 2004 and 2014 was 32.2% (USFWS 2015). Four of the five recovery units are in a state of decline, with 11 of the 17 subpopulations registering declines in adult tortoises ranging from 26.6 to 64.7% during the 10 years (USFWS 2015). Most of the increasing subpopulations were in Nevada. Population densities for adults ranged from 1.5 to 7.2/km^2 in declining populations as of 2014 (USFWS 2015).

Extensive research has been published in peer-reviewed journals on many aspects of natural history, general ecology, physiological ecology, reproduction, health and diseases, population attributes, causes of death, movements and home range, predators, head-starting, translocation, and many other topics, making *G. agassizii* likely the most well-researched non-marine turtle species (Lovich and Ennen 2013b). Over 400 journal articles were published as of 2018, most between 1990 and 2018, as well as hundreds of reports (see three annotated bibliographies covering almost 160 years: Hohman *et al*. 1980, Grover and DeFalco 1995, Berry *et al*. 2016). Some information has been integrated into recovery programs, but many of the recovery measures recommended in the first Recovery Plan (USFWS 1994) have not been implemented as of 2020.

Economic relevance: The approximate cost of USD 100 million to develop and implement the first and second Recovery Plans is significant within the regulatory, scientific and local economic sectors involved and much remains to be implemented (USFWS 1994, 2011; Averill-Murray *et al*. 2012).

Conservation Measures needed:

The USFWS (1994) published recommended regulations for the areas that were designated as critical habitat. They described activities to be prohibited (e.g., all vehicle activity off designated roads; all competitive and organized recreational vehicle events on designated roads; habitat destructive military manoeuvres, clearing for agriculture, landfills and other surface disturbances; domestic livestock grazing, grazing by feral burros and horses; vegetation harvest; collection of biological specimens or vegetation harvest except by permit; dumping and littering; and deposition of captive or displace desert tortoises except under authorized translocation research projects; uncontrolled dogs out of vehicles; discharge of firearms except for hunting of game between September and February. There were many other recommended management actions but few of these recommendations were adopted when critical habitat units were officially described (USFWS 1994), and others have only been partially implemented by 2020. There were also recommendations for monitoring and research. In the second recovery plan, the USFWS (2011) identified and ranked (Darst *et al.* 2013) priority actions for recovering the Desert Tortoise and established regional Recovery Implementation Teams to implement these recovery actions. These Recovery Implementation Teams identify local, regional, and range-wide actions by submitting proposals to team members for discussion and prioritization. Ultimately the proposals are submitted to range-wide Management Oversight Groups composed of state, federal, and county government agencies for review, discussion, and potential sources of funding. Some projects are successfully funded and implemented, while many recommended in 1994 remain unfulfilled.

In association with the following standardized categories of Conservation Actions Needed, we provide

the following notes:

1.1. Land/water protection -> Site/area protection

a. Better protection of Critical habitats could ensure that populations of tortoises become stable and/or increase. Examples of protective measures included in recovery measures for the tortoise are exclusion fencing and culverts along highways and roads; reduction in populations of hyper-predators such as the Common Ravens; control and removal of newly introduced and previously existing non-native plants; and control of recreational vehicle use.

2.1. Land/water management -> Site/area management

a. The first recovery plan identified site-specific or critical habitat-specific measures to ensure protection of habitat and reduction of deaths of tortoises from anthropogenic sources (USFWS 1994). Most of these recommendations are still relevant. The Recovery Implementation Teams have provided recommendations similar to those in the first recovery plan. Many of these measures remain to be implemented. For example, in the State of California where most desert tortoise habitat and populations occur, acquisition of private land would be beneficial, because a substantial portion of habitat is in multiple private ownership. Both the USFWS and State of California recommend that developers of tortoise habitat acquire replacement habitat for habitat lost to development, and such actions have been occurring for ~20 years. Another topic and critical area that would benefit from protection is the population and hybrid zone with *G. morafkai* east of the Colorado River in Arizona (Edwards *et al*. 2015). This small population is not protected under the federal Endangered Species Act (Edwards *et al*. 2015).

2.2. Land/water management -> Invasive/problematic species control

a. Non-native grasses (e.g., *Schismus arabicus*, *S. barbatus*, *Bromus tectorum*, *B. madritensis rubens*) and forbs (e.g., *Brassica tournefortii*, *Hirschfeldia incana*) present serious and severe problems to tortoises because tortoises are selective in the choice of forage (Jennings and Berry 2015). The non-native annuals contribute to changes in forage availability, habitat structure, and increases in fire (D'Antonio and Vitousek 1992). These non-native species thrive under disturbance and spread via roads, livestock, military maneuvers, and disturbances created by recreational vehicle use off-road (e.g., D'Antonio and Vitousek 1992, Brooks and Berry 2006, Brooks *et al*. 2006, Brooks and Matchett 2006). The grasses are highly combustible and fire-prone in wildlands that did not evolve with short-term fire cycles (D'Antonio and Vitousek 1992). The grasses also compete with native annuals used as forage by the tortoises, and the species of grasses contain little nutrition, require water to metabolize, cause weight loss in the tortoises, and can become embedded in the jaws (Medica and Eckert 2007; Hazard *et al*. 2009, 2010; Drake *et al*. 2016). Similarly, *Brassica tournefortii* competes with native species used for forage and often occurs in dense stands, inhibiting movements of tortoises (Berry *et al*. 2014b).

3.2. Species management -> Species recovery

a. Species management and recovery are guided by the Recovery Plan and the U.S. Fish and Wildlife Service. On-the-ground management is by the administering agency, e.g., U.S. Bureau of Land Management, National Park Service, Department of Defense, States (for state land), and private owners. That being said, much can be done by implementing actions recommended in the first Recovery Plan (USFWS 1994) and by restoring degraded habitat (e.g., Abella and Berry 2016); controlling recreation vehicle use off-road and reducing fragmentation of habitat; limiting spread of invasive, non-native grasses and forbs; controlling hyper-predation in common ravens (USFWS 2008) and coyotes; preventing dogs and dog packs from running loose in the desert; and acquiring habitat.

4.3. Education & awareness -> Awareness & communications
a. See Conservation Actions in Place. Expansion of on-going programs to prevent take or shooting in the wild and release of captive tortoises of several species.

In association with the following standardized categories of Research Needed, we provide the following notes: While research on some topics is desirable, more is known about *G. agassizii* than most other reptiles (Lovich and Ennen 2013b, Berry *et al*. 2016 and references therein). Instead, implementation of previously identified actions to protect populations and habitat is more critical, specifically actions that will reduce deaths and loss or degradation of habitat.

