

48th Annual Gopher Tortoise Council Meeting

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ABSTRACTS

Student Oral Presentations

*denotes presenter

Detection of *Mycobacterium leprae*, the Causative Agent of Hansen's Disease (Leprosy), in the Soil of a Wildlife Burrow in Florida

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Mycobacterium leprae is one of the bacterial agents responsible for Hansen's Disease (also known as leprosy). In humans, infection with *M. leprae* can cause chronic disease primarily characterized by damage to the skin and peripheral nerves. Although the majority of the human population has natural immunity to developing Hansen's disease, an increase of locally-acquired new cases in the state of Florida has led to rising concern and investigation of zoonotic vectors, including nine-banded armadillos (*Dasypus mexicanus*, formerly *D. novemcinctus*). Here, we present findings of the detection of viable *M. leprae* bacteria in the soil of an abandoned nine-banded armadillo burrow in central Florida. In the beginning of 2026, viable *M. leprae* was detected in the soil of this burrow through both qPCR and RNA viability methods. Soil from the burrow was re-sampled six months after the initial detection. Although negative via RNA viability methods, DNA was still detected via qPCR in these samples. Wildlife burrows are often utilized by multiple species; such is the case for gopher tortoises (*Gopherus polyphemus*) and armadillos, which have been observed sharing burrows dug by either species. This interspecies utilization of burrows creates opportunities for pathogen transmission and potential disease

acquisition. This case adds to emerging evidence that direct exposure to soil potentially contaminated with *M. leprae* may represent a risk for transmission to humans, including wildlife professionals who work in or around animal burrows. Proper precautions should be taken to avoid disease transmission while working at burrow sites, especially if soil is being handled or disrupted.

Substrate Effects on the Locomotor Performance and Escape Behaviors of Florida Scrub Lizards

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Individual substrate type has been shown to influence locomotor performance. However, habitats are often composed of a mosaic of substrates. Few studies have quantified how transitions between substrates affect escape behavior or locomotor performance. In this study, male Florida scrub lizards (*Sceloporus woodi*) were collected from longleaf pine and Florida scrub sites in Ocala National Forest and transported back to the lab. Individuals were randomly assigned to one of three substrates (sand, leaf litter, or a transition from sand to leaf litter). Lizards were sprinted down a 2m racetrack and recorded using high-speed video. Videos were analyzed to measure sprint speed, acceleration, and escape behaviors including intermittent locomotion and bipedal locomotion with additional escape behavior trials conducted in the field. Substrate data was collected from each site, and the most common substrates found were leaf litter and sand. Additional results will be presented on the locomotor performance of *S. woodi* on the three track types along with the escape behavior trials. Preliminary lab results suggest that locomotor performance of *S. woodi* does not vary by substrate. However, lizards use bipedal locomotion the most when they encounter a transition in substrate, then on sand, and the least on leaf litter. Therefore, escape behavior is highly relevant as lizards modulate their escape behavior based on the presence of transitions in substrate and individual substrate type. These data will inform land management decisions for this imperiled species as prescribed burning can impact the amount of leaf litter, and it may help explain differences in predation attempts across habitat types.

Cognition and Conservation: Understanding Individual Variance and its Applications

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Cognition—how an animal perceives, learns about, remembers, and uses information to make decisions—forms the fundamental underpinnings of behavior. Applying an understanding of the function and mechanisms behind animal behavior could serve to enhance wildlife conservation at both a species and individual level. Based on our previous studies with gopher tortoises, we developed a behavioral test to assess individual tortoises' responses to novel environments and objects, as well as their ability to rapidly learn a discrimination task consisting of stimuli composed of color/position compound cues. This test was given to a population of waif tortoises that had been released at a recipient site, and was conducted alongside the collection of behavioral data, which involved camera trapping at 68 burrows for 100 days each over a period of 14 months. Together, these data allow us to assess variability among individuals, both cognitively and behaviorally, to determine if it is possible to develop and administer, prior to release, a cognitive test that will allow us to predict subsequent performance in the wild. This could potentially open a new avenue for conservation efforts focusing on head-starting, translocating, and re-wilding populations of tortoises, by allowing for the opportunity to optimize placement of individuals and providing the potential to develop cognitive training programs for those identified as less likely to survive.

Cold Dormancy Induces a Large, Transient, and Dormancy-specific Transcriptomic Response in Blood from Hatchling Gopher Tortoises

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Gopher tortoises (*Gopherus polyphemus*) in the northern parts of their range undergo seasonal cold dormancy, yet the molecular basis of this response remains uncharacterized. Head-starting programs, widely used in reptile conservation to accelerate growth and improve early survival, often bypass this natural dormancy period, leaving a gap in understanding how skipping dormancy affects the molecular processes underlying fitness-relevant traits. We quantify the genome-wide transcriptomic response to cold dormancy in the blood of head-started hatchlings and determine the extent to which the response persists after emergence. Hatchlings from a wild population at Geneva Wildlife Management Area, Alabama, were assigned to one of two treatments: (1) Constant-Warmth (standard head-starting conditions without dormancy), or (2) Cold-Dormancy (simulated winter). Blood RNAseq data was collected: (i) Dormancy (6mo. old), (ii) 3-Weeks Post-Dormancy (7mo. old), and (iii) 3-Months Post-Dormancy (11mo. old). Our results indicated that 7968 genes (41% of the blood transcriptome) were differentially expressed between the treatment groups at the Dormancy timepoint. This dropped sharply to 10% of genes by 3-Weeks Post-Dormancy, and just 0.06% by 3-Months Post-Dormancy. Longitudinal analysis within each treatment demonstrates the dynamic transcriptome changes were occurring over time in the Cold-Dormancy treatment (44% of genes changing across

timepoints), relative to the Constant-Warmth treatment where only 5% of genes were changing across timepoints. Our results demonstrate that cold dormancy triggers a dramatic, transcriptomic response in the blood that nearly returns to normal by 3-Months Post-Dormancy, though a small subset of genes show a persistent signature of the dormancy. Ongoing pathway enrichment will test whether this response reflects a stress program or metabolic suppression. This will clarify whether bypassing dormancy in early life protects animals from physiological stress, ultimately informing whether cold dormancy should be incorporated into future head-starting protocols.

