42nd Annual Gopher Tortoise Council Meeting

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Virtual

The Burrow

FULL-LENGTH ORAL PRESENTATION ABSTRACTS

Adapted Release Methods Effects on Hatchling Emergence, Dispersal, and Survival: Preliminary Results

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Gopher tortoises (*Gopherus polyphemus*) are most vulnerable during the hatchling life stage, with an estimated 90% mortality within their first year. One method to address this is by headstarting hatchlings until they reach a less vulnerable size. However, this practice is not permitted in the state of Florida, nor is it logistically feasible on a large scale. Therefore, alternative methods must be tested for efficacy and feasibility. Previous research suggests that, aside from nest predation, most hatchling mortality occurs within first 30 days after emergence, primarily a result of mammalian predation. In attempt to increase survivability, we conducted a pilot study at Nokuse Plantation for two new release methods. To promote a more natural emergence, we released hatchlings deeper into an inactive adult burrow (~0.5 m) or buried hatchlings ~17 cm deep in a simulated "nest" in the apron. Release sites were two inactive adult tortoise burrows (40 m apart) in a 27.5-ha area protected by an electric fence, with five hatchlings per treatment released at each burrow. Emergence and dispersal were determined through direct observation, camera traps, and/or radiotelemetry. Tortoises were tracked 5-7 times per week. Aluminum flashing and pinwheels were added around the immediate release area as additional, low-cost visual and auditory predator deterrents. Four nest-released tortoises were excluded from analyses due to transmitter attachment failure. Overall, it took 6.2 days on average for a hatchling to emerge with a 3.96 m average initial dispersal distance. Burrow-released tortoises (n=9) averaged 5.6 d (0-18 d) to emergence with an average initial dispersal of 3.78 m (0.74-11.18 m). Nest-released tortoises (n=6) averaged 7.2 d (6-11 d) to emergence with an average initial dispersal of 4.29 m (1.02-7.54 m). As of abstract submission, one tortoise had not emerged from the release burrow, and no confirmed predation or mortality had been observed.

The Relocation and Conservation of Gopher Tortoises in Florida: Are Long-term Protected Recipient Sites Effective?

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Since 2009 about 71,000 gopher tortoises have been legally relocated within Florida. Most tortoises (≈92.4%) were taken to 39 long-term protected recipient sites (including 31 for-profit private lands); 14 sites had multiple phases resulting in 64 separate permits. In March 2020 the Florida Fish and Wildlife Conservation Commission (FWC) provided a preliminary evaluation of these long-term sites, finding that: 1) reporting data were inconsistent, 2) mortality events were often not reported, and 3) current monitoring requirements are insufficient to measure population trends over time or to inform improvements to the state permitting guidelines. Alarmed over these findings, I independently reviewed the online permitting files for these sites and found that: 1) the percent increase in authorized stocking densities at many recipient sites were hundreds-to-thousands of times greater than the estimated resident tortoise population, 2) only one site (Nokuse Plantation) demonstrated evidence of significant past harvest, 3) the proposed management activities were insufficient to support the permitted carrying capacity of most sites, and 4) 36 of the 39 sites were already protected under an existing conservation easement. Based on these findings, in August 2020 the GTTAG voted to recommend that FWC consider the following actions:

1. Analyze the existing 2009-2020 gopher tortoise relocation ("Conservation") permits to obtain more accurate estimates of tortoise: burrow correction factors, tortoise densities, and size/age structure in relation to habitat and soil types, season, geographic region, vegetation structure, habitat fragmentation, etc.
2. Develop detailed recommendations for maximizing the carrying capacity of future recipient sites.
3. Where feasible, strongly recommend prescribed fires immediately preceding belt transect or line-transect distance sampling of tortoise burrows on recipient sites to improve detectability.
4. Consider financial/permitting options for increasing the carrying capacity of public lands.

