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Abstracts for Oral Presentations

**denotes student presenter*

Year-round Plasma Steroid Hormone Profiles and Reproductive Ecology of Gopher Tortoises (*Gopherus polyphemus*) at the Southernmost Edge of Their Range

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Populations of wide ranging ectotherms often exhibit variation in traits that are influenced by local environmental conditions. Although the gopher tortoise, *Gopherus polyphemus*, is well studied in pine flatwoods habitats across their range, there is a paucity of data for populations existing in the southern extreme portion of the range. We examined the reproductive physiology of a coastal dune population on the southern extreme edge of their range to determine if reproductive cycles vary across populations. Here we present the first year-round sex hormone profiles for a wild population of gopher tortoises. Male testosterone concentrations varied across the year ($F_{11,54} = 2.52$, $P = 0.015$) with elevated values from September–December and minimal levels from April–July, with the exception of a secondary peak during the month of June. Female testosterone and estradiol concentrations varied across the sampling period (T: $F_{11,66} = 8.54$, $P < 0.001$, E: $F_{11,66} = 4.57$, $P < 0.001$) with highest values from August–February, and lowest levels from May–July. Female progesterone concentrations varied over the year ($F_{11,64} = 3.29$, $P = 0.002$) and displayed a bi-modal distribution with peak concentrations in November and March. These data suggest this population has an extended breeding season from fall through spring with mating likely occurring from September through March, and females depositing two clutches of eggs during a winter and early spring nesting season. This pattern is similar to reproductive patterns described for tropical and sub-tropical chelonians but differs from that of gopher tortoise populations in northern portions of the range where hibernation may last for five months and a single clutch of eggs are deposited in late spring.

Effects of Elevation and Microtopography on Burrowing Intensity of the Gopher Tortoise at Avon Park Air Force Range in South-central Florida

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In southern Florida, optimal habitat for gopher tortoises (*Gopherus polyphemus*) is largely unavailable and most extant populations persist in mesic pine flatwoods and Florida scrub. In mesic flatwoods habitats that dominate the southern Florida landscape, groundwater is seasonally close to the surface and standing water may be present during periods of high rainfall, raising questions about the effects of elevational gradients and microtopography on burrow-site selection. In the present study, we used inhomogeneous Poisson point process models with LiDAR-derived digital elevation models to test whether burrowing intensity increased with increasing elevation within two flatwoods and four scrub sites at the Avon Park Air Force Range in south-central Florida. For each site, we used polynomial regression to decompose the elevation surface into systematic and random components representing elevational trends and local topographic relief, respectively. We detected

an effect of elevation on burrowing intensity at three of four scrub sites and both flatwoods sites. At each of these sites, there was a significant increase in burrowing intensity with an increase in local topographic relief and the effect of local relief was always more substantial than the effect of elevational gradients. In one case, the effect of the elevational gradient could not be detected before accounting for the effect of local relief and, in several other cases, there was a strong effect of local relief despite a negative association between the trend surface and burrowing intensity. Overall, our results demonstrate a positive and profound effect of subtle changes in microtopography on gopher tortoise burrowing intensity that was not readily detectable by visual observation and that may not have been fully resolved without decomposition of the elevation surface.

Can We Protect Gopher Tortoise Mitigation Land?

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Land that has been used for gopher tortoise mitigation is protected in a variety of ways. Each type of protection has a responsible party that is tasked with enforcing that protection. How does this enforcement play out in the real world? Split Oak Forest Wildlife and Environmental Area (SOFWEA) is a currently unfolding case study of how the South Florida Water Management District, Florida Fish and Wildlife Conservation Commission, U.S. Fish and Wildlife Service, Orange County, Osceola County, and Florida Communities Trust approach their obligation to enforce the legal protections afforded to gopher tortoise mitigation property. The legal protections afforded to SOFWEA reach beyond gopher tortoise relocation and mitigation, including conservation easements, federal mitigation banking permits, public ownership, and other contractual restrictions. We assume this land is protected, but is it? We have documented how the entities listed above have responded to the Central Florida Expressway Authority and the Osceola County Expressway Authority's plans to build a toll road through SOFWEA since 2016. The outcome of this case will have ramifications for gopher tortoise habitat throughout the Southeast.

Using Radio-telemetry to Track Seasonal Distribution and Home Ranges of Gopher Tortoises on a Barrier Island in Southwest Florida

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The gopher tortoise occupies multiple habitat types throughout the Coastal Plains ecosystem of southeastern United States. Understanding the spatial ecology across all habitats is needed to inform best management practices. In Pine Flatwoods habitats, male gopher tortoises exhibit a larger home range than females, but all adults generally maintain home ranges under one hectare. Recent reports indicate tortoises in mesic flatwoods and scrub habitats exhibit home ranges that can reach 6 hectares. This study examines the home range and movement of 17 Gopher Tortoises in a coastal dune population in southwest Florida. Ten tortoises were radio tracked from September 2013 through April 2015, and seven additional tortoises were tracked from July 2016 through April 2017. Tortoises were located once or twice per week, depending on weather conditions. Home range size was calculated from minimum convex polygons using convex hull geometry in QGIS. All animals were active year-round, and males had a larger home range than females (male = 0.8 ha, female = 0.28 ha) ($F_{1,16}$=7.6, P=0.02) over the total study period. Female tortoises utilized only 21% of their total home range

during the warmest three months of the year (July-September), but occupied 52% of their home range during the coolest three months (December-February). Males utilized 26% of their home range during the hottest and coolest three-month periods. Home range sizes were found to be similar to those data recorded in pine upland habitats, and much lower than from mesic flatwoods and scrub. The animals primarily utilized the coastal dune habitats, but also would exhibit movements through the beach zone that included reaching the water. The size of their home range suggests abundant resources in these habitats, or may simply be a reflection of the restricted environment surrounded by mangrove estuaries and the sea.

Evaluation of Electric Fences to Exclude Predators on Gopher Tortoise Translocation Sites

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Newly translocated gopher tortoises (*Gopherus polyphemus*) likely face greater predation than natural populations due to a lack of immediate refugia (burrows) and greater mobility during acclimation to a novel environment. There are many predators of gopher tortoises, but coyotes (*Canis latrans*) are often the most significant threat to adult gopher tortoises, along with raccoons (*Procyon lotor*) and domestic dogs. We evaluated the effectiveness of predator exclusion at Nokuse Plantation, a 54,000 acre preserve in northwest Florida, using different combinations of silt and electric fencing (5000-6000 volts) over the past 12 years. Predation rates were determined by regularly searching recipient sites for gopher tortoise shells and assigning cause of death (predation/no predation) based on type of damage/injury to the shell. Because juvenile gopher tortoises are often completely consumed by mammalian predators, we did not attempt to measure predation rates of juveniles (CL < 180 mm). From 2007-2018, 217 adult tortoises were confirmed predated, representing 6.7% of total adult tortoises released at Nokuse. Predation on adult gopher tortoises was greatly reduced by electric fences; 158 of those (72.8%) were predated in sites without electric fencing whereas 59 (27.2%) were predated in sites with electric fencing. These results demonstrate that electric fencing is an effective option to reducing predation on adult gopher tortoises. For an average enclosure (80 acres/7000 ft perimeter), silt fencing costs $0.87/ft, while adding a self-contained electric fence system will cost an additional $1.13/ ft. After silt fence removal, we recommend keeping electric fences in place (by modifying the wire configuration to allow unimpeded movement of tortoises), thus maintaining an area of reduced predation to a core population of adults and juveniles. Despite the increased cost of electric fences, they must be considered when the long-term goal of a translocation program is to establish viable gopher tortoise populations.

The Anatomy of Deeds, Restrictions and Easements for Wildlife Practitioners

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Wildlife practitioners and environmental specialists are being called upon to assess and quantify compounded impacts to mitigation lands as various forms of development encroach upon protected lands. Consideration of potential impacts to existing conservation, mitigation or otherwise protected lands can be a complex process involving many areas of expertise. The initial task must be to identify the location and form(s) of protection(s) that were originally put in place to comply with public funding requirements and/or to meet permit conditions and regulatory rules and regulations. The project reconstruction process generally entails detailed research, thorough review of matters of record title affecting the subject property and compiling a key map to serve as a communication aid. Comprehending and interpreting the language and content of deeds, deed restrictions, easements and other agreements can be challenging for even the most experienced professionals. Few environmental specialists are equipped with the background or training necessary to do this work efficiently.

