



Department of Defense Legacy Resource Management Program

Recommended Best Management Practices for the Gopher Tortoise (*Gopherus polyphemus*) on Department of Defense Installations

Department of Defense Partners in Amphibian and Reptile Conservation



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Introduction

Gopher Tortoise (*Gopherus polyphemus*) populations west of the Mobile and Tombigbee rivers (LA, MS, west AL) are federally listed as Threatened under the Endangered Species Act (ESA). Elsewhere—as of 2021—the tortoise is considered an at-risk species that is a Candidate for listing by the U.S. Fish and Wildlife Service (USFWS). The Department of Defense (DoD), through its Partners in Amphibian and Reptile Conservation (PARC) network, and the USFWS have developed these Best Management Practices (BMPs) for the Gopher Tortoise. The management practices described in this document were developed specifically for DoD installations but are also suitable for implementation throughout the range of this species.

These BMPs are intended as guidelines for resource managers to plan, prioritize, and implement management for the conservation benefit of the Gopher Tortoise, while also providing information to comply with regulatory processes such as Environmental Protection Agency’s National Environmental Policy Act (NEPA) and associated components (i.e., Environmental Assessments and Environmental Impact Statements). Implementation of these BMP guidelines should support military readiness activities, be documented in installation Integrated Natural Resource Management Plans (INRMPs), and should align with existing efforts among the DoD, federal/state agencies, and non-governmental organizations to prevent this species’ decline and preclude further ESA listing.

Species Profile

Description: Gopher Tortoises are terrestrial turtles. Adults vary in size, averaging 10 inches (25 cm). Shells of adults (Figures 1 and 4) are tan, brown, or gray. Hind feet are stumpy and elephantine; forelimbs are adapted for digging. Hatchlings (Figure 2) and juveniles have yellow-orange blotches that fade with age. Sexual maturity is reached in about a decade in southern populations; two decades in the northern part of the range (Tuberville et al. 2009). Gopher Tortoises can live 60 to 80 years. Adult males have a concavity in the plastron (lower shell); females have a flat plastron. The presence of Gopher Tortoises is relatively easy to detect due to the conspicuous and distinctive burrows they create (Figures 3 and 4).



Figure 1. Adult Gopher Tortoise



Figure 2. Hatchling Gopher Tortoise



Figure 3. Active Gopher Tortoise burrow



Figure 4. Adult Gopher Tortoise at burrow entrance

Range: The Gopher Tortoise occurs in the Gulf and Atlantic Coastal Plains in six states: southeastern Louisiana, southeastern Mississippi, southern Alabama, southern Georgia, Florida (with the exception of southern portions of the state), and southwestern South Carolina (Figure 5).