Burrow Characteristics and Habitat Associations and of Gopher Tortoises in Urban Pine Rockland Reserves (Miami, Florida, USA)

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The ecology and conservation of Gopher Tortoises at the extreme southeastern limit of the range is poorly understood. We examined burrow characteristics and habitat associations of gopher tortoise burrows in two pine rockland natural areas within the highly urbanized Miami-Dade County (Florida, USA). We measured width, depth, and orientation of burrows at each site. We compared a suite of 11 habitat features (including canopy cover, understory density, ground cover, soil depth and soil compaction) at random points and at gopher tortoise burrows in each of the two sites. Burrows widths were similar between sites, and included burrows of both adults and juveniles – evidence that both populations are reproducing. Burrows were very shallow (most <2m) compared to burrow depths reported from other sites (>4m), likely because soil depth is very shallow in extreme south Florida. We found differences in habitat variables among sites, among point types (random points and burrows) and between active and inactive burrows – and canopy cover, bare ground cover, and soil depth were among the major variables associated with burrows and active burrows. The habitat associations of the burrows were similar to studies from other areas, yet the shallow burrows and strong association with deep soils appear to be a strong response to very limited soils in pine rockland habitats. We discuss vegetative associations of gopher tortoises in the context of management in urban natural areas and implications for protection of gopher tortoises at the southern limit of their geographic range.

Climate variability influences aspects of gopher tortoise fecundity

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Long-term capture-mark-recapture (CMR) datasets with linked fecundity data are critical for estimating how environmental variability affects population trends in long-lived species, including gopher tortoises (*Gopherus polyphemus*), because fecundity is more likely to be sensitive to climatic variability than survival in long-lived species. Our objective was to estimate effects of climatic variation on gopher tortoise fecundity using a 25-year CMR dataset collected at Fort Stewart Army Reserve in Georgia. Adult tortoises were captured primarily in the summer via bucket trapping or hand capture. All females were ultrasounded to detect the presence of shelled eggs, and subsequently x-rayed to measure clutch size. We searched for effects of climate (maximum temperature, precipitation, and monthly temperature range) on two aspects of fecundity (probability of reproducing and clutch size) using a moving window analysis in the 24-month period prior to the summer census date. Probability of reproduction and clutch size both increased with female body size. In addition, probability of reproducing was negatively affected by the monthly temperature range of the previous summer (May-July), and clutch size was positively correlated with the maximum temperature of the previous June. The timing of these climatic effects overlaps with the initiation of vitellogenesis for egg production. Summer monthly temperature range has decreased and June maximum temperatures have increased over the past three decades at FSAR – changes that could actually lead to increases in gopher tortoise productivity. However, the overall effect of climate change on gopher tortoise population dynamics will depend on whether there are compensatory responses by other vital rates such as hatching success or juvenile survival.

Baseline stress metrics in head-started gopher tortoises (*Gopherus polyphemus*) and their relationship with post-release survival

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Chronic stress can have wide ranging adverse effects on wildlife, including immune suppression, reductions in growth or reproduction, and aberrant behaviors. Stress in wildlife can be induced by many different variables, including environmental pollutants, anthropogenic changes to the landscape, and even animal conservation programs. With over half of all extant turtle species threatened by extinction, there are many conservation initiatives, such as translocation and captive rearing, being implemented to potentially recover populations. Yet how they affect baseline stress levels remains relatively unexplored, as has the role of stress in influencing the outcomes of those interventions. We aim to characterize baseline stress metrics of clinically healthy head-started gopher tortoises (*Gopherus polyphemus*) reared indoors for an extended duration (2.5 – 3.5 years). We measured a suite of stress metrics including plasma and fecal corticosterone, heterophil:lymphocyte ratios, and lactate levels in 25 head-started gopher tortoises as pre-release variables that could potentially predict post-release survival. We will summarize results and evaluate the role of individual stress metrics, cohort (*i.e.*, head-starting duration), and body size (midline carapace length) in predicting survival to dormancy. Our results have the potential to refine head-starting techniques, such as the optimal duration in captivity, and may prove useful in predicting post-release movement and survival of head-started gopher tortoises. Ultimately, this would allow researchers to optimize head-starting techniques and manage this species of conservation concern more effectively.

