

2022 WILDLIFE DIVERSITY PROGRAM ANNUAL REPORT



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Southern Hognose Snake (Jeff Hall)

The North Carolina Wildlife Resources Commission's (NCWRC) Wildlife Diversity (WD) Program is housed within the agency's Inland Fisheries (Aquatic Wildlife Diversity) and Wildlife Management divisions. Program responsibilities principally include surveys, research and other projects for nongame and endangered wildlife species. Nongame species are animals without an open hunting, fishing or trapping season.

Program Updates - 2022

As conservation work has become more complex over the past several years, our biologists have taken on diverse responsibilities from the core roles of providing expert advice on species conservation, to working with landowners, and putting conservation on the ground. They have also been applying for grants, publishing study results, and recruiting and managing volunteers.

Responding to these emerging and persistent needs, in 2022 we created a Science Support Team within the Wildlife Management Division's WD section. Comprising skilled outreach and education staff and biologists, this new group will collaborate with our taxa and field biologists to:

- Organize management of and assist with training and outreach events for the thousands of North Carolinians who volunteer for projects like the NC Bird Atlas, NABat surveys, and Sea Turtle monitoring;
- Provide support for report and publication writing (e.g., Wildlife Action Plan, Species Conservation Plans, grant reports, peer-reviewed publications);
- Provide assistance with fieldwork, data management, and project management as needs and capacity allow.

NCWRC's Programmatic Safe Harbor and Candidate Conservation Agreements for 21 Aquatic Species

On November 24, 2022, the U.S. Fish and Wildlife Service and the NCWRC officially executed the NCWRC's Programmatic Safe Harbor Agreement and Candidate Conservation Agreement with Assurances for 21 imperiled aquatic species in North Carolina. These agreements are issued under Section 10(a)(1)(A) of the Endangered Species Act and are a type of Enhancement of Survival Permit. For these agreements, the NCWRC plans to implement conservation actions through reintroductions of the 21 imperiled aquatic species into suitable habitat within the historical range of the species. This landmark agreement has been years in the making and involves participation and support of many partners and stakeholders. The species include Appalachian Elktoe, Atlantic Pigtoe, Brook Floater, Cape Fear Shiner, Carolina Heelsplitter, Carolina Madtom, Cumberland Moccasinshell, Dwarf Wedgemussel, Green Floater, James Spiny mussel, Lake Sturgeon, Long-solid, Magnificent Ramshorn, Neuse River Waterdog, Orange-fin Madtom, Roanoke Logperch, Robust Redhorse, Spotfin Chub, Tar River Spiny mussel, Tennessee Clubshell, and Yellow Lance.



Yellow Lance (NCWRC)



Roanoke Logperch (NCWRC)



Spotfin Chub (Dr. Luke Etchison)



Magnificent Ramshorn (NCWRC)

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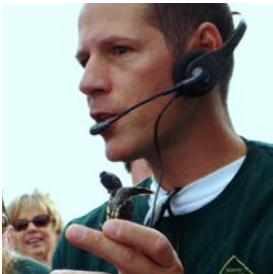


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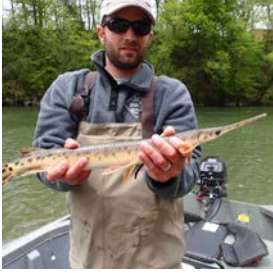
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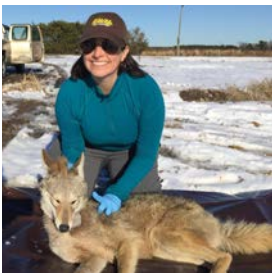
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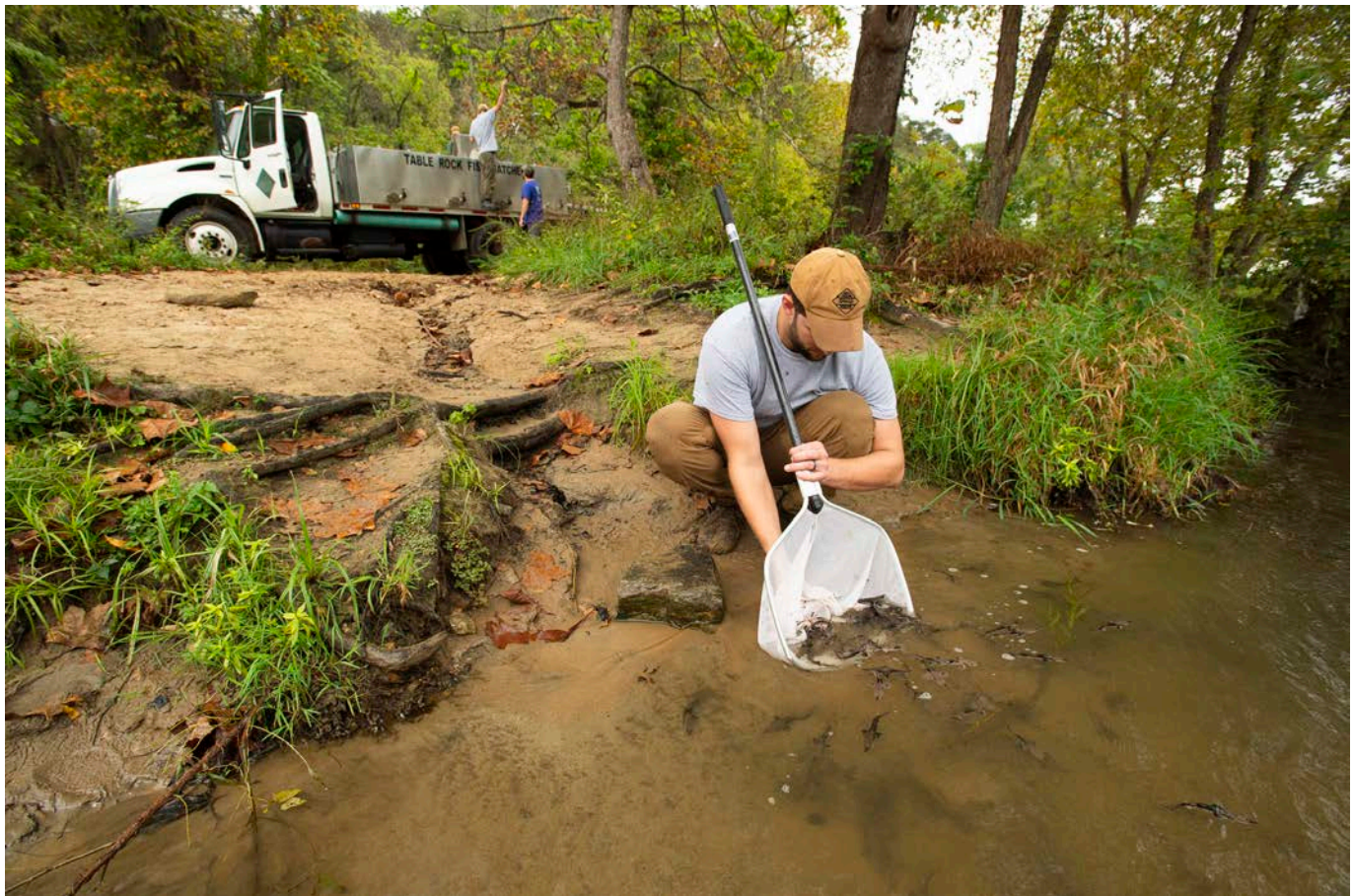
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Dr. Luke Etchison, Western Region Aquatic Wildlife Diversity Coordinator, releases hatchery raised Lake Sturgeon into the French Broad River. (NCWRC)

BIRDS

Northern Saw-whet Owl Bioacoustics Project Expands

by Christine Kelly/ Western Bird and Carolina Northern Flying Squirrel Biologist

In late winter 2022, it was time for the next step in a bioacoustics project for Northern Saw-whet Owls. This effort was initiated last year when Wildlife Diversity staff did a trial run using large audio recorder units (ARUs) from the NCWRC's

wild turkey study. The article, "[State of the Gobble](#)," was featured in the January/February 2022 issue of Wildlife in North Carolina magazine. To sample extensive areas in remote parts of the owl's range, biologists need a smaller, compact

ARU. In March 2022, Dr. DJ McNeil from the University of North Carolina-Wilmington helped Commission biologists deploy five dozen small ARUs across four massifs in western North Carolina. The objective this season is to record as many

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calls of northern saw-whet owls as possible. These calls will be used to build a call recognizer that can sort through thousands of wave files to detect the signature of an owl call. Thus, this go-around, biologists biased sampling sites to locations with recent or historic records of a saw-whet owl. These ARUs were retrieved in April 2022. NCWRC biologists are planning the next phases with Dr. McNeil. We anticipate deploying ARUs randomly across the potential range of the owl. They will use information from their trial study to inform the design of a long-term monitoring program that will answer questions such as, “What is the occupancy rate of northern saw-whet owls in conifer, mixed-species, and deciduous forests?”, “At what time in the spring are the owls most detectable?”, and “What time of night do they call the most?” These questions will help biologists fine-tune their sampling to the season and time of night when the owls are most easily detected on an ARU to facilitate long-term monitoring.



Clockwise from top left: During deployment, Wildlife Diversity Technician Clifton Avery spotted this saw-whet owl poking its head out of a nest box in spruce forest managed by the NCWRC. Dr. DJ McNeil deploys a small ARU for owls in March 2022; Left: A small Automated Recording Unit attached to a red spruce tree in saw-whet owl habitat (Christine Kelly)

Northern Saw-whet Owls and Other Species Use Nest Boxes Built and Erected by Staff and Students in 2021

by: Christine Kelly/ Western Bird and Carolina Northern Flying Squirrel Biologist

Regular readers of the Wildlife Diversity Quarterly Reports may recall reading about a nest box project for Northern Saw-whet Owls in the [first quarter 2021 report](#). Haywood Community College students built and posted 10 wood nest boxes on the William H. Silver Game Land (Haywood County) with NCWRC biologists in March 2021. We are pleased to report that a pair of the tiny owls took to one of the boxes this year. An adult saw-whet owl peered out of the box during quick box checks in late March and mid-April 2022. Nesting was confirmed in May 2022

when a nestling poked its head out of the box. Two other owl boxes were claimed as den sites by small mammals. A Red Squirrel's moss nest occupied one box, and another was filled to the brim with the characteristic finely shredded Yellow Birch bark of a Carolina Northern Flying Squirrel nest. These are just some of the bird and mammal Species of Greatest Conservation Need (SGCN) that call the William H. Silver Game Land home. NCWRC biologists are working with the staff forester to restore red spruce forest for these species on the game land.