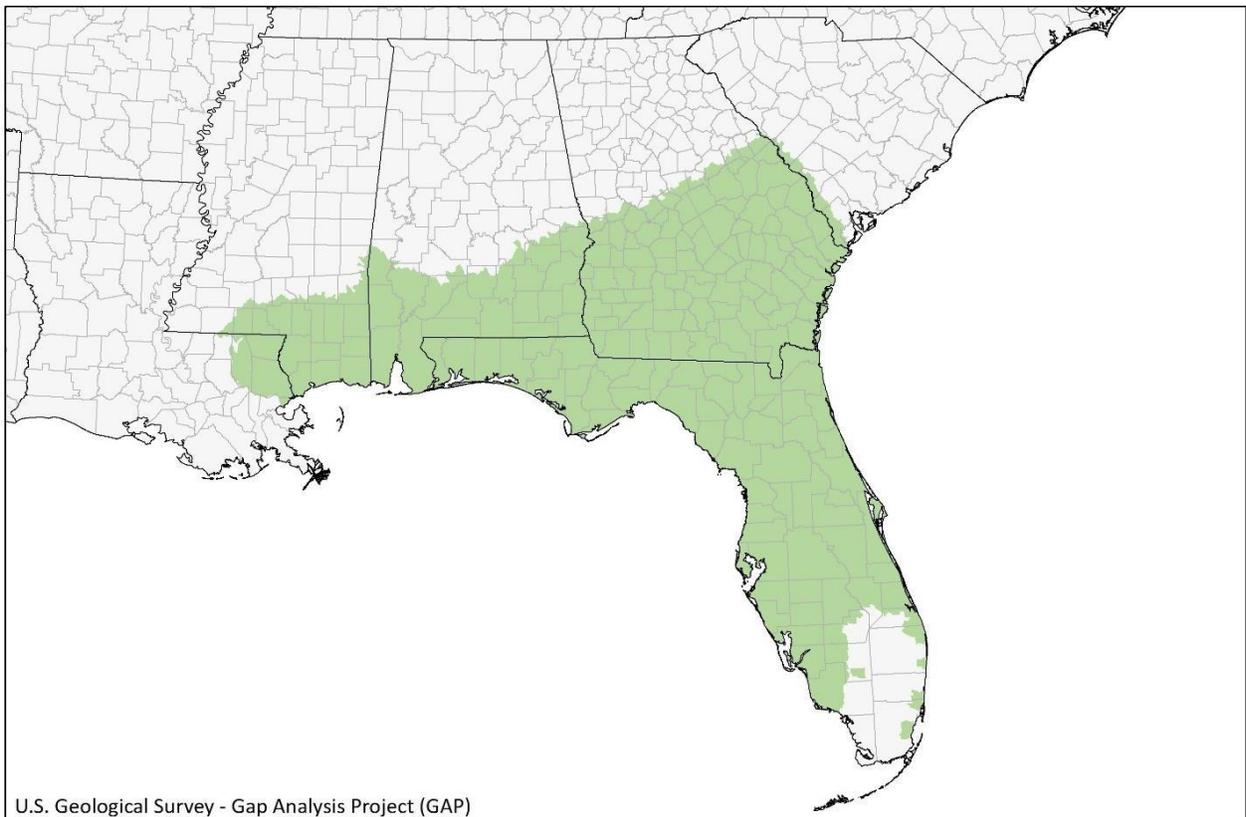


Figure 5. Approximate range of the Gopher Tortoise. U.S. Geological Survey (USGS) - Gap Analysis Project (GAP), 2018, Gopher Tortoise (*Gopherus polyphemus*) rGOTOx_CONUS_2001v1 Range Map: U.S. Geological Survey data release, <https://doi.org/10.5066/F7TT4Q2F>

Distribution on Military Sites: The Gopher Tortoise is confirmed present on the following 31 military sites:

- Air Force: Avon Park Air Force Range (FL); Cape Canaveral Air Force Station (FL); Eglin Air Force Base (FL); Hurlburt Field (FL); MacDill Air Force Base (FL); Moody Air Force Base (GA); Patrick Air Force Base (FL); Patrick Air Force Base-Jonathan Dickinson Missile Tracking Annex (FL); Patrick Air Force Base-Malabar Transmitter Annex (FL); Tyndall Air Force Base (FL)
- Army: Fort Benning (AL/GA); Fort Gordon (GA); Fort Rucker (AL); Fort Stewart (GA); Camp Blanding Joint Training Center (FL); Camp Shelby Joint Forces Training Center (MS)
- Marine Corps: Marine Corps Logistics Base Albany (GA); Marine Corps Recruit Depot Parris Island (SC); Marine Corps Support Facility Blount Island (FL); Townsend Bombing Range (GA)
- Navy: Naval Air Station Jacksonville (FL); Naval Air Station Jacksonville-OLF Whitehouse (FL); Naval Air Station Jacksonville-Rodman Bombing Target Range (FL); Naval Air Station Pensacola (FL); Naval Air Station Pensacola-Saufley Field (FL); Naval Air Station Pensacola-Naval Outlying Field Bronson Field (FL); Naval Air Station Whiting Field (FL); Naval Air Station Whiting Field-Outlying Land Field Holley (FL); Naval Station Mayport (FL); Naval Support Activity Orlando (FL); Naval Submarine Base Kings Bay (GA)

The Gopher Tortoise is considered unconfirmed, but potentially present on the following military sites. For these particular sites, specimens have been found in the same county, but not within the boundaries of the installation.

- Air Force: Jacksonville Air National Guard (FL)
- Army: Camp Villere (LA)
- Marine Corps: Marine Corps Air Station Beaufort (SC)
- Navy: Naval Air Station Whiting Field-NOLF Evergreen (AL); NOLF Harold (FL); NOLF Pace (FL); NOLF Santa Rosa (FL); NOLF Spencer (FL); NOLF Wolf (AL); Naval Station Mayport-Greenfield Plantation (FL); Naval Station Mayport-Naval Fuel Depot (FL); Naval Station Mayport-Ribault Bay Village Housing (FL); Naval Support Activity Panama City (FL)