Effects of gopher tortoise (*Gopherus polyphemus*) exclusion on understory plant community dynamics in a longleaf pine forest

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Longleaf pine (*Pinus palustris*) communities in the southeastern United States are known for being one of the most species rich terrestrial systems in North America. While the role of fire frequency and management has received considerable attention, the impact of herbivory on longleaf pine diversity and productivity has been relatively overlooked. The gopher tortoise (*Gopherus polyphemus*) is a keystone herbivore in sandhill communities that are common in long leaf pine ecosystems. Gopher tortoises are a colonial species with an intimate home range and relatively low metabolic costs making it an ideal model organism to study the effects of herbivory. We hypothesized that gopher tortoise herbivory acts as an intermediate level disturbance that suppresses plant productivity and facilitates diversity in understory communities. In January 2019, we established herbivore-exclusion plots amongst a gopher tortoise colony at Splinter Hill Bog Preserve in southwest Alabama. We measured the response of plant species diversity, composition and productivity throughout a single growing season to quantify the short-term impacts of this exclusion on understory plant communities. We found that plots excluded from tortoise herbivory had significantly taller plants, increased plant cover, and species compositional shifts. Gopher tortoise exclusion also significantly reduced plant diversity, evenness and richness. We support our hypothesis that gopher tortoise herbivory can significantly alter the dynamics of understory plant communities in a single growing season. Our results provide evidence that evolutionary trajectories in species rich systems are typically influenced by multiple disturbance types at differing levels of intensity.

SPEED-TALK ORAL PRESENTATION ABSTRACTS

Closing the Gap: Addressing Gopher Tortoise Research Needs to Inform Practice and Policy

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The Gopher Tortoise Permitting Guidelines provide a comprehensive overview of the permitting process developed as one tool to accomplish the goal and objectives set forth in Florida Fish and Wildlife Conservation Commission's (FWC) Gopher Tortoise Management Plan. These permitting guidelines are informed by science and revised as new research becomes available. Here we highlight FWC's current data collection efforts and identify high priority research needs to raise awareness of knowledge gaps. Our aim is to promote research that can directly influence policy and management actions for the gopher tortoise.

Plasticity in Gopher Tortoise Nesting Behaviors and Fecundity in a Translocated Population

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Understanding how species will respond to climate change is crucial to conserving global biodiversity. The intensity and rapidness with which the climate is changing suggest that adaptive evolution could be too slow to keep pace with climate change. Alternative mechanisms, such as physiological and behavioral plasticity, may be required for species to persist. Gopher tortoises (*Gopherus polyphemus*) are a threatened, keystone species that play essential roles in upland habitats throughout the southeastern United States. Climate change could have diverse and strong effects on the fecundity and population demographics of gopher tortoises, as they are long-lived reptiles that rely on environmental temperatures for thermoregulation and sex determination. We used a population of translocated gopher tortoises at Nokuse Plantation, located in the panhandle of Florida, as a common garden experiment to assess whether plasticity of several nesting behaviors (i.e., nest temperature, depth, and orientation) and components of fecundity (i.e., clutch size, egg size, hatching success, sex ratios) can compensate for changes in environmental conditions. If tortoises exhibit plasticity by matching nesting behavior to local conditions, we predicted that distance from natal site would have no effect on nesting behaviors and fecundity. We compared nest characteristics among translocated females (from across the state of Florida) and examined how geographic and environmental distance from natal origin impacted aspects of fecundity. Our findings indicate that the environmental distance from natal site may negatively impact hatch success for large females, while female reproductive investment (i.e., clutch size and egg mass) stays the same. Geographic distance had no impact on female fecundity or nesting behavior. We will discuss the implications of these findings and how they contribute to our understanding of gopher tortoise resilience to impending environmental changes and best practices for translocations in terms of suitable translocation distance from natal site.