Seasonality of Ophidiomycosis in Snakes: The Case of Eastern Indigos

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Emerging infectious diseases, especially environmentally transmitted fungal diseases, can pose significant threats to wildlife and are of growing conservation concern. Snake fungal disease, also called ophidiomycosis, is an emerging fungal disease caused by the keratinophilic fungus *Ophidiomyces ophidiicola* that has been known to impact eastern indigo snakes (*Drymarchon couperi*). While the eastern indigo snake system has been continuously monitored for ophidiomycosis, the overarching dynamics and drivers of infection patterns observed remain understudied and poorly understood. Most mechanistic models of environmental transmission derive from host population infection models (e.g., SIR differential equation model). A potentially simpler approach may be to use theory from island biogeography, treating hosts as islands that the pathogen can colonize and become extinct from. Here, I analyze the patterns and drivers in seasonal infection of ophidiomycosis by synthesizing literature to describe observed parameters for seasonal patterns of infection, documenting host and environmental empirical seasonal patterns of infection for eastern indigo snakes, and applying island biogeographic theory to help understand seasonality in ophidiomycosis, based on the eastern indigo snake system.

The First High-quality, Haplotype-resolved *de novo* Genome Assembly of the Gopher Tortoise (*Gopherus polyphemus*)

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The gopher tortoise (*Gopherus polyphemus*) is a keystone species of southeastern United States ecosystems, with its burrows providing important habitat for hundreds of other species. Despite its ecological and conservation importance, the absence of a high-quality species-specific reference genome for *G. polyphemus* has limited genomic studies and required many analyses to rely on genomes from related *Gopherus* species. Here, we present the first high-quality, haplotype-resolved de novo genome assembly for *G. polyphemus*, providing a species-specific genomic resource for future research and conservation applications. We generated the assembly by integrating Oxford Nanopore ultra-long reads, PacBio HiFi reads, and Omni-C chromatin-contact data. Assembly with Verkko produced two phased haplotypes of 2.521 and 2.510 Gb. Following Omni-C contact-map inspection and comparative scaffold validation, both haplotypes resolved into 26 chromosome-scale scaffolds, consistent with the expected haploid chromosome number, with only a few short unplaced scaffolds remaining. Scaffold N50 values were 150.58 and 143.73 Mb for haplotypes 1 and 2, respectively. Both haplotypes achieved 99.5% BUSCO completeness, and HiFi-based Merquy evaluation yielded consensus quality values of 74.30 and 72.44, demonstrating high completeness, contiguity, and sequence accuracy. This new reference provides a foundation for investigating population structure, adaptive variation, disease susceptibility, immune function, and genome evolution directly within *G. polyphemus*. As an initial application, we are using the phased assembly to characterize major histocompatibility complex (MHC) architecture and variation between haplotypes. Together, these resources establish a genomic foundation for biological and conservation research in one of the most ecologically important species of the southeastern United States.

Professional Oral Presentations

*denotes presenter

Uncovering Health Threats and Conservation Needs for Louisiana's Critically Imperiled Gopher Tortoises (*Gopherus polyphemus*)

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Chelonians are among the most endangered reptiles, with 57.9% at risk, and the family Testudinidae has the highest average threat level (4.06). The gopher tortoise (*Gopherus polyphemus*), part of this threatened family, is a keystone species and ecosystem engineer. Its burrows shelter over 360 species, helping maintain habitat stability and ecological balance in longleaf pine ecosystems. They also disperse seeds for at least 69 plant genera, supporting ecosystem health. However, their population has decreased by 80% since the late 20th century and is now classified as critically endangered by the IUCN. Louisiana has the most threatened

populations, with about nine subpopulations, each with fewer than 50 individuals on private lands, and only two on public lands. The Louisiana Department of Wildlife and Fisheries runs an active recovery program focused on habitat management, juvenile head-starting, and translocations. No current health assessment has been done for this population. The last one occurred two decades ago and showed 26% seropositivity for *Mycoplasma agassizii* and low heavy metal bioaccumulation. This study aimed to update the 20-year health status of the westernmost gopher tortoise population and provide data to guide future conservation and recovery efforts. The primary goal was to capture free-ranging tortoises across two seasons and conduct a thorough health assessment under sedation. This assessment included population demographics, physical health, clinical pathology (such as blood counts, plasma chemistry, protein electrophoresis, and serum vitamin D), infectious diseases like *Mycoplasma* spp., herpesvirus, ranavirus, among others, analysis of the oral microbiome, heavy-metal exposure (arsenic, lead, thallium, cadmium, zinc), and population genetics. The findings support conservation strategies for this species in Louisiana and contribute to its long-term management.

Conservation Easements Provide Large-scale Perpetual Land Protection and Essential Revenue Generation for a Private Preserve in Northwest Florida

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Nokuse is a 56,000-acre privately-owned conservation area located within the Northwest Florida Sentinel Landscape and Northwest Florida Greenway in Walton County, Florida. For 26 years, Nokuse has acquired and protected land using conservation easements with Federal, State, and private partners in an area with one of the fastest growing human populations in Florida. Conservation easement funds were provided by a variety of state and federal sources, including the Florida Department of Environmental Protection's Florida Forever Program, U.S. Forest Service Florida National Scenic Trail, Northwest Florida Water Management District, and the U.S. Department of War, Readiness and Environmental Protection Integration Program (REPI). Conservation easement sales ensure perpetual protection of critical habitats for rare and listed species and threatened natural communities and provide a revenue stream that offsets land costs and helps fund the purchase of new tracts. Much of Nokuse is located within Eglin Air Force Base Class 1 Restricted Use Air Space, Critical Approach Areas, and Cruise Missile Corridors and land has been strategically purchased to utilize REPI program funds. Nokuse pays 100% of the fee-simple acquisitions and receives 50% of the conservation easement value from the REPI program. With each land purchase and subsequent conservation easement sale to the Air Force, Nokuse creates a revolving fund that allows continued purchase and perpetual protection of the land. This innovative approach permits Nokuse to move rapidly to protect land slated for development in a competitive real estate market and assures that 50% of the development value from each purchase will be immediately used to purchase new tracts for conservation. There are many state, federal, and private conservation easement programs

available to landowners throughout the range of the gopher tortoise that provide compensation and property tax exemptions for perpetual protection of their land.