Video of an adult Northern Saw-whet Owl peering out of a nest box



An adult Northern Saw-whet Owl peers out of its nest box in mid-April: Left: Clifton Avery celebrates after discovering that a Northern Saw-whet Owl took up residence in a relatively new owl box.

All photos: Anthony Squitier

Staff Prepare for Second Season of Henslow's Sparrow Research Project

by John Carpenter, Eastern Landbird Biologist

During the first quarter of 2022, preparations were made for the second field season of the agency's Henslow's Sparrow (HESP) research project. This collaborative effort, which includes North Carolina State University and the U.S. Geological Survey's North Carolina Cooperative Fish and Wildlife Research Unit, is designed to help biologists better understand how these state-listed endangered sparrows are responding to habitat management on the NCWRC's Voice of America Game Land. Biologists are conducting surveys to estimate population size and using cutting-edge tracking equipment developed by Cellular Tracking Technologies to map movements and habitat use of male Henslow's Sparrows. To harness the power of this equipment and detection system, they established two sensor stations, each equipped with a 30-ft. antenna and paired with a grid of "nodes" that continuously communicate with each other to track the movements of birds wearing a solar-powered transmitter. Preliminary results indicate that the HESP population includes 392 males (95% Confidence Interval: 314-539 males) and an annual population growth rate of 2%. Tracking data are being evaluated to produce territory and home range estimates, which will include maps that predict a sparrow's probability of using an area within the game land. On a related note, the Henslow's Sparrow Draft Conservation Plan was available for public comment for 30 days during this quarter. Staff will review and respond to comments, then present the plan to the Commission Board. Species conservation plans present biological information, causes of decline, conservation goals and potential conservation actions, and are intended to guide agency efforts to maintain and increase populations of declining species in North Carolina.



Henslow's Sparrow wearing a solar-powered transmitter (Emily Nastase/NCSU)

Aerial Surveys for Inland Waterbirds Begin

by Carmen Johnson, Waterbird Biologist; Constance Powell and John Lynch, Wildlife Technicians

In late March 2022, the NCWRC Waterbird Team began an effort to conduct aerial surveys for inland nesting long-legged wading birds. Flights were scheduled to search for nests before leaf-out to prevent foliage from hampering detectability by surveyors. Heron and egret colonies can be found along the edges of marshes, estuaries, ponds, lakes, Carolina bays, and rivers. Here, the birds can forage in the shallow water and build their nests in water-surrounded trees that protect them from mammalian predators.

These surveys provide the NCWRC with data to better understand these populations and aid management decisions. Staff are grateful to Laura Early with the non-profit SouthWings, who organized the flights for them, and especially to volunteer pilot Art Falk who flew them in his Cessna 182Q.

Staff also are thankful to have had the experienced help of Eastern Wildlife Diversity Supervisor Dave Allen on two of their surveys this spring. Dave retired at the end of March, and they are honored he spent some of his last days with the NCWRC in the field with them.



Art Falk's Cessna 182Q (Constance Powell)



Technicians Constance Powell and John Lynch ready to fly (Constance Powell)

Biologists Assist with Multi-State Brown Pelican Tracking Project

by Carmen M. Johnson, Waterbird Biologist, John Lynch and Constance Powell, Waterbird Technicians

During summer 2022, N.C. Wildlife Resources Commission (NCWRC) staff helped researchers outfit adult Brown Pelicans with high-resolution GPS satellite transmitters. Previously, Dr. Patrick Jodice (Clemson University) and Dr. Brad Wilkinson (Duke University) captured and fitted 45 birds with these transmitters in South Carolina, and they are now expanding efforts into North Carolina, Georgia and northern Florida. Begun in 2017, the project examines habitat

use patterns, foraging behaviors, and migratory corridors of Brown Pelicans in the South Atlantic Bight.

Pelicans from a colony near Oregon Inlet were tagged during a two-day effort in early June. A snare-pole was used to secure the pelicans from the outskirts of the colony to minimize disturbance. During attachment of the transmitters, birds were weighed, and measurements of culmen (the upper ridge along a bird's beak) and

tarsus (the part of the bird's leg between what appears to be the backward-facing 'knee' and the 'ankle') were recorded. Blood and feather samples were also collected. Three pelicans were captured, tagged, and successfully released during this effort, and we look forward to seeing the maps that will be created from the data collected, showcasing breeding ranges, migratory pathways, wintering locations and site fidelity.



Left: Attaching transmitter harness to the bird as NCWRC Biologist Kimberly Smith looks on; After being fitted with a transmitter, this Brown Pelican quickly rejoined the colony. (Constance Powell)

High Number of Dead, Dying Shearwaters Concern Waterbird Biologists

by Carmen Johnson, Waterbird Biologist, John Lynch, Constance Powell, Wildlife Diversity Technicians

This summer, the Waterbird Team worked with the Southeastern Cooperative Wildlife Disease Study (SCWDS) and Dr. Anna Robuck, a researcher with the National Oceanic and Atmospheric Administration, to increase their understanding of Great Shearwater mortality events along the coast. Throughout the spring and summer, agency staff, partners and beachgoers reported high numbers of lethargic or dead shearwaters on beaches up and down the Atlantic Coast. It is not unusual for these birds, which migrate from the south Atlantic to the waters off the coast each year, to wash up on North Carolina shores. However, the high number of animals seen this season raised concerns that Highly Pathogenic Avian Influenza (HPAI), or another disease, could be behind the event, known as a “wreck.” Although some birds were taken to wildlife rehabilitators, most did not survive and over 100 birds were collected and sent to SCWDS and Dr. Robuck for testing. Necropsies of the birds found that all were emaciated, some had internal parasites, and others had ingested micro plastics. None of the shearwaters tested positive for HPAI. Based on previous wreck events, staff believe the birds were in poor physical condition due to starvation and were then blown inland during storm events like the ones that occurred around Mother’s Day and the Fourth of July. Through earlier work, Dr. Robuck has learned that climate change is likely playing a part by producing storm events earlier in the season and disrupting the shearwaters’ prey base of forage fishes, leading them to ingest more plastics. Samples from the mortalities submitted by the Waterbird Team will be part of additional work comparing stranded birds, bycatch birds and healthy, live birds.



Wildlife Diversity technician John Lynch packs shearwater carcasses for shipment at NCSU's Center for Marine Sciences and Technology (Constance Powell)



Great Shearwater (Cornu Laurent)

Staff Conduct Breeding Season Surveys for Oystercatchers and Plovers

by Carmen Johnson, Waterbird Biologist, John Lynch, Constance Powell, Wildlife Diversity Technicians



Between late April and mid-June, the Waterbird Team took part in the North Carolina coast-wide breeding survey of American Oystercatchers and Wilson's Plovers, both species of special concern in North Carolina. Breeding surveys are conducted every three years and divide the coast into plots defined by management jurisdiction and ownership, habitat and size. Surveyors visited each plot within a 4-hour window around high tide, surveying by boat, foot or kayak to record detections of pairs and single, nonterritorial birds. Where nesting activity was occurring, surveyors noted nest location and the number of eggs or chicks (if found). They also documented any banded birds seen during the surveys. Final numbers are still being tallied but preliminary results from this year's survey found 343 territorial pairs, 31 non-territorial pairs, and 89 individual American Oystercatchers. For Wilson's Plovers, 278 territorial pairs, 7 non-territorial pairs, and 37 non-paired birds were detected. All data collected from this multi-agency effort will be compiled and used to help monitor the status of the two species in North Carolina and throughout their ranges.

Staff detected many American Oystercatchers during surveys in April through June, including pairs (below), nesting chicks and eggs (right) and tagged birds (above)

(John Lynch)



Bird Crew Conducts Rangewide Golden-winged Warbler Survival Study

by: Christine Kelly/ Western Bird and Carolina Northern Flying Squirrel Biologist

In late April and May, the Western Wildlife Diversity bird crew captured and color-banded 22 Golden-winged Warblers in the Cheoah Mountains (Graham County) for a study led by the University of Maine. The objective of the study, “Estimating the survival rate

of Golden-winged Warblers for a range-wide integrated population model” is to better understand annual survival of this rapidly declining migratory bird. That is, do they make it from one breeding season to the next? In particular, how are the under-studied females faring?

Between jaunts to western North Carolina to nest in brushy old field habitat or patches of recently logged forest, Golden-winged Warblers make a 2,000-mile trip to their wintering grounds in the Andes Mountains of northern South America. Quality habitat is needed at each

leg of the journey that comprises their full annual life cycle.

To fill in these knowledge gaps, the principal investigators enlisted nearly a dozen state, federal, and non-governmental partners in the eastern U.S. to study golden-wings in their states. The data that the NCWRC helps collect will be plugged into the population model that will inform the U.S. Fish and Wildlife Service’s decision about whether to federally list the species.

The NCWRC team fitted 12 of the birds (five females, seven males) with nanotags, a type of

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Clifton Avery attaches a nanotag to a male Golden-winged Warbler



Wildlife Diversity Technician Clifton Avery and Wildlife Diversity Biologist Chris Kelly band and take measurements from a Golden-winged Warbler they captured in the Cheoah Mountains.



University of Maine graduate student Emily Filiberti (left) helps Clifton Avery and Chris Kelly of the NCWRC and Aimee Tomcho of Audubon NC learn to use the Lotek receiver. i)

All photos: Anthony Squitier

coded radio transmitters that are detectable on the growing Motus Wildlife Tracking Network of fixed radio telemetry receiver stations. Partners in the University of Maine Golden-winged Warbler study met

in April for practice attaching the nanotags and using the tracking equipment. Biologists hope that some of these tagged birds are picked up on Motus receiver stations during migration and at their

overwintering sites in Colombia and Venezuela. The bird crew will search for the tagged and color-banded golden-wings via ground tracking next spring when they return to nest in the Cheoah Mountains.



