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Gopherus polyphemus

Management Plan for Gopher Tortoise (*Gopherus polyphemus*) Populations in Georgia from
2019-2049

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Adult Gopher Tortoise (*Gopherus polyphemus*)

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Executive Summary

Gopher tortoises (*Gopherus polyphemus*) are known for their elephantine hind feet and flattened, shovel-like forelimbs adapted for digging burrows. Burrows offer shelter from heat, fires, and predators, and serve as refugia for more than 350 other species including, the gopher frog (*Lithobates capito*), eastern diamondback rattlesnake (*Crotalus adamanteus*), burrowing owls (*Athene cunicularia*) and the endangered indigo snake (*Drymarchon couperi*). For this reason, gopher tortoises are considered a keystone species. Gopher tortoises are distributed throughout South Carolina, Georgia, Florida, Alabama, Louisiana, and Mississippi in the southeastern United States. Gopher tortoises are commonly found in upland habitats with well-drained sandy soils and diverse groundcover lacking understory hardwoods. Their diet consists of grass-like herbaceous plants, fruits and flowers such as prickly pear cactus (*Opuntia*), wild grape (*Vitis vinifera*), legumes (*Fabaceae*), dandelions (*Taraxacum*), and grass-leaved golden asters (*Chrysopsis graminifolia*). Ecological concerns threatening gopher tortoise populations include deforestation, habitat fragmentation, and disease. Sociocultural and economic threats to gopher tortoises include human consumption, illegal pet trade and habitat development. All these issues have been documented in Florida, where most research for this species has been conducted. The scope of this management plan focuses in Georgia where these threats are relevant and create concerns to gopher tortoise populations. The goal of this management plan is to increase and stabilize gopher tortoise populations in Georgia from 2019-2049. Objectives of this goal include: increase adult gopher tortoise survivorship by 6% in thirty years, increase gopher tortoise hatchling survivorship by 10% in thirty years and increase and preserve gopher tortoise habitat, by 20% in twenty years throughout the state of Georgia. Actions focus on promoting the increased survivorship of hatchling and adult gopher tortoises, and increasing habitat needed for their survival. Emphasis is placed on reducing adult road mortality, anthropogenic transmission of upper-respiratory tract disease (URTD), nest protection, implementing headstarting programs to reduce hatchling predation, and using conservation easements and periodic fire to increase longleaf pine habitat. If gopher tortoise populations continue to decline the ecosystem in which they inhabit will collapse due to their role as a keystone species. With proper management this species can have stable and sizable populations for the state of Georgia.

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History

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species listed the gopher tortoise (*Gopherus polyphemus*) as vulnerable in 1996, the classification of vulnerable is given due to the lack of information on the species and the need for an update on the listing. Gopher tortoises are legally protected throughout its range but is only federally protected in the western part of their range in Louisiana, Mississippi, and Alabama (Bennett and Buhlmann 2007).

Gopher tortoises occur in upland habitats throughout the coastal plain of the southeastern United States. Due to declines in gopher tortoise populations in the western part of their range, there is a lack of information on the status and distribution gopher tortoises in Louisiana, Mississippi and Alabama (Catano and Stout 2015). Much of the research done on the gopher tortoise has been conducted in the eastern end of its range, in Florida, but can be applied to the remaining geographic scope of this management plan for the southeastern United States (Catano and Stout 2015).

The climate in the southeastern United States is humid subtropical, with an average precipitation of 1.4 meters (Bishop et al. 2019). Common wildlife in the longleaf pine forest in the southeastern United States include the red-cockaded woodpeckers (*Leuconotopicus borealis*), whitetail deer (*Odocoileus virginianus*), bobwhite quail (*Colinus virginianus*), and the fox squirrel (*Sciurus niger*) (Engstrom 1993). The gopher tortoise has experienced an 80% decline in their populations over the last century in all its range, due to deforestation, habitat destruction, and anthropogenic causes.

Natural History

Species Identification

Gopher tortoises are terrestrial turtles of moderate size averaging 22-28cm long. The gopher tortoise can be identified by its flattened shovel like forelimbs and elephantine hind feet adapted for digging burrows (Kent et al. 1997).

Breeding

Gopher tortoises are slow to reach sexual maturity, have relatively low fecundity, and a long-life span (Landers 1980). Male gopher tortoises reach sexual maturity at a slightly younger age compared to females who reach sexual maturity at 9-21 years of age depending on latitude (Landers et al. 1980, Diemer and Moore 1994). Breeding season for the gopher tortoise is



Figure 1. gopher tortoise (*Gopherus polyphemus*) with stumpy hind feet and forelimbs covered with large scales.

generally March – October. Females excavate nest often in burrow mounds or on burrow aprons from mid-May to late June, with only one clutch laid annually (Landers et al. 1980). Gopher tortoise average clutch size is 5-6 eggs, but larger clutch sizes have been reported (Landers et al. 1980, Butler and Hull 1996). The egg incubation period is 80-100 days, depending on geographic range (Iverson 1980).

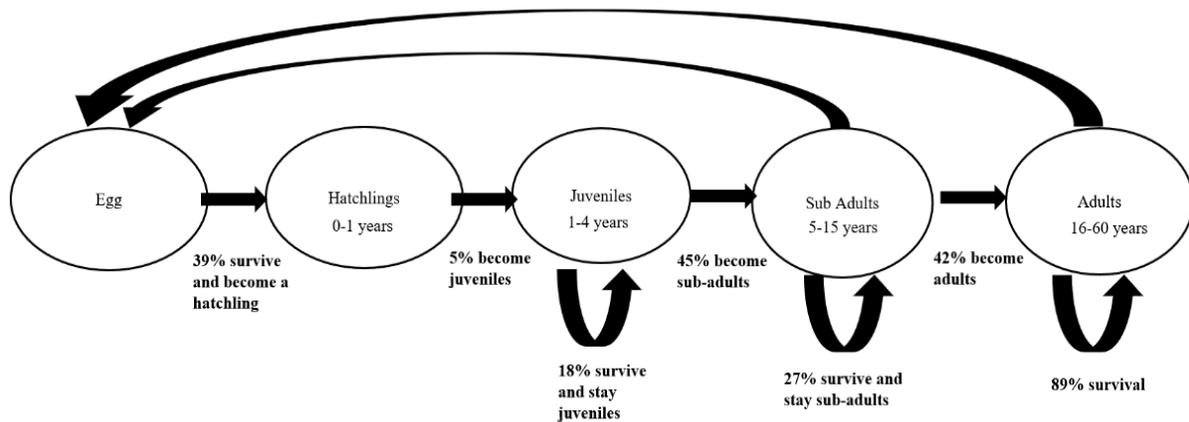


Figure 2. Life cycle of the gopher tortoise (*Gopherus polyphemus*) with survival rates from each stage.

