*LEAD IN EDUCATION AND SCIENCE TOWARD CONSERVATION OF SOUTH ATLANTIC AND OTHER WETLAND ECOSYSTEMS*

James C. Kennedy
WATERFOWL & WETLANDS CENTER
CLEMSON UNIVERSITY

# CLEMSON UNIVERSITY
## JAMES C. KENNEDY WATERFOWL & WETLANDS CONSERVATION CENTER
# 2022
*annual report*

# Susan Accettullo

*February 17, 1982 – October 15, 2022*

We dedicate the 2022 Annual Report to our Kennedy Center friend, colleague, and student: Susan Accettullo. Susan, an M.S. student at Clemson University and a Kennedy Center student, passed away on 15 October 2022, following a tragic accident. Rest in peace, dear friend.

## Thank you to our sponsors, cooperators, and friends:

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On our front cover
James C. Kennedy and Alder

# FROM THE DIRECTOR

When I drafted this article in August, I had written, "Susan Accettullo is in the midst of her first field season collecting data on reptile and amphibian diversity in wetland impoundments." Unfortunately, Susan never had a chance to finish her research summary for this report. Susan was involved in a tragic accident, and doctors placed her in an induced coma. She peacefully passed away on the morning of 15 October 2022. Susan was a wonderful, caring person enjoying her new role as an M.S. student in wildlife and wetlands conservation. We will miss you, Susan, I will miss you, and the world will miss you. My sincerest condolences to Susan's family.

I marked my first anniversary as Director of the James C. Kennedy Waterfowl and Wetlands Conservation Center on 13 August 2022. Over the past year, I spent many hours in online training related to biosafety, animal care during research, appropriate credit card use, defensive driving, mentoring and supervising students, leadership, drafting research grants, and a host of other topics. I also attended numerous seminars and webinars and read many books and research papers to learn more about South Carolina and the southeast coast. Looking back, I am struck by how fast the year went by, how much we have accomplished, and how much more I had hoped to do. I must constantly remind myself that developing a world-class research and education center is a marathon, not a sprint.

Every day we make progress on developing the James C. Kennedy Waterfowl and Wetlands Conservation Center, educating students, conducting outreach, and creating original research. However, as with all endeavors, some days are more exciting and productive than others. The successful submission (or even better, the acceptance) of a grant application or a manuscript is cause for excitement and celebration. Still, the non-stop writing effort preceding the submission sometimes wears thin. I must remind myself that long-term success results in improved wetland conservation, waterfowl productivity, or a well-trained biologist or manager. When I view success from that lens, I think we had a productive and successful year, which I present in detail below.

There were many positives during my first year in this position. I met many wonderful and hospitable people eager to invite me to their properties and share their knowledge and management techniques. I spent a lot of time meeting biologists, managers, faculty, and students to discuss management issues and potential research projects. I am excited about the many fantastic waterfowl and wetland managers in South Carolina and look forward to learning and interacting with them more over the next decade. I am hesitant to mention specific names since many positive and engaging individuals exist. Still, I did want to acknowledge the retirement of Dr. Ernie Wiggers and the hiring of Dr. Andrew Bridges at the Nemours Wildlife Foundation. I appreciated the advice and insights from Dr. Wiggers during my first few months on the job. I also appreciate the continued collaborations with Dr. Bridges and look forward to furthering collaborative endeavors.

We portray many of our accomplishments in detail on the following pages of this report. Here are just a few of our highlights.

We have hired Dr. Angela Hsiung as a postdoctoral researcher. Angela is 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.

Our cooperative eight-state wood duck project just finished year three of the study, and we are already gearing up for the project's final year. I appreciate being included in this regional study to assess the contribution of nest boxes to the recruitment of wood ducks in the southeast and the mid-Atlantic United States. Partners include Nemours Wildlife Foundation, University of Delaware, Mississippi State University, Louisiana State University, Delaware Wild Lands, Delaware Department of Natural Resources & Environmental Control, Maryland Department of Natural Resources, South Carolina Department of Natural Resources, Georgina Department of Natural Resources, Florida Fish & Wildlife Commission, Louisiana Department of Wildlife and Fisheries, U.S. Fish and Wildlife Service, the USGS-bird Banding Laboratory, and the Kennedy Center. I thank all the individuals involved, especially Beau Bauer (Nemours Wildlife Foundation) and the technicians hired through Clemson University and employed by the James C. Kennedy Waterfowl and Wetlands Conservation Center during 2022: Marissa Ardovino, James Cadolino, Jace Cobb, Chuck Farrell, Carter Freymiller, Nick Makarewicz, Sanketh Menon, Rene Padilla, Max Rollfinke, and Erin Tighe.

Jake Shurba and Emily Miller completed their M.S. degrees working on the multistate wood duck project and are continuing their education by pursuing Ph.D. degrees. Congratulations to Jake and Emily! See the Student Awards section for more details.

Cindy Von Haugg and Jordan McCall completed their first field seasons for their M.S. degrees. Cindy is working on wood duck hen use of natural cavities, and Jordan is working on wetland-waterbird habitat relations. We welcome Miriam Boucher and Akshit Suthar, who are starting the Fall semester of 2022 and pursuing Ph.D. degrees in conjunction with the Kennedy Center.

We held our Annual Meeting on 14 June 2022. Thanks to everyone for their participation. I especially appreciate the Advisory Council's advice and input on our projects and future directions. I appreciate everyone's time and energy in making this meeting a success.

I created a new program called the Clemson University Kennedy Waterfowl and Wetlands Conservation Center Graduate Student Partners Program. The program is designed for graduate students that are not enrolled at Clemson University but are supported by the time, talent, or resources of the Kennedy Center. The benefits of being in the Graduate Student Partners Program include the potential for exchanging ideas, sharing research equipment, receiving financial support, and collaborating on grants, papers, and other products. Moreover, we feature the students on the Kennedy Center's social media, website, and reports. In exchange, the students help elevate the profile of the Kennedy Center by acknowledging our contributions in papers, posters, and other products by including Center personnel as co-authors or collaborators, depending on the level of engagement. We welcome Stephen Clements, Andrew MacKenzie, Jessica Bryzek, and Sindupa De Silva into the program.

I will continue to promote our mission, "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." Waterfowl will always be central to our mission. However, I take a holistic approach to wetland conservation and believe we must understand all species and interactions within a wetland system. Thus,

we will study amphibians, reptiles, small mammals, songbirds, plants, invertebrates, biogeochemistry, water quality, ecosystem services, human dimensions, and many other components of wetlands to maximize wetland conservation efforts in wetlands across the world.

I appreciate Mr. Kennedy's trust in Clemson University in establishing the James C. Kennedy Waterfowl and Wetlands Conservation Center and this endowed professorship and directorship. I also value Dr. Todd Petty and Clemson University's confidence in me by appointing me to this prestigious position. I thank my wife, Heather, for enduring support during this hectic, stressful, and productive first year. Finally, I appreciate all who have supported the Center since its inception.

I look forward to a better and more productive second year of 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 INTERNSHIPS

## BASELINE WETLAND CONDITIONS ON HOBCAW BARONY AND DEBORDIEU COLONY

*Anna Koon*
*Senior, Wildlife and Fisheries Biology, and*
*James C. Kennedy Waterfowl & Wetlands Conservation Center*
*Professional Internship and Co-op Program Intern*

My name is Anna Koon, and I am a senior at Clemson University. I will graduate in May 2023 with a B.S. in Wildlife and Fisheries Biology and minors in Animal and Veterinary Sciences and Biological Sciences.

This summer, I worked at the Belle W. Baruch Institute of Coastal Ecology and Forest Science through the James C. Kennedy Waterfowl and Wetlands Conservation Center. I interned under Jordan McCall, a Clemson graduate student, on data collection for her master's project. Her research aims to establish the baseline conditions of wetlands, waterfowl, and other birds within the DeBordieu and Hobcaw Barony communities.

My internship partner, Carly Sprott, and I had primary responsibilities to conduct vegetation and macroinvertebrate studies within the areas mentioned above. We identified local flora at over 100 wetland sites and became familiar with the coastal vegetation. We also took water and soil samples to sort through them and locate various species of macroinvertebrates.

It was an excellent opportunity to be in the field all summer and gain more experience working on research projects and learning about coastal and wetland ecology. I saw abundant wildlife and many species I had never seen before. Many of the points we went to were only accessible via kayaking, so I could see a more comprehensive array of ecological diversity and allowed me to observe a few secretive marsh birds.

After graduating, I hope to pursue a career in wildlife and natural resource conservation. I am also interested in zoology and wildlife rehabilitation and would like to incorporate that into whatever the future holds for me. After gaining a few years of work experience after graduation, I plan to go back to school to obtain a master's degree!

I am very grateful to have had the opportunity to work at the Kennedy Waterfowl & Wetlands Conservation Center this summer! I am especially appreciative of my mentor, Dr. Jim Anderson, the Kennedy Waterfowl & Wetlands Conservation Center director, and Jordan McCall for allowing me to work on this project and gain so much new knowledge and experience for the future!

# SUMMER INTERNSHIPS

## WETLAND SURVEYS ON HOBCAW BARONY AND DEBORDIEU COLONY

*Carly Sprott*
*Senior, Wildlife and Fisheries Biology, and*
*James C. Kennedy Waterfowl & Wetlands Conservation Center*
*Professional Internship and Co-op Program intern*

My name is Carly Sprott, and I will graduate in May of 2023 with a degree in Wildlife and Fisheries Biology from Clemson University. I have served as an officer for The Clemson chapter of the Wildlife Society and Tigers for Tigers, a conservation club.

I spent this summer collecting field data from May through the end of July 2022 for a graduate student working towards her M.S. degree, Jordan McCall. Jordan's research is to establish baseline conditions of wetlands, waterfowl, and other birds at Hobcaw Barony and DeBordieu Colony. I worked with an intern partner, Anna Koon, and our primary duties were vegetation surveys, macroinvertebrate collections, and monthly water testing. Macroinvertebrate surveys were necessary as these species are a food source for waterbirds and reflect the health and productivity of wetlands. Jordan focused on point count bird and secretive marsh bird surveys, which we were able to assist with on occasion. We were also able to help with another study that focused on tree plot surveys and wood duck cavity searches.