Video clip of a slow motion release of a nanotagged female Golden-winged Warbler (Clifton Avery)



A tiny nanotag sits on the back of a male Golden-winged Warbler



Golden-winged Warbler habitat, consisting of a six-year-old harvest unit surrounded by forest



A mist net deployed at first light to capture Golden-winged Warblers nesting in a six year old logging unit on the Nantahala National Forest.

All photos: Anthony Squitier

Golden-winged Warbler Tracking

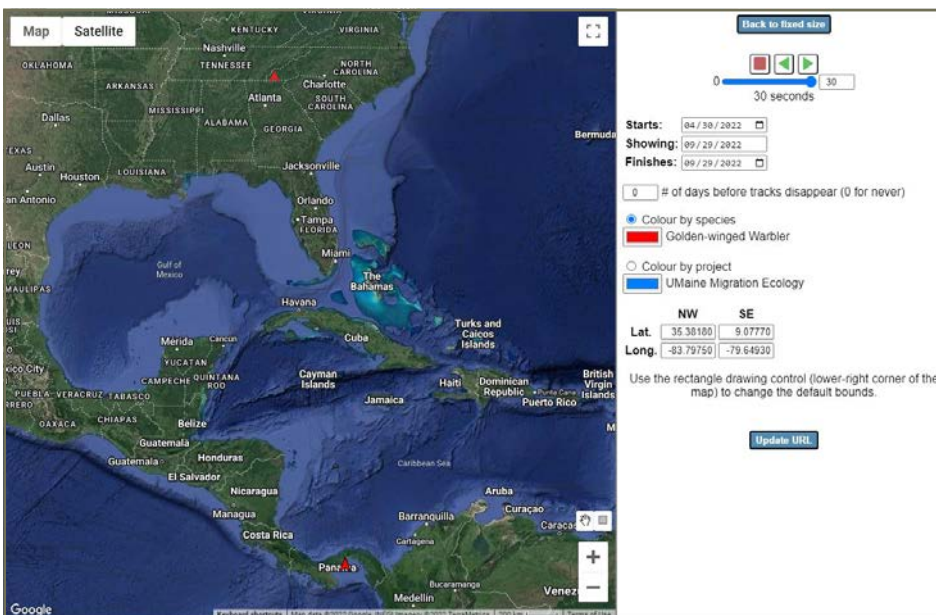
by: Christine Kelly/ Western Bird and Carolina Northern Flying Squirrel Biologist

As reported in our second quarter report, the NCWRC contributed to a rangewide survival study of Golden-winged Warblers, led by the University of Maine. The first part of the study was completed this past spring, when NCWRC biologists and other partners fitted Golden-winged Warblers with tiny radio tags (nanotags).

The second part of the study will take place in spring 2023, when biologists attempt to relocate these individuals on the breeding grounds to determine annual survival. But in the interim, NCWRC biologists

had an opportunity to observe the breeding population in the Cheoah Mountains (Graham County) more closely. The mountain bird crew checked on the tagged and color-banded individuals on a bi-weekly basis throughout the summer. Radio signals led them to tagged females on nests, while males maintained their territory boundaries from favorite song perches. As the summer progressed, staff observed spatial shifts, likely attributed to the adult birds tending to their newly volant offspring. By Aug. 12, only two males could still

be relocated by their radio signals, and by Aug. 23, none were detected. With migration in full swing, biologists were thrilled to discover that one of the birds, a male tagged on his breeding grounds in Graham County on April 30, was alive and on the move. On Sept. 29 at 10:15 p.m., his radio tag “pinged” a Motus Wildlife Tracking receiver station in Panama City, Panama. He is on his way to his wintering grounds in northern South America. Biologists await his return to North Carolina in spring 2023.



The red arrow in North Carolina marks the location where male Golden-winged Warbler #75 was captured on his breeding territory in April 2022. A Motus Wildlife Tracking receiver station in Panama City, Panama (lower red arrow) detected this bird's radio tag on the night of Sept. 29, 2022. (Motus.org website)



A tiny nanotag sits on the back of a male Golden-winged Warbler (Anthony Squitieri)

New Technology Will Help Biologists Track and Study Avian Species of Greatest Conservation Need

by John Carpenter, Eastern Land Bird Biologist

Recently, Wildlife Diversity program staff, along with NC State University and UNC-Wilmington, hosted and attended a Cellular Tracking Technology (CTT) workshop to demonstrate the potential this state-of-the-art equipment has for studying many Species of Greatest Conservation Need. The workshop included both a field demonstration at the Voice of America Game Land and a virtual meeting to discuss data management. CTT is a company offering radio, cellular and satellite telemetry systems that allow researchers to track animals' movements continuously through time. A CTT system includes an array of solar-powered receiver "nodes" spaced 100-200 m apart throughout

the desired habitat in a 1-km² grid, a sensor station and transmitter tags mounted on the target animals. Typically, the sensor station is located at the center of the node array, mounted on a 20- to 30-foot tower topped with an omni-directional antenna and a variety of other antennae aimed along cardinal directions or as needed to support effective communication between nodes and the sensor station. It is powered with a solar panel and battery. Transmitter tags attached to the target animals may be battery powered, solar powered or a combination. Each node will detect an animal's unique transmitter frequency within approximately 200 m and relay its location back to the sensor station.

From there, the station uploads the animal's location data to a central repository, which communicates with a server that displays the data in near real time via the CTT user portal. This automated telemetry system not only produces significantly more accurate and detailed animal space use metrics, allowing for study of habitat utilization, home range size and seasonal movements, but it also frees up field staff from labor intensive manual telemetry methods, allowing staff to allocate more time to other components of their studies. The NCWRC is currently using this technology to study several avian Species of Greatest Conservation Need, including Henslow's and Salt-marsh Sparrows.



Left: Henslow's Sparrow wearing solar-powered transmitter (Emily Nastase); Attendees at CTT field demo, Voice of America Game Land examine the sensor station. (John Carpenter)

NC Bird Atlasers Had Busy Spring Season

by John Carpenter, Eastern Land Bird Biologist, Scott Anderson, Science Support Coordinator

The North Carolina Bird Atlas had many accomplishments from April through June 2022. The Wildlife Diversity program's field staff conducted over 1,100 standardized

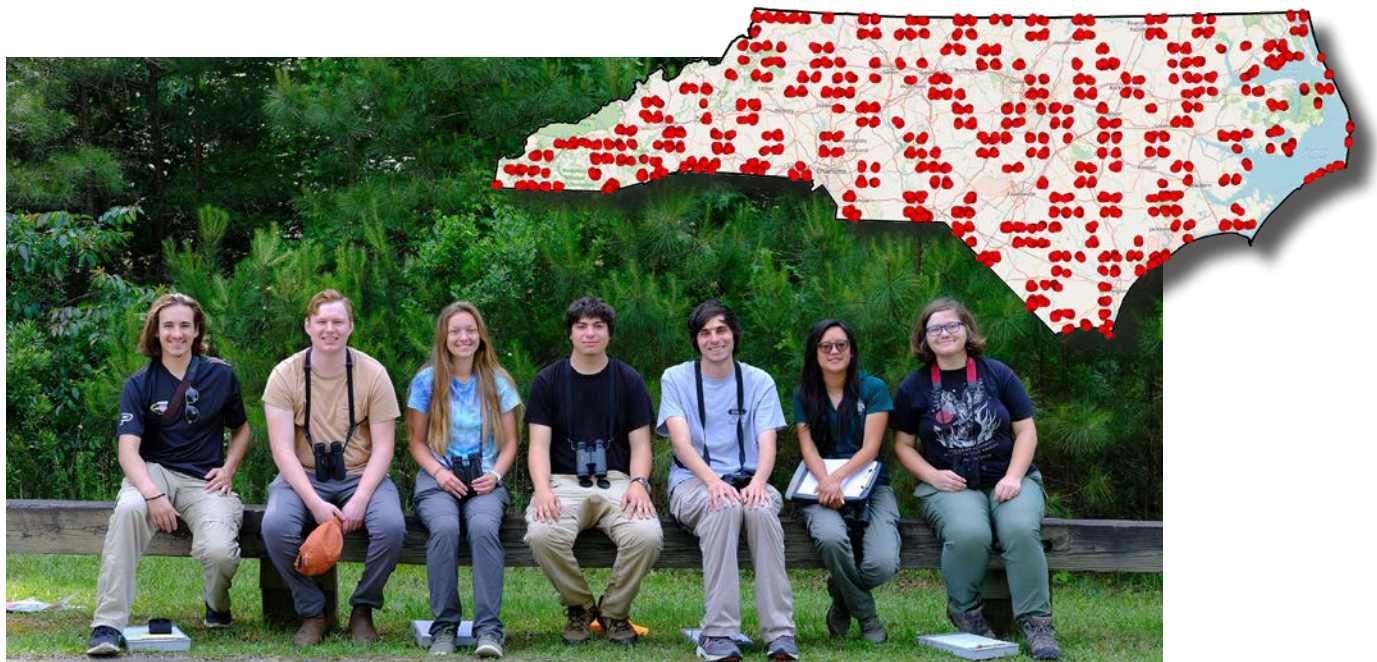
Atlasers have been busy! As of early July, NCWRC biologists have data from almost 90% of their priority blocks and 193 species confirmed as breeding in the state.

avian point count surveys, which brings the total number completed (including those from 2021) to over 2,200. The data obtained from these surveys will be used to develop density estimates and

detection probabilities for many bird species. In addition, North Carolina — along with three other states (Maine, New York, and Maryland/DC) and two Canadian provinces (Newfoundland and Ontario) — participated in the 2nd Annual Big Atlas Weekend Competition. All of our results — including

total number of participants and hours dedicated to atlasing — increased significantly compared to last year's event. During the early mornings and evenings from June 24-26, 2022, more than 190

atlasers contributed 490 hours and identified 162 species in 362 atlas survey blocks. As of early July, we have data from almost 90% of our priority blocks and 193 species confirmed as breeding in our state! This huge accomplishment has been made possible by the efforts of 1,442 atlasers (most of whom are volunteers) who have submitted 80,381 checklists since the project began last year. As this summer winds down, we will remain busy preparing for the atlas's second winter season, organizing data, and engaging with our volunteers to encourage their continued participation in this growing citizen science project.