Diet

In the southeastern United States, the gopher tortoise diet is classified as predominately herbivorous. They are known to eat more than 1,000 species of plants through their range and more than 200 species in their habitat (Garner and Landers 1981). Feeding activity is generally restricted to 50m from the burrow but are known to travel over 100m from its burrow to forage (Garner and Landers 1981). Gopher tortoises consume grass like herbaceous plants, mushrooms, fruits and flowers such as saw palmetto berries (*Serenoa repens*), prickly pear cactus fruit (*Opuntia*), blackberries (*Rubus*), blueberries (*Vaccinium*), wild grape (*Vitis vinifera*), legumes (*Fabaceae*), grass-leaved golden aster (*Pityopsis graminifolia*), bahia grass (*Paspalum notatum*), dandelions (*Taraxacum officinale*), broadleaf plantain (*Plantago major*), St. Augustine (*Stenotaphrum secundatum*), and bluegrass (*Poa pratensis*) (Garner and Landers 1981).

Grasses have the highest percent biomass in the gopher tortoise diet in the southeastern United States. Grasses make up 70-80% of the adult gopher tortoise diet and 31-58% of juvenile gopher tortoise diet during summer months (Garner and Landers 1981). Legumes such as the sensitive briar (*Mimosa nuttallii*) and hoary pea (*Tephrosia lindheimeri*) are the most important forbs in the spring for juvenile gopher tortoises due to their high amounts of protein and phosphorus that is essential for juvenile growth (Garner and Landers 1981 and Mushinsky et al. 2003). For the gopher tortoise early spring is the period where dietary requirements are the most crucial. This is due to their body reserves being depleted during winter dormancy and the females need for nutrients for egg formation. Female gopher tortoises have been observed eating insects, bones and feathers which is likely due to their need for nutrients in the animal matter such as

concentrated phosphorous, calcium and protein which is all needed for egg formation (Garner and Landers 1981). Dew and moisture content in the plants provide gopher tortoises with most of the water they need for survival. Tough, fibrous, and less digestible grasses such as wiregrass (*Aristida stricta*) is almost completely avoided by juvenile gopher tortoises (Macdonald and Mushinsky 1988 and Mushinsky et al. 2003). Juveniles tend to travel short distances and forage for short periods of time compared to adults. This is likely due to thermal constraints and predation of the juvenile tortoises (Mushinsky et al. 2003). Since juvenile gopher tortoises spend short periods of time foraging and travel short distances they seem to only persist in pristine habitats.

Habitat

Gopher tortoise habitat is described as upland dry sandy habitats such as longleaf pine forest and oak sandhills with well drained, deep sandy soils with sparse tree canopy and abundant low growing vegetation (Eubanks et al. 2003 and Berish et al. 2012). Primary cover for the gopher tortoise includes the burrows they dig. Their burrows are essential for their survival which they provide protection from cold, heat, drought, forest fires, and predators (Dziadzio and Smith 2016). Burrows are on average twelve meters long and three meters deep with a 29° angle declination which remains a relatively constant temperature and humidity of approximately 27°C throughout the year (Dziadzio and Smith 2016). Gopher tortoises often use more than one burrow during the active period of the year but utilizes one burrow in the winter months. On average male gopher tortoises occupy on average 10 burrows and females use 5 burrows per year (Eubanks et al. 2003).

Destruction of longleaf pine forest is the most significant threat to gopher tortoise populations. Gopher tortoises need large areas of undeveloped land that is not fragmented by buildings, roads, as well as other structures but the dry upland areas that provide prime tortoise habitat are targeted by developers that need to avoid wetlands for new housing subdivisions and industrial centers (Yager et al. 2007). Habitat management is essential to gopher tortoise survival. As longleaf pine forest decrease, suitable habitat for gopher tortoises cover such as burrows and foraging grounds is decreased also.

Distribution

The gopher tortoise is found in the southeastern United States from southeast South Carolina to eastern Louisiana (Eubanks et al. 2003).



Figure 3. Distribution of the gopher tortoise (*Gopherus polyphemus*).