1.1. Research -> Taxonomy
a. Genetic relationships between and within populations: human-mediated translocations of tortoises have occurred for decades, some authorized, some not (see Murphy et al. 2007). One recent question is the source of tortoises in Anza Borrego Desert State Park in the Colorado Desert of California. One might expect that the source would be tortoises occurring in the Colorado Desert, but instead tortoises have genotypes typical of the southwestern Mojave Desert population (Manning and Edwards 2019). More information on nearby tortoises (e.g. Lovich *et al.* 2020) occurring on the east-facing slopes of the Peninsular Range north of the Park may shed light on whether this is a naturally occurring population or a source that came from human-mediated translocations.
b. Translocation of thousands of tortoises has occurred in the last >20 years. Yet the only information available as to whether these translocated tortoises have been assimilated into the recipient or existing resident populations is research by Mulder *et al.* (2017) on assimilation of translocated males into the population of resident tortoises. Much more needs to be done on following males and females over a 10- to 20-year period to determine if and when adult males are assimilated into resident populations.

1.2. Research -> Population size, distribution & trends
a. More information on current population attributes such as size-age class structure, recruitment of juveniles into adult populations, sex ratios of adult tortoises, and causes and contributors to death is highly desirable. Landscape sampling undertaken and managed by the U.S. Fish and Wildlife Service's Desert Tortoise Recovery Office has provided valuable region-wide information on adult densities but not on other essential population attributes (i.e., Allison and McLuckie 2018). Resurvey of long-term, mark-recapture tortoise plots has been spotty for the past 20 years while support has increased for line-distance sampling representatively and on a landscape scale (see USFWS 2015, Allison and McLuckie 2018). Nonetheless, it is clear (USFWS 2011) that species recovery cannot be assumed based on patterns of adult counts alone, and active work to describe vital rates across the range will be an important part of assuring tortoise populations reflect healthy population dynamics or determining regional and size-specific recovery needs.

1.3. Research -> Life history & ecology
a. More information is needed on survival of neonate, juvenile, and immature size classes (first 12 to 15 years of life) and causes of mortality in the wild. Frequent input of new data on causes of and contributors to mortality for all size classes is essential for improving management of the species and for achieving upward trends.

1.5. Research -> Threats
a. The USFWS developed a model to identify major threats to the species (Darst *et al*. 2013); the information in this model is based on published research only, and not on the hundreds of reports and manuscripts available in Annual Reports to the USFWS on research permits. The model is outdated and needs major revisions to more accurately reflect available information and more recent priorities. In addition, support could be provided to speed up publication of important research projects that will lead to more protective management actions.

3.1. Monitoring -> Population trends
a. Monitoring is especially needed on population attributes in critical habitat, near highways, and in critical habitat near urban areas.

3.4. Monitoring -> Habitat trends
a. Monitoring is especially needed on wildfires, non-native plants, seed beds, and recovery of preferred forage plants.

Credits

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Bibliography

Abella, S.R. 2008. A systematic review of wild Burro grazing effects on Mojave Desert vegetation, USA. *Environmental Management* 41: 809–819.

Abella, S.R. and Berry, K.H. 2016. Enhancing and restoring habitat for the desert tortoise *Gopherus agassizii*. *Journal of Fish and Wildlife Management* 7: 1–25.

Agha, M., Lovich, J.E., Ennen, J.R., Augustine, B., Arundel, T.R., Murphy, M.O., Meyer-Wilkins, K., Bjurlin, C., Delaney, D., Briggs, J., Austin, M., Madrak, S.V. and Price, S.J. 2015. Turbines and terrestrial vertebrates: Variation in tortoise survivorship between a wind energy facility and an adjacent undisturbed wildland area in the desert Southwest (USA). *Environmental Management* 56: 332–341.

Allison, L. 2019. Translocations, changes in density, and survivorship in the large-scale translocation site, Nevada, 1997-2015. *44th Desert Tortoise Council Symposium 2019*: Abstract, pg. 3.

Allison, L. 2020. Survivorship of Resident and Translocated Tortoises from 2013-2018 in the Greater Trout Canyon Area, Nevada. *45th Desert Tortoise Council Symposium 2020*: Abstract, pg. 1.

Allison, L.J. and McLuckie, A.M. 2018. Population trends in Mojave Desert Tortoises (*Gopherus agassizii*). *Herpetological Conservation and Biology* 13(2): 433–452.

Anderson, K. and Berry, K.H. 2019. *Gopherus agassizii* (Agassiz's Desert Tortoise). Predation. *Herpetological Review* 50: 351.

Anonymous. 2018. *Wildlife officials find non-native tortoises in Red Cliffs Desert Reserv*. St. George Spectrum and Daily News, Oct. 21, 2018 online.

Averill-Murray, R.C., Darst, C.R., Field, K.J. and Allison, L.J. 2012. A new approach to conservation of the Mojave Desert tortoise. *BioScience* 62: 893–899.

Barrows, C.W. 2011. Sensitivity to climate change for two reptiles at the Mojave-Sonoran Desert interface. *Journal of Arid Environments* 75: 629–635.

Berry, K.H. 1986. Incidence of gunshot deaths in desert tortoises in California. *Wildlife Society Bulletin* 14: 127–132.

Berry, K.H. and Medica, P. 1995. Desert tortoises in the Mojave and Colorado deserts. In: E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran and M.J. Mac (eds), *Our Living Resources. A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems*, pp. 135–137. U.S. Department of the Interior, National Biological Service, Washington, DC.

Berry, K.H. and Murphy, R.W. 2019. *Gopherus agassizii* (Cooper 1861) – Mojave Desert Tortoise, Agassiz's Desert Tortoise. In: A.G.J. Rhodin, P.C.H. Pritchard, P.P. van Dijk, R.A. Saumure, K.A. Buhlmann, J.B. Iverson and R.A. Mittermeier (eds), *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*, Chelonian Research Monographs 5(13): 109.1–45. Chelonian Research Foundation, Lunenburg, MA, USA.

Berry, K.H., Bailey, T.Y. and Anderson, K.M. 2006. Attributes of desert tortoise populations at the National Training Center, Central Mojave Desert, California, USA. *Journal of Arid Environments* 67 (Supplement): 165–191.

Berry, K.H., Coble, A.A., Yee, J.L., Mack, J.S., Perry, W.M., Anderson, K.M. and Brown, M.B. 2015. Distance to human populations influences epidemiology of respiratory disease in desert tortoises. *Journal of Wildlife Management* 79: 122–136.

