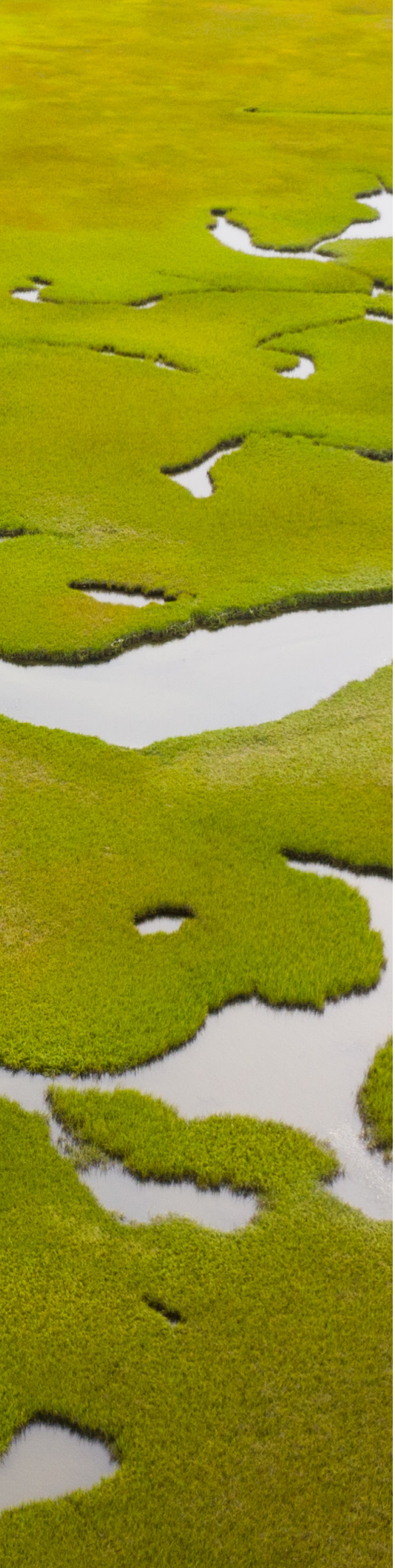
James C. Kennedy
WATERFOWL & WETLANDS CENTER
CLEMSON® UNIVERSITY

2023 ANNUAL REPORT



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“LEAD IN SCIENCE AND EDUCATION TO SUSTAIN WATERFOWL AND WETLANDS OF SOUTH ATLANTIC COASTAL ECOSYSTEMS (AND OTHER WETLAND ECOSYSTEMS) AND TRAIN FUTURE WATERFOWL AND WETLAND ECOLOGISTS AND MANAGERS.

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Message from THE DIRECTOR

As the old saying goes, time flies when you are having fun! I must be having loads of fun as another year has passed too quickly. I marked my second anniversary as Director of the James C. Kennedy Waterfowl and Wetlands Conservation Center on 13 August 2023. My wife, Heather, and I moved into our new home in Georgetown in November 2022, and we have fallen in love with our little community. This year, I spent more time on the science and education that I love to do. I continue to meet people, visit new lands, mentor graduate students to prepare them for a career in waterfowl and wetlands and conduct and publish research.

We have nine students actively conducting research in the Kennedy Center (6 Ph.D. and 3 M.S.) and four students (3 Ph.D. and 1 M.S.) in our Graduate Student Partners Program. Dr. Angela Hsiung has completed her one-year postdoc working with the Center and collaborators Dr. Beth Ross and Dr. Heath Hagy from the U.S. Fish and Wildlife Service to investigate the cross-seasonal effects of winter waterfowl survival on population growth rates. We are actively working on these publications.

Our cooperative eight-state wood duck project finished year four of the study, and the intensive data analyses will start soon. Beau Bauer (Nemours Wildlife Foundation) provides a synopsis of the work later in this report for the four states (South Carolina, North Carolina, Georgia, and Florida) where the Kennedy Center was involved with data collection.

Cindy Von Haugg and Jordan McCall completed their second and final field seasons for their M.S. degrees. Cindy works on wood duck hen use of natural cavities, and Jordan works on wetland-waterbird habitat relations. Miriam Boucher had a hectic year collecting alligator parts for her diet, microplastics, and forever chemicals study. Akshit Suthar collected preliminary data on waterbird use

of historic rice field impoundments. We welcome new students Crystal Anderson, Rene Brown, Bobby Greco, Julie Grinstead, and Christopher Pettengill. See the Student Awards and Research Abstracts sections for more details about our students.

We held our Annual Meeting on 11 July 2023. Thanks to everyone for their participation. I especially appreciate the Advisory Council's advice and input on our projects and future directions. We had an extremely informative discussion on research needs and potential projects.

Our big administrative task for the year was to update the Kennedy Center's website. The result is an updated and eye-catching website portraying the diversity of projects and students conducting research. We also continue to maintain our Facebook page. I invite you to visit and interact with our online presence.

I appreciate Mr. Kennedy's continued trust in Clemson University in establishing and maintaining the James C. Kennedy Waterfowl and Wetlands Conservation Center and this endowed professorship and directorship. Drs. Keith Belli, Greg Yarrow, Paula Agudelo, and Todd Petty were instrumental in allocating funding to hire a wildlife biologist position to help obtain grants for the Kennedy Center. The plan is to hire someone for this position by year's end.

I hope you enjoy reading the articles about our students and their fantastic work. I am proud of their accomplishments and our progress in the past two years, and I look forward to an even more productive year ahead for waterfowl and wetland conservation.

Take care,

James T. (Jim) Anderson, Ph.D.

Director, James C. Kennedy Waterfowl and Wetland Center
James C. Kennedy Endowed Professor of Waterfowl and Wetland Ecology

Summer INTERNSHIP

WETLAND ASSESSMENT IN COASTAL SOUTH CAROLINA

Blair Abernathy
Senior, Wildlife and Fisheries biology, and James C. Kennedy Waterfowl & Wetlands Conservation Center,

Professional Internship and Co-op Program Intern

MY name is Blair Abernathy, and I am currently a Senior at Clemson University. I will finish my studies in May 2024 with a B.S. in Wildlife and Fisheries Biology and a minor in Forestry. This summer, I worked with the James C. Kennedy Waterfowl and Wetlands Conservation Center at the Belle W. Baruch Institute of Coastal Ecology and Forest Science in Georgetown, South Carolina. I interned for Jordan McCall, a graduate student at Clemson, collecting data for her master's project. Her study is to establish baseline conditions for wetlands, ducks, and other waterbirds in the DeBordieu Colony and Hobcaw Barony.

I partnered with Jack Corbin this summer, and our main objectives were to conduct vegetation and benthic macroinvertebrate investigations in the areas above or ponds and salt marshes. We identified many types of native flora and were acquainted with coastal vegetation in over 50 wetland areas. We collected water and soil samples to identify different invertebrate species. We also sorted the benthic samples by searching through the vegetation and soil, looking for macroinvertebrates. This internship helped me acquire confidence in various professional abilities, including communication, adaptation to new things, how important wetlands are, and species identification. Using field equipment and tools, such as a water column and PVC core sampler, a kayak, Arc GIS, and operating ATVs and trucks, has also improved my field data collection skills.

I plan to pursue a career in wildlife biology, studying endangered species like the Red-Cockaded Woodpecker. I am also interested in working with waterfowl and learning more about them. I greatly appreciate the opportunity to work this summer at the Kennedy Waterfowl & Wetlands Conservation Center! I am incredibly grateful to my mentor, Dr. Jim Anderson, director of the Kennedy Waterfowl & Wetlands Conservation Center, and Jordan McCall for allowing me to work on this project and learn so much new information and experience for the future!

Research
ABSTRACT

UNDERSTANDING WATERBIRD HABITAT RELATIONS WITH ANTEBELLUM RICE FIELDS USING DRONES AND AUTONOMOUS RECORDING UNITS IN COASTAL SOUTH CAROLINA

Akshit R. Suthar
Ph.D. Student, James C. Kennedy Waterfowl & Wetlands Conservation Center, Clemson University

Globally, humans have modified millions of acres of wetlands to grow rice for consumption. Rice culture in the southeastern United States began in the 1670s, was primarily successfully developed, managed, and driven by the labor of enslaved persons, and ended with the U.S. Civil War. Humans transformed tidal swamps and hardwood bottomland forests into highly managed farming systems during this time. These systems left behind a legacy of land use when abandoned after slavery. Almost 95,506 ha of rice fields are mapped today and categorized as tidal functional, tidal broken, and inland in five major coastal South Carolina river basins (Figure 1). Over half have been abandoned or are no longer wholly impounded. The remainder is managed as public land for wildlife management and private land for hunting clubs.

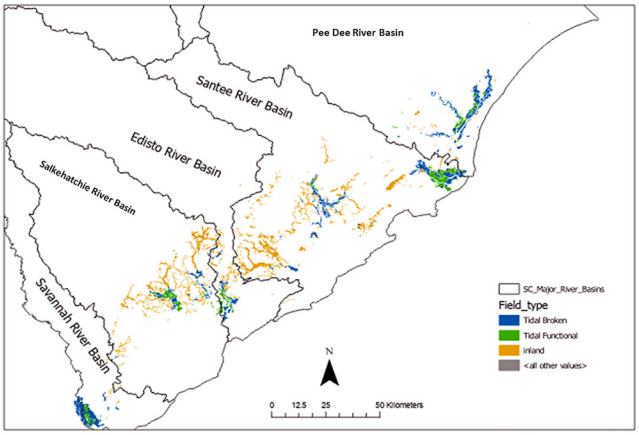


Figure 1. Historic rice fields' location and geographic extent in five major coastal South Carolina river basins (from Hanks et al.).

On average, 27% of dabbling ducks in the Atlantic Flyway winter in the South Atlantic region, particularly in South Carolina. Antebellum rice field impoundments provide feeding, breeding, and nesting habitats to rare and endangered species, including wood storks (*Mycteria americana*), American white pelicans (*Pelecanus erythrorhyncho*), roseate spoonbills (*Platalea ajaja*), and black rails (*Laterallus jamaicensis*). Environmental forces that have been influenced by climate change are causing increased degradation and loss of the antebellum rice field infrastructure.

The conservation of antebellum rice fields presents a complex challenge, with questions about whether they should be preserved for their cultural significance, restored to their pre-agricultural state, or managed as wildlife habitats. There is also debate about the impact of impoundments on coastal wetlands and waterbird habitats, with some scientists arguing that managed impoundments are more beneficial than unmanaged tidal marshes. In contrast, others claim that waterbirds would use tidal wetlands if impoundments did not exist.

Objectives of our study are to 1) Quantify the abundance and occupancy of waterbirds in antebellum rice fields; 2) Evaluate waterbird habitat association using wetlands characteristics such as percent open water, vegetation patterns, and composition to understand the benefits of managed and unmanaged antebellum rice field impoundments; 3) Determine waterbird habitat suitability across antebellum rice fields using

environmental modeling; and 4) Evaluate the effectiveness of uncrewed aircraft system (i.e., drone) and autonomous recording unitsin detecting and quantifying waterbirds in antebellum rice fields.

In February 2023, we conducted a preliminary survey at the Tom Yawkey Wildlife Center to test the field methodology. This introductory survey compared waterbird counts and diversity between tidal functional and broken impoundment using a DJI Phantom-4 RTK drone and a 20-megapixel camera (Figure 2). We also assessed the efficacy of ground-based point count and the aerial survey covering the entire tidal functional impoundment. Preliminary findings showed significant waterbird numbers and species diversity variations across impoundment types and survey methods. The tidal functional impoundment drone survey documented 3,779 waterbirds across 14 species (Figure 3), encompassing diverse functional groups like wading birds, waterfowl, and shorebirds. The commonly observed species were northern shoveler (*Spatula clypeata*), northern pintail (*Anas acuta*), and American coot (*Fulica americana*).

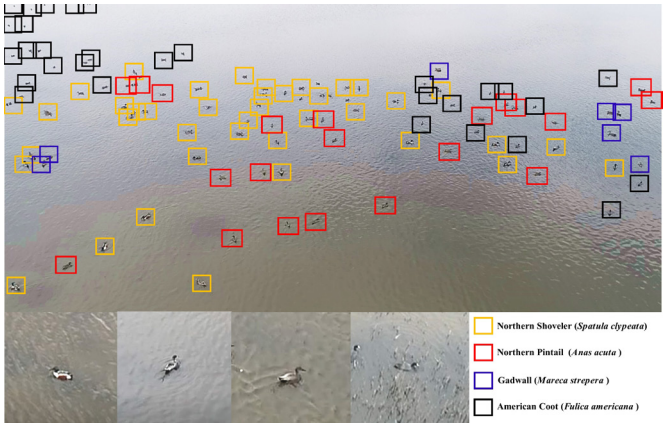


Figure 2. Aerial image from DJI Phantom 4 RTK drone with 20 MP camera resolution to count waterbirds in rice field impoundment.

The tidal broken impoundment displayed a substantially lower waterbird count, totaling 18 individuals from 4 species (Figure 3); only the wading bird functional group was observed. The most commonly observed species were black-crowned night heron (*Nycticorax nycticorax*) and little blue heron (*Egretta caerulea*). The drone enabled efficient aerial surveys within the tidal functional impoundment, resulting in 3,779 waterbirds, 503.2% higher than the 625 from the ground survey (Figure 4). Furthermore, the aerial survey identified 14 species, a 7.7% increase compared to the 13 species (Figure 4) recorded during the ground survey within the tidal functional impoundment. The preliminary study suggests that conserving and managing tidal functional impoundments are crucial to supporting diverse waterbird communities in coastal South Carolina. This study demonstrated the effectiveness of drones in accurately identifying and quantifying waterbirds compared to ground-based surveys.

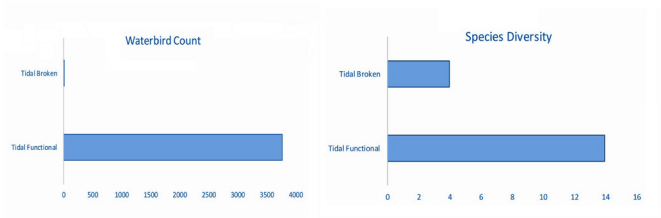


Figure 3. Comparison of waterbird count and species diversity between Tidal Broken and Tidal Functional rice field impoundments using drone-based aerial survey

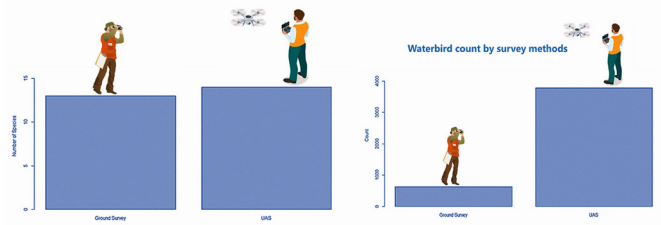


Figure 4. Comparison of waterbird counts and species diversity between drone-based aerial and ground-based point count methods.

Research
ABSTRACT

EARLY EFFECTS OF WETLAND RESTORATION IN WEST VIRGINIA RIPARIAN WETLANDS: AN UPDATE

Andrew MacKenzie
M.S. Wildlife and Fisheries Resources
West Virginia University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partners Program

Wetlands are precious ecosystems that offer a host of benefits. They serve as a natural filtration system, purifying water by trapping pollutants and sediments and reducing erosion. Wetlands play a critical role in flood control by acting like a sponge, absorbing and storing excess rainfall, and reducing flood peaks. Moreover, they are biodiversity hotspots, providing a home to various plants and animals, including many threatened and endangered species. Wetlands also serve as natural buffers against flooding, thus protecting our communities.

Urban development, road construction, agriculture, and other anthropogenic activities have led to wetland reduction at an alarming rate. The loss of wetlands led to a process known as wetland mitigation. Wetland mitigation is a process designed to counterbalance these losses. It involves creating, enhancing, or restoring wetlands where they have been destroyed or severely degraded. The importance of wetland mitigation lies in its ability to replace the lost functions of the original wetlands, in turn helping to protect our environment, combat climate change, and preserve biodiversity.

In June 2021, a wetland mitigation project began in Preston County, West Virginia. Two first-order streams, Ruby Run and Stony Run, and their adjacent wetlands were restored. Efforts for the restoration started by grading the bank to reattach the floodplain, create new wetlands, and restore the stream channel. Additionally, invasive species (multiflora rose [*Rosa multiflora*] and autumn olive [*Elaeagnus umbellate*]) were removed. In July 2021, stream structures were added for bank stabilization and habitat for aquatic fauna. Next, two native seed mixtures (Ernst Seeds Eastern Native Habitat, CREP Mix, and Ernst Seeds Floodplain Mix) were spread, and biodegradable coir wire was placed to reduce erosion. In March 2022, planting of native herbaceous and woody vegetation began. Eight species of bare-root saplings were planted (American plum [*Prunus americana*], common buttonbush [*Cephalanthus occidentalis*], eastern cottonwood [*Populus deltoides*], eastern ninebark [*Physocarpus opulifolius*], eastern redbud [*Cercis canadensis*], pin oak [*Quercus palustris*], swamp white oak [*Quercus bicolor*], and river birch

[*Betula nigra*]), along with three species of live staked species (black elderberry [*Sambuccus nigra*], black willow [*Salix nigra*], and red-osier dogwood [*Cornus sericea*]). In May 2022, the woody vegetation planting was complete, and the restoration efforts ended.