North Carolina Bird Atlas field technicians (left to right: Davis Balser, Dan Watson, Adrianna Nelson, Clayton Gibb, Matt Janson, Elsa Chen, and Martina Nordstrand) with map of completed avian point count survey locations (NCWRC)

REPTILES

Innovative New Monitoring Techniques Show Promise for Evaluating the Status of Bog Turtles in NC and Throughout the Species' Range

by Gabrielle Graeter, Conservation Biologist/Herpetologist

Bog turtles and their habitat — mountain bogs — are a high priority for conservation in North Carolina. The bog turtle, *Glyptemys muhlenbergii*, is both federally (S/A) and state threatened. The NCWRC monitors this species to understand population status and trends. However, studying rare or elusive species like the bog turtle

presents a unique challenge. They are often very difficult to find, and it can take a lot of effort to find even one turtle at a known population. In the past year, through a collaboration with multiple conservation partners, including the U.S. Fish and Wildlife Service (USFWS), Tangled Bank Conservation and Clemson University, we have been

testing new innovative techniques for estimating bog turtle occupancy and abundance in bog habitat, in the hopes that we will be able to find ways to more effectively monitor this species.

With our partners, we have tested two passive sampling techniques. A sampling technique is passive if the animal does not need to be

continue on next page



physically captured, reducing stress and habitat disturbance. One of the two sampling techniques is also a remote sampling method. A sampling method is considered remote if the researcher does not need to be present during data collection, which can save time and resources. The passive and remote method is a modified camera-trap technique, where a wildlife camera is mounted in an upside-down 5-gallon bucket that has openings cut out on opposite sides and is placed on the ground within the wetland in places we would expect turtles to travel (Figure 1).

The bucket-camera traps were set for three to four weeks, with traps removed and photos evaluated afterwards (Figure 2). We also

evaluated the use of testing for the presence of environmental-DNA, also known as “e-DNA”, in water samples. Environmental DNA originates from cellular material shed by organisms (via skin, excrement, etc.) into aquatic or terrestrial environments. Multiple water samples were collected at each bucket camera-trap location and subsequently tested for the presence of bog turtle DNA via quantitative PCR in the lab.

Our conservation partner, Tangled Bank Conservation, evaluated the accuracy and utility of these two methods at 11 sites that were known to have bog turtles. Preliminary findings indicate that both methods can provide a quick and comparatively inexpensive method

of estimating occupancy and relative abundance of bog turtles. Bog turtles were positively identified as present in each of the 11 sites evaluated using both techniques! We were able to determine the number of days that the camera traps must be deployed to have a high chance (95%) of documenting a bog turtle if they are present, as well as how many water samples are needed to accomplish the same goal. One of the most difficult parts of the project is reviewing and organizing all the photos generated from the camera trapping. We are in our second season of setting the camera traps and, as we learn more, we are learning and adjusting our methodologies, including our approach to photo review!



Figure 1. Biologists setting bucket-camera traps in a wetland in May 2022 (NCWRC)



Figure 2. Example of a photo captured from a bucket-camera trap. This one shows a juvenile bog turtle traipsing through. (Mike Knoerr)

161 Cold-Stunned Sea Turtles Stranded During 2021-2022 Winter

by Dr. Matthew Godfrey, Sea Turtle Biologist



During winter months, NCWRC biologists and the North Carolina Sea Turtle Stranding and Salvage Network respond to sea turtles that strand due to hypothermia or cold-stunning along the NC coast. The 2021-22 winter produced 161 cold-stunned sea turtles from late November through February, but most of these cold stuns occurred over 3 consecutive cold snaps in January. There were 92 live turtles that were taken to rehabilitation centers, 54 of which have been released to date. Most cold stuns are recovered from Cape Lookout Bight and Pamlico Sound along Hatteras, but cold-stunned turtles can sometimes be found in more remote locations, such as Cedar Island.

Partners with NCSU CMAST and NOAA Beaufort respond to a remote cold stun on Cedar Island. The subadult loggerhead was alive and had been cold-stunned. It was transported to the Karen Beasley Sea Turtle Rescue and Rehabilitation Center. (Larisa Avens, NOAA Beaufort)

How YOU Can Support Wildlife Conservation in North Carolina

Whether you hunt, fish, watch, or just appreciate wildlife, you can help conserve North Carolina’s wildlife and their habitats and keep North Carolina wild for future generations to enjoy.

How? It's as easy as 1, 2, 3.

- 1 Donate to the Nongame and Endangered Wildlife Fund by checking Line No. 30 on your N.C. State Tax Form.
- 2 Purchase a Wildlife Conservation Plate, which features an illustration of a Pine Barrens Treefrog, for \$30, with \$20 going to the agency's Nongame and Endangered Wildlife Fund.
- 3 Donate to the Wildlife Diversity Endowment Fund, a special fund where the accrued interest — not the principal — is spent on programs that benefit species not hunted or fished. ncwildlife.org/donate



Four Leatherback Sea Turtle Nests Found on North Carolina Shores So Far this Summer May Be Attributed to One Female

by Dr. Matthew Godfrey, Sea Turtle Biologist

Sea turtles deposit their eggs on North Carolina beaches between May and August each summer. The overwhelming majority of sea turtle nests observed in North Carolina are laid by loggerhead sea turtles, followed by small numbers of nests laid by green turtles, Kemp's ridleys and, more rarely, leatherback sea turtles. To date this summer, four leatherback nests have been found on North Carolina beaches. The first nest occurred on Cape Lookout National Seashore, and National Park Service staff were able to observe the female as she nested

in the late afternoon. The second nest was found on Oak Island, over 100 miles away; the turtle was also observed nesting during daylight hours. The third nest was found on Caswell Beach, adjacent to Oak Island, but the turtle nested during the cover of darkness. The fourth nest was found on Cape Hatteras National Seashore, again laid during nighttime hours. Each nest was separated by 10 days, which is the average number of days between successive nests laid by individual females for this species, leading to speculation

that all nests belonged to a single female. To test for identity of the mother, a DNA sample was collected from each nest. The samples came from the eggshell of one of the small albumen-filled "eggs" that contain no yolk or embryos, which typically number between one and three dozen in each leatherback sea turtle nest. The ecological benefit of these "yolkless" eggs remains a mystery, although some hypothesize that they may serve a deterrent to predators or help maintain humidity in the nest cavity during incubation.



An adult leatherback sea turtle nesting on North Core Banks, Cape Lookout National Seashore, during the afternoon May 5, 2022. The turtle is being checked for tags (it had none). (Cape Lookout National Seashore)



Small "yolkless" eggs in a leatherback sea turtle nest (Dr. Matthew Godfrey)

Sea Turtle Hatchling Success for 2022 Nearly 50% Above the Annual Average Based on Previous Five Years

by Dr. Matthew Godfrey, Sea Turtle Biologist and Sarah Finn, Coastal Wildlife Diversity Biologist

As Labor Day drew to a close, the sea turtle nesting season wound down in North Carolina. In contrast, the end of the summer corresponds to the peak in hatchlings emerging from incubating sea turtle nests along the coast. Hatchling sea turtles emerge from their nests almost exclusively at night and scramble down the beach to the ocean. The network of volunteers and cooperators that make up the NCWRC's Sea Turtle Project waits three days,

after hatchlings first emerge from each nest, before inventorying its contents to check on hatching success. This is also an opportunity to liberate any live hatchlings that might be stuck in the nest, so they too can crawl down the beach to the water. Nest excavations often draw nearby beach visitors, so they provide an opportunity for people to observe hatchlings and learn about sea turtle conservation efforts in North Carolina. By mid-September,

125,866 sea turtle hatchlings had already emerged from nests laid in the state, with more likely to come in the following several weeks. This is nearly 50% above the annual average (86,522) based on the previous five years. The high number of hatchlings is a result of not only a big nesting year in 2022, but also a relatively calm coastal storm season, which has allowed most nests to reach the end of incubation without erosion or extreme washover.



Loggerhead hatchlings in Carteret County scramble to the ocean after being released from the bottom of a nest undergoing inventory to characterize hatching success. (NCWRC)



Volunteers at Pine Knoll Shores in Carteret County evaluate the contents of a sea turtle nest 72 hours after hatchlings emerged and liberate any live hatchlings stuck in the nest cavity. (NCWRC)

296 Live and 206 Dead Sea Turtles Recovered during Cold-Stunning Events in December

by Dr. Matthew Godfrey, Sea Turtle Biologist and Sarah Finn, Coastal Wildlife Diversity Biologist

The North Carolina Sea Turtle Stranding and Salvage Network, coordinated by NCWRC biologists, monitors sea turtle strandings along North Carolina’s coast. During winter months, when inshore water temperatures drop below 50°F, sea turtles begin to strand due to cold-stunning (similar to hypothermia). Historically, cold stuns in North Carolina aggregate in two main hotspots: Cape Hatteras and Cape Lookout National Seashores. The 2022-23 cold-stun season in North Carolina began on Dec. 19 and lasted through the end of the year. The peak of cold stunning occurred between Dec. 24-26 (Fig 1). To date, 296 live and 206 dead turtles were recovered during this cold-stunning event. Live turtles were taken to rehabilitation facilities: the STAR Center at NC Aquarium Roanoke Island, NC Aquarium at Pine Knoll Shores, and the Karen Beasley Sea Turtle Rescue and Rehabilitation Center in Surf City. Several turtles that entered rehabilitation were released following brief treatment thanks to help from UNCW R/V Seahawk, NCSU CMAST, and warm water adjacent to shore at Cape Lookout. As air temperature moderates, inshore water temperatures will rise above the threshold for cold-stunning. However, if turtles remain in inshore waters, another wave of cold-stunning can occur with the next cold snap.