Through this internship, I gained confidence in many professional skills such as communication, adaptability, and species identification. Also, using various field equipment and tools such as a water column and PVC core sampler, a wedge prism relascope, a clinometer, a tree cavity inspection camera, and DBH tape have all increased my competence in collecting data in the field.

The highlight of the summer for me was having the opportunity to survey over 100 wetland sites and encounter diverse wildlife. This enabled me to increase my ability to identify numerous species of coastal South Carolina flora and fauna accurately. Some wildlife we saw were American alligators, timber rattlesnakes, pinewood treefrogs, fox squirrels, coyote pups, feral hogs, white-tailed deer, egrets, herons, bald eagles, osprey, and a sea turtle. While I don't yet know what the future holds, I hope to pursue a career focusing on preserving natural habitats, especially those of endangered species. I am interested in herpetology and would love to work with reptiles and amphibians. In the future, after gaining a few years of work experience, I also hope to obtain my master's degree.

I appreciate this opportunity to work with Dr. Jim Anderson, Director of the Kennedy Center, and other staff at the Baruch Institute at Hobcaw Barony. This experience has undeniably solidified my desire to work in wildlife management.

## RESEARCH ABSTRACT

### EARLY EFFECTS OF WETLAND RESTORATION IN WEST VIRGINIA RIPARIAN WETLANDS

*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*

Wetlands are one of the most critical yet threatened ecosystems in the world. Anthropogenic activities such as agriculture, road construction, and urbanization have reduced wetlands worldwide. Land managers across the United States have begun to restore and create new wetlands through wetland mitigation to minimize the loss of wetlands. While the mitigation process is crucial in maintaining these ecosystems, built, restored, and reference wetlands may vary in biodiversity. However, there is a lack of scientific literature evaluating how these wetlands compare before, during, and after restoration.

In June 2021, wetland restoration at the Ruby Run and Stoney Run study sites started. Ruby Run and Stoney Run are first-order streams of Deckers Creek in Preston County, West Virginia. The efforts of the restoration began with stream bank grading to reattach the floodplain and create wetland areas, stream channel restoration, removal of invasive species (multiflora rose [*Rosa multiflora*] and autumn olive [*Elaeagnus umbellate*]), and the addition of structures in the stream. In July 2021, two native seed mixtures (Ernst Seeds Eastern Native Habitat and CREP Mix and Ernst Seeds Floodplain Mix) were spread, and biodegradable coir wire was placed to reduce erosion. In March 2022, the 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.

These restoration efforts will result in 3 chapters of my thesis. The first chapter will evaluate the effects of stream, wetland, and riparian restoration on the biotic community at Ruby Run. I will use the baseline data from Becker et al. (2022) and compare these to future data I will collect from June 2021–August 2023. The Becker et al. data will be "pre-assessment data," and the information I will record will be "active restoration data" and "post-assessment data." The active restoration of Ruby Run started in June 2021 and ended in May 2022. The post-assessment period began in June 2022, after the restoration was completed. The second chapter will determine the effects of hardwood biochar on woody plant growth characteristics (i.e., height, diameter) and the survival

rate of woody vegetation within Ruby Run and Stoney Run. The third chapter will assess the community composition and structure of the macroinvertebrate community at Ruby Run and Stoney Run. I will determine the tributaries to quantify the effects of sedimentation on the macroinvertebrate community from watershed disturbance and combined stream and wetland mitigation techniques.

Becker D. N., J. A. Hubbart, and J. T. Anderson. 2022. Biodiversity monitoring of a riparian wetland in a mixed-use watershed in the Central Appalachians, USA, before restoration. Diversity 14(4):304. https://doi.org/10.3390/d14040304

## RESEARCH ABSTRACT

### CROSS-SEASONAL EFFECT OF WINTER SURVIVAL ON WATERFOWL POPULATION GROWTH

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

There has been considerable effort in researching the population ecology of waterfowl in North America. However, most studies on waterfowl population dynamics focus on annual and breeding season survival and their effects on the population growth rate. In contrast, our understanding of the contribution of winter survival variation to the population growth rate is limited. Lack of knowledge of the cross-seasonal effects of winter survival may limit our ability to manage waterfowl populations during the nonbreeding season effectively. In July 2021, the Kennedy Center, joined by Dr. Heath Hagy (Waterfowl Ecologist, USFWS) and Dr. Beth Ross (Quantitative Ecologist, USFWS), initiated a project investigating the effect of winter survival on the annual population growth rate of waterfowl species in the Atlantic Flyway.

The Atlantic Flyway stretches from Maine to Florida in the U.S. and includes several Canadian provinces. The southern portion of the flyway boasts an abundance of managed and unmanaged tidal and non-tidal wetlands and hosts millions of waterfowl during the winter. Gaining a better understanding of how winter conditions within the south Atlantic Flyway affect winter survival and overall population growth will help elucidate the importance of winter habitat for waterfowl populations in the region. Doing so requires analyzing large-scale, long-term data.

North American waterfowl conservation has benefited from decades of population monitoring programs on breeding populations and birds harvested during the hunting season. These long-term datasets include 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 that were harvested and reported by hunters (Figure 1). These data can be analyzed under a common framework called an integrated population model (IPM). One advantage of using an IPM to estimate population demographic rates is that it includes sub-models linked by shared population parameters (Figure 2), which allows for more precise estimates (i.e., reduced uncertainty) as multiple datasets inform them.

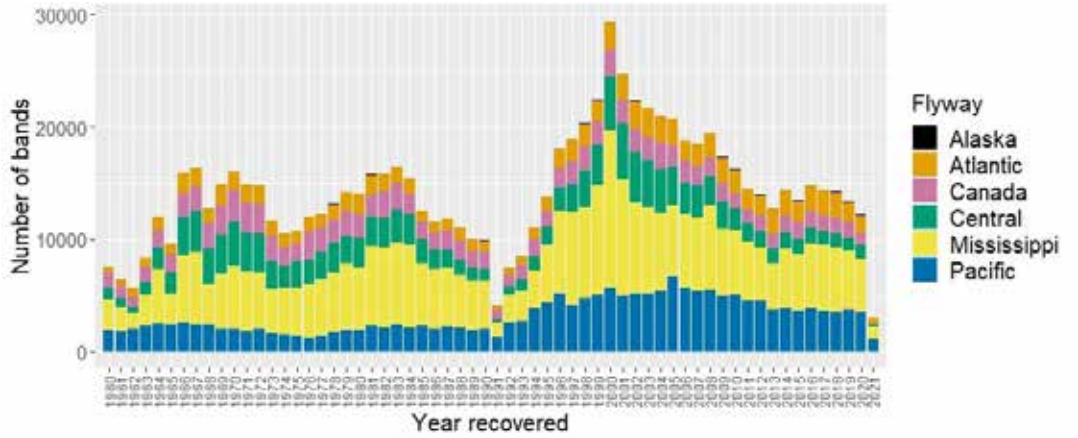



*Figure 1. Number of bands from harvested mallards reported by hunters to the USGS Bird Banding Lab from 1960 to 2021 within each flyway in the U.S. and Canada. The band-recovery data help inform survival probability estimation for the species in the integrated population model.*

The population parameters that are of particular interest are survival probabilities (S), fecundity (F), annual population abundance (N), and growth rate (Figure 2). Because each data type was collected during different parts of the waterfowl's yearly cycle, analyzing them under the IPM allows researchers to estimate both annual and seasonal (i.e., winter) survival probabilities. Following parameter estimation, researchers will conduct a retrospective analysis that examines how population change is influenced by winter survival historically. The research will cover a few key harvested species, including mallards, gadwall, northern pintail, and green-winged teal. Following the first phase of the analysis, the team plans to expand the study to assess how much Atlantic Flyway waterfowl winter survival contributes to the continental population growth rate.

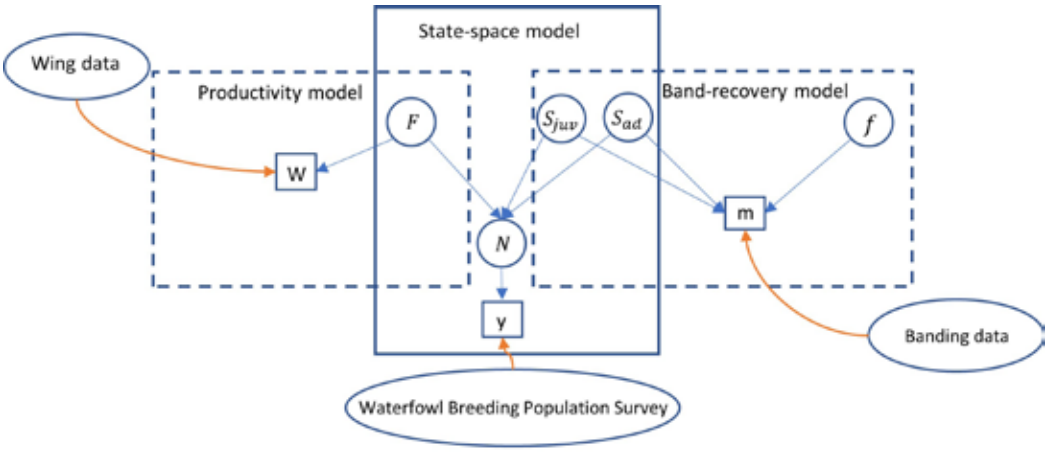



*Figure 2. Graphical representation of the integrated population model for the waterfowl population in the Atlantic Flyway and eastern region of Canada. Large rectangles are the sub-models within the IPM. Small circles are estimated parameters which include annual population size (N), fecundity (F), survival probability of juveniles ($S_{juv}$) and adults ($S_{ad}$), and band-recovery probability (f). Small squares are the data informing parameter estimation, and ovals are the data sources. Figure adapted from Kéry and Schaub (2012)[1] .*


*Figure 3. Trail camera photo of mallards taken in Hatchie National Wildlife Refuge, TN (Photo courtesy of Heath Hagy, USFWS).*

## RESEARCH ABSTRACT

### OCCURRENCE OF CAVITIES SUITABLE FOR WOOD DUCKS NESTING IN SOUTH CAROLINA FOREST TYPES

*Cindy L. Von Haugg*
*M.S. Student, James C. Kennedy Waterfowl & Wetlands Conservation Center, Clemson University and Nemours Wildlife Foundation*

Wood ducks (*Aix sponsa*) are innately cavity nesters. Although they will readily nest in artificial nest boxes, evidence in northern portions of the breeding range suggests that most duckling production in the U.S. is from cavity-nesting populations. Stand and tree characteristics of natural cavities suitable for wood duck nesting have been defined in the U.S. Midwest regions. However, few overlap with forest types and tree species prevalent across their southern breeding range. Due to the intensity and resource requirements of cavity studies in southeast forest types, extant studies are limited to a single land ownership class, distinct forest type, or are not exclusive to cavities suitable for wood ducks. As a result, nest box programs within the southeast region persist without understanding cavity occurrence or the ability to quantify their relative abundance.