Diseases

Diseases are important factors influencing the persistence of wildlife populations. Impacts of diseases can be significantly severe in populations that are experiencing habitat stress caused by anthropogenic activities including habitat fragmentation (Ozgul et al. 2009). Several diseases have been documented in the gopher tortoise such as respiratory and pharyngo-esophageal iridovirus infection, herpesvirus and most notably upper-respiratory tract disease (URTD) (Westhouse et al. 1996). Upper-respiratory tract disease is an emergent disease that has moved rapidly from obscurity to major concern in gopher tortoise populations but has no effect on human populations (McCoy et al. 2007). Clinical signs of URTD in the gopher tortoise include excessive tearing and ocular discharge, conjunctivitis, and swelling of the eyelids and ocular glands, and mucoid, purulent and serous discharge from nares (Brown et al. 1999, McGuire et al. 2014). URTD is caused by the bacteria *Mycoplasma agassizii* and is easily transmitted through direct contact between tortoises and through contact with nasal secretions (McGuire et al. 2014 and Jacobson et al. 2014). Chronic diseases such as URTD have the potential to cause severe consequences for gopher tortoise populations by altering demographic rates such as survival and reproduction (Ozgul et al. 2009). URTD is seldom detected in juveniles due to having minimal direct interactions with adults, thus transmission likely occurs as gopher tortoises reach sexual maturity where there is an increase in interactions due to courtship (McGuire et al. 2014). Gopher tortoise populations are highly sensitive to changes in adult survival even small declines in adult survival can significantly decrease gopher tortoise populations. Critically ill gopher tortoises have been seen to exhibit altered behavioral patterns such as basking on cold days which may make the tortoise more susceptible to predation (McLaughlin et al. 2000). Adult tortoises infected with *Mycoplasma agassizii* may become slow and malnourished, leading to dehydration, emaciation, and decreased reproductive success (Brown et al. 1999). Factors that most likely contribute to outbreaks of URTD include environmental changes and human impacts such as habitat disturbance, translocation, pollution, drought, and flooding (Mendoza 2008). These stressors could cause tortoises infected with *Mycoplasma agassizii* but with no clinical signs of URTD to develop clinical signs (Ozgul et al. 2009). The releasing of captive tortoises or relocation of infected tortoises should be avoided to decrease the likeliness of the spread of URTD throughout gopher tortoise populations. Currently, there is no control from URTD spreading. Upper-respiratory tract disease coupled with habitat destruction and environmental stress is believed to be a significant factor in the declining populations of the gopher tortoise (McCoy et al. 2007).

Conservation Needs

Ecological

Gopher tortoises can dig large, deep burrows that are approximately twelve meters long and three meters deep which remain a relatively constant temperature and humidity. More than 350 other species of mammals, birds, reptiles, amphibians and invertebrates including the endangered indigo snake (*Drymarchon couperi*) are known to use the burrows for protection and shelter from heat, fires and predators (Kent et al. 1997, Cantano and Stout 2015). For these reasons, the

gopher tortoise is considered a keystone species by creating biodiversity in the endangered longleaf pine (*Pinus palustris*) ecosystems (Catano and Stout 2015). If gopher tortoise populations continue to decline the ecosystem in which they inhabit will collapse. Therefore, management actions to increase the gopher tortoise populations will benefit hundreds of invertebrate and vertebrate species (Catano and Stout 2015).

Deforestation is a threat to gopher tortoise populations in almost all their range in the southeastern United States. Due to cumulative impacts of a changing environment, the longleaf pine forest is one of the most endangered ecosystems in the United States. Less than four percent of longleaf pine forest remains of the original 90-million-acre forest of South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. Gopher tortoises usually live in well drained, sandy soils that are generally associated with longleaf pine, and oak sandhills (Diemer et al. 2012). Gopher tortoises are also found in dry prairies, coastal grassland, scrub, and dunes (Castellon et al. 2012, Pawelek and Kimball 2014). Longleaf pine ecosystems are characterized by open pine barrens and savannas with diverse groundcover composed of grasses and lacking understory hardwoods (Landers et al. 1995). The diverse herbaceous groundcover is needed for foraging, while open canopy conditions are needed for nesting and thermoregulation of the gopher tortoise. Throughout the gopher tortoise range there has been an 80% decline in their populations in the last 100 years due to a decline in longleaf pine forest (Yager et al. 2007). Destruction of the forest is the most significant threat to gopher tortoise populations. Roughly 80% of gopher tortoises original habitat has been lost to urbanization and agriculture. Gopher tortoises need large areas of undeveloped land that is not fragmented by buildings, roads, as well as other structures (BenDor et al. 2009).

The main ecological concerns threatening the gopher tortoise populations in the southeastern United States are habitat destruction, fragmentation and anthropogenic causes. As longleaf pine forest decrease, suitable habitat for the tortoise is also decreased. Hundreds of other species use or completely depend on gopher tortoise burrows for protection from a variety of factors. If a decrease in these burrows was to occur, hundreds of other species will be subjected to negative effects (Catano and Stout 2015).

Sociocultural and Economic

Occasionally gopher tortoises are captured for human consumption, however they are not as sought after as other families in the order *Testudines* such as the snapping turtle (*Chelydra serpentina*). Historically, gopher tortoise populations have been affected by harvest throughout their range prior to its range wide protection (Taylor 1982). Due to their obvious burrow locations, docile nature and slow movements, the gopher tortoise is easily susceptible to harvest by humans (Taylor 1982). The cause of human predation of the gopher tortoises is to provide food, especially in economically disadvantaged areas. Their meat was often considered the “Florida chicken”, “Georgia bacon” or “Hoover chicken” decades ago (Taylor 1982, Mushinsky et al. 2006). Today, illegal harvest of the gopher tortoise is localized and sporadic, but some populations may still be decreased by human consumption, especially on private lands where there is little management (Mushinsky et al. 2006).

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The gopher tortoise is often found in habitats that are desirable by humans for development (Lazzari 2017). Property owners must obtain permits to capture and relocate all gopher tortoises before any land clearing, or development is implemented. Some private landowners resist federal regulations that protect gopher tortoises because it may limit economic return from current forest management practices that could be destroying tortoise habitat. Nearly 70% of the southeastern United States forest is privately owned (Hudson 2007).

The range of the gopher tortoise is confined to the southeastern United States, which is a region that is predominantly privately owned, meaning that the persistence of the gopher tortoise is greatly dependent on how private landowners manage their land (Underwood et al. 2012). Section (9) of the ESA states that it is unlawful to harm threatened species such as the gopher tortoise and Section (4) which ensures the development of a recovery plan to reduce threats to the gopher tortoise are often not successful where a large portion of gopher tortoise habitat is under private ownership (Hudson 2007, Underwood et al. 2012). The decisions private land owners make regarding their land management can potentially influence the persistence of the gopher tortoise (Underwood et al. 2012).

The increased interest of the pet trade for the gopher tortoise presents a threat to the survivorship of all ages. Due to relatively slow sexual maturity collecting gopher tortoise hatchlings, juveniles, and adults can reduce populations.