Berry, K.H. (ed.). 1984. The status of the desert tortoise (*Gopherus agassizii*) in the United States. Report to the U.S. Fish and Wildlife Service from the Desert Tortoise Council on Order No. 11310–0083–81.

Berry, K.H., Gowan, T.A., Miller, D.M. and Brooks, M.L. 2014b. Models of invasion and establishment for African mustard (*Brassica tourneforti*). *Invasive Plant Science and Management* 7: 599–616.

Berry, K.H., Hoover, F.G., and Walker, M. 1996. The effects of poaching desert tortoises in the Western Mojave Desert: Evaluation of landscape and local impacts. *Desert Tortoise Council Symposium Proceedings 1996*: Abstract 45.

Berry, K.H., Keith, K. and Bailey, T. 2008. Status of the desert tortoise in Red Rock Canyon State Park. *California Fish and Game* 94: 98–118.

Berry, K.H., Lyren, L.L., Yee, J.L. and Bailey, T.Y. 2014a. Protection benefits desert tortoise (*Gopherus agassizii*) abundance: the influence of three management strategies on a threatened species. *Herpetological Monographs* 28: 66–92.

Berry, K.H., Lyren, L.M., Mack, J.S., Brand, L.A. and Wood, D.A. 2016. Desert Tortoise Annotated Bibliography, 1991-2015. U.S. Geological Survey Open-File Report 2016-1023. 312 pp. Available at: http://dx.doi.org/10.3133/ofr20161023.

Berry, K.H., Spangenberg, E.K., Homer, B.L. and Jacobson, E.R. 2002. Deaths of desert tortoises following periods of drought and research manipulation. *Chelonian Conservation and Biology* 4: 436–448.

Berry, K.H., Yee, J.L. and Lyren, L.M. 2020c. Feral burros and other influences on desert tortoise presence in the western Sonoran Desert. *Herpetologica* 76(4): 403-413. DOI: 10.1655/Herpetologica-D-20-00023.1.

Berry, K.H., Yee, J.L., Shields, T.A. and Stockton, L. 2020a. The catastrophic decline of tortoises at a fenced Natural Area. *Wildlife Monographs* 205: 1-53. DOI: 10.1002/wmon.1052.

Berry, K.H., Yee, J., Lyren, L. and Mack, J.S. 2020b. An uncertain future for a population of desert tortoises experiencing human impacts. *Herpetologica* 76: 1-11.

Bjurlin, C.D. and Bissonette, J.A. 2004. Survival during early life stages of the desert tortoise (*Gopherus agassizii*) in the south-central Mojave Desert. *Journal of Herpetology* 38: 527–535.

Boarman, W.I. 1993. When a native predator becomes a pest: a case study. In: S.K. Majumdar, E.W. Miller, D.E. Baker, E.K. Brown, JR. Pratt and R.F. Schmalz (eds), *Conservation and Resource Management*, pp. 191–206. The Pennsylvania Academy of Science.

Boarman, W.I. and Berry, K.H. 1995. Common Ravens in the southwestern United States, 1968-92. In: E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D.Doran and M.J. Mac (eds), *Our Living Resources. A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems*, U.S. Department of the Interior, National Biological Service, Washington, DC.

Bowles, A.E., Eckert, S., Starke, L., Berg, E., Wolski, L. and Matesic Jr, J. 1999. Efffects of flight noise from jet aircraft and sonic booms on hearing, behavior, heart rate, and oxygen consumption of desert tortoises (*Gopherus agassizii*). U.S. Air Force Research Laboratory. AFRL-HE-WP-TR-1999, 131 pp.

Braun, J., Burgess, T., Witte, C., Lamberski, N. and Rideout, B. 2019. Assessment of Mojave desert tortoise health inside and outside the large scale translocation site. *Abstracts from the 44th Annual Meeting and Symposium of the Desert Tortoise Council held February 21-23, 2019, in Tucson, Arizona*: Abstract, pg. 6.

Brooks, M.L. 2003. Effects of increased soil nitrogen on the dominance of alien annual plants in the Mojave Desert. *Journal of Applied Ecology* 40: 344–353.

Brooks, M.L. and Berry, K.H. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. *Journal of Arid Environments* 67: 100–124.

Brooks, M.L. and Matchett, J.R. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980–2004. *Journal of Arid Environments* 67 (Supplement): 148–164.

Brooks, M.L., Matchett, J.R. and Berry, K.H. 2006. Effects of livestock watering sites on alien and native plants in the Mojave Desert, USA. *Journal of Arid Environments* 67 (Supplement): 125–147.

Burbey, T.J. 2002. The influence of faults in basin-fill deposits on land subsidence, Las Vegas Valley, Nevada, USA. *Hydrogeology Journal* 10: 525–538.

Burge, B.L. 1977. Movements and behavior of the desert tortoises, *Gopherus agassizi*. . M.S. Thesis, University of Nevada, Las Vegas.

Bury, R.B. and Corn, P.S. 1995. Have desert tortoises undergone a long-term decline in abundance? *Wildlife Society Bulletin* 23: 41–47.

Bury, R.B. and Luckenbach, R.A. 2002. Comparison of desert tortoise (Gopherus agassizii) populations in an unused and off-road vehicle area in the Mojave Desert. *Chelonian Conservation and Biology* 4: 457–463.

California Department of Fish and Game Code. 1939–1981. Legislative history and regulations, Sections 200–203.1, 206, 2078, 208–210, 5000–5002, 5060, 5061. California Fish and Game Code, Sacramento, USA.

California Department of Fish and Wildlife. 2016. State and federally listed endangered and threatened animals of California. California Department of Fish and Wildlife. Biogeographic Data Branch, California Natural Diversity Database, Sacramento, USA. Available at: https://www.wildlife.ca.gov/data/cnddb.

Chaffee, M.A. and Berry, K.H. 2006. Abundance and distribution of selected elements in soils, stream sediments, and selected forage plants from desert tortoise habitats in the Mojave and Colorado deserts, USA. *Journal of Arid Environments* 67: 35–87.

Christopher, M.M., Berry, K.H., Henen, B.T., and Nagy, K.A. 2003. Clinical disease and laboratory abnormalities in free-ranging desert tortoises in California (1990–1995). Journal of Wildlife Diseases 39:35–56.

Cooper, J.G. 1861. New Californian animals. *Proceedings of the California Academy of Sciences, San Francisco* 2: 118–123.

Daly, J.A., Buhlmann, K.A., Todd, B.D., Moore, C.T., Peaden, J.M. and Tuberville, T.D. 2019. Survival and movements of head-started Mojave desert tortoises. *Journal of Wildlife Management* 83: 1700–1710.

