Tom Yawkey Wildlife Center

2021-2023 BIENNIAL REPORT

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OUR MISSION

Continue the legacy established by Tom and Jean Yawkey of conducting waterfowl, wetlands and wildlife management activities supported by natural resources research and providing unique educational opportunities by interpreting the property's diverse cultural and natural history.

HISTORY

Considered one of the most outstanding gifts to wildlife conservation in North America, the Tom Yawkey Wildlife Center includes North, South, Sand and Cat Islands. These coastal islands located at the mouth of Winyah Bay in Georgetown County total approximately 24,000 acres of marsh, managed wetlands, longleaf pine forests, beaches and maritime forests. The property was willed to the South Carolina Department of Natural Resources in 1976 by the late Thomas A. Yawkey to be utilized as a wildlife preserve, waterfowl preserve and research area. Not only did Mr. Yawkey bequeath the land, but he also established a trust for the perpetual operation of the Tom Yawkey Wildlife Center by way of the Yawkey Foundation. Mr. Yawkey was specific in his wishes regarding the overall utilization of the area and charged the Yawkey Foundation Trustees to see the area was treated as a gift to wildlife and not for generalized public recreation. All expenses for the operation of the Tom Yawkey Wildlife Center are paid by The Yawkey Foundation. In 1977 the property was dedicated as a Heritage Preserve under the South Caroline Heritage Trust Program.

The property is managed for a wide variety of wildlife including game, non-game and endangered species. There are 30 managed wetlands providing over 3,000 acres of habitat for waterfowl, wading birds and shorebirds. The 14 miles of protected beach is home to the federally protected loggerhead sea turtles, red knot and sea beach amaranth. There are over 7,000 acres of longleaf pine habitat that is home to the federally endangered red-cockaded woodpecker.

The Tom Yawkey Wildlife Center also hosts an active natural resources research program with over 100 research projects conducted on the property since the 1980's. In 2013 a partnership was developed with the Clemson University Baruch Institute of Coastal Ecology and Forest Science to help coordinate the research programs. There are numerous active projects with participation from various universities and other partners including the Savannah River Ecology Laboratory, Belle Baruch Foundation, Nemours Wildlife Foundation and the James C. Kennedy Waterfowl and Wetlands Conservation Center.

Education is an important part of the mission of the Tom Yawkey Wildlife Center, and this provides an opportunity to bring researchers, educators, land managers, students, and the public together with in- depth educational visits. Our goal is to educate individuals on the legacy of Tom and Jean Yawkey, the cultural richness and diverse natural history of the lands that make up the Tom Yawkey Wildlife Center, and the current wildlife management and research activities taking place.

THOMAS AUSTIN YAWKEY and JEAN REMINGTON YAWKEY

Thomas Austin Yawkey was born in 1903 in Detroit, Michigan to Thomas and Augusta Yawkey Austin. When Tom was just seven months old, his father died and Tom's mother moved with him and his sister to New York City to be near her brother, William Yawkey. Tom was raised and educated in the New York City area, but sadly by the age of 16, both his mother and his uncle William died of the Spanish Flu. Tom was left in the care of guardians and was heir to a considerable fortune that had been accumulated by the Yawkey family through lumber, mining, and oil industries throughout the Midwest over the prior century. Tom continued his education, attending Yale University where he graduated cum laude in 1925 with a degree in Engineering. The experiences and losses during Tom's early life shaped him into a man who deeply valued family, friendships and loyalty, and paved the way for a lifetime dedicated to sharing his vast resources with individuals, families and communities that he felt could use a helping hand. Jean Remington Hollander was born in 1909 in Brooklyn, New York and was raised and educated in Freeport, New York on Long Island. Always a hard worker, Jean moved to New York City after graduating from high school and started her career as a model and salesperson in a New York City fashion house and actively volunteered with the Red Cross during World War II. Tom and Jean married in 1944 in Georgetown, South Carolina.

In 1914, Tom's uncle, William Yawkey, purchased interest in land along the shoreline in Georgetown County, South Carolina. Tom visited Georgetown frequently as a child and developed a great love of the outdoors and wildlife. Upon his uncle's death, Tom inherited this land and in 1925, bought out most of the surrounding owners for the purposes of preserving the land as a wildlife refuge. Though Tom lived in both New York City and Boston, he spent his winters in Georgetown and developed a great love for the community and its natural resources. Tom was an avid outdoorsman and self-taught ornithologist, and carefully managed this special place through his own conservation practices, producing an area reserved for waterfowl, sea turtles, alligators, and other wildlife. Upon his death in 1976, Tom donated this land to the South Carolina Department of Natural Resources and established a perpetual endowment fund to ensure the continued maintenance and upkeep of the vast property. Now encompassing more than 24,000 acres, the Tom Yawkey Wildlife Center is considered to be one of the most outstanding grants to wildlife conservation efforts in North America. The area provides world-renowned research and education programs through its marshes, marine wetlands, forests, and sandy beaches, which play host to hundreds of species of coastal wildlife and serve as undisturbed habitat for migratory waterfowl, bald eagles, alligators, and several endangered species.

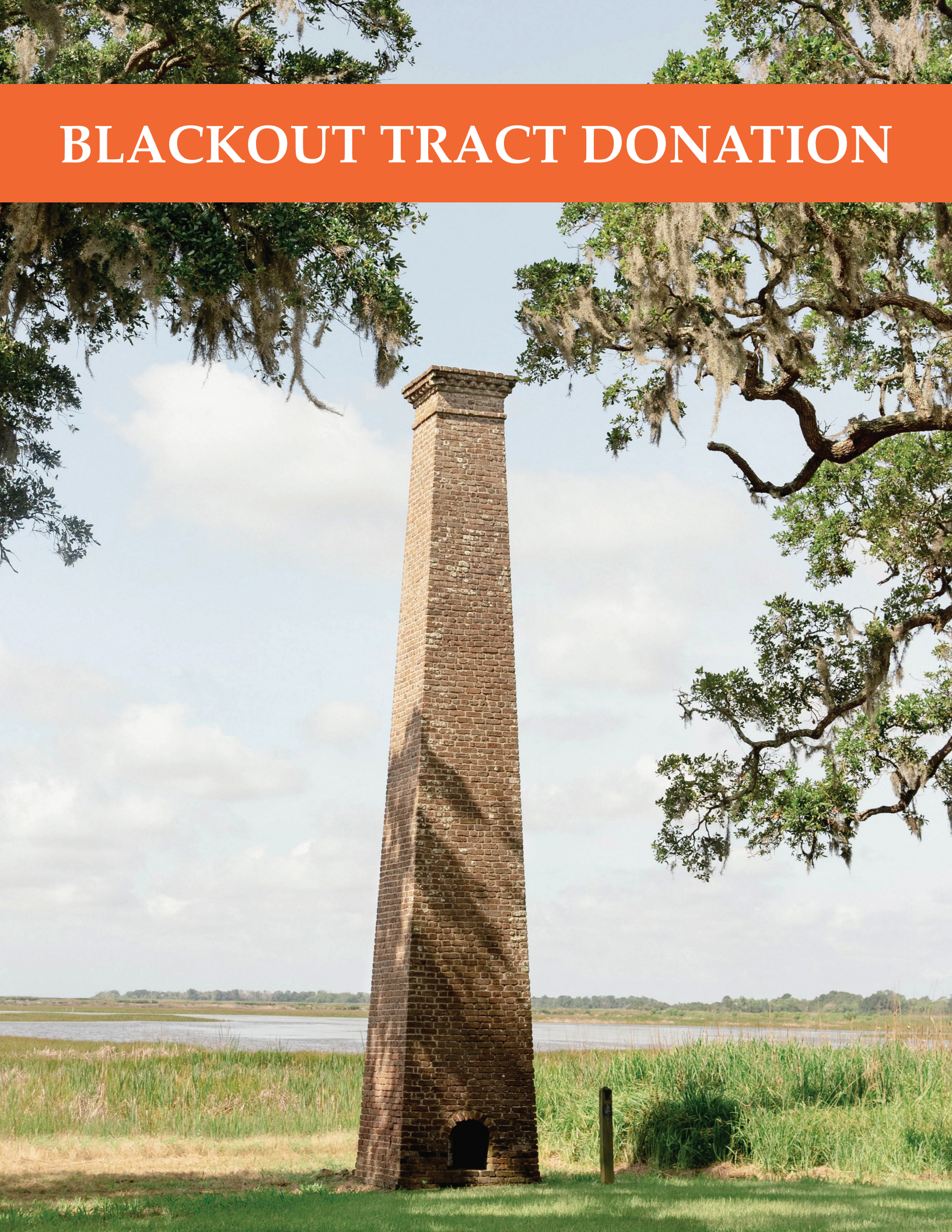
In early 1933, Tom Yawkey purchased the Boston Red Sox. At that time, the Red Sox were among the worst teams in baseball, having losing records in each of the prior 14 seasons. The team's home, Fenway Park, was rundown and in disrepair due to lack of investment. Tom Yawkey loved the game of baseball and invested heavily in both rebuilding the team and Fenway Park. Tom hired hundreds of workers, laboring around

the clock, in order to have Fenway Park ready for opening day in April 1934. Tom's commitment to the City of Boston, and to providing work opportunities for hundreds of people in the middle of the Great Depression, was widely praised. Fenway Park and the Boston Red Sox became one of Boston's most prized jewels during Tom Yawkey's four decades as Owner/President (1933 to 1976). He also served as Vice-President of the American League of Major League Baseball from 1956 to 1973. For his outstanding contributions to the game of baseball, Tom Yawkey was posthumously inducted into the National Baseball Hall of Fame in 1980.

Tom Yawkey's reputation was as a private and generous man who gave freely of his time and money to people and organizations in need. He often helped people directly with private gifts to support medical, college, and other expenses – typically with the stipulation that his gifts were to be anonymous. Whether through providing funding to establish a much-needed hospital in rural Georgetown, SC in 1945, or quietly supporting the early research of a local doctor focused on cancer research, Dr. Sidney Farber, and ultimately designating the Dana Farber Cancer Institute's "Jimmy Fund" (the official charity of the Boston Red Sox) in 1953, Tom is fondly remembered by those who knew him – former players, employees, and friends – as a man who lived by his personal motto, "Do What is Right. Do it Quietly. And Don't Expect Praise for Being Kind."