Writing the Tortoises Into the Deal: A Conservation Easement Case Study from South Alabama

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Big Creek is a 690-acre property in Covington County, Alabama, that was managed for industrial pine for decades. During baseline fieldwork in fall 2023, we mapped at least 165 active gopher tortoise burrows, most of them in a fresh clearcut of a failed sand pine plantation that never closed its canopy. That openness made it a local refugium. The population likely exceeds 100 animals and is among the largest on private land in the county. That finding changed how the conservation easement was written. This talk follows the project from the baseline survey to the final easement. I'll show how the tortoise concentration shaped the Special Natural Areas and the management terms for fire, canopy, and timber harvest. I'll also cover what worked, what was harder than expected, and what I'd do differently. The takeaway is that a baseline report can do more than document conditions. It can steer an easement toward the species that matter most on the ground.

Grant-supported Outreach and Research Enhances Gopher Tortoise Conservation at Gulf State Park in Alabama

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The Donna J. Heinrich Grant provided an opportunity to evaluate upland species associated with known gopher tortoise habitat at Gulf State Park while expanding public and educational outreach. We started an inventory of upland species documenting species richness and abundance and documenting the distribution of gopher tortoises throughout the park. These research activities were then incorporated into two complementary education and outreach programs designed to connect students and the public with gopher tortoise conservation. 1) At Gulf Shores City Schools, project activities were integrated into school curricula and clubs, providing students with hands-on opportunities to participate in data collection, analyze findings, and develop habitat management plans. This project extended beyond traditional science courses to incorporate engineering and statistics, allowing students to apply interdisciplinary skills to real-world conservation challenges and problem-solving. 2) By sharing the goals and results thus far of the project with the public we increased public interest and engagement in gopher tortoise conservation through a variety of outreach activities. Lastly, an unexpected result was that this effort culminated in the inaugural Habitat Hustle 5K and Fun

Run, which attracted more than 200 participants and generated over \$17,000.00 to support future gopher tortoise and habitat conservation projects at Gulf State Park. Collectively, this project demonstrates how grant-supported research, education, and public outreach can work together to generate valuable conservation data, provide meaningful experiential learning opportunities, and build broader community support for gopher tortoise conservation in Alabama.

A First Look into Dispersal and Site Characteristics of a Persistent Translocated Gopher Tortoise Population

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As rapid development degrades gopher tortoise habitat across the state of Florida, the need for understanding and improving translocation outcomes for this keystone species is critical. Over the course of 20 years, Nokuse Land Conservancy has received nearly 6000 translocated gopher tortoises from across the state. We conducted burrow surveys at the sites of soft-release pens established between 2006 and 2025 to assess site fidelity and the characteristics of sites with the most persistent populations. From June - August 2026, we used line-transect distance sampling to survey 29 release sites (total area: 495 ha), observing 788 burrows across 180km of transect (128km inside of former pens + 52 km external out to 500m from pen edge), while also recording fine-scale vegetation data. Initial results from a hierarchical spatial distance-sampling model reveal high variation in density between former release pens (median: 0.33 tortoises/ha; range: 0.1 - 1.8), implying high dispersal and/or mortality for most sites, with persistent populations characterized by habitat-typical density at others. Active burrows were strongly associated with historic pen fence lines, and burrow density declined rapidly outside of the old fence perimeter. These effects did not diminish with time since release. Density decreased with canopy cover and understory height, and was lower on restored center-pivot agriculture relative to restorations of historic silviculture and cleared, unfarmed land. Future analysis will explore effects of land use history, soil composition, microtopography, and fire history. These surveys laid crucial groundwork for ongoing projects evaluating red imported fire ant density as well as invertebrate burrow commensal populations. Our findings demonstrate that some translocated tortoises maintain high site fidelity over decades. These initial insights highlight the importance of strategic site placement and open-canopy maintenance, and demonstrate the need for long-term monitoring and reporting across all recipient sites.

Construction and Conservation: ALDOT's Gopher Tortoise Management

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“Bridging” the gap between the continuing stresses on our transportation infrastructure and a growing list of species conservation concerns can be challenging. One such corridor project in Mobile County challenged how the Alabama Department of Transportation (ALDOT) addressed potential impacts to the federally threatened population of gopher tortoises (*Gopherus polyphemus*) found west of the Mobile and Tombigbee rivers. The highway needed to be constructed – the tortoises needed a home. ALDOT, with the help of a number of agency partners, developed a 600+ acre conservation area that would serve as a relocation site for any tortoise that would potentially be impacted by transportation activities within Mobile, Washington, and Choctaw counties. Since its official establishment in November 2004, the on-site population has nearly doubled in size and the current carrying capacity exceeded sparking the need for further expansion. This presentation will cover the history behind site development, population trends for multiple species, and expectations for the future on ALDOT’s gopher tortoise conservation area.

Similarities and Distinctions of Gopher Tortoise and Nine-banded Armadillo Burrow Commensals in South Mississippi

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Gopher tortoises (*Gopherus polyphemus*), ecosystem engineers, are a keystone species of conservation interest as their burrowing behavior has a significant impact on the geomorphology and ecology of their habitats in the southeastern US. Also over the last century the nine-banded armadillo (*Dasypus novemcinctus*), another burrowing ecosystem engineer, has expanded its range into the southeastern US. In southern Mississippi at the Grand Bay National Estuarine Research Reserve land management activities are employed to maintain pine savanna ecosystems. As little work has been done to compare and contrast burrow commensalism between the gopher tortoise and armadillo, we sought to monitor burrows of the two engineer species for vertebrate community composition and visitation rates as they may carry natural resource management implications for the Reserve. Data were collected at 12 burrows per species from November 2023 – April 2025. Microhabitat data were also collected for use in analyses. In total, 74 species were observed at burrows for a total of 15,162 visitation events. Forty-nine species were observed utilizing both burrow types while 13 were only found at tortoise burrows, and 12 were only found at armadillo burrows. Results have shown areas of ecological redundancy and distinction between vertebrate community usage of both burrow types. While certain species and behaviors were only seen at certain burrow types the ability of the armadillo, especially in areas where gopher tortoises may be low in number or extirpated, to provide some ecosystem benefit may provide land managers context for how to manage or monitor this neo-native species across the landscape.