The three chapters of my proposed thesis will evaluate the ecological effects of these restoration efforts. My first chapter will assess the impact of the restoration efforts on the biotic community. I will use previously recorded data as a baseline and compare this to the data I collected from June 2021 – September 2023. Previously collected data will be "pre-restoration," data from June 2021 – May 2022 will be "active-restoration," and data gathered from June 2021 – September 2023 will be "post-restoration." I have just finished data collection and am currently analyzing my data and results. My second chapter will compare the effects of a soil amendment mixture, 90%compost:10% biochar. I have recorded growth (height and stem area at ground level) and survivorship. I will conduct my last measurements during the dormant season (November 2023). My third chapter assesses sedimentation, the trap method, and the abundance and diversity of macroinvertebrates. I am currently sifting my soil samples to get a composition profile; this will then be used as a predictor variable to determine the effects on macroinvertebrates. I collected macroinvertebrates using three trap methods (kick net sample, hand-scrub sample, and Hester-Dendy sample); I will use these trap methods as a predictor variable to evaluate trap bias for macroinvertebrates.

Research
ABSTRACT

INVESTIGATING CROSS-SEASONAL EFFECTS OF ENVIRONMENTAL DRIVERS OF WATERFOWL POPULATION GROWTH RATES

Angela Hsiung, Ph.D.
Postdoctoral Researcher, James C. Kennedy Waterfowl & Wetlands Conservation Center, Clemson University

Migratory waterfowl experience different environmental conditions during each part of their annual cycle. However, most studies of waterfowl populations focus on a single part of the annual cycle (e.g., breeding season). As a result, our understanding of the population dynamics of waterfowl species over the entire annual cycle is limited. In 2022, the Kennedy Center collaborated with Drs. Beth Ross (U.S. Fish and Wildlife Service) and Heath Hagy (U.S. Fish and Wildlife Service) on a study to better understand cross-seasonal effects of environmental factors on population vital rates across the full annual cycle and drivers of waterfowl population growth using an integrated population model (IPM).

IPMs leverage information from different data sources to estimate population vital rates essential for understanding drivers of population growth. By combining different data types (e.g., productivity and capture-recapture) under the same analysis, IPMs allow ecologists to study the full annual cycle of animal populations and the cross-seasonal effects of environmental drivers on population growth rate. We used an IPM to estimate age- and sex-class-specific annual and seasonal survival probabilities, annual productivity, and population growth rates mallards (*Anas platyrhynchus*) and green-winged teals (*Anas crecca*) in the Atlantic, Mississippi, and Central Flyways in North America. We analyzed long-term datasets collected between 2005–2019 for mallards and 1992–2019 for green-winged teals. The data included breeding population and habitat surveys, data collected on wings of harvested ducks sent by hunters to the U.S. Fish and Wildlife Service each year, and data on banded ducks harvested and reported by hunters each year. In addition to estimating population vital rates, we aimed to assess environmental factors such as winter precipitation and temperature on the seasonal survival of each species. We also estimated the effects of the same environmental factors and the cross-seasonal effect of breeding habitat quantity (i.e., the number of ponds on the breeding ground) on productivity. Finally, we conducted a retrospective analysis to examine the contribution of each population vital rate and population structure to the overall population growth rate.

We found that winter precipitation positively affected mallard productivity the following year but did not affect green-winged teal productivity (Figure 1). Additionally, the availability of breeding ponds had a weak positive impact on green-winged teal productivity but no effect on mallard productivity. This pattern could be explained by the difference in body size between the two species. Larger-bodied dabbling ducks, such as mallards, form pair bonds earlier during the fall and winter compared to small-bodied species, such as blue-winged and green-winged teal. As such, male mallards may require more resources during the winter to maintain pair bonds than green-winged teal.

Further, having a smaller body size, green-winged teal may not be able to store much energy reserve during the winter before spring migration to the breeding grounds. As such, they rely more on

exogenous energy sources on the breeding ground to fuel reproductive activities. In contrast, mallards could depend more on the energy gained on the wintering ground for reproduction, resulting in a correlation between their productivity and winter precipitation.

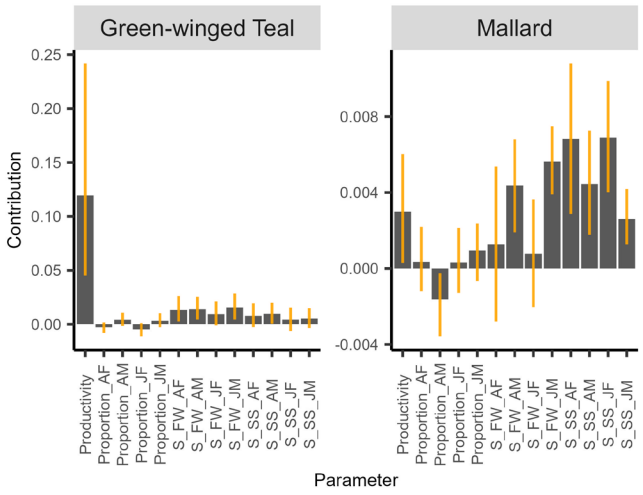


Figure 1. Estimated environmental covariate effects on mallard and green-winged teal productivity in the Atlantic, Mississippi, and Central flyways. Colored density plots represent posterior sample distribution for each covariate effect. Solid black points represent the posterior sample means of the estimates. Thin horizontal lines represent 95% Bayesian credible intervals. Thick horizontal lines represent one standard deviation of the posterior sample distribution.

Our results demonstrated that spring/summer survival and juvenile and adult females contributed the most to the variation in the population growth rate of mallards, while productivity had the highest contribution to green-winged teal population growth rate (Figure 2). These results could be explained by slightly different life histories between mallards and green-winged teals. Mallards are longer-lived compared to green-winged teals and generally have higher survival probabilities and lower productivity (ratio of juveniles to adults) compared to green-winged teals. Therefore, the survival of females could have a more substantial influence on the overall population growth of mallards. This study provides valuable information for waterfowl biologists and managers to better allocate resources towards managing waterfowl populations during the part of the annual life cycle of a waterfowl population that is the most influential to population growth.

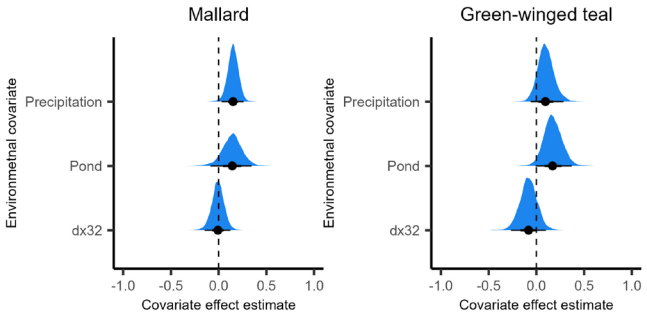


Figure 2. Contribution of vital rates and population structures to the variance of population growth rate over the study period for mallards and green-winged teals within the study region. "S_FW" fall-winter survival, and "S_SS" denotes spring-summer survival. "Proportion" indicates the proportion of a specific age-sex class population. "AF" denotes adult female, "AM" denotes adult male, "JF" denotes juvenile female, and "JM" denotes juvenile male. Grey bars represent the means of the contributions, while vertical orange lines represent 95% credible intervals. Note the difference in y-axes scales between figures.compare this to the data I collected from June 2021

We appreciate financial support from the U.S. Fish and Wildlife Service, Nemours Wildlife Foundation, and Ducks Unlimited.

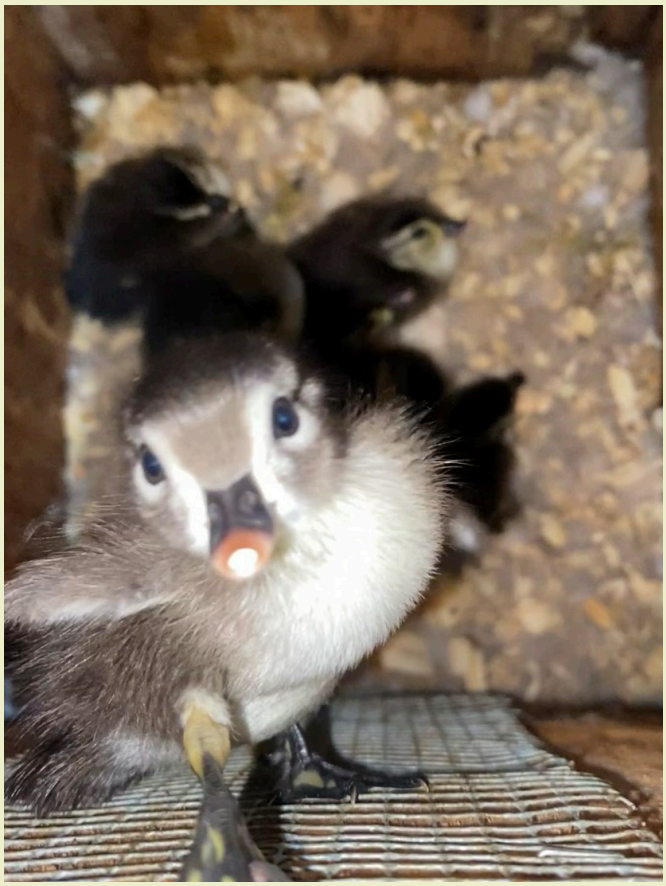
Research
ABSTRACT

REGIONAL EXAMINATION OF THE CONTRIBUTION OF NEST BOXES TO WOOD DUCK RECRUITMENT IN THE SOUTHEAST AND MID-ATLANTIC UNITED STATES

Beau Bauer
Wildlife Biologist, Nemours Wildlife Foundation

The Nemours Wildlife Foundation (Yemassee, SC) began a partnership with the James C. Kennedy Waterfowl and Wetlands Conservation Center and the South Carolina Department of Natural Resources in 2019 to initiate a pilot study investigating the contribution of artificial nest boxes to wood duck recruitment. The need for this information was identified by waterfowl biologists representing state and federal natural resources agencies, NGOs, and university professors across the mid- and south Atlantic Flyway. This pilot study and partnership started a four-year study (2020–2023) with study sites spanning the mid-south Atlantic and lower Mississippi Flyways. During this time, the Kennedy Center handled data collection in Florida, Georgia, North Carolina, and South Carolina through two M.Sc. students (Emily Miller and Jacob Shurba), a large number of technicians, logistical and personnel support from Florida Fish and Wildlife Conservation Commission, Georgia Department of Natural Resources, South Carolina Department of Natural Resources, U.S. Fish and Wildlife Service, and, for the final year, sub-regional coordinator, Nick Makarewicz.

From 2020–2022, in addition to the 2019 SC pilot study, field work prioritized marking recently hatched ducklings with web tags before box exodus. This allowed us to use recruitment (i.e., female tagged ducklings documented subsequently surviving and breeding as adults) as a vital rate metric to evaluate nest boxes' contribution to the population. Through weekly nest box monitoring, incubating females were captured on nests, banded with USGS leg bands, and inspected for previously attached web tags. For the final 2023 field season, emphasis was placed on hen captures to detect web tags, as tagging additional ducklings would not have provided valuable data after the project termination due to the cessation of monitoring activities.



The wood duck ducklings are ready to leave the nest box. (Photo by the late Natalie Hahs)

The Kennedy Center's contribution to this one-of-a-kind landscape-scale study cannot be understated, as

these efforts represented half of this project's overall data and spatial representation. Approximately 600 nest boxes were sampled yearly during 2020–2023 across the four Kennedy Center states. Overall nest box use averaged 81% (FL, = 91%; GA, = 62%; NC, = 75%; SC, = 94%). Overall nest fates, including the pilot study, averaged 51% successful (FL, = 45%; GA, = 47%; NC, = 60%; SC, = 51%), 23% abandoned (FL, = 29%; GA, = 32%; NC, = 14%; SC, = 18%), 21% depredated (FL, = 18%; GA, = 15%; NC, = 21%; SC, = 30%), and approximately 5% unknown or other fates (e.g., flooding events). Across all years, 10,904 ducklings were web-tagged across these four states (FL = 1,769; GA = 1,209; NC = 3,204; SC = 4,722). The team banded 1,069 adult female wood ducks (FL = 240, GA = 141, NC = 269, SC = 419). Field crews recaptured 1,163 previously marked birds (many individuals were recaptured multiple times), including 215 web-tagged females documented as being recruited into the adult population (FL = 56, GA = 11, NC = 22, SC = 126).

Nick Makarewicz (L, Clemson University) and Nicholas Porter (R, Nemours Wildlife Foundation) checking wood duck boxes on Roanoke River National Wildlife Refuge, NC. (Photo: Beau Bauer)

Close-up of a wood duck duckling (Photo by Nick Makarewicz)

With the addition of data collected by partners in Delaware, Louisiana, Maryland, and Mississippi, this is likely the most extensive coordinated box-nesting wood duck study to date. Across all eight participating states, the cumulative nest box sample size averaged approximately 1,400 boxes yearly. Throughout this study, there have been five M.S. students and one Ph.D. student representing four endowed university waterfowl programs (Emily Miller and Jacob Shurba, Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center [Jim Anderson, Ph.D. and Rick Kaminski, Ph.D.]; Dylan Bakner, Louisiana State University H. Dale Hall Ducks Unlimited Endowed Professorship in Wetlands and Waterfowl Conservation [Kevin Ringelman, Ph.D.]; Taylor Gibson and Hunter Mentges, Mississippi State University James C. Kennedy Endowed Chair in Waterfowl and Wetlands Conservation [J. Brian Davis, Ph.D.]; Blake Struthers, University of Delaware Waterfowl and Upland Gamebird Center [Chris

Williams, Ph.D.]). Plans are underway to conduct the final, comprehensive analyses in collaboration with the aforementioned university partners. We provide a special thanks to the Delaware Department of Natural Resources and Environmental Control, Delaware Wild Lands Inc., Maryland Department of Natural Resources, U.S. Fish and Wildlife Service Refuge System, South Carolina Department of Natural Resources, Georgia Department of Natural Resources, Florida Fish and Wildlife Conservation Commission, Louisiana Department of Wildlife and Fisheries, Mississippi Department of Wildlife, Fisheries, and Parks, and private landowners for their financial, logistical, and technical support. This study has provided much-needed information to manage wood ducks better and trained dozens of students and technicians in critical skills as future wildlife professionals and conservationists.

We extend our deepest condolences to the friends and family of Natalie Hahs. Natalie was a Florida Fish and Wildlife Commission wood duck technician. She passed on July 4, 2023.

Research
ABSTRACT

REVITALIZING CONSERVATION AND MANAGEMENT OF AMERICAN CROCODILE (*CROCODYLUS ACUTUS*) IN LAGO ENRIQUILLO, DOMINICAN REPUBLIC

Bobby Greco
Ph.D. student, James C. Kennedy Waterfowl & Wetlands Center, Clemson University

American crocodiles (*Crocodylus acutus*) are large neotropical crocodiles that occur on the Atlantic and Pacific coasts of Mexico, Central America, and northern South America, as well as the Caribbean islands of Cuba, Jamaica, Hispaniola, and the southern tip of Florida. Crocodiles are predominately a coastal species found in various freshwater, brackish, and marine habitats, including estuarine sections of rivers, mangrove swamps, coastal lagoons, offshore islands, and atolls.

Crocodiles are listed as "Vulnerable" by the International Union for the Conservation of Nature and Natural Resources (IUCN) and listed in Appendix I of the Convention on Trade in Endangered Species of Flora and Fauna (CITES). Though a few crocodile populations have begun recovering since the implementation of IUCN and CITES, many populations throughout its range are still threatened with extirpation due to rapid habitat loss, pollution, and overhunting. One of the problems limiting conservation efforts is that the population status of crocodiles in some countries, such as the Dominican Republic (DR), is data deficient.

Historically, Lago Enriquillo had the largest population of crocodiles, with over 500 breeding adults in the 1970s and early 1980s. The population saw significant declines in the late 1980s and early 1990s, and in 1992, it was estimated that 160 adults and subadults were in the lake. A management plan was created in 1992 and implemented in 1993, but it was only short-term because a head-start program was seemingly successful, and the population size appeared to increase. Ultimately, the population declined again. Population estimates from our 2021 survey estimate that only 40-60 breeding adults are left. Prevailing observations suggest the population faces threats such as illegal hunting, climatic stressors, and an overburden of predation by native and invasive species, affecting successful nesting and survival. Hatchling survival is meager, with little to no recruitment due to a lack of protected or accessible freshwater in conjunction with the principal natural nursery's location, which is adjacent to a dense egret rookery and the main road that is easily accessible to feral cats; both are known to depredate hatchlings or nests heavily. Our data suggest that the DR population of crocodiles is critically endangered and continuing to decline due to the pressures of hunting, fishing, and habitat destruction (anthropogenic and natural lake level fluctuations). Implementing a long-term conservation management plan is critical to the survival and recovery of this population.

Protecting crocodiles and their habitat in DR

is necessary because the species may provide critical ecological, economic, and cultural services. Crocodiles are a top predator that can be an indicator species for healthy ecosystems because they range widely across different wetland habitat types and require healthy prey populations to thrive. Protecting critical crocodile habitat also safeguards other species sharing these habitats. Crocodiles have also been economically beneficial in many parts of their range through ecotourism and sustainable farming for meat and skins. In addition, one god ("cemí") of the Taino people was represented by a crocodile, and many people in the Caribbean today claim Taino ancestry. Therefore, crocodiles are culturally significant to the Caribbean, and the cultural ties can help increase people's interest and pride in the species as it has in other parts of its range.