This oral presentation is designed to demystify the interpretation of standard real estate transaction documents and to offer an approach for using these resources effectively. In this presentation, the examples used to illustrate the relevant concepts are drawn from actual documents and the author's "work in progress" on issues related to Split Oak Forest Wildlife and Environmental Area (SOFWEA). SOFWEA is a Mitigation Park in Orange and Osceola, Counties, Florida that was established in 1994 and has been managed by the Florida Fish and Wildlife Conservation Commission. SOFWEA is currently in the path of proposed alignment(s) for the Osceola Parkway Extension under study by the Central Florida Expressway Authority.

Effects of Experimental Translocation on Gopher Frog (*Lithobates capito*) Survival and Movement

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The gopher frog (*Lithobates capito*) is a candidate for federal protection and a gopher tortoise (*Gopherus polyphemus*) commensal. Florida regulations previously allowed their translocation from development sites along with gopher tortoises until concerns about potential impacts lead to a halt in the practice, pending research. We conducted a pilot study to evaluate effects of translocation on gopher frog survival and movement by radio-tracking 23 experimentally translocated frogs, compared with 24 non-translocated frogs (from this and previous studies). Sixty-five percent of translocated frogs survived compared with 79% of non-translocated animals. There was no significant effect of translocation, but there was a strong negative effect of daily probability of movement (DPM) on survival for both groups. Frogs that died also spent more days at the surface, suggesting that movement and time outside refugia was risky, irrespective of translocation status. However, translocated frogs had significantly higher DPM than non-translocated frogs. Both groups had high DPM and mortality during the first month of monitoring. For non-translocated frogs, DPM was high during the first month, in part, because more than half of the frogs were captured at breeding ponds and monitored as they moved within ponds and then back to the uplands. For translocated frogs, which did not visit ponds, we suspect the high rate of movement was a behavioral response to translocation, including movement by frogs searching for refugia in an unfamiliar landscape. However, translocated frogs had decreasing DPM over time and eventually attained DPM, and thus survival rates, that were comparable to non-translocated frogs. Additional research is needed to confirm our results at other sites, to assess strategies for improving post-translocation survival, and to evaluate disease transmission and other potential risks.

Health and Density Effects on Overwintering Behavior of Translocated Gopher Tortoises in Northwest Florida

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Gopher tortoises (*Gopherus polyphemus*) are listed as threatened throughout most of their range and are facing population declines as a result of direct habitat loss and fragmentation. Translocation of tortoises from lands that will be destroyed by development has become an important tool for conserving this species. Temperature plays an important role in tortoise health, as tortoises can thermoregulate and induce a fever response to fight illness by altering their behavior, such as emerging to bask. This behavioral shift is most noticeable during the winter, when tortoises are thought to be relatively inactive. We investigated the overwintering behavior of healthy (H) translocated gopher tortoises and tortoises "at risk" (AR) for developing disease, determined through health assessment, at two release sites during the 2016-17 inactive season using temperature loggers epoxied to the carapace. The sites were a high-density site (DB1; 18 tortoise/ha) and a medium density site (SR1; 7.7 tortoises/ha). Overwintering onset, duration, and termination were determined for 23 tortoises representing 10 donor sites from seven Florida counties. Ten tortoises (three H, seven AR) did not overwinter. For overwintering tortoises, onset occurred between 12 November 2016 and 25 January 2017, and termination occurred between 18 February and 20 March 2017. AR tortoises had shorter overwintering periods (mean=83 days) than H tortoises (mean=101.7 days) overall (p=0.006). DB1 tortoises had shorter overwintering periods (mean=83 days) than SR1 tortoises (mean=109.6 days) with combined health groups (p=0.02). Larger differences can be seen with separation of both health group and site, with H tortoises in SR1 demonstrating the longest overwintering durations (p=0.007). Though overwintering behavior is most affected by health status, tortoise density has an additional effect on overwintering behavior. Lack of overwintering during the cooler months may result in further decreased health and body condition, potential cold stunning, and an increased risk for predation.

Gopher Tortoise (*Gopherus polyphemus*) Movement and Habitat Associations on Working Forest Landscapes

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Gopher tortoises (*Gopherus polyphemus*) are a keystone species in southern pine (*Pinus* spp.) ecosystems. Due to population declines over the last century, gopher tortoises are listed as threatened under the Endangered Species Act in the western portion of their range. Much of the private land where gopher tortoises occur within this range is managed primarily for timber production. While past research has shown gopher tortoise occur within production forestry sites, more information on their response to forest management is needed to understand conservation value of private, working forests for this species. Therefore, we are examining population and movements of gopher tortoise to habitat conditions on working pine forests in Washington Parish, Louisiana and Perry County, Mississippi. We paired burrow surveys with radio-telemetry to evaluate working forest landscape conditions suitable for gopher tortoises. We also compared our results to previous studies at these sites to evaluate population age structure and movement and space use patterns in response to habitat management. During 2017 and 2018, we radio-tagged a total of 19 gopher tortoises with VHF transmitters and fitted 10 of these 19 individuals with GPS data loggers. Of the radio-marked (both VHF transmitters and GPS data loggers) tortoises, we calculated home ranges for 15 individuals. Average home range size (95% minimum convex polygon) differed significantly by sex (male=1.52 ha, SE=0.49; female=0.39 ha, SE=0.36; p-value=0.038), but not by site (Washington Parish=0.90 ha, SE=0.39; Perry County=1.10 ha, SE=0.58; p-value= 0.75). At the Washington Parish site, gopher tortoises were mostly constricted to utility right-of-ways and road sides; whereas, tortoises were dispersed through forest stands at the Perry County site. Our results concur with past studies, where a combination of factors, including forest management history, midstory and understory density, and soil conditions (e.g., drainage class) affect gopher tortoise spatial ecology.

Gopher Tortoise Population Survey and Management on St. Catherines Island

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St. Catherines Island (SCI), a barrier island off the coast of Midway, Georgia is home to the longest intensively monitored translocated gopher tortoise (*Gopherus polyphemus*) population in North America. A population of 74 gopher tortoises was translocated from a development site in Bulloch County, Georgia to the island's North Pasture region in 1994. Approximately 30 tortoises previously released on SCI were already established in the pasture. Since 1994, several waif and/or rehabbed tortoises have also been released on the island. The population has been monitored long-term for health, disease, reproduction, genetics, spatial ecology, and nutrition. However, since the original translocation, a complete tortoise population survey has not been conducted. During 2017-2018, we surveyed the entire range of gopher tortoise burrows on SCI. Each burrow was marked with a unique identification number and its activity status was designated as "active," "inactive" or "abandoned." GPS coordinates and measurements of the burrow mouth were collected. Wildlife cameras were deployed on a subset of burrows to assess tortoise and commensal activities. After all burrows were marked, each was inspected with a burrow-scope to detect the presence of a tortoise and/or commensals. Tortoises found outside of burrows were photographed, given health assessments, and identified by notch code and PIT tag number. Over 800 gopher tortoise burrows were discovered during the survey. Scoping detected the presence of more than 200 tortoises. Maps generated with ArcGIS software analyzed the population's spatial ecology and depicted relationships between biological and environmental variables. Burrow cameras revealed a range of tortoise and vertebrate commensal interactions. Thirty-five tortoises were encountered, assessed, and assigned identification numbers. As the longest monitored translocated gopher tortoise population, continued research, monitoring and management are critical. The combined burrow survey, scoping, and wildlife camera work provided the only long-term post-translocation data of its kind.

A Bayesian Hierarchical Model to Account for Bias in Gopher Tortoise Distance Sampling

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Line-transect distance sampling (LTDS) is the standard method for estimating abundance and density of gopher tortoise (*Gopherus polyphemus*) populations. We present a Bayesian model for line-transect distance sampling in which the use of burrow width as a covariate helps to account for detection bias of all burrows present and improves precision of estimated density. By modeling the number of burrows missed, by size interval, as a latent quantity, we also produce a detection-adjusted size frequency distribution of occupied burrows, an indicator of population age structure. We compare the raw distribution of burrow diameter found during LTDS and the estimated posterior distribution of burrow diameter when detection probabilities are accounted for. We further compare the density point estimates and CV produced from DISTANCE 6.2 and our own model for both a simulated and real dataset. Under simulated data, and regardless of simulated population density, approximated burrow size distributions for the smallest burrow widths (≤10 cm) from our model were consistently closer to the true distribution than estimates produced from the raw LTDS data. Except at lowest population density (1 individual/hectare), the point estimates from our bias-adjusted model were more accurate than those from

DISTANCE 6.2. In our real datasets, we found substantial underestimation of juvenile (≤ 10 cm) tortoises at all evaluated sites. Our bias-adjusted model provides a powerful tool for understanding the distribution of an individual-level attribute that dually affects the detection of organisms and is informative about population status.