GPS technology reveals larger home ranges for immature Gopher Tortoises

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Movement data, such as home ranges, provide insight into the types and amount of habitat needed to support species, which is critical for conservation planning of wildlife populations. Gopher Tortoises are experiencing ongoing population declines and warrant additional habitat protection and management throughout their range. Conservation assessments for Gopher Tortoises are currently limited by scant knowledge of the ecology of younger age classes. We implemented a short-term study of immature Gopher Tortoise spatial ecology at Archbold Biological Station, Florida to determine home range size, movements, and activity levels of 3-7-year-old tortoises. GPS technology allowed us to obtain high temporal resolution tracking data (~10-fold increase compared to the radio tracking frequency in prior studies). Despite the relatively short duration of our study (≤ 40 days), immature Gopher Tortoises (n = 6) at Archbold Biological Station had home range sizes ranging from 0.38-1.46 ha, which are 6-8 fold larger than previously reported annual home range estimates. Maximum daily displacements from their primary burrow averaged 23 m, which is also significantly greater than the average of 8 m reported by Wilson et al. (1994). Additionally, the mean daily distance traveled (0900-1300 hr) per tortoise ranged from 43–79 m. Our results illustrate the importance of employing new technologies to track previously difficult-to-observe life stages to improve conservation efforts for imperiled species.

Identification of a novel mortality-associated *Helicobacter* species in gopher tortoises (*Gopherus polyphemus*), qPCR test development and validation, and an epidemiological survey

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The genus *Helicobacter* includes spiral-shaped bacteria in the phylum Proteobacteria, class Epsilonproteobacteria, order Campylobacteriales, that have been associated with disease in animals, including reptiles. Three wild gopher tortoise (*Gopherus polyphemus*) index cases presented between 2012 and 2019 with nasal discharge, lethargy, and weight loss. Cytological examination of nasal discharge from all 3 tortoises identified marked heterophilic and mild histiocytic rhinitis with abundant extracellular and phagocytized spiral shaped bacteria that stained positive with Warthin-Starry stain. Polymerase chain reaction (PCR) and sequencing of the 16S rRNA gene revealed this to be a novel *Helicobacter* species. Two died despite treatment attempts, and the third was moribund and was euthanized. Histological examination of the nasal mucosa (n=3) showed granulocytic to lymphocytic rhinitis with variable mucosal hyperplasia, erosion, and ulceration; Warthin-Starry staining highlighted the presence of spiral bacteria in the untreated tortoise. Genus-specific primers were designed, and the *gyrA* and *groEL* genes were amplified by PCR and sequenced. Phylogenetic analysis shows that this organism and other previously characterized *Helicobacter* from tortoises form a clade. Development and cross-validation of two qPCR diagnostic assays for the *gyrA* and *groEL* genes showed significant correlation of the results of two assays ($P<0.0001$). These assays were used to survey nasal wash samples from 31 rehabilitating gopher tortoises. Mortality of tortoises significantly correlated with higher *Helicobacter* loads detected by qPCR ($P = 0.028$). Upper respiratory disease in tortoises may involve complex microbial ecology; factors beyond *Mycoplasmopsis* (*Mycoplasma*) *agassizii* and appropriate quarantine protocols for tortoises during rehabilitation should be taken into account.

How many viable Gopher Tortoise populations in Georgia are bisected or bordered by roads?

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In Georgia, the majority of Gopher Tortoise (*Gopherus polyphemus*) populations considered to be viable have been identified and efforts are currently underway to permanently protect approximately half of these populations. However, even after the land supporting populations has been protected, there are still significant hurdles for maintaining population viability. For example, because road mortality has been shown to have significant negative impacts on some turtle populations, understanding the proximity of these populations to roads may be important. Here, I examine how roads in southern Georgia border or bisect viable tortoise populations. In total, there were approximately 101,000 km of roadways within the Gopher Tortoise's Georgia range. Almost all of the identified viable tortoise populations had one or more roads either bordering or bisecting the tortoise habitat (0–75.6 km of roadway). Approximately 60% of all roads associated with viable tortoise populations were classified by the Georgia Department of Transportation as small, unpaved roads. However, 64 (52%) of the viable Gopher Tortoise populations were completely bisected by at least one two-lane paved road. The average daily traffic volumes along these paved roads ranged from 110–6,660 vehicles per day. For comparison, the 15 instances where roads were used as a barrier separating two viable Gopher Tortoise populations had traffic volumes ranging from 480–4,335 vehicles per day (five road segments bisecting a single population had higher traffic volumes than roads dividing multiple populations). Overall, roads are likely impacting many of Georgia's viable tortoise populations, but there is little data to suggest how tortoises in these populations may be interacting with roads. Dead on the road tortoises are rarely reported, making it challenging to identify potential mortality hotspots. The road segments identified here with the highest traffic volumes represent ideal locations to conduct additional research and potentially pursue mitigation measures.