D'Antonio, C.M. and Vitousek, P.M. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. *Annual Reviews in Ecology and Systematics* 23: 63–87.

Darby, N., Hughson, D. and Gauthier, M. 2021. Recovery progress at Mojave National Preserve. 46th Annual Symposium of the Desert Tortoise Council (virtual). February 25, 2021. Abstract. Available at: https://www.deserttortoise.org..

Darst, C.R., Murphy, P.J., Strout, N.W., Campbell, S.P., Field, K.J., Allison, L.J. and Averill-Murray, R.C. 2013. A strategy for prioritizing threats and recovery actions for at-risk species. *Environmental Management* 51: 786-800.

Donoghue, S. 2006. Nutrition. In: D.R. Mader (ed.), *Reptile Medicine and Surgery*, pp. 251–298. Saunders Elsevier, Inc, USA.

Drake, K.K., Bowen, L, Nussear, K.E., Esque, T.C., Berger, A.J., Custer, N.A., Waters, S.C., Johnson, J.D., Miles, A.K. and Lewison, R.L. 2016. Negative impacts of invasive plants on conservation of sensitive desert wildlife. *Ecosphere* 7(10): e01531.

Edwards, T., Berry, K.H., Inman, R.D., Esque, T.C., Nussear, K.E., Jones, C.A. and Culver, M. 2015. Testing taxon tenacity of tortoises: evidence for a geographic selection gradient at a secondary contact zone. *Ecology and Evolution* 5: 2095–2114.

Edwards, T., Karl, A.E., Vaughn, M., Rosen, P.C., Melendez Torres, C. and Murphy, R.W. 2016. The desert tortoise trichotomy: Mexico hosts a third, new sister-species of tortoise in the *Gopherus morafkai–G. agassizii* group. *ZooKeys* 562: 131-158. doi: 10.3897/zookeys.562.6124.

Ennen, J.R., Lovich, J.E., Meyer, K.P., Bjurlin, C.D. and Arundel, T.R. 2012. Nesting ecology of a population of *Gopherus agassizii* at a utility-scale wind energy facility in southern California. *Copeia* 2012: 222–228.

Ernst, C.H. and Lovich, J.E. 2009. *Turtles of the United States and Canada. Second Edition*. Johns Hopkins University Press, Baltimore, Maryland.

Esque, T.C., Nussear, K.E., Drake, K.K., Walde, A.D., Berry, K.H., Averill-Murray, R.C., Woodman, A.P., Boarman, W.I., Medica, P.A., Mack, J. and Heaton, J.S. 2010. Effects of subsidized predators, resource variability, and human population density on Desert Tortoise populations in the Mojave Desert, USA. *Endangered Species Research* 12: 167–177.

Farnsworth, M.L., Dickson, B.G., Zachmann, L.J., Hegeman, E.E., Cangelosi, A.R., Jackson Jr, T.G. and Scheib, A.F. 20115. Short-term space-use patterns of translocated Mojave desert tortoise in Southern California. *PLoS ONE* 10: e0134250.

Field, K.J. 2019. History of the large-scale translocation study site in Nevada. *44th Desert Tortoise Council Symposium 2019*: Abstract, pp. 18-19.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8: 629–644.

Foster, A.L., Berry, K., Jacobson, E.R. and Rytuba, J.J. 2009. American Geophysical Union, Fall Meeting 2009. Abstract B32B-04.

Freilich, J.E., Burnham, K.P., Collins, C.M. and Garry, C.A. 2000. Factors affecting population assessments of desert tortoises. *Conservation Biology* 14: 1479–1489.

Germano, D.J. 1992. Longevity and age-size relationships of populations of desert tortoises. *Copeia* 1992(2): 367–374.

Grover, M.C. and DeFalco, L.A. 1995. Desert tortoise (*Gopherus agassizii*): Status-of-knowledge outline with references. U.S. Department of Agriculture, Forest Service. Intermountain Research Station. General Technical Report INT-GTR-316, 140 p.

Hardy, R. 1976. The Utah population – A look in the 1970's. *Desert Tortoise Council Symposium Proceedings 1976*: 84–88.

Hazard, L.C., Shemanski, D.R. and Nagy, K.A. 2009. Nutritional quality of natural foods of juvenile desert tortoises (*Gopherus agassizii*): energy, nitrogen, and fiber digestibility. *Journal of Herpetology* 43: 38–48.

Hazard, L.C., Shemanski, D.R. and Nagy, K.A. 2010. Nutritional quality of natural foods of juvenile and adult desert tortoises (*Gopherus agassizii*): calcium, phosphorus, and magnesium digestibility. *Journal of Herpetology* 44: 135–147.

Henen, B.T. 1997. Seasonal and annual energy budgets of female desert tortoises (*Gopherus agassizii*).

Ecology 78: 283–296.

Hohman, J.P., Ohmart, R.D. and Schwartzmann, J. 1980. *An Annotated Bibliography of the Desert Ttortoise (*Gopherus agassizi*)*. Desert Tortoise Council Special Publication No. 1.

Homer, B.L., Berry, K.H., Brown, M.B., Ellis, G. and Jacobson, E.R. 1998. Pathology of diseases in wild desert tortoises from California. *Journal of Wildlife Diseases* 34: 508–523.

Homer, B.L., Li, C., Berry, K.H., Denslow, N.D., Jacobson, E.R., Sawyer, R.H. and Williams, J.E. 2001. Soluble scute proteins of healthy and ill desert tortoises (*Gopherus agassizii*). *American Journal of Veterinary Research* 6s: 104-110.

Hughson, D.L. 2009. Human population in the Mojave Desert: resources and sustainability. In: R.H. Webb, L.F. Fenstermaker, J.S. Heaton, D.L. Hughson, E.V. McDonald and D.M. Miller (eds), *The Mojave Desert*, pp. 57–77. University of Nevada Press, Reno, Nevada.

Inman, R., Fotheringham, A.S., Franklin, J., Esque, T., Edwards, T. and Nussear, K. 2019. Local niche differences predict genotype associations in sister taxa of desert tortoise. *Diversity and Distributions* 25: 1194–1209.

IUCN. 2021. The IUCN Red List of Threatened Species. Version 2021-2. Available at: www.iucnredlist.org. (Accessed: 04 September 2021).

Iverson, J.B. 1992. *A Revised Checklist with Distribution Maps of the Turtles of the World*. Privately published, Richmond, Indiana.