Range-wide Analysis of the Distribution, Conservation Status, and Habitat Requirements of the Florida Sand Skink (*Plestiodon reynoldsi*): Unveiling the Truth

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The Florida Sand Skink ("FSS", *Plestiodon reynoldsi*) is a small "sand-swimming" lizard currently restricted to a few disjunct ancient ridge systems in peninsular Florida, USA. It has been federally listed as "Threatened" since 1978, primarily as a result of habitat loss, degradation, and fragmentation. Here, we summarize historical and recent data (through 2015) from 13 sources to describe the distribution, conservation status, and rates of occupancy of FSSs in natural and human-altered habitats throughout their range. FSSs were detected by visual encounter and/or cover board surveys at 1508 (70.5%) of 2138 sampling locations in 6 counties with 86.6% of the sample collected after 2000. In 61 (0.4-ha) trap-out enclosures at 9 sites in 4 counties, FSS densities averaged 181.1 individuals/ha (95% CI = 144.3 ─ 218.2/ha) and the estimated population on conservation areas of the Lake Wales Ridge alone was 2.16M individuals (95% CI = 1.72 ─ 2.60M). Detailed analyses confirm that FSSs are restricted to about 20 well-drained soil types (no verifiable records from poorly-drained soils) which historically supported native xeric habitats (sandhill, scrub, scrubby flatwoods, or unburned xeric hammock). Most (90.3%) positive localities were ≥ 25 m above msl but reliable records to 7.6 m on suitable soils and habitat exist, particularly east of the Mount Dora Ridge. FSSs were detected at 92% of 1126 native xeric sites. At 844 human-altered sites with historically suitable soils, FSS were undetected if the soils were rendered "non-swimmable" by roads or buildings and in all of 144 surveys of densely planted, sod-forming grasses. FSSs recolonized at least 47.9% of 725 altered sites directly connected to native xeric habitats with swimmable soils, but were undetected in all of 146 sites isolated by non-swimmable soils. Some of our findings are contrary to the literature, suggesting caution should be used when interpreting limited data.

Long-term Patterns of Abundance of Gopher Tortoises on the Conecuh National Forest

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We performed a mark-recapture study of Gopher Tortoises on three sites on the Conecuh National Forest of southcentral Alabama. Starting in 1991, tortoises were captured in wire live traps, measured for body size, marked with file marks along the marginal scutes, and released to the burrows from which they were captured. Age of each individual was estimated from counts of annuli on plastral scutes. From 1991-1998 all three sites were sampled on a near-annual basis. From 1999-2003 additional annual samples were taken for one site. All sites were resampled twice between 2013 and 2017. Program MARK was used to estimate patterns of survival and abundance on each site. Survival of tortoises was similar across all three sites and did not differ among size/age classes. Our data indicate 90% survival from one sample to the next, even for the smallest individuals. On two sites, populations of 20-30 individuals were present across the 25-year period of study. For the third study site abundance doubled from about 30 individuals to about 60 individuals. However, migration of individuals on to and off of each site likely occurred, yielding estimates of 70-173 individuals in the superpopulation occupying the sites. Our data provide novel insights into population stability of Gopher Tortoises at the northern periphery of the geographic range of the species.

The Big Turtle Year: Celebrating Wild Turtles Across the United States

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Turtles play significant ecological roles and are visible elements in many habitats. A long list of diverse threats to species globally has contributed to ~59% of all turtles being threatened with extinction. Working in negative synergy, these threats present broad and immediate conservation challenges for one of the most endangered wildlife taxa in the world. Despite the urgency of the situation, opportunities for conservation are abundant and the charismatic attraction of turtles makes them an excellent group for education and outreach efforts to enhance ecological, conservation, and environmental awareness. The United States is the most turtle-rich country (62 species and 89 terminal taxa), with many taxa of conservation concern. While species from areas such as Asia, South America, and Madagascar often receive the majority of conservation attention, the plight of species within the U.S. quietly goes unnoticed. The goal of The Big Turtle Year initiative is to increase awareness regarding the status of these often overlooked species and to emphasize their rich diversity, natural history, and conservation. Throughout 2017, Florida Turtle Conservation Trust researchers visited numerous sites accompanied by other biologists and conservationists in an effort to see as many species as possible during a single year, while examining threats and conservation actions needed. In addition, a national lecture series will disseminate the information gathered to a wide range of audiences, including stakeholders. For more information, please visit www.thebigturtleyear.org.

The Ins and Outs of Gopher Tortoises: Foraging Habitat and Harbored Parasites

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The gopher tortoise (*Gopherus polyphemus*) is a species under significant stress due to human intrusion on their habitat. These stressors are varied in different parts of the Southwest Florida region, based upon the habitat. The purpose of this research is to determine possible correlations between habitat composition and parasite load. Four distinctive environment types, all of which have elements of human impact, were chosen for this study: semi-urban, captive, coastal scrub, and pine forest. Scat was collected in each of these ecosystems in the early wet season between May and July. Samples were tested using fecal flotation for parasite ova. In addition, numerous samples were analyzed by fecal flotation and sedimentation by Heather Walden at University of Florida. Parasite loads varied slightly in each environment type, with the highest concentrations being found in the pine forest habitat. This habitat also had the highest tortoise population density of the sample sites. The lowest counts of parasites were observed in captive populations. Despite differences in parasite load, the same three varieties (strongylids, oxyurids, and ascarids) were found to be present in each location, aside from one captive population (Naples Zoo) in which no parasites were detected. Proportional load of parasite types was also very similar between sampling locations. Preliminary findings show that similar parasite types are likely to be found in most Southwest Florida habitats, and that more densely populated locations may have higher loads than sparser density populations. This research adds to the growing field focusing on parasitic species affecting the gopher tortoise. The more information that is known about the species, the better management and conservation plans can be made to maintain its survival in a rapidly changing environment such as Southwest Florida.

The Influence of Prescribed Fire on Site Selection in Snakes in the Longleaf Pine Ecosystem

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Prescribed fire is an essential tool for the restoration and maintenance of the longleaf pine (*Pinus palustris*) ecosystem. This type of management benefits many endemic snake species that are associated with open canopy pine forests and rich herbaceous ground cover. Few studies have examined the role that fire history has on site selection by snakes. Therefore, our objectives were to quantify time since last fire and fire frequency (within a 10 year period) for sites selected by radio-telemetered snakes of five species in a mature longleaf pine forest managed with prescribed fire. We examined data collected from previous radio-telemetry studies conducted on our 12,000 ha study site over a nine year period (2003-2012). Preliminary results indicate that the Florida pine snake (*Pitouphis melanoleucus*) and eastern coachwhip (*Coluber flagellum*) were most likely to select sites that had been burned within the previous year. Most of the locations selected by the eastern diamondback rattlesnake (*Crotalus adamanteus*) and eastern kingsnake (*Lampropeltis getula*) were in areas that had been burned within two previous years. The gray rat snake (*Pantherophis spiloides*) selected sites that were either burned within two previous years or sites that had not been burned in 10 years. Overall, snakes selected sites in areas that experienced a range of fire frequencies, including sites burned seven times within a 10-year period (*P. melanoleucus*) to sites that were not burned at all (*P. spiloides*).