Our project intends to reignite interest and knowledge about American crocodiles in DR through a head-start, protection, and monitoring program while simultaneously interacting with communities to rebuild pride and stewardship of crocodiles and their habitat, which can also have a positive umbrella effect on other local species. The goal is to obtain the data necessary to implement the most appropriate crocodile conservation and management plan to ensure the species' survival and build local and national capacity to provide long-term management in Lago Enriquillo.

I will create four chapters for my dissertation from the research conducted during this project. The first chapter will focus on creating a more representative population estimate using N-mixture models with data from a multi-year and multi-season nocturnal eyeshine survey dataset. The second chapter will focus on head-start individuals' growth, health, and survivability compared to wild individuals from the same cohort. The third chapter will focus on which environmental variables influence crocodile habitat selection within Lago Enriquillo. The fourth chapter will focus on diet, size and sex-related dietary patterns, niche width, and what crocodiles eat versus what is available. The findings of this research will help make more informed management decisions, such as priority areas in the lake to protect and monitor.

Research
ABSTRACT

WILL OYSTERS ASSIST RECOVERY AT A LITTLE EDISTO SALTMARSH?

Christopher Pettengill
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Restoration of altered coastal wetlands can be complicated due to their structure. Moreover, unlike many freshwater wetlands, the criteria for measuring restoration success in saltwater environments are not codified. There are shared elements of freshwater and saltwater ecosystems, such as patterns of colonization by plants and indicators of wetland hydrology. However, other organisms and processes are unique to brackish and saltwater systems. Oysters are a "keystone" species in salt marshes that contribute numerous ecosystem services, including shoreline protection, water quality, and sediment retention. Environmental engineers and conservationists have recently devoted significant resources to creating new oyster beds and restoring damaged ones.

This experiment aims to test how oysters influence biotic and abiotic environmental variables at a restoration site, a set of saltwater impoundments that have limited connectivity to the tidal creek. This study will contribute to calculating the monetary value of oyster ecosystem services per unit area. Our restored site will be compared to natural systems with oyster beds and locations without oyster beds.
This experiment is part of a more considerable restoration effort at the site. The primary goal of the restoration project (sponsored by Southeast Mitigation LLC and in coordination with Lee Taylor, Edisto Shellfish LLC) is to restore tidal flow to a set of saltwater impoundments that have limited connectivity to the tidal creek. In the spring of 2024, several channels will be made into the berms to increase the impoundments' connections to the tidal creek, which should result in greater variation in water depth with the tide. We will record the resulting change in hydrology and biotic community and compare them with naturally-formed reference sites.

Restoration management actions following the creation of channels will include the introduction of native saltmarsh plant species in the lower and upper marsh (*Sporobolus alterniflorus, Salicornia sp., Borrichia frutescens*), as well as the deployment of oyster beds in the deep-water areas of the marsh,

where they are less likely to be frequently exposed to the air. Oyster cultch material will be varieties that have already been shown to be successful in South Carolina restoration projects. Since bagged shell is often unavailable or prohibitively expensive, we intend to repurpose crab traps and use other innovative methods as a colonization site for oyster larvae.

Existing protocols for assessing oyster bed restoration account for their total extent (acreage) but do not evaluate the effectiveness of their ecosystem services. We hope to find an optimal methodology to create and monitor long-term sustainable oyster beds that support sediment retention, assist in cycling nutrients such as phosphorus and nitrogen, and create habitat for wildlife.

Research
ABSTRACT

WOOD DUCK NEST CAVITY SUITABILITY AND CAVITY OCCURRENCE IN SOUTH CAROLINA FORESTS

Cindy L. Von Haugg
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Wood ducks (*Aix sponsa*) garner significant ecologic and economic importance as the second most harvested waterfowl species in two of the four migratory flyways in North America. Still, the accuracy of population estimates, relative to other duck species, is stifled by the wood duck's secretive nature and nesting habitat. Suitable nest site availability is critical in identifying where breeding habitat persists and is essential for bridging the gap in knowledge of the reproductive ecology and demographic vital rates of cavity-nesters. Yet, we can still not define areas affording adequate nest sites without knowing which characteristics to look for. The primary difficulty stems from the need to climb trees, which omits the ability to measure cavities on limbs or in trees unsafe to climb. Various pole-mounted cameras, smartphone Light Detection and Ranging devices (LIDAR), and size estimations from the ground have been used to evaluate exterior cavity dimensions, thereby decreasing the need to climb trees. Nevertheless, the inability to accurately measure internal tree cavity dimensions has remained problematic.

To overcome this issue, we developed a method allowing external and internal cavity dimension measurements to be taken from the ground. Our approach uses a device consisting of a 1) telescopic pole, 2) wireless cavity inspection camera with a monitor, and 3) reference scale allowing an object of known length to be viewed and recorded inside the cavity. We tested our method using simulated cavities (n = 20), assessed accuracy by comparing the estimated and actual measurements and evaluated precision between 2 observers. The differences between estimated and precise measurements were minimal. There was no difference between observer measurements for entrance width, entrance height, platform width, and platform length (P > 0.05), but there was a difference for platform depth (P = 0.016). The time to complete a single cavity survey in the field (n = 37) averaged 12.2 (SE = 6.9) minutes.

This method was integral to accomplishing our objectives: 1) collect forest metrics and cavity measurements to identify significant characteristics contributing to the presence of cavities and cavities suitable for nesting wood ducks; and 2) evaluate the relative abundance of cavities and suitable cavities across the dominant forest types of the South Carolina (n = 5) (i.e., 1) loblolly pine (*Pinus taeda*), 2) oak (*Quercus* spp.) and hickory (*Carya* spp.), 3) oak, gum (*Liquidambar styraciflua*), and cypress (*Taxodium* spp.), 4) oak and pine, and 5) longleaf pine (*P. palustris*).

We randomly selected 20-m radius plots (n = 32 per strata) to conduct our surveys at Francis Marion National Forest in Berkeley and Charleston Counties and Hobcaw Barony in Georgetown County, South Carolina, USA. Within plots, all trees >22 cm diameter at breast height (DBH) were measured and examined for cavity presence and suitability. Due to inadequate knowledge of cavity occurrence in the southeastern region, we based suitability on the minimum and maximum dimensions recorded in extant literature for cavities used by wood ducks to ensure detection of potential cavities. The presence of cavities and suitable cavities were recorded. Cavities had entrance dimensions ≥4 x 4 cm (size of the camera head) and platform depth ≥4 cm. Suitable cavities were defined as having entrance dimensions ≥6 x 6 cm (28 cm^2), platform depth ≥10 cm and ≤450 cm, platform dimensions ≥14 x 15 cm (165 cm^2), absence of standing water or debris, and not hollow to the ground.

We completed 160 plots and collected data for 4,633 suitable trees and 226 suspected cavities. Of the 197 confirmed cavities, suitable cavities made up 15% (n = 30). Of the 126 cavities deemed "unsuitable," 70% had an unsuitable entrance, platforms, or depth, and 30% were hollow or had standing water or debris present. This is important to note because the cavities in the 70% category have the potential to be suitable in the future, while holes that are hollow or have debris do not. We ran an analysis on the least square means, for an unbiased means comparison, for cavity presence in the different forest types, which returned a significant difference between oak, gum, cypress stands and both loblolly and longleaf pine stands with ($F_{4, 4624}$ = 4.29, P = 0.0018; Figure 1). Results of a generalized regression and best-fit model of standardized factors (Table 1) revealed a significant relationship between tree density, site index, DBH, and stand age. The presence of cavities (P < 0.05), but DBH was the only significant variable contributing to suitable cavity presence (P < 0.05), likely due to the insufficient sample size. We used our analysis results to create a heat map using optimized hot spots for areas with >95% and >99% confidence intervals for the highest and lowest suitable cavity occurrence probabilities. Continued surveys targeting areas more likely to have cavities will help increase cavity accuracy and precision and suitable cavity estimates with increased sample sizes.

The study is funded through the South Carolina Department of Natural Resources, the Kennedy Center, and the Nemours Wildlife Foundation. Dr. Anderson and Cindy thank the Nemours Wildlife Foundation, Belle W. Baruch Foundation, South Carolina Department of Natural Resources, U.S.

Fish and Wildlife Service, U.S. Forest Service, and technician Luke Berardinelli for hosting and facilitating the research.

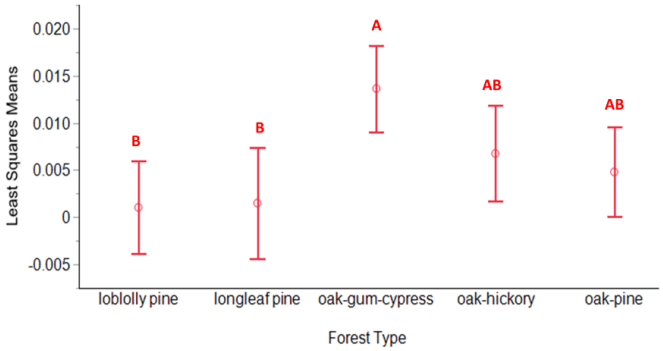

Figure 1. Least square means analysis for cavity presence in South Carolina, USA's five dominant forest types. 2022.

Term	Parameter Estimate	Std Error	*p*-value
Intercept	-3.610	0.098	<.0001*
Tree density	0.164	0.080	0.0411*
Site index	0.313	0.102	0.0021*
DBH	0.509	0.061	<.0001*
Stand age	0.363	0.083	<.0001*

Term	Parameter Estimate	Std Error	*p*-value
Intercept	-5.629	0.261	<.0001*
Tree density	-0.326	0.217	0.1317
Site index	-0.109	0.152	0.4739
DBH	0.765	0.106	<.0001*
Stand age	0.342	0.190	0.0716

Table 1. Results of a generalized regression of standardized factors contributing to cavities (left) and suitable cavities (right) at Francis Marion National Forest in Berkeley and Charleston Counties and Hobcaw Barony in Georgetown County, South Carolina, USA. 2022.

Research
ABSTRACT

UNDERSTANDING THE HUMAN DIMENSIONS OF WETLAND COASTAL RESILIENCY AND INCREASING COMMUNITY SUPPORT THROUGH EDUCATION

Crystal Anderson
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Wetlands provide an abundance of ecosystem services crucial to the ecological health of coastal regions (MEA 2005, Barbier et al. 2011) and the societal and psychological well-being of the people who occupy these areas (MEA 2005). These ecosystem services consist of provisioning food, fiber, fuel, and biochemical materials; regulating climate through hydrological flows, carbon sequestration, purification of water, and erosion regulation; protection from sea level rise; providing cultural protection and recreational opportunities; and ecological functions through soil formation and nutrient cycling (MEA 2005, McLeod et al. 2011, Okruszko et al. 2011). As lawsuits contesting the definition of wetlands through the Clean Water Act reach federal court, a growing number of protections are being lost. As human populations continue to grow in coastal areas, wetlands may experience devastating declines in wildlife habitat, water quality, and recreational activities, in conjunction with the loss of natural protection the sea islands provide against the onslaught of climate change (Pejchar et al. 2007, Schmidt et al. 2014).

There are many stakeholders within the coastal barrier islands of the southeastern United States. The Gullah Geechee Nation, one of the oldest freed slave populations in America, is part of the Sea Island culture that still retains much of its African traditions and values. The Ace Basin of South Carolina contains a vast network of conservation groups, plantations, and private landowners who wish to preserve the area's ecological importance in the face of climate change. The influx of people from around the country, drawn to coastal South Carolina for its beauty and cost of living, create a new demographic of stakeholders. However, some may lack the knowledge of our local ecosystems to protect our natural resources.

Often, scientists are guilty of speaking to stakeholders in a foreign language of scientific jargon on climate resiliency and wetland protection. Resilience from an ecological standpoint differs from resilience from a social perspective. It is often defined by

government entities or elite majorities that fail to connect the social needs to the environmental needs of a community (MacKinnon and Derickson 2012). Worse yet, coastal resilience does not always equate to climate justice for underserved communities already subjected to systemic inequities (Derickson 2016, Hardy et al. 2022), and programs that aim to increase resilience through redevelopment do not always correlate with the needs and desires of the community (Derickson 2016). Education may be key to creating lasting coastal resilience to climate change regardless of stakeholder demographics.

Using surveys and focus groups to understand the thoughts and beliefs of local stakeholders where wetland loss and coastal resilience are of most significant concern may give insight into educational frameworks that can be used to garner community support. According to previous research, the things we experience in the informative years before age eleven carry over with us into our adult preferences and attitudes (Khan and Kellert 2003, Wells and Lekies 2006, Jensen and Olsen 2019), therefore creating surveys for educators at various grade levels will allow us to determine the current status of wetland education and coastal resiliency within schools. Surveys to the public and stakeholders in the area can shed light on what previous educational experiences have been most profound in establishing environmentally friendly behaviors. Analysis of survey data can help determine the best way to educate current stakeholders and future generations on coastal resilience and wetland conservation while maintaining social justice through climate justice.

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Research
ABSTRACT

AVIAN USE OF WETLANDS IN COASTAL SOUTH CAROLINA

Jordan McCall
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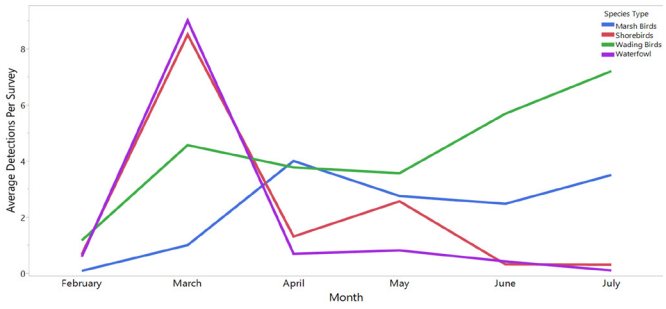
The South Coastal Plain of South Carolina is essential for migrating, wintering, and breeding waterfowl and other waterbirds. It is comprised of 7 main wetland type classifications: (1) estuarine deepwater, (2) estuarine wetland, (3) freshwater emergent, (4) freshwater forested and shrub, (5) freshwater ponds, (6) lakes, and (7) riverine wetlands. Despite the significance of the Hobcaw Barony in a region historically known as a waterfowl hunting paradise, the long history of the Belle W. Baruch Institute of Coastal Ecology and Forest Science on Hobcaw Barony and the establishment of the James C. Kennedy Waterfowl and Wetlands Conservation Center at the Baruch Institute in 2014, no comprehensive study of waterbirds has occurred on site. Thus, this study aims to form a fundamental wetland and waterbird data baseline as the beginning of a long-term dataset.

This study along the South Carolina coast began in January 2022, encompassing extensive, conserved lands and highly developed and altered landscapes. Two field seasons have since been completed from January-July of 2022 and 2023. Research sites are at the Hobcaw Barony (~16,000 acres) and the DeBordieu Colony (~2,700 acres). Our primary objectives are to model winter and spring waterbird-habitat relations and document spring migration chronology.

In 2022, we performed point count surveys at 97 randomly selected wetlands, varying by type, and secretive marsh bird surveys at 12 emergent freshwater wetlands to estimate occupancy rates, species diversity, species abundance, and migration chronology. Wetland-level data (e.g., water quality, water regimes, vegetation, macroinvertebrates) were also collected to model waterbird use and selection of wetlands. During 2023, we focused on the most productive wetland subtype from the previous season. We randomly selected 98 new wetlands, most

not surveyed last year. The survey protocol remained the same as the previous season.

Preliminary results revealed that in 2022, we detected 29 species of waterbirds, and in 2023, we detected 42 species of waterbirds across both sites. Preliminary results from 2022 suggest that shorebirds and waterfowl peaked in March, secretive marsh birds peaked in April, and wading birds peaked in June. Our results indicate that avian diversity is greatest in estuarine wetlands and freshwater ponds, potentially due to abundant macroinvertebrates. The most abundant macroinvertebrate taxa detected in 2022 were chironomids (*Chironomidae*) and scuds (*Gammaridae*). We look forward to combining the 2023 data with data from 2022 to investigate further which wetland variables are affecting each wetland type's productivity. These data will improve understanding of wetland-waterbird relations along the South Atlantic Coastal Zone and enhance the conservation and management of these wetlands for waterbirds.



The James C. Kennedy Waterfowl and Wetlands Conservation Center and the DeBordieu Colony funded this project. Additionally, I thank the Kennedy Center, DeBordieu Colony, Nemours Wildlife Foundation, Belle W. Baruch Foundation, and Clemson's Department of Forestry and Environmental Conservation for hosting and facilitating this research, and technician Jack Corbin, and UPIC interns Anna Koon, Carly Sprott, and Blair Abernathy for their assistance in the lab and field. '

Research
ABSTRACT

WATERFOWL AND BANANA WATER LILY ECOLOGY AND MANAGEMENT

Julie A. Grinstead
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The wetlands of coastal South Carolina are home to waterfowl who breed, nest and migrate throughout the region. Although much has been learned about the aquatic plant banana water lily (*Nymphaea mexicana*) as a food source for waterfowl, our research question is how to maximize banana water lily as an effective wildlife management tool. The goal is to assess waterfowl management, plant ecology, and the ecology and natural history of banana water lilies. The objectives of this study are to 1) design a field study using exclosures and control plots to evaluate the annual productivity and reproduction of the plants under foraged and protected conditions, 2) evaluate waterbird and macroinvertebrate associations, and 3) determine the nutrient content of seeds, rhizomes, and tubers. Fieldwork will occur on public and private lands near the Baruch Institute of Coastal Ecology and Forest Science (located on the 16,000-acre Hobcaw Barony property), dedicated to research and education. This two-year project began in the fall of 2023.