Habitat: Gopher Tortoises are found in uplands, especially those with relatively well-drained, sandy soils. Frequent fire (or a fire surrogate, like mowing) is required to maintain viable populations. Habitats include longleaf pine (*Pinus palustris*)-turkey oak (*Quercus laevis*) sandhills, scrub, xeric hammock, pine flatwoods, dry prairie, coastal grasslands and dunes, mixed hardwood-pine communities, and a variety of disturbed habitats (Auffenberg and Franz

1982). Diverse herbaceous ground cover is needed for foraging, and open, sunlit areas are required for nesting. Where fire suppression has led to canopies becoming too dense, tortoises may be displaced to roadsides and transmission line rights of way where they can find herbaceous ground cover and sun exposure. Current evidence suggests populations in fire-suppressed areas are unlikely to be viable.

Gopher Tortoises excavate long, deep burrows that provide protection from extreme temperatures, predators, and fire. Many burrows are excavated over a lifetime, and a tortoise typically uses 3 to 10 each year. Tortoise burrows, both occupied and abandoned, provide an important landscape feature used by other species of conservation concern including Gopher Frogs (*Rana sevosia*, *Rana capito*), Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*), and Eastern Indigo Snakes (*Drymarchon couperi*).

Behavior: Gopher Tortoises spend most of their time in a burrow, with occasional emergence during the day to bask, feed, and reproduce. Except for south Florida, where breeding may be year-round, breeding occurs from March through October. Females nest in May or June, typically burying four to ten eggs in the soil at the mouth of the burrow. The number of eggs produced is thought to be lower in poor-quality sites and greater in high-quality sites. Hatchlings emerge in late August or early September.

Home range size and movements increase with age and body size, and home range area tends to vary with habitat quality, becoming larger in areas of poor habitat (Guyer et al. 2012). Males typically have larger home ranges than females. Mean home ranges in Alabama, Florida, and Georgia outside the federally listed area have varied from 1.3 to 5.2 acres (2.2 to 3.2 ha) for males and 0.2 to 2.5 acres (0.09 to 1.0 ha) for females (Auffenberg and Franz 1982; Castellón et al. 2018; Diemer 1992; Guyer 2003; McRae et al. 1981). In poor quality habitats female home ranges expand to be nearly as large as those of males (Guyer et al. 2012)

Threats: Primary threats to Gopher Tortoises include 1) destruction or degradation of habitat, including residential and commercial development (urban sprawl), conversion of open longleaf pine woodlands to other silvicultural or agricultural land use, phosphate and sand mining, solar farms, shrub and midstory encroachment from lack of fire or insufficient fire; 2) fragmentation by roads which results in road mortality as well as reproductive isolation; and 3) establishment and spread of invasive species (Means and Grow 1985, USFWS 2013). In addition, the introduction of noxious fumes (typically gasoline) which is sometimes used to drive rattlesnakes from burrows, can result in Gopher Tortoise mortality (Means 2009). Predation on eggs and hatchlings by imported red imported fire ants (*Solenopsis invicta*) can limit or prevent reproduction. Mammalian predators such as raccoons (*Procyon lotor*), coyotes (*Canis latrans*), feral pigs (*Sus scrofa*), and free-ranging dogs can have significant impacts, especially on nests and younger tortoises. Human predation of tortoises for food is no longer common (and is illegal in all states), but still occurs in some areas. A mycoplasma bacterial infection, known as Upper Respiratory Tract Disease (URTD), has been implicated in die-offs of Gopher Tortoises (Berish et al. 2010) but recent studies indicate that it is unlikely that a single mycoplasma infection alone causes die-offs (Goessling et al. 2019; McGuire et al. 2014).

Conservation Status

The Gopher Tortoise is a species of conservation concern because of significant declines across its range. It is designated as a Species of Greatest Conservation Need (SGCN) in each of the six states in which it occurs, and considered Vulnerable by the International Union for Conservation of Nature (IUCN), while the “western population” (west of the Mobile and Tombigbee rivers including southwest AL, south MS, and southeastern LA) is listed as Threatened under the ESA (USFWS 1987). The remaining geographic range of the species in AL, GA, FL, and SC was petitioned for federal listing in 2011. In the 12-month finding on that petition, USFWS determined that the Gopher Tortoise warrants listing range-wide and considered the eastern metapopulation to be a Candidate species for listing. A Candidate Conservation Agreement (CCA) for the Gopher Tortoise was signed in December 2008 to implement proactive Gopher Tortoise conservation measures across its eastern range. Stakeholders in the CCA include four the four military services (Army, Navy, Air Force, Marine Corps), U.S. Forest Service, USFWS, the fish and wildlife agencies of FL, GA, AL, and SC, and related non-profit organizations. Currently, USFWS is conducting a Species Status Assessment for the entire range of the species, which will be used to make a final decision regarding its federal status, including the eastern population (USFWS 2020).