Legal

International and Federal Laws

The gopher tortoise is protected throughout its range by a variety of state, federal and international laws. On an international level, the gopher tortoise is protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Hudson 2007). The gopher tortoise is listed in Appendix II of CITES, meaning the species is not currently threatened with extinction, but it is in danger of becoming threatened by extinction if international trade is not controlled (Hudson 2007). Section 7(a)(2) of the Endangered Species Act (ESA) ensures that any action funded or carried out by federal agencies will not imperil the existence of the gopher tortoise or result in the destruction of critical habitat for the tortoise (Hudson 2007). Section 9(a)(1) of the ESA states that it is illegal to harm, harass, hunt, shoot, wound, kill, trap, capture or collect listed species such as the gopher tortoise (Hudson 2007). Section 4(f) states that the Fish and Wildlife Service (FWS) must develop recovery plans to promote the conservation of the gopher tortoise (Hudson 2007).

State Laws

State laws and protection for the gopher tortoise vary significantly throughout their range in the southeastern United States. Florida law (Chapter 68A-27, Florida Administrative Code), makes it illegal to take, harm, harass, capture, possess, sell, or transport any gopher tortoise or parts, or their eggs (Hudson 2007). This law also states that it is illegal to damage or destroy gopher

tortoise burrows with the exceptions of a commission permit (Hudson 2007). The only protection for gopher tortoises in Georgia includes the designation as a nongame species. East of the Tombigbee and Mobile Rivers in Alabama where the ESA does not cover, gopher tortoises are listed as a game species with no open season (Hudson 2007). In both Mississippi and South Carolina, the gopher tortoise is listed as endangered. The state of Louisiana provides the gopher tortoise with no protection beyond that of the ESA (Hudson 2007).

Statement of Need

The need for the gopher tortoise to be managed originates from ecological, sociocultural and economic issues, as outlined above. Gopher tortoises are considered keystone species throughout their range by creating biodiversity in the longleaf pine forest ecosystems. Gopher tortoise burrows provide protection for hundreds of species. Without gopher tortoise population management, biodiversity in the ecosystem will decline. Gopher tortoise populations are currently declining at an increased rate and will continue to do so until something is done (Appendix D). Issues including habitat destruction and deforestation are threats to the gopher tortoise population. The gopher tortoise needs protecting in the southeastern United States. Managers must confront these problems in the before the gopher tortoise becomes extinct.

Goals, Objectives, and Courses of Action

Goal & Objectives

The goal for this Gopher Tortoise Management Plan is to increase and stabilize gopher tortoise (*Gopherus polyphemus*) populations in longleaf pine forests throughout the state of Georgia from 2019-2049.

Objective 1: Increase adult gopher tortoise survivorship by 6% in thirty years throughout the state of Georgia.

Objective 2: Protect nest and increase gopher tortoise hatchling survivorship by 10% in thirty years throughout the state of Georgia.

Objective 3: Increase and preserve gopher tortoise habitat (longleaf pine forests), by 20% in twenty years throughout the state of Georgia.

Actions

Objective 1: Increase adult gopher tortoise survivorship by 6% in thirty years throughout the state of Georgia.

Action 1.1- Educate the public using informational brochures to prevent direct mortality of adult gopher tortoises (See Appendix A).

Educating the public and new residents in Georgia will be influential in the success of gopher tortoise management. The majority of land in Georgia is privately owned, therefore working with landowners and educating them on issues concerning the gopher

tortoise and what they can do to assist in the recovery of this species will be beneficial (Hudson 2007, Underwood et al. 2012). Most private landowners are unaware of habitat requirements for the gopher tortoise. Educating current and new residents in Georgia about the tortoise, where they exist and the role the species plays in the ecosystem will be influential to prevent further development of habitat (Underwood et al. 2012). The majority of the gopher tortoise's range is on privately owned land, educating private landowners about the gopher tortoise will increase public support and will encourage landowners to conserve critical habitat (Hudson 2007). Habitat conservation is critical to increase the availability of reproductive habitat and decrease development that causes direct mortality to adult gopher tortoises, which decreases survivorship (Tuberville et al. 2014). The survivorship of adult gopher tortoises is essential to increase the number of reproductive individuals within the population, increasing the number of eggs laid each breeding season (Tuberville et al. 2014).

Implementing informational brochures containing information about gopher tortoises and their habitat requirements will in hopes increase knowledge of gopher tortoises to private landowners and the public. Educating residents about the gopher tortoise and the conservation efforts being implemented to save the species, has potential to greatly impact the recovery of the species.

Action 1.2- Decrease road mortality of adult gopher tortoises by using geographic information system (GIS) techniques to identify potential road crossing areas. Once they reach their adult size, gopher tortoises rarely die (Alford 1980). Road mortality is one of the highest causes of death in adult gopher tortoises, specifically females during the breeding season (Alford 1980). Population projections for the gopher tortoise suggest that increasing adult survivorship by 6% can have a significant impact on stabilizing their populations (Appendix D). Therefore, reducing road mortality will have an increase in adult gopher tortoise populations.

Implementing signs warning motorists of tortoise crossings are an essential part in reducing direct road mortality (Ives-Dewey and Lewandowski 2012). Gopher tortoise crossing signs will be posted along high traveled routes and areas with high rates of road mortality. Constructed barriers will be installed to direct gopher tortoises away from areas where there is a high risk of road mortality.

Action 1.3- Reduce anthropogenic transmission of upper-respiratory tract disease (URTD) in gopher tortoise populations. URTD is seldom detected in juveniles due to having minimal direct interactions with adults, thus transmission occurs as gopher tortoises reach sexual maturity where there is an increase in interactions due to courtship (Brown et al. 1999, McGuire et al. 2014). Gopher tortoise populations are highly sensitive to changes in adult survival even small declines in adult survival can significantly decrease gopher tortoise populations (McCoy et al. 2007).

Establish educational flyers to educate the public of the risks to gopher tortoise populations from URTD when gopher tortoises are moved illegally (Appendix E).