Our goal is to determine the relative abundance of natural cavities while modifying survey methods to reduce ground survey intensity and increase the accuracy and versatility of cavity occurrence predictions to enable multifaceted use for future studies. This year we completed forest inventory surveys in South Carolina's primary forest types to determine suitable cavity stand- and tree-level characteristics. We stratified our study area by dominant forest types within the South Carolina coastal plain ($n$ = 5). We collected stand, tree, and cavity measurements within randomly selected 20-m radius plots ($n$ = 32 per strata) at Francis Marion National Forest in Berkeley and Charleston Counties and Hobcaw Barony in Georgetown County, South Carolina USA. All trees >22 cm diameter at breast height were measured and examined for cavity presence within plots. If a cavity was present, a wireless camera fixed to a telescopic pole (Figure 1) was used to record external and internal dimensions. Modifications to the mounted camera eliminated the need to climb trees, decreased the amount of time at each plot, and allowed access to cavities on limbs and in snags that would not otherwise be accessible. Due to inadequate knowledge of cavity occurrence in the region, I based suitability on the minimum and maximum dimensions recorded in past literature for cavities used by wood ducks to detect potential cavities. Accordingly, suitable holes 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. Cavities deemed suitable will be checked each year at the end of the nesting season. Use and successful, depredated, or abandoned nest fate will be determined by observing egg membranes, signs of predation, or non-viable eggs, respectively.

During our first year, 160 plots were surveyed, with 4,631 trees measured and examined for cavity presence. Loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*), laurel oak (*Quercus laurifolia*), sweetgum (*Liquidambar styraciflua*), swamp black gum (*Nyssa biflora*), water oak (*Q. nigra*), and bald cypress (*Taxodium distichum*) were the most frequently measured trees. Preliminary results suggest suitable cavity occurrence is greatest in oak-gum-cypress forests (Figure 2). Thirty-nine suitable cavities were located and checked, but no evidence of wood duck use was observed. Further analysis will direct future cavity surveys to areas with a higher probability of cavity occurrence. Throughout the second field season, radio-marked wood duck hens will be monitored across the South Carolina Lowcountry National Wildlife Refuge Complex to locate used cavities and identify characteristics associated with observed nest fates. Classifying features of suitable nesting cavities in the southeast and those that contribute to use and success are vital to understanding the population dynamics of cavity-nesting wood ducks and increasing wood duck recruitment. Identification of natural cavities, associated habitat characteristics, and potential cavity trees promotes efficient management of nesting

wood ducks. It may help direct artificial nest-box programs to areas depauperate of natural cavities, thus, promoting overall wood duck production.

The study is funded through the Kennedy Center, Nemours Wildlife Foundation, and the South Carolina Department of Natural Resources.

Dr. Anderson and Cindy thank the Kennedy Center, 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. Wireless Cavity Inspection Camera (David Luneau, www.ibwo.org, Little Rock, AR, USA) fixed to a 15.24-m telescopic pole and modified to collect internal cavity dimensions and monitor cavity use.*

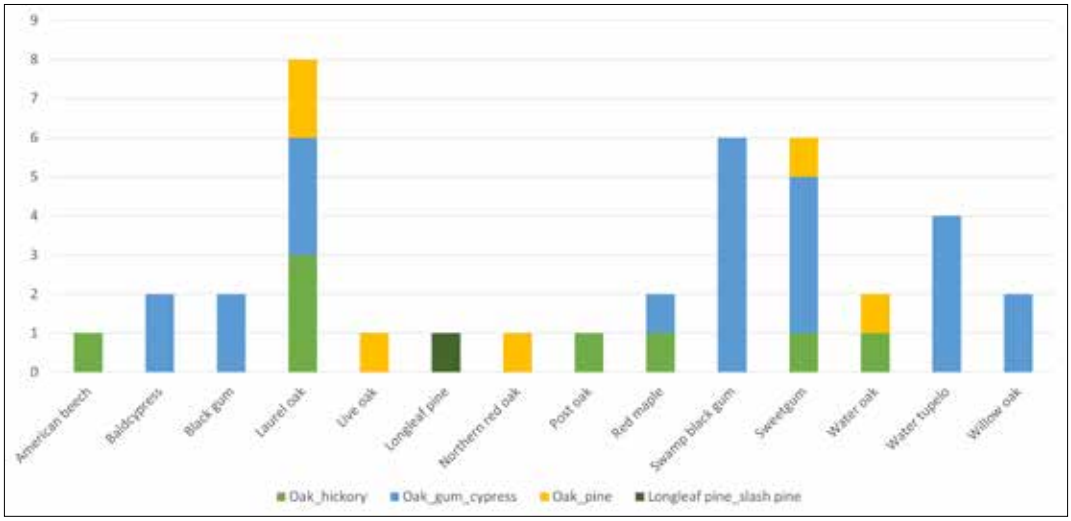



*Figure 2. The number of suitable cavities by tree species and forest type located during forest inventory surveys in 2022 at Francis Marion National Forest in Berkeley and Charleston Counties and Hobcaw Barony in Georgetown County, South Carolina, USA.*

## 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*
*Ph.D. Student, Department of Wildlife, Fisheries, and Aquaculture and James C. Kennedy Waterfowl & Wetlands Endowed Program, Mississippi State University.*

*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 used by wintering waterfowl that range from tidal managed and non-managed marshes to inland bottomland swamps and impounded crops. Hydrologically managed tidal impoundments (MTIs) along the coast are among the most critical aquatic resources for waterfowl and other waterbirds in the Atlantic Flyway. Many MTIs in the South Atlantic are remnant rice fields created in the 17th to 19th centuries. Managers now manage these impoundments for naturally occurring submersed aquatic vegetation (SAV) and associated seeds, tubers, and aquatic invertebrates. There are information voids for MTIs and other wetland types in the South Atlantic, such as current estimates of wetland carrying capacity for migrating and wintering waterfowl in coastal and inland areas. Moreover, region-specific food habits data for duck species and acreage estimates of privately managed impoundments are outdated or lacking. In this study, we aim to estimate the energetic density of key wetland types used by waterfowl in the South Atlantic by conducting SAV sampling and rapid assessments of moist-soil and flooded corn impoundments on public and private lands. Energetic density is a measure of carrying capacity derived by pairing forage biomass estimates with true metabolizable energy values of the measured forage types. In addition, many of the existing food habits studies on waterfowl in the region were conducted in the 1960s and 1970s using outdated methodologies. Thus, we will evaluate the diets of waterfowl in the area using DNA analysis of feces collected from hunter-harvested ducks to reveal prey types consumed regionally by waterfowl. We could then exclude prey items seldom consumed from overall carrying capacity estimates. Finally, we will use remotely sensed data to digitize wetlands on private lands to improve the current managed wetland inventory. Our results will enhance the bioenergetics model the Atlantic Coast Joint Venture and its partners use to meet population-based habitat objectives the North American Waterfowl Management Plan set.

## RESEARCH ABSTRACT

### RECRUITMENT, COST INDEXES, AND MANAGEMENT OF BOX-NESTING WOOD DUCKS IN SOUTH CAROLINA AND NORTH CAROLINA

*Emily M. Miller*
*Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center*

Wood ducks (*Aix sponsa*) have experienced one of the most significant declines and recoveries among species of North American waterfowl (*Anatidae*). With the enactment of the Migratory Bird Treaty Act (1918) and the installation of hundreds of thousands of artificial nest structures for this cavity-nesting species in North America, wood duck populations have recovered and remain sustainably harvested resources. However, long-term research on box-nesting wood ducks at the Savannah River Ecology Laboratory has suggested recruitment rates of females from box-nesting populations are too low to be self-sustaining without immigration of hens from other complexes of boxes and natural cavities.

North and South Carolina have intensive nest box programs for wood ducks on public and private lands, numbering thousands of boxes. Therefore, I conducted a study in 2020 and 2021 at Lake Moultrie in South Carolina and in North Carolina at Mattamuskeet and Roanoke River National Wildlife Refuges (NWR) and Heron Bay, a private property adjoining Mattamuskeet NWR. I monitored nearly 400 boxes examining wood duck reproductive and recruitment data. I also calculated cost indexes of yearling female recruits over the 20-year longevity of nest boxes. During the 2020-2022 field seasons, I evaluated strategies to deter rat snakes (Pantherophis alleghaniensis) and woodpeckers. Both are significant predators of wood duck eggs at my study sites.

Box use was high at all sites in 2020–2021 but was greater at Lake Moultrie (98%) than the pooled average for North Carolina sites (86%). Across all areas and years, nest success was 54.6%, and the frequencies of successful and unsuccessful nests did not differ between sites in 2020 but in 2021. The difference between years can be attributed to increased snake predation (9%) from 2020 to 2021. An average of 2.31 more ducklings exited successful nests in boxes at Lake Moultrie than from the North Carolina sites in 2020, but 1.84 more ducklings hatched from North Carolina boxes in 2021. Despite the between-year differences, no difference in the number of ducklings exiting boxes occurred between sites when I pooled yearly data (i.e., 11.3 ducklings/successful nest). I calculated an index of the wood duck box construction and maintenance cost over 20 years with yearling female recruits. I used a published recruitment rate and the average recruitment rate from Lake Moultrie from 2020–2021. The average cost per recruit was 1–4 times less than the cost of the box and its management over 20 years, suggesting cost-efficiency based on this approach.