Research
ABSTRACT

REGIONAL ALLIGATOR DIET AND UTILITY AS INDICATORS OF CONTAMINANTS OF EMERGING CONCERN

Miriam Boucher
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Human-produced contaminants, including per- and polyfluorinated substances (PFAS) and microplastics, pose environmental risks. PFAS are a large class of synthetic fluorinated organic chemicals with carbon-fluorine bonds. This group of chemicals is used in various applications, including no-stick coatings and flame retardants in fire-fighting equipment. In the environment, PFAS are resistant to degradation and are considered "forever chemicals." PFAS bioaccumulate and biomagnify in living organisms, impacting health. Similarly to PFAS, microplastics are ubiquitous in the environment, may harm ecological integrity and organismal health, and function as a vector for the magnification and transfer of toxic chemicals that sorb to the surface of microplastic particles. As contaminants of emerging concern, research on PFAS and microplastics is critical to addressing data gaps to quantify and understand potential impacts on wildlife; one management strategy to assess and monitor water quality is using indicator species that reflect the biotic or abiotic state of the environment.

Miriam inserts a lubricated hose into a live alligator to collect stomach content samples through stomach flushing. Photo Credit North Carolina Wildlife Resources Commission 2023.

American alligators (*Alligator mississippiensis*) are ubiquitous in freshwater and brackish wetlands throughout the southeastern United States, including the coastal plain of South Carolina. Alligators are an effective indicator species to measure environmental contamination of contaminants, including heavy metals and persistent organic pollutants within wetland ecosystems. Moreover, they are a highly managed species, captured annually for research and management programs and harvested legally through public and private hunting. As such, exploring alligators as candidate indicator species for PFAS and microplastics in water resources in South Carolina and across their range is possible. In addition to contaminants, there is a need for more data on alligator diets throughout their range. There is currently no published diet study of alligators in South Carolina. As the primary exposure pathway for contaminants, determining trends in the alligator diet is vital to elucidating patterns of contaminant exposure in alligators.

Miriam Boucher (far right) and collaborators from the SCDNR at Santee Coastal Reserve in Charleston County, SC. An adult alligator post-processed after using stomach flushing to collect stomach contents. Photo credit: Miriam Boucher.

Our research is a regional effort to explore alligators' diets at a broad scale and elucidate patterns of alligator exposure to contaminants of emerging concern (i.e., PFAS and microplastic). We are collaborating with state agencies, private landowners, hunters, game processors, and licensed trappers to collect samples from alligators across the region. Our sampling effort covers alligators in North Carolina, South Carolina, Georgia, Florida, Mississippi, Louisiana, and Texas. It is a combination of data derived from non-lethal alligator stomach flushing and the collection of whole bellies from harvested alligators. In our first year, we collected 305 samples from alligators across these seven states. Anecdotal observations of diet items indicate dietary variance between inland and tidally influenced wetlands and between Atlantic and Gulf Coast states. We anticipate sample analysis over the 2023–2024 fall and winter will produce meaningful insight into alligator diet and contribute novel data regarding PFAS and microplastic contamination in alligators. Nine undergraduate Clemson University students' participation in a Creative Inquiry course aided sample analysis.

This project is made possible by all of our collaborators, and we are incredibly grateful for your time, effort, and support in facilitating the collection of alligator samples. Thank you all, and we look forward to collaborating with you again next year!

Miriam and Randeep Singh with Shane Smith, owner of Red Antler Processing in Yazoo City, MS. All Mississippi alligator samples came from the over 300 alligators processed at Red Antler during the 2023 fall recreational alligator hunt in Mississippi.

A red river crawfish flushed from the stomach of an adult alligator sampled at Lake Waccamaw in collaboration with Alligator Biologist Alicia Wassmer and the NCWRC. Photo credit: North Carolina Wildlife Commission.

Dr. Stoner (left), Jeff Holliday (center), and Miriam Boucher (right) pictured with the crocodilian snout opener post-strength test.

Research
ABSTRACT

EFFECTS OF WATER QUALITY ON OYSTER HABITATS, VEGETATED COMMUNITIES, AND FISH SPECIES

Rene Brown
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The presence and abundance of different fish species is an indicator of the water quality, habitat conditions, and vegetated communities. Despite their potential for significant levels of natural fluctuation, fish communities can serve as helpful indicators of the health of an ecosystem. Oysters are crucial in various ways as they clean the water through filter feeding and help sustain vibrant recreational fisheries. The number of oysters has declined substantially. Some populations have been extirpated, while others have had population declines due to erosion from construction, wetland loss, pollution, overharvesting, changing ocean conditions, freshwater discharges, illness, and damaged fishing gear.

Little Edisto Island salt marsh plant and fish communities could be enhanced with water quality improvement by expanding oyster populations. This study will look at how the water quality affects these significant ecological elements on the island and, in turn, how biota influence water quality. We will gather and examine data through a thorough set of water quality tests to determine the degree of such influence.

The study will monitor key water quality parameters such as phosphorus, nitrogen, water temperature, pH, dissolved oxygen levels, salinity, nutrient concentrations, and pollutant levels across multiple sampling sites on Little Edisto Island. The hypotheses are as follows: 1) Water quality parameters, such as pH, dissolved oxygen, and salinity, exhibit significant

seasonal variations, and these fluctuations influence the vitality and distribution of oyster habitats, vegetation communities, and fish species on the island; 2) The impact of water quality on oyster habitats, vegetation communities, and fish species varies among sampling sites on Little Edisto Island, with some locations more vulnerable to water quality-related effects than others. To test for things like phosphorus, nitrogen, dissolved oxygen, salinity, water, and temperature, we will take 3 water samples from each low marsh region and deep-water habitat at least once every month. We will use various techniques and instruments, including the Global Household Aqua sensing TDS Meter. A sample will be obtained every 10 to 15 meters along the transect. Fish will also be sampled using a seine net once every month; the process will be replicated multiple times each time, and the number will be noted. The data will be collected over an extended period to account for seasonal variations. Preliminary findings will be assessed to determine if the water quality on the island exhibits some variations, with certain sites displaying elevated levels of specific pollutants and nutrients. The analysis of these findings will be crucial for understanding the potential implications for oyster habitats, vegetation communities, and fish species in the region.

The study will also evaluate the diversity and health of fish species, plant communities, and oyster populations through field surveys and observations. The objective is to compare these biological markers with data on water quality to see whether there are any notable links or impacts. This research project contributes to the broader goal of conserving and protecting the fragile coastal ecosystems of Little Edisto Island. The outcomes of this study may provide valuable insights into the potential effects of water quality on the island's natural resources, which can guide future conservation and management efforts.

Research
ABSTRACT

RELATIONSHIPS BETWEEN WATERSHED LAND-USE PRACTICES, GEOGRAPHY, AND CLIMATE ON WETLAND MACROINVERTEBRATE DIVERSITY AND ABUNDANCE.

Sindupa De Silva
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West Virginina University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partners Program

Wetlands are precious ecosystems that provide benefits to humans and wildlife alike. Wetlands help clean freshwater resources by intercepting and attenuating surface runoff and floodwaters and sequestering and storing excess nutrients and pollutants. Wetlands are also hotspots for biodiversity because they provide essential foraging, nursery, and shelter habitats for aquatic, terrestrial, and avian organisms. Wetlands offer additional benefits through hunting, fishing, trapping, and foraging opportunities, as well as opportunities for recreation, ecotourism, education, and cultural heritage. All the above is possible because of the intricate relationships between biotic and abiotic components within wetland ecosystems.

Sindupa De Silva collecting a core sample and a D-net sweep sample from a wetland.

In the U.S., no comprehensive federal law protects wetlands from degradation and loss from watershed-scale anthropogenic disturbance. The Clean Water Act (CWA) provides the most federal protections by regulating pollution and discharge that could be introduced into "waters of the U.S." [WOTUS]. However, the continuously challenged definition and interpretation of WOTUS excludes specific wetland systems from CWA protections. This lack of comprehensive protections puts wetlands at risk of degradation and loss, along with all the benefits they provide to humans and wildlife. Therefore, understanding the impacts of anthropogenic watershed land-use practices on a wetland's ecosystem health will help in the efforts to advance comprehensive wetland protections.

Picked macroinvertebrate specimens from sorting through sampled material.

To understand how anthropogenic watershed land-use practices impact a wetland's ecosystem health,

we can evaluate how they affect wetland ecosystems' biotic and abiotic components. One of the ways we did this was by studying the relative diversity and abundance of aquatic macroinvertebrates from the flooded and impounded portions of 85 selected wetlands across West Virginia from 2019 to 2022. We collected macroinvertebrate specimens using D-net sweeps (N = 5) and Core samples (N = 10) from each wetland in the Spring and Fall seasons (Fig. 1). We are currently identifying all the collected specimens (Fig. 2). Midge larvae (Chironomids) (Fig. 3) and dragonflies (Gomphidae) (Fig. 4) are well-represented in the samples. We will evaluate each sampled wetland's relative diversity and abundance with its respective watershed land cover and land-use practices, local geography, and the total approximate water input per season.

Identified Chironomidae (Midge) larvae from a core sample.

We hypothesize that wetlands with more disturbed watersheds will have lower diversity and abundance of aquatic macroinvertebrates. Therefore, these wetlands will have poorer capabilities to perform their functions and ecosystem services. The results of this project will not only help us better understand the relationship between watershed land-use practices, geography, and local climate on wetland ecosystem health. These findings will also help the state of West Virginia develop an index of biologic integrity [IBI] for wetland macroinvertebrates. Our results will contribute to the long-term efforts to advance more comprehensive wetland regulations, thereby protecting the benefits wetlands provide to humans and wildlife alike.

Identified Gomphidae (Dragonfly) larvae from a D-net sweep sample.

Research
ABSTRACT

WATERFOWL DIETS AND WINTER FORAGING HABITAT IN SOUTH ATLANTIC COASTAL AND INLAND WETLANDS: IMPROVING INPUTS FOR BIOENERGETICS MODELING FOR REGIONAL CONSERVATION PLANNING

Stephen A. Clements
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Mississippi State University, Mississippi State, Mississippi 39762, USA

2022 Inductee: Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partners Program

South Atlantic regional states of North Carolina and South Carolina contain diverse wetlands that range from tidal managed and non-managed marshes to inland bottomland swamps and impounded crops. All of these systems are used by migrating and wintering waterfowl, however, hydrologically managed tidal impoundments (MTIs) along the coast are among the most important aquatic resources for waterfowl and other waterbirds in the Atlantic Flyway. Many of the MTIs in the South Atlantic are remnant rice fields created in the 17th–19th centuries that are now managed for naturally occurring submersed aquatic vegetation (SAV) and associated seeds, tubers, and aquatic invertebrates. However, region-specific estimates of waterfowl forage production in MTIs and other managed wetlands are lacking. To further understand the resources that managed wetlands provide to migrating and wintering waterfowl in the South Atlantic, our study aims to 1) estimate the forage biomass, and subsequently energetic density, of three managed wetland types, 2) evaluate the diets of waterfowl using those wetlands, and 3) digitize private impoundments to improve the current wetlands inventory used in bioenergetic models.

We are researching public and private lands across 6 regions annually receiving high waterfowl use in North Carolina and South Carolina. During each field season's late summer and early fall, we sample MTIs, moist-soil wetlands, and impounded corn fields to obtain forage production estimates before the arrival of migrating waterfowl. To sample MTIs, we collect SAV samples and/or soil cores from 20 randomly selected points in each wetland. In the laboratory, we sieve samples to separate and sort vegetation, seeds, and macroinvertebrates, which are then dried in an oven at 60–70°C for 24–48 hours to a constant mass and weighed. Data is then extrapolated to estimate kg/ha of forage and kcal/ha of energy produced. We use rapid assessment techniques to sample moist soil and flooded corn impoundments to estimate seed production in the field.

Diet studies of waterfowl continentally are numerous. However, the South Atlantic has unique management practices that stem from historic manipulations

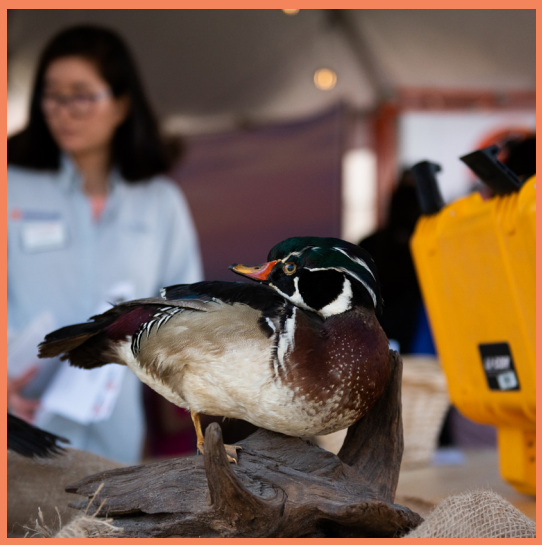
to the landscape and subsequently provide a suite of plant species adapted to tolerate the region's salinity, tides, and soils. Thus, it is important to have contemporary region-specific food habits data for waterfowl species in the region to ensure we are accounting for the correct forage items in our energetic density estimates. To investigate waterfowl diets in the region, we are using DNA analysis of feces collected from hunter-harvested ducks to reveal prey types consumed. We are also collecting a subset of samples by harvesting and dissecting waterfowl we observed actively foraging to compare traditional visual identification methodology to the newer DNA methodology.

In our 2021 and 2022 field seasons, we collected 366 SAV samples and 847 soil cores from 44 MTIs and conducted 45 moist soil and 39 corn assessments. Additionally, 702 feces samples have been taken from hunter-harvested American wigeon (*Mareca americana*), blue-winged teal (*Spatula discors*), gadwall (*Mareca strepera*), green-winged teal (*Anas crecca*), mottled duck (*Anas fulvigula*), northern pintail (*Anas acuta*), northern shoveler (*Spatula clypeata*), ring-necked duck (*Aythya collaris*), and wood duck (*Aix sponsa*). Moreover, we collected 85 actively foraging waterfowl for comparison across sampling methodologies. Preliminary results indicate that the forage biomass production is 619, 254, and 4,092 kg/ha in SAV, moist-soil, and flooded corn habitats, respectively. However, we are still working on incorporating seed biomass with the vegetation and macroinvertebrate estimates associated with SAV. Although corn impoundments have a greater biomass, these habits work in unison to meet the nutritional requirements of waterfowl. Preliminary diet data indicate that seeds of widgeon grass (*Ruppia maritima*) and dwarf spikerush (*Eleocharis parvula*), midge larvae, and snails are the most common food items found in ducks. Results from this study will improve the bioenergetics modeling efforts of the Atlantic Coast Joint Venture and its partners to meet population-based habitat objectives set by the North American Waterfowl Management Plan and provide management implications for wetland managers in the South Atlantic.

OUTREACH & EDUCATION

SOUTHEASTERN WILDLIFE EXPOSITION

In partnership with the Baruch Institute of Coastal Ecology and Forest Science and Clemson University's College of Agriculture, Forestry, and Life Sciences, the Kennedy Waterfowl and Wetlands Conservation Center participated in the Southeastern Wildlife Exposition in Charleston, South Carolina, February 17 to 19, 2023. It was a fantastic opportunity to talk about our research on wetlands, waterfowl, alligators, and other critters! The Kennedy Center appreciates all of the students, staff, and faculty who spent their weekends at the event, and we especially appreciate all who visited our tent.