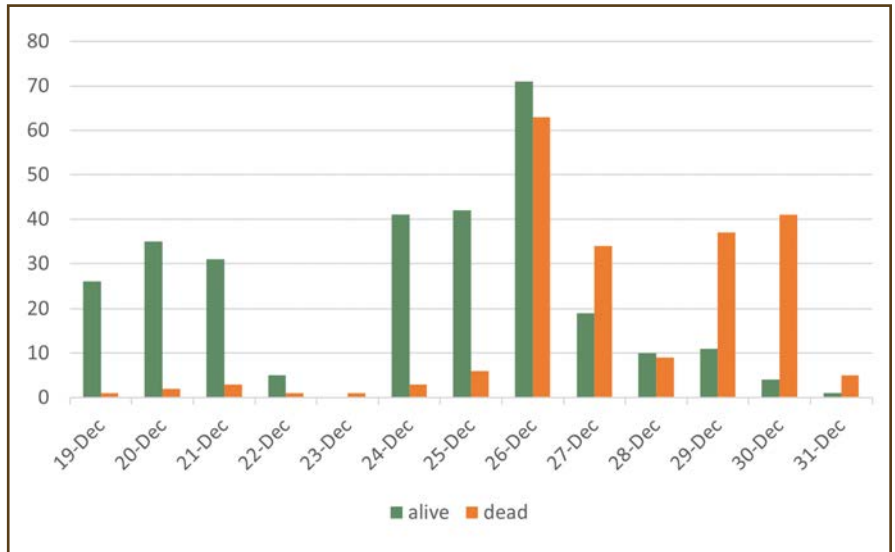


Fig. 1 Preliminary totals for the cold-stunning event that began Dec. 19, 2022



Cape Lookout National Seashore ranger responding to a cold stunned loggerhead sea turtle

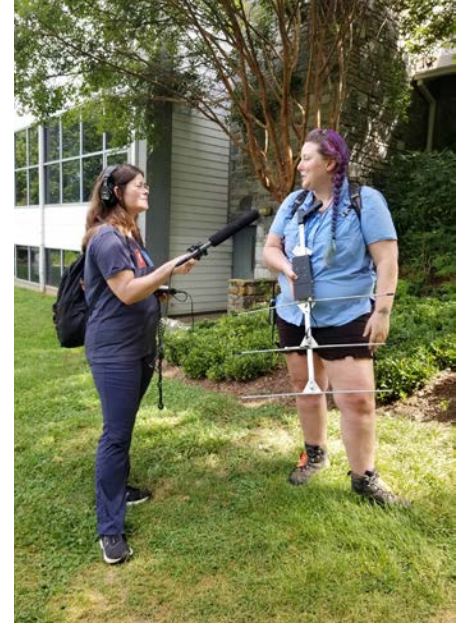
Getting the Word Out About NCWRC Reptile Projects

by Gabrielle Graeter, Conservation Biologist/Herpetologist

Recently, popular science media outlets have taken an interest in featuring NCWRC reptile projects on their platforms. NCWRC Conservation Biologist Gabrielle Graeter was interviewed by NPR and PBS to discuss the importance of two projects in the state involving box turtles and bog turtles. These interviews were great opportunities to inform the public about the importance of these species and the threats they are facing across the state. These stories highlight collaborative conservation efforts between the NCWRC, other organizations and agencies, and community scientists who are working together to gather data and conserve these two species.

The first interview featured the Box Turtle Connection (BTC) project, which is a long-term, state-wide collaborative study that aims to assess the status and trends in box turtle populations, identify their threats and determine conservation strategies. This project is community-science driven, as data are collected across the state by trained volunteer Project Leaders. NPR Science Correspondent, Nell Greenfieldboyce, joined Graeter at the NC Arboretum, one of the BTC study sites, along with other BTC

staff and the NC Arboretum Project Leader to discuss the project. They discussed the general status of box turtles, the objectives of the Box Turtle Connection project and the educational aspect of the BTC. The story is available on NPR's [website \(www.npr.org\)](http://www.npr.org). The second interview featured conservation work being done by the NCWRC and conservation partners to help manage bog turtle populations in the state. Bog turtles are listed as Threatened in North Carolina due to population declines associated mostly with habitat loss and degradation of habitat quality. There has been great effort by the NCWRC and other partner organizations to implement various conservation methods to improve bog turtle habitat, survivorship and population status. A film crew from the UNC Hussman School of Journalism and Media and a PBS North Carolina videographer joined Graeter at a bog where they discussed the natural history, ecology and status of the bog turtle, the threats the species and its habitat face, and the conservation work the NCWRC and its partners are doing. This film will come out in fall 2023 on the show, Sci NC on [PBS North Carolina](https://video.pbsnc.org/show/sci-nc/) (<https://video.pbsnc.org/show/sci-nc/>).



NPR Science Correspondent Nell Greenfieldboyce interviewing a Box Turtle Connection project leader, July 2022 (Gabrielle Graeter)



Students from the UNC Hussman School of Journalism and Media filming bog turtle hatchlings for the PBS North Carolina show Sci NC, September 2022. (Gabrielle Graeter)

Planning and Coordination are Key in Implementing Bog Turtle Conservation Projects with the Partners for Fish and Wildlife Program

by Gabrielle Graeter, Conservation Biologist/Herpetologist

Bog turtles and their habitat — mountain bogs — are significant conservation concerns in North Carolina; therefore, the NCWRC prioritizes conservation and management of wetlands with known bog turtle populations. The bog turtle (*Glyptemys muhlenbergii*, federally (S/A) and state-listed threatened) and mountain bogs face a myriad of threats, such as predation, fragmentation by roads, excessive shading from woody vegetation, and changes in hydrology.

Much bog habitat management by the NCWRC has been funded using State Wildlife Grant funds and has relied heavily on assistance from volunteers during workdays and has been small in scale. Recently, the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program (PFW) funding received by NCWRC has helped reduce the need for volunteers during bog habitat management and restoration projects. The PFW Program focuses on privately owned lands, and through the program, NCWRC provides technical and financial assistance to landowners interested in restoring and enhancing wildlife habitat. Through the PFW Program, NCWRC is working with contractors and private landowners to accomplish much more bog habitat

enhancement than would have been possible otherwise. For example, at one site, staff from multiple divisions, including Engineering and Habitat Conservation, completed a design, addressed permitting needs, and lined up a contractor to help restore hydrology in a former

wetland that was impacted by a driveway (Figure 1). Soon, contractors will reduce woody vegetation in an area of the wetland that has become overgrown and too shaded for bog turtles. Additionally, non-native invasive plants, such as multi-flora rose, will be removed.

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Figure 1. A former wetland that will have its hydrology restored in spring 2022 with USFWS's Partners for Fish and Wildlife program grant to the NCWRC (Gabrielle Graeter)

REPTILES

At a second site, a restoration design plan will address severe head-cutting erosion that is affecting wetland hydrology. At a third site, staff will improve bog turtle nesting habitat and protect nests

with predator excluder cages until the eggs hatch in late summer. The fourth project involves installing a short wildlife fence to create a safe under-road passage for bog turtles and other wildlife via existing bridges

(Figure 2). For each of these sites' projects, NCWRC staff developed detailed landowner agreements and project plans, and organized many meetings with partners and the private landowners to ensure success.



Figure 2. Examples of wildlife exclusion fencing used to reduce bog turtle mortality on roads (from Animexfencing.com). This type of fencing will be installed using PFW funds at a property in North Carolina to direct bog turtles and other small wildlife into existing under-road passages. (Gabrielle Graeter)



Bog turtle (Jeff Hall)

AMPHIBIANS

Staff Detect No Gopher Frog Breeding Activity in the Sandhills

by Dr. Jeff Humphries, Eastern Amphibian and Reptile Biologist

During the first quarter of 2022, N.C. Wildlife Resources Commission biologists in the Sandhills continued their annual Gopher Frog surveys. Gopher Frogs are one of the rarest frogs in North Carolina and currently only occur in six to seven populations statewide. On the Sandhills Game Land, staff have been monitoring breeding of these frogs since 2010. During that time, frogs have bred every year except for 2011-2013 when water wasn't present in any breeding wetlands.

During this year's breeding season, Gopher Frogs did not attempt to breed in any known breeding wetlands, despite some wetlands being at least partially full of water. This year's lack of breeding may just be an anomaly, but could have something to do with climate change and changes in the patterns of rainfall events this time of year. Regardless of the cause of lack of breeding, monitoring these wetlands annually is key to tracking the health of populations of Gopher Frogs and other species of concern.



Gopher frogs mating underwater in the Sandhills of North Carolina in 2021 (Michael Martin);

Below: Gopher frog in the Sandhills (Jeff Hall)



Gopher Frog (Jeff Hall)

Staff Create Burrows around Wetland in Hopes of Increasing Survival of Released Juvenile Gopher Frogs

by Dr. Jeff Humphries, Eastern Amphibian and Reptile Biologist

The State Endangered Gopher Frog is extremely rare in North Carolina, currently found in only seven populations in the southeastern portion of the state. On the Sandhills Game Land, in Scotland County, only one natural wetland is reliably used by Gopher Frogs for breeding. Because of the precarious nature of only having one small population on the property, the NCWRC has teamed up with the North Carolina Zoo for six years to “headstart” juvenile frogs in an attempt to increase the number of animals on the landscape and increase survival of juveniles. Headstarting has involved collecting small portions of egg masses from the natural wetland and raising tadpoles in large plastic tubs until they metamorphose into young frogs. They are then released back to the wild.

In 2022, Gopher Frogs did not breed anywhere on the game land for the first time in nine years because of low water levels and possibly other factors. Therefore, biologists did not have an opportunity to continue the headstarting program this year using eggs from the natural wetland.