To deter rat snakes from entering nest boxes during the 2020-2022 field seasons, I attached a black cotton sock containing one cup of Snake-A-Way® pellets on nest boxes above the predator guard at boxes with previously recorded or current snake predation of wood duck eggs. An empty black sock was deployed likewise as a control in this experiment. Across all years

and sites, snakes were responsible for 61% of nest depredations. Using the Schnabel method, I estimated 146 rat snakes using nest boxes at Lake Moultrie, where snake depredation of eggs was highest. I PIT tagged 127 snakes among all North Carolina sites and Lake Moultrie, where captured snakes consumed 642 eggs. Snake pellets were deployed 58 times across field sites where I encountered snakes; there were 20 snake encounters after pellets were deployed compared to no encounters after the remaining 38 pellets deployments. However, I did not detect a significant difference in the number of snakes accessing boxes treated or not treated with pellets, suggesting Snake-A-Way® pellets may not reduce predation events from rat snakes in the method applied. I deployed trail cameras in each state to determine how snakes circumvent functional predator guards. Snakes wrap their body around the post and use predator guards to leverage their ascent upward to access the box entrance.

To deter woodpeckers from entering nest boxes during the 2020-2022 field seasons, I attached a Bird-B-Gone® plastic hawk decoy to boxes with previously recorded woodpecker depredations of wood duck eggs. After 12 days of incubation, I deployed decoys to discourage hen abandonment of nests from the hawk effigy. Across all years and sites, woodpeckers were responsible for 33.6% of nest depredations. I recorded 50 woodpecker encounters for nest boxes with and without the hawk decoy. There was a significant difference in the number of successful nests in boxes containing the hawk decoy across 2021–2022, suggesting hawk decoys may reduce predation events from woodpeckers. My study indicates a need for continued recruitment data and sensitivity analysis to determine if rat snakes, woodpeckers, and other agents of nest loss are decreasing recruitment rates from boxes.

## RESEARCH ABSTRACT

# CHRONOSEQUENCE APPROACH TO WOODY VEGETATION DEVELOPMENT IN RESTORED WETLANDS, WEST VIRGINIA, USA

*Jessica Bryzek*
*M.S. Wildlife and Fisheries Resources*
*West Virginia University*

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

Many anthropogenic land use practices have led to the degradation of wetlands, making them globally imperiled ecosystems. Conflicts between the natural and built environments necessitate unique solutions to provide a compromise or balance between development and natural ecosystem attributes. Within the United States, wetland mitigation is a federally regulated restoration strategy that offsets and compensates for impacts to aquatic resources encountered during development through mitigation and involves numerous governmental agencies at the federal, state, and local levels, as well as other nonprofit and for-profit entities. Wetland mitigation restores a previously degraded wetland by actively reviving lost ecosystem attributes.

Restoration involves many components, such as rehabilitating physical processes, re-grading the topography to restore hydrology and ecological processes, and re-established appropriate wetland vegetation communities. Revegetation is a significant component of restoration and can occur through active planting or seeding or involve a more passive approach with natural colonization from the seed bank or surrounding landscape driving colonization. Vegetation forms the foundation of the wetland ecosystem, and in certain wetland types, woody vegetation is the workhorse of the ecosystem, providing structural and functional support (Figure 1). Woody vegetation refers to durable trees and shrubs that survive over the years to become stationary features in the landscape. Woody vegetation stores carbon in soils, provides habitat and food for fish and wildlife species, contributes organic matter additions, enhances soil stabilization, recycles nutrients, and regulates water quality and quantity.

This research study investigates woody vegetation development post-restoration using a chronosequence approach. A chronosequence research design is used to study successional processes and examines attributes from study sites that represent a variety of ages. For this study, forty restored wetlands in West Virginia varied from 1 to 29 years since restoration at the time of field sampling in 2021. Using a stratified random sample approach, circular plots 100 $m^2$ in area (diameter = 5.6 m) were randomly generated in each national wetland inventory habitat type. While the minimum number of plots per site was four, the number of plots depended on the

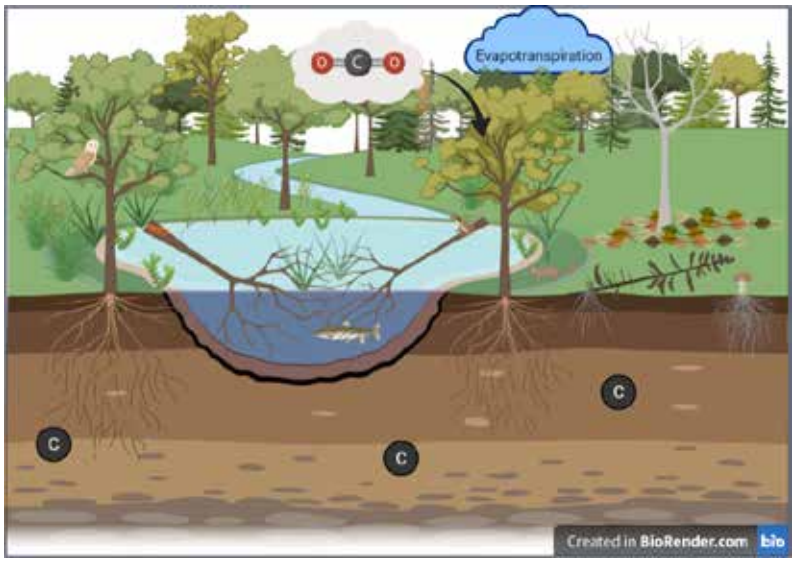



*Figure 1. Woody vegetation provides functional and structural support within wetland ecosystems, including carbon storage, habitat and food for fish and wildlife species, organic matter additions, soil stabilization, nutrient recycling, and water quality and quantity regulation.*

wetland size, with the total plot area representing at least 2% of the total wetland area to achieve a sufficient sample size. Within each plot, all woody vegetation, trees, and shrubs were identified to the species level, enumerated, and the stem diameter at the groundline was measured to 0.01 cm using digital calipers. For multi-stemmed species, the five largest stems were measured and summed to represent the individual.

A total of 16,428 stems were measured, representing 63 unique species. Smooth alder (*Alnus serrulata*) was the most common species, representing 18.6% of all sampled stems. The next most numerous species and their frequency of detection include White meadowsweet (*Spiraea alba*) (16.4%), brushy St. John's Wort (*Hypericum densiflorum*) (11.3%), silky dogwood (*Cornus amomum*) (9.2%), steeplebush (*Spiraea tomentosa*) (7.8%), black willow (*Salix nigra*) (5.1%), silky willow (*Salix sericea*) (4.2%), silver maple (*Acer saccharinum*) (3.3%), American sycamore (*Platanus occidentalis*) (3.2%), buttonbush (*Cephalanthus occidentalis*) (2.3%), and multiflora rose (*Rosa multiflora*) (2.1%). The other 52 species represented less than 2% of measured stems. The most widely distributed species across all study sites and the number of study sites detected include black willow (*Salix nigra*) (30), silky dogwood (*Cornus amomum*) (28), buttonbush (*Cephalanthus occidentalis*) (25), smooth alder (*Alnus serrulata*) (22), American sycamore (*Platanus occidentalis*) (17), multiflora rose (*Rosa multiflora*) (17), black elderberry (*Sambucus nigra ssp. canadensis*) (14), and red maple (*Acer rubrum*) (10.) The other 55 species were documented at less than 10 study sites. Woody vegetation data were summarized at the site level into seven woody vegetation indices and compared along the chronosequence gradient. Indices include species richness, native species richness, the proportion of species facultative or wetter according to wetland indicator status, abundance weighted floristic quality index, stem density, and basal area represented as stem area at groundline were used to evaluate community development. Linear and nonlinear regression analysis was used to investigate the longitudinal development of the woody vegetation indices and evaluate the restoration trajectory for each index. Preliminary results reveal most indices fluctuated along the chronosequence gradient with statistically non-significant trends. However, the stem area at the groundline does follow a non-linear growth pattern, with the slowest growth observed during the first ten years followed by a more rapid growth period.

This research aims to evaluate the long-term development of the woody vegetation community post-restoration. Wetlands restored for mitigation must be monitored for 5 to 10 years post-restoration, with performance standards evaluating ecosystem development and progress through metrics related to the soil, hydrology, vegetation, and other ecosystem components. This research study investigates the development of woody vegetation indices post-restoration to track ecosystem development to assess their feasibility as performance standards.

*Figure 2. Jessica Bryzek, an M.S. student at West Virginia University, conducts woody vegetation field sampling in a restored wetland in West Virginia*

## RESEARCH ABSTRACT

# AVIAN USE OF WETLANDS IN COASTAL SOUTH CAROLINA

*Jordan McCall*
*M.S. Student, James C. Kennedy Waterfowl & Wetlands Conservation Center, Clemson University*

The South Atlantic Coastal Plain of South Carolina is an important region for migrating, wintering, and breeding waterfowl and other waterbirds. Most management strategies in South Carolina wetlands are targeted at waterfowl, but other species benefit from practices such as moist-soil management. For example, shorebird use-days can surpass annual waterfowl use under traditional waterfowl management. Additionally, songbird studies indicate that generally mature-forest species increase the use of forested wetlands during the post-fledging period for predator avoidance and food acquisition. Despite this importance, little is known about the use of specific wetland types and the influence of wetland loss and conversion on avian habitat use.

*Figure 1. Jordan McCall, M. S. student, completing a point-count survey at an estuarine wetland.*

*Figure 2. McCall, sorting through a macroinvertebrate core sample in the field.*

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

We performed point count surveys at 97 randomly selected wetlands, varying by type, and secretive marsh bird surveys at 12 freshwater emergent wetlands to estimate occupancy rates, species diversity, species abundance, and migration chronology from January to July 2022 (Figure 1). Wetland-level data (e.g., water quality, water regimes, vegetation, and macroinvertebrates) were also collected to model wetland use and selection by waterbirds (Figure 2). For the second field season, we will readjust which wetland types will be surveyed based on analysis results from this season.

Preliminary results suggest that great egrets (*Ardea alba*) and willets (*Tringa semipalmata*) are most abundant in natural wetlands and American wigeon (*Mareca americana*) and snowy egrets (*Egretta thula*) are most abundant in altered wetlands (Figure 3). Results also suggest that avian diversity is greatest in estuarine and marine wetlands, potentially due to abundant macroinvertebrates (Figures 1 & 2). These data will improve understanding of wetland-waterbird relations along the South Atlantic Coastal Zone and enhance conservation and management of these wetlands for waterbirds.