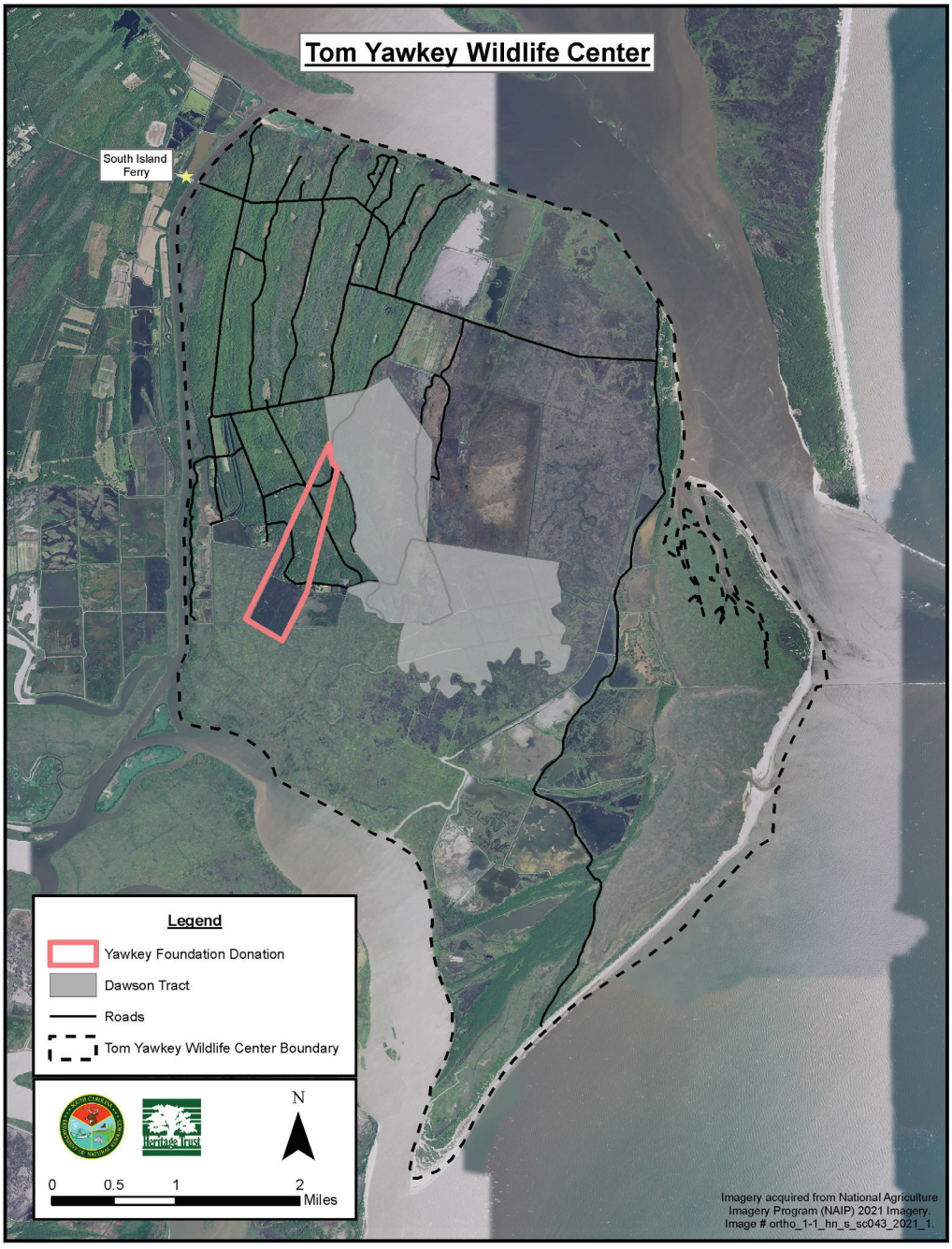
After marrying Tom Yawkey in 1944, Jean dedicated her life to their ownership of the Boston Red Sox and to improving the communities in which she and Tom lived, ensuring a legacy that both employees and fans would be proud of. Following her husband's death in 1976, Jean Yawkey became the majority owner and general partner of the Boston Red Sox and followed Tom's wishes and objectives regarding the management of the team. Jean knew that Tom always strove to produce a team that Red Sox fans would be proud to call their own. Over the twenty-five years that Jean Yawkey ran the Boston Red Sox, the team won more games than any other team in baseball, aside from the New York Yankees. Jean became a Director of the National Baseball Hall of Fame in Cooperstown and holds the distinction of being the first woman ever elected to serve on the Hall of Fame's board. In honor of her role in baseball, Jean has a place of pride at the Museum as a part of the permanent exhibit, "Diamond Dreams: Women in Baseball." She was also instrumental in guiding the early vision of the newly formed Tom Yawkey Wildlife Center.

BLACKOUT TRACT DONATION

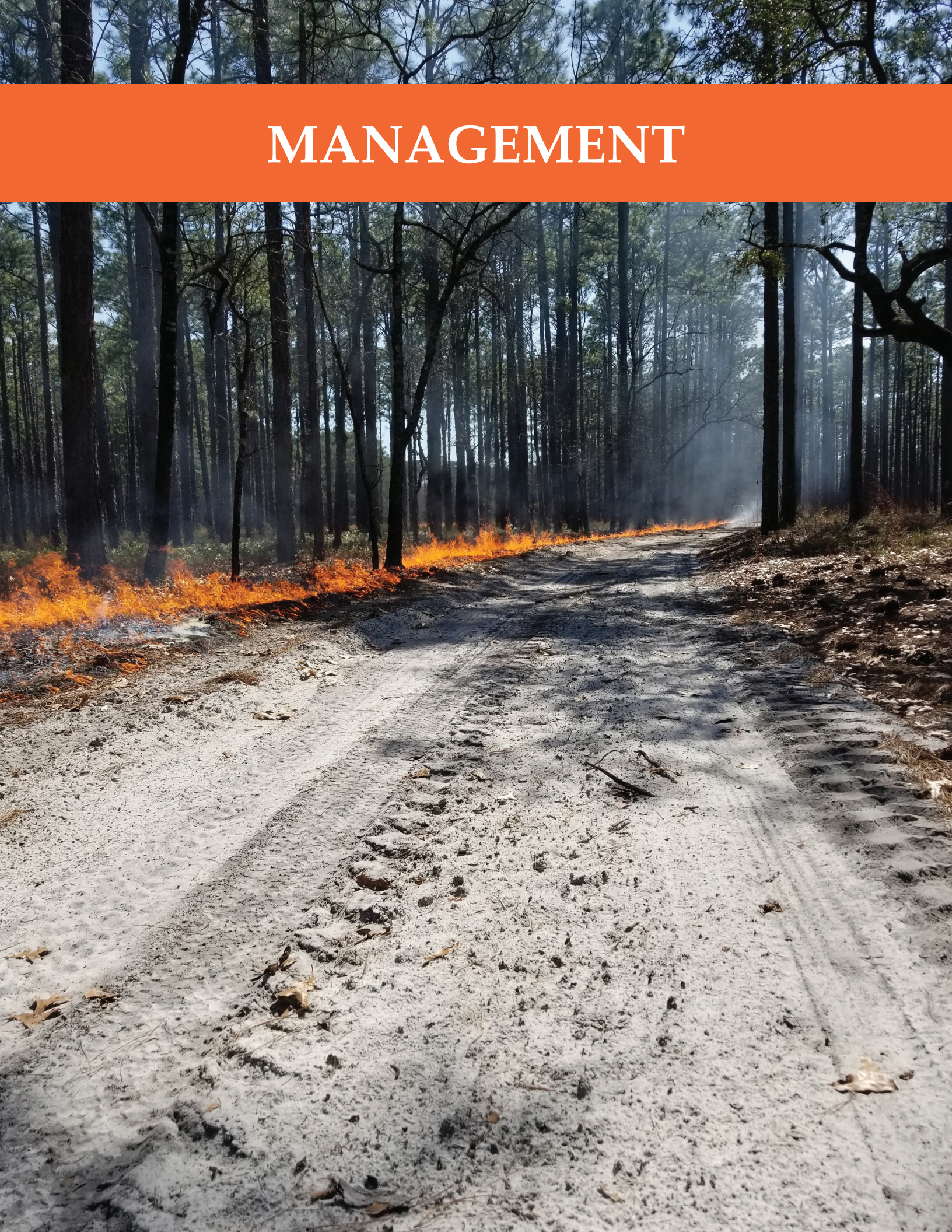


BLACKOUT TRACT DONATION

In December 2021, one of the last remaining inholdings within the Tom Yawkey Wildlife Center was donated by The Yawkey Foundation to the South Carolina Department of Natural Resources. The 269-acre property known as the Blackout Tract was acquired by The Yawkey Foundation from the Bergland family who had owned the property for several generations. The property was once part of the Bell Isle Plantation and contains the Belle Isle Rice Mill Chimney, a structure on the National Register of Historic Places. In addition to its historic significance, there are 161 acres of upland pine and a 108-acre brackish managed wetland. The up-land pine stands include a portion of the foraging habitat for a red-cockaded woodpecker cluster currently located on the Tom Yawkey Wildlife Center. The brackish managed wetland consistently has high utilization by waterfowl, wading birds and numerous shorebird species. A former residence on the tract will be utilized as short-term housing for college groups, graduate students and other researchers.



MANAGEMENT



MANAGEMENT HIGHLIGHTS

- Three rice trunk water control structures were constructed and installed in managed wetlands.
- Staff sprayed 419 acres of the invasive exotic plant common reed with approved aquatic herbicides.
- Prescribed fire was applied to 2,572 acres of longleaf pine and brackish marsh.
- The South Island Landing parking lot was reengineered and renovated in conjunction with Georgetown County , the Department of Natural Resources and the Yawkey Foundation. A portion of the renovation provides dedicated parking and dock space for the Tom Yawkey Wildlife Center on the mainland.
- Dr. Thomas Rainwater's project received a $10,000.00 gift from the Spring Island Trust through the Clemson University Foundation to conduct alligator research on Spring Island, South Carolina. This research will complement current alligator work at Yawkey Wildlife Center and other areas of the South Carolina coastal plain.
- Dr. Rainwater acquired funding of $40,000.00 from the Clemson University Experiment Station to hire former Clemson master's student Randeep Singh as a Wildlife Research Technician for one year.
- Dr. Jim Anderson (Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center), Dr. Stefanie Whitmire (Clemson University Baruch Institute), and Dr. Rainwater were awarded $46,000.00 in grant funding from the Clemson University College of Agriculture, Forestry, and Life Sciences (CAFLS) to support a two-year PhD graduate research assistantship in Environmental Toxicology. The dissertation project will focus on American alligators as sentinels of microplastics contamination in coastal South Carolina.
- SCDNR was awarded $315,000.00 from the Competitive State Wildlife Grants program for a project entitled "Black Rail Habitat Creation and Restoration: Designing Management Techniques to Expand the Black Rail Population along the Atlantic Coast". This will fund a full-time position for three years to conduct black rail research and management at the Tom Yawkey Wildlife Center.
- A 2,500-foot setback dike was substantially completed within the Lower Reserve managed wetland on South Island. This project was funded by the Federal Emergency Management Agency and will help mitigate against sea level rise within the wetland complex. Lower Reserve provides habitat for wintering waterfowl, migratory shorebirds and many other wetland dependent species.
- Five hundred feet of the perimeter dike at Lower Goose Pasture managed wetland were retopped to ensure protection against high tide events.
- Fifty-two acres of openings were planted with wildlife food crops. In addition, twenty-six acres were winter disked to provide food and cover for bobwhite quail and other native species.
- Two thousand feet of the Main Dike on South Island were renovated to allow vehicular traffic. This will eventually replace the lower road that is currently being impacted by rising water levels.