Instead, North Carolina Zoo biologists were successful in breeding captive frogs that originated from the Sandhills Game Land and raising tadpoles to metamorphosis. Over 110 juvenile Gopher Frogs were released to a wetland that NCWRC biologists have been restoring in order to add another wetland where Gopher Frogs may grow up and breed in the future. Previous studies of released juvenile frogs have shown that most released frogs don’t find shelter in burrows very quickly after release at the wetland

and succumb to predators such as Black Racers, non-native fire ants, and a few other predators. With that in mind, this year NCWRC biologists created burrows around the release wetland by using metal poles to bore holes in the sand several feet deep and about an inch in diameter. Staff are monitoring the use of these burrows by juvenile frogs, and so far, the technique appears to be successful. They check burrows with flashlights and have mounted camera traps on some burrows nearby to observe burrow use, behavior, and possible interactions with predators. Staff will continue to monitor this site to measure the effectiveness of headstarting Gopher Frogs and to determine whether these artificial burrows can help increase survival of frogs in these pine woods that the captively raised frogs have never seen before.



Left: A juvenile Gopher Frog using a burrow created by NCWRC biologists. These burrows should provide protection from predators, giving them a better chance of survival. Right: Juvenile Gopher Frog released to a restored wetland (Michael Martin)

Staff Note Early Breeding for Gopher Frogs and Mysterious Die-offs of Amphibians in Sandhills and Eastern North Carolina Wetlands

by Dr. Jeff Humphries, Eastern Amphibian and Reptile Biologist

In the third quarter, NCWRC biologists continued to monitor Gopher Frogs and other frog species using isolated wetlands in the Sandhills and eastern part of the state, in addition to conducting surveys for other amphibian species. Of note this fall, Gopher Frogs were detected breeding in September on Fort Bragg Military Installation, earlier than they have ever been recorded breeding in North Carolina before. These rare frogs normally breed from February to April but will occasionally breed with large storm events in the fall, such as the remnants of hurricanes or tropical storms. This is the first year staff have documented Gopher Frogs breeding in September, not coinciding with a large storm event. Gopher frogs deposited egg masses in one pond on Fort Bragg and one pond on Holly Shelter Game Land in mid-September this year, earlier than has ever been reported. These breeding events change the way biologists survey for this species, based on egg laying.

Biologists also discovered a large die-off of adult frogs on Fort Bragg, in a wetland where large populations of Gopher Frogs used to occur, but where the populations of Gopher Frogs have appeared to decline heavily over the last decade. Several dozen Pine Woods

Treefrogs and one Cope's Gray Treefrog were discovered deceased, but they were too decomposed to analyze for pathogens or cause of death. Staff will continue to monitor this site to try to figure out the cause of die-offs of adult frogs and a subsequent apparent die-off of tadpoles. The decline of frog species is a major concern for biologists throughout the world, so monitoring populations is extremely

important. This is an ongoing monitoring project, and, it is hoped, they will discover reasons for die-offs in the future. Continued monitoring of isolated wetlands and understanding reasons for amphibian population fluctuations, including emerging diseases and mitigating their effects, as well as ensuring natural resources remain stable and intact, are high priorities for the Wildlife Diversity Program.



Freshly laid Gopher Frog egg mass
(Mike Martin)



Ornate Chorus Frog, a quickly declining species in NC (Dr. Jeff Humphries)



A borrow pit on Fort Bragg, NC. Once a stronghold for Gopher Frogs, it no longer appears to maintain a population of this imperiled species. However, this species bred here in September 2022 (2 egg masses) for the first time in about a decade.
(Mike Martin)

Zigzag Salamander Surveys Conducted in Buncombe, Madison Counties

by Lori Williams, Western Amphibian Biologist

In early spring 2022, Wildlife Diversity staff focused terrestrial surveys on a rare, little-studied, woodland salamander in the mountain region, the Southern Zigzag Salamander. Listed as state Special Concern and a Species of Greatest Conservation Need in the N.C. Wildlife Action Plan (2015), Southern Zigzag Salamanders can be difficult to find outside of early spring because of their tendency to remain underground in loose, well-drained soils and rocky slopes during the warmer months

of the year. The distribution of these salamanders is poorly understood and currently includes only three mountain counties in the greater French Broad River Valley: Buncombe, Madison, and Yancey (historical museum records also include one record each from Henderson and Haywood). Biologists' main objective this spring was to expand their knowledge of where the species occurs. Staff surveyed 20 sites in Buncombe and Madison counties, finding Southern Zigzag Salamanders in

seven, six of which were at new sites. All were found on public lands, including both the east and west sides of the French Broad River. In past surveys, the relative abundance of Southern Zigzag Salamanders has been low compared to more commonly found salamanders, and this spring's results were similar with only 42 individuals found in total. Future survey work will continue to focus on understanding distribution of this rare species in North Carolina.

Bottom photo: Adult Southern Zigzag Salamanders typically have more muted coloration overall, but the orange "wash" under the arms is a good clue for identifying the species regardless of age. Right photo: The Southern Zigzag Salamander gets its name from the reddish-brown stripe with irregular edges on its back, particularly evident in younger individuals (Photos: Ben Dalton)



Staff Observe Negative Trends in Nest Success of Green Salamanders During Summer Surveys

by Lori Williams, Western Amphibian Biologist

In summer 2022, staff and a volunteer continued monitoring nest success of state threatened Green Salamanders as they have for over a decade. The number of nests monitored any given year has been from 12 to 42, and success rate has ranged from a low of 38% (2018) to a high of 92% (2010, 2012, 2021), with an average of 76%. This year's success rate of 50% is the second lowest on record (n = 20 nests) and adds to the downward trend they have observed over the years (Fig. 1). This quarter, staff also worked closely with a private contractor to complete a population analysis for Green Salamanders using survey data from 2000-2021. Similar to the negative trend with nest success, preliminary results of that analysis suggest a significant population decline of more than 50% for the Blue Ridge Escarpment Green Salamander population in North Carolina over the past two decades. Extensive periods of severe drought during this time (late 2006-2008 and 2016) appear to be a major factor in declines.



A female Green Salamander contorted around her egg clutch in a rock crevice. Without the female present to brood the nest, eggs quickly grow fungus and perish or are easily preyed upon. (Alan Cameron)

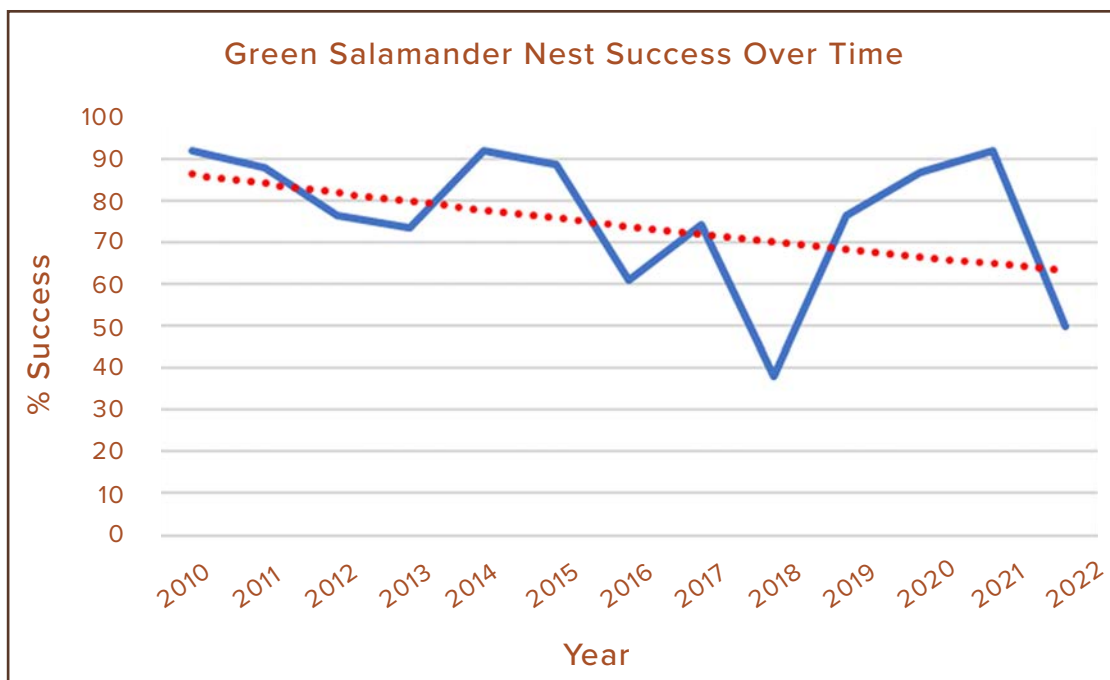


Figure 1. Green Salamander nest success rate (2010-2022) showing a negative trend over the last 13 years. Sample size ranged from 12 to 42 nests.

Salamander Surveys Continue in Western North Carolina

by Lori Williams, Western Amphibian Biologist

Wildlife Diversity staff had a productive spring salamander season, surveying for at least 13 of the 30 salamander Species of Greatest Conservation Need (SGCN) found in the mountain region in a variety of upland, wetland, riparian and rock outcrop habitats. We discovered new sites for some and updated old records for others. One highlight of the quarter was successful stream surveys for state threatened Junaluska Salamanders (*E. junaluska*), a rare and poorly studied species in Graham County. Staff were able to update historical records from three streams, where Junaluska Salamanders had not been documented in the past 10,

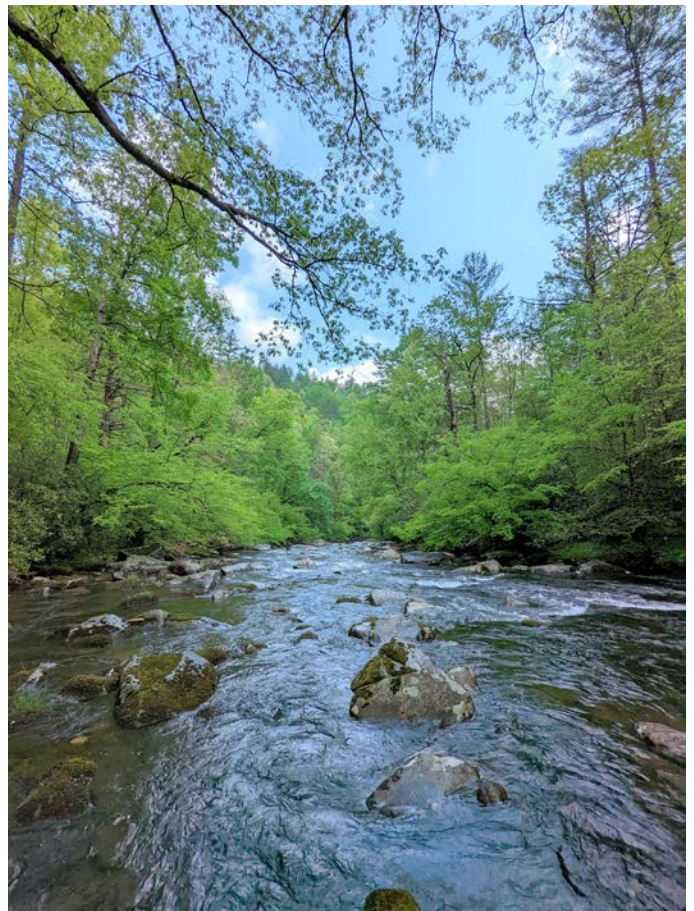
25, and 30 years, respectively, and increase the extent of known distribution in one stream by 6 km. Another exciting event was finding the species in a previously unknown stream in the Joyce Kilmer Wilderness. Juvenile Junaluska Salamanders are particularly difficult to identify and distinguish from the common Blue Ridge Two-lined Salamander. However, the use of descriptions and diagrams in published literature, as well as online photos from confirmed records, was of significant help when larvae were encountered. Future work will include continued efforts to document new streams for the species.