*Figure 3. Great egret (Ardea alba) at the DeBordieu Colony.*

This project is funded by the James C. Kennedy Waterfowl and Wetlands Conservation Center and the DeBordieu Colony.

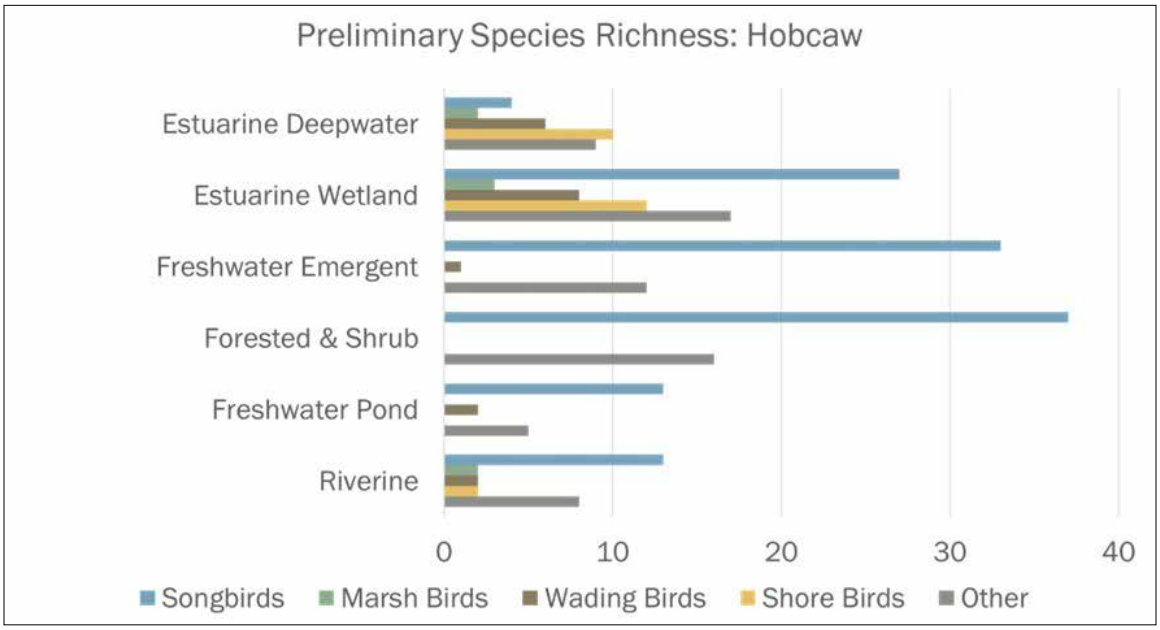



*Figure 4. Preliminary species diversity results at the Hobcaw Barony*

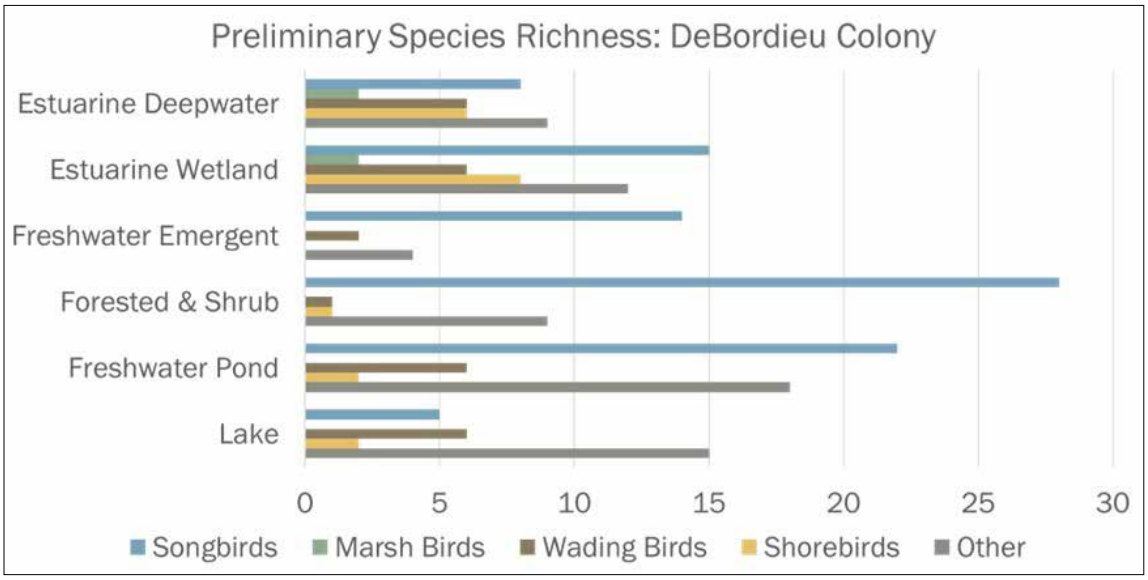



*Figure 5. Preliminary species diversity results at the DeBordieu Colony.*

## RESEARCH ABSTRACT

# REPRODUCTIVE ECOLOGY AND MICROBIAL COMMUNITIES FROM WOOD DUCKNEST BOXES IN GEORGIA AND FLORIDA

*Jacob A. Shurba,*
*Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center*

Wood ducks (*Aix sponsa*) are an important game species throughout the Atlantic Flyway. Historically, their populations were almost locally destroyed in the early 20th century due to overhunting and losing their preferred habitat. The re-establishment of the species in their historical range is greatly attributed to the placement and management of artificial nest boxes in their selected habitat types. At this time, every state in the Atlantic Flyway has an active box management program operated by state and federal agencies and private landowners. However, no large-scale regional study of the reproductive biology of box-nesting wood ducks has been conducted across multiple states, nor has an analysis of box use been accomplished. When these boxes are placed near each other in large numbers, this can lead to overuse by multiple hens throughout a nesting season. When overuse of boxes occurs, it can result in a buildup of bacteria, parasites, and other potentially detrimental pathogens that can affect the egg's ability to hatch.

Between 2020 and 2021, I performed a study examining the reproductive ecology of wood ducks and bacterial growth from nest boxes in Georgia and Florida. My objectives were to 1) estimate the percent use of nest boxes and percent nest success of wood ducks, and calculate the average number of ducklings that departed nest boxes within Georgia and Florida, 2) calculate the cost per female recruit from nest boxes between Florida and Georgia, 3) determine if the use of different types of shavings have any effect on nest box use, nest success, and the number of ducklings successfully exiting boxes, 4) determine if the use of different types of shavings (cedar and aspen) has an impact on the growth of nest-box microbes, and 5) determine if there are preventative measures managers may use to keep microbes from negatively affecting eggs.

In 2020, I monitored 142 nest boxes in Florida and 123 in Georgia, which decreased to 138 and 120 in Florida and Georgia, respectively, in 2021. In Florida, 90.3% of nest boxes and in Georgia, 60.5% of nest boxes were used by wood ducks across both years. Nest success (defined as the occurrence of one or more eggs successfully hatching in a nest) across both years and states was 40.9%. Nearly twice as many ducklings successfully exited boxes from Georgia than in Florida, with averages of 11.46 and 6.86 ducklings exiting boxes from Georgia and Florida, respectively.

The calculated cost per yearling female wood duck over 20 years was $108.35 in Florida and $86.68 in Georgia. The cost per female wood duck in Georgia was about half the cost for the box material and annual maintenance for 20 years. However, more data are necessary to conclude if nest-box programs are cost-effective in Georgia and Florida. I found that the type of shavings

used in nest boxes had no impact on box selection and use, nest success, or ducklings successfully exiting nest boxes. Additionally, using different types of shavings did not impact the prevention of microbial growth on eggs in nest boxes. While there are no explicit recommendations for what type of nesting material to use in nest boxes, it is recommended that managers regularly clean and provide maintenance to their nest boxes before, during, and after the breeding season.

## RESEARCH ABSTRACT

# RELATIONSHIPS BETWEEN WATERSHED LAND-USE PRACTICES, GEOGRAPHY, AND CLIMATE ON WETLAND FUNCTIONS AND ECOSYSTEM SERVICES

*Sindupa De Silva*
*Ph.D. Student, Division of Forestry and Natural Resources*
*West Virginia University*

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

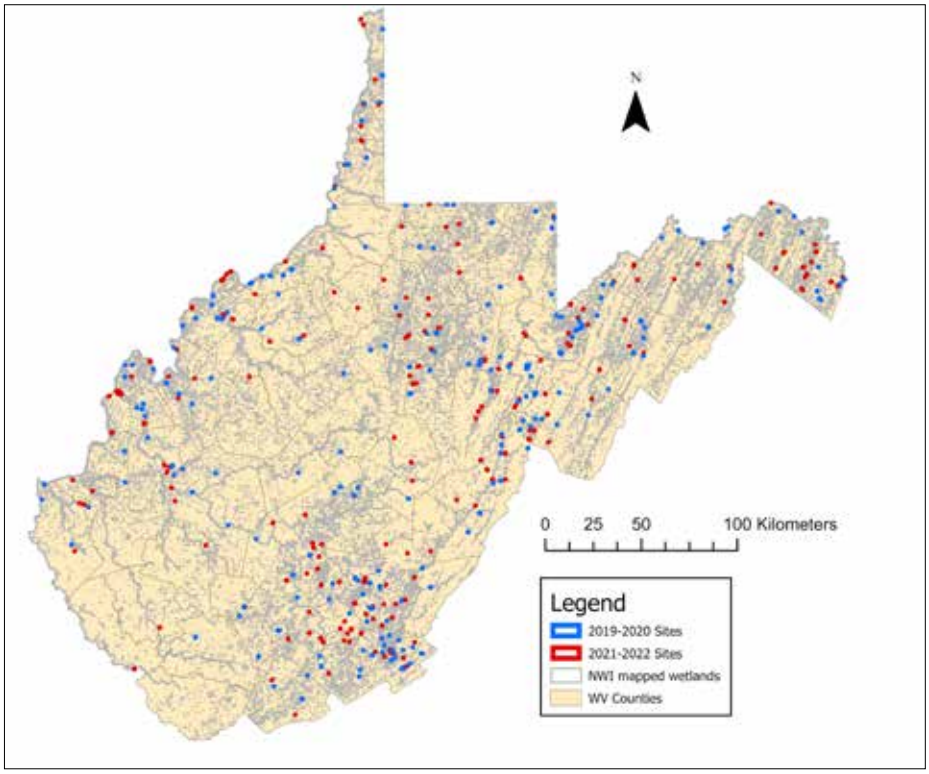
Wetlands are inherently invaluable ecosystems that provide numerous benefits to humans and wildlife through their functions and ecosystem services. Wetlands intercept and attenuate surface runoff and floodwaters, which helps reduce flood risks and erosion, and protects aquatic ecosystems from sedimentation. By attenuating runoff and flood waters, wetlands sequester and store excess nutrients and pollutants in the water. Wetlands provide essential foraging, nursery, and shelter habitat for many organisms and are biodiversity hotspots. Resource use opportunities, such as hunting, fishing, trapping, foraging, and timbering, offer additional value. Recreation, ecotourism, education, and cultural heritage are also essential values of wetlands. All of this is made possible because of the intricate relationships between at wetland's biotic and abiotic components.