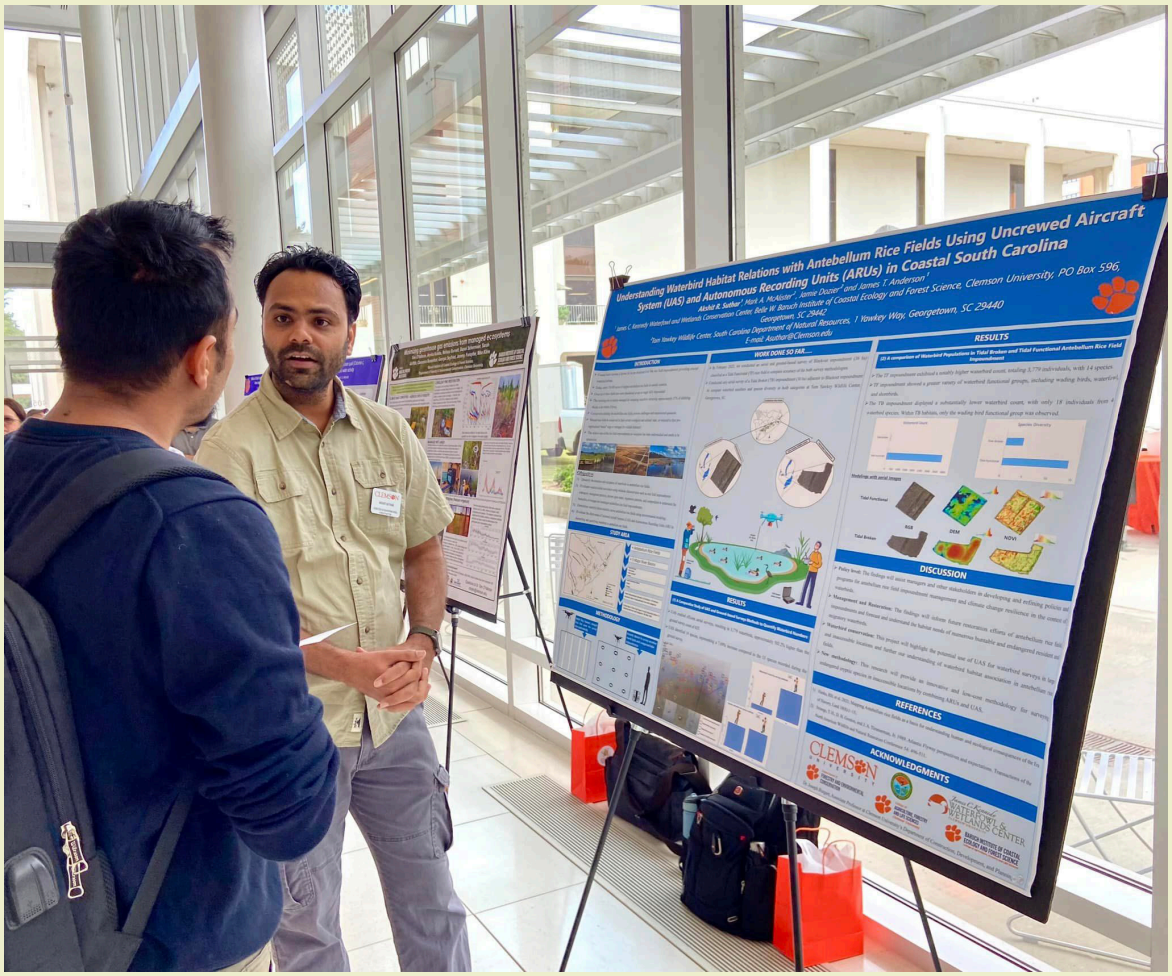



CLEMSON

THE WILDLIFE SOCIETY STUDENT RESEARCH WEBINAR

The Wildlife Society's Wetland Working Group awarded Miriam Boucher, Clemson University Kennedy Center Graduate Student, a $1,000 scholarship to support her research on alligators, plastics, and associated contaminants. Miriam presented her research online as part of The Wildlife Society's Wetland Working Group Student Research Seminar on 26 April 2023. Congratulations, Miriam, on winning the scholarship and being recognized for your important work!

AGRICULTURAL TECHNOLOGY SPOTLIGHT



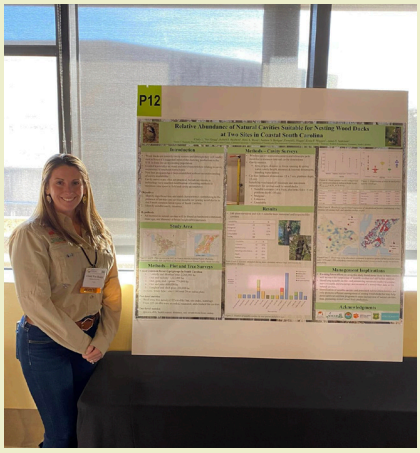
Akshit Suthar, a Ph.D. student at the James C. Kennedy Waterfowl and Wetlands Conservation Center, recently presented his groundbreaking research on waterbird habitat relations with antebellum rice fields in coastal South Carolina. His use of cutting-edge drone technology and bioacoustics is pushing the boundaries of conservation science, as demonstrated at the 2nd Annual Agricultural Technology Spotlight Event at Clemson University!

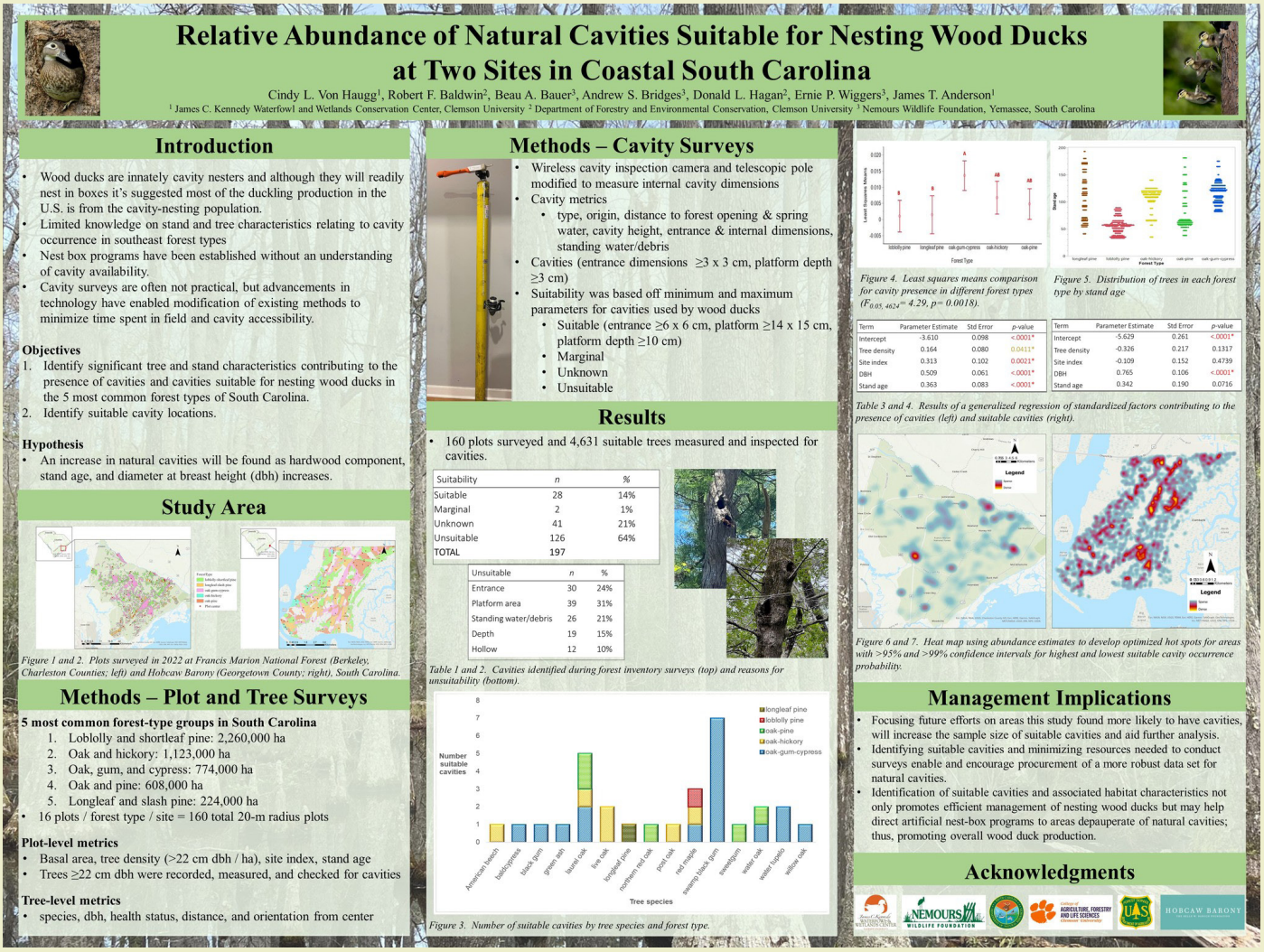
WILDLIFE EDUCATION AT THE WEBB CENTER

Kennedy Center Graduate student Cindy Von Haugg joined 4-H, SCDNR, and Carey Black from Blackwater Kennels for a day of shooting sports and natural resources with the Wild @ Webb Experience at the James W. Webb Wildlife Center and Game Management Area. An educational introduction to waterfowl and wood duck research was followed by telemetry and sporting dog demonstrations, and it's safe to say it was just as much fun for the adults as it was for the youth!

AWARD WINNING POSTER

The Clemson University Kennedy Waterfowl and Wetlands Conservation Center is pleased to announce that Cindy Von Haugg (Kennedy Center M.S. student) was awarded the Best Poster Presentation at the Southeastern Association of Fish and Wildlife Agencies 76th Annual Conference. The conference was held in October 2022 in Charleston, West Virginia. Cindy's poster was titled "Relative Abundance of Natural Cavities Suitable for Nesting Wood Ducks at Two Sites in Coastal South Carolina." Congratulations, Cindy!





WETLAND SCIENCE AND PRACTICE PUBLICATION

Andrew MacKenzie, a graduate student at West Virginia University and a Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partner, was the lead author of the article “Restoring a First Order Stream and Adjacent Riparian Wetlands In West Virginia: Integrating Lessons from Science and Practice” published in Wetland Science and Practice. Andrew was invited to submit the article after winning the Outstanding Student Poster Presentation at the last annual Society of Wetland Scientists meeting. Co-authors included West Virginia University researchers Walter E. Veselka, Dr. Paul Kinder, Dr. Michael P. Strager, Dr. Shawn T. Grushecky, Dr. Jason A. Hubbart, and Dr. Jim Anderson, Director of the James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University. Congratulations, Andrew!

Restoring a First Order Stream and Adjacent Riparian Wetlands In West Virginia: Integrating Lessons from Science and Practice

Andrew MacKenzie[1], Walter E. Veselka, Paul Kinder, Michael P. Strager, Shawn T. Grushecky, Jason A. Hubbart, and James T. Anderson[2]

Visual Abstract. Panel 1 (left; Pre-Restoration): A degraded wetland as a cattle pasture featuring song sparrows (*Melospiza melodia*), earthworms (*Oligochaeta*), and multiflora rose (*Rosa multiflora*). Panel 2 (Active Restoration): Streambank grading, seeding, coir mesh installation, live-staking, rock vanes, wood vanes, and woody vegetation planting. Panel 3 (Post-Restoration): Early restoration habitat, featuring meadow jumping mice (*Zapus hudsonius*), yellow flatsedge (*Cyperus flavescens*), flat-headed mayflies (*Eperous* sp.). Panel 4 (Future Outlook): Projected outlook of our restoration featuring tree swallows (*Tachycineta bicolor*), common buttonbush (*Cephalanthus occidentalis*), and narrow-winged damselflies (*Enallagma* sp.). (Scientific Illustration by J. Spahr Science Visuals; permission to use granted.)

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2. James C. Kennedy Waterfowl and Wetlands Conservation Center, Belle W. Baruch Institute of Coastal Ecology and Forest Science, Clemson University, P.O. Box 596, Georgetown, SC 29442, USA

ABSTRACT

Stream and wetland mitigation knowledge and understanding are rapidly evolving. However, the objectives of mitigation are wide-ranging. In 2021, a branch of Deckers Creek (Preston Co., West Virginia, USA) was restored by bank recontouring, reconnecting the incised channel to the constructed bankfull bench floodplain, creating small wetlands, and planting native riparian vegetation. Our research objectives were to 1) provide annual biodiversity and abundance data before, during, and after mitigation efforts and 2) assess woody-vegetation growth (height and diameter) and survivorship of a 10% biochar and 90% compost mixture. The complexity of mitigation warrants discussing challenges before, during, and after mitigation occurs. During restoration efforts, we encountered several challenges that were overcome through perseverance and collaboration. We incorporated ideas and practices from academia and the private sector to provide a detailed list of challenges encountered during our mitigation efforts, the solutions enacted, and future management implications to streamline mitigation planning.

INTRODUCTION

Mitigation is praised as significant progress for counteracting wetland and stream losses compared to the previous on-site, in-kind creation activities to satisfy permitting conditions. Instead of parcels spread out like postage stamps matching disturbances across the landscape, mitigation banking allows for bundling smaller impacts in a watershed, economy of scale, and projects protected in perpetuity. However, aquatic mitigation assessment is inherently complex because of wetland and stream managers' wide-ranging objectives and goals, which often differ from researchers and mitigation practitioners (bankers) (Strager et al. 2011). Because of the complex aquatic and wetland mitigation needs, researchers must communicate practices and findings to the mitigation practitioners and wetland managers through peer-reviewed literature, conversations, and other outlets. The importance and complexity of mitigation warrant the need to share success stories and failures

KENNEDY CENTER ADVISORY COUNCIL MEETING

At our 2023 Advisory Council meeting on July 11th, we witnessed impressive talks and research updates by our excellent graduate students! Their dedication to studying wetlands and dependent wildlife is remarkable.

These bright young minds are working towards a better future for waterfowl, wetlands, and other wetland-dependent wildlife conservation. We thank our Advisory Council for their continuous support and guidance. Together, we are making great strides in our mission to protect and restore wetlands habitat.

Lucas Clay: Landscape-Scale Carbon Cycling in Coastal Ecosystems and Implications for Blue Carbon Restoration Projects

Jim Anderson: An Overview of the James C. Kennedy Center

Cindy Von Haugg: Caught on Camera: Tree Cavities, Wood Ducks, and More!

Miriam Boucher: Alligator Diet and Utility as an Indicator of Contaminants of Emerging Concern

Akshit Suthar: Understanding Waterbird Habitat Relations with Antebellum Rice Fields Using Uncrewed Aircraft System (UAS) and Autonomous Recording Units (ARUs) in Costal South Carolina

Stephen Clements: Waterfowl Diets and Forage Biomass in South Atlantic Coastal Wetlands

Nick Masto: Waterbird-habitat Relationships in South Carolina: Implications for Protection, Restoration, and Management of Coastal and Inland Wetlands

Angela Hsiung: Using Integrated Population Models to Assess Drivers of Population Dynamics of Mallards in North America

KEYNOTE ADDRESS

Dr. Jim Anderson, Director of the James C. Kennedy Waterfowl and Wetlands Conservation Center, provided the Keynote Address, "My Journey as a Wetland Scientist: Under the Sphagnum Moss to the Mountain Top and Down the Other Side," at the 96th Annual Meeting of the West Virginia Academy of Sciences meeting at Pipestem State Park, WV. The fun and informative talk held on 6 April, 2024 was well attended and resulted in numerous questions and discussions during the day.

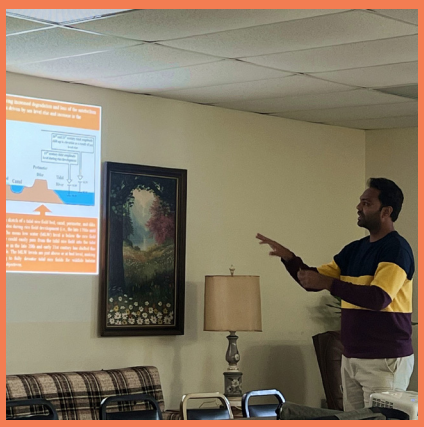
MY JOURNEY AS A WETLAND SCIENTIST: UNDER THE SPHAGNUM MOSS TO THE MOUNTAIN TOP AND DOWN THE OTHER SIDE

Wetlands are life; wetlands have been my professional life for 36 years and part of my personal life for over 50 years. In this presentation, I will take you on a path of personal growth, scientific discovery, and coming to grips with our collective past. I have three goals to accomplish with this presentation: 1) inspire young scientists to follow their dreams by presenting "My Life in Wetlands," 2) deliver the results of our Mountain State wetland discoveries, and 3) discuss a future wetland initiative inspired by past cultural atrocities. The remainder of this abstract is focused on objective two. Wetlands are transitional areas between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. In the United States, when a wetland is converted to a non-wetland, a new wetland must be created, or a former wetland must be restored to mitigate the loss of wetland function. Moreover, numerous conservation programs exist to create and restore wetlands. One primary function of wetlands is to provide wildlife diversity and wildlife habitat. For 25 years, my students and I have studied wetland biodiversity and ecosystem services of created and natural wetlands of West Virginia. For the most part, we found that mitigated and other restored wetlands provided suitable habitats for birds, amphibians, small mammals, invertebrates, and vegetation. However, the community composition and abundance of species vary. Wetland restoration has improved over time, although older wetlands perform better than younger wetlands, indicating wetlands need time to develop correctly. Results suggest that in many circumstances, mitigated wetlands and natural wetlands are functionally and compositionally similar when the restoration is appropriately conducted.

PRAIRIE POTHOLE COURSE

Akshit Suthar, a Ph.D. student at the James C. Kennedy Waterfowl & Wetlands Conservation Center, Clemson University, had the privilege of being selected as one of twelve graduate students from North America for the 2023 Waterfowl Breeding Ecology Field Course organized by Delta Waterfowl in collaboration with Louisiana State University.

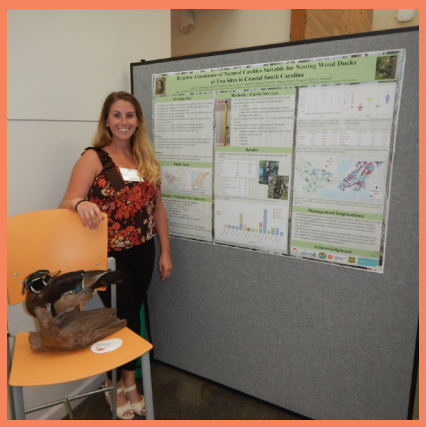
During this immersive experience, Akshit explored the waterfowl breeding grounds in North America's Prairie Pothole Region, often called the "Duck Factory." With a focus on waterfowl breeding ecology, Akshit gained valuable knowledge in essential nest-searching techniques such as chain dragging for upland nesters and conducting over-water nest searches. Additionally, he learned about waterbird identification, aquatic invertebrates, wetlands management, and the seasonal dynamics and threats to this crucial ecosystem.