Regional Structure in Pathogen Prevalence May Explain Counterintuitive Geographic Patterns in Post-translocation Survival in the Gopher Tortoise

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Pathogen transmission is a potential risk during animal translocation. In mitigation translocation, animals are often released at high density alongside conspecifics from distant populations, conditions likely to favor transmission and exposure to novel pathogens or strains. Where pathogen prevalence has strong regional structure, managers could use it to limit translocations that expose vulnerable populations to carriers from elsewhere. Here we present evidence of strong regional structure in two important gopher tortoise pathogens across Florida. Quantitative PCR screening of more than 400 adult tortoises statewide showed that *Mycoplasma agassizii* and *Anaplasma* sp. are substantially more common in the peninsula and least frequent in the western panhandle: 1%, 14% and 22% of animals from the panhandle, north Florida and central Florida for *M. agassizii*, and 3%, 20% and 61% for *Anaplasma*. A complementary serology dataset collated from 3,055 individuals at 77 sites across 12 published studies reveals the same pattern for *M. agassizii*, with central Florida tortoises showing substantially higher antibody detection. This regional pattern coincides with a previously identified effect of translocation origin on survival at Nokuse Land Conservancy, a large recipient site in the Florida Panhandle: tortoises from central Florida had higher survival, consistent with the hypothesis that pathogen-naïve individuals from low-prevalence regions are more susceptible to pathogens acquired in mixed-origin soft-release pens. Resampling recaptured animals within a few years of release shows *M. agassizii* prevalence rising from 9% at intake to 31%, a pattern not seen in *Anaplasma* sp. Together these findings invert our earlier interpretation of the regional survival effect. Rather than taking the higher survival of central Florida tortoises moved to the panhandle as a sign of minimal environmental mismatch, we suggest that long-distance translocation of carriers from high-prevalence populations may put naïve individuals from low-prevalence regions at risk.

Relative Body Size and Genetic Relatedness Structure Female-Female Social Interactions in Gopher Tortoises

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Growing evidence of sociality in reptiles challenges the longstanding view that reptiles are predominantly asocial. Gopher tortoises (*Gopherus polyphemus*) are particularly notable among reptiles, and chelonians in particular, as their sociality has been recognized for more than 40 years. However, research on gopher tortoise social behavior has largely focused on mating systems and male–female interactions, leaving female–female interactions comparatively understudied. We systematically monitored female–female interactions in a previously genotyped population of gopher tortoises using high-definition trail cameras. Our objectives were to (1) characterize the network structure of female interactions and (2) determine whether body size and pairwise relatedness influenced the likelihood of aggressive and non-aggressive interactions using exponential random graph models (ERGMs). During six months of observation, we recorded 349 interactions among 37 females, including 65 visits, 141 aggressive encounters, and 143 non-aggressive encounters. Females interacted with a median of four other females (mean node degree = 4.06, range = 1–9). Network edge density was 0.127, indicating that approximately 13% of all possible female connections were observed. Aggressive encounters were widespread, with 89% of females (33/37) engaging in at least one altercation. Greater relative body size asymmetry was associated with a higher probability of both aggressive and non-aggressive encounters. However, relatedness had opposing effects across interaction types: altercations were more likely between less related pairs, but non-aggressive interactions were more likely among more related pairs. Our results provide novel evidence of size-mediated social dynamics and kin-based sociality among female *Gopherus*.

Amphibian Diversity in the North American Coastal Plain Global Biodiversity Hotspot

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The North American Coastal Plain (NACP) has been recognized as one of the top 36 global biodiversity hotspots based on the criteria of having at least 1500 endemic vascular plants and losing 70% or more of its historical vegetation cover. The NACP is home to seven of the world's 10 salamander families, including the NACP endemic families Amphiumidae, Sirenidae, and near-endemic Proteidae. In the 20 states that lie completely or partly in the NACP, 135 species of amphibians have all or part of their geographic distributions. Among these are 72 salamanders (53% of the NACP amphibian species) and 63 frogs (47%). Thirty-one of these

salamanders and 20 frogs are strictly endemic in the NACP. Compared with the California Floristic Province—the only original 35 global biodiversity hotspot in the United States and Canada—the NACP has fewer plants but considerably more amphibians (72 salamanders with 31 endemics and 63 anurans with 20 endemics vs. 49 salamanders with ~11 endemics and 30 anurans with ~5 endemics). The NACP ranks slightly less than equal in salamander species richness compared with the first-ranking Appalachian region, but greater in anurans than anywhere in the U.S. and Canada. Significant biogeographical patterns are discussed, including the eastern Gulf Coastal Plain amphibian hotspot within the NACP hotspot.

Toward a Site-Specific Framework for Gopher Tortoise Recipient Sites: Soil Suitability, Carrying Capacity, Habitat Restoration, and Adaptive Management

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Gopher tortoise (*Gopherus polyphemus*) recipient sites are essential to successful relocation and long-term conservation; however, existing permitting frameworks in Florida and Georgia often do not fully account for site-specific variation in soils, habitat condition, restoration potential, carrying capacity, and ecological connectivity. We examine practical challenges encountered during recipient-site evaluation, permitting, restoration, and management and propose opportunities for incorporating greater site-specific flexibility while maintaining rigorous conservation standards. Generalized soil mapping can inaccurately characterize localized conditions, potentially excluding otherwise suitable habitat. We propose that soil suitability determinations allow refinement through field investigation and documentation by qualified professional soil scientists. Similarly, predetermined stocking standards, including Georgia Department of Natural Resource's two-tortoise-per-acre holding pen/recipient-site density limitation, should be evaluated alongside demonstrated habitat quality, forage availability, soil characteristics, management intensity, and long-term carrying capacity. Recipient-site evaluation should also recognize restoration potential. While degraded sites with appropriate soils are often restored through integrated mechanical vegetation reduction, selective herbicide treatment, prescribed fire, and aggressive post-treatment management, these efforts must be aggressively maintained to ensure habitat success. A successful restoration approach developed through field application illustrates the importance of treatment sequencing and continued management following initial restoration. Additional considerations include population sex ratios, site configuration, acclimation fencing, and potential effects of confinement structures (silt fence) on the movement of commensal species, especially during breeding season. We propose an adaptive recipient-site framework emphasizing site-specific professional assessment, measurable restoration performance standards, monitoring, and long-term habitat management. Such an approach could improve recipient-site capacity and ecological function while preserving the conservation objectives underlying Florida and Georgia relocation programs.