Provide sanitation, disinfection, and diagnostic protocols for landowners conducting permitted relocations. Gopher tortoises can be infected with upper-respiratory tract disease but show no clinical signs (Brown et al. 1999). Therefore, translocation of infected tortoises could introduce the disease into new populations, causing detrimental effects (McCoy et al. 2007). A blood test can be done to determine if a gopher tortoise has ever been exposed to *Mycoplasma agassizii* but does not tell whether a tortoise is currently infected. To determine if a gopher tortoise is currently infected with URTD, the nasal passages must be flushed, a sample collected and grown in a laboratory (McCoy et al. 2007).

Action 1.4- No Action- If no action is implemented to increase adult gopher tortoise survivorship, gopher tortoise populations will continue to decline as they have for the past several decades. Current population projections for adult gopher tortoises predicts that, with unchanged adult survivorship, the gopher tortoise will be extinct by 2079 (Appendix D).

Final Courses of Action: Actions 1.1, 1.2 and 1.3.

Action 1.1 will be implemented before or within the first year of the management plan to gain insight on the public's current knowledge regarding gopher tortoises. Placing gopher tortoise crossing signs on roads as mentioned in Action 1.2 will be applied during the scope of this management plan to reduce adult gopher tortoise mortality. The distribution of URTD educational flyers in Action 1.3 will occur within the first year of the implemented management plan. Sanitation, disinfection, and diagnostic protocols as mentioned in Action 1.3 will be implemented for the entirety of the management plan to decrease adult mortality.

Assessment Protocol: An increase in adult gopher tortoise survivorship, as outlined in the above actions, will be considered successful at completing objective 1, if adult gopher tortoise survivorship is increased by 6% in thirty years. This objective will be considered successful if the overall awareness of the gopher tortoise increases by 20% in five years. This percentage will be assessed by implementing a survey to private landowners and the public within the first year of the implemented management plan (Appendix B). A follow up survey will be distributed yearly to evaluate if landowners or the public are gaining knowledge related to gopher tortoises and their habitat requirements (Appendix C). Road mortality will be monitored by technicians walking high travelled routes during the nesting season and recording tortoise deaths before the implementation of signs warning motorists of tortoise crossings (Aresco 2005).

If this objective is not met within the thirty-year timeline then the next step includes mailing out, or emailing, surveys to residents of Georgia, and implementing barriers such as drift fences and under-road culverts to mitigate road mortality of adult gopher tortoises (Conover 1997, Aresco 2005).

Objective 2: Protect nest and increase gopher tortoise hatchling survivorship by 10% in thirty years throughout of state of Georgia

Action 2.1- To protect gopher tortoise nests, they must be located first. Gopher tortoise mating season is April through July, with females laying eggs between May and June. Beginning in April, female gopher tortoises will be captured, and radio transmitters will be attached to their shells (Smith et al. 1997, Epperson and Heise 2003). Each tortoise will be located every few days to ensure each females nest will be located. Once all radiotagged gopher tortoise nest are located, nest protection will be implemented, or eggs will be excavated from the nest and taken to headstarting programs (Quinn et al. 2018).

Action 2.2- Conduct nest protection and headstarting programs for gopher tortoise hatchlings. Once nest locations are identified, eggs will be taken from the wild and into captivity to be incubated and hatched (Quinn et al. 2018). The gopher tortoises will then be released into protected habitat once they are large enough to be less vulnerable to predators (Quinn et al. 2018). For nest where head-start programs are not implemented nest protection will be applied. Construction of nest protection cages around gopher tortoise nest will be put into effect to deter predators such as raccoons (*Procyon lotor*), Virginia opossums (*Didelphis virginiana*), nine-banded armadillos (*Dasypus novemcinctus*), skunks (*Mephitis mephitis*), bobcats (*Lynx rufus*), and gray foxes (*Urocyon cinereoargenteus*) (Perez-Heydrich et al. 2012, Smith et al. 2013).

Action 2.3- Reduce predation of gopher tortoise hatchlings. Headstarting programs have been shown to increase survivorship of hatchling tortoises by 53% (Perez- Heydrich et al. 2012). The hatchling age class is the most vulnerable to predation due to their soft shells and small size, with an average 5% of hatchlings surviving their first year. Predation is highest during the first year of life, with most predation occurring within the first 30 days of hatching (Epperson and Heise 2003, Smith et al. 2013). Headstarting programs are pivotal in the survival of hatchlings. Eggs are raised and hatched in captivity and then are released once they are large enough to be less susceptible to predation.

Action 2.4- No Action- If no action is implemented to protect gopher tortoises' nest and to increase gopher tortoise hatchling survivorship, their populations will continue to decline. Current population projections for gopher tortoise hatchling to juvenile survivorship predicts that, without proper management, the gopher tortoise will be extinct by 2088 (Appendix D).

Final Action: Actions 2.1, 2.2, and 2.3.

All actions will be implemented during the entirety of the management plan. Action 2.1, locating gopher tortoise nest will begin in April every year for the scope of the management plan. Actions 2.2 and 2.3 to protect nest and implement headstarting programs will be applied once nest are located every year until 2049.

Assessment Protocol: For objective 2 to be considered successful, a minimum of a 10% increase in hatchling gopher tortoise survivorship within Georgia will be achieved by 2049. Epperson and Heise (2003), discovered the gopher tortoise hatchling stage is one of

the most influential stage classes to populations. Population models created for this plan reinforce those findings (Appendix D). A 10% increase in survivability will be successful by protecting gopher tortoise nest sites with cages, preventing predators from getting into nest and eating the eggs. Upon emergence of hatchlings in nest where headstarting programs are not implemented, transmitters will be attached to the first vertebral scute of the hatchlings to identify rates of predation on hatchlings without headstarting programs (Smith et al 2013).

For objective 2 to be considered unsuccessful, a minimum of 10% increase in gopher tortoise hatchling survivorship within Georgia was not achieved. This could be due to lack of nests monitored or identified, or a lack of hatchlings radiotransmitted for predation rates. If the reason was due to inadequate nest protection, then additional methods will be researched to prevent predation on gopher tortoise nest (Perez-Heydrich et al. 2012, Smith et al. 2013). If the reason is due to lack of nests identified, then additional adult female gopher tortoises will be captured and a radiotransmitter will be adhered to the carapace to be able to identify nest sites for an additional five years (Smith et al 2013). These methods will be continued until gopher tortoise hatchling survivorship increases by a minimum 10% from base rate.