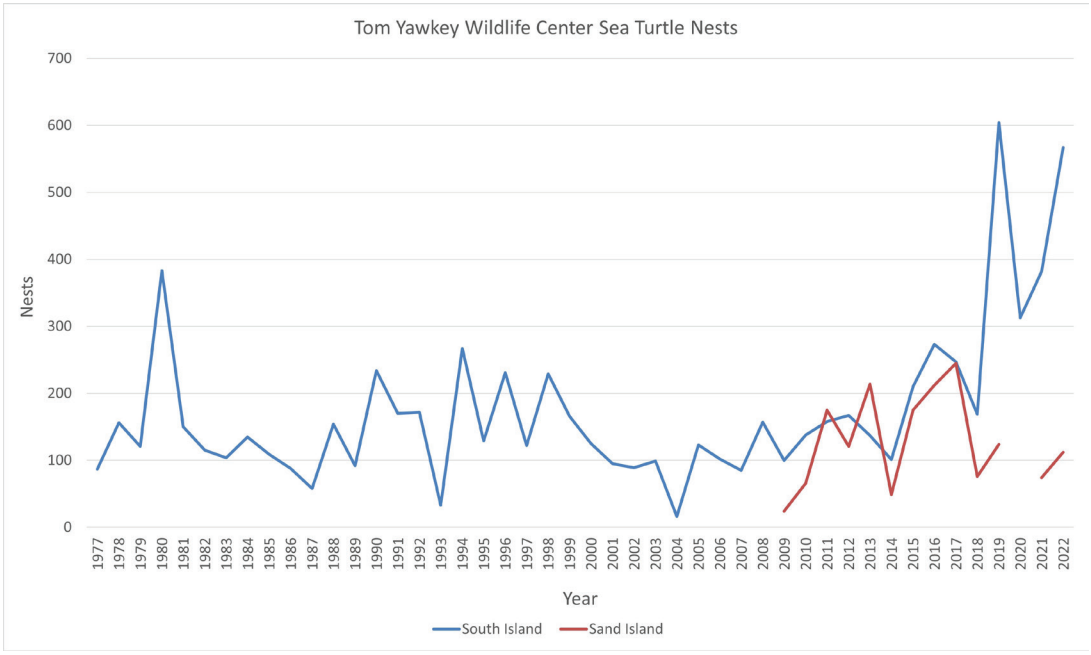
LOGGERHEAD SEA TURTLE

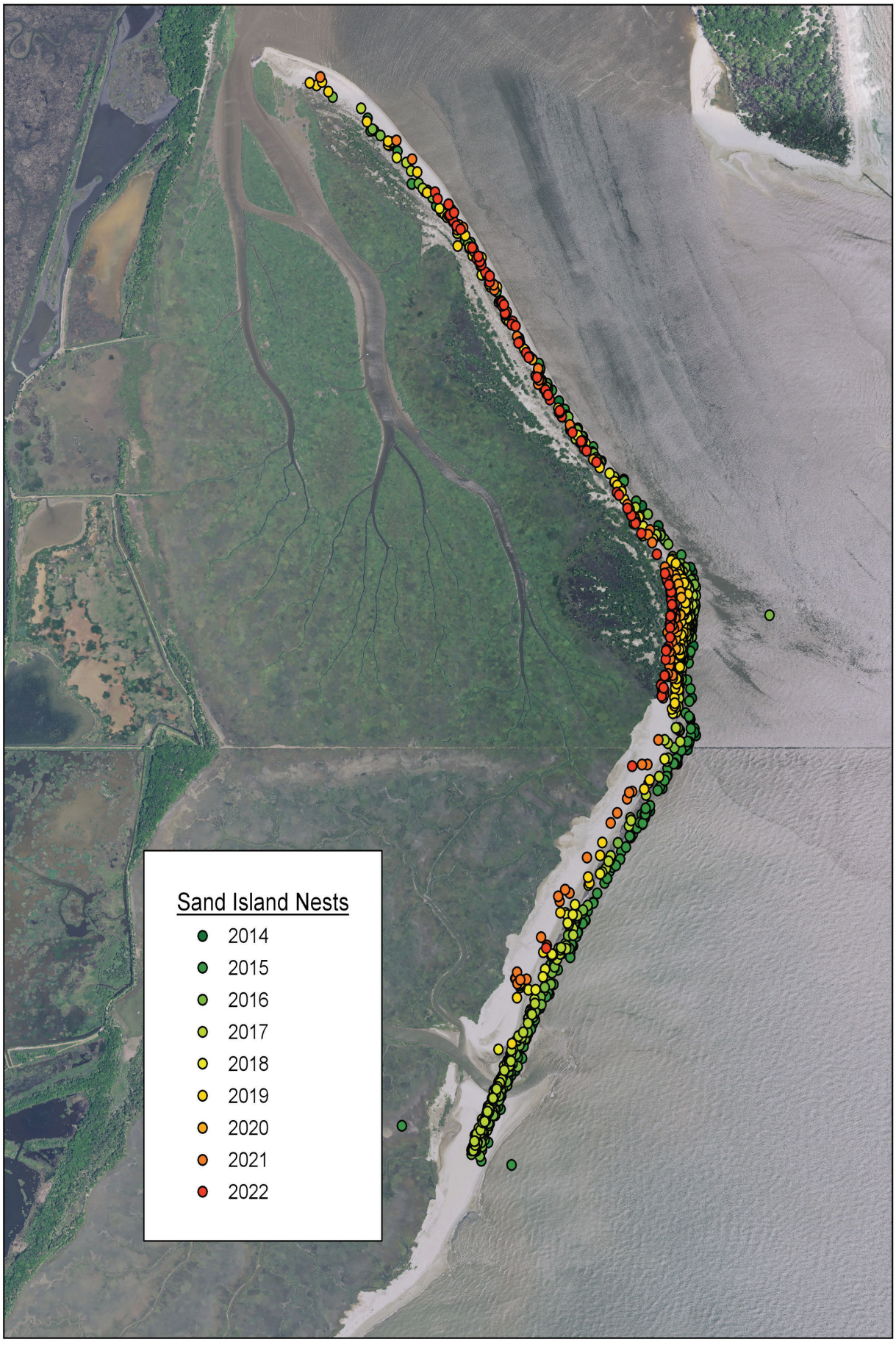
The loggerhead sea turtle is a large marine turtle (average 250 lbs.) with populations ranging around the globe. Overall, the population is in decline and is listed as endangered by the International Union of the Conservation of Nature. The United States population is separated into 5 distinct groups, all of which are listed as either threatened or endangered since 1978. South Carolina's loggerhead sea turtles are part of the Northern Recovery Unit, the second largest recovery unit in the United States. Initial population declines in the Northern Recovery Unit were attributed to entrapment and drowning of adult sea turtles in trawler nets on commercial fishing fleets and the loss of nesting habitat from coastal development.

Loggerhead sea turtles require 27-35 years to reach sexual maturity. When large numbers of the adults are removed from the population effects on nesting are observed immediately and population recovery can take decades. Regulations enacted in 1989 requiring turtle excluder devices (TEDs) on trawler nets greatly reduced adult turtle mortality and nesting numbers have been on a steady rise in the Northern Recovery Unit.

The Tom Yawkey Wildlife Center's beaches have always been an important site for loggerhead sea turtle nesting. In the late 1960's a close friend of Tom Yawkey, Thomas Samworth, collected several years of nesting data. Official surveys by SCDNR staff began on South Island in 1977. Since 1977 the South Island beach has served an important role of being one of three index beaches used to track nest success of loggerhead sea turtles on South Carolina's coast. All beaches of the YWC (South, Sand, and North Islands) are surveyed for nests at least every other day and are important sites for a 10-year region wide genetics study. The surveys show an upward trend in sea turtle nesting, potentially reflecting the long-term gains of using TEDs (e.g., nesting spiked in 2019 or approximately when nestlings from 1989 would start to become sexually mature).

Unfortunately, climate change poses another risk to loggerhead sea turtles. Increased frequency of large tidal events and increasing numbers of hurricanes have caused beaches to erode and dune lines to develop steep escarpments. These changes to beaches reduce nesting habitat and make some beaches impassable to nesting turtles. The results of these changes are being tracked at YWC and throughout the region to help plan for the continued success of this species.




Sand Island Nests
2014
2015
2016
2017
2018
2019
2020
2021
2022

SURVEYS

SURVEY AND MONITORING HIGHLIGHTS

Inventories of species or particular habitat types are essential data sets for effectively targeting conservation efforts, formulating management policies, prioritizing research, and designing appropriate monitoring protocols. Baseline surveys are necessary to document the presence and abundance of species on the Tom Yawkey Wildlife Center and subsequently identify conservation and research needs. There are currently 18 routine long-term surveys that take place on the Tom Yawkey Wildlife Center ranging from point counts to line transects. Highlights include:

- 169 red-cockaded woodpecker cavity trees were "peeped" utilizing a wireless digital camera system. This method allows for safer monitoring for the birds and staff conducting the surveys.
- Monthly waterfowl and wading bird point counts were conducted within the managed wetlands to monitor use trends. The high count numbers were 13,462 waterfowl and 1,151 wading birds.
- Weekly shorebird utilization censuses were conducted within the managed wetlands during peak spring and fall migration periods. High count days were over 13,000 individuals of 18 species.
- Two bobwhite quail calling cock count transects were conducted on Cat Island.
- Alligator spotlight counts were conducted quarterly in Spring, Summer, Fall and Winter.
- The 13-mile white-tailed deer spotlight transect was conducted for the 38th consecutive year.
- Furbearer track plot counts were conducted around the managed wetlands, front beach and longleaf pine stands.
- Camera traps detected black rail nesting activity in several managed wetlands.
- Four black rail playback point counts were conducted on Cat and South Islands.