State threatened juvenile Junaluska Salamander (Ben Dalton)



Adult Junaluska Salamanders are easier to identify but can be elusive in field surveys (Lori Williams)



Junaluska Salamander stream habitat, Graham County, NC (Ben Dalton)

Staff Use eDNA Methodology to Detect Presence of Listed Salamanders in Western North Carolina Rivers

by Lori Williams, Western Amphibian Biologist

Since 2012, western region staff and project partners have successfully used environmental DNA (eDNA) methodology to help inventory and monitor populations of giant aquatic salamanders, Eastern Hellbender and Mudpuppy, both of which are state listed as Special

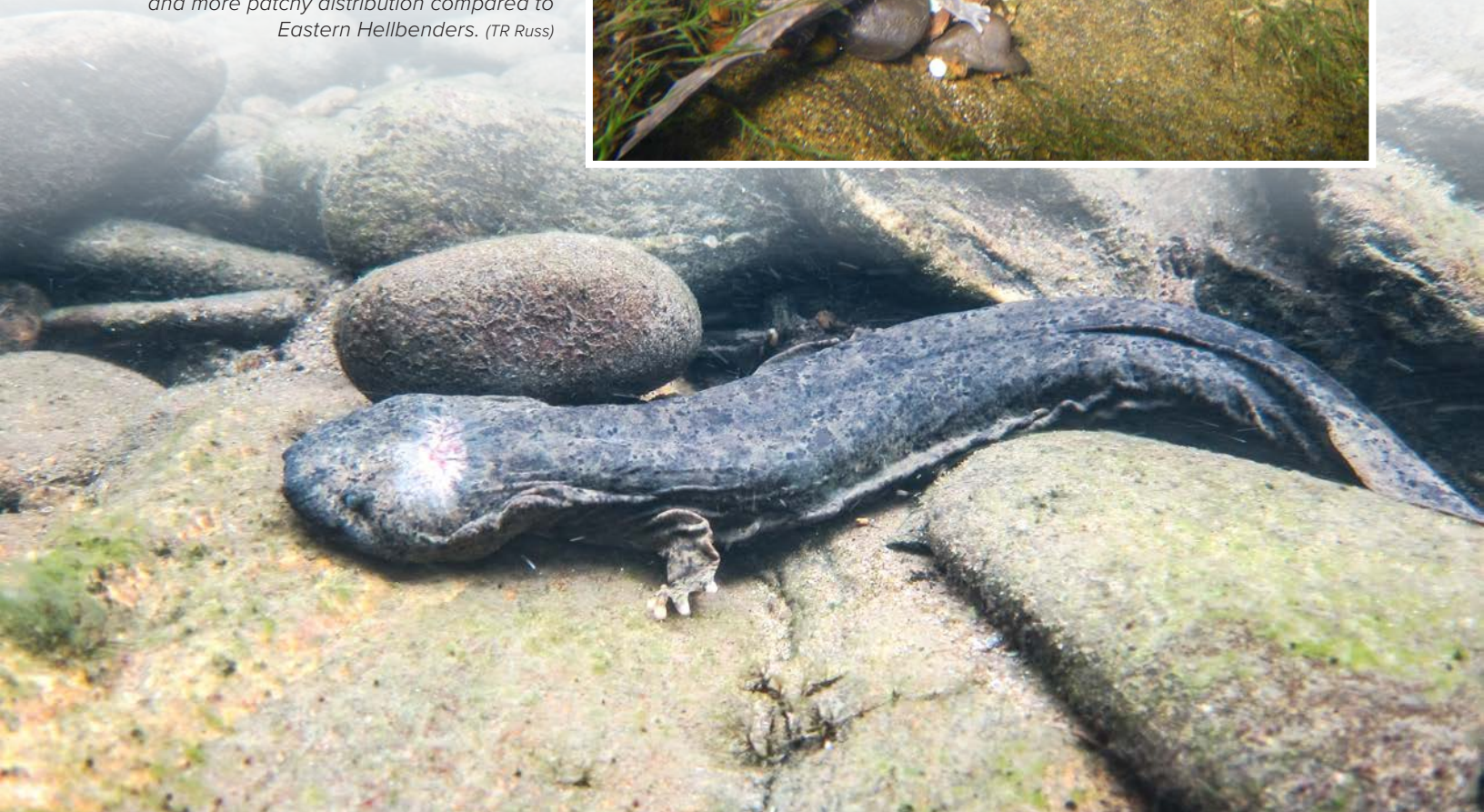
Concern. By collecting, filtering and analyzing samples of river water, biologists can determine the presence of these target species, thus providing a type of rapid assessment tool to help inventory and monitoring efforts. A major benefit of eDNA sampling is the detection

of target species in new waterways that were previously unknown in terms of species distribution. Since 2012, biologists have discovered 38 new hellbender streams in 15 counties with eight new streams found this fall season in the latest round of sampling. Out of 681

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Below: An adult Eastern Hellbender during breeding season with fight wounds; breeding season is the best time to use eDNA sampling for hellbenders as there is more DNA in the water. (Lori Williams)

Right: An adult Mudpuppy; eDNA sampling is more challenging for this species due to their smaller size, different activity patterns, and more patchy distribution compared to Eastern Hellbenders. (TR Russ)



hellbender eDNA samples over the years, 304 have been positive (44.6%; Fig. 1). For mudpuppies, out of 640 samples, 42 have been positive (6.6%; Fig. 2), but staff have documented 17 new waterways in nine counties and expanded the mudpuppy distribution to all river basins within the species' range in western North Carolina. The next step with this eDNA project for both species is to follow-up with field surveys to pair physical captures or confirmed observations with positive eDNA locations. Staff also have a field study underway to examine how far downstream eDNA might travel from source animals and still be detected. The next phase of that study will be completed in spring 2023. Ultimately, staff hope to develop a survey methodology that will result in more efficient occupancy surveys and monitoring.



Wildlife Diversity technician, Reed Rossell, in the lab processing river water samples with a vacuum flask, special filters to trap DNA, and an electric pump. (Lori Williams)

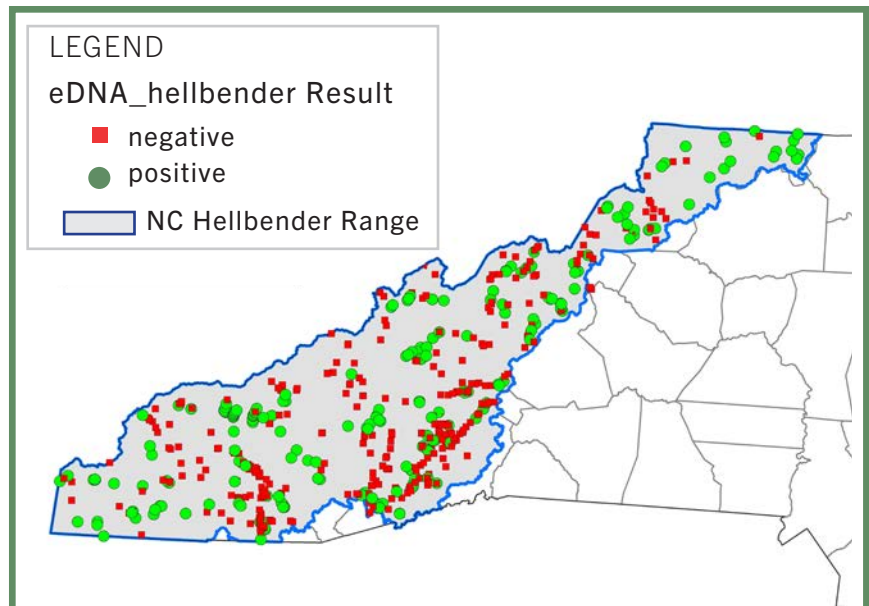


Fig. 1 Eastern Hellbender (*Cryptobranchus a. alleganiensis*) environmental DNA (eDNA) sampling to date