Objective 3: Increase and preserve gopher tortoise habitat (longleaf pine forest), by 20% in twenty years throughout the state of Georgia

Longleaf pine (*Pinus palustris*) forest once encompassed more than 90-million-acres of North America, less than 3.4 million acres remain. Longleaf pine ecosystems are among the most biologically diverse ecosystems in the world providing critical habitat for 29 endangered and threatened species including the gopher tortoise.

Action 3.1- Increase protection of potential habitat on private lands through conservation easements (Merenlender et al. 2003, Rissman et al. 2006). Conservation easements involve the acquisition of land through either donation or purchase of rights associated with land to provide protection for its natural resources. Conservation easements provide landowners with an opportunity for property tax reductions or exemptions. Georgia is composed of approximately 24-million-acres of forests, 90% being privately owned. Conservation easements will allow for the permanent conservation of biodiversity of longleaf pine forests of private lands where landowners have donated or sold the easement (Merenlender et al. 2003, Rissman et al. 2006). With conservation easements, longleaf pine forests on privately owned land can be protected by Georgia's Natural Resource Conservation Service and the United States Department of Agriculture (USDA).

Action 3.2- Fire suppression may be the most ecologically significant cause for the decline in longleaf pine forests (Brockway and Outcalt 2000). An absence of fire can delay or prevent the natural regeneration of longleaf pines, allowing for invasion of longleaf pine sites by hardwood trees or competitive southern pines such as slash pine (*Pinus elliotii*) and loblolly pine (*Pinus taeda*), therefore making the land inhabitable for

the gopher tortoise (Brockway and Outcalt 2000). Benefits of periodic fire for longleaf pine forests and the gopher tortoise include diverse herbaceous groundcover dominated by wiregrass, forbs, and graminoids, and widely spaced overstories (Yager et al. 2006). These conditions provide both the diverse herbaceous groundcover needed for foraging and the open canopy conditions needed for thermoregulation and nesting by the gopher tortoise (Yager et al. 2006).

Due to this, Action 3.2 will focus on restoring 20% of state land and wildlife management areas of longleaf pine forest where the majority of trees are seedlings. Using techniques demonstrated by Brockway and Outcalt (2000), 2.2kg/ha of the herbicide hexazinone will be applied 4 years prior to the prescribed fire to provide the highest control for hardwoods and other pines that compete with longleaf pines.

Action 3.3- Minimize deforestation of gopher tortoise habitat by cutting timber in habitat that is less suitable for gopher tortoises.

This action would help stop habitat loss for the gopher tortoise, however, it is unrealistic to expect all timber cutting in gopher tortoise habitats to stop. Gopher tortoises are found in sandy uplands which is where large mature longleaf pine trees are found, these trees are desired by foresters while the land is desired by developers (Van Lear et al. 2005, Berish et al. 2012). These trees are a source of turpentine, pine oil, mulch, poles, and plywood (Van Lear et al. 2005).

Action 3.4- No Action- If longleaf pine forests continue to decrease, suitable foraging and cover habitat for gopher tortoises is also decreased. Without proper habitat for gopher tortoises, they are unable to dig their burrows, forage, and will lack the suitable habitat needed for nesting (Yager et al. 2006). As the longleaf pine forests decrease as will gopher tortoise populations.

Final Action: Actions 3.1, 3.2.

Action 3.1 to increase protection of potential habitat on private lands will be applied throughout the scope of the management plan. Action 3.2 will be implemented within the first 10 years of the management plan.

Assessment Protocol: An increase in longleaf pine forest, as outlined in the above actions, will be considered successful at completing objective 3, if habitat for gopher tortoises, is increased by 20% in twenty years. This percentage will be assessed by employing GIS techniques to evaluate current longleaf pine forests, and longleaf pine forests in twenty years. If GIS techniques show a 20% increase in habitat in twenty years, then this objective will be considered successful. This objective is critical to the success of gopher tortoises in Georgia since gopher tortoises are unlikely to live in habitat other than longleaf pine forests (Berish et al. 2012). Gopher tortoise habitat is described as open pine barrens with diverse groundcover composed of grasses and lacking understory hardwoods, this is the type of habitat that should be increased for gopher tortoise use (Landers et al. 1995).

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Gopherus polyphemus

If this objective is not met within the twenty-year timeline, the first step is to assess why this objective failed. Once a conclusion is met as to why this objective was not achieved the next step would be a land trust option for private landowners, to protect its conservation needs by limiting development (Merenlender et al. 2003). The overall goal of this objective is to increase and preserve longleaf pine habitats to stop development and succession of areas gopher tortoises need.

Conclusion

Gopher tortoise populations are declining range-wide, not only in Georgia. By focusing our efforts on reducing adult mortality, especially on roadways, reducing nest and hatchling predation, and increasing suitable habitat, we can most effectively promote the continued persistence of this species. By implementing the final courses of actions outlined in this plan (1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, and 3.2) gopher tortoise populations in Georgia will increase to achieve the goal of increasing and stabilizing gopher tortoise populations in the longleaf pine forest in Georgia from 2019-2049. Successful implementation of this management plan will allow us to not only better understand gopher tortoise population dynamics, and habitat needs, but will also serve as a model for conservation in other states in which gopher tortoises are found. As an individual species, the gopher tortoise contributes significantly to their ecosystem. Gopher tortoise burrows provide protection and habitat for hundreds of other species, making the tortoise a keystone species. With proper management of gopher tortoise populations and restoring habitat, a wide array of other species will benefit.

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Appendix A: Educational Brochure



Gopher Tortoise habitat, longleaf pine forest.

Role as a Keystone

Species:

- More than 350 other species called commensals including mammals, birds, reptiles, amphibians and invertebrates such as the endangered indigo snake are known to use gopher tortoise burrows for protection and shelter from heat, fires and predators.
- Without the gopher tortoise, the populations of these species that seek refuge or live in the burrows would be reduced greatly.