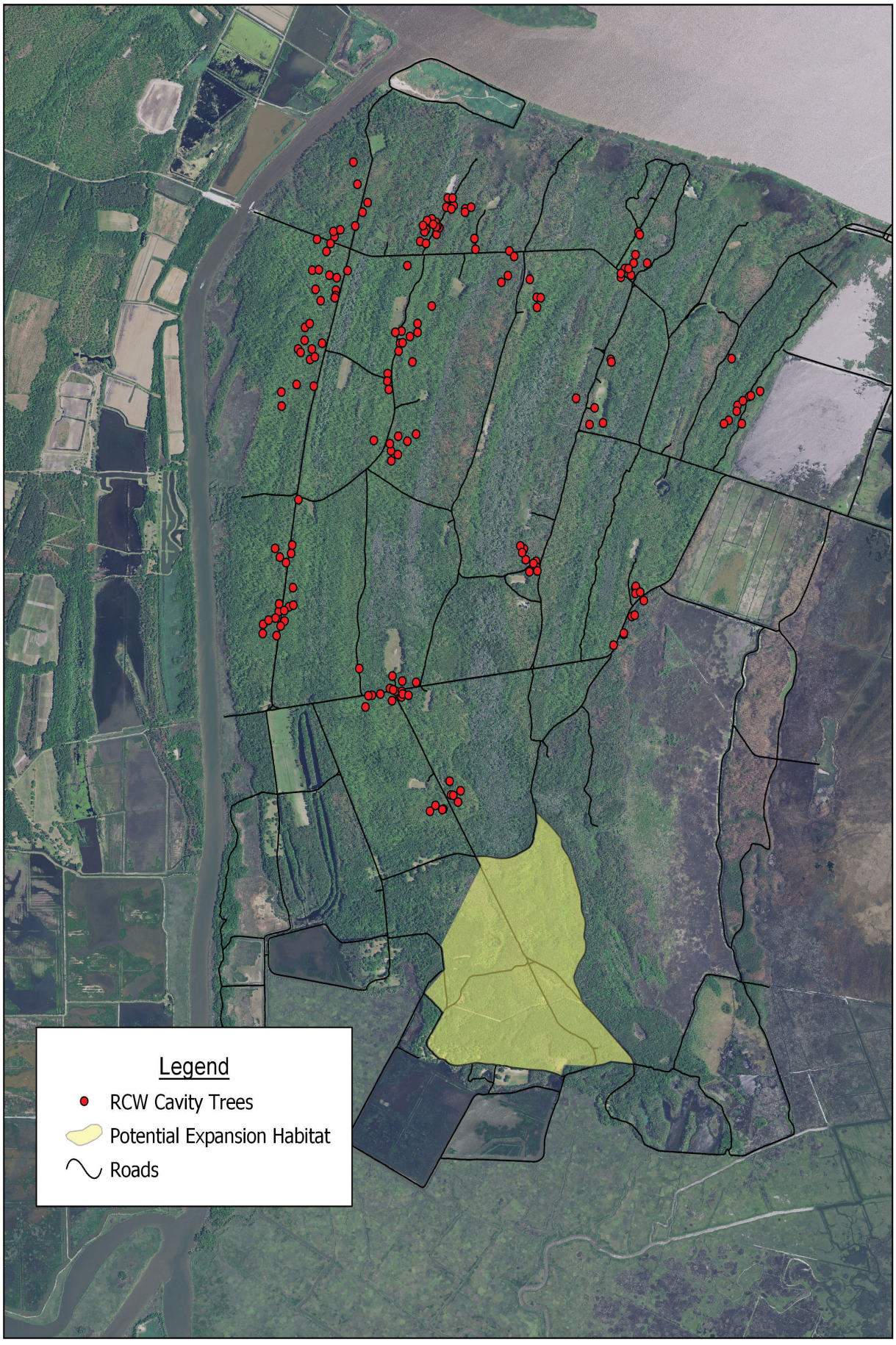
RED COCKADED WOODPECKER SURVEYS

The red-cockaded woodpecker (RCW) is a specialized species adapted to the longleaf pine ecosystem. These birds prefer an open-understory pine forest with large, widely spaced older-growth trees. During the early to mid-20th Century, expansive timber harvest and the exclusion of fire from the landscape across the southeast reduced the range of the longleaf pine by nearly 96% from 90 million acres to its present 3.4 million acres. As a result of this loss of habitat, the RCW population declined from an estimated 920,000 clusters, or family groups, at the time of European settlement to a low of 4,000 widely scattered, isolated, and declining clusters in 1979. With this precipitous population decline the RCW was one of the first species to be listed as Federally Endangered in 1970.

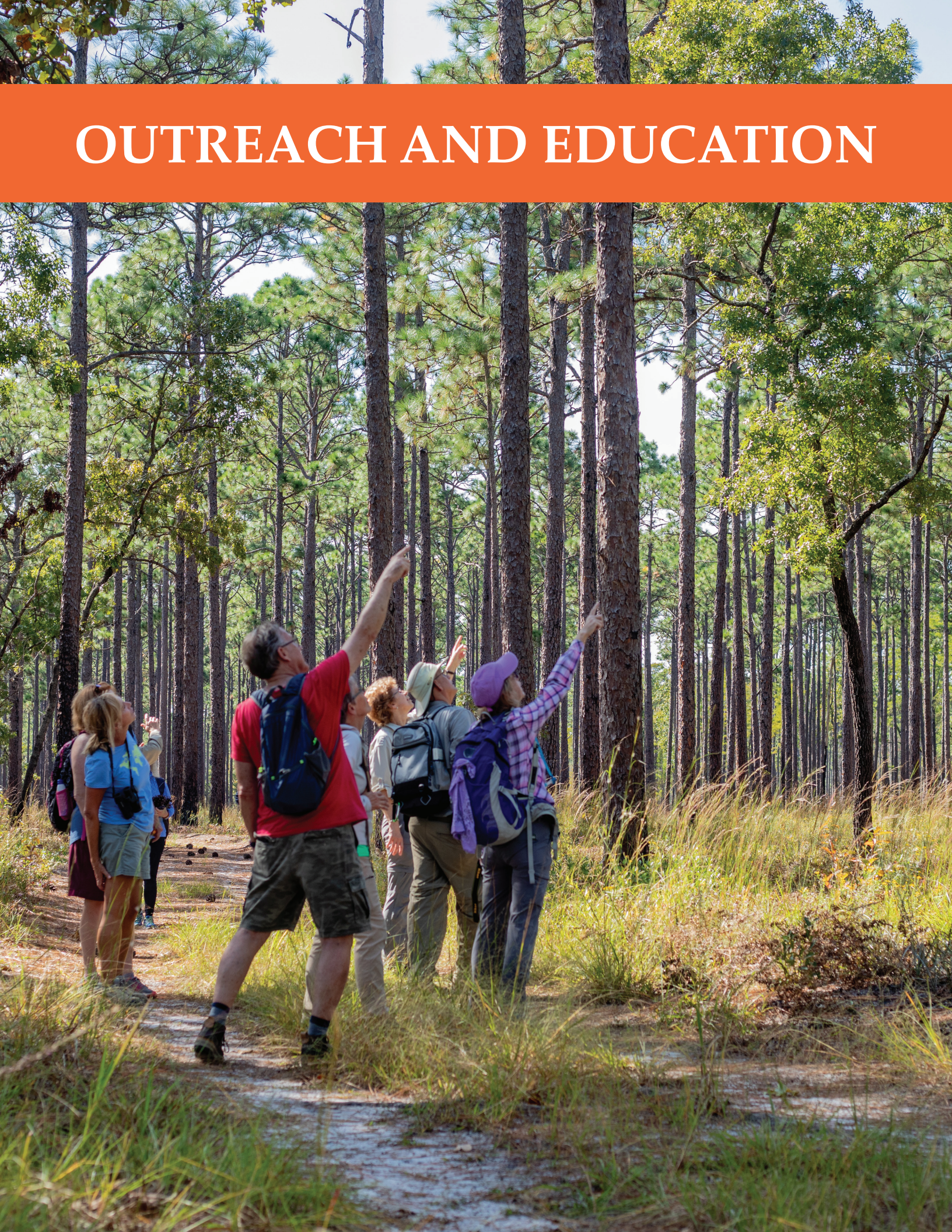
Like many of the forests in the southeastern coastal plain, the Tom Yawkey Wildlife Center's (YWC) upland pine forests were extensively clearcut at the turn of the 20th Century. This harvesting along with the exclusion of fire from the landscape greatly reduced quality habitat available for RCWs and other longleaf pine obligate species. In the 1960's, thanks to the foresight of Tom Yawkey and his land managers, broad- based ecosystem management was implemented on Cat Island. Small-scale timber thinning operations were used to reduce tree density. Prescribed fire was intensively reintroduced and opened the understory by removing invasive hardwood species. This habitat management allowed a small remnant population of RCWs to thrive and expand, unlike the broader range-wide population that showed steady declines until the mid-1990's. This success was documented when the United States Fish and Wildlife Service (USFWS) named the YWC a *Significant Support Population*, a designation that defines a property that has a population goal of 10 or more active clusters, that are highly aggregated in space, and has a good probability of persistence over 20+ years.

Formal surveys of the RCW population at the YWC began in 1977 by biologists with SCDNR's Nongame and Endangered Species section and sporadically continued until YWC staff took over surveying responsibilities in 2008. During that time the RCW population at had grown from 1 active cluster with 5 cavity trees to 15 active clusters with 177 cavity trees. In 2015 the YWC reached the minimum population recovery goal of 15 clusters set by the USFWS Recovery Plan. The current management plan for the Tom Yawkey Wildlife Center has a more ambitious goal of 20 active clusters. In 2021, 17 active clusters were documented.

Staff continues to maintain high quality habitat in the upland pine forests on Cat Island with a 2-3-year prescribed fire rotation. The construction of the swing bridge also allows for timber management through selected thinning.


Legend
RCW Cavity Trees
Potential Expansion Habitat
Roads

OUTREACH AND EDUCATION



OUTREACH AND EDUCATION HIGHLIGHTS

The mission of the Outreach and Education program at the Tom Yawkey Wildlife Center is to educate individuals on the legacy of Tom and Jean Yawkey, the cultural richness and diverse natural history of the property, and the current wildlife management and research activities through minimally impactful guided interpretive visits. The Tom Yawkey Wildlife Center provides an opportunity to bring researchers, educators, land managers, students and the public together for programs. This ability to control access and provide a knowledgeable guide allows more in-depth tours and a one-on-one experience with the natural resources. Highlights from the year include:

- Conducted 287 guided educational field trips for 3,900 individuals.
- Conducted 21 public presentations at locations other than the Tom Yawkey Wildlife Center.
- Hosted 36 class labs for students from Horry-Georgetown Technical College, Clemson University, College of Charleston, University of South Carolina and Wofford College.
- Mentored 6 students from Horry-Georgetown Technical College, Wofford College and Clemson University as interns. These students logged over 6,000 hours working with Tom Yawkey Wildlife Center staff and researchers.
- Staff produced 99 posts on Facebook and 72 posts on Instagram that had over 260,000 views. Currently the Tom Yawkey Wildlife Center Facebook page has 6,263 followers and the Instagram page has 1,220 followers.
- Guided five Eagle Scout projects and hosted two Boy Scout camporees.

RESEARCH

OUTREACH AND EDUCATION HIGHLIGHTS

The past year has been another exciting and productive time for the Tom Yawkey Wildlife Center (YWC)- Clemson University Baruch Institute of Coastal Ecology and Forest Science (CU-BICEFS) Wildlife Research Program. Our primary goals since the inception of the program have been to remain highly productive with our ongoing wildlife research projects; disseminate the results of our work to a variety of audiences; provide educational opportunities for students, scientists, and the public; and maintain and create collaborative relationships with a diversity of partners. Despite continued challenges associated with the COVID-19 pandemic in 2021, the collective effort of our team, collaborators, and partners during this time allowed us to adapt to these challenging conditions, keep our projects on track, and accomplish our goals.

From a research perspective, we collaborated on over 20 different wildlife research projects, including 15 at YWC, four in other areas of the South Carolina coastal plain, and five abroad (Australia, Belize, Lao PDR, Myanmar, South Africa). These projects focused on the biology, ecology, and ecotoxicology of a variety of wildlife species including alligators, crocodiles, turtles, snakes, bobcats, bats, and birds. Hand in hand with our research efforts, we continued to actively share our research findings with the public, publishing 17 peer-reviewed scientific papers, including three associated with research conducted at YWC, and making numerous presentations on wildlife biology, conservation, and management to a variety of audiences (e.g., scientists, students, public).

During 2020-2022, we were also able to maintain momentum with our education and outreach endeavors. We and our colleagues continued to mentor several graduate students on their Ph.D. and M.S. research projects involving alligator ecology and ecotoxicology, many of which were or continue to be conducted on YWC. We also hosted and mentored undergraduate students from multiple universities who had the opportunity to work as summer interns on various wildlife projects at YWC. And, despite continued restrictions related to COVID-19, we were still able to safely provide field trips and research opportunities at YWC to both local and visiting scientists and students.

Finally, we continued working with over 40 of our academic, private, and governmental partners to implement collaborative projects in wildlife research and conservation at YWC, across the South Carolina coastal plain, and beyond. Through all these activities, we were able to maintain long-term research, initiate novel research projects, mentor students, educate and provide unique experiences for the public, and create and strengthen collaborations with numerous partners, all of which continued setting the foundation for continued success in wildlife research at YWC/CU-BICEFS.

The following pages of this report highlight many of our recent and ongoing wildlife research projects at YWC. We are grateful to our staff, collaborators and partners for their continued expertise and support, particularly during another year of challenges, and greatly look forward to new and continued collaborations, stimulating learning experiences, and exciting scientific discoveries.