Skins for Sale: A Legal and Unquantified Threat to the Eastern Diamondback Rattlesnake

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Eastern Diamondback Rattlesnake (*Crotalus adamanteus,* EDB) populations face declines throughout their range and in 2011 were petitioned for Federal listing. Since the petition to the U.S. Fish and Wildlife Service, little action has been taken to protect this species and the next review in the listing process will be in 2024. EDB protections vary by state but are most protected in North Carolina and Louisiana, at the edges of their range, where all direct take is prohibited. Partial protections exist in South Carolina, Alabama, and Mississippi, but Florida and Georgia offer no legal protections, leaving them completely unprotected across the remaining stronghold in their range. Known threats to EDBs include rattlesnake roundups, exploitation for the skin trade, malicious killings by humans, road mortality, and habitat destruction, degradation, and fragmentation. Life history traits such as relatively low lifetime fecundity and low recruitment rates make it difficult for EDBs to recover from human-caused mortality. Although the EDB skin trade is documented, it is not a well understood threat due to a lack of regulation and reporting. EDBs are collected and brought to general stores, which serve as collection points for skin dealers, in multiple states where individuals are paid by the foot. In 2018 we received a ledger documenting the sale of 1,136 EDBs from 2008-2016 into the skin trade from one such general store in southern Alabama. EDBs were collected in all months, but the highest numbers were collected between July and October, corresponding with their mating season. Snake length was between 2 and 6.5 ft (avg 4 ft) and the average purchase price was $2.33 per foot. This unregulated annual collection and sale equates to a modern bounty system and may be a significant threat to EDB populations in many areas throughout their range.

Nest site, nest temperature, and hatching outcomes across an environmental gradient in the gopher tortoise

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Understanding how population vital rates respond to environmental factors across an existing gradient can reveal the degree to which species may be vulnerable or resistant to decline following anthropogenic climate change. In long-lived species, adult survival is likely to be robust to climate variation, whereas components of fecundity are more likely to be sensitive to environmental variation. Here, we investigate how female gopher tortoise nesting decisions (nest position, depth, aspect and shadiness) are related to nest temperatures, and how these variables jointly influence hatching success. We assessed these effects using a structural equation model to account for direct and indirect pathways of effects on hatching success. We collected data from five sites spanning the latitudinal gradient of the species' range in Georgia and Florida, totaling 68 wild nests from 2018 and 2019 with nest temperature data recorded with iButton temperature dataloggers. As expected, mean nest temperature is predicted by site climate, as well as nest shadiness and depth, while nest temperature variability was predicted by distance onto the apron and nest depth, indicating that female nesting behaviors influence the nest thermal environment. Mean nest temperature did not affect hatching success; instead, we found simultaneous positive effects of nest temperature variability and nest depth on hatching success, suggesting that female nesting decisions influence hatching success. Future directions will include developing a more biologically meaningful metric that may better capture the relevant aspects of nest temperature, and adding data from 2020 to increase sample sizes at each site, allowing for between-site comparisons.