Social Use of Olfactory Cues from the Mental Glands of Gopher Tortoises (*Gopherus polyphemus*)

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The Gopher Tortoise (*Gopherus polyphemus*) is a socially aggregating species that has been suggested to communicate chemically through olfactory cues present in glandular secretions. One gland in particular, the chin or mental gland, is a large subdentary gland that seasonally secretes during the tortoise mating season and is morphologically larger in males, similar to other secondary sexual characteristics of other species thought to be involved in female mate-choice. Yet, no current study has examined a behavioral response of both male and female tortoises to olfactory presentations of this cue, which would suggest pheromonal function of this gland. In this study, we examine behavioral presentations of pooled male mental gland secretions presented on cotton swabs vs. both a positive (acetone) and negative (distilled water) control to both male and female gopher tortoises. As suggested by other studies, both sexes exhibited olfactory investigation significantly more towards the mental gland treatment than to either positive ($p=0.0004$) or negative ($p=0.0002$) controls. Principal component analyses of seven observed behaviors were also analyzed for both controls vs. the mental gland secretion treatment in a one-way ANOVA, yielding significantly more tortoise activity ($p=0.0003$) towards the mental gland treatment vs. the positive control for component 1, which included behaviors of sniffing, head bobbing, biting at, and eating near the swab (no effect of sex; $p=0.4$). Similar groupings of behaviors were also observed in the mental gland vs. negative control experiment, suggesting the repeatability of the behaviors analyzed and an observed social function directed towards a biological olfactory cue *only*. This is the first study to empirically show pheromone usage in gopher tortoises to elicit social behaviors that could be important to mate-choice.

An Island of Misfit Tortoises: Estimating the Survival of Translocated Waif Tortoises

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Due to many anthropogenic threats, the gopher tortoise (*Gopherus polyphemus*) is declining throughout its range. Although habitat management plays an important role in the species' conservation, alone it may be insufficient to recover severely depleted populations. As a result, population augmentation through translocation—the movement of animals from one location to another—has become a valuable conservation tool. While there are risks associated with any translocation, waif tortoises—animals that have been collected illegally, been injured and rehabilitated, or have unknown origins—are generally excluded from translocations due to heightened concerns of introducing disease or altering the genetics of the recipient population. Additionally, because waif tortoises are often housed in captivity for extended periods, the survival of translocated waifs may be lower than the survival rates reported for wild tortoise translocations. However, if these risks could be managed, waif tortoises could provide the needed numbers and genetic diversity to stabilize populations and prevent extirpations. In the early 1990s, a small population of gopher tortoises ($n \leq 10$) was discovered near Aiken, South Carolina. This discovery expanded the species' known range and resulted in the creation of the Aiken Gopher Tortoise Heritage Preserve (AGTHP). Due to the preserve's dire need for augmentation, the state's lack of suitable donor populations, and the site's isolation from other tortoise populations, the AGTHP provided the rare opportunity to study the effect of waif tortoise translocation without jeopardizing a viable population. Since 2006, over 280 tortoises have been introduced to the preserve. In order to evaluate the efficacy of the reintroduction efforts to date, we conducted recapture efforts from May-July in 2017 and 2018. We assessed post-release survivorship and site fidelity of waifs and evaluated health through physical examination and testing for common pathogens. Here we present the results of our recapture efforts and survivorship estimates.

Gopher Tortoise (*Gopherus polyphemus*) Conservation Through Education, Research, and Rehabilitation at the Georgia Sea Turtle Center/Jekyll Island Authority

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The biggest threats to gopher tortoises (*Gopherus polyphemus*) in Georgia include habitat loss and degradation, automobile mortality and morbidity, and disease. The Georgia Sea Turtle Center (GSTC) integrates education, research and rehabilitation to benefit native chelonians including gopher tortoises. Gopher tortoises are presented to our hospital for a variety of problems including trauma from several causes (e.g. automobiles, predators, heavy machinery, etc.), disease, starvation, and a variety of miscellaneous issues. Common treatments and procedures include nutritional support through tube feeding and esophagostomy tubes, shell fracture repair and wound care with a variety of methods (e.g. Vacuum Assisted Wound Care, honey therapy, Redi-heal and bone cement, therapeutic laser therapy), blood drawing for a variety of diagnostics, radiology, CT and other advanced imaging, endoscopy, and surgical approaches to access the coelomic viscera for a variety of procedures. Over a million people have had the opportunity to learn about native turtles though interactive educational exhibits and programs at the GSTC since its opening 11.5 years ago. Visitors can view patients and various procedures through an exhibit gallery window and an elevated walkway that divides the hospital tanks in the rehabilitation area. Regular patient updates are presented by educators that focus on the medical issues

pertaining to individual patients, but more importantly discuss the population effects of the various threats and what the average person can do to help. The staff conducts regular educational outreach program for schools. Professional training is available through an Americorps program, veterinary student externships, and graduate student research projects. The GSTC has partnered with several conservation organization to assist in gopher tortoise translocations and health related research. St. Catherines Island has been a release site for many of the displaced tortoises that have gone through rehabilitation over the years.

An Introduction to the Gopher Tortoise Demography Working Group

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The task of predicting gopher tortoise demographic rates and population trajectories—at the local scale or range-wide—has been hindered by information gaps across all life stages. For example, detection issues have made juvenile recruitment difficult to monitor; and the potential for movement has thrown into question the ability to estimate true survival rates even for adults in marked populations. Nevertheless, the need for accurate predictive models has intensified as a listing decision for the eastern part of the tortoise's range approaches. The impetus for creation of a working group to advance demographic understanding of gopher tortoise populations across the range came out of a meeting held with state, federal, and research organization partners in November 2017 at the Jones Ecological Research Center, and organized by the Gopher Tortoise Council (GTC). One goal was to establish target numbers of viable populations for each state intersecting the range (AL, FL, GA, LA, MS, SC). However, doubt was expressed about predictions of persistence probability produced by an existing range-wide viability model, and how to apply the model to certain parts of the range. In this presentation, we will make the case for establishing a demographic working group under the auspices of the GTC; enumerate the goals identified by the group's steering committee; and solicit participation from the general GTC membership. Goals for the group include: 1) collecting and archiving population data from throughout the range, both published and not, that may be used to estimate demographic parameters; 2) conduct an updated, range-wide population viability analysis, guided by stakeholder input; and 3) impel and coordinate new research so as to maximize its utility in filling demographic knowledge gaps.

Identifying Site Characteristics that Influence Conservation Efforts for Gopher Tortoise on Private Lands

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There is currently a strong interest in maintaining and/or establishing representative populations of gopher tortoise throughout their former range in the southeastern coastal plain. One of the challenges in achieving this goal is being able to predict the effectiveness of conservation practices when applied on the landscape of forest stands that vary widely in terms of soil types, land use histories, and management regimes. These varied stand characteristics drive patterns in vegetation communities which in turn likely affect how structural components of

gopher tortoise habitat respond to management practices such as prescribed fire and stand thinning. To better understand the interactions between forest site characteristics, management practices, and gopher tortoise habitat, we are conducting an evaluation of the Natural Resources Conservation Service's Working Lands for Wildlife partnership which has incentivized conservation practices on private lands throughout the coastal plain. The primary objective of this research is to model the relationship between site characteristics, conservation practices, vegetation response, and gopher tortoise populations. In 2017 and 2018 we surveyed the vegetation communities and gopher tortoise populations on 290 privately-owned forest stands in Georgia, Alabama, and Florida where conservation practices had been previously incentivized and implemented. We used a modified line-transect-distance-sampling survey design and a Bayesian hierarchical model to estimate gopher tortoise density on each stand. Initial results suggest that sites on xeric soils with undisturbed herbaceous communities may respond well to management and are likely to be occupied by tortoises. Ongoing statistical modeling will provide quantitate estimates of effect sizes and test alternative hypotheses regarding habitat drivers of gopher tortoise density. We expect this study will contribute to the design and targeting of conservation efforts on private lands which are an essential part of the larger conservation effort for gopher tortoises and savanna-like ecosystems in the Southeast.