Thomas Rainwater, PhD, Research Coordinator
CLEMSON UNIVERSITY RESEARCH PARTNERSHIP

PEER-REVIEWED PUBLICATIONS

Evidence of Determinate Growth in an American Alligator Based on Long- Term Recapture and Osteohistological Confirmation

Thomas R. Rainwater[1,4], Holly N. Woodward[2], Allan R. Woodward[3], Phillip M. Wilkinson[4].
2021. The Anatomical Record, 1-8.

[1]Tom Yawkey Wildlife Center Heritage Preserve, South Carolina Department of Natural Resources, Georgetown, SC
[2]Department of Anatomy and Cell Biology, Oklahoma State University Center for Health Sciences, Tulsa, OK
[3]Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, Gainesville, FL
[4]Belle W. Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC

Despite the general perception that crocodilians exhibit indeterminate growth, recent long-term field studies and laboratory investigations have independently suggested that growth in these animals is determinate. In this study, we had the unique opportunity to examine skeletal growth is a wild adult American alligator (*Alligator mississippiensis*) based on change in body length measurements (snout- length length) in the field and confirm these findings using osteohistological analysis (presence/absence of an external fundamental system [EFSI]) of long bones. The alligator was captured and measured five times over 7 years and exhibited no discernable growth during that period, suggesting skeletal maturity had been attained at or prior to its first capture. Our field assessment of determinate growth in this alligator was osteohistologically confirmed by the presence of an EFS in the animal's humerus, femur, tibia, and fibula. To our knowledge, this study is the first to report determinate growth in a wild crocodilian using both field and laboratory methods, providing further evidence of this growth pattern in crocodilians.

Incubation Temperature and Maternal Resource Provisioning, but Not Contaminant Exposure, Shape Hatchling Phenotypes in a Species with Temperature-Dependent Sex Determination

Samantha L. Bock[1,2], Matthew D. Hale[1,2,3], Thomas R. Rainwater[4,5], Philip M. Wilkinson[4], Benjamin B. Parrot[1,2]. 2021. Biological Bulletin, 241(8).

[1]Eugene P. Odum School of Ecology, University of Georgia, Athens, GA
[2]Savannah River Ecology Laboratory, Aiken, SC
[3]Department of Biology, University of Virginia, Charlottesville, VA
[4]Tom Yawkey Wildlife Center Heritage Preserve, South Carolina Department of Natural Resources, Georgetown, SC
[5]Belle W. Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC

The environment experienced during embryonic development is a rich source of phenotypic variation, as environmental signals have the potential to both inform adaptive plastic responses and disrupt normal developmental programs. Environment-by-embryo interactions are particularly consequential for species with temperature-dependent sex determination, a mode of sex determination common in non-avian reptiles and fish, in which thermal cues during a discrete period of development drive the formation of either an ovary or a testis. Here we examine the impact of thermal variation during incubation in combination with developmental exposure to a common endocrine-disrupting contaminant on fitness-related hatchling traits in the American alligator (Alligator mississippiensis), a species with temperature-dependent sex determination. Using a factorial design, we exposed field-collected eggs to five thermal profiles (three constant temperatures, two fluctuating temperatures) and two environmentally relevant doses of the pesticide metabolite dichlorodiphenyldichloroethylene; and we quantified incubation duration, sex ratios, hatchling morphometric traits, and growth (9–10 days post-hatch).

Whereas dichlorodiphenyldichloroethylene exposure did not generally affect hatchling traits, constant and fluctuating temperatures produced diverse phenotypic effects. Thermal fluctuations led to subtle changes in incubation duration and produced shorter hatchlings with smaller heads when compared to the constant temperature control. Warmer, male-promoting incubation temperatures resulted in larger hatchlings with more residual yolk reserves when compared to cooler, female-promoting temperatures. Together, these findings advance our understanding of how complex environmental factors interact with developing organisms to generate phenotypic variation and raise questions regarding the mechanisms connecting variable thermal conditions to responses in hatchling traits and their evolutionary implications for temperature-dependent sex determination.

Intrinsic and Extrinsic Factors Interact During Development to Influence Telomere Length in a Long-Lived Reptile

Junsoo Bae[1,2], Emily M. Bertucci[1,3], Samantha L. Bock[1,3], Matthew D. Hale[1,3], Jameel Moore[1,4], Philip M. Wilkinson[5], Thomas R. Rainwater[5,6], John A. Bowden[7], Therese Koal[8], Hai PhamTuan[8], Benjamin B. Parrott[1,3]. 2021. Molecular Ecology, 110, 1-14.

[1]*Savannah River Ecology Laboratory, Aiken, SC*
[2]*Augusta University, Augusta, GA*
[3]*Eugene P. Odum School of Ecology, University of Georgia, Athens, GA*
[4]*Benedict College, Columbia, SC*
[5]*Tom Yawkey Wildlife Center, South Carolina Department of Natural Resources, Georgetown, SC*
[6]*Belle W. Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC*
[7]*Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL*
[8]*Biocrates Life Sciences AG, Innsbruck, Austria*

The mechanisms connecting environmental conditions to plasticity in biological aging trajectories are fundamental to understanding individual variation in functional traits and life history. Recent findings suggest that telomere biology is especially dynamic during early life stages and has long-term consequences for subsequent reproduction and survival. However, our current understanding is mostly derived from studies investigating ecological and anthropogenic factors separately, leaving the effects of complex environmental interactions unresolved. American alligators (Alligator mississippiensis) are long- lived apex predators that rely on incubation temperature during a discrete period during development and endocrine cues to determine sex, making them especially vulnerable to current climatic variability and exposure to anthropogenic contaminants interfering with hormone function. Here, we combine field studies with a factorial design to understand how the developmental environment, along with intrinsic biological variation contribute to persistent telomere variation. We found that exposure to a common endocrine disrupting contaminant, DDE, affects telomere length, but that the directionality is highly dependent upon incubation temperature. Variation in hatchling growth, underlies a strong clutch effect. We also assess concentrations of a panel of glucocorticoid hormones and find that contaminant exposure elicits an increase in circulating glucocorticoids. Consistent with emerging evidence linking stress and aging trajectories, GC levels also appear to trend with shorter telomere length. Thus, we add support for a mechanistic link between contaminants and glucocorticoid signaling, which interacts with ecological aspects of the developmental environment to alter telomere dynamics.

Summer Ichthyoplankton Assemblage Diversity Within a Southeastern United States Estuary

Bruce W. Pfirrmann[1], Matthew E. Kimball[1], Marvin M. Mace III[1], and Brendan D. Turley[2]. 2021. Estuaries and Coasts, 44: 253-268.

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We evaluated spatial, short-term, and decadal-scale variability in the summer ichthyoplankton assemblages within the North Inlet-Winyah Bay estuarine system, Georgetown County, South Carolina, USA. Ichthyoplankton were collected weekly from late May to early September 2016 on nighttime flood tides using a 1-m diameter, 1-mm mesh plankton net at three sites of varying salinity and proximity to inlets. Nearly 30,000 fishes representing 59 taxa were collected from all three sites over the 14-week study period. *Gobiidae* and *Anchoa* spp. dominated the overall community, composing between 69 and 94% of the total catch at each of the three sites. Weekly densities of all taxa combined did not vary between sites, yet diversity metrics (richness, evenness, Shannon-Weiner index, and Simpson's index) were greatest at the highest salinity site, and overall assemblage composition significantly varied among sites. Non-metric multidimensional scaling suggested a shift in the assemblage at all sites corresponding to an increase in water temperature throughout the summer. Differences in family-level assemblage composition between this study and previous work from the 1980s were detected, differences which may be indicative of regional-scale environmental change. Overall, the summer ichthyoplankton assemblages resembled those from other estuaries along the southeastern US Atlantic coast and temperate regions worldwide, generally dominated by a few taxa and composed of a mixture of estuarine-, estuarine and nearshore-, and continental shelf-spawning taxa.

Investigation Into the Occurrence of Juvenile Common Snook, a Subtropical Estuarine Sport Fish, in Saltmarshes Beyond Their Established Range

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Given recent trends of warming water temperatures and shifting fish distributions, detecting range expansion is important for resource management and planning. The subtropical common snook Centropomus undecimalis (hereafter referred to as snook) is an estuarine species that historically extended from the tropics to southern portions of Florida and Texas, but this range has been expanding for the past decade. We collected juvenile snook (n = 16; size range = 96–210-mm standard length [SL]) in saltmarshes of South Carolina, which is well outside their usual range but not unprecedented. Growth rates of juvenile snook in South Carolina (0.72-mm SL d−1) were similar to those reported for Florida during a cold period, but faster than rates reported for Florida during a recent period of mild winters (0.49-mm SL d−1). Based on collection and estimated hatch dates, and supported by winter water temperature records, juvenile snook overwintered for at least 1 year allowing them to grow to sizes that are typical for emigration from nursery habitats to open estuarine shorelines. Continued work is needed to determine whether there is potential for ongoing range expansion of snook to the region, and a strategy is proposed to focus on future research.

Genetic Data Disagree with Described Subspecies Ranges for Seaside Sparrows on the Atlantic Coast

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Seaside Sparrows (*Ammospiza maritima*) are tidal salt marsh endemic passerines found along the Atlantic and Gulf coasts of North America. Currently, there are 7 described subspecies, and "MacGillivray's" Seaside Sparrow (*A. m. macgillivraii*) is the name given to the Atlantic coast subspecies breeding from North Carolina to northern Florida. In 2019 the US Fish and Wildlife Service received a petition to list this subspecies under the Endangered Species Act due to shrinking populations and loss of marsh habitat, which necessitated a Species Status Assessment. As part of the Species Status Assessment, we analyzed genetic (microsatellite and mitochondria) data from 464 Seaside Sparrows from Connecticut to Florida, USA, to infer population connectivity (gene flow) among Atlantic coast populations, and to assess the concordance of population genetic data with the putative ranges of the subspecies. Bayesian cluster analysis (program STRUCTURE) indicates three genetically distinct population segments: (1) Florida + Georgia, (2) Charleston, South Carolina, and (3) North Carolina to Connecticut. The population in Charleston, South Carolina was the most strongly differentiated based on microsatellite data, and harbored a unique mitochondrial haplotype not shared by other sampling locations, possibly reflecting long-standing isolation. Our results indicate population genetic discordance with currently described ranges of the subspecies of Seaside Sparrow and provide grounds for the consideration of separate management plans for the three populations.

Eastern Black Rail Detection Using Semi-Automated Analysis of Long-Duration Acoustic Recordings

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Detecting presence and inferring absence are both critical in species monitoring and management. False negatives in any survey methodology can have significant consequences when conservation decisions are based on incomplete results. Marsh birds are notoriously difficult to detect, and current survey methods rely on traditional labor-intensive methods, and, more recently, passive acoustic monitoring. We investigated the efficiency of passive acoustic monitoring as a survey tool for the cryptic and poorly understood Eastern Black Rail (Laterallus jamaicensis jamaicensis) analyzing data from two sites collected at the Tom Yawkey Wildlife Center, South Carolina, USA. We demonstrate two new techniques to automate the reviewing and analysis of long-duration acoustic monitoring data. First, we used long-duration false- color spectrograms to visualize the 20 days of recording and to confirm presence of Black Rail "kickee- doo" calls. Second, we used a machine learning model (Random Forest in regression mode) to automate the scanning of 480 consecutive hours of acoustic recording and to investigate spatial and temporal presence. Detection of the Black Rail call was confirmed in the long-duration false-color spectrogram and the call recognizer correctly predicted Black Rail in 91% of the first 316 top-ranked predictions at one site. From ten days of continuous acoustic recordings, Black Rail calls were detected on only four consecutive days. Long-duration false-color spectrograms were effective for detecting Black Rail calls because their tendency to vocalize over consecutive minutes leaves a visible trace in the spectrogram. The call recognizer performed effectively when the Black Rail call was the dominant acoustic activity in its frequency band. We demonstrate that combining false-color spectrograms with a machine-learned recognizer creates a more efficient monitoring tool than a stand-alone species-specific call recognizer, with particular utility for species whose vocalization patterns and occurrence are unpredictable or unknown.