Survival of Immature Gopher Tortoises Recruited into a Translocated Population

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Population manipulations such as translocation and head-starting are increasingly used as recovery tools for chelonians. However, evaluating success of individual projects can require decades of monitoring to detect population trends in these long-lived species. Furthermore, there are often few benchmarks from stable, unmanipulated populations against which to compare demographic rates, particularly for the immature stages. We used 8 years of mark-recapture data to estimate apparent survival of immature gopher tortoises recruited into an introduced population of gopher tortoises (Gopherus polyphemus) first established on St. Catherines Island, Georgia, USA in 1987. During 2006-2013, we conducted targeted trapping of immature gopher tortoises and compared survival of the hatchling, juvenile and subadult stages among treatments: 1) individuals released shortly after hatching from eggs obtained from gravid female founders ('direct releases'); 2) individuals reared in captivity for 6-9 months following hatching ('head-starts'); and 3) individuals first encountered as free-ranging, wild-recruited offspring ('wild recruits'). Among the candidate models we examined, the best fit model included additive effects of tortoise stage and treatment, however, overlapping 95% credible intervals among treatments (CI) suggested that survival did not vary significantly among treatments. Annual apparent survival increased over the immature period, highlighting the importance of calculating separate estimates for the different immature stages. Across all treatments, the additive model estimated annual apparent survival probability to be 0.37 (CI: 0.25 – 0.48) for hatchlings, 0.71 (CI: 0.61 – 0.81) for juveniles, and 0.83 (CI: 0.74 – 0.94) for subadults. Our study, in combination with previous monitoring efforts at St. Catherines Island, provides strong evidence that the translocation and subsequent population augmentation efforts have been successful in establishing a robust population of gopher tortoises. Additionally, our results provide estimates of demographic rates for life stages that are poorly understood but critical to understanding population dynamics of this imperiled species.

Gopher Tortoise Survey Results at Fort Rucker, Alabama

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The gopher tortoise (*Gopherus polyphemus*) is a fossorial species found in uplands of the southeastern U.S.; the species has declined range-wide due largely to habitat loss. The gopher tortoise is federally listed as threatened in western Alabama, Mississippi, and Louisiana. The eastern populations of the gopher tortoise (east of the Tombigbee River in Alabama, Georgia, Florida, and South Carolina) is currently a candidate for federal listing as threatened and the species is a priority Army "Species at Risk" for our study site located at Fort Rucker in Southeastern Alabama. As part of the Candidate Conservation Agreement for the gopher tortoise, surveys were undertaken to assess the status of the species on Fort Rucker in 2019. A three-observer line-transect distance sampling survey was conducted to estimate population size and density and to describe the population structure. The sampling area was stratified into high and moderate quality habitat using field assessments, forest inventory data, and current aerial photography. The site included a total of 7,226 ha of potential habitat (5,831 ha of moderate quality habitat and 1,395 ha of high quality habitat). We sampled transects totaling 85,807 meters in length and observed 302 tortoise burrows, of which 122 were occupied by tortoises (42.7%). The overall population estimate was 2,872 tortoises (95% CL: 2,078-3,9870, CV= 0.16), with a density of 0.40 tortoises/ha (95% CL: 0.29-0.55). High quality habitat supported a density of 1.08 tortoises/ha compared (95% CL: 0.68-1.72, CV=0.26) to 0.23 tortoises/ha in moderate quality habitat (95% CL: 0.16-0.35, CV=0.22). Seventy-eight percent of observed burrows were in the adult size class (>23cm in width) and 28% were in the juvenile/sub-adult size class (<23cm). Management that includes frequent prescribed fire and forest thinning can help maintain and improve habitat quality for the regionally significant gopher tortoise at Fort Rucker.

POSTER PRESENTATION ABSTRACTS

Changing Perceptions of Wildlife: How Collaboration can Protect Gopher Tortoises (*Gopherus polyphemus*) while Maintaining Industrial Progress

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Protecting wildlife on multi-use lands while simultaneously supporting beneficial industries is often an uneasy topic for wildlife advocates, and requires complex solutions developed through innovative partnerships. Through strategic planning and key partnerships, ecologists and industry can come to an agreement on clashing goals: protecting wildlife amidst advancing industry progress. Initiated in 2015, the University of Georgia has maintained a positive collaboration with Southern Ionics Minerals, a subsidiary of Chemours, to protect wildlife, focusing mainly on gopher tortoises (*Gopherus polyphemus*), at heavy mineral sand mines in South Georgia. Collectively, we maintain a multifaceted approach to protect gopher tortoises and other wildlife from mining activities through on-the-ground wildlife impact mitigation, ecological research, and educating mine personnel. This collaboration has supported multiple research projects that study the ecology, reproduction and health of relocated gopher tortoises from the mineral mines. Through the relocation and headstarting of gopher tortoises, we have contributed to augmenting minimal viable populations of gopher tortoises on Georgia Department of Natural Resources Wildlife Management Areas. Our critical and challenging balance is avoiding local extirpation of gopher tortoises from habitats surrounding the mines while accommodating industrial activities that are vital to resources used commonly in our society. These efforts have been made possible by proactively maintaining open communication between miners, wildlife professionals, and natural resource agencies. Here, we present some of the challenges and successes we have faced throughout this collaboration and the ways that gopher tortoises have benefited as a result.