Old Tortoises, New Threat? Investigation of a Respiratory Disease Outbreak in a Sentinel Population of Gopher Tortoises

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Disease effects are a significant conservation concern for both aquatic and terrestrial chelonians, including North American tortoises (*Gopherus* spp.). Although upper respiratory tract disease (URTD) is common in Gopher Tortoises (*G. polyphemus*) and sometimes causes mortality, relationships among infection status, clinical signs, and long-term health outcomes are poorly understood. We recently detected the first severe cases of URTD in Gopher Tortoises at Archbold Biological Station, providing a unique opportunity to investigate disease dynamics in concert with long-term demographic research. In spring-summer 2025, we collected oral-cloacal swabs for diagnostic testing for 24 potential pathogens (qPCR; n = 61) and initiated frequent visual health assessments and behavioral monitoring of a representative subset of 48 radio-tagged adults. Pathogen prevalence based on PCR was 44% for Tortoise *Helicobacter* sp., 13% for *Mycoplasma agassizii*, and 6% for *Emydomyces testavorans*. Six of eight *Mycoplasma agassizii*-positive tortoises were co-infected with *Helicobacter*. Logistic regression models indicated young adults (≤ 15 yr old) were more likely to be PCR-positive for *M. agassizii* than older adults. Among younger adults, those that were *Mycoplasma agassizii*-positive in spring-summer had significantly smaller home ranges from July-October (n = 12, W = 32, p = 0.02). Space use and movement frequency did not differ between *Helicobacter*-positive and negative tortoises (n = 41; Wilcoxon rank-sum tests, all p $\geq$ 0.24). Neither sex nor age class significantly affected the risk of developing severe nasal discharge. Nasal discharge prevalence peaked at ~75% in January and remained > 50% from February through August. Despite persistently high prevalence of clinical signs, even the most severely affected tortoises resumed activity in spring and there was only one possible disease-related mortality. Further analyses and ongoing monitoring of disease prevalence and effects in this sentinel population will clarify the individual- and population-level impacts of URTD and aid development of appropriate management responses.

Conservation Easements: Strategy, Stewardship, and Long-Term Success

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Conservation easements are one of the most vital tools available for permanent land protection, yet successfully implementing them requires navigating financial, procedural, and management

complexities. This presentation provides a practical overview of conservation easements, detailing the operational mechanics and key considerations necessary to ensure lasting success. I will explore the primary pathways for land protection, including donated and purchased easements. There are many financial strategies, such as grants and tax-incentivized donations, that offset the high costs of land conservation. This presentation will also touch on the real-world impacts of an easement on a landowner and how best to navigate and minimize those impacts. Those impacts include both the timing of an easement and a well-drafted management plan capable of standing the test of time. Finally, with over 1,700 land trusts across the United States actively driving these efforts, we will touch upon the growing career opportunities within the sector. Because perpetuity is a long time, thoughtful planning and informed decision-making are essential.

An Overview of Conservation Easements: the Good, the Bad, and the Gopher

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This talk explores how conservation easements—voluntary legal agreements that protect conservation values while keeping land in private ownership—can help safeguard tortoise habitat against development and fragmentation. This talk will give an overview of how easements work in conjunction with land trusts or other organizations. It will also examine how easement provisions can limit certain activities on a particular property such as development but can provide for continued habitat management, including prescribed fire, appropriate forest management, and habitat restoration. There are several benefits to easements such as permanent restrictions on development, financial and tax incentives. However, there can be drawbacks such as legal and tax scrutiny if the easement is improperly structured or overvalued. Additionally perpetual adherence to the restrictions and ongoing monitoring can be perceived as burdensome. However, easements can be a great way to establish long-term land protection that tortoises need through protected acreage with lasting ecological benefits.

The History of Eastern Indigo Snake Monitoring at Avon Park Air Force Range

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Avon Park Air Force Range (APA FR) harbors a sizeable amount of suitable, fire-managed habitat for Eastern Indigo Snakes (*Drymarchon couperi*) in peninsular Florida, a region considered to be a stronghold for the species. Early targeted surveys at APA FR yielded nearly 50 observations of Eastern Indigo Snakes between 1994 and 1998. Subsequently, a robust population survey was

conducted 2002–2004 using constant effort trapping. They captured a total of 32 individuals, of which 19 were encountered moving along roads and disturbed areas rather than at a trap line. Over the last 20 years, 19 Eastern Indigo Snakes have been recorded, mostly found during periods of intensive Gopher Tortoise surveys. Notably, no detections (on roads or otherwise) resulted from the most recent Gopher Tortoise surveys occurring 2022–2023, despite scoping over 1,400 burrows and walking 227 km of transects. Likewise, over 7,000 camera-trap days since 2021 have produced no detections at drift fences, including at sites where live trapping once successfully captured the species. Neither have 5,870 km of road cruising effort conducted during the winter breeding season 2024–2026. Only three individuals have been observed recently, each spotted crossing a road in 2020, 2022, and 2026. Examining three decades of observations at APAFR highlights the importance of reporting opportunistic sightings alongside intensive, targeted effort. It also underscores the challenges we face in monitoring a wide-ranging cryptic species that persist at low densities. The recent scarcity in observations compared to historic conditions raises important questions about the species' current status at APAFR, despite the protections and land management benefits of the Air Force mission. Accordingly, a renewed, range-wide focus on monitoring and reporting is essential to understand whether similar declines or shifts in detectability are occurring elsewhere across the species' distribution, particularly as another federal species status review approaches.