A Window Into the Breeding Ecology and Molt of the Eastern Black Rail

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Knowledge of the ecology of the Eastern Black Rail (Laterallus jamaicensis jamaicensis) has remained nearly as elusive as the rail itself. Camera trapping methods facilitated the first study of breeding phenology and chick development, courtship and brood rearing behaviors, and flightless molt phenology and duration. Broods (n = 33) were observed between August 2015 - September 2019. Chicks were capable of flight at approximately 40 days after hatching. Nesting was initiated as early as 17 April 2019 (–x = 5 June ± 30.0 SD) and fledging occurred as late as 30 September 2019 (–x = 10 August). Behavioral observations combined with phenology data provided evidence of pairs raising two or more broods during a breeding season. Flightless molt (n = 10 adults in molt), which was initiated as early as 15 August 2019 and completed as late as 11 October 2019, was completed within approximately 21 days of initiation. Conservation and management strategies should take into consideration periods of vulnerability, which coincide with increasingly severe and frequent coastal flooding events and hurricanes. It is necessary to understand factors key to fecundity and survival to effectively develop conservation strategies to ensure the persistence of the subspecies.

Hidden in Plain Sight: Integrated Population Models to Resolve Partially Observable Latent Population Structure

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Population models often require detailed information on sex-, age-, or size-specific abundances, but population monitoring programs cannot always acquire data at the desired resolution. Thus, state uncertainty in monitoring data can potentially limit the demographic resolution of management decisions, which may be particularly problematic for stage- or size-structured species subject to consumptive use. American alligators have a complex life history characterized by delayed maturity and slow somatic growth, which makes the species particularly sensitive to overharvest. Though alligator populations are subject to recreational harvest throughout their range, the most widely used monitoring method (nightlight surveys) is often unable to obtain size class-specific counts, which limits the ability of managers to evaluate the effects of harvest policies. We constructed a Bayesian integrated population model (IPM) for alligators in Georgetown County, SC, using records of mark–recapture–recovery, clutch size, harvest, and nightlight survey counts collected locally, and auxiliary information on fecundity, sex ratio, and somatic growth from other studies. We created a multistate mark–recapture–recovery model with six size classes to estimate survival probability, and we linked it to a state-space count model to derive estimates of size class-specific detection probability and abundance. Because we worked from a count dataset in which 60% of the original observations were of unknown size, we treated size class as a latent property of detections and developed a novel observation model to make use of information where size could be partly observed. Detection probability was positively associated with alligator size and water temperature, and negatively influenced by water level. Survival probability was lowest in the smallest size class but was relatively similar among the other five size classes (>0.90 for each). While the two nightlight survey count sites exhibited relatively stable population trends, we detected substantially different patterns in size class-specific abundance and trends between each site, including 30%–50% declines in the largest size classes at the site with greater harvest pressure. Here, we illustrate the use of IPMs to produce high-resolution output of latent population structure that is partially observed during the monitoring process.

American Alligator Diet and Prey Guarding

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American Alligators are opportunistic, generalist predators, and their diet has been well-studied throughout most of their range. Several investigations have noted over 20 mammal species in the alligator diet identified from stomach contents or scat. Here we provide records of two mammal species that have rarely or never been reported in previous dietary studies of American alligators.

Our data were collected at two South Carolina Department of Natural Resources wildlife management areas (WMA) in coastal South Carolina that consist of tidal wetlands, maritime and pine forests, sand beaches, and tidal managed impounded wetlands. Our first observation occurred on 29 July 2021 on the Botany Bay Plantation Heritage Preserve WMA, Botany Island in Charleston County. An alligator was observed walking across a mowed field 100 m from a tidal marsh with a dead prey item protruding from the left side of the alligator's jaws. The resolution of the photograph was somewhat low, but by enlarging the image we were able to discern a carapace with multiple bands, characteristic of a Nine-banded Armadillo (*Dasypus novemcinctus*) we were unable to determine if the armadillo had been killed or scavenged by the alligator. To our knowledge, this observation constitutes only the fourth report of armadillo in the diet of alligators. Previously, McNease and Joanen (1977) found armadillo remains in 0.9% of alligator stomachs (N = 314) examined in Louisiana found armadillo hair in 9% of alligator fecal samples (N = 33) examined in Georgia, and Vliet (2020) described an alligator that routinely scavenged armadillos killed by a dog at a private residence in Florida. Although consumption of armadillos by alligators appears to be relatively uncommon, its occurrence will likely increase as the former continues to extend its range toward the alligator's northeastern distributional limit in South and North Carolina.

Our second observation occurred on 7 September 2021 on the Thomas A. Yawkey Wildlife Center (YWC) in Georgetown County. At 0837 h, we observed the partially submerged carcass of a Coyote (*Canis latrans*) at the edge of a small water hole adjacent to an earthen causeway extending through 2.1 km of tidal marsh separating Cat Island and South Island. The carcass appeared bloated, with several white skin patches on the head sloughing off, and on closer inspection the posterior half of the Coyote was absent. Within 2 min of our arrival, the carcass was pulled underwater by an adult (ca. 270 cm TL) alligator, which rolled multiple times before both disappeared, a common crocodilian behavior when subduing or dismembering prey. After 5 min we left the area and returned to the water hole at 1001 h where we found the head (left ear, left eye, open mouth) and anterior torso (left shoulder and forelimb) of the Coyote visible at the water's surface. Within 3 min, the carcass was once again pulled underwater (alligator not visible), and we left the area immediately. The next day, 8 September 2021, we returned to the water hole multiple times throughout the day, and during most visits the alligator's head (but not the Coyote carcass) was visible at the water's surface upon our arrival, but the animal submerged within seconds. On 9 September 2021 at 0848 h, we returned to the water hole to find the alligator, with what appeared to be the Coyote carcass grasped in its jaws, visible at the water's surface. The alligator then quickly submerged. At 1630 h we placed four game cameras (Reconyx® XR6 Ultrafire) around the water hole and while doing so noticed a strong

odor of decomposition. Over the course of the following night, 9 September to the morning of 10 September 2021, the alligator (but not the Coyote carcass) was photographed several times by the game cameras at the water's surface. On the afternoon of 10 September 2021, a series of photographs showed the alligator positioned directly adjacent to the edge of the water hole, its head extended above the water's surface and jaws grasping a white fleshy mass with a canine forelimb attached. At 1719 h, a Turkey Vulture (*Cathartes aura*), likely attracted by olfactory cues appeared on the bank of the water hole and approached the water's edge to within ca. 1 m of the alligator and Coyote carcass. At 1721 h, the alligator was photographed partially on land where the Turkey Vulture had been less than 1 min before (Fig. 1D, E), presumably in response to the vulture's presence and an attempt to guard the carcass; the vulture was not seen in subsequent images. The alligator returned to the water, and the Coyote carcass was last seen (in the alligator's jaws) at 1745 h. On 11 September 2022, the alligator was photographed basking on land directly adjacent to the water hole during six separate events between 0909 h and 1656 h (total of 3.58 h), on 12 September was observed basking only once, from 1155–1240 h, and left the water hole at 2017 h on 14 September.

To our knowledge, this is the first report of *A. mississippiensis* consuming a Coyote; however, such occurrences are not unexpected as alligators commonly prey on Domestic Dogs, and four introduced Red Wolves (*Canis rufus*) were killed by alligators on barrier islands in South Carolina and Florida, including three on Bull Island, ca. 48 km south of YWC. As with armadillos, the incidence of Coyote predation by alligators will likely become more common as these canids continue to expand into the northeastern reaches of the alligator's range.

Finally, our observed interaction between the alligator and Turkey Vulture likely represents an incidence of prey guarding behavior by the former. Although general accounts refer to alligators guarding their prey, to our knowledge this is the first reported observation of this behavior. Interestingly, Platt et al. (2021) reported an instance where a dead but uneaten Turkey Vulture was found beside a fresh Raccoon (*Procyon lotor*) carcass just beyond the entrance of an alligator burrow and they speculated the vulture may have been killed by the resident alligator, presumably while guarding the raccoon carcass. Both Turkey Vultures and Black Vultures (*Coragyps atratus*) probably compete with alligators for uneaten portions of larger prey items, and active guarding may prevent the loss of prey items to these scavenging birds.

Quantifying Circulating IgY Antibody Responses against Select Opportunistic Bacterial Pathogens and Correlations with Body Condition Factors in Wild American Alligators

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Abstract: Little is known about the disease ecology of American alligators (*Alligator mississippiensis*), and especially how they respond immunologically to emerging infectious diseases and zoonotic pathogens. In this study, we examined serum samples collected from wild alligators in Florida (2010–2011) and South Carolina (2011–2012, 2014–2017) for antibody responses to multiple bacteria. Immunoglobulin Y (IgY) was purified from serum to generate a mouse monoclonal antibody (mAb AMY-9) specific to the IgY heavy chain. An indirect ELISA was then developed for quantifying antibody responses against whole cell *Escherichia coli*, *Vibrio parahaemolyticus*, *Vibrio vulnificus*, *My- cobacterium fortuitum*, *Erysipelothrix rhusiopthiae*, and *Streptococcus agalactiae*. In Florida samples the primary differences in antibody levels were between January–March and late spring through summer and early fall (May-October), most likely reflecting seasonal influences in immune responses. Of note, differences over the months in antibody responses were confined to *M. fortuitum*, *E. rhusiopthiae*, *V. vulnificus*, and *E. coli*. Robust antibody responses in SC samples were observed in 2011, 2014, and 2015 against each bacterium except *E. coli*. All antibody responses were low in 2016 and 2017. Some of the highest antibody responses were against *V. parahaemolyticus*, *M. fortuitum*, and *E. rhusiopthiae*. One SC alligator estimated to be 70+ years old exhibited the highest measured antibody response against *V. parahaemolyticus* and *M. fortuitum*. By combining data from both sites, we show a clear correlation between body-mass-indices (BMI) and antibody titers in all six of the bacteria examined. Our study provides a critical antibody reagent and a proof-of-concept approach for studying the disease ecology of alligators in both the wild and in captivity.