Maximizing the Efficacy of Eastern Diamondback Translocation to Minimize Human-Snake Interactions

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The eastern diamondback rattlesnake (*Crotalus adamanteus*; EDB) is a large-bodied, venomous reptile that suffers from large-scale habitat loss and fragmentation. The species is currently under review as a candidate for threatened status under the Endangered Species Act. Human-rattlesnake interactions involve risk of hospitalization and death for humans, and regularly result in snake mortality. Translocation is used to manage human-rattlesnake interactions; however, it is often performed without regard to the snake's home range. The post-translocation behavior of snakes is characterized as erratic, often increasing exposure to anthropogenic environments. Research indicates that these erratic post-translocation movements can be largely attributed to homing instincts within a novel landscape. In this study, we examined the utility of EDB translocations on a military installation that historically managed human-rattlesnake encounters by moving nuisance rattlesnakes to new locations within the installation. Specifically, we translocated telemetry-equipped EDBs at two scales: 1) intra-home range and 2) extra-home range. We used pre- and post-translocation telemetry data to quantify how translocation distances interacted with EDB movement ecology to mitigate encounters. The potential for human-snake interaction is determined using a modification of cost distance analysis. The post-translocation movement patterns of free-ranging telemetered snakes are cross-referenced with a landscape classified for human use. Habitats likely to represent higher risk of human-snake interactions such as roads and mowed areas are assigned higher cost scores than low-risk areas. This study will provide a greater understanding of EDB movement ecology following translocations, a critical component to EDB conservation and maximizing the efficacy of translocation techniques.

Movement Ecology, Homing Behavior, and Pathogen Infections in Gopher Tortoises (*Gopherus polyphemus*) Following Temporary Exclusion

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In the wake of human expansion, relocations and the loss of habitat can be stressful to an organism, plausibly leading to population declines. Frequent exclusions and relocations have contributed to the gopher tortoise (*Gopherus polyphemus*) being state-designated as threatened in Florida. Prior studies suggest that *G. polyphemus* engages in homing behavior, a mechanism that may enable individuals to counteract stressors resulting from relocation and exclusion. In this study, we radio-tracked, camera trapped, and collected pathogen samples from a cohort of *G. polyphemus* from Halpata Tastanaki Preserve (Marion County, FL), including 24 relocated adults (11 males, 13 females) and 13 control adults that were neither excavated nor relocated (4 males, 9 females). Tracking and sampling took place for 11 months following excavation, including relocation for two weeks, exclusion from original burrows for four months, and continued monitoring with no movement barriers for seven months. We evaluated habitat usage, burrowing behavior, movements, growth, and pathogen infections among control versus relocated and excluded individuals. We found that *G. polyphemus* engages in homing behavior, but only in males. Burrowing behavior was also found to be qualitatively different between males and females. Body condition and pathogen infections were unaffected by relocation and exclusion, nor were they statistically correlated. Overall, we conclude that temporary relocation and exclusion, at least for the time periods within our study, did not have significant impacts on *G. polyphemus*. This approach may therefore be a preferred short-term mitigation strategy when burrow locations pose temporary threats to resident tortoises.

Do Aggregated Populations of Gopher Tortoises (*Gopherus polyphemus*) Remain Socially Isolated Following Translocation?

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The gopher tortoise (*Gopherus polyphemus*) is one of the most commonly translocated reptile species. In Florida, these translocations often aggregate multiple populations of gopher tortoises in long-term protected sites. For a wide range of species, translocation success is often measured in terms of site-fidelity following release of animals, and this aspect of the practice has been followed for gopher tortoises. However, it has been reported that a native, intact population of gopher tortoises may exhibit an extensive social network. This network is defined by interconnected subunits of the population the authors termed “cliques”. Behavioral responses to a disruption of the social network in gopher tortoise populations has not been reported previously. Because translocation of gopher tortoises is likely to continue in the face of urban development, it is important to determine if aggregated populations form novel social networks. It is possible that multiple populations of gopher tortoises being held within the same translocation pen could remain socially isolated from each other. To test that hypothesis, we tracked the movements of 61 Incidental Take Permit (ITP) gopher tortoises translocated to Nokuse Plantation in Walton Co., FL from June – September 2017. Tortoises came from seven source populations from six Florida counties and were released into a single holding pen. Movements were tracked via radio telemetry and burrow scoping 4-7 days/week and burrow use was recorded for individual. Burrow shares (two individuals in a single burrow at the same time) and burrow chases (one tortoise occupying a burrow previously occupied by another individual within 24 hours) were recorded. Burrow shares and chases were used to construct an individual x individual matrix, which was then analyzed to determine social network structure. Preliminary analysis suggests that source populations do not remain socially isolated from one another within the same translocation pen.

Ecology of Gopher Tortoises in Pine Rocklands Habitat in Miami, Florida

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Gopher tortoises are the only tortoise native to the southeastern United States, and are listed by Florida's state wildlife agency as a threatened species and a species of greatest conservation need. In extreme southern Florida, gopher tortoises face challenges from unique geology (seasonally flooded and/or shallow rocky soils); biology (introduced species and emerging infectious diseases); and human impacts (urbanization and habitat loss, fire suppression, anthropogenic displacement). Here, we characterize population biology, ecosystem role, and management challenges for gopher tortoises with the Richmond Pine Rocklands - a ~450 ha, isolated habitat fragment harboring a large number of threatened and endangered species in Miami-Dade County, Florida. Tortoise burrow surveys indicate a large number of apparently active burrows distributed throughout the property, yet lower burrow occupancy than in other studies. The current population is apparently represented by few adults, yet consistent yearly reproduction. We report exposure to two *Mycoplasma* pathogens among individuals within this isolated population, though we report no clinical symptoms of disease. We discuss challenges for management of this population, including small population size and negative anthropogenic impacts that should inform management decisions for threatened keystone species in a globally imperiled ecosystem.

Abstracts for Poster Presentations

**denotes student presenter*

The Spatial Co-distribution of Burrows in Two Syntopic Populations of Nine-banded Armadillo (*Dasypus novemcinctus*) and Gopher Tortoise (*Gopherus polyphemus*)

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The gopher tortoise (*Gopherus polyphemus*) and the nine-banded armadillo (*Dasypus novemcinctus*) now cohabit pine forests in the southeastern United States, but no studies to date have formally examined the spatial co-distribution of burrows within an area to determine if the burrowing processes are dependent or independent. We sampled burrow locations within two pine stands [the complete extent of a 13.4 ha loblolly pine stand at Moody Air Force Base (MAFB) and a 6.3 ha rectangular subregion of slash pine stand at the Lake Louise Field Station (LLFS) in Lowndes County, Georgia] and used univariate and bivariate versions of Besag's *L*-function to examine dependency between burrows. At LLFS, we located 34 gopher tortoise burrows and 15 armadillo burrows; the null hypothesis of complete spatial randomness (CSR) could not be rejected for each point pattern and the null hypothesis of independence of components (based on random toroidal shifting of the point patterns) could not be rejected for the bivariate pattern. At MAFB, we located 162 gopher tortoise burrows and 242 armadillo burrows (an additional 28 coopted burrows were identified but not included in subsequent analyses); the null hypothesis of complete spatial randomness could not be rejected for gopher tortoise burrows, but there was strong evidence against CSR for armadillos, which was partly explained by locations of man-made berms and areas with high vegetative density. The null hypothesis of complete spatial randomness and independence (evaluated by simulating random point patterns from a fitted multitype model) could not be rejected for the bivariate pattern. Results from both sites suggest that the processes driving the distribution of gopher tortoise burrows are independent of the processes driving the distribution of armadillo burrows. These results have important implications for management of habitats where gopher tortoises and armadillos co-occur.

Managing a Waif Recipient Site

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Circle B Bar Reserve is a 1,267-acre site located just south of Lakeland in Polk County, Florida. Since 2013, Circle B Bar Reserve has served as a designated waif gopher tortoise recipient site, permitted by Florida Fish and Wildlife Conservation Commission (FWC). A waif gopher tortoise is a displaced tortoise that has been removed from the wild and is not associated with a permitted relocation effort. These tortoises cannot be returned to their original population because their origin is generally unknown, or the site does not have suitable habitat. At Circle B, releasable gopher tortoises are discharged into a 110-acre upland site. This site is sandy, well drained, open habitat with sufficient area for forage and protection from surrounding gopher tortoise populations. More than 70 tortoises have been released into the upland site. A research project to track waif tortoise social interactions and burrow establishment using game cameras and telemetry has been initiated.