Jacobson, E.R. and Berry, K.H. 2012. Mycoplasma testudineum in free-ranging desert tortoises, *Gopherus agassizii*. *Journal of Wildlife Diseases* 48: 1063–1068.

Jacobson, E.R., Berry, K.H., Stacy, B., Huzella, L.M., Kalasinsky, V.F., Fleetwood, M.L. and Mense, M.G. 2009. Oxalosis in wild desert tortoises, *Gopherus agassizii*. *Journal of Wildlife Diseases* 45: 982–988.

Jacobson, E.R., Berry, K.H., Wellehan Jr., J.F.X., Origgi, F., Childress, A.L., Braun, J., Schrenzel, M., Yee, J. and Rideout, B. 2012. Serologic and molecular evidence for Testudinid herpesvirus 2 infection in wild Agassiz's desert tortoises, *Gopherus agassizii*. *Journal of Wildlife Diseases* 4: :747–757.

Jacobson, E.R., Brown, M.B., Wendland, L.D., Brown, D.R., Klein, P.A., Christopher, M.M. and Berry, K.H. 2014. Mycoplasmosis and upper respiratory tract disease of tortoises: A review and update. *The Veterinary Journal* 201: 257–264.

Jacobson, E.R., Gaskin, J.M., Brown, M.B., Harris, R.K., Gardiner, C.H., LaPointe, J.L., Adams, H.P. and Reggiardo, C. 1991. Chronic upper respiratory tract disease of free-ranging desert tortoises (*Xerobates agassizii*). *Journal of Wildlife Diseases* 27: 296–316.

Jacobson, E.R., Heard, D. and Berry, K.H. 2013. Necropsies of a Russian Tortoise (*Testudo horsfieldii*) and Agassiz's desert tortoise (*Gopherus agassizii*) from California. Report to the U.S. Geological Survey, Riverside, California.

Jacobson, E.R., Wronski, T.J., Schumacher, J., Reggiardo, C. and Berry, K.H. 1994. Cutaneous dyskeratosis in free-ranging desert tortoises, *Gopherus agassizii*, in the Colorado Desert of southern California. *Journal of Zoo and Wildlife Medicine* 25: 68-81.

Jennings, W.B. 1993. Foraging ecology and habitat utilization of the desert tortoise (*Gopherus agassizii*) at the Desert Tortoise Research Natural Area, East Kern County, California. U.S. Bureau of Land Management, Riverside, California. Contract No B95-C2-0014.

Jennings, W.B. and Berry, K.H. 2015. Desert tortoises (*Gopherus agassizii*) are selective herbivores that track the flowering phenology of their preferred food plants. *PLoS ONE* 10(1): e0116716.

Keith, K., Berry, K.H. and Weigand, J. 2008. When desert tortoises are rare: testing a new protocol for assessing status. *California Fish and Game* 94: 75–97.

Kim, C.S., Anthony, T.L., Goldstein, D. and Rytuba, J.J. 2014. Windborne transport and surface enrichment of arsenic in semi-arid mining regions: Examples from the Mojave Desert, California. *Aeolian Research* 14: 85–96.

Kim, C.S., Stack, D.H. and Rytuba, J.J. 2012. Fluvial transport and surface enrichment of arsenic in semi-arid mining regions: examples from the Mojave Desert, California. *Journal of Environmental Monitoring* 14: 1798–1813.

Knight, R.L. and Kawashima, J.Y. 1993. Responses of Raven and Red-tailed Hawk populations to linear right-of-ways. *Journal of Wildlife Management* 57: 266–271.

Kristan III, W.B. and Boarman, W.I. 2003. Spatial pattern of risk of common raven predation on desert tortoises. *Ecology* 84: 2432–2443.

Lei, S.A. 2009. Rates of soil compaction by multiple land use practices in southern Nevada. In: R.H. Webb, L.F. Fenstermaker, J.S. Heaton, D.L. Hughson, E.V. McDonald and D.M. Miller (eds), *The Mojave Desert. Ecosystem Processes and Sustainability*, pp. 159–167. University of Nevada Press, Reno, Nevada.

Longshore, K.M., Jaeger, J.R. and Sappington, J.M. 2003. Desert tortoise (*Gopherus agassizii*) survival at two eastern Mojave Desert sites: Death by short-term drought? *Journal of Herpetology* 37: 169–177.

Lovich, J.E. and Ennen, J.R. 2013a. Assessing the state of knowledge of utility-scale wind energy development and operation on non-volant terrestrial and marine wildlife. *Applied Energy* 103: 52–60.

Lovich, J.E. and Ennen, J.R. 2013b. A quantitative analysis of the state of knowledge of turtles of the United States and Canada. *Amphibia-Reptilia* 34: 11–23.

Lovich, J.E., Edwards, T., Berry, K.H., Puffer, S.R., Cummings, K.L., Ennen, J.R., Agha, M., Woodard, R., Brundige, K.D. and Murphy, R.W. 2020. Refining genetic boundaries for Agassiz's desert tortoise (*Gopherus agassizii*) in the western Sonoran Desert: the influence of the Coachella Valley on gene flow among populations in southern California. *Frontiers of Biogeography* 12(3): 1–14.

Lovich, J.E., Ennen, J.R., Madrak, S., Meyer, K., Loughran, C., Bjurlin, C., Arundel, T., Turner, W., Jones, C. and Groenendaal, G.M. 2011. Effects of wind energy production on growth, demography and survivorship of a desert tortoise (*Gopherus agassizii*) population in southern California with comparisons to natural populations. *Herpetological Conservation and Biology* 6(2): 161-174.

Lovich, J.E., Ennen, J.R., Yackulic, C.B., Meyer-Wilkins, K, Agha, M., Loughran, C., Bjurlin, C., Austin, M. and Madrak, S. 2015. Not putting all their eggs in one basket: bet-hedging despite extraordinary annual reproductive output of desert tortoises. *Biological Journal of the Linnean Society* 115: 399–410.

Lovich, J.E., Yackulic, C.B., Freilich, J.E., Agha, M., Austin, M., Meyer, K.P., Arundel, T.R., Hansen, J., Vamstad, M.S. and Root, S.A. 2014. Climatic variation and tortoise survival: Has a desert species met its match? *Biological Conservation* 169: 214–224.

Mack, J.S., Schneider, H.E. and Berry, K.H. 2018. Crowding affects health, growth, and behavior in headstart pens for Agassiz's desert tortoise. *Chelonian Conservation and Biology* 17: 14–26.

Manning, J.A. and Edwards, T. 2019. Genetic origins and population status of desert tortoises in Anza-Borrego Desert State Park, California. *44th Symposium of the Desert Tortoise Council*: Abstracts pp. 31-32.