48th Annual Gopher Tortoise Council Meeting

ABSTRACTS

Poster Presentations

*denotes presenter; §denotes student presenter

Habitat Shifts in Florida Cottonmouths (*Agkistrodon conanti*) within a Fire-Managed Longleaf Pine Ecosystem

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Florida cottonmouths (*Agkistrodon conanti*) or “water moccasins” are generally considered semi-aquatic snakes associated with wetlands, floodplains, and other mesic habitats. However, long-term monitoring at Tall Timbers in the Red Hills region of northern Florida has revealed consistent use of upland longleaf pine habitats. Using data from identical drift-fence arrays and sampling protocols established during a 2003–2005 study, we compared historical captures with contemporary sampling conducted from 2024–2026 to evaluate changes in cottonmouth habitat use across a 20-year period. Historical sampling documented frequent captures of cottonmouths within upland habitats despite the species' traditional association with aquatic environments. Contemporary sampling confirmed continued use of upland longleaf pine habitats and revealed substantially higher capture rates across all habitat types than those observed historically. Body size differed among habitat types, with snakes captured in uplands significantly larger than those captured in bottomlands, and the probability of upland capture increased with snake size. Together, these findings suggest that upland habitats play a larger role in the ecology of Florida cottonmouths than previously recognized. Several factors may contribute to this pattern, including changes in prey availability, prescribed fire, hardwood removal, altered habitat structure, or other management-driven landscape changes. This study highlights the value of long-term replicated monitoring for detecting ecological changes that may not be apparent in short-term studies and provides new insight into the ecology of a species that is traditionally considered closely tied to aquatic habitats.

Protein-Supported Gene Annotation of the Gopher Tortoise (*Gopherus polyphemus*) Genome

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Genomic resources for the gopher tortoise (*Gopherus polyphemus*) remain limited, particularly for protein-coding gene annotation. We assembled a 2.315 Gb *G. polyphemus* genome de novo from Oxford Nanopore ultra-long reads using Flye, producing 1,658 contigs with an N50 of 14.99 Mb. Genome completeness was high, with 99.5% of BUSCOs (Benchmarking Universal Single-Copy Orthologs) complete. Repetitive regions were identified using RepeatModeler and soft-masked with RepeatMasker, resulting in 44.9% of the genome masked prior to gene prediction. An initial BRAKER3 annotation using four reference turtle proteomes (*Gopherus evgoodei*, *Chelonoidis abingdonii*, *Chrysemys picta bellii*, and *Chelonia mydas*) produced a substantially incomplete predicted proteome, with 37.1% complete BUSCOs. To improve gene prediction, we modified the protein evidence set to include nine reference proteomes (*Gopherus agassizii*, *Gopherus evgoodei*, *Chelonoidis abingdonii*, *Mauremys mutica*, *Terrapene triunguis*, *Caretta caretta*, *Lepidochelys kempii*, *Lepidochelys olivacea*, *Pelodiscus sinensis*), representing both closely related *Gopherus* species and more phylogenetically divergent turtles. The proteomes were combined and filtered to remove unusually short or long proteins and sequences containing high proportions of ambiguous amino acids before being used as evidence in BRAKER3. The resulting predicted protein set contained 42.4% complete BUSCOs (37.4% single-copy and 5.1% duplicated), 12.4% fragmented, and 45.2% missing, representing a modest improvement over the four-proteome annotation. However, the contrast between genome completeness and predicted protein completeness indicates that many expected genes remain unidentified, likely because protein evidence alone provides insufficient support for accurately resolving gene structures. Future work will incorporate RNA-seq data to provide transcript evidence and improve gene prediction, in addition to validation and functional annotation. Together, this work will help generate a more complete genomic resource for comparative, functional, and conservation studies.

Snake Community Habitat Patterns in a Longleaf Pine Woodland

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Snake community studies are important for understanding species resource needs and potential interactions. Our main objective was to examine habitat features that explain patterns of snake occurrences within a longleaf pine (*Pinus palustris*) woodland. To address this, we captured snakes at eight sites using snake box traps arrays from March through August 2026. We collected habitat data that included ground cover and tree structure measurements within a 100-m buffer surrounding each array. We used Non-metric Multidimensional Scaling (NMDS) to characterize and Permutational Multivariate Analysis of Variance (PERMANOVA) to test for spatial patterns in snake community composition. We used Principal Component Analysis (PCA) to reduce habitat variables into habitat gradients that could be examined with snake community

patterns. We captured 379 snakes comprised of 15 species. Snake community composition differed among snake trap arrays (PERMANOVA, $F_{4,47} = 2.16$, $p = 0.003$). The first two axes of the PCA explained 78% of habitat variation between arrays and was comprised of the following variables with strong loadings (≥ 0.4): overstory pine area (ha), overstory hardwood area (ha), % herbaceous vegetation, % woody vegetation, % coarse woody debris, % bare ground, and distance to wetland (m). Eight snake species (*Agkistrodon contortrix*, *Cemophora coccinea*, *Crotalus horridus*, *Coluber constrictor*, *Lampropeltis elapsoides*, *Pantherophis alleghaniensis*, *Pantherophis guttatus*, and *Pituophis melanoleucus*) had strong correlations ($r \geq 0.6$) with the two primary PCA axes and showed interspecific variation in their relationship to habitat gradients. Understanding how snake communities partition habitat resources can guide managers in promoting snake diversity and the conservation of imperiled species.