Gopher Tortoise Movement Patterns within Zoo Miami's Pine Rockland Ecosystem

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The Gopher Tortoise (*Gopherus polyphemus*) is a keystone species in ecosystems where it occurs and is native to the southeastern United States. South Florida's subtropical climate and its unique communities of flora and fauna differ from much of the range of the species – though few studies have examined tortoise biology in the southern end of the species' range. We studied movement patterns of Gopher Tortoises within a critically endangered pine rockland ecosystem surrounding Zoo Miami (Miami-Dade County). We equipped eight tortoises, six females and two males, with radio-transmitters and followed them for a period of ~1 year and used Global Positioning System (GPS) devices to mark tortoise locations, which we processed in Quantum Geographical Information System (QGIS) software. We used location data to determine each tortoise's minimum home range and overlap, weekly travel distance, and number of burrows used. Female and male tortoises used an average of 2.75 and 4 burrows, respectively. Females tended to have a larger home range (0.926-3.86 ha) but moved shorter distances (8.56-12.3 m) per week compared to the males who had a small home range (0.734 ha) yet moved, on average, 49 m per week. Information from this project will help conservation biologists understand space use and habitat requirements for tortoises in pine rocklands ecosystems. In addition, minimum home ranges allow us to predict if the habitat can support a future increase in the species population.

Headstarting Gopher Tortoises from a Heavy Mineral Mine Site in Southeast Georgia

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Headstarting is the practice of rearing offspring to be released into the wild once they reach a size in which they are less vulnerable to predation. Headstarting can be used to boost an existing population (thereby increasing gene flow in a population) while simultaneously translocating animals out of harm's way from planned land development practices. The University of Georgia's Odum School of Ecology has partnered with a surface mining company, Southern Ionics Minerals, LLC, to clear mining lands of gopher tortoises (*Gopherus polyphemus*) and commensal species prior to mining activities in southeast Georgia. Over the past three years, we have collected and incubated 122 gopher tortoise eggs from this mining site. This age class is frequently under-detected due to the difficulty associated with locating nests. We conduct nest searches from June to September by carefully excavating adult tortoise burrow aprons and burrow mouths to a depth of ~20 cm. Nests are carefully excavated by hand or hand trowels; a mark is placed on the top of the eggs using a sharpie to prevent accidental rotation; and the eggs are transported in a sand-filled ice chest. Eggs are incubated in an augmented Hovabator incubator which can reliably incubate over 100 eggs at a time at 30°C. Upon emergence, hatchlings are reared in a custom climate-controlled setup composed of six glass terraria arranged on a metal shelving rack. All individuals are fed to satiation once daily. After ~9 months, headstarts are released at a designated state-owned Wildlife Management Area into a mixed population of resident and translocated gopher tortoises. In the future, we hope to further our on-site research to investigate the survival and performance of headstarted individuals at this site.

Temporary Exclusion for Gopher Tortoises: Does it Work?

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Responsible relocation from development sites is used as a mechanism to restore and maintain secure, viable populations of gopher tortoises (*Gopherus polyphemus*) in Florida. Large development projects often require relocation of individuals to an off-site recipient area as they frequently result in permanent loss of gopher tortoise habitat, but not all development projects result in permanent habitat loss. Temporary exclusion is an on-site relocation permit option for gopher tortoises in Florida, primarily intended for the installation or maintenance of major linear transmission lines (e.g., natural gas or electric) with the condition that habitat will be restored post-utility line installation. Thus, it is intended to incur no permanent loss of gopher tortoise habitat along the project right-of-way (ROW) and allow tortoises that have been temporarily displaced by construction activities to repatriate the ROW following habitat restoration. However, scientific data documenting the efficacy of this relocation option are limited. The primary goal of this study is to evaluate the success of gopher tortoise on-site relocation via temporary exclusion. We will examine burrow density, population structure, and recapture rates of temporarily excluded animals for 2-3 years following exclusion and habitat restoration. We will also evaluate habitat (i.e., herbaceous vegetation restoration and soil suitability) to determine the success of restoration practices on maintaining suitable habitat for tortoises. Preliminary data will be presented for the first year of this multi-year study.

Seed Composition of *Gopherus polyphemus* Scats in Zoo Miami Pine Rocklands FL

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Plant-animal interactions are major processes in ecological systems. In this study, we investigated the overlooked role of gopher tortoises (*Gopherus polyphemus*), a South Florida keystone species, as potential seed dispersal agents by assessing the seed composition in their diets to better understand what role they may or may not play in this capacity within critically endangered pine rockland forests. Our original hypothesis was that the gopher tortoises within Zoo Miami's pine rockland forest were primarily consuming fleshy fruits such as cabbage palm (*Serenoa repens*) berries, locust berries (*Byrsonima lucida*), and other fleshy plant matter. We collected scat samples from wild gopher tortoises living in the pine rocklands habitat surrounding Zoo Miami and subsequently dissected the scat in search for seeds they consumed. We extracted 2,484 seeds from 54 samples that came from 10 individual tortoises as well as opportunistically collected scat samples from throughout the pine rockland. Of the 2,484 individual seeds we collected, we were able to distinguish 33 different plant species (including morphospecies). The 12 most abundant seed species in the scat encompassed nearly 90% of all the seeds excreted by the tortoises. While only three of the 12 most abundant seed species were non-native, none were classified as Category I invasives at the time of this study. Contrary to our initial hypothesis, the tortoises were largely eating dry, fibrous grasses and leaf material. Given that the tortoises were eating mainly groundcover plants, they seemed to be consuming the seeds as bycatch rather than selectively feeding on them, therefore supporting Janzen's "Foliage is the Fruit" hypothesis. Due to the prevalence of various seeds and seed species in the tortoise scat, it is likely that gopher tortoises may be serving as a dispersal agent for some of the plants they consume within the pine rocklands.

Why Did the Tortoise Cross the Road?

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In front of the USF-Sarasota-Manatee campus, there is a six-acre Gopher Tortoise protected area. This habitat is separated into three sections by roads leading into the university. Underneath the entrances, three concrete tunnels were installed when the habitat was developed to facilitate safe tortoise crossing. This project set out to assess the efficacy of the tunnels to better understand tortoise movement throughout this fragmented habitat and to and gain insight into the patterns of tortoise foraging. No underground tortoise crossings were observed. In addition to anecdotal evidence of above-ground tortoise crossing, our evidence suggests that the two primary plots are fairly self-sustainable for foraging.

Burrow Use and Selection by Invasive Burmese Pythons in Southwestern Florida

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Burmese pythons are established invaders of natural ecosystems in southern Florida and are greatly affecting many native species with which they co-occur. They have been implicated in the severe declines of meso-mammal populations throughout the southern Everglades, and are also likely affecting populations of large mammals and birds. In southwestern Florida, Burmese pythons have access to dry upland hammock and scrub, uncommon habitats in most of the python's Florida range. Pythons commonly use animal burrows within these upland habitats for refuge and reproductive purposes. This behavior is significant as it could negatively impact native burrow-dwelling species, could affect the geographic range in the southeastern United States that pythons could potentially establish, and could have significant implications on the management of invasive pythons. We used a comparative design with radio telemetry-tagged pythons to describe and assess burrow selection by Burmese pythons in their southwestern Florida range. Our results suggest that Burmese pythons are selecting the burrows they occupy nonrandomly based on the characteristics of the burrows and the surrounding habitat.

Mating System and Seasonality of the South Florida Gopher Tortoise (*Gopherus polyphemus*)

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Gopher tortoises (*Gopherus polyphemus*) in South Florida are subject to ecological conditions that differ from those across the rest of its range. While the climate is temperate, habitats are highly fragmented and typically considered suboptimal. Though few studies exist that have quantified the effects that these variations have on gopher tortoise behavior, a growing body of evidence suggests that lower latitude populations exhibit numerous reproductive differences. The present study reports on the reproductive phenology and mating system of a small gopher tortoise population on 36.83 ha Florida Atlantic University Preserve in southern Palm Beach County. Between August 2017 and July 2018, remote game cameras and radio telemetry were used to monitor reproductive interactions and movement patterns within the population. Though mating season reportedly occurs in late spring, we observed year-round reproductive behaviors that peaked during the winter months. Intraspecific interactions and movement patterns suggest a scramble competition polygyny mating system,

which is characteristic in populations responding to increased competitor density. These findings indicate adaptive mating behavior and underpin the need for management practices that incorporate an understanding of latitude specific reproduction and the factors that can influence it.