McLuckie, A.M. and Fridell, R.A. 2002. Reproduction in a desert tortoise (*Gopherus agassizii*) population on the Beaver Dam Slope, Washington County, Utah. *Chelonian Conservation and Biology* 4: 288–294.

McLuckie, A.M., Fridell, R.A., Kellam, J.O., Schijf, M.J. and Rognan, C.B. 2021. Fire mortality within the Red Cliffs Desert Reserve. 46th Annual Desert Tortoise Council Symposium (virtual), February 18th, 2021. Abstracts. Available at: https://www.deserttortoise.org.

McLuckie, A.M., Fridell, R.A., Schiif, M.J. and Rognan, C.B. 2019. Status of translocated tortoises in southwest Utah: A summary of growth, movement and survival. *44th Symposium of the Desert Tortoise Council 2019*: Abstracts, pg. 33.

McLuckie, A.M., Lamb, T., Schwalbe, C.R. and McCord, R.D. 1999. Genetic and morphometric assessment of an unusual tortoise (*Gopherus agassizii*) population in the Black Mountains of Arizona. *Journal of Herpetology* 33: 36–44.

Medica, P.A. and Eckert, S.E. 2007. *Gopherus agassizii* (Desert Tortoise). Food/mechanical injury. *Herpetological Review* 38: 445-447.

Medica, P.A., Nussear, K.E., Esque, T.C. and Saethre, M.B. 2012. Long-term growth of desert tortoises (*Gopherus agassizii*) in a southern Nevada population. *Journal of Herpetology* 46: 213–220.

Mueller, J.M., Sharp, K.R., Zander, K.K., Rakestraw, D.L., Rautenstrauch, K.R. and Lederle, P.E. 1998. Size-specific fecundity of the desert tortoise (*Gopherus agassizii*). *Journal of Herpetology* 32(3): 313–319.

Mulder, K.P., Walde, A.D., Boarman, W.I., Woodman, A.P., Latch, E.K. and Fleischer, R.C. 2017. No paternal genetic integration in desert tortoises (*Gopherus agassizii*) following translocation into an existing population. *Biological Conservation* 210: 318–324.

Munson, S.M., Long, A.L., Wallace, C.S.A. and Webb, R.H. 2016. Cumulative drought and land-use impacts on perennial vegetation across a North American dryland region. *Applied Vegetation Science* 19: 430–441.

Murphy, R.W., Berry, K.H., Edwards, T. and McLuckie, A.M. 2007. A genetic assessment of the recovery units for the Mojave population of the desert tortoise, *Gopherus agassizii*. *Chelonian Conservation and Biology* 6: 229–251.

Murphy, R.W., Berry, K.H., Edwards, T., Leviton, A.E., Lathrop, A. and Riedle, J.D. 2011. The dazed and confused identity of Agassiz's land tortoise, *Gopherus agassizii* (Testudines, Testudinidae) with the description of a new species, and its consequences for conservation. *ZooKeys* 113: 39–71.

Nafus, M.G., Esque, T.C., Averill-Murry, R.C., Nussear, K.E. and Swaisgood, R.R. 2016. Habitat drives dispersal and survival of translocated juvenile desert tortoises. *Journal of Applied Ecology* 54(2): 430-438. DOI:10.1111/1365-2664.12774.

Nagy, K.A., Hillard, L.S., Tuma, M.W. and Morafka, D.J. 2015b. Head-started Desert Tortoises (*Gopherus agassizii*): movements, survivorship and mortality causes following their release. *Herpetological Conservation and Biology* 10: 203–215.

Nagy, K.A., Hillard, S., Dickson, S. and Morafka, D.J. 2015a. Effects of artificial rain on survivorship, body condition, and growth of head-started desert tortoises (*Gopherus agassizii*) released to the open desert. *Herpetological Conservation and Biology* 10: 535–549.

Nelson, B. 2010. Huge 100-pound African tortoise found roaming Arizona desert. Mother Nature Network. Available at: https://www.mnn.com/. (Accessed: 21 December 2010).

Nussear, K.E., Tracy, C.R., Medica, P.A., Wilson, D.S., Marlow, R.W. and Corn, P.S. 2012. Translocation as a conservation tool for Agassiz's desert tortoises: survivorship, reproduction, and movements. *Journal of*

Wildlife Management 76: 1341–1353.

Oftedal, O.T. 2002. Nutritional ecology of the desert tortoise in the Mojave and Sonoran deserts. In: T.R. Van Devender (ed.), *The Sonoran Desert Tortoise: Natural History, Biology and Conservation*, pp. 194–241. The University of Arizona Press and the Arizona-Sonora Desert Museum, Tucson, Arizona.

Oftedal, O.T., Hillard, S. and Morafka, D.J. 2002. Selective spring foraging by juvenile desert tortoises (*Gopherus agassizii*) in the Mojave Desert: Evidence of an adaptive nutritional strategy. *Chelonian Conservation and Biology* 4: 341–352.

Ottley, J.R. and Velázques Solis, V.M. 1989. An extant, indigenous tortoise population in Baja California Sur, Mexico, with the description of a new species of *Xerobates* (Testudines: Testudinidae). *Great Basin Naturalist* 49: 496–502.

Prose, D.V. 1985. Persisting effects of armored military maneuvers on some soils of the Mojave Desert. *Environmental Geology and Water Sciences* 7: 163–170.

Prose, D.V. 1986. Map of areas showing visible land disturbances caused by two military training exercises in the Mojave Desert, California. U.S. Geological Survey Miscellaneous Field Studies, Map MF-1855, Reston, Virginia.

Prose, D.V. and Wilshire, H.G. 2000. The lasting effects of tank maneuvers on desert soils and intershrub flora. U.S. Geological Survey, Open-File Report OF 00-512.

Provencher, L., Tuhy, J., York, E., Green, G. and Anderson, T. 2011. Landscape Conservation Forecasting for Washington County’s National Conservation Areas. Report to the St. George Field Office, BLM. The Nature Conservancy, Reno, Nevada.

Rao, L.E. and Allen, E.B. 2010. Combined effects of precipitation and nitrogen deposition on native and invasive winter annual production in California deserts. *Oecologia* 162: 1035–1046.

Rautenstrauch, K.R. and O'Farrell, T.P. 1998. Relative abundance of desert tortoises on the Nevada Test Site. *Southwestern Naturalist* 43: 407–411.