The field course provided hands-on experience and offered the chance to attend informative lectures and network with fellow students and prominent organizations like USFWS, USGS, Duck Unlimited, and the Prairie Pothole Joint Venture. These connections and the acquired knowledge will undoubtedly shape Akshit's future research and conservation efforts. Akshit expresses immense gratitude to Delta Waterfowl for providing this invaluable opportunity. Congratulations, Akshit, on your selection!

BEHIND THE GATE

James C. Kennedy Waterfowl & Wetlands Conservation Center shared their research with interested community membres at the 28 July 2023 Behind the Gate Event. Thank you to the Pate Foundation and the Baruch Institute of Coastal Ecology and Forest Science for sponsoring this opportunity.

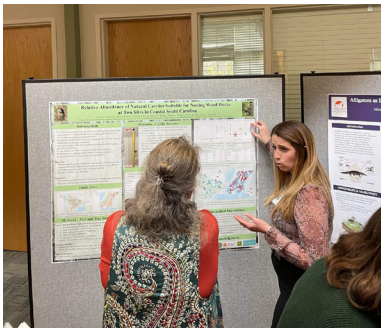


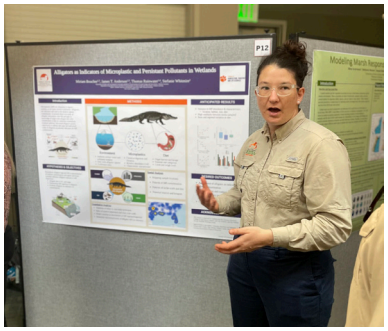
THREE-MINUTE THESIS COMPETITION WINNER

Sindupa De Silva, a Ph.D. candidate at West Virginia University and a Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partner, shared his research with the West Virginia University community during the 3 Minute Thesis Competition. Sindupa beat out all competitors and won the 2023 West Virginia Univesity 3 Minute Thesis Competition for his talk on wetland water quality. Congratulations, Sindupa!

SOCIETY OF WETLAND SCIENTISTS SOUTH ATLANTIC CHAPTER 2023 CONFERENCE

The Clemson University James C. Kennedy Waterfowl and Wetlands Conservation center had a strong showing at the Society of Wetland Scientists South Atlantic Chapter 2023 Conference. The conference was held at the Clemson University Baruch Institute of Coastal Ecology and Forest Science. Thanks to our students and staff for sharing their research with the scientific community.





Student PROFILES

AKSHIT SUTHAR

Ph.D. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Akshit was born and raised in rural India, where he completed his undergraduate studies in chemistry at Gujarat University and his master's degree in environmental science at Krantiguru Shyamji Krishna Verma Kachchh University with a thesis entitled "Assessment of Avian Diversity of Tapkeshwari Hill, Kachchh District, Gujarat, Reference to Their Conservation Perspective." It was the pioneer study on the avifauna of the hilly thorn forest of central Kachchh. His passion and research interest in avian ecology, how they interact with various environmental variables and modify the landscape, brought him to Clemson University, where he is a Ph.D. student with Dr. Jim Anderson.

During his undergraduate studies, he had opportunities to assist with various research projects. Akshit assisted with the ecological monitoring of House Sparrows with the World Wide Fund for Nature-India, ecology of Sloth Bear and Human-Sloth Bear interactions with the Wildlife Institute of India, and an ecological assessment of Mugger Crocodile with the Gujarat State Forest Department. He learned various ecological research methodologies, data collection, and analysis from experienced scientists.

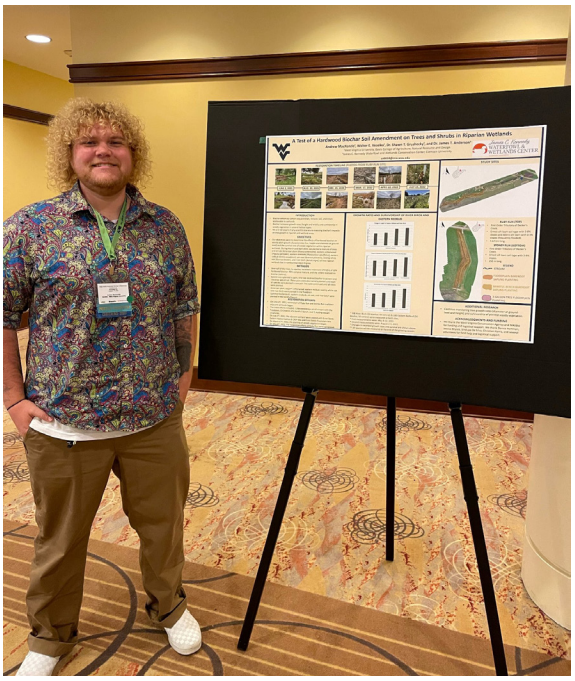
In 2014, Akshit joined a local organization called Sahjeevan in Gujarat, India, where he led a project on environmental education and community-based conservation of rare and endangered biodiversity, especially the Great Indian bustard, White-napped Tit, waterfowl, and wetland birds. He enabled the active participation of local people and relevant stakeholders to ensure long-term conservation benefits; later, the National Biodiversity Authority of India appreciated this project. In 2016, Akshit moved to central Gujarat, where he joined the Gujarat Ecological Society and worked on various projects like ecological profiling of multiple regions, state environment atlas, benchmark survey of the coastal and marine environment, and mitigation of human-animal conflicts. He rediscovered the Smooth-coated Otters in Gujarat and carried out the first systematic survey to determine the status, distribution, and conservation threats to the species, which was recognized by the International Otter Survival Fund-United Kingdom and received the "Otter Oscar-2019" award in the research category.

Akshit is very excited to be part of the James C. Kennedy Waterfowl and Wetlands Conservation Center at Clemson University and assess the impact of climate change and habitat assessment of wetlands birds in the former rice fields of coastal South Carolina using various traditional and modern field techniques, citizen science and duck harvest data, and statistical and ecological modeling.

ANDREW MacKENZIE

M.S. student, Division of Forestry and Natural Resources, West Virginia University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partners Program



Andrew MacKenzie is a graduate student at West Virginia University, pursuing an M.S. in Wildlife and Fisheries Resources and a University Teaching Certificate. Before seeking his M.S., Andrew received his B.S. in Wildlife and Fisheries Resources at West Virginia University with minors in Agriculture and Natural Resources Law and Conservation Ecology. Throughout his undergraduate career, he interned at Gator Country in Beaumont, Texas, focusing on community outreach and education of southeastern amphibians and reptiles. Andrew has also assisted in data collection of Wood Turtle abundance and movement within the Allegheny National Forest of Pennsylvania. Additionally, he was a technician for Dr. James (Jim) Anderson's lab. As a technician, Andrew had the opportunity to assist several graduate students in data collection and processing samples for their projects. The opportunities as a technician led Andrew to pursue his passions of teaching higher education and conducting wetland research.

Andrew's graduate research aims to assess the ecological impacts of wetland restoration techniques used in West Virginia riparian wetlands. Andrew is quantifying the changes in community composition of anurans, birds, fish, macroinvertebrates, turtles, small mammals, and vegetation by collecting abundance and diversity data during and after wetland restoration and comparing his data to previously collected pre-restoration data. He is assessing the impacts of a soil amendment, 10% biochar and 90% compost, on the growth rates and survival of woody vegetation planted during the wetland restoration. Andrew's research will provide insight into biological and ecological responses from riparian wetland restoration for several taxonomic groups. This research aims to provide insight into the effectiveness of several wetland restoration practices.

Andrew enjoys birding, fishing, hiking, and waterfowl hunting in his free time. You can often find Andrew around various hiking trails and ponds with his fiancé, Tara, and two dogs, Scout and Smokey.

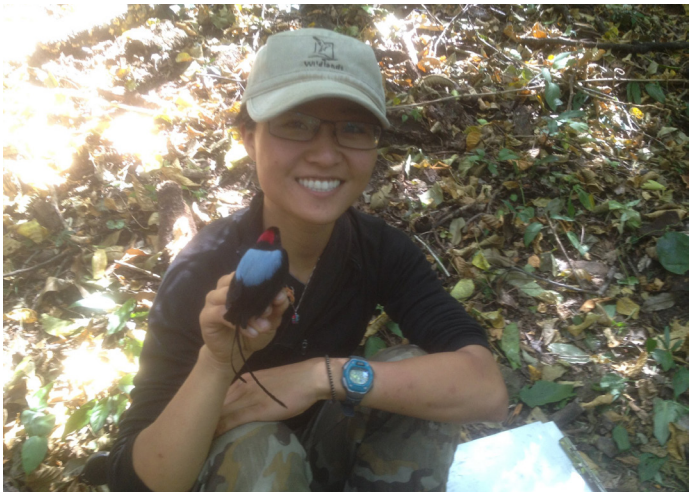
DR. ANGELA HSIUNG

Postdoctoral Scholar, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Angela was a postdoctoral researcher working with Dr. Jim Anderson at Clemson University's James C. Kennedy Waterfowl and Wetlands Conservation Center from July 2022 until July 2023. She received her B.S. in Wildlife, Fish, and Conservation Biology from the University of California–Davis, where she started cultivating her passion for conserving wildlife and fish populations. It was also through UC Davis that she took a hunter education course and went on her first – and only so far – duck hunting trip, where she bagged exactly one mallard.

Angela went on to work on several field projects conducting bird, small mammal, and fish surveys, taking her from old-growth forests in Oregon to Amazonian rainforests in Peru. Her passion for avian research led her to Athens, Georgia, to pursue an M.S. degree at the University of Georgia's (UGA) Warnell School of Forestry and Natural Resources, where she studied the movement ecology of Long-tailed Manakins, a neotropical songbird, in agricultural landscapes in Costa Rica. Wanting to work more closely with imperiled species and contribute to their conservation and management, Angela pursued a Ph.D. in the Integrative Conservation Program at UGA, focused on using quantitative and qualitative tools to help inform the conservation decision-making of imperiled sucker fish in the southeast.

Dr. Hsiung worked with Dr. Anderson along with Drs. Beth Ross and Heath Hagy from the U.S. Fish and Wildlife Service investigating cross-seasonal effects of winter waterfowl survival on population growth rates during the rest of the annual cycle by leveraging different types of data (e.g., banding, harvest, population surveys) while analyzing them under a common framework to understand better population dynamics of waterfowl species in the Atlantic Flyway. She is completing two project manuscripts and has joined Western Ecosystems Techology, Inc. as a statistician.



BOBBY GRECO

Ph.D. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Bobby is a Rocky Hill, Connecticut, native with a deep passion for all things relating to herpetofauna. He is a Ph.D. student advised by Dr. Jim Anderson at Clemson University and a Crocodile Research Coalition (CRC) member. Bobby began applying his love for herpetofauna while earning his B.S. in Ecology and Evolutionary Biology at the University of Connecticut. During his undergraduate, he assisted with herpetofauna projects in Dr. Tracy Rittenhouse's lab and the Connecticut Department of Energy and Environmental Protection (CT DEEP). The most notable projects included assessing the impacts of road salt and elevated temperature on wood frog tadpole growth and development, assessing the effects of urbanization on stream salamander species assemblages, wood turtle surveys, and acoustic surveys for the recently described Atlantic coast leopard frog. After graduating, he spent a few years gaining more experience conducting research abroad with Morelet's and American crocodiles in Belize with CRC, working in husbandry with American alligators at Gator Country in Southeast Texas, conducting translocation and behavior research of dunes sagebrush lizard in Northwestern Texas for Texas A&M University, and assisting in managing herpetofauna populations in Connecticut with CT DEEP and Quinn Ecological. While working for CT DEEP and Quinn Ecological, he worked on a water quality project with common snapping turtles as the model species, assisted in a state-wide snake fungal disease project, conducted a state-wide spotted turtle survey, managed bog turtle habitat, and monitored rare herpetofauna populations across the state.

His time in Belize was a major influence on his career path. During his internship with CRC, he learned the ropes of international research and conducting lasting conservation work. He was involved in many projects, including nationwide surveys for native crocodiles, general biodiversity surveys, wildlife husbandry and rehabilitation, and educational outreach. While working for CRC, he developed a close relationship with his friend and mentor, Dr. Marisa Tellez. She posed an opportunity to him to assist the Dominican Ministry of Environment and Natural Resources (MENR) and local NGOs with their declining American crocodile population in Lago Enriquillo. Bobby took this opportunity and made it into his master's thesis and joined Dr. Adam Rosenblatt's lab at the University of North Florida (UNF). For his master's thesis, he conducted the first nationwide population survey of American crocodiles in the Dominican Republic since the 1980s as a large-scale collaboration with MENR, local NGOs, CRC, and UNF. Besides his thesis research, Bobby worked on various other projects in the Rosenblatt lab, most notably a diet study of American alligators in urban versus natural habitats.

Between finishing his M.S. and beginning his Ph.D., he spent a year in the private sector with a consulting firm in Jacksonville, Florida. Some of the highlights of his time in consulting include coral and seagrass surveys for the U.S. Army Corps of Engineers, herpetofauna, mist net, and Bachman's sparrow surveys for the U.S. Navy, and monitoring manatee and gopher tortoise on construction projects.

Bobby is eager to join the team at Clemson and the Kennedy Center. His dissertation will expand his master's thesis. It will focus on the American crocodiles' population and community dynamics in Lago Enriquillo, Dominican Republic, to provide pertinent information for the long-term conservation of the species and its habitat. He hopes to use the platform the James C. Kennedy Waterfowl and Wetlands Center at Clemson University provides to bring light to research and conservation in the Dominican Republic and the notable species that call it home to a broader audience.

CHRISTOPHER PETTENGILL

Ph.D. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Christopher Pettengill is a Ph.D. research assistant at the James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University. His research focus encompasses the community ecology, ecosystem functions, and services of wetlands, including how these may change in response to ecosystem disturbance. He is always excited to contact stakeholders that use wetlands for recreation or ecosystem services such as water filtration. Christopher's philosophy is that wetland conservation relies on a positive public perception of these ecosystems.

Ecology is a significant part of Christopher's life. This interest started from his appreciation for the diversity of different habitat types near where he lived (forests, ponds, streams, fields), which he enjoyed exploring. These early experiences helped to shape his research goals in ecology and environmental issues. Over time, he has developed a strong interest in ecosystem services and how habitat restoration can help improve these services.

While working towards his bachelor's degree at SUNY Brockport (Rochester, New York), Christopher was introduced to wetland ecology and was quickly enthralled by these unique ecosystems. In addition to taking classes, he also conducted an independent research project where he attempted to find a relationship between stream macroinvertebrate diversity and the diversity of riparian vegetation.

At the University of Alabama, where he obtained his master's degree in Biological Sciences, he studied the impacts of beaver dam removal from ponds across various successional states in Talladega National Forest (Moundville, Alabama). Christopher found that although dam removal did not significantly alter the invertebrate community diversity, seasonal differences between samples were sometimes very significant. The most surprising conclusion of the experiment was how functional trait diversity, particularly the proportions of different functional feeding groups, remained consistent across time. This finding is surprising because samples from later in the experiment had a significantly lower abundance of all invertebrates, but proportionally rare functional groups persisted.

Besides his projects, Christopher also assisted researchers working on fire-suppression projects and hemlock wooly-adelgid impacts on Eastern Hemlock (Tsuga canadensis) in western New York. Additionally, for many years he volunteered for a local herbarium in Rochester, New York, where he learned about plant identification and specimen preparation. His volunteer work at the herbarium also introduced him to horticulture. Christopher hopes to one day put that knowledge to use and construct a garden or raised beds when he owns a home.

Salt marshes are an environment that Christopher has long wished to study, starting from a young age when he took part in summer marine science education camps at Wallop's Island, Virginia. Christopher believes the conservation of salt marshes is critical since they provide many services that benefit humans living in coastal areas (storm-surge protection, nurseries for sportfish, carbon storage) and help combat climate change's effects. Christopher welcomes the opportunity to participate in a significant coastal habitat restoration effort. Christopher is looking forward to the challenges and experiences that await at Edisto Island!

Christopher enjoys hiking, fishing, kayaking, and traveling in his spare time.

Christopher is studying methods to improve restoration success in salt marsh ecosystems. Christopher is interested in learning how including oyster beds in the restoration design will enhance ecosystem services at the site. Additionally, he will look at the potential larger, regional-scale impacts of restoring the site's ecosystem functioning. Christopher predicts that more saltwater organisms will enter the newly created habitats after they remove barriers to the site.