On-site Relocation: An Evaluation of Success

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Many studies have analyzed the effects of off-site relocation on gopher tortoises (*Gopherus polyphemus*); however, there is little information available regarding on-site tortoise relocation much less the success. Tortoises commonly inhabit residential lawns and other green space in Florida, often coinciding with people with little conflict or risk to human or tortoise safety. With the frequent co-occurrence of humans and tortoises, burrows are occasionally dug in potentially compromising areas such as under a/c units, propane tanks, or in septic fields. The Gopher Tortoise Permitting Guidelines (revised January 2017) created by the Florida Fish and Wildlife Conservation Commission (FWC) state that a Burrow or Structure Protection (BSP) permit can be issued if a burrow is in an area that may jeopardize a structure, or the burrow location risks the tortoise's safety. BSP permits are issued on a case-by-case basis and require on-site relocation of the gopher tortoise. On-site relocation is required whereby the tortoise is captured and moved to a suitable area elsewhere on the property. The homeowner must also discourage the tortoise from burrowing in the compromising location again, often accomplished by collapsing the burrows and covering the area with gravel, pavers, or logs. Since 2011, FWC has issued 160 BSP permits to concerned citizens in Florida for tortoise burrows located in structurally compromising areas on their property. The objective of this study is to investigate the result of these small-scale relocations and determine if tortoises remain on-site following permitted relocation. Findings from this study may help inform future revisions of FWC's permitting guidelines for BSP and other permit types requiring on-site relocation and green space regulation. Because this study is currently ongoing, we will present preliminary results.

The Vertebrate and Invertebrate Gopher Tortoise Burrow Commensals in Southeast Florida

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The gopher tortoise, *Gopherus polyphemus*, is a keystone species that digs extensive burrows providing a novel microhabitat also used by over 360 other vertebrate and invertebrate species. Limited information is available regarding gopher tortoise burrow commensal species in southeast Florida, especially regarding invertebrates. This study investigates the gopher tortoise burrow commensals at six sites in subtropical southeast Florida, with varying degrees of habitat management. Vertebrate commensal species are identified using a burrow scoping system and game cameras. Several methods are being employed to collect invertebrate species to aid in their identification, consisting of insect pitfall traps, baiting with gopher tortoise feces, burrow facade traps, UV light, mesh tents, and active searching at burrow entrances. This project is ongoing and preliminary results will be presented. The objective of this research is to compile an account of vertebrate and invertebrate species dependent on gopher tortoise burrows in this region, accumulate information on threatened, endangered, and invasive species, add to the distributional information on obligate invertebrate species, and to present information to land managers concerned with maintaining biodiversity.

Demographic Consequences of Habitat Modification for Gopher Tortoises Inhabiting a Sandhill "Island" in Southern Florida

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The greatest threats to the long-term viability of Gopher Tortoise (*Gopherus polyphemus*) populations are habitat loss and fragmentation through increased urbanization and habitat degradation through fire suppression. Although Florida is considered a stronghold for the species, the state has experienced a decline in available upland habitat of more than 80% since the 1960s. Because remaining natural habitats often exist as "islands" within a mosaic of anthropogenic land uses, there is a need to understand the demographic responses of Gopher Tortoise to varying land uses and habitat management regimes. Here we utilize data collected at Archbold Biological Station in south-central Florida to examine within-population differences in demographic parameters among fire-suppressed sandhill, restored sandhill, and former sandhill (i.e., ruderal) habitats. Using program MARK, we estimated population size and sex-specific and habitat-specific survivorship based on a 6-year (2012-2017) mark-recapture effort. We also analyzed individual growth trajectories and clutch sizes to determine whether growth rates or reproductive output were associated with variation in tortoise density among habitat types. Tortoises in the open, ruderal habitat exist at much higher density (8.24/ha) than in adjacent restored (1.73/ha) or fire-suppressed (0.26/ha) sandhill units. Despite higher tortoise density within the ruderal habitat, we found no significant differences in survivorship, body condition, reproductive output, or growth rate among the three habitat types. Females inhabiting ruderal habitat also exhibited the largest asymptotic body size. Our results suggest that availability of open, ruderal habitats dominated by non-native grasses can enable persistence of Gopher Tortoise populations through extended periods of fire suppression. Thus, such human-modified areas may be important components of the habitat mosaic currently available to this at-risk species.

Accounting for Demographic Plasticity in Climate Change Planning for Gopher Tortoises

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Climate change intensifies the challenges of conserving threatened and endangered species (TES), as habitat protection and restoration initiatives must account for new risks and uncertainties. Reliance on standard habitat models for performing climate vulnerability assessments may not adequately assess risk from climate change because most TES assessments place more focus on the nature and magnitude of exposure to change than species' adaptive capacity to change. To overcome these shortfalls, this project investigates how demographic plasticity will affect population viability in a changing world. Gopher tortoises (*Gopherus polyphemus*) are an excellent study species for testing this concept because the many prior translocations are "common garden" experiments that enable investigation into the inherent ability of individuals to acclimate to novel environments. In addition, extensive existing research provides a foundation for understanding the effects of environmental variability on demography. Our research objectives are to understand the complex pathways through which environmental conditions influence tortoise population vital rates, and use this information to derive population

growth rates, assess viability, and quantify critical habitat breadth. Field data-collection efforts began in summer 2018, with a focus on measuring vital rates for which linkages with environmental drivers are poorly understood – including offspring production, age-at-maturity, and hatchling sex ratios. At Nokuse Plantation (Florida), 14 nests were found, laid by females that had been translocated up to 350 miles from their natal habitat. In Georgia (Fort Stewart and George L. Smith State Park), 10 nests were found – hatchlings from these nests will be reared in captivity and used to develop a hatchling sex identification procedure. Ultimately, we will use the results of our study to develop a conservation planning tool to aid managers in protecting existing gopher tortoise populations under a changing climate and develop translocation strategies that account for the species' demographic plasticity.

A Survey of the Arthropod Species in *Gopherus polyphemus* Burrows in Two Habitats at the FAU Preserve

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Gopherus polyphemus is a keystone species that provides shelter to over 350 organisms, including 60 vertebrates and 290 invertebrates. The invertebrate species were last documented in 1939, and to our knowledge, only one study has been published on a caterpillar that was found to be a parasite of gopher tortoise carapace since (Deyrup and Eisner 2005). This study will survey the different arthropods that inhabit the gopher tortoise burrows in both the grassy and scrub area of the FAU preserve. The diversity of arthropods associated with gopher tortoise burrows will be compared between habitats. The preliminary results collected from March through July 2018 show a total of eight arthropod orders found in the FAU Preserve. These orders were collected from 29 burrows from the grass and scrub at FAU. Four of the eight arthropod orders found within burrows were in both the grassy and scrub habitats. Only the orders Ixodida and Diptera that were found have been previously documented in the 1939 study. The remaining six orders and the families within them were not cited in that study and consist of new records.

Investigating Stump Holes as Vertebrate Refugia in the Longleaf Pine Ecosystem

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Underground refugia are of particular importance in the longleaf pine ecosystem; providing protection from fire in addition to extreme temperatures and predation. Although burrows of the gopher tortoise (*Gopherus polyphemus*) are well-studied and well-recognized as a valuable vertebrate refugium in this ecosystem, the value of pine stump holes as a refugium is under-studied. We conducted a pilot study monitoring vertebrate use of 10 stump holes with trail cameras over the course of one year (September 2016 – August 2017) on Ichauway in Baker County, GA. We documented at least 29 species at stump holes and recorded animals using these habitat features as both refugia and foraging sites. A similar trail camera study was conducted at Ichauway in 2014 investigating vertebrate gopher tortoise (*Gopherus polyphemus*) burrow commensals and documented 36 species. Only 15 of the species documented in that study overlap with those documented in our study. Currently we are investigating the differences between vertebrate use of stump holes of different decay stages and gopher tortoise burrows with a larger scale camera study. Additionally, we are investigating refugia selection by Eastern

diamondback rattlesnakes (*Crotalus adamanteus*) through an overwinter telemetry study. As a species that has been documented using both gopher tortoise burrows and stump holes, we are interested in what Eastern diamondbacks are selecting on our study site and if availability of these refugia within their home ranges influences this selection.