Rostal, D.C., Lance, V.A., Grumbles, J.S. and Alberts, A.C. 1994. Seasonal reproductive cycle of the desert tortoise (*Gopherus agassizii*) in the eastern Mojave Desert. *Herpetological Monographs* 8: 72–82.

Rostal, D.C., Wibbels, T., Grumbles, J.S., Lance, V.A. and Spotila, J.R. 2002. Chronology of sex determination in the desert tortoise (*Gopherus agassizii*). *Chelonian Conservation and Biology* 4(2): 313–318.

Sadoti, G., Gray, M.E., Farnsworth, M.L. and Dickson, B.G. 2017. Discriminating patterns and drivers of multiscale movement in herpetofauna: The dynamic and changing environment of the Mojave desert tortoise. *Ecology and Evolution* 7(17): 7010-7022. DOI: 10.1002/ece3.3235.

Selzer, M.D. and Berry, K.H. 2005. Laser ablation ICP-MS profiling and semiquantitative determination of trace element concentrations in desert tortoise shells: documenting the uptake of elemental toxicants. *Science of the Total Environment* 339: 253–265.

Stamos, C.L., Nishikawa, T. and Martin, P. 2001. Water supply in the Mojave River ground-water basin, 1931-00, and the benefits of artificial recharge. U.S. Geological Survey Fact Sheet 122-0.

Stebbins, R.C. 1966. *A Field Guide to Western Reptiles and Amphibians*. Houghton Mifflin, Boston.

Stebbins, R.C. 2003. *A Field Guide to Western Reptiles and Amphibians. 3rd ed*. Houghton Mifflin Co., New York, New York.

Steiger, N.J., Smerdon, J.E., Cook, B.I., Seager, R., Williams, A.P. and Cook, E.R. 2019. Oceanic and radiative forcing of medieval megadroughts in the American Southwest. *Science Advances* 5: eax0087.

Tracy, C.R., Averill-Murray, R.C., Boarman, W.I., Delehanty, D., Heaton, J.S., Mccoy, E.D., Morafka, D.J., Nussear, K.E., Hagerty, B.E. and Medica, P.A. 2004. Desert Tortoise Recovery Plan Assessment. Report to the U.S. Fish and Wildlife Service, Reno, Nevada.

TTWG (Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Bour, R. Fritz, U., Georges, A., Shaffer, H.B. and van Dijk, P.P.). 2017. Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (8th Ed.). In: Rhodin, A.G.J., Iverson, J.B., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Pritchard, P.C.H., and Mittermeier, R.A. (eds), *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*, pp. 1-292. Chelonian Research Monographs.

Tuberville, T.D., Buhlmann, K.A., Sollmann, R., Nafus, M.G., Peaden, J.M., Daly, J.A. and Todd, B.D. 2019. Effects of short-term, outdoor head-starting on growth and survival in the Mojave desert tortoise (*Gopherus agassizii*). *Herpetological Conservation and Biology* 14: 171–184.

Tuma, M.W., Millington, C., Schumaker, N. and Burnett, P. 2016. Modeling Agassiz's Desert Tortoise population response to anthropogenic stressors. *Journal of Wildlife Management* 80: 414–429.

Turner, F.B., Berry, K.H., Randall, D.C. and White, G.C. 1987. Population ecology of the desert tortoise at Goffs, California, 1983–1986. Report to the Southern California Edison Company, Research and Development Series 87-RD-81.

Turner, F.B., Medica, P.A. and Lyons, C.L. 1984. Reproduction and survival of the desert tortoise (*Scaptochelys agassizii*) in Ivanpah Valley, California. *Copeia* 1984(4): 811–820.

USBLM [U.S. Bureau of Land Management]. 1980. The California Desert Conservation Area Plan, 1980. Department of the Interior, Bureau of Land Management, Sacramento, California.

USBLM (U.S. Bureau of Land Management). 2019. West Mojave Route Network Project. and Final Supplemental Environmental Impact Statement for the California Desert District. Moreno Valley, California. BLM/CA/DOI-BLM-CA-D080-2018-0008-EIS.

U.S. Census Bureau. 2010. Available at: www.census.gov.

USDD (U.S. Dept. of Defense, Dept. of the Navy). 2017. Record of Decision on the Supplemental environmental impact statement for land acquisition and airspace establishment to support large-scale Marine Air Ground Task Force live-fire and maneuver training at Marine Corps Air Ground Combat Center, Twentynine Palms, California. 10 February 2017.

USFWS (U.S. Fish and Wildlife Service). 1980. Endangered and threatened wildlife and plants: Listing as threatened with critical habitat for the Beaver Dam Slope population of the desert tortoise in Utah. *Federal Register* 45: 55654–55666.

USFWS (U.S. Fish and Wildlife Service). 1985. Endangered and threatened wildlife and plants: finding on desert tortoise petition. *Federal Register* 50: 49868–49870.

USFWS (U.S. Fish and Wildlife Service). 1989. Endangered and threatened wildlife and plants; emergency determination of endangered status for the Mojave population of the desert tortoise. *Federal Register* 54: 32326.

USFWS (U.S. Fish and Wildlife Service). 1990. Endangered and threatened wildlife and plants: determination of threatened status for the Mojave population of the desert tortoise. *Federal Register* 55: 12178–12191.

USFWS (U.S. Fish and Wildlife Service). 1994. Desert tortoise (Mojave population) Recovery Plan. U.S. Depart of the Interior, Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2008. Environmental Assessment to implement a desert tortoise recovery plan task: Reduce Common Raven predation on the desert tortoise. Final. U.S. Department of the Interior, Fish and Wildlife Service, Ventura, California.

USFWS (U.S. Fish and Wildlife Service). 2010. Mojave Population of the Desert Tortoise (*Gopherus agassizii*). 5-Year Review: Summary and Evaluation. Desert Tortoise Recovery Office, U.S. Department of the Interior, Fish and Wildlife Service, Reno, Nevada.

USFWS (U.S. Fish and Wildlife Service). 2011. Revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*). U.S. Department of the Interior, Fish and Wildlife Service, Reno, Nevada, USA.

USFWS (U.S. Fish and Wildlife Service). 2015. Range-wide Monitoring of the Mojave Desert Tortoise (*Gopherus agassizi*i): 2013 and 2014. Annual Report. U.S. Department of the Interior, Fish and Wildlife Service, Reno, Nevada, USA.

USGAO (US General Accounting Office). 2002. Endangered Species: Research Strategy and Long-Term Monitoring Needed for the Mojave Desert Tortoise Recovery Program. Report no. GAO-03-23. Available at: www.fws.gov/nevada/desert_tortoise/dt_reports.html. (Accessed: 27 July 2012).