Recommended Best Management Practices for Gopher Tortoises on Military Sites

In general, troop and light vehicle movements and weapons firing are compatible with Gopher Tortoise conservation. Activities involving heavy equipment and/or digging have potential to be harmful. Implementation of some habitat management practices should be performed when tortoises are not active to reduce negative impacts. Appendix 1 lists various specific activities and their potential for impact. Document performance of any of the following BMPs, whether current or future, in the installation’s INRMP. The USFWS may consider these proactive conservation actions prior to making a listing determination for this species.

1. **Identify and protect Gopher Tortoise burrows and habitat.** Survey potential habitat on the installation (see Inventory and Monitoring techniques below) for Gopher Tortoise burrows. Develop a Geographic Information System (GIS) layer for the Gopher Tortoise population and its habitat on the installation. Based on current use, soils, and vegetation, designate non-fragmented¹ areas of occupied as well as potentially suitable habitat as Gopher Tortoise Habitat Management Units (HMUs). This supports CCA Section 10.1.1 commitments to identify suitable or potentially suitable habitat for and areas occupied by the Gopher Tortoise. Areas known to support Gopher Tortoises can be posted, as necessary, with official signage along roads and other human travel corridors to inform personnel about the actual or potential presence of Gopher Tortoises and their vulnerability to military operations and other human activities. Include a contact number on signage to report observations of illegal and/or unauthorized operations and activities.
2. **Use prescribed fire to maintain habitat.** Land management for Gopher Tortoises should maintain diverse herbaceous ground cover for foraging and open, sunlit areas for

¹ Non-gated paved roads or unpaved roads with significant traffic or high cut road banks that would interfere with Gopher Tortoise movement constitute fragmentation and will divide otherwise contiguous HMUs.

burrowing and nesting. Habitat in good condition usually can be maintained using only prescribed fire on a regular basis (i.e., every one to three years). Growing season (April-June) burns are recommended, but if conditions are not suitable during the growing season for a scheduled burn, maintain the frequency of the fire return interval by applying a dormant season burn rather than waiting for the following growing season. Take precautions (for example buffer zones around burrows) when disking fire lanes so that Gopher Tortoises and their burrows are not harmed. Current silvicultural standards for Red-cockaded Woodpecker (RCW; *Picoides borealis*) management on installations is consistent with requirements for Gopher Tortoise habitat, with which both species often share.

3. **Where needed, use thinning and/or herbicide to improve and maintain habitat.** Gopher Tortoises require an open forest canopy with trees at a density of no more than 50 sq ft per acre basal area to allow sufficient sunlight penetration to support ground-cover forage plants. In cases where trees and shrubs cannot be reduced by prescribed fire alone, mechanical thinning or other mechanical and/or herbicidal treatments may be required. Thinning opens the canopy and creates conditions more suitable to the safe application of prescribed fire. Other mechanical techniques that may be appropriate for certain sites include chopping, mulching, and mowing. Herbicides can also be used to reduce shrub and hardwood densities. Individual stems can be selectively killed by basal bark spraying or stem injection (“hack-n-squirt”). If herbicides are used, it is important to select a chemical that has the desired effect on shrubs and hardwoods but does not significantly harm native, herbaceous ground cover.
4. **Instruct equipment operators to avoid Gopher Tortoises and their burrows.** Vehicles and heavy equipment can collapse Gopher Tortoise burrows. Burrows can be marked (usually with flagging) ahead of planned operations and buffer zones around burrows can be established to alert equipment operators of their presence. Log loading areas and skid trails in forest thinning operations should avoid a 15- to 25-foot radius around Gopher Tortoise burrows so that burrows are not buried. Adult tortoises will often retreat into their burrows before being noticed, but even if not, they (and their burrows) can generally be seen and avoided. However, hatchlings are more vulnerable and unlikely to be noticed. Because hatchlings are more numerous in September and October, activities that require heavy equipment should be avoided or minimized in those months if possible (Ashton and Ashton 2008). Disking of wildlife food plots containing Gopher Tortoise burrows should be avoided. Although adults may not be harmed, the shallow burrows of hatchlings put them at greater risk.
5. **Control and/or eradicate invasive non-native species.** Cogongrass (*Imperata cylindrica*) is probably the single most invasive non-native plant species that changes the physical habitat structure and adversely impacts Gopher Tortoises. Other invasive plants that may impact tortoise habitat include but are not restricted to Mimosa or Silktree (*Albizia julibrissin*), Shrub Lespedeza (*Lepedeza bicolor*), Centipede Grass (*Eremochloa ophiuroides*), and Natal Grass (*Melinis repens*). Problematic invasive non-native animal species include red imported fire ants and feral hogs. The best procedures for controlling invasive species are those that both effectively limit their proliferation and minimize potentially harmful impacts to tortoises, and will vary according to species in