Waterfowl Diets and Winter Foraging Habitat in South Atlantic Coastal and Inland Wetlands: Improving Inputs for Bioenergetics Modeling for Regional Conservation Planning

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South Atlantic regional states of North Carolina, South Carolina, Georgia, and Florida contain vast and dynamic wetlands along the Atlantic Coast. Coastal wetlands include managed and non-managed tidal fresh, brackish, and salt marsh that are used extensively by migrating and wintering waterfowl and other waterbirds. Hydrologically managed tidal impoundments (MTIs) are considered among the most important systems for waterbirds in the region. Recent studies have exposed information voids regarding MTIs and other wetland types in the South Atlantic, such as estimates of forage availability for migrating and wintering waterfowl in coastal and inland areas. In addition to forage availability, region specific food habits data for duck species and acreage estimates of privately managed impoundments are outdated or lacking altogether. Thus, landscape-scale research is needed in the South Atlantic Region to obtain estimates of food abundance and test assumptions for bioenergetics modeling used in conservation planning by the Atlantic Coast Joint Venture and its partners to meet population-based habitat objectives set by the North American Waterfowl Management Plan. The objectives of our study are to 1) estimate the frequency of occurrence and relative abundance of diet items consumed by ducks in the South Atlantic, 2) estimate the energetic density (kcal/ha) of waterfowl forage in various wetland types of the region, and 3) improve the wetlands inventory of the South Atlantic by locating and digitizing private impoundments managed for waterfowl. In fall 2021, we conducted waterfowl forage sampling in 20 MTIs, 18 moist soil impoundments, and 12 agriculturally planted impoundments on public and private lands in South Carolina. From those samples, we will estimate the biomass of each waterfowl forage item and combine biomass with previously published energetic values to calculate the energetic density produced within the focal wetland types. To improve the accuracy of our estimates, we collected feces samples from >300 hunter harvested ducks during the 2021-2022 waterfowl hunting season to identify food items consumed by ducks using DNA analysis. These results will help us identify common food items consumed by ducks and exclude those not consumed by ducks from biomass estimates. We plan to continue sampling efforts in autumn-winters 2022 and 2023 and incorporate wetlands in neighboring states (e.g., North Carolina). Information from this research will provide a better understanding of the energetic carrying capacity of South Atlantic wetlands with respect to migrating and wintering waterfowl and reveal management implication for managers regarding prey item selection by waterfowl.

A Survey of South Carolina Beaches for Plastic Litter

Bonnie Ertel and John Weinstein, The Citadel Graduate College

Our global plastic pollution problem is well documented, and during the ongoing COVID-19 pandemic the daily use of personal protective equipment (PPE) and single use plastics has increased and may therefore contribute significantly to the abundance of plastic litter in our environment. In the U.S., preliminary work assessing volunteer litter cleanups suggests that plastic litter has increased in abundance and prevalence since the onset of the pandemic in both rural and coastal areas. However, without standardized methodology and sampling effort it is difficult to track litter trends or compare beaches along a coastline. This project utilized standard beach litter monitoring methods established by OSPAR, a commission of 15 countries and the EU, whose goal is to protect the marine environment of the North-East Atlantic. By applying OSPAR monitoring methods to both popular and remote beaches (n=8) along the Southeastern U.S. Atlantic coast (NC, SC, GA, FL) in both the summer and fall months of 2021, we were able to obtain a baseline understanding of U.S. beach litter abundance and distribution. At each site we sampled a 100 m wide stretch of beach in a methodical pattern, searching for all visible litter which was categorized and recorded using the OSPAR survey data form. Utilizing these standardized sampling methods enabled us to compare litter abundance within U.S. beaches and to the French Atlantic coastline to better understand global sources, distribution, and fate of plastic litter.

South Island at the Tom Yawkey Wildlife Center Heritage Preserve managed by the South Carolina Department of Natural Resources (DNR) was the most remote beach we sampled for this study, with no nearby buildings or public infrastructure on the island. During our initial sampling in August 2021, South Island had 11 items/100m; during our follow-up sampling in December 2021, South Island had 13 litter items/100m. The majority of litter on South Island was plastic (82% and 77% for fall and winter, respectively). No PPE items were found on South Island during these sampling events. South Island was one of the cleanest beaches we sampled, second only to Driftwood Beach on Edisto Island- which is also managed by SCDNR. While Edisto Island was possibly cleaned by visitors or volunteers, South Island is not accessible to the public for cleanups.

During our fall sampling, we mapped litter location using the app Marine Debris Tracker developed by NOAA and found that most litter items were located close to the high tide line. This was evident at most U.S. beaches sampled in this study and indicates that most items were likely deposited by oceanic tides and currents. South Island has restricted access, so litter most likely was deposited by external sources. During our winter sampling, we measured the profile and slope of each beach using the Emery Method South Island's beach had an overall slope of -29%.

We are currently working on comparing our U.S. beach results to French beaches with similar surrounding land use and beach characteristics. Using OSPAR protocols, we will compare abundance and types of litter between these two countries with coastlines along the Atlantic to better understand the fate of plastic litter in our global oceans.

Gullah Geechee Fishing Village Research at the Tom Yawkey Wildlife Center Heritage Preserve

Jodi A. Barnes, Archaeologist, South Carolina Department of Natural Resources

Located on a narrow strip of land between Mosquito Creek and Winyah Bay on South Island, the Gullah Geechee Fishing Village was brought to SCDNR's attention when human remains were found eroding from the shore after Hurricane Irma in 2017. With funding from a Hurricane Irma Emergency Supplemental Historic Preservation Grant, we are conducting archival, oral history, and archaeological research to learn about the Black and White fisherman who lived and worked at this site and biological analysis on the human remains to identify descendants and provide a proper burial. The research built upon the shoreline survey, which included land-scape mapping, systematic surface collection, and shovel test pit (STP) survey. We used the STPS and surface finds overlaid on the maps and plats, like the 1928 sketch map of the village, to target households for additional testing. In the fall, the team excavated 18 1x1 meter test units across the landscape. The artifacts show that the site has a long history with the pre-contact ceramics suggesting that Native Americans lived or visited here since at least the Woodland period and the fishing weights, tablewares, and everyday artifacts suggesting the locations of households and two occupations – one late 18th to early 19th century and one late 19th to early 20th century.

We compiled primary sources including maps and plats, newspaper articles, census records, and photographs to help interpret the artifacts and provide historic context. In addition, the team contracted with Dr. Gillian Richards-Greaves, a cultural anthropologist at Coastal Carolina University, developed an oral history per-missions form, compiled interview questions, prepared letters to engage local communities in the research, and identified potential interviewees. We also worked with Dr. Bill Stevens, Assistant Richland County Coroner, to carry out additional forensic tests, including full DNA phenotyping and genetic genealogy. He sent sample to Kalina Kassadjikova at the University of California, Santa Cruz, to obtain a sample of autosomal DNA single nucleotide polymorphisms. Kassadjikova completed the DNA extraction and is beginning the DNA sequencing which will be analyzed for ancestry and potential relatedness to living individuals. The project will aid in the development of protocols for addressing heritage at risk and tell the multi-dimensional history of fishing, climate, and Gullah Geechee life.

Heritage at Risk Shoreline Survey at the Tom Yawkey Wildlife Center Heritage Preserve

Jodi A. Barnes, Archaeologist, South Carolina Department of Natural Resources

Fieldwork for the Hurricane Irma Emergency Supplemental Historic Preservation Grant funded project included pedestrian and boat survey, landscape mapping, and a 30-meter interval shovel test pit (STP) survey. The team utilized new ArcGIS software including Collector and Survey123 to capture and edit data in the field. This technology aids the analysis of results with the ability to see distribution maps of positive STPs as they are dug and compare that data with historic maps, like the 1880s E. P. Alexander's map of Cat and South Is-lands. The team dug 1242 STPs along a 120-meter periphery alongside the shore of parts of Cat, South, and North Islands. Of those, 396 STPs were positive. In addition, we mapped a number of landscape features including brick scatters, brick foundations, wells, roads, and historic flora plantings. At one site, SCIAA archaeologist, Josh Chaplin found a Morrow Mountain point, which dates to the archaic period. We also found artifacts connected to a 20th century sawmill and its worker housing, a plantation site, a Civil War Redoubt, house sites, and more. The artifacts from these sites have been washed, sorted by material, analyzed, and the data entered into DAACS, the Digital Archaeological Archive of Comparative Slavery. In addition, the team re-analyzed the collections from the 2003 excavations at the North Island Lighthouse and the collections from previous pedestrian surveys of the property. We also compiled primary sources including maps and plats, newspaper articles, census records, and photographs to help interpret the artifacts and provide historic context. Dr. Lindsey Cochrane, an archaeologist at East Tennessee State University, created a predictive model to estimate at a site-specific level the timing of shoreline changes from global sea level rise. The team worked with other SCDNR staff to develop protocols to map the shoreline bordering the identified archaeological sites to document the impacts of erosion to them. The data will be used develop a program to monitor the effects of erosion and other environmental changes to the sites and access future research priorities.

Early-Life Survival Depends on Incubation Temperature, But Not Sex, in the American Alligator: Exploring the Adaptive Value of Temperature-Depen- dent Sex Determination

Samantha Bock, Odum School of Ecology & Savannah River Ecology Laboratory, University of Georgia

Many ectotherms, including all crocodilians, rely on temperature cues experienced during development to determine offspring sex. Ever since the first descriptions of temperature-dependent sex determination (TSD) were made over 50 years ago, an understanding of its adaptive significance has remained elusive, especially in long-lived taxa. One novel hypothesis predicts that TSD should be evolutionarily favored when two criteria are met – (1) incubation temperature influences juvenile survival and (2) sexes mature at different ages. Under these conditions, a sex-dependent effect of temperature on fitness arises through differences in age at sexual maturity, with the sex that matures later benefiting disproportionately from incubation temperatures that promote juvenile survival. Here, we test this hypothesis in the American alligator, a TSD species displaying a stark sex difference in age at first reproduction. By implementing a combination of artificial incubation experiments and mark-recapture methods, we disentangle the effects of incubation temperature and sex on annual survival in alligator hatchlings at two geographically distinct sites. Hatchlings incubated at male-promoting temperatures consistently exhibited higher survival compared to those incubated at female-promoting temperatures. Interestingly, this pattern appears independent of hatchling sex, as females incubated under male-promoting temperatures exhibited similar survival to their male counterparts. These findings support the hypothesis that TSD represents an adaptive sex-allocation strategy in this species. Ongoing work aims to understand the role of temperature- dependent hatchling phenotypes in mediating observed differences in early-life survival.

Ecotoxicology as a Function of Ontogenetic Shift and Diet

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The American alligator (*Alligator mississippiensis*) is an apex predator that can accumulate heavy metals including mercury (Hg) in high concentrations through prey consumption. While several studies have aimed to assess Hg presence in blood and tissue throughout their range, little is known about the ecological drivers of toxicant accumulation in alligators. Additionally, few studies have encompassed multiple size classes and both sexes across multiple sites. The objective of this study was to address how ontogenetic dietary shifts interact with site-specific factors (e.g., freshwater v. marine prey, trophic level of prey) to influence total mercury (THg) accumulation. This study was conducted by obtaining blood samples and stomach contents of alligators (n=230) of all size classes at three locations to assess trends across unique habitats: Okefenokee Swamp, GA (acidic blackwater), Jekyll Island, GA (developed barrier island) and the Tom Yawkey Wildlife Center, SC (undeveloped barrier island). Among captures at Yawkey, mean total Hg in alligator blood was 74.4 ng/g (min-max ± SD = 17.8 – 302.5± 55.9 ng/g, mean =74.4ng/g, N=70.) In addition to Hg analysis, stable isotopes analysis was conducted as an ecological tool for interpreting feeding habits. Specifically, stable isotope values of nitrogen (δ15N) have been used to estimate trophic position of organisms due to the predictable enrichment of δ15N in consumer tissues relative to their diet. We hypothesized a positive relationship between Hg, δ15N, and alligator length which would indicate that larger animals feed at higher trophic levels and consume more Hg. Furthermore, carbon (δ13C) signatures can give insight into the location of feeding in an environment. Results indicate positive relationships between Hg, δ15N, and δ13C in relation to alligator length at two of the three sites (Okefenokee and Yawkey). The results of this study may provide evidence that varying levels of Hg in apex predators are directly related to dietary shifts and habitat, furthering the value of alligators as bioindicators of mercury in locations they inhabit.