Utility of Remote Cameras for Assessing Gopher Frog Occupancy and Activity Patterns at Gopher Tortoise Burrows

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Gopher Frogs (*Lithobates capito*) occur throughout the southeastern Coastal Plain, where they depend on both suitable upland habitats and nearby wetland breeding sites. Life history data for juvenile and adult Gopher Frogs outside of the breeding season is difficult to collect, as individuals spend most of the day underground in the burrows of Gopher Tortoises (*Gopherus polyphemus*) or small mammals. During October–November 2016, we deployed remotely-triggered wildlife cameras at 120 potentially occupied tortoise burrows distributed across five management units consisting of scrub or flatwoods habitats at Avon Park Air Force Range (Highlands and Polk counties, FL). We also inspected the interior of every burrow with a camera scope as a secondary method of confirming burrow occupancy by Gopher Frogs. We describe several simple modifications made to camera traps to improve quality of nighttime images, when most images of Gopher Frogs were collected. We detected Gopher Frogs at 20 of the 120 monitored Gopher Tortoise burrows. Rates of burrow occupancy by Gopher Frogs were similar between scrub (16.67%) and flatwoods (15.27%) sites. Gopher Frogs were detected by camera scope only at only 2 Gopher Tortoise burrows, thus camera traps largely outperformed scopes in detecting Gopher Frogs. The data collected as part of this study will be useful for clarifying activity patterns and microhabitat preferences of Gopher Frogs during the non-breeding season.

Gopher Tortoises and Heavy Mineral Mining: A Mitigation Strategy and Ongoing Research

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Gopher tortoises (*Gopherus polyphemus*) frequently are translocated to avoid direct mortality due to various land development practices. Heavy mineral sand mining is one such activity that occurs in southeast Georgia. Here, we present our meticulous strategy for locating, excavating, and translocating tortoises out of mine site impact areas. Since March 2016, we have translocated 318 tortoises, excavated and incubated 122 eggs, and cleared 692 ha of land from properties leased by Southern Ionics Minerals, LLC. All tortoises removed from mining lands have undergone an extensive health assessment with Dr. Terry Norton of the Georgia Sea Turtle Center in addition to being screened for a suite of nine common infectious diseases. Of note, we have observed a low occurrence rate of infectious diseases in these screenings from this population. Recipient sites are selected at state-owned Wildlife Management Areas (WMAs) through coordination with the Georgia Department of Natural Resources in order to meet the current and future habitat needs of translocated and resident individuals at the site. Temporary recipient site pens (to increase site fidelity) are constructed from durable silt fencing materials using heavy machinery and pneumatic tools. Two appropriately sized starter burrows are created inside the pens for each translocated tortoise of all age classes that are placed in the pen. Eggs collected from the mine site are incubated until hatching and then headstarted at our indoor facility for ~9 months prior to release at the designated WMA. At our first recipient site, a subset of translocated and resident adult tortoises are

monitored with modified GPS loggers, VHF radio transmitters, iButtons (for thermal selection), game cameras, as well as audio recorders. Analyses of these monitoring data are ongoing. Our goal is to maximize both research and conservation opportunities from this population of tortoises impacted by this heavy mineral sand mining operation.

Determining Presence of Carolina Gopher Frogs and Frosted Flatwoods Salamanders Using eDNA and Conventional Surveys

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Frosted Flatwoods Salamanders (*Ambystoma cingulatum*) and Dusky Gopher Frogs (*Rana capito*) are two species endemic to the imperiled longleaf pine savanna ecosystem, consequently, both species have been reduced in abundance and range. Both species have life histories that largely limit surveys to the breeding season when adults and larvae may be found in ephemeral, upland isolated wetlands. The species' use of aquatic habitats suggests that survey data may be improved by including environmental DNA (eDNA) as protocol. In this ongoing study, we conducted eDNA surveys in combination with traditional trapping, auditory, and visual surveys to examine the presence of *A. cingulatum* and *R. capito*. Survey sites were located in the South Carolina coastal plain and include areas where these species have historically been found as well as new sites that have been selected based on land use history and habitat characteristics. Several historic breeding ponds returned positive results for gopher frogs. We plan to conduct further surveys throughout 2018. We hope to gather further information on the reliability of eDNA data and survey new sites to determine the presence of gopher frogs and flatwoods salamanders within their historic range.

Characterizing Vocalizations in Gopher Tortoises

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As part of an ongoing gopher tortoise (*Gopherus polyphemus*) translocation project in southeast Georgia, we are examining the social interactions between resident and translocated individuals at a local Wildlife Management Area. We employed multiple techniques to study the integration of translocated individuals into a resident population as part of an on-going study: gps and vhf telemetry, and game cameras positioned to overlook the burrow aprons of resident and translocated females. Vocalizations have been observed in turtles and tortoises, they have not been characterized in gopher tortoises. We are interested in incorporating these potential communications into our current research. Our specific goal is to identify the frequencies at which gopher tortoises are vocalizing and to classify the different vocalizations as associated with different behavioral interactions. During the 2018 season, we deployed five SM4 Wildlife Acoustic audio recorders at female burrows that had demonstrated the most frequent social interactions along with those that resulted in copulation. To analyze our data, we are using Kaleidoscope, an acoustic analysis software that separates and classifies different vocalizations. By pairing game cameras with audio recorders at female burrow aprons, we can "train" the software using audio files where we have a known interaction between individuals. To train Kaleidoscope, we manually identify and label vocalization clusters that can then be used as a filter, allowing Kaleidoscope to more accurately screen for tortoise vocalizations in new recordings. We are able to analyze audio data, pairing the vocalization events with behavioral interactions on the game cameras.

Analysis of Associated Vertebrate Species of Gopher Tortoise Burrows

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Gopherus polyphemus are land dwelling diurnal reptilians found in the southeastern region of the United States where they are federally listed as threatened due to decreases in population numbers over the past few decades. This species of tortoise has well adapted limbs utilized to engineer underground networks of burrows in ecological areas containing sandy soils. These burrows are home to over 340 invertebrate and 60 vertebrate species, making the gopher tortoise a keystone species. Many of these species are often classified as commensal species of gopher tortoises, but several of these claims have not been verified through experimentation. In this study, a survey of vertebrate species was taken using remote camera trapping at three study sites in South Florida with differing vegetation types: scrub (Jonathan Dickinson State Park), grassy (Florida Atlantic University Preserve), and pine (Pine Jog Nature Center). M-880 Digital Game Cameras were set up one meter in front of burrows. Cameras contained motion detectors with an infrared LED flash to take photos at night. From December 2015 to June 2018, 21 vertebrate species were observed in pine, 19 vertebrate species were observed in grassy, and 18 vertebrate species were observed in scrub. This could be due to the differences in vegetation type, size, or surrounding urbanization. One common species found at all three sites was the native eastern cottontail rabbit (*Sylvilagus floridanus*). Utilizing the same photos from the survey, interactions between gopher tortoises and eastern cottontail rabbits will be observed to conclude if the two share a commensal or non-commensal relationship. Signs of a non-commensal relationship include a gopher tortoise displaying territorial behaviors in the presence of an eastern cottontail. Territorial behaviors include blocking, charging, and/or head bobbing. This research will aid in a better understanding the role of gopher tortoises as keystone species.

Gopher Tortoise Burrow Use by Commensal Species in the Pine Rocklands (Miami-Dade County)

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The Gopher Tortoise (*Gopherus polyphemus*) is a keystone species in all habitats they inhabit because of their burrow's importance for refuge they provide for commensal species. In the pine rocklands, South Florida's most biodiverse habitat, there have been no studies of use of tortoise burrows to date. We deployed motion-activated trail cameras at active Gopher Tortoise burrows within Zoo Miami's pine rockland habitat to capture animal interactions and understand which species use Gopher Tortoise burrows. We rotated trail cameras among burrows, and compiled data on burrow use by mammals, reptiles, amphibians, and birds. We observed many native and non-native species that make use of burrows, both in diurnal and nocturnal camera videos. Common commensal native species include the Eastern Coachwhip *(Masticophis flagellum flagellum*), Hispid Cotton Rat (*Sigmodon hispidus*), and Eastern Cottontail (*Sylvilagus floridanus*); and some observed non-native species include Black Rat (*Rattus rattus*) and Red-footed Tortoise (*Chelonoidis carbonaria*). Camera videos provide a broader insight on the role this keystone species plays in South Florida's pine rockland habitat. This project lays the groundwork for documenting native, non-native, and naturalized species, such as Coyotes (*Canis latrans*), that have been observed on Zoo Miami grounds and adjacent properties to help incentivize the protection of Gopher Tortoises and their commensal species through a management plan.