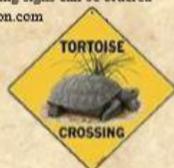


Threats Gopher Tortoises Face in the State of Georgia:

- Habitat loss due to deforestation, fragmentation, and lack of fire used as a forestry practice.
- Automobile and agricultural machinery related mortality.
- Predators such as coyotes, racoons, and armadillos.
- Human related transmission of upper-respiratory tract disease (URTD).

How You Can Help:

- Do not take gopher tortoises and move them to different areas to prevent the possible spread of URTD.
- If a tortoise is crossing the road you may move them across the road in the same direction in which it was headed. **Do not put your life in danger to move the tortoise.**
- Tortoise crossing signs can be ordered from wildcotton.com



About the Gopher Tortoise:

Identification:

- Known for their elephantine hind feet and flattened, shovel-like forelimbs adapted for digging burrows

Where they live:

- Upland dry sandy habitats such as longleaf pine forest and oak sandhills with well drained, deep sandy soils with sparse tree canopy and abundant low growing vegetation

What they eat:

Graze naturally on a wide variety of plant types such as:

- Broadleaf grasses
- Wiregrass
- Dandelions
- Grass-like asters



SAVING A KEYSTONE SPECIES: THE GOPHER TORTOISE

Living with the Gopher Tortoise and How YOU can help this declining species.

Help their Habitat!

- Gopher tortoises need sunny areas with sparse tree canopy cover. Don't allow trees and shrubs to create too much shade on your land. Provide as much low growing vegetation as possible.
- Support forestry practices such as prescribed burning and tree thinning as ways to improve gopher tortoise habitat.
- Use caution when mowing your lawn to avoid collapsing burrows.



Using prescribed burning as a forestry practice in longleaf pine forest to improve the gopher tortoise's habitat.

Private Lands and Gopher Tortoise Management:

- Approximately 90% of all forest in Georgia is privately owned.
- Management activities on private lands can enhance the condition of the habitat and benefit the gopher tortoise.
- Prescribed burning is the most important habitat management practice used to maintain suitable gopher tortoise habitat.
- Other habitat enhancement techniques include:
 - Mowing
 - Herbicides
 - Roller Chopping
- Incentive programs are available to encourage private landowners to apply conservation activities benefiting the gopher tortoise.



Appendix B

Gopher Tortoises (*Gopherus polyphemus*) in Your Backyard

There is a proposed management plan to increase the populations of gopher tortoises in the state of Georgia. This survey's intended purpose is to gain insight into the public's current knowledge about the gopher tortoise and their conservation needs.

1. Would you be able to identify a Gopher Tortoise if you saw one?
 - a. YES
 - b. NO

2. Are you familiar with the status of the Gopher Tortoise?
 - a. YES
 - b. NO

3. Are you aware of the role Gopher Tortoises play in their environment as a keystone species?
 - a. YES
 - b. NO

4. Are you aware of Gopher Tortoises habitat requirements?
 - a. YES
 - b. NO

5. If no, would you be interested in learning about specific habitat requirement for the Gopher Tortoise?
 - a. YES
 - b. NO

6. Are you currently a private landowner in the State of Georgia?
 - a. YES
 - b. NO

7. If yes, as a private landowner do you participate in any of the follow practices on your land?
 - a. Prescribed Burning
 - b. Mowing/ Roller Chopping
 - c. Tree Thinning
 - d. Herbicides
 - e. None of the Above
 - f. Other (Please Specify): _____

8. As a resident of Georgia, have you encountered tortoises on or near roads?
 - a. Yes, the tortoise was alive
 - b. Yes, the tortoise was dead or hit by a vehicle
 - c. I have never encountered a tortoise on or near a road

9. What are some concerns or questions that you, as a resident have concerning the Gopher Tortoise and their management?

Thank you for completing our survey, your answers are valued and will be used to gain insight on the public's current knowledge regarding the Gopher Tortoise.

Appendix C

Yearly Gopher Tortoise (*Gopherus polyphemus*) follow up survey

This survey is distributed yearly to residents and private landowners in Georgia. The purpose of this survey is to evaluate the public's knowledge regarding Gopher Tortoise management and conservation needs.

1. Would you be able to identify a Gopher Tortoise if you saw one?
 - a. YES
 - b. NO

2. Are you familiar with the status of the Gopher Tortoise?
 - a. YES
 - b. NO

3. Are you aware of the role Gopher Tortoises play in their environment as a keystone species?
 - a. YES
 - b. NO

If yes, why are Gopher Tortoises considered a keystone species in their environment?

4. Are you aware of Gopher Tortoises habitat requirements?
 - a. YES
 - b. NO

If yes, what are the habitat requirements for Gopher Tortoises?

If no, would you be interested in learning about specific habitat requirement for the Gopher Tortoise?

- a. YES
 - b. NO

5. Are you currently a private landowner in the State of Georgia?
 - a. YES
 - b. NO

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Gopherus polyphemus

6. If yes, as a private landowner do you participate in any of the follow practices on your land?
- a. Prescribed Burning
 - b. Mowing/ Roller Chopping
 - c. Tree Thinning
 - d. Herbicides
 - e. None of the Above
 - f. Other (Please Specify): _____

7. As a resident of Georgia, have you encountered tortoises on or near roads?
- a. Yes, the tortoise was alive
 - b. Yes, the tortoise was dead or hit by a vehicle
 - c. I have never encountered a tortoise on or near a road

If yes, have you noticed signs warning motorist of tortoise crossings?