Promoting Coexistence: Tortoise Conservation Messaging in Urban Areas

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The gopher tortoise (*Gopherus polyphemus*) is a keystone species occurring in upland habitats in the Southeast United States, including in Florida where it is listed as a state-designated threatened species. Suburban residential communities with open, grassy areas and suitable soil are frequently used habitats for gopher tortoises. The Florida Fish and Wildlife Conservation Commission (FWC) has long offered public education and outreach opportunities and materials to promote coexistence with gopher tortoises, particularly in these urban areas. This includes fact sheets and decals highlighting road safety, best practices for pets and tortoises co-occurring, and more. These resources are readily available on the FWC's [Gopher Tortoise Education Resources](#) webpage. However, humans and tortoises are increasingly sharing space within expanding urbanized areas in Florida. This has fueled conservation challenges, such as the creation of waif gopher tortoises (animals removed from the wild, from an unknown origin, and not associated with an FWC permit) and increases in burrow disturbances related to development. To combat these challenges, the FWC seeks to create a targeted outreach campaign to continue promotion of coexistence and conservation of tortoises within suburban and urban communities. This poster highlights the FWC's current strategies for educational messaging and public involvement in gopher tortoise conservation, as well as the ways we are looking to improve our understanding of tortoise-human interactions. By better understanding coexistence challenges through education, outreach, and research, the FWC can continue addressing conservation needs for urban tortoise populations. Ideally, this poster will serve to prompt discussion amongst members of the Council to share strategies for educational messaging and learn from one another's experiences.

Diagnosis for a Declining Tortoise: Systematic Bias or Extinction Debt?

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Population Viability Analyses (PVA) can inject quantitative rigor into conservation decisions fraught with uncertainty, and were central to the species status assessment of the gopher tortoise when considering it for listing under the Endangered Species Act. Although complex PVAs are attractive for their nuance and realism, a “back to basics” approach to modeling can address critical conservation questions head-on without the technical overhead and loss of clarity associated with more complex approaches. Here we perform a simple matrix-based population assessment for the gopher tortoise, a declining keystone species of the southeastern United States. We demonstrate that gopher tortoise populations currently have little room for growth under reported rangewide demographic rates, and that this finding cannot be explained by simplifying modeling assumptions such as invariant age at maturity or constant juvenile survival. We compared gopher tortoise yearling recruitment and age-at-maturity to 30 other chelonian species and found that yearling recruitment is particularly low compared with similarly late-maturing species. Increases in juvenile recruitment consistent with reversal of human-altered predator regimes (including exotic and subsidized predators) substantially improved the conservation outlook, pushing population growth rates above replacement for most populations across the range assuming high (but realistic) rates of survival. This pared-down approach to PVA thus revealed management-relevant insights (i.e., predator control could make populations viable) that run counter to conventional wisdom about turtles and tortoises (and predictions from an influential and much more complex gopher tortoise PVA) that adult survival is the most important limiting demographic rate. Simple PVAs could act as counterpoint and complement to more complex demographic models in future species evaluations.

Monitoring the Behavior of Gopher Tortoises (*Gopherus polyphemus*) in Mesic Flatwoods Using Tri-axial Accelerometers

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Gopher tortoises (*Gopherus polyphemus*) are a species of high ecological value and conservation concern. Florida law requires the relocation of gopher tortoises from land scheduled for development to recipient sites that are protected from future development and

which fulfill gopher tortoise habitat requirements, namely abundant herbaceous forage, minimal canopy cover, and deep, well-drained soils. Mesic flatwoods are a habitat common on recipient sites in Central Florida, and though they provide tortoises with both herbaceous forage and an open canopy, they are characterized by shallow, poorly drained soils which are prone to flooding during Florida's wettest months. Consequently, mesic flatwoods are designated as sub-optimal tortoise habitat, and sites containing them are limited in the number of displaced tortoises they can receive. However, despite these soils, gopher tortoises can still occupy and be abundant in mesic flatwoods. Therefore, the aim of this study is to improve our understanding of gopher tortoise ecology in mesic flatwoods. We will be employing tri-axial accelerometers on gopher tortoises to monitor and quantify their behavioral patterns at a site dominated by mesic flatwoods and eventually establish a baseline algorithm to predict behavior based on accelerometry data. We will also be evaluating the overall efficacy and optimal methods for employing accelerometers on gopher tortoises. The results could improve decisions related to the translocation of gopher tortoises to mesic flatwoods habitats and lead to new ways to study tortoise behavior.

Wildlife Interactions Caught on Camera in Snake Box Traps

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The development of snake box trap arrays has revolutionized community level snake research. These arrays often include a large central box trap with four drift fences that each lead to a smaller box trap at the end of each fence. Numerous studies have reported high snake diversity and capture of large numbers of snakes with this method, as well as considerable bycatch of other taxa. In our study, we deployed game cameras in 16 box traps at eight arrays in longleaf pine (*Pinus palustris*) dominated forest communities in southwestern Georgia, to monitor snake behavior and interactions between snakes and non-target taxa. Cameras were deployed from March 25 to July 31, 2026. Fifteen snake species (n = 99) were captured within that period in snake box traps. Fourteen species (n = 93) were observed on camera within snake traps of which 26% of snakes (of 10 species) escaped between trap checks. Non-target bycatch observed on camera included 5 species of lizards, 4 frogs, 2 turtles, 10 mammals, and 5 birds. Observed snake behaviors included copulation, defensive interactions, predation events, and trap escapes.

Exploring the Potential Use of Trail Cameras in Scoring Body Condition in Gopher Tortoise

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Conventionally, monitoring gopher tortoise populations—including their numbers, behaviors, and health—has been conducted through in-person observations by researchers. However, this approach is time consuming, limited to a small snapshot in time and human movement through an area can disturb the tortoises. Advancing technology has improved the accessibility, reliability, and image quality of trail cameras, and therefore they now provide an alternative means of population monitoring. One potential application of camera traps is the remote assessment of individual body condition scores to evaluate population health. To explore the efficacy of this approach, over the span of 12 months we opportunistically assessed, in-person, the body condition scores of waif gopher tortoises that had been released onto a recipient site. Scoring was done using a system previously developed for assessing body condition scores of desert tortoises (*Gopherus agassizii*), which ranges from 1 (Emaciated) to 9 (Morbidly Obese). We also collected video footage of the same tortoises from trail cameras placed at burrow entrances taken within 20 days of the date of the in-person assessment. These videos were incorporated into a survey, which was subsequently distributed to professionals and volunteers with experience working with gopher tortoises. They were asked to score the animals from the video footage using the same body condition scoring system that was used to assess the tortoises in-person. Scores from this survey will be compared to the scores from the in-person assessment to investigate whether trail cameras can be used to reliably assess body scores in gopher tortoises. This potentially opens up new opportunities for the in-situ assessment of health in this species.