need of control and numerous criteria specific to each installation. Therefore, consult your natural resources staff for invasive species control guidelines for your installation.

6. **Manage predator populations.** If Gopher Tortoise nests and hatchlings are being lost to high levels of predation, implement measures to manage predator populations. Subsidized predators are species whose populations have increased in part due to enhancement of food and habitat provided directly or indirectly by humans. Raccoon, fox (*Vulpes* sp.), and coyote are natural predators of Gopher Tortoises and their nests. Household garbage—a source of food—should not be accessible to these animals in areas where maintenance of tortoise populations is a priority.
7. **Prevent predation by pets.** Free-ranging dogs can be predators of Gopher Tortoises. Installation residents should not allow unsupervised dog access to Gopher Tortoise habitat, where they might kill tortoises. Increased adult mortality, especially of adult females, is the quickest way to extirpate a tortoise population (Tuberville et al 2009; Folt et al. 2021).
8. **Monitor Gopher Tortoise populations.** Periodic monitoring of existing Gopher Tortoise populations is critical to understanding if a population is increasing or decreasing. Survey methods (see Inventory and Monitoring techniques below) and level of effort are variable and can be tailored to available time and funding constraints.
9. **Identify HMUs that could support Gopher Tortoise translocation by serving as recipient sites.** These are large, relatively unfragmented areas that currently have low density Gopher Tortoise populations, are capable of supporting greater densities, and are not expected to be subjected to activities with potential to harm Gopher Tortoises (Appendix 1).
10. **Identify HMUs with Gopher Tortoise densities and foreseeable conflict with present and projected mission activities.** If unavoidable mission activities will adversely and permanently degrade/fragment/destroy occupied Gopher Tortoise habitat, installations may consider translocating Gopher Tortoises from these HMUs to those identified above, in concert with Section 10.1.2 of the CCA. Coordinate with the appropriate state wildlife agency for permitting requirements and guidelines before capturing and/or translocating Gopher Tortoises.
11. **Maintain and manage corridors for connectivity.** Corridor(s) should be maintained or, if necessary, established to allow movement of Gopher Tortoises among HMUs so they can fulfill essential life requirements (i.e., breeding) and sustain genetic and population viability.
12. **Develop fact sheets and outreach tools.** Soldiers and other personnel involved in “on the ground” activities frequently lack awareness of the presence and biology of Gopher Tortoises, their high conservation priority as a Species at Risk, and/or their vulnerability to certain training and land management practices. Although no training activities are restricted by these guidelines, soldiers and other personnel (including contractors)

involved in field activities should receive training or literature on how to minimize impacts whenever practical while still accomplishing mission goals. Outreach and education materials should include Gopher Tortoise and Gopher Tortoise burrow identification, the relevance of Gopher Tortoise conservation to the DoD mission, and information on how certain activities (e.g., heavy wheeled and tracked vehicle operation and mechanical digging) may directly harm Gopher Tortoises, damage burrows and nests, affect the ability of Gopher Tortoises to forage or nest, and have potential for significant habitat damage. Educational fact sheets and pamphlets, like the one at www.fws.gov/northflorida/gophertortoise/gopher_tortoise_fact_sheet_web.pdf can be developed and shared with military and civilian personnel to inform them about this at-risk species.

13. **Prohibit collection of Gopher Tortoises.** Collection of Gopher Tortoises has negative impacts to populations due to their longevity and delayed sexual maturity and—without special permit—is an illegal activity in all states where tortoises occur. Other than justifiable capture and release for monitoring, ecological studies, disease testing, etc., natural resource managers should prohibit collection of Gopher Tortoises on military sites.
14. **Keep records.** Record and retain permanently all survey, inspection and monitoring data for Gopher Tortoise populations and habitats for trend analysis. Installation biologists and foresters should maintain close coordination and conduct an internal Gopher Tortoise installation progress review at least once a year. Develop Gopher Tortoise maps using survey data to accurately depict the location of Gopher Tortoise colonies, burrows, and HMUs. Update maps at least every 5 years. Maps used internally can be tailored to the users (e.g., trainers and foresters) and distributed for use by those conducting land use activities on the installation, including military training, forest management, construction projects, and range maintenance.