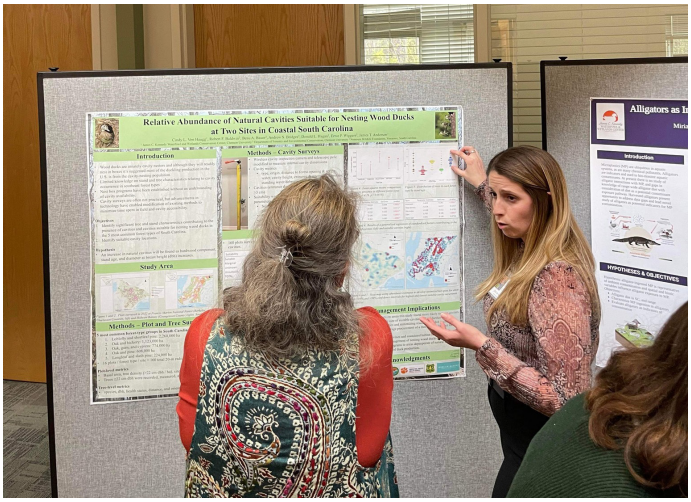
CINDY VON HAUGG

M. S. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Cindy Von Haugg, AWB®, is a Wildlife Biology M.S. student at Clemson University's James C. Kennedy Waterfowl and Wetlands Conservation Center. She is a student veteran who served nine years in the Air Force before receiving her B.S. in Wildlife Management from the State University of New York at Cobleskill. While pursuing her undergraduate degree, she was active in New York State's Chapter of Ducks Unlimited and quickly developed a strong passion for waterfowl research. Various technician positions fostered her interest in nesting ecology. After working as a field technician on a wood duck recruitment study through Clemson, she enrolled as a graduate student in August 2021.

Her graduate research aims to determine the availability and abundance of tree cavities suitable for nesting wood ducks in southeast forest types by examining forest plot-inventory variables and monitoring radio-tagged wood duck hens. She also observed identified cavities for use and success. Cindy will extrapolate her findings from Francis Marion National Forest and Hobcaw Barony at the Baruch Institute of Coastal Ecology and Forest Science to predict widespread suitable cavity occurrence in sampled forest types using LiDAR and multispectral imagery. By identifying the current and projected availability of natural cavities and habitat characteristics selected by cavity-nesting wood ducks, this research will help state, federal, and private waterfowl managers increase forest and target species management effectiveness of natural cavities. In the future, she hopes the results of this study will best direct nest box placement to areas with the lowest natural cavity abundance, thereby increasing their contribution to wood duck recruitment and cost-effectiveness.

In her spare time, Cindy enjoys spending quality time with her husband, Matt, and 3 furbabies, Louie, Roxie, and YetiMoe. You can often find them sightseeing, wandering the woods, or yelling at a football game.



CRYSTAL ANDERSON

Ph. D. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Crystal Anderson is a South Carolina native. Born in the midlands and raised in the upstate, she resides on the coast with her husband, Will, and their two kids. She has lived and traveled all over the United States and parts of Europe, greatly appreciating many varied and beautiful ecosystems while showing her different ways of managing environmental and wildlife issues.

Crystal earned her bachelor's in wildlife and fisheries biology and her master's in forest resource management, studying the human dimensions of invasive plants in recreational areas. Crystal's research with the James C. Kennedy Waterfowl Center focuses on understanding the human dimensions of wetland coastal resiliency and increasing community support through education. Using surveys, she will determine stakeholder beliefs and attitudes towards wetlands, climate change, coastal resiliency, and historical and emotional values for communities in the coastal area of South Carolina and Georgia. These data can then be used to formulate targeted approaches to increasing wetland education across different demographics.

Crystal is a published author, having co-written "Winter Tree Identification for the Southern Appalachians and Piedmont - a Photographic Guide" with Dr. Donald Hagan and Hailey Malone. Crystal used her skills in photography to capture all the detailed images in this beautiful tree identification guide.

Outside of research, Crystal teaches full-time at Horry-Georgetown Technical College in Georgetown, South Carolina. Her courses include mensuration, forest ecology, vertebrate biology and natural history, forest protection, forestry statistics, soil science and plant fertility, and recreation management. Her time as a student and teacher has shown her the joy and value of education and how it can impact our communities and their ecological future. She brings her excitement for the environment into the classroom daily and hopes that her students go forward with the same enthusiasm for environmental conservation and preservation.

JESSICA BRYZEK

M. S. Student, Division of Forestry and Natural Resrouces, West Virginia University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Concervation Center Graduate Student Partners Program

Jessica Bryzek graduated with her M.S. from West Virginia University in December 2022. Originally from Indiana, Jessica received a B.S. in General Biology from Ball State University in 2018. Throughout her undergraduate career, Jessica worked in various seasonal positions that introduced her to aquatic habitats and the creatures that call them home, including freshwater mussels, fish, benthic macroinvertebrates, and aquatic vegetation. Before attending graduate school, she completed an AmeriCorps service term with Appalachian Forest National Heritage Area. She then worked in the non-profit sector in aquatic resource conservation with Trout Unlimited in West Virginia.

Jessica's M.S. research assessed performance standards for wetland mitigation, focusing on woody vegetation community development post-restoration. She argues for the potential of data-driven performance standards to bridge the science–practice–policy divide of wetland mitigation while also providing an entrance into resilient ecosystems by transforming science into policy and policy into practice. Jessica is more broadly interested in understanding the relationship between natural and built environments.

She aspires for a career advocating for adopting a new ecological paradigm that recognizes the Rights of Nature. This growing movement realizes the fundamental rights of ecosystems and species to exist. After graduating from West Virginia University, Jessica worked as a Stream Partners AmeriCorps Vista with the West Virginia Department of Environmental Protection and the Conservation Legacy. In her free time, Jessica enjoys spending time in the woods backpacking and trail running or tending to the garden at home with her chickens.

JORDAN McCALL

M.S. Student, Wildlife Biology, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Jordan McCall is an M.S. student at Clemson University's James C. Kennedy Waterfowl and Wetlands Conservation Center. She is originally from Chapin, SC, and received her bachelor's degree in wildlife and fisheries biology from Clemson University in 2021.

Throughout her undergraduate career, she contributed to the Southeastern Wood Duck Project, where she got valuable experience maintaining wood duck boxes and in the laboratory processing disease samples from these boxes. This experience sparked her passion for wetland and waterfowl management and created many opportunities for her to pursue a career in wetland management. She also interned with the Nemours Wildlife Foundation, contributing to black rail, RCW, and alligator research surveys.

Her M.S. research intends to create a baseline of wetland conditions in the Hobcaw Barony and the DeBordieu Colony, as limited data is available in these areas. The research consists of point-count surveys, secretive marsh bird surveys, and macroinvertebrate surveys to evaluate the productivity of wetland types.

In Jordan's free time, she enjoys watching true crime documentaries, enjoying the beach, and spending time with her six siblings.

JULIE A. GRINSTEAD

Ph. D. Student, ames C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Julie is originally from Ann Arbor, Michigan, where she learned to love the outdoors and the Great Lakes! She moved to New York City as an adult and did medical transcription. Living in the big city made her long for nature, so she pursued a conservation and ecology career.

Julie is a doctoral student working with Dr. Jim Anderson through Clemson University's James C. Kennedy Waterfowl and Wetlands Conservation Center. After obtaining a B.A. in liberal arts from the University of Michigan-Ann Arbor, she received her B.S. in Environmental Biology from the State University of New York's College of Environmental Science and Forestry (SUNY-ESF), where she cultivated her passion for the conservation of wildlife. Her interest in wetlands began with the course Ecological Engineering in the Tropics, which included a field trip to Costa Rica, where she visited a mangrove marsh that had been restored after being altered by a shrimp factory.

She spent a summer tracking wild turkeys east of Lake Ontario using telemetry, radio transmitters, and GPS with the New York State Department of Environmental Conservation. Julie also participated in a Canada goose

bird banding event in northern New York. Then, Julie went on to work with Baltimore Woods Nature Center in Marcellus, New York, where she used ArcGIS to map the pattern and distribution of 12 invasive plants on their 175-acre nature preserve. Her passion for GIS and ecology led her to pursue an M.A. degree in geography (environmental and resource management track) at the State University of New York's Binghamton University (SUNY-BU), where she studied the spatial relationship between pesticide use and Lyme disease across counties of New York State. Julie presented her poster at the American Association of Geographers meeting in Washington, D.C., in 2021, where she won third prize in her session. Julie has been a teaching assistant for several courses and taught math and statistics at a small college in Michigan, which helped hone her teaching skills.

Wanting to do more in ecology and conservation, Julie is pursuing a Ph.D. in the Wildlife and Fisheries Biology program at Clemson University, focused on using banana water lily and water-shield plants as tools for wetland management of waterbirds.

Currently, Julie is working with Dr. Anderson and Dr. Lydia O'Halloran, Research Assistant Professor at the Baruch Institute of Coastal Ecology and Forest Science, to explore the ecology of banana water lily and water-shield aquatic plants as well as macroinvertebrate and waterbird associations.

In her spare time, Julie can be found bicycling down the trails of Georgetown County or hanging out with her indoor cats!

MIRIAM BOUCHER

Ph.D. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Miriam is a Canadian native with a big passion for crocodilians and is easily distracted by reptiles. She is a Ph.D. student with Dr. Jim Anderson at Clemson University. Her ability as an athlete led her to pursue a B.S. in Environmental Biology at Wingate University, North Carolina, as a Women's Soccer Team goalkeeper. Miriam has a vested interest in international conservation, and after completing her B.S., she headed to Brazil. There, she worked with the NGO Iracambi in the Atlantic Forest, managing the research center's volunteers and running a camera trapping program cataloging wildlife on the private reserves. Her lifelong passion for crocodilians took her from the jungles of Brazil to Belize's idyllic beaches as she began her work with American crocodiles.

In Belize, she met her long-time mentor and friend, Dr. Marisa Tellez, and supported Dr. Tellez's research on American crocodile parasitology. Her work in Belize inspired her master's thesis, and she completed an M.S. at West Virginia University under Dr. Jim Anderson. Miriam's thesis focused on investigating American crocodile behavior and bioacoustics in Belize. Her work contributed to the first time-activity budgets for American

crocodiles in the wild and the first dedicated study of American crocodile vocalizations. Afterward, she joined Dr. Tellez full-time in Belize as the Crocodile Research Coalition's (CRC) Research Coordinator. During her time with the CRC, Miriam conducted nationwide population surveys of Morelet's and American crocodiles, implemented a country-wide education and outreach program, developed research funding, led a project in Nicaragua, and trained numerous interns and visiting scholars.

With her work focused primarily on the academic and not-for-profit sectors, Miriam decided to grow her experience with industry and wildlife management. She returned home to her native Alberta to take up an environmental scientist role for a consulting firm. She worked on large construction projects supporting the appropriate implementation of wildlife mitigation and adherence to federal and provincial wildlife regulations. The highlight of her time in Alberta was helping to lead a monitoring project of snakes in southern Alberta.

Miriam is excited to be part of the Clemson University and the Kennedy Center team to implement a novel study of the American alligator diet in South Carolina and investigate plastic ingestion in alligators to explore potential toxicological impacts. The Kennedy Center appreciates the Clemson University Experiment Station and the Clemson University College of Agriculture, Forestry, and Life Sciences for funding Miriam. Miriam looks forward to working with hunters and trappers to collect stomachs from harvested gators; she wants them if you've got guts!

RENE BROWN

M.S. Student, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

Rene Brown's interest in sciences began at a young age in Jamaica. She was exposed to animal husbandry on her grandfather's livestock farm. She spent countless hours observing and understanding how animals live, believing that animals had so many yet-to-be-understood behaviors. She remembered catching small fish in the river and taking them home to keep as pets. Unfortunately, they died within two weeks of living in a homemade aquarium. Their lifespan puzzled her and made her wonder what she was doing wrong. At that time, she only had a basic understanding of fish survival, but her interest in animal adaptation to different environments grew as she learned more about sciences and wildlife. Studying biology at an undergraduate level at Allen University (Columbia, SC) helped her to analyze the relationship between animals and the environment.

Rene conducted research projects with her mentor on microRNA biogenesis in corn and was selected to present the research projects before the Allen University Board of Trustees. During the summer of 2022, she volunteered at Hope Zoo in Jamaica and interned with Caribbean Coastal Area Management. These opportunities helped her develop skills such as working with diverse teams, time management, goal setting, punctuality, effective communication, and flexibility.

At the Little Edisto restoration site, Rene is researching ways to improve salt marsh restoration by evaluating bird habitat, water quality, and fish. Rene Brown is curious how oyster beds in the restoration plan would improve the site's ecosystem services. Rene is also interested in assessing water quality and avian habitat to determine their interactions with oyster beds.

SEBASTIAN MENDOZA

Research Technician, James C. Kennedy Waterfowl and Wetlands Conservation Center, Clemson University

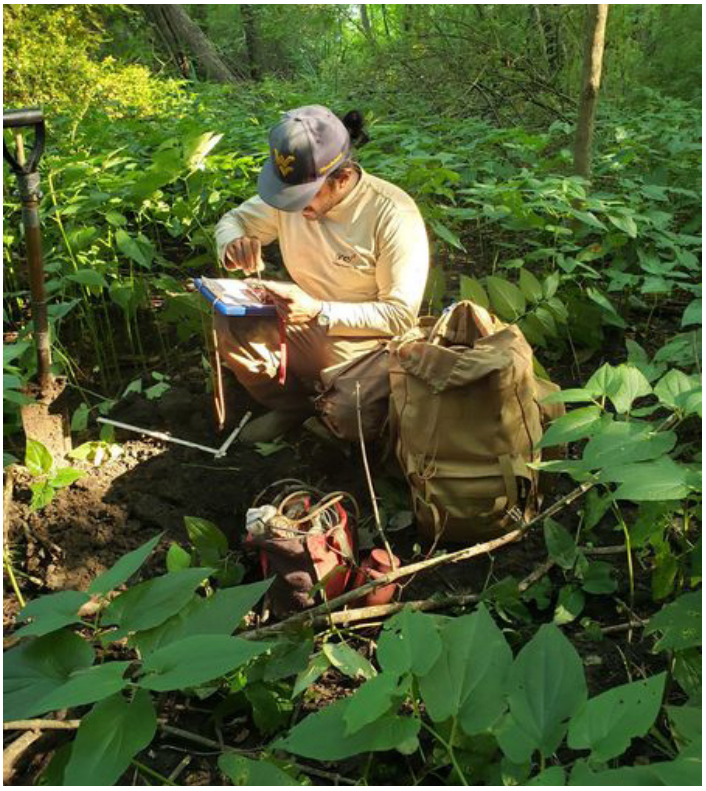
The Kennedy Center welcomed Sebastian Mendoza to the 2023 wood duck team. Sebastian assisted Cindy Von Haugg with her project studying cavity-nesting wood ducks (Aix sponsa) by tracking nesting and brood-rearing hens using VHF/GPS transmitters and assessing cavity availability in coastal South Carolina.

Sebastian loves birds and wildlife conservation and has traveled from Arizona to join us this past field season. He's previously worked at Bitter Lakes National Wildlife Refuge, where he served as an ACE intern with the U.S. Fish and Wildlife Service stationed in New Mexico. His experience conducting weekly waterfowl, sandhill crane, and shorebird surveys has dramatically helped the team scout for wood duck presence. Sebastian also brought with him the telemetry experience he gained while working with various species, such as the Mexican gray wolf (Canis lupus baileyi), Bolson Tortoise (Gopherus flavomarginatous), prairie rattlesnake (Crotalus virdis) and Merriam's kangaroo rat (Dipodomys merriami). Thank you for your contributions, Sebastian.

SINDUPA DE SILVA

Ph. D. Student, Division fo Forestry and Natural Resources, West Virginia University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Concervation Center Graduate Student Partners Program



Sindupa De Silva is a Ph.D. candidate at West Virginia University. Originally from Kandy, Sri Lanka, Sindupa received a B.S. in Wildlife Conservation Biology (2014) and an M.S. in Environmental Science (2016) from Southeast Missouri State University. Sindupa has worked for the Missouri Department of Conservation (2014–2019) in several roles and across various aquatic ecosystems, from subterranean streams to the Mississippi River, studying fish populations, ecology, and water quality.

Sindupa's current research involves assessing wetlands across West Virginia to understand how anthropogenic land-use practices influence wetland ecosystem health and their ability to perform their functions and ecosystem services. Sindupa aspires to conserve and protect freshwater ecosystems through education, research, advocacy, and management recommendations to sustain clean and accessible freshwater resources.

STEPHEN CLEMENTS

Ph. D. Student, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University

2021 Inductee: Clemson University Kennedy Waterfowl and Wetlands Concervation Center Graduate Student Partners Program

Stephen Clements is a Ph.D. student at Mississippi State University studying waterfowl diets and forage biomass in South Atlantic wetlands. Originally from Mt. Pleasant, SC, Stephen received a B.S. in Environmental and Natural Resources from Clemson University (2016) and an M.S. in Wildlife, Fisheries, and Aquaculture from Mississippi State University (2019). Stephen worked for USDA's National Wildlife Research Center before returning to Mississippi State for his Ph.D. His current work evaluates migrating and wintering waterfowl diets using South Atlantic wetlands through traditional and modern sampling techniques. In addition, Stephen is estimating the forage biomass and energetic density provided to waterfowl by key wetland types of the region. This work will improve carrying capacity modeling efforts by the Atlantic Coast Joint Venture and its partners, who strive to meet population-based habitat objectives set by the North American Waterfowl Management Plan.

Stephen's career interests include facilitating applied research to help conserve our natural resources, particularly waterfowl and wetlands. In his free time, Stephen enjoys hunting, fishing, and boating.

Student AWARDS & ACHIEVEMENTS

Student AWARDS & ACHIEVEMENTS

We are pleased to announce fellowships, assistantships, scholarships, and other scholarly honors awarded to Kennedy Center undergraduate and graduate students during 2022–2023. Our goal is to continue to grow our student numbers, especially our graduate program. Students are our future waterfowl and wetland managers, biologists, and researchers. We are training and mentoring the future stewards of wetlands and waterfowl at the Kennedy Center and are proud of our student's accomplishments. Congratulations to all our students for their current and future accomplishments.