Influence of Complete Egg Removal During Early Incubation on Maternal Female Alligator Nest Attendance

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Each June, breeding female American alligators (*Alligator mississippiensis*) build nest mounds out of vegetation in which they deposit up to 60 eggs. The eggs remain covered in the nest for ~65 days until hatching. During this 9-week period, the maternal female remains close to the nest to protect against predators and assist the young to the water after hatching. This behavior is called nest attendance. Every year, hundreds of clutches of alligator eggs are legally collected from wild nests in the southeastern U.S. for research, farming, and ranching purposes. However, little is known regarding the influence of complete egg removal by humans during early incubation on maternal female alligator nest attendance. The aim of this study was to address this data gap. We hypothesized that maternal female alligators can detect when entire egg clutches have been removed from nests and as a result will not attend those nests. In 2020, we located 19 alligator nests on the Tom Yawkey Wildlife Center, South Carolina in which eggs had been recently deposited. We removed complete clutches from eight of these nests ("treatment"), recovered (repaired) the egg cavities with nest material (unlike natural nest predators), and then placed an automated game camera (5 min time lapse) at these and the remaining 11 nests containing clutches ("control") to monitor maternal female alligator nest attendance throughout the incubation period. Contrary to our hypothesis, maternal female alligators did attend nests from which entire clutches were removed. In fact, preliminary analysis suggests that although considerable variation existed among individuals, these females attended nests longer (mean # hours) than females at nests still containing clutches. Further, at eight control nests (clutch present) predated by raccoons (Procyon lotor), mean nest attendance (hours) was greater after predation than prior to predation. Results of this study suggest female alligator nest attendance may be "hard-wired" (e.g., hormonally regulated) such that most females will attend nests throughout the normal incubation period regardless of nest fate during that time. Differences in alligator nest attendance may be related to differences in individual behavior of maternal females, which in turn may be influenced by age, body size, hormone concentrations, and previous nesting experience. Further studies over multiple years and with larger sample sizes are needed to more adequately address these questions.

A Bob-Tale of Two Islands: Comparing Space Use and Toxicant-Exposure Between Bobcat Populations in Coastal South Carolina

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Rodenticides are common environmental toxicants found in wildland-urban interfaces. Second-generation anticoagulant rodenticides (SGAs) are frequently encountered by non-target wildlife through ingestion of affected prey. Wildlife populations on barrier islands may be particularly vulnerable to non-target exposure given the lack of movement and recolonization potential from neighboring unimpacted populations. Bobcats (*Lynx rufus*) on Kiawah Island, South Carolina (Charleston County) experienced a population decline beginning in 2019, decreasing from an estimated 30 individuals to as few as 10. Several bobcat deaths were confirmed to be the result of acute SGA poisoning, signaling a need to assess the effects of SGAs on Kiawah bobcats and potential areas of exposure more finely. SGA exposure by bobcats could be related to their movement behavior, which is known to be influenced by human disturbance and development, prey availability, and intrinsic factors like sex and seasonal changes in life history. In addition to bobcat space use in response to these intrinsic and environmental factors possibly influencing SGA exposure, once exposed, little is known about the effects of SGAs on bobcat behavior and movement. To broaden the scope of understanding, we will juxtapose the Kiawah Island population with another bobcat population on South Island, South Carolina within the Tom Yawkey Wildlife Center (Georgetown County). By tracking bobcats at both sites, we will be able to compare differences in fine-scaled movement patterns of bobcats within similar environments but differing levels of human disturbance and rodenticide exposure. The goal will be to closely examine the connection between space use patterns and SGA exposure. Finally, because bobcat diet is directly related to SGA exposure risk, comparing prey preference of bobcats on Kiawah (exposed) to bobcats on Yawkey (un- or less exposed) may provide greater insight into the link between site-specific diet and exposure risk.

THESES AND DISSERTATIONS

Early Life History of Tarpon in South Carolina Estuaries: Assessment of Juvenile Recruitment and Validity of Aging and Back-Calculation Methods

Garrett M. Elmo. 2021. MS Thesis, Coastal Carolina University, Conway, SC

I investigated habitat use and age estimation methods for juvenile tarpon (*Megalops atlanticus*) to better understand use of natural and managed habitats in coastal South Carolina and to provide guidance for estimating life history characteristics that are dependent on age data. Tarpon were sampled during July – November 2019 in natural marsh pools of North Inlet estuary, and in managed impoundments of Kiawah Island and Tom Yawkey Wildlife Center Heritage Preserve to compare arrival duration (duration of ingress) and size structure (standard length, SL) of tarpon in these habitats. The accuracy and precision of age estimation and back-calculation methods were assessed using oxytetracycline to chemically mark juvenile tarpon for an annual increment validation study, a marginal increment analysis study, a controlled back-calculation validation study, and a controlled daily increment periodicity study. One-hundred and two juvenile tarpon (36 – 333 mm SL) were collected during July – November 2019. Tarpon from natural marsh pools (North Inlet estuary; 65.4 ± 20.2 mm) were smaller than those from managed impoundments (Kiawah Island and Yawkey Preserve; 253.9 ± 41.6 mm), with no overlap in size between habitat types. Mean tarpon length was relatively constant throughout the study in natural marsh pools (65 mm SL), but mean tarpon length increased from 180 mm SL in August to 289 mm SL in October in managed impoundments. Peak catch-per-unit-effort occurred from August (natural marsh pools) into September (managed impoundments), and then declined as water temperatures decreased from late October into November. The absence of SL overlap between habitats and increasing tarpon SL over time in marsh impoundments compared to the minimal change in SL over time observed for marsh pools suggests (1) tarpon are transient in vi marsh pools early in life, (2) tarpon do not enter impoundments until reaching a certain SL, (3) small juvenile tarpon are cryptic in impoundments and larger juvenile stage tarpon are more susceptible to capture, or (4) a combination of (1), (2), and (3). Oxytetracycline marks were visible on all the otoliths of recaptured tarpon (n = 22), prior to a newly formed annulus, validating true age and that one annulus is deposited yearly. However, annuli in scales were more easily identified by readers, thus leading to more accurate and precise estimates of age from scales (100% accuracy of age estimates for age-1 fish) compared to otoliths (88% accuracy). Marginal increment analyses indicated that tarpon annuli are deposited in the spring (March-April) on juvenile tarpon scales and otoliths. Back-calculated lengths were significantly different from measured lengths. Daily increment estimates from otoliths were inaccurate and imprecise, with no correct age estimates and a mean absolute difference of 21 d (37%) from known age. Increments were crowded near the otolith edges, resulting in underestimation of daily increments; therefore, juvenile tarpon daily increment periodicity was unable to be validated. These findings provide valuable information about habitat utilization of juvenile tarpon, provide support for scales as a viable accurate and precise non-lethal age estimation option that will allow researchers to study age, growth, and habitat quality of juvenile tarpon without sacrificing individuals, and validates annual increment periodicity and timing of annulus formation that will aid in future age estimation efforts of juvenile tarpon. Future research should address potential ontogenetic shifts in habitat use by young juvenile tarpon (ages 0-1) and differential growth across habitats, investigate the use of scales for age estimation of older juvenile tarpon (≥age 2), investigate the use of other non-lethal structures for accuracy and precision of age estimation methods, and investigate the vii relationship between otolith and somatic growth for young juvenile tarpon (<age 0) to allow for informed management of this species.

Temperature and Hormonal Drivers of Immune Performance in Vertebrates

Ashley Anne Lavere. 2020. MS Thesis, University of Georgia, Athens, GA

Immunity is a physiological process crucial to survival. Thus, identifying factors influencing immunity is important for understanding variation in an organism's fitness across contexts. In this thesis, I used microbial killing assays to examine temperature and hormonal drivers of immune performance across vertebrates. First, by testing testosterone-immunity relationships in alligators, I found that interactions with co-circulating hormones and temperature may be important mediators of testosterone-immunity trade- offs. Second, by assessing immune performance of endotherms and ectotherms across temperatures, I found that immune performance across temperatures depended on thermoregulatory strategy and that thermoregulatory strategy determined whether temperature-imposed trade-offs on immunity. Third, I showed that variability in immune performance depended on microbial context, with the presence of testosterone-immunity tradeoffs and temperature-dependent shifts in immune performance varying across the different microbes used to quantify immune performance. In aggregate, this work provides insights into immunological trade-offs and intrinsic and extrinsic factors influencing these trade-offs.

IN THE MEDIA

Online article entitled "Clemson researcher details discovery of rare, white-skinned alligators in coastal SC" published by Clemson University describing the discovery of wild leucistic (white skin, blue eyes) hatchling alligators in coastal South Carolina by Thomas Rainwater and colleagues.

Online article entitled "American Alligator's Sex Ratios Could Go Haywire" published on Samantha Bock's research and recent paper on the influence of climate change on alligator nest temperatures, embryonic development, sex ratios, and ultimately population demography.

Newspaper article ("A rare discovery: Clemson researcher publishes details on 6 white alligator hatchlings") and online ("Researchers detail findings of rare, white-skinned alligator hatchlings in Lowcountry") published by the Post and Courier Newspaper about the discovery of six rare white ("leucistic") alligators in coastal South Carolina by Thomas Rainwater and colleagues.

Online news article entitled "Ecoviews: Why would fish follow a turtle?" about a paper published on a nuclear-follower foraging relationship between spiny softshell turtles and fish (Platt, S.G. and T.R. Rainwater. 2021. Observations of a nuclear-follower foraging association between Spiny Softshell Turtles (Apalone spinifera) and fish in an urban drainage canal in Louisiana. (Southeastern Naturalist 20(4): N108-N114)

PROFESSIONAL PRESENTATIONS

Singh, R., T.R. Rainwater, P.M. Wilkinson, S.G. Platt, B. Song, C.M.B. Jachowski. Factors influencing nest attendance of American alligators in coastal South Carolina. Poster presentation at the 2021 Clemson University South Carolina Department of Natural Resources Cooperators Meeting. Clemson, SC. 23 September 2021.

Singh, R., T.R. Rainwater, P.M. Wilkinson, S.G. Platt, B. Song, C.M.B. Jachowski. Factors influencing nest attendance of American alligators in coastal South Carolina. Oral and poster presentations at the "Behind the Gate" Summer Student Research Event, Clemson University Baruch Institute of Coastal Ecology and Forest Science, Hobcaw Barony, Georgetown, SC. 30 July 2021.

Rainwater, T.R. Biology of American Alligators in Coastal South Carolina: Recent Discoveries and Collaborative Opportunities. (Virtual presentation) Clemson University Department of Forestry and Environmental Conservation and Natural Resources Graduate Student Association Fall Ecology and Natural Resources Speaker Series. Clemson, SC. 19 November 2021.

Rainwater, T.R. Current Research on the American Alligator in Coastal South Carolina. Virtual Trust Talks, Spring Island/Spring Island Trust. Spring Island, SC. 14 October 2021.

Rainwater, T.R. Dragons of the Lowcountry: American Alligators in Coastal South Carolina. Cypress Gardens Summer Seminar Series. Cypress Gardens, Monck's Corner, SC. 21 August 2021.

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