Benefits of Gopher Tortoise Best Management Practices to Military Training Operations

1. Identification of occupied habitat enables military planners to consider these sensitive areas when developing and/or scheduling training and maneuvering activities.
2. Stable or expanding Gopher Tortoise populations on DoD lands may be considered by USFWS when making decisions regarding species listing or down-listing.
3. Management of invasive species lessens the damage they may cause to training and maneuver area conditions and provide natural, realistic training environments.

DoD PARC Points of Contact

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Military Service Points of Contact

Contact your Military Service headquarters natural resources personnel with questions regarding Gopher Tortoise and conservation actions:

Navy: Jeff Gardner (jeffrey.a.gardner2@navy.mil; 202 685-9330)

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Inventory and Monitoring Techniques for Gopher Tortoises

Gopher Tortoise surveys may be desired for different purposes, including detection of tortoise presence; estimating population size, density, and trends; and assessing the effects of habitat management or restoration over time. Specific objectives determine the survey timing and method, and consideration of funding and time may also be factors in determining which survey method to use.

The U.S. Army Engineer Research and Development Center's Gopher Tortoise Survey Handbook (Smith et al. 2009, www.fws.gov/southeast/pdf/methodology/gopher-tortoise-survey-handbook.pdf) was developed to standardize sampling tortoise populations, and much of the language in this section is modified from that handbook.

Although diverse herbaceous ground cover and an open canopy are important components of tortoise habitat, soil type is the single most reliable indicator of suitable habitat. Gopher Tortoises require deep, sandy soils. Suitable tortoise soils are typically classified by the Natural Resources Conservation Service (www.nrcs.usda.gov/wps/portal/nrcs/site/soils/) as well-drained or excessively well-drained (Appendix 2).

If the goal is to estimate population size, all areas with suitable soils should be surveyed. Tortoises can persist in small patches of suitable vegetation along roadsides, power line rights-of-way, and fallow fields; therefore, in appropriate soils, these areas should also be included in a sampling frame. In defining suitable tortoise habitat for surveys, a suite of factors should be considered including soil type, vegetation, land use, and fire history. Wetland and floodplain soils should be excluded because they generally represent unsuitable habitat. The sample area should include only actual or potential tortoise habitat, since sampling in areas not suitable for tortoises will skew the resulting density measures negatively.

Line Transect Distance Sampling (LTDS)

Line transect distance sampling (LTDS, Buckland et al. 2001) is a recommended method for Gopher Tortoise surveys (Smith et al. 2009) because of its ability to provide robust estimates of tortoise density. The open-source software program Distance 7.3 (<https://distancesampling.org/>, Thomas et al. 2010) can be used to create survey designs and analyze data in a variety of ways. LTDS can sample both high- and low-density populations and is easy to employ at large scales. Details of conducting LTDS are provided in Smith 2009 (see link above), but basic elements are summarized here.

The first step in designing a survey using LTDS is to define the specific habitat to be sampled, called the “sampling universe.” The second step is defining the area within the sampling universe to be surveyed, called the “sampling frame” (e.g., a GIS map with suitable habitat delineated or the population of desired inference). The third step is distributing a sample across the sampling frame. To avoid bias, the sample should be randomly selected or placed within all available suitable habitat.

Once a potential sampling frame is defined, a pilot survey is conducted to determine the tortoise encounter rate (Buckland et al. 2001), (i.e., the number of tortoises observed along a length of transect). The pilot survey data is used to determine the sampling intensity needed for the full survey.

A pilot survey can also be used to verify tortoise presence/absence (if this is not known), or to determine the distribution of tortoises across a sampling frame (see below). For surveys to estimate population density, observation of 10 to 15 tortoises is usually sufficient to determine the encounter rate. The encounter rate can then be used to calculate the total length of transect necessary to detect at least 60 to 80 tortoises, and to derive estimates with the desired confidence intervals and coefficient of variation.