A Decadal Reassessment of Gopher Tortoise (*Gopherus polyphemus*) Population Dynamics and a Contemporary Evaluation of Pocket Gopher (*Geomys pinetis*) Occurrence in the Red Hills Region

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This project will focus on reassessing the status of the gopher tortoise (*Gopherus polyphemus*) population in the Red Hills region based on a 12-year comparative resurvey. Initial surveys conducted in 2015 spanned 18 different properties across the Red Hills region of north Florida and south Georgia. These surveys covered almost 32,500 ha of privately owned land primarily managed for northern bobwhite using single tree selection and frequent fire. The total population was estimated using Line Transect Distance Sampling (LTDS) in Program Distance and burrow scoping to determine occupancy status. From the 2015 surveys, the population density across the 18 properties was estimated to be 0.39 ± 0.07 tortoises/ha. Twelve years later utilizing the same methodology, these surveys will be repeated to obtain an updated gopher tortoise population estimate for the Red Hills region. This project will be completed from 2026-2028 with surveys beginning in January 2027. This region is a stronghold for gopher tortoises

with 40% of the 162,000 ha of private land permanently protected under conservation easement. These new population estimates are vital to understand population dynamics and evaluate the impacts of land management of Red Hills gopher tortoises. New population estimates will be compared to historical and present habitat management on each property. Additionally, the Southeast FireMap will be used to examine how prescribed fire has changed on each property over time. Alongside the gopher tortoise surveys, southeastern pocket gopher (*Geomys pinetis*) mound locations will be collected for a contemporary habitat occupancy assessment. Pocket gophers and gopher tortoises are both burrowing species that thrive in sandy, well-drained soils, managed with frequent fire. The spatial overlap of these two species will fill critical community level knowledge gaps regarding the coexistence of two keystone burrowing species.

Gopher Tortoise Research Needs: Updated Priorities for the Call for Research and Outreach Proposals Program

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The Gopher Tortoise (*Gopherus polyphemus*) was listed as a State-designated Threatened species in Florida in 2007, and the Florida Fish and Wildlife Conservation Commission (FWC) created its first Gopher Tortoise Management Plan in concert with this listing decision. The most recent version, effective as of April 2025, identifies 63 conservation actions, 10 of which are focused on research needs. To support research efforts, the FWC established the [Call for Research and Outreach Proposals Program](#) in 2021. This program funds actionable science and outreach initiatives using gopher tortoise mitigation contributions. Since the establishment of this program, the FWC has funded 17 projects for a total of over \$680,000 with topics ranging from evaluating survey methodology, improving our understanding of translocation outcomes, creating updated predictive population models, and building upon our knowledge of disease detection and predictability. The FWC's Call for Proposals Program will continue to prioritize projects aligned with conservation actions identified in the Management Plan, or seek to address emerging conservation challenges, when applicable. As part of this poster presentation, we will provide information on the FWC's priority research topics as well as the process and deadlines for those interested in applying during the 2027 funding cycle.

Behavior Trials of Headstarted Gopher Frogs (*Rana capito*): Refugia Choice & Boldness

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Gopher frogs (*Rana capito*) choice of refugia is essential to the survival of juvenile frogs given their post-metamorphosis transition from wetland to upland. Discerning what types of refugia are most often chosen by juvenile gopher frogs and their boldness when dispersing can aid in the best management practices for headstarting efforts. To understand juvenile gopher frog boldness and choice of refugia, we conducted behavioral trials of individual frogs within experimental arenas. In total, we conducted behavior trials on 192 newly metamorphosed headstarted gopher frogs, with two video recordings per individual conducted one week apart to evaluate repeatability of individual behavioral responses. The 1.2-meter diameter experimental arenas had a sand substrate and then an artificial burrow, coarse woody debris, and wire grass, all equidistant from one another. Each behavior trial involved a recorded video where individual frogs were placed in the center of the experimental arena, allowed to acclimate for 2-minutes, then given 10-minutes to move freely within the arena. Currently, we are reviewing videos from the first set of behavior trials for each frog to evaluate the latency to first movement, a metric of boldness, and refugia selection choices at the conclusion of the 10-minute trial. During this preliminary analysis of choice and boldness, the frogs were observed choosing any of the three refugia, escaping the arena or not locomoting throughout the duration of the trial. We will discuss an overview of the study methods, preliminary data, and plans for future analyses with reference to post release monitoring.

Evaluating Gopher Tortoise Use of CRP Longleaf Pine

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Longleaf pine savannas once covered the southeastern United States but have been reduced to a fraction of their historical extent, largely replaced by row-crop agriculture and dense loblolly or slash pine plantations. This loss has had major consequences for the wildlife that is dependent on the open-canopy, fire-maintained longleaf savannas, particularly the gopher tortoise (*Gopherus polyphemus*). Although the USDA Conservation Reserve Program (CRP) includes a longleaf pine practice (CP36) designed to restore longleaf on private lands, empirical evaluations of its wildlife benefits in the southeastern U.S. remain extremely limited. This research hopes to examine how CRP longleaf pine (CRP-LLP) plantings support wildlife communities compared to mature naturally regenerated longleaf pine and conventional non-LLP pine plantations in southwestern Georgia. Across these different stand types and age classes, I am quantifying mammal diversity, bat activity, and the distribution of two burrowing keystone species: gopher tortoises and southeastern pocket gophers (*Geomys pinetis*). Field methods include camera trapping, AHDriFT arrays, bat acoustic monitoring, and systematic transect surveys for tortoise burrows and pocket gopher mound systems. Because gopher tortoises are sensitive to canopy structure, groundcover composition, and fire frequency, their occurrence provides a strong indicator of whether CRP-LLP stands are developing the open, herbaceous conditions characteristic of functional longleaf pine savannas. By comparing burrow

density and spatial distribution across land-use types, this project will help determine whether CRP enrollments are having measurable wildlife benefits, as they are intended. This research addresses a critical knowledge gap in longleaf restoration on private lands and will inform landowners, conservation practitioners, and policymakers about the role of CRP in supporting tortoise habitat, commensal species, and overall biodiversity.