BLAIR ABERNATHY received the James C. Kennedy Undergraduate Scholarship. She is a Wildlife and Fisheries Biology major with a minor in Forestry.

CRYSTAL ANDERSON received a James C. Kennedy Ph.D. Research Assistantship. She completed her M.S. in Forestry from Clemson in 2023.

MIRIAM BOUCHER, a Kennedy Center Ph.D. student, finished her first year of a two-year Clemson University Experiment Station and College of Agriculture, Forestry and Life Sciences Environmental Toxicology Graduate Research Assistantship. Miriam also received a $1,000 scholarship from The Wildlife Society's Wetland Working Group, a $1,200 award from the Slocum-Lunz Foundation, and $1,500 from the Clemson University Graduate Travel Fund to support her research.

RENE BROWN, a Kennedy Center M.S. student, earned a STEM All In Fellowship and a Clemson University Experiment Station and College of Agriculture, Forestry and Life Sciences Environmental Toxicology Graduate Research Assistantship.

LUCAS CLAY, M.S., and former Kennedy Center Ph.D. Fellow is a Ph.D. student working with Dr. Tom O'Halloran studying carbon cycling and ecosystem services. Lucas recently took a position as a Forestry Extension Associate with Clemson University while he continues his Ph.D.

STEPHEN CLEMENTS, Kennedy Center Graduate Student Partner Ph.D. student, continues his fieldwork in coastal South Carolina.

SINDUPA DESILVA, Kennedy Center Graduate Student Partner Ph.D. student and doctoral candidate at West Virginia University, is in the final stages of his dissertation work studying wetland water quality in West Virginia. Sindupa received a Jon A Kusler Scholarship to attend the National Association of Wetland Managers meeting.

BOBBY GRECO, a first year Kennedy Center Ph.D. student, received a Teaching Assistantship from the Biology Department at Clemson University.

ANDREW MACKENZIE, Kennedy Center Graduate Student Partner and West Virginia University M.S. student, is in his final year of his M.S. Program studying wetland restoration. Andrew was awarded a $500 Travel Grant from the Society of Wetland Scientists' South Atlantic Chapter to attend the Joint Aquatic Sciences Meeting, where he was awarded the Best Student Poster. Andrew also received a Jon A Kusler Scholarship to attend the National Association of Wetland Managers meeting.

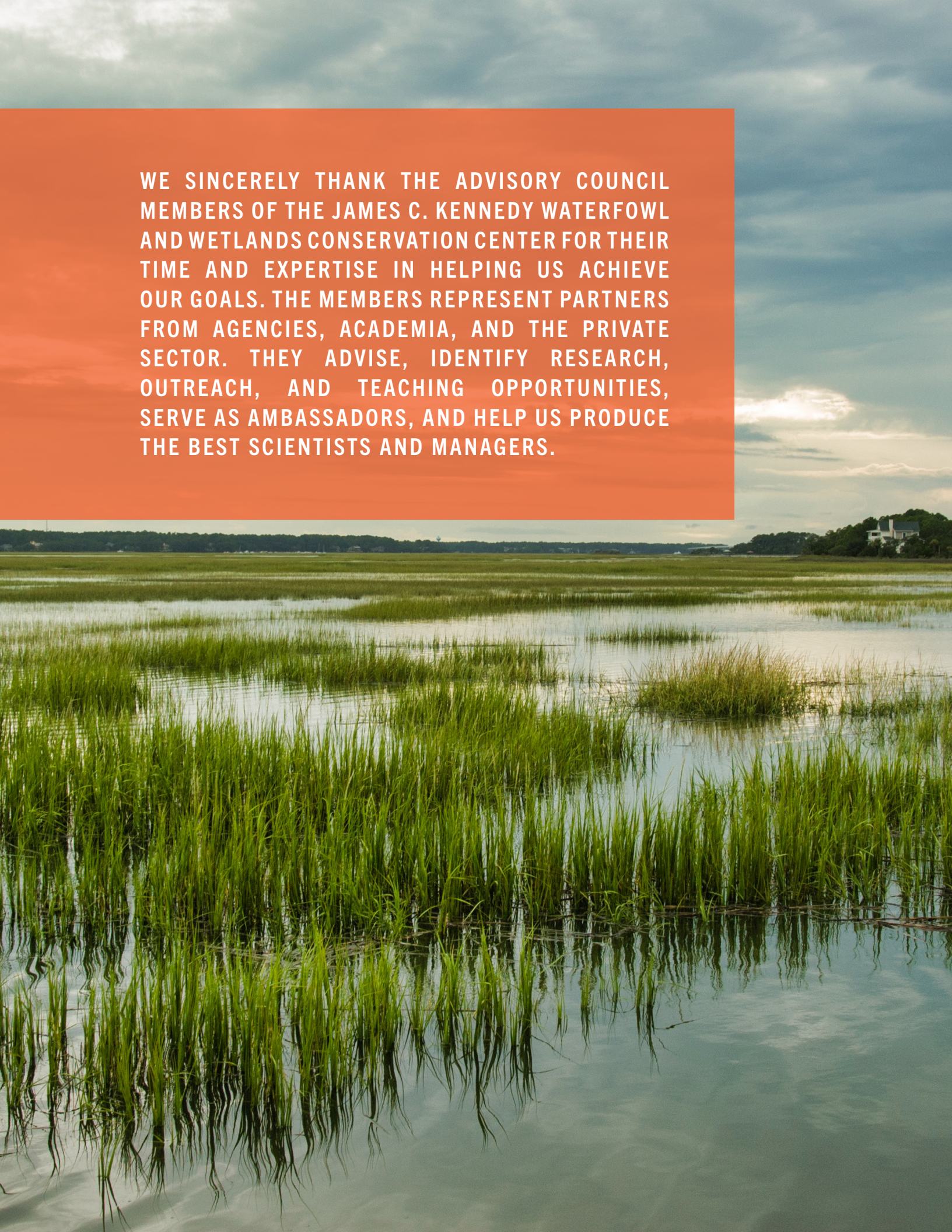
JORDAN MCCALL, a Kennedy Center M.S. Student Fellow, has completed her second year of data collection for her thesis evaluating migration chronology and waterbird habitat use.

NICK MASTO, a former Kennedy Center M.S. student and a Tennessee Tech Ph.D. student, was inducted into the Kennedy Center Graduate Partners Program and will gradaute with his doctorate in December 2023.

CHRISTOPHER PETTENGILL, a Kennedy Center Ph.D. student, is in his first year working on his dissertation incorporating oysters into salt marsh restoration.

AKSHIT SUTHAR, a Kennedy Center Ph.D. Fellow recipient has started data collection for his dissertation on coastal waterbird habitat use of historic rice fields. Akshit received $500 from The Wildlife Society's Biodiversity Working Group and $500 from The Wildlife Society's Human Dimensions Working Group to attend the 30th Annual Conference of The Wildlife Society in November 2023. Akshit also received an all-expenses paid trip to the Delta Waterfowl Foundation 2022 Graduate Waterfowl Field Course, focused on the prairie potholes.

CINDY VON HAUGG, a Kennedy Center M.S. Student, has completed her second and final field season evaluating natural cavity availability for wood ducks. Cindy received $1,500 from the Clemson University Graduate Travel Fund for conference attendance. Cindy was awarded the Best Poster Presentation at the Southeastern Association of Fish and Wildlife Agencies 76th Annual Conference and won third place in the Society of Wetland Scientists, South Atlantic Chapter Conference, student poster contest. Cindy also received $500 from The Wildlife Society to attend the 30th Annual Conference of The Wildlife Society in November 2023.



WE SINCERELY THANK THE ADVISORY COUNCIL MEMBERS OF THE JAMES C. KENNEDY WATERFOWL AND WETLANDS CONSERVATION CENTER FOR THEIR TIME AND EXPERTISE IN HELPING US ACHIEVE OUR GOALS. THE MEMBERS REPRESENT PARTNERS FROM AGENCIES, ACADEMIA, AND THE PRIVATE SECTOR. THEY ADVISE, IDENTIFY RESEARCH, OUTREACH, AND TEACHING OPPORTUNITIES, SERVE AS AMBASSADORS, AND HELP US PRODUCE THE BEST SCIENTISTS AND MANAGERS.

2023 Advisory COUNCIL

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BEAU BAUER Wildlife Biologist, Nemours Wildlife Foundation

ANDREW S. BRIDGES President & CEO, Nemours Wildlife Foundation

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JIM CLARK Plantation Manager

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MICHAEL PREVOST Wildlife Biologist and Land Manager, Rochelle Plantation

AARON PIERCE Director of Conservation Science and Planning, Ducks Unlimited

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CRAIG SASSER Refuge Manager, U.S. Fish and Wildlife Service

RICK SAVAGE Executive Director, Carolina Wetlands Association

S. MAZEIKA PATRICIO SULLIVAN Director, Baruch Institute of Coastal Ecology and Forest Science

MARSHALL TRULUCK Manager, Milton Hall Plantation

GREG YARROW Professor, Clemson's Department of Forestry and Environmental Conservation

PUBLICATIONS *(n=16)*

Anderson, J. T., editor. 2023. Advances in Environmental Sustainability: Proceedings of the 2022 8th International Conference on Advances in Environment Research. Springer 172 pp. ISBN 978-3-031-26364-4, ISBN 978-3-031-26365-1 (eBook) https://doi.org/10.1007/978-3-031-26365-1

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McCall, J. E., J. A. Bryzek, C. L. Von Haugg, M. Boucher, S. De Silva, A. MacKenzie, A. R. Suthar, A. C. Hsiung, K. L. Noe, S. Accettullo, and J. T. Anderson. 2022. What is a wetland? [Audio podcast]. In The World of Wetlands, Episode 1. The Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center. https://open.spotify.com/episode/4DMNeDVYeLQqFNLTeNKNfs

Millikin, A. R., S. Coster, A. Welsh, and J. T. Anderson. 2023. Pool age and local habitat are associated with effective number of breeders in spotted salamander populations colonizing created vernal pools. Diversity 15(124):1-17. https://doi.org/10.3390/d15020124.

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Oral & Poster PRESENTATIONS *(n=31)*

Abernathy, B., D., J. E. McCall, and J. T. Anderson. 2023. UPIC internship: Avian use of wetlands in Georgetown, SC. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC. (Poster)

Anderson, J. T. 2023. My journey as a wetland scientist: Under the sphagnum moss to the mountain top and down the other side. 96th Annual Meeting of the West Virginia Academy of Sciences, Pipestem, WV. (Invited-Keynote Speaker)

Anderson, J. T. 2022. Identifying wetlands and their importance. North Carolina Wetlands Law and Compliance Webinar. Half Moon Education, Inc. Virtual. (Invited)

Anderson, J. T. 2022. Wetland preservation, restoration, creation and enhancement. North Carolina Wetlands Law and Compliance Webinar. Half Moon Education, Inc. Virtual. (Invited)

Anderson, J. T. 2022. Overview of the James C. Kennedy Waterfowl and Wetlands Conservation Center. South Carolina Department of Natural Resources and Clemson University Annual Cooperators Meeting, Clemson, South Carolina. (Invited)

Boucher, M., J. T. Anderson, T. Rainwater, and S. Whitmire. 2023. Alligators as indicators of microplastic and persistent pollutants in wetlands. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC. (Poster)

Boucher, M., T. Rainwater, S. Whitmire, and J. T. Anderson. 2023. Alligators as indicators of microplastic pollution in wetlands. The Wildlife Society, Wetlands Working Group, Online. (Invited)

Boucher, M., J. T. Anderson, T. Rainwater, and S. Whitmire. 2023. Alligators as indicators of microplastic and persistent pollutants in wetlands. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC. (Poster)

Bryzek, J., C. T. Rota, W. Veselka, E. Byers, and J. T. Anderson. 2022. State wetland mitigation standards: Performance standards and monitoring criteria. National Association of Wetland Managers Annual State/Tribal/Federal Coordination Meeting, Shepherdstown, West Virginia.

De Silva, S., J. A. Hubbart, M. P. Strager, C. T. Rota, E. A. Byers, and J. T. Anderson. 2022. Wetlands and water quality: relationships with watershed land cover/land-use, soils, and water inputs. National Association of Wetland Managers Annual State/Tribal/Federal Coordination Meeting, Shepherdstown, West Virginia. (Invited)

De Silva, S., J. A. Hubbart, M. P. Strager, C. T. Rota, E. A. Byers and J. T. Anderson. 2023. Water quality in West Virginia wetlands and their relationships with watershed land cover/ land-use practices. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC.

Hsiung, A, B. E. Ross, H. M. Hagy, and J. T. Anderson. 2023. Evaluating the cross-seasonal effect of winter survival on continental waterfowl population growth rate. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC.

MacKenzie, A., D. N. Becker, C. M. Lituma, C. C. Arantes, and J. T. Anderson. 2023. Wetland mitigation impacts on avian biodiversity: an update. Mountaineer Chapter of the Audubon Society, Morgantown, WV. (Invited)

MacKenzie, A., W. E. Veselka, P. Kinder, S. T. Grushecky, and J. T. Anderson. 2023. Early indications: using a biochar soil amendment to enhance woody vegetation growth and survivorship in two north central West Virginia riparian wetlands. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC.

MacKenzie, A., W. E. Veselka, S. T. Grushecky, and J. T. Anderson. 2022. A test of a hardwood biochar soil amendment on trees and shrubs in riparian wetlands. 2022 North American Biochar & Bioenergy Conference, Morgantown, West Virginia. (Poster). Second Place Poster.

McCall, J., and J. T. Anderson. 2022. Wetland productivity for waterbirds in Georgetown, South Carolina. College of Agriculture, Forestry, and Life Sciences Graduate Student Research Symposium, Florence, South Carolina (Poster).

McCall, J., D. Kunkel, J. D. Lanham, and J. T. Anderson. 2022. Waterbirds temporal trends and habitat relations in Georgetown County, South Carolina. 76th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, Charleston, West Virginia (Poster).

McCall, J., and J. T. Anderson. 2023. Wetland type productivity for waterbirds: 2022 recap and 2023 sneak peek. DeBordieu Colony Board Meeting, Georgetown, South Carolina (Invited).

McCall, J., and J. T. Anderson. 2023. Avian-wetland habitat relations and temporal trends within the South Atlantic Coastal Zone. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC.

Molina, J. T., C. C. Arantes, B. A. Murry, and J. T. Anderson. 2023. Integrating data sets to understand climate change vulnerability for West Virginia watersheds. West Virginia American Fisheries Society 2023 Meeting, Morgantown, West Virginia.

Molina, J. T., C. C. Arantes, B. A. Murry, and J. T. Anderson. 2022. Integrating data sets to understand climate change vulnerability for West Virginia watersheds. 76th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, Charleston, West Virginia.

Shurba, J., K. Whitehead, K. Barrett, G. Yarrow, R. Kaminski, and J. T. Anderson. 2022. Effects of nest materials on wood duck box selection, nest success, and microbial growth from nest boxes in Georgia and Florida. 76th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, Charleston, West Virginia.

Shurba, J., K. Whitehead, K. Barrett, G. Yarrow, R. Kaminski, and J. T. Anderson. 2023. Effect of nesting material on wood duck nest box selection, reproduction, and eggshell bacteria. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC.

Suthar, A. R., and J. T. Anderson. 2023. Understanding waterbird habitat relations with antebellum rice fields using unmanned aerial vehicles (UAVs) and autonomous recording units (ARUs) in coastal South Carolina. Second Annual Ag Tech Spotlight Event, Clemson, SC. (Poster)

Suthar, A. R., M. A. McAliser, J. Dozier, and J. T. Anderson. 2023. Understanding waterbird habitat relations with antebellum rice fields using uncrewed aircraft (UAV) and autonomous recording units (ARUs) in coastal South Carolina. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC. (Poster)

Suthar, A. R., and J. T. Anderson. 2023. Understanding waterbird habitat relations with antebellum rice fields using unmanned aerial vehicles (UAVs) and autonomous recording units (ARUs) in coastal South Carolina. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC. (Poster)

Von Haugg, C. L., R. F. Baldwin, B. A. Bauer, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2023. Relative abundance of natural cavities suitable for nesting wood ducks at two sites in coastal South Carolina. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC. (Poster)

Von Haugg, C. L., R. F. Baldwin, B. A. Bauer, A. S. Bridges, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2022. Relative abundance of natural cavities suitable for nesting wood ducks at two sites in coastal South Carolina. Society of Wetland Scientists South Atlantic Chapter 2023 Conference, Georgetown, SC. (Poster). *Third Place Poster Presentation

Von Haugg, C. L., R. F. Baldwin, B. A. Bauer, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2022. Relative abundance of natural cavities suitable for nesting wood ducks at two sites in coastal South Carolina. 76th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, Charleston, West Virginia (Poster).

Von Haugg, C. L., B. A. Bauer, R. F. Baldwin, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2022. Tree cavity availability for nesting wood ducks across South Carolina forest types. College of Agriculture, Forestry, and Life Sciences Graduate Student Research Symposium, Florence, South Carolina (Poster).

Von Haugg, C. L., R. F. Baldwin, B. A. Bauer, A. S. Bridges, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2022. Relative abundance of natural cavities suitable for nesting wood ducks. South Carolina Chapter of The Wildlife Society, Columbia, South Carolina.


James C. Kennedy
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