U.S. Global Change Research Program. 2017. Climate Science Special Report: fourth National Climate Assessment, Volume 1 (Wuebbles, D.J., Fahey, D.W., Hibbard, K.A., Dokken, D.J., Stewart, B.C., and Maycock, T.K. [eds.]. U.S. Global Change Research Program, Washington DC.

von Seckendorff Hoff, K. and Marlow, R.W. 2002. Impacts of vehicle road traffic on desert tortoise populations with consideration of conservation of tortoise habitat in southern Nevada. *Chelonian Conservation and Biology* 4(2): 449–456.

Walde, A.D., Harless, M.L., Delaney, D. and Pater, L.L. 2007. Anthropogenic threat to the Desert Tortoise (*Gopherus agassizii*): litter in the Mojave Desert. *Western North American Naturalist* 67: 147–149.

Wallis, I.R., Henen, B.T. and Nagy, K.A. 1999. Egg size and annual egg production by female desert tortoises (*Gopherus agassizii*): The importance of food abundance, body size, and date of egg shelling. *Journal of Herpetology* 33: 394–408.

Webb, R.H. and Stielstra, S.S. 1979. Sheep grazing effects on Mojave Desert vegetation and soils. *Environmental Management* 3: 517–529.

Webb, R.H. and Wilshire, H.G. (eds). 1983. *Environmental Effects of Off-Road Vehicles*. Springer Verlag, New York.

Winters, J.M., Wellehan, J.F.X., Apakupakul, K., Palmer, J, Brenn-White, M., Standorf, K., Berry, K.H., Childress, A.L., Koplos, P., Garner, M.M. and Deem, S.L. In preparation. A novel herpesvirus detected in three different species of chelonians.

Woodbury, A.M. and Hardy, R. 1948. Studies of the desert tortoise, *Gopherus agassizii. Ecological Monographs* 18: 145-200.

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External Resources

For Supplementary Material, and for Images and External Links to Additional Information, please see the Red List website.

Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
3. Shrubland -> 3.4. Shrubland - Temperate	-	Suitable	Yes

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
1. Residential & commercial development -> 1.1. Housing & urban areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.2. Commercial & industrial areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.3. Tourism & recreation areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 1. Ecosystem stresses -> 1.3. Indirect ecosystem effects 2. Species Stresses -> 2.1. Species mortality 2. Species Stresses -> 2.2. Species disturbance		
2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.2. Small-holder farming	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.3. Agro-industry farming	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.2. Small-holder grazing, ranching or farming	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.3. Agro-industry grazing, ranching or farming	Ongoing	Majority (50-90%)	Slow, significant declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		

3. Energy production & mining -> 3.1. Oil & gas drilling	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
3. Energy production & mining -> 3.2. Mining & quarrying	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
3. Energy production & mining -> 3.3. Renewable energy	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
4. Transportation & service corridors -> 4.1. Roads & railroads	Ongoing	Majority (50-90%)	Slow, significant declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.1. Species mortality		
4. Transportation & service corridors -> 4.2. Utility & service lines	Ongoing	Whole (>90%)	Slow, significant declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
5. Biological resource use -> 5.1. Hunting & trapping terrestrial animals -> 5.1.1. Intentional use (species is the target)	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	2. Species Stresses -> 2.1. Species mortality		
6. Human intrusions & disturbance -> 6.1. Recreational activities	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
6. Human intrusions & disturbance -> 6.2. War, civil unrest & military exercises	Ongoing	Minority (50%)	Causing/could cause fluctuations	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
6. Human intrusions & disturbance -> 6.3. Work & other activities	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
7. Natural system modifications -> 7.1. Fire & fire suppression -> 7.1.1. Increase in fire frequency/intensity	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.1. Species mortality		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.8. Abstraction of ground water (unknown use)	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		

8. Invasive and other problematic species, genes & diseases -> 8.1. Invasive non-native/alien species/diseases -> 8.1.1. Unspecified species	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
8. Invasive and other problematic species, genes & diseases -> 8.3. Introduced genetic material	Ongoing	Minority (50%)	Negligible declines	Low impact: 4
	Stresses:	2. Species Stresses -> 2.3. Indirect species effects		
8. Invasive and other problematic species, genes & diseases -> 8.5. Viral/prion-induced diseases -> 8.5.1. Unspecified species	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	2. Species Stresses -> 2.1. Species mortality		
9. Pollution -> 9.2. Industrial & military effluents -> 9.2.2. Seepage from mining	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
11. Climate change & severe weather -> 11.1. Habitat shifting & alteration	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
11. Climate change & severe weather -> 11.2. Droughts	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		

Conservation Actions in Place

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action in Place
In-place research and monitoring
Action Recovery Plan: Yes
Systematic monitoring scheme: Yes
In-place land/water protection
Conservation sites identified: Yes, over entire range
Area based regional management plan: Yes
Occurs in at least one protected area: Yes
Invasive species control or prevention: Yes
In-place species management
Harvest management plan: No
Successfully reintroduced or introduced benignly: Yes
Subject to ex-situ conservation: Unknown
In-place education
Subject to recent education and awareness programmes: Yes

Conservation Action in Place
Included in international legislation: Yes
Subject to any international management / trade controls: Yes

Conservation Actions Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action Needed
1. Land/water protection -> 1.1. Site/area protection
2. Land/water management -> 2.1. Site/area management
2. Land/water management -> 2.2. Invasive/problematic species control
3. Species management -> 3.2. Species recovery
4. Education & awareness -> 4.3. Awareness & communications

Research Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Research Needed
1. Research -> 1.1. Taxonomy
1. Research -> 1.2. Population size, distribution & trends
1. Research -> 1.3. Life history & ecology
1. Research -> 1.5. Threats
1. Research -> 1.6. Actions
3. Monitoring -> 3.1. Population trends
3. Monitoring -> 3.4. Habitat trends

Additional Data Fields

Distribution
Estimated area of occupancy (AOO) (km^2): 116993
Continuing decline in area of occupancy (AOO): Yes
Estimated extent of occurrence (EOO) (km^2): 166000
Continuing decline in extent of occurrence (EOO): Yes
Upper elevation limit (m): 1,570

Population
Population severely fragmented: Yes
Habitats and Ecology
Continuing decline in area, extent and/or quality of habitat: Yes
Generation Length (years): 20-32,30

The IUCN Red List Partnership

The IUCN Red List of Threatened Species™ is produced and managed by the IUCN Global Species Programme, the IUCN Species Survival Commission (SSC) and The IUCN Red List Partnership.

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