In the U.S., the Clean Water Act (CWS) provides federal protection to wetlands by regulating pollution and discharge that humans can introduce into navigable waters of the U.S. However, the variability in the definition and interpretation of "navigable waters of the U.S." can include or exclude specific wetland systems from protection. The CWA also does not provide protections to wetlands from watershed-scale specific anthropogenic disturbance. Therefore, the lack of comprehensive protections puts wetlands at risk of degradation and loss, along with all the benefits they provide through their functions and ecosystem services. I believe that understanding the impacts of anthropogenic watershed land-use practices on a wetland's ability to perform functions and ecosystem services will help fill a gap in information that will help in the efforts to advance comprehensive protections.

To understand how anthropogenic watershed land-use practices impact a wetland's ability to perform functions and ecosystem services, we can evaluate how they affect the biotic and abiotic components that help wetlands perform their functions and ecosystem services. To do this, I studied 200 wetlands across West Virginia from 2019 to 2022 to evaluate their water quality, soil composition, and characteristics, and their aquatic macroinvertebrate and vegetation composition. I measured the wetland's representative water quality once per season, macroinvertebrate relative diversity and abundance in the spring and fall, vegetation diversity and abundance during the summer, and soil composition and characteristics during each season. I will evaluate all the variables above with each wetland's watershed land cover/ land-use practices, total approximate water inputs, and any other natural or artificial structures that enhance or restrict the hydrologic conductivity of the wetland.

I hypothesize that wetlands with more disturbed watersheds will have poorer water quality, soil composition, and macroinvertebrate and vegetation composition. I also hypothesize that wetlands with more disturbed watersheds will have less ability to perform their functions and ecosystem services. The results of this project will help understand the relationship between watershed land-use practices, geography, and climate on

wetland functions and ecosystem services. My findings will help West Virginia develop its wetland water quality standards and create indexes of biological integrity for wetland macroinvertebrates and vegetation. My results will also contribute to the efforts to advance more comprehensive wetland regulations and consequently protect the numerous benefits wetlands provide to humans and wildlife.




*Wetlands selected for 2019-2020 and 2021-2022 from the National Wetland Inventory map of all wetlands in West Virginia using a probabilistic sample draw.*

## RESEARCH ABSTRACT

# CONTRASTING CARBON SEQUESTRATION AND GREENHOUSE GAS EXCHANGE IN TIDAL AND IMPOUNDED WETLANDS

*Dr. Tom O'Halloran and Lucas Clay, Ph.D. student*
*Baruch Institute of Coastal Ecology and Forest Science*

There is increasing interest in using land to sequester carbon and reduce greenhouse gas emissions. Since wetlands are natural sources of methane, a potent greenhouse gas, they are the subject of investigation for potential management interventions that could reduce emissions. For example, managers can temporarily reduce water levels to aerate soils and reduce methane production. Meanwhile, tidal coastal wetlands store large quantities of carbon in the soil. However, these coastal wetlands are under pressure from sea level rise, and questions surrounding the stability of such carbon stores need to be answered. To that end, Dr. Tom O'Halloran at Clemson's Baruch Institute has partnered with the Kennedy Center, the North Inlet-Winyah Bay National Estuarine Research Reserve (NI-WB NERR), and the Department of Energy's AmeriFlux network to expand work measuring greenhouse gas exchange at two wetland sites near Georgetown, SC (Figure 1).

The North Inlet Crab Haul Creek tower was established in the NI-WB NERR in collaboration with Dr. Erik Smith of the University of South Carolina in 2017. As part of AmeriFlux's Year of Methane, the AmeriFlux Management Project Tech Team has loaned a methane sensor to this site for 2021-2022. This tower effectively created a site pair with the Minim Creek Brackish Impoundment tower at Annandale Plantation, which has operated with a methane sensor since becoming operational in March 2020. In summer 2022, work expanded at Annandale to include plant-level measurements of methane using custom chambers and a portable greenhouse gas lab supported by the National Science Foundation (Figure 2). The research towers continuously measure a suite of meteorological and water quality variables, as well as the exchange of carbon dioxide and methane between the wetland and the atmosphere.

Meanwhile, weather conditions and plant phenology vary naturally with the seasons, while water levels and salinity vary due to management in the impoundment. The tower then detects changes in ecosystem photosynthesis, respiration, and methane production caused by this environmental variability. With this information, we will quantify greenhouse gas budgets and compare them against the value

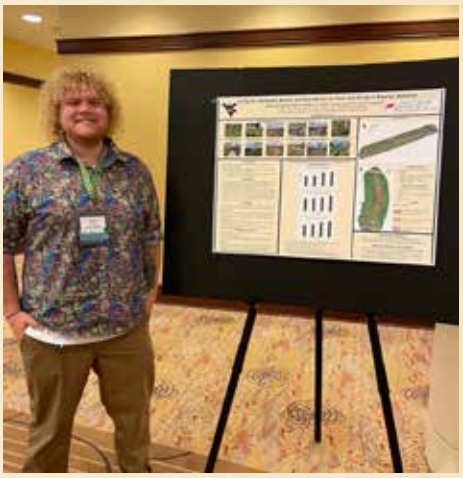

*Figure 1. Aerial views of the North Inlet flux tower (US-HB1), which is in the tall-form Spartina alterniflora zone along Crab Haul Creek and US-HB4, a managed, impounded wetland adjacent to Minim Creek, a branch of the Santee River. Photos by Erik Smith (left) and Tom O'Halloran (right).*

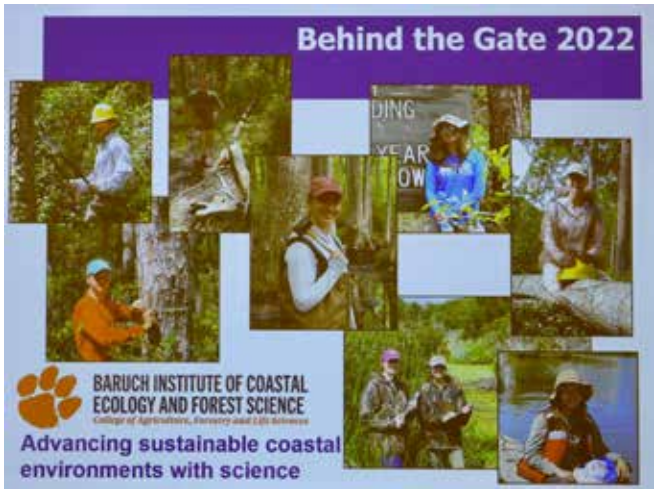
of other ecosystem services. The pilot study is funded through an Equipment Grant and Graduate Research Assistantship from the Clemson University College of Agriculture, Forestry and Life Sciences. An SC Sea Grant Consortium grant initially supported the salt marsh tower. Funding is currently being sought to expand the study to tidally influenced control sites and other hydrologic regimes along the estuary (e.g., further upriver). Dr. O'Halloran thanks Dr. Anderson and the Kennedy Center, Clemson CAFLS, and Mr. Dan Ray and Mr. Bill Mace of Annandale Plantation for hosting the research.

*Figure 2. Postdoc Georgia Seyfried (left) and graduate student Annika Kuleba deploy whole plant chambers to measure methane fluxes in saltmarsh bulrush at US-HB4.*

# OUTREACH AND EDUCATION

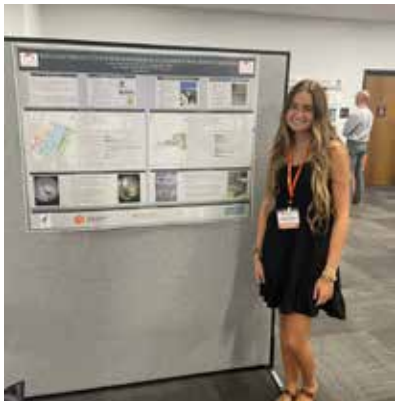
The Kennedy Center spent considerable time conducting informal and formal outreach and education during the past year. We gave numerous talks at meetings, visited landowners in the field to exchange ideas and information, hosted visitors, had informal conversations, and conducted many other activities to get the word out about what we have been doing. Our biggest hang-up with outreach and education is we are not good at remembering to take pictures. In the future, we hope to expand our outreach activities, particularly with landowners (and to take more photos).