- a. YES
- b. NO

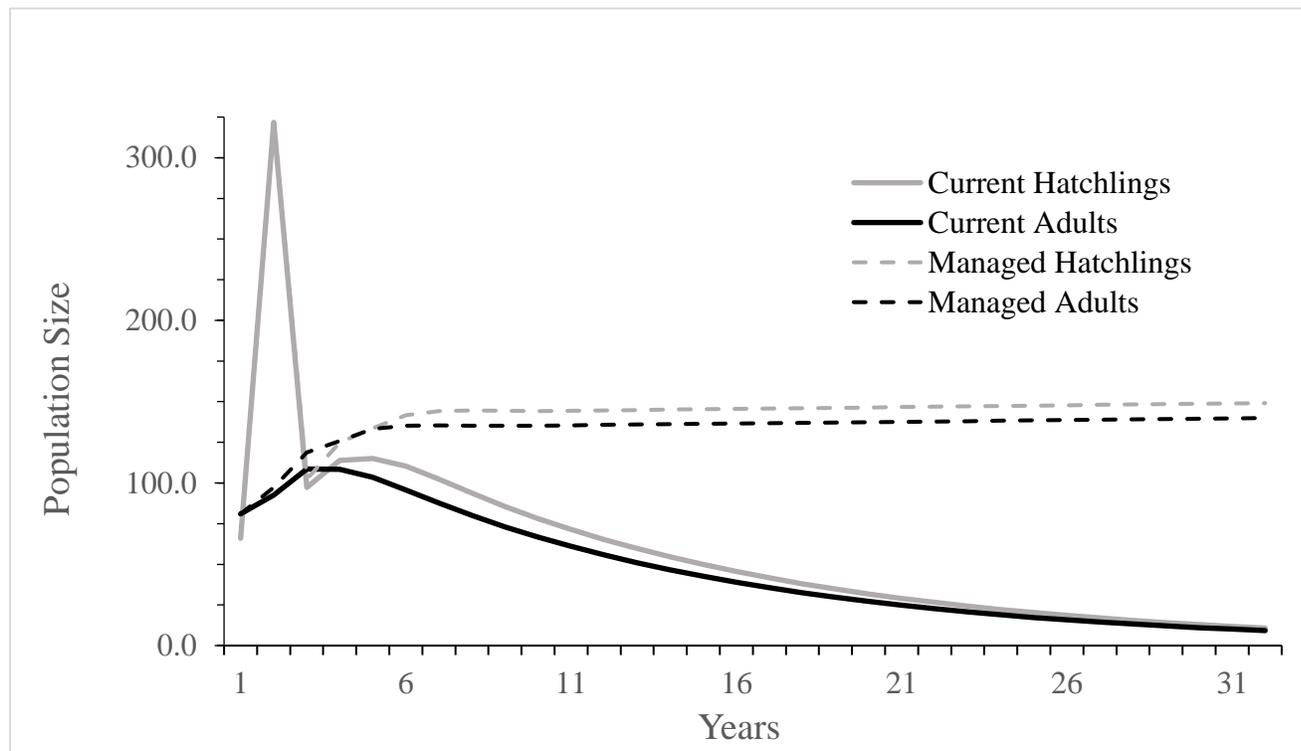
8. What are some concerns or questions that you, as a resident have concerning the Gopher Tortoise and their management?

Thank you for completing our survey, your answers are valued and will be used assess the public's knowledge regarding the Gopher Tortoise.

Appendix D

	<i>F</i> (e)	<i>F</i> (h)	<i>F</i> (j)	<i>F</i> (sa)	<i>F</i> (a)
Egg:	0	0	0	1.0625	2.4475
Hatchlings:	0.39	0	0	0	0
Juveniles:	0	0.05	0.185	0	0
Subadults:	0	0	0.45	0.275	0
Adults:	0	0	0	0.425	0.89

Stage Structured Matrix Model for *Gopherus polyphemus*



Current population projections for adult and hatchling gopher tortoises in Georgia in 30 years with a hatchling survivorship of 5% and adult survivorship of 89% and population projections with the proposed management plan for adult and hatchling gopher tortoises in Georgia in 30 years if adult survivorship increased by 6% and hatchling survivorship by 10%.

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Gopherus polyphemus

Sensitivity matrix					
		$F(h)$	$F(j)$	$F(sa)$	$F(a)$
Egg	0.1044	0.0102	0.0007	0.0005	0.0087
Hatchlings	0.0560	0.0239	0.0016	0.0012	0.0204
Juveniles	1.0246	0.4372	0.0300	0.0211	0.3735
Subadults	1.6599	0.7083	0.0486	0.0342	0.6051
Adults	2.4361	1.0394	0.0713	0.0502	0.8880
Elasticity matrix					
	$F(h)$	$F(sj)$	$F(lj)$	$F(sa)$	$F(a)$
Egg	0	0	0	0.000572894	0.023342624
Hatchlings	0.023915518	0	0	0	0
Juveniles	0	0.023915518	0.006068867	0	0
Subadults	0	0	0.023915518	0.010291839	0
Adults	0	0	0	0.023342624	0.864634599

Sensitivity and Elasticity matrix for *Gopherus polyphemus*.

Appendix E: Educational Flyer

Upper-Respiratory Tract Disease (URTD): An Emergent Disease in Gopher Tortoise Populations

What can happen when gopher tortoises are moved illegally

Background:

Upper-respiratory tract disease is an emergent disease that has moved rapidly from obscurity to major concern in gopher tortoise populations. URTD is caused by the bacteria *Mycoplasma agassizii* and is easily transmitted through direct contact between tortoises and through contact with nasal secretions.

Clinical Signs of URTD:

- Excessive tearing and ocular discharge
- Conjunctivitis
- Swelling of the eyelids and ocular glands
- Discharge from nares
- Tortoises can be infected with *Mycoplasma agassizii* but show no clinical signs of URTD.



Problems with moving Gopher Tortoises from one area to another:

- Stressors such as habitat disturbance, translocation, and pollution can cause tortoises infected with URTD but with no clinical signs to develop clinical signs.
- Infected tortoises relocated to areas with healthy tortoise populations could cause that population to decline.
- Gopher tortoise populations are highly sensitive to changes in adult survival even small declines in adult survival can significantly decrease gopher tortoise populations.

How YOU can help:

- Do not move Gopher Tortoises from one habitat to another.
- If you notice a sick tortoise, report it!