Six basic assumptions of LTDS must be met for accurate population density estimates:

1. All burrows and tortoises are found directly on the transect centerline.
2. Objects are detected at their initial location, prior to any response to the observer.
3. Transect length is measured accurately.
4. Perpendicular distance from the transect to the burrow is measured accurately.
5. The transects themselves, or systematic placement of the transects, is random.
6. There are no more tortoises in a burrow that the scope indicates is occupied. Telemetry work has documented that double occupancy of burrows occurs throughout the year and is particularly common during winter months, potentially making LTDS estimates biased (consistently too low), especially in winter.

Since surveys are focused on observations of occupied burrows, the location of the burrow entrance serves as the location of the individual. Any tortoises observed on the surface are recorded in the same manner as a burrow. Because LTDS counts tortoises and not burrows, it is critical that tortoise burrows be examined with a camera to confirm tortoise presence. It is also critical that field personnel receive training in the use of a burrow camera system and identification of occupied burrows. Even experienced observers cannot always determine whether a burrow is occupied, and it is important to report the percentage of burrows for which occupancy could not be determined.

Although LTDS work can be conducted with a tape measure and compass instead of GPS and field computer, the recommended approach requires the following equipment:

- Burrow calipers
- Global Positioning System (GPS)²
- ArcGIS and ArcPAD or similar software
- Distance 7.3 software (<https://distancesampling.org/>)
- Burrow camera (5–6 m scope length)³
- Datasheets

Three observers are required to cover transects. One person searches the centerline and the area close to the centerline for burrows. Two additional observers search on either side of the centerline weaving back and forth to detect burrows from the centerline outward. See Smith et al. (2009) for further details about conducting the pilot and full surveys to arrive at a population estimate.

Population Monitoring

If LTDS survey protocols are consistently applied, periodic re-sampling at permanent transects can be used to monitor tortoise densities over time. This is particularly important when the objective is to monitor effects of management or restoration activities on tortoise populations. To detect population trends over a 20-year period, it is recommended that monitoring programs include re-sampling at 3- to 5-year intervals. A more intensive and more frequent sampling regime may be required for critically endangered populations or populations perceived as declining, to detect and react to trends quickly. More intensive and frequent sampling may also be important to determine if populations are responding to newly implemented management practices.

Alternative to LTDS for Long-Term Monitoring: Monitoring of Local Populations

As an alternative to LTDS, especially on large installations, representative local populations can be selected for long-term study. For most areas in the northern portion of the range, local Gopher Tortoise populations are known to consist of 20 to 100 adults (Goessling et al. 2021; Eubanks 2003). Mark-recapture analysis using Cormack-Jolly-Seber methods for open populations provides unbiased estimates of abundance, and therefore density. Local populations typically will be selected based on land managers who use their experience to select areas of high local abundance. Such areas can be surveyed for burrows until some threshold of distance to the next burrow is reached (some researchers have used 50m), which established the extent of the local population. Telemetry work has documented tortoises within such aggregations interact with each other during a season of activity rather than interacting with animals at burrows outside the aggregation. Animals at such sites are trapped, marked, and released. A burrow scope is used to detect all occupied burrows and traps are placed at all occupied burrows to capture all current residents of the population. This procedure is repeated over at least three sampling periods (typically three separate years), the minimum effort required for statistical

² The use of a GPS with real-time submeter accuracy and field computer (e.g., Trimble Nomad) is recommended. This system requires ArcGIS and ArcPAD, or similar software.

³ Burrow camera systems are commercially available (e.g., <http://www.burrowcam.com/>) or can be custom made.

analysis of the mark-recapture records. Output from these data estimate apparent survivorship (losses due to mortality or emigration), recruitment (additions due to immigration or reproduction) and abundance. Additional analysis can be used to estimate population growth rate (Folt et al. 2021).

Presence-Absence Surveys

If the objective of a survey is simply to confirm tortoise occurrence on a site, all burrows encountered can be examined with a camera until a tortoise is observed, after which no more sampling is required. For some purposes, this simple confirmation of presence may initially be adequate for preliminary planning actions. This informal method would require significantly less effort than estimating population size, and if the length of transect and number of tortoises is recorded, the information could later be used as a pilot study using LTDS. Negative evidence from a single survey (i.e., not finding burrows or live tortoises) cannot be interpreted as confirmation that tortoises are absent from a site. This conclusion can only be reached if the survey is repeated frequently enough to achieve adequate statistical power (Bausell and Li 2002), or if a census is conducted (all burrows known and confirmed to lack a tortoise).