Behind the Gate 2022
BARUCH INSTITUTE OF COASTAL
ECOLOGY AND FOREST SCIENCE
Advancing sustainable coastal
environments with science




Protecting the
Nation's Wetlands







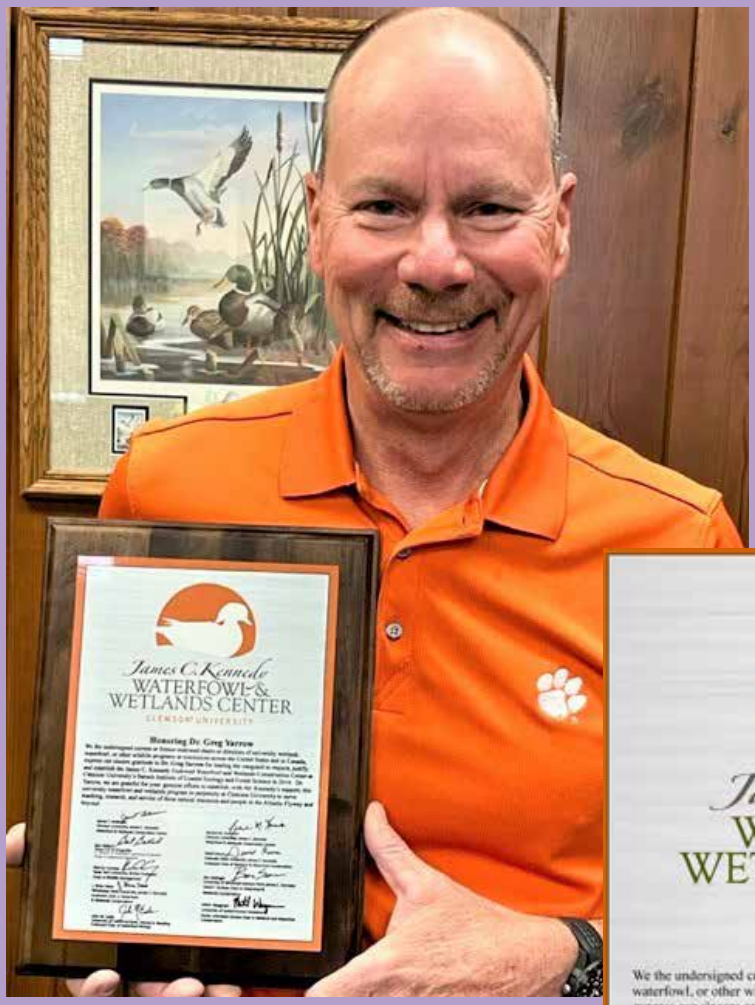






## Consortium Recognizes Professor Greg Yarrow for his Vision and Skill in Attracting the James C. Kennedy Waterfowl and Wetlands Conservation Center to Clemson University

The James C. Kennedy Waterfowl and Wetlands Conservation Center at Clemson University and colleagues from across the United States and Canada recognized Professor Greg Yarrow for his contributions to establishing the Kennedy Center at Clemson University. Dr. Yarrow was surprised and humbled during a small ceremony held in November 2021 to honor his contributions. With Mr. Kennedy's generous support, we appreciate your time and commitment to attracting the Center to Clemson University. Thank you, Greg, for all your efforts in bringing the Kennedy Center to the South Carolina coast. Congratulations, Dr. Greg Yarrow!





James C. Kennedy
WATERFOWL &
WETLANDS CENTER
CLEMSON UNIVERSITY

**Honoring Dr. Greg Yarrow**

We the undersigned current or former endowed chairs or directors of university wetland, waterfowl, or other wildlife programs at institutions across the United States and in Canada, express our sincere gratitude to **Dr. Greg Yarrow** for leading the vanguard to request, justify, and establish the James C. Kennedy Endowed Waterfowl and Wetlands Conservation Center at Clemson University's Baruch Institute of Coastal Ecology and Forest Science in 2014. Dr. Yarrow, we are grateful for your genuine efforts to establish, with Mr. Kennedy's support, this university waterfowl and wetlands program in perpetuity at Clemson University to serve teaching, research, and service of these natural resources and people in the Atlantic Flyway and beyond.

# STUDENT AWARDS & ACHIEVEMENTS

We are pleased to announce fellowships, assistantships, scholarships, and other scholarly honors awarded to Kennedy Center undergraduate and graduate students during 2021–2022. We are redoubling our efforts to make students the central foci of the Center. 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.

**Miriam Boucher,** a Kennedy Center Ph.D. student, received a 2-year Clemson University Experiment Station and Clemson University College of Agriculture, Forestry and Life Sciences Environmental Toxicology Graduate Research Assistantship. Miriam will be working on an alligator-microplastics study in coastal wetland systems.

**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.

**William Goldstein,** a senior in high school, was selected as a summer intern for the Kennedy Center through the Governor's School for Science and Math.

**Anna Koon** is a senior Wildlife and Fisheries Biology major at Clemson University, with minors in Animal and Veterinary Sciences and Biological Sciences. She was selected as a Kennedy Center, Clemson University Professional Internship and Co-op Program intern for summer 2022 and received the Kennedy Center's undergraduate scholarship for 2022–2023. She is a member of Clemson's Chapter of The Wildlife Society and Clemson Collegiate Horsemen's Association. After graduation, she hopes to pursue a wildlife and environmental conservation career.

**Jordan McCall,** a Kennedy Center M.S. Student Fellow, with support from the Debordieu Colony, completed her thesis proposal, "Avian Habitat Relations and Temporal Trends within the South Atlantic Coastal Zone." Jordan was a previous recipient of a Kennedy Center undergraduate scholarship. She also was honored by receiving the Outstanding Senior in Wildlife and Fisheries Biology from Clemson University's College of Agriculture, Forestry and Life Sciences (CAFLS) for 2021–2022 and was awarded $500 from the CAFLS Undergraduate Research Competition for her proposal "Wetland type use and selection by waterbird species on the South Carolina coast."

**Emily Miller,** a Kennedy Center M.S. Student Fellow, and Nemours Wildlife Foundation student, completed her thesis entitled "Recruitment, Cost-Benefits, and Management of Box-nesting Wood Ducks (Aix sponsa) in South Carolina and North Carolina" in May 2022. Emily is pursuing her Ph.D. at SUNY College of Environmental Science and Forestry.

**Jacob Shurba,** a Kennedy Center M.S. Student and Nemours Wildlife Foundation and South Carolina Department of Natural Resources graduate student, completed his thesis entitled "Reproductive Ecology and Microbial Communities From Wood Duck Nest Boxes in Georgia and Florida" in May 2022. Jake is pursuing his Ph.D. at Auburn University.

**Carly Sprott** is a senior Wildlife and Fisheries Biology major. She was selected as a Kennedy Center, Clemson University Professional Internship and Co-op Program intern for summer 2022 and received the Kennedy Center's undergraduate scholarship for 2022–2023. Carly is an active participant in Clemson's student chapter of The Wildlife Society and served as its treasurer in 2021. She also is an officer of the Tigers for Tigers conservation club. She plans to pursue a career focusing on conserving the natural habitats of endangered species.

**Akshit Suthar,** Kennedy Center Ph.D. Fellow recipient will be studying coastal waterbird habitat use of historic rice fields in relation to climate change and other perturbations.

**Cindy Von Haugg,** a Kennedy Center M.S. Student Fellow and Nemours Wildlife Foundation and South Carolina Department of Natural Resources graduate student, has completed her research proposal and first field season evaluating natural cavity availability for wood ducks. Cindy surveyed 160 plots and measured more than 4,600 trees during the spring and summer of 2022. Cindy continues her project, "Wood Duck Use and Success in Tree Cavities of Southeastern Forest Types," in 2023 with phase 2, which involves capturing and tracking hen wood ducks.


Boucher


Clay


Goldstein


Koon


McCall


Miller


Shurba


Sprott


Suthar


Von Haugg

# 2022 ADVISORY COUNCIL MEMBERS

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 science and managers.

- **Billy Dukes,** Chief of Wildlife, South Carolina Department of Natural Resources (SCDNR)
- **John Andrae,** Interim Director, Baruch Institute of Coastal Ecology and Forest Science
- **Jason Ayers,** Wildlife Biologist, U.S. Fish and Wildlife Service
- **Beau Bauer,** Wildlife Biologist, Nemours Wildlife Foundation
- **Andrew S. Bridges,** President & CEO, Nemours Wildlife Foundation
- **Billy Dukes,** Chief of Wildlife, South Carolina Department of Natural Resources (SCDNR)
- **Jim Clark,** Plantation Manager
- **Jamie Dozier,** Project Leader, Tom Yawkey Wildlife Center, SCDNR
- **Sherri Fields,** Director of Conservation, Audubon South Carolina
- **Travis H. Folk,** Wildlife Biologist, Folk Land Management, Inc.
- **Thomas Rainwater,** Wildlife Research Scientist, Yawkey Wildlife Foundation and Belle W. Baruch Institute of Coastal Ecology and Forest Science
- **Molly R. Kneece,** State Waterfowl Biologist, SCDNR
- **Buford Mabry,** Wildlife Biologist, SCDNR (Retired)
- **Bill Mace,** Manager, Annandale Plantation
- **Bob Perry,** Palmetto Natural Resources Management, LLC
- **Todd Petty,** Chairperson, Clemson Department of Forestry and Environmental Conservation
- **Michael Prevost,** Wildlife Biologist and Land Manager, Rochelle Plantation
- **Emily Purcell,** Director of Conservation Programs—South Atlantic, Ducks Unlimited, Inc.
- **Craig Sasser,** Refuge Manager, U.S. Fish and Wildlife Service
- **Rick Savage,** Executive Director, Carolina Wetlands Association
- **Marshall Truluck,** Manager, Milton Hall Plantation
- **David Wielicki,** Executive Director, South Carolina Waterfowl Association
- **Greg Yarrow, Professor,** Clemson's Department of Forestry and Environmental Conservation

## Publications (*n* =16)


Anderson, J. T. 2021. Harvest of fish and wildlife: New paradigms for sustainable management. (Book Review). Journal of Field Ornithology 92:537. https://doi.org/10.1111/jofo.12391

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Gulette, A. L., D. J. Brown, and J. T. Anderson. 2022. Geographical distribution. Apalone spinifera (spiny softshell). Herpetological Review 53:260.

Gulette, A. L., D. J. Brown, and J. T. Anderson. 2022. Geographical distribution. Sternotherus odoratus (Eastern musk turtle). Herpetological Review 53:261-262.

Gulette, A. L., D. J. Brown, L. Schumacher, and J. T. Anderson. 2022. Geographical distribution. Pseudemys rubriventris (Northern red-bellied cooter). Herpetological Review 53:261.

Kaminski, R. M., M. G. Brasher, and N. M. Masto. 2022. Will the ducks bounce back? Ducks Unlimited Magazine/May-June 2022:32-34.

Miller, E. M. 2022. Recruitment, cost indexes, and management of box-nesting wood ducks in South Carolina and North Carolina. Thesis, Clemson University, Clemson, South Carolina, USA.

Rounsville Jr., T. F., R. E. Rogers, A. B. Welsh, C. W. Ryan, and J. T. Anderson. 2022. Novel hair snare and genetic methods for non-invasive bobcat detection. Ecology and Evolution 12(1):1-12. https://doi.org/10.1002/ece3.8435

Shurba, J. 2022. Reproductive ecology and microbial communities from wood duck nest boxes in Georgia and Florida. Thesis, Clemson University, Clemson, South Carolina, USA.