Observations of Gopher Tortoise (*Gopherus polyphemus*) Recruitment Following Prescribed Fire on a Private, Working Forest Landscape in Louisiana

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The gopher tortoise (*Gopherus polyphemus*), a keystone species in southern pine (*Pinus* spp.) ecosystems, is listed as threatened under the Endangered Species Act in the western portion of its range. Approximately 70% of potential tortoise habitat is on privately owned lands often managed for timber production. Tortoise ecology on private, working forest landscapes remains poorly understood. Therefore, from 2017–2020, we used burrow and mark-recapture surveys to examine tortoise response to active forest management within a private, working forest in Washington Parish, Louisiana. In January and February 2019, three pine stands and portions of adjoining rights-of-way (176ha) were treated with prescribed fire. In March 2020, one of these stands (42ha) was burned again. Prior to 2019, these stands had not been burned in 10 years although they did receive herbicide treatments to reduce understory vegetation and thinning operations to reduce basal area. We captured 40 individuals (16 females, 23 males, and 1 juvenile). For the stand burned both years, we observed an increase in burrow activity and three juvenile tortoise burrows (burrow width of 5.5–7.0cm; one occupied) after prescribed fire treatments. Additionally, we captured a juvenile tortoise (straight-line carapace length = 6.0cm) in 2020 within a right-of-way burned in 2019. Although we observed signs of reproduction, including depredated nests and a single inactive juvenile burrow, on this site prior to prescribed fires, observations of successful recruitment have been sparse since the 1990's, and this juvenile was the first immature tortoise captured in 10 years. While juveniles may have been present but not detected prior to prescribed fires, we estimate that juveniles detected in 2020 were hatched in 2019 based on annuli rings, straight-lined carapace length, and burrow widths. Prescribed fire, combined with other forest management practices, may have improved conditions for gopher tortoise reproduction on this site.

Use of annual and lifetime home ranges to evaluate movement patterns of Gopher Tortoises at the northern limit of their geographic range

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Studies of movement distances, largely derived from use of telemetry during a season of activity, have provided crucial data for delimiting the content of local populations. However, examination of capture locations of individuals during long-term monitoring of local populations might also inform conservation efforts of the content of local populations. We use a novel data set from a local population of Gopher Tortoises on the Conecuh National Forest in south-central Alabama to examine annual home ranges of individual tortoises based on a season of telemetry (2000) and lifetime home ranges of those same individuals based on long-term capture records (1992-2020). These tortoises occupy a study site characterized by a roughly circular core area and an elongate southwestern extension from the core. During 2000, individuals monitored with telemetry (N = 34) included six that were relocated fewer than 15 times. Because these individuals also were captured, at most, one other time during long-term monitoring, we infer that they immigrated from the site. We also inferred that individuals captured 4 or fewer times were floaters that likely also immigrated to the study site or emigrated from it over the long term. Those captured 5 or more times during long-term monitoring were inferred to be residents (likely present on the site during the entire study period). Floaters appear to be female biased and, based on 2000 data, we estimate 18% of individuals may immigrate annually. Of 12 residents in 2000, only one had movements extensive enough to include both the core and southwest extension. However, capture records for those same 12 individuals documented that nine visited both the core and southwestern extension. These data provide a preliminary estimate for migration rates between local populations within a metapopulation and suggest that lifetime home ranges are 2.5 to 5 times larger than annual home ranges.