High Priority Research Questions

Confirmation of Gopher Tortoises at Unconfirmed Military Sites

Many DoD installations (see Distribution on Military Site above) throughout the range of the Gopher Tortoise have the potential to have populations of this species, however their presence is unconfirmed. It is recommended that surveys be conducted to confirm the presence or absence of the species on those military lands.

Population Size and Trends

Gopher Tortoises live long lives and do not reproduce until an advanced age. These characteristics make populations extremely vulnerable to even low levels of adult female mortality. Therefore, the stability of a Gopher Tortoise population on a military installation is influenced by population size (number of individuals present), demography (survivorship, recruitment, sex and age ratios), and population growth rate. Surveys that focus on population size and trends are needed on DoD sites.

Additional Sources of Information on Gopher Tortoises

- Range-Wide Conservation Strategy for the Gopher Tortoise (USFWS): <https://www.fws.gov/southeast/pdf/strategy/gopher-tortoise-conservation-strategy-v2.pdf>
- Gopher Tortoise Council: <https://gophertortoisecouncil.org/>
- NatureServe: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.105196/Gopherus_polyphemus
- IUCN: <https://www.iucnredlist.org/es/species/9403/12983629>

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Appendix 1. Training activity where Gopher Tortoise burrows are present

(Source: CH2MHill, 2008)

TRAINING ACTIVITY	Potential Adverse Impacts
MANEUVER AND BIVOUAC	
Hasty defense, light infantry, hand tool digging only, no deeper than 2 feet	NO
Hasty defense, mechanized infantry/armor	YES
Deliberate defense, light infantry	NO
Deliberate Defense, mechanized infantry/armor	YES
Establish command post, light infantry	NO
Establish command post, mechanized infantry/armor	YES
Assembly area operations, light infantry/ mechanized infantry/armor	YES
Establish CS/CSS sites	YES
Establish signal sites	YES
Foot transit through the colony	NO
Wheeled vehicle transit through the colony	YES
Armored vehicle transit through the colony	YES
Cutting natural camouflage	NO
Establish camouflage netting	NO
Vehicle maintenance	YES
WEAPONS FIRING	
7.62mm and below blank firing	NO
.50 cal blank firing	NO
Artillery firing point/position	NO
MLRS firing position	NO
All others	NO
NOISE	
Generators	NO
Artillery/hand grenade simulators	NO
Hoffman type devices	NO
PYROTECHNICS/SMOKE	
CS/riot agents	NO
Smoke, haze operations only, generators or pots, fog oil and/or graphite flakes (3)	NO
Smoke grenades	NO
Incendiary devices to include trip flares	NO
Star colonies/parachute flares	NO
YES HC smoke of any type	NO
DIGGING ALLOWED	
Tank ditches	YES
Deliberate individual fighting positions	YES
Crew-served weapons fighting positions	YES
Vehicle fighting positions	YES
Other survivability/force protection positions	YES
Vehicle survivability positions	YES

Appendix 2. Gopher Tortoise soils (not comprehensive)

Habitat Classification	Soil Series
Highly Suitable	Alaga, Alpin, Astatula, Bigbee, Blanton, Candler, Buncombe, Eustis, Foxworth, Fripp, Kureb, Lakeland, Lakewood, Nugent, Paola, St. Lucie, Troup, Wadley, Wagram
Suitable	Albany, Apopka, Ailey, Autryville, Bama, Barnwell, Benndale, Bonifay, Bonneau, Cahaba, Chisolm, Cowarts, Cuthbert, Dothan, Eddings, Faceville, Fuquay, Harleston, Heidel, Izagora, Lucedale, Lucy, McLaurin, Norfolk, Orangeburg, Orlando, Poarch, Prentiss, Ruston, Shubuta, Smithdale, Suffolk, Sunsweet, Tavares, Vacluse
Marginal	Alapaha, Angie, Basin, Baxterville, Bibb, Boswell, Canaveral, Centenary, Chipley, Coosaw, Duplin, Echaw, Emporia, Eulonia, Falkner, Florida, Foreston, Freest, Freestone, Georgeville, Goldsboro, Greenville, Grover, Gundy, Hiwassee, Johns, Leefield, Lorman, Lynchburg, Malbis, Marlboro, Mashulaville, Murad, Myatt, Nankin, Neeses, Nemours, Noboco, Ochlockonee, Ocilla, Osier, Pacolet, Petal, Quitman, Ridgeland, Saucier, Savannah, Seagate, Susquehanna, Toccoa, Uchee, Yauhannah