Slabe, V.A., J. T. Anderson, B. A. Millsap, J. L. Cooper, A. R. Harmata, Marco Restani, R. H. Crandall, B. Bodenstein, P. H. Bloom, T. Booms, J. Buchweitz, R. Culver, K. Dickerson, R. Domenech, E. Dominguez-Villegas, D. Driscoll, B. W. Smith, M. J. Lockhart, D. McRuer, T. A. Miller, P. A. Ortiz, K. Rogers, M. Schwarz, N. Turley, B., M. E. Finkelstein, C. A. Triana, C. R. DeSorbo, and T. E. Katzner. 2022. Demographic implications of lead poisoning for eagles across North America. Science 375:779-782.

Veselka, W. IV, W. S. Kordek, and J. T. Anderson. 2021. Using multiple taxa and wetland classification schemes for enhanced detection of biological response signatures to human impairment. Ecological Indicators 133:1-6. https://doi.org/10.1016/j.ecolind.2021.108391

Xia, W., B. Zhu, Z. Shuanghu, H. Liu, X. Qu, Y. Liu, L. G. Rudstam, J. T. Anderson, L. Ni, and Y. Chen. 2022. Climate, hydrology, and human disturbance drive long-term (1988-2018) macrophyte patterns in water diversion lakes. Journal of Environmental Management 319:115726. https://doi.org/10.1016/j.jenvman.2022.115726

## Oral and Poster Presentations (*n* = 36)

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

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

Anderson, J. T. 2021. An overview of the Kennedy Waterfowl and Wetlands Conservation Center. Pate Foundation. Virtual.

Anderson, J. T. 2021. Faunal response to wetland mitigation. 2021 2nd International Symposium on Water, Ecology and Environment. Virtual.

Anderson, J. T. 2021. If we build it, will they come? Response of biota to wetland mitigation in the Central Appalachians. Department of Forestry and Environmental Conservation, Clemson University. Virtual.

Bryzek, J., C. T. Rota, E. Byers, W. Veselka, and J. T. Anderson. 2022. Chronosequence approach to using woody vegetation as an indicator of wetland mitigation restoration trajectory in West Virginia. National Mitigation and Ecosystem Banking Conference, Boise, Idaho.

Bryzek, J., C. Rota, W. Veselka, E. Byers, and J. T. Anderson. 2022. Woody vegetation development and restoration trajectory in mitigated wetlands in West Virginia. Davis College of Agriculture, Natural Resources and Design Twenty-Sixth Annual Graduate Student Research and Creative Scholarship Conference, Morgantown, West Virginia.

Bryzek, J., C. T. Rota, E. Byers, W. Veselka, and J. T. Anderson. 2022. Feasibility of stem-area-at-groundline to assess woody vegetation development in mitigated wetlands. Joint Aquatic Sciences Meeting 2022, Grand Rapids, Michigan.

Clark, J., A. S. Hagan, M. Folk, and J. T. Anderson. 2022. Vegetative and biogeochemical comparison of two wetlands at Brosnan Forest Coldwater Branch Mitigation Bank. Clemson University Water Research Symposium, Clemson, South Carolina. (Poster)

Clay, L., T. L. O'Halloran, J. T. Anderson, and R. Kaminski. 2022. Contrasting carbon dioxide and methane fluxes between proximal tidal saltmarsh and impounded brackish marsh wetlands in coastal South Carolina, USA. Joint Aquatic Sciences Meeting 2022, Grand Rapids, Michigan.

Clay, L., T. L. O'Halloran, and J. T. Anderson. 2022. Comparing carbon dioxide and methane fluxes between a natural salt marsh and managed wetlands. South Carolina Sea Grant Consortium Research Symposium, Charleston, South Carolina. (Poster)

Clay, L., T. L. O'Halloran, and J. T. Anderson. 2022. Comparing carbon dioxide and methane fluxes between a natural salt marsh and managed wetlands. Clemson University Water Research Symposium, Clemson, South Carolina. (Poster)

Crandall, R., V. A Slabe, T. A Miller, A. Duerr, M. Braham, T. Katzner, and J. T Anderson. 2021. Non-lead ammunition distribution programs to offset golden eagle mortalities in Wyoming. Raptor Research Foundation 2021 Annual Conference. Virtual.

De Silva, S., J. A. Hubbart, M. P. Strager, E. A. Byers, R. E. Kellner, C. T. Rota, and J. T. Anderson. 2021. Relationships between landuse practices, geography, and global climate change to wetland water quality functions. INTECOL Wetlands Conference. Virtual.

De Silva, S., J. A. Hubbart, M. P. Strager, E. A. Byers, R. E. Kellner, C. T. Rota, and J. T. Anderson. 2022. Assessing seasonal wetland water quality in relation to watershed land cover/land use. Mid-Atlantic Wetland Working Group-New England Biological Assessment of Wetlands Working Group, Linthicum Heights, Maryland.

De Silva, S., J. A. Hubbart, M. P. Strager, E. A. Byers, R. E. Kellner, C. T. Rota, and J. T. Anderson. 2022. Influences of watershed scale stressors and local climate to wetland ecosystem health. Joint Aquatic Sciences Meeting 2022, Grand Rapids, Michigan.

Hernandez-Rubio, L. A. 2021. Assessment of credentials and experiences for a successful career in waterfowl science and conservation. Presented at 75th Annual Southeastern Association of Fish and Wildlife Agencies, Roanoke, Virginia, 18-20 Oct. via Zoom.

Hernandez-Rubio, L. A. 2021. Assessment of credentials and experiences for a successful career in waterfowl science and conservation. Presented at The Wildlife Society Annual Virtual Conference, 1-5 Nov.

Hernandez-Rubio, L. A. 2021. Waterfowl Professionals' and Students' Perceptions of Graduate Student Publication Practices. Poster, Presented at The Wildlife Society Annual Virtual Conference, 1-5 Nov.

Hernandez-Rubio, L. A. 2021. Advancing waterfowl ecology and management: Assessments of an online course, professional credentials, and graduate student publication performance. Dissertation defense seminar, Clemson University, Clemson, South Carolina.

Hernandez-Rubio, L. A. 2021. Assessment of credentials and experiences for a successful career in waterfowl science and conservation. Seminar given to the North American Waterfowl Professional Education Plan steering committee, April 27th.

MacKenzie, A., D. N. Becker, C. M. Lituma, C. C. Arantes, and J. T. Anderson. 2022. Impacts of riparian wetland mitigation on avian composition. Great Lakes Wetlands and Waterfowl Graduate Student Symposium, Winous Point, Ohio. (Invited).

MacKenzie, A., D. N. Becker, W. E. Veselka, C. M. Lituma, C. C. Arantes, J. A. Hubbart, and J. T. Anderson. 2022. A wetland mitigation program to improve aquatic and riparian ecology in Preston County, WV. Davis College of Agriculture, Natural Resources and Design Twenty-Sixth Annual Graduate Student Research and Creative Scholarship Conference, Morgantown, West Virginia. (Poster)

MacKenzie, A., D. N. Becker, and J. T. Anderson. 2022. Avian and small mammal response during wetland restoration. 77th Annual Northeast Fish and Wildlife Conference, Long Branch, New Jersey. (Poster)

MacKenzie, A., D. N. Becker, and J. T. Anderson. 2022. Avian composition prior and during wetland restoration. Brooks Bird Club 2022 Annual Meeting, Terra Alta, West Virginia (Invited).

MacKenzie, A., D. N. Becker, J. T. Anderson. 2022. Bird and small mammal response during riparian wetland restoration. Joint Aquatic Sciences Meeting 2022, Grand Rapids, Michigan (Poster).

McCall, J., and J. T. Anderson. 2022. Wetland productivity for avian species in Georgetown SC. DeBordieu Colony Board Meeting, Georgetown, South Carolina (Invited).

McCall, J., and J. T. Anderson. 2022. Wetland type mapping and abundance on Hobcaw Barony. Clemson College of Agriculture, Forestry, and Life Sciences Undergraduate Research Symposium, Clemson, South Carolina (Poster).

McCall, J., and J. T. Anderson. 2022. Avian use of wetlands in Georgetown, South Carolina. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, South Carolina (Poster).

Miller, E. M., C. L. Von Haugg, R. M. Kaminski, B. A. Bauer, and J. T. Anderson. 2021. Effects of rat snakes on box-nesting wood ducks in South Carolina. Southeastern Association of Fish and Wildlife Agencies Annual Conference. Roanoke, Virginia. (Poster)

Molina, J. T., C. C. Arantes, B. A. Murry, J. T. Anderson, and W. Veselka. 2022. Integrating data sets to understand climate change vulnerability for aquatic fauna in West Virginia watersheds. Joint Aquatic Sciences Meeting 2022, Grand Rapids, Michigan.

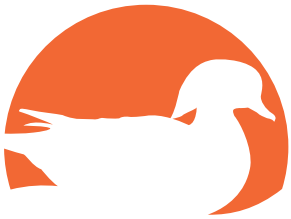
Noe, K., M. W. Frantz, C. T. Rota, and J. T. Anderson. 2022. Small mammal communities are mostly similar between mitigated and natural wetlands in West Virginia. 77th Annual Northeast Fish and Wildlife Conference, Long Branch, New Jersey.

Noe, K., M. W. Frantz, C. T. Rota, and J. T. Anderson. 2022. Similarities and differences in small mammal communities of mitigated and natural West Virginia wetlands. Davis College of Agriculture, Natural Resources and Design Twenty-Sixth Annual Graduate Student Research and Creative Scholarship Conference, Morgantown, West Virginia.

Noe, K. L., M. W. Frantz, C. T. Rota, and J. T. Anderson. 2022. Mitigated versus natural wetlands: how do small mammal communities compare? Joint Aquatic Sciences Meeting, Grand Rapids, Michigan.

Slabe, V. A, J. T. Anderson, et al. 2021. Demographic implications of lead poisoning for eagles across North America. Raptor Research Foundation 2021 Annual Conference. Virtual.

Von Haugg, C. L., B. A. Bauer, R. F. Baldwin, D. L. Hagan, E. P Wiggers, and J. T. Anderson. 2022. Occurrence of cavities suitable for wood duck nesting in coastal South Carolina forest types. Behind the Gate, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, South Carolina (Poster).



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