Investigating vertebrate relationships of the south Florida gopher tortoise: a study of vertebrate species within scrub, pine rockland, coastal hammock and grassland habitats

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Gopherus polyphemus, commonly known as the gopher tortoise, is a chelonian keystone species that is endemic to the southeastern United States. They create networks of underground burrows that are home to an additional three hundred and fifty species, where approximately 60 of these species are vertebrates (Dziadzio & Smith, 2016). Gopher tortoise's in south Florida have been shown to have year round activity due to a warmer climate, which can affect the species associated with burrows (Moore, Strattan, & Szabo, 2009). Gopher tortoises are a threatened species in the state of Florida, and data from this study can be used to develop more effective habitat management plans for their south Florida populations. This study is designed to investigate the potential environmental factors that may affect the presence of vertebrate species at the gopher tortoise burrows. In this study, camera trapping was used at four different study sites in south Florida to investigate the different factors such as habitat type, plant community, and seasonality that affect the vertebrate species that are present within the burrow. Cameras were placed at various locations across south Florida at Deerfield Island Park, Florida Atlantic University Preserve, Pondhawk Natural Area, and Zoo Miami. A list of vertebrates present and their potential to be a commensal or non-commensal will also be recorded for each site. This data can then be used to drive future studies in determining if these vertebrate species could potentially be commensals of the gopher tortoise.

Vertebrate and Invertebrate Commensals in Gopher Tortoise Burrows of Southeast Florida

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Gopher tortoise (*Gopherus Polyphemus*) burrows provide a unique microhabitat used by hundreds of vertebrate and invertebrate species. Prior to this study, limited information was available regarding burrow commensal species in southeast Florida, especially for invertebrate taxa. This study is an in-depth investigation of vertebrate and invertebrate gopher tortoise burrow commensals and is the first to document obligate invertebrate commensals (OIC) in this region. The objective was to test a variety of non-invasive methods effective for surveying commensals, compile an account of species dependent on gopher tortoise burrows in southeast Florida, accumulate information on threatened, endangered, and invasive species, add to the distributional information on OIC's, and present information to land managers. Three pine flatwoods and three scrub habitats, with varying degrees of management were surveyed. Eighty-nine species were identified. This study was a substantial step toward documenting gopher tortoise burrow commensals in this region.

Restoring Sandhill and Managing Ruderal Habitat for Gopher Tortoises at Archbold: Initial Results and Lessons Learned

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Despite wide recognition of the benefits of prescribed fire for Gopher Tortoises (*Gopherus polyphemus*) and other threatened species, there are no blueprints and many uncertainties for managers charged with restoring and managing anthropogenically altered habitats. In 2013, we initiated habitat restoration combined with intensive tortoise monitoring at Archbold Biological Station in south-central Florida. Red Hill at Archbold is an example of a rare southern ridge sandhill (or "high scrubby pine") community and the site of a 53-year tortoise mark-recapture study. Our goal is to improve habitat for Gopher Tortoises by re-establishing natural fire regimes in long-unburned sandhill while optimizing management of the ruderal habitat (Hill Garden) where most tortoises currently reside. Here we report on initial tortoise responses to mechanical clearing and burning of 37 ha of fire-suppressed sandhill and lessons learned during this initial restoration phase. While we are seeing promising increases in densities of burrows and tortoises (including juveniles) suggestive of immigration and enhanced recruitment, expansion of invasive exotics is causing us to slow the pace of burning and rethink the timing and sequencing of different practices. For example, to reduce post-fire seed rain of exotic species, we are now chemically treating invasive species along unit edges prior to burning. Invasive grasses (e.g., *Melinis repens*, *Urochloa maxima*) pose a particular challenge for sandhill restoration, though we have found it beneficial to retain dense Bahiagrass (*Paspalum notatum*) cover in Hill Garden. Mowing is a useful strategy for managing roadsides and ruderal habitats provided it is timed to prevent tortoise mortality. Likewise, growing-season prescribed burns should be timed to ensure regrowth of vegetative cover before hatchlings emerge in late summer. Our initial experiences are helping to inform development of integrated, unit-specific management prescriptions for future mechanical, fire, and exotics treatments on Red Hill.