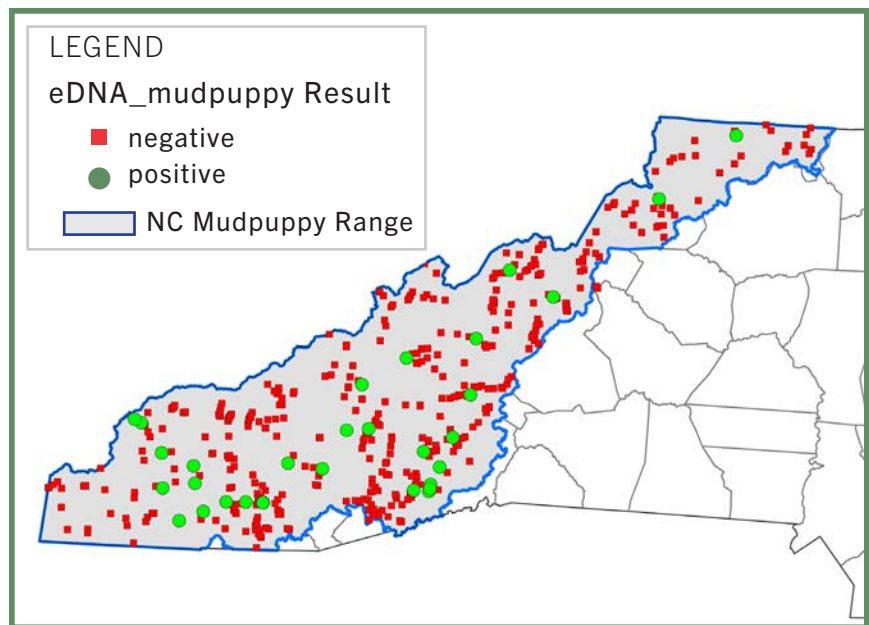


Fig. 2. Mudpuppy (*Necturus maculosus*) environmental DNA (eDNA) sampling to date

Manuscript Published on Ranking Wetland Quality and Functionality Based on Amphibian Species Habitat Preferences

by Dr. Jeff Humphries, Eastern Amphibian and Reptile Biologist

In the 4th quarter, NCWRC biologists and partners published a journal manuscript regarding the use of amphibian species ranking scores to estimate the relative health of wetland and aquatic communities in North Carolina. This is the first time in North Carolina where amphibian wetland use data and expert opinion have been synthesized to measure wetland habitat quality in addition to using species richness and abundance alone. For example, on the North Carolina Coastal Plain, wetlands that have a higher number of habitat specialists such as Gopher Frogs, Tiger Salamanders,

etc., would rank higher in quality than wetlands that only contain habitat generalists such as Southern Leopard Frogs or Spring Peepers. This is a much more comprehensive way of assessing wetlands than using species richness alone, and it is a way of including amphibians in ranking wetland quality in addition to plant communities or other measures that have traditionally been used. We cite an example of using this ranking method based on real-world data from a 3-year research collaboration between the NCWRC and NC Department of Environmental Quality. We hope that

this quantitative method of ranking wetland quality and functionality based on amphibian species habitat preferences will be used by other entities in preserving and restoring high quality wetlands in North Carolina.

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A NEW DATABASE FOR FACILITATING EVALUATION OF WETLAND AND AQUATIC AMPHIBIAN COMMUNITIES IN NORTH CAROLINA

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Abstract: Wetland condition assessment is often performed by land managers, federal and local governments, and conservation organizations to document current condition and potentially take action to protect or restore valuable wetland resources. These condition assessments often include data collection or surveys of biotic communities such as vegetation, macroinvertebrate, and amphibian communities. Assessment tools for gauging quality of these communities are needed to allow scientists to understand overall condition. To facilitate a better understanding of amphibian communities found in wetlands and associated habitat quality, we created ratings of anthropogenic disturbance sensitivity for wetland and aquatic amphibian species in North Carolina. With adequate surveys of amphibian communities, these ratings can be input into an index of amphibian wetland habitat quality for North Carolina wetlands, the Amphibian Quality Assessment Index (AQAI). Comparison of the AQAI against amphibian species richness in a 3-yr study in 16 wetlands showed the two indices to be correlated but not strongly so. The AQAI has the advantage of providing additional habitat quality information beyond indices based solely on species richness and abundance.

Key Words: amphibian; wetland; aquatic; habitat; assessment; coefficient of conservatism; C-value; North Carolina.



A wetland restoration project on Sandhills Game Land that was studied and used as an example in the published manuscript (inset). (Dr. Jeff Humphries)

NCPARC



N.C. Partners in Amphibian and Reptile Conservation Updates

by Jeff Hall, Partners in Amphibian and Reptile Conservation Biologist

The first quarter of 2022 was historically poor for many breeding amphibians. As an example, this is the first year since staff have been monitoring for Gopher Frogs (15 years now) when no breeding was detected in any of the seven populations in North Carolina. Similarly, poor breeding conditions existed for the Ornate Chorus Frog and Southern Chorus Frog.



*Above, Southern Chorus Frog; below, Ornate Chorus Frog
(Jeff Hall)*



Reptile & Amphibian Field Surveys Proved Fruitful

Survey efforts for the Neuse River Waterdog proved very fruitful in the first quarter. As with the past several years, NCWRC staff supported efforts of a graduate student at N.C. State University and helped conduct surveys at several sites. One of the sites staff surveyed this year held some historical numbers, but in a

good way! On day two of surveys (traps are set on day one), staff caught 46 waterdogs at a site including one trap that held 14 individuals. Among those 46 animals, staff caught two adults that were very large, including two nearly 12 inches in length. Day three yielded 18 waterdogs, day four included eight

and day five held six. Total captures for the week included 78! Images of each animal were recorded each day, so staff will be combing through those images to determine whether any animals caught on subsequent days were recaptures. Staff are excited to see these salamanders doing so well at a site!



Partners in Amphibian and Reptile Conservation Biologist Jeff Hall holds an adult Neuse River Waterdog (Kabryn Mattison); right, Wildlife Diversity Technician Kabryn Mattison with recently trapped Neuse River Waterdogs (Jeff Hall)



Among the species staff found during reptile surveys in February and March were (left to right) Carolina Pigmy Rattlesnake in Carteret County, Eastern Diamondback Rattlesnake from Onslow County, and Scarlet Kingsnake from Brunswick County. (Jeff Hall)

Reptile & Amphibian Surveys Involved Many Staff, Partners, Volunteers

Amphibian and reptile surveys during the second quarter involved many staff from the NCWRC, partner agencies and volunteers from the public. Sites assessed ranged from game lands to state parks to national forests. Species targeted included Mabee’s Salamander, Pine Barrens Treefrog, Spotted Turtle,

Pigmy Rattlesnake, and Timber Rattlesnake. Two new sites were documented for Mabee’s Salamander including a new county of occurrence: Beaufort County.

Timber Rattlesnake surveys were again significantly assisted by community science records sent to us on rattlesnake@ncwildlife.org.

Already, we have received well over 100 sightings for 2022. These records have been incredibly helpful in identifying key areas of conservation significance for rattlesnakes, as well as leading staff to promising sites for tissue collection, in the form of shed skins, for an ongoing genetic assessment.



Among the species staff found during amphibian and reptile surveys in the second quarter 2022 included (clockwise from top left) Mabee’s Salamander larva in Beaufort County; Timber Rattlesnake in western North Carolina; Timber Rattlesnake in western North Carolina; Spotted Turtle (Jeff Hall)

Reptile & Amphibian Field Surveys Conducted for Several Species of Greatest Conservation Need

Efforts in surveys and monitoring for amphibian and reptile Species of Greatest Conservation Need during this quarter involved many staff from the NCWRC, partner agencies and volunteers from the public and ranged across the state. Species targeted on game lands, state parks and national forests included Pigmy Rattlesnake, Timber Rattlesnake, Eastern Coachwhip, Southern Hognose Snake, Black Swamp Snake, Glossy Crayfish Snake and Gopher Frog. Additional assistance was provided for monitoring of the American Alligator and Eastern Hellbender.



(Jeff Hall)



(Jeff Hall)



Left: Wildlife Biologist Jeff Hall and Wildlife Technician Kabryn Mattison restrain a captured American Alligator, which was measured and marked before being released. (Kimberly Smith); Bottom photo: Wildlife Technician Kabryn Mattison spies an Eastern Hellbender out on the crawl (Ben Dalton)

Timber Rattlesnake surveys in western North Carolina continued to be heavily assisted by community science records sent to rattlesnake@ncwildlife.org. These sightings have led to the discovery of several important areas for rattlesnakes.

Snake Surveys, ARD Placements, Habitat Assessments, Pond Restoration Activities Kept Staff Busy During Last Quarter

Field highlights for the final quarter of 2022 included upland snake surveys, placement of automated recording devices, winter amphibian habitat assessments, and pond restoration activities. Several Species of Greatest Conservation Need were encountered during snake surveys including Carolina Pigmy Rattlesnake, Timber Rattlesnake, Southern Hognose Snake, Northern Pine Snake, and Eastern Coachwhip. Surveys were conducted at

numerous sites along the Coastal Plain and Sandhills. At one of the sites, NCWRC staff were able to assist NC Museum of Natural Sciences staff in locating and exhuming a Northern Pine Snake nest to determine how many eggs were laid and how many hatched successfully. Seven eggs were unearthed, and all had hatched. Data on survival and fecundity in snakes can be difficult to come by so observations like this are very valuable.

Over a dozen automated audio recording devices (aka frogloggers) were deployed for detection of winter-breeding anurans such as Southern Chorus Frog, Ornate Chorus Frog, and Gopher Frog. Many of these species have shown declines in recent years. Staff participated in ongoing restoration work in ponds at several game land sites in hopes of helping these and other amphibians.



Above: NCWRC and NC Museum staff dig up Northern Pine Snake nest. Left: hatched Northern Pine Snake eggs recovered from excavated nest (Jeff Hall)



During fall surveys in the Coastal Plain and Sandhills, staff encountered several Species of Greatest Conservation Need including (clockwise from top left): Carolina Pigmy Rattlesnake, Timber Rattlesnake, Eastern Coachwhip (being held by Wildlife Technician Mike Martin), Southern Hognose Snake, and Northern Pine Snake (Jeff Hall)



NCPARC Meetings

NCPARC held its annual meeting jointly with the N.C. Herpetological Society in May, the 4th North Carolina Congress of Herpetology. The meeting was a successful virtual event covering four days, with 141 registrants averaging 60-80 attendees each session. The meeting included a diversity of opportunities such as presentations, workshops, networking sessions and a trivia night! All presentations and activities were well received. We hope next year's meeting will be held in person.



SAVANNA RIVER COLLABORATIVE MEETING

In August, partners from North and South Carolina gathered at the Savannah River Site (SRS), near Aiken, S.C., to discuss management and conservation of the Gopher Frog. Both states have assisted one another in the past with information about breeding phenology, head-starting and genetics work, and this meeting was a great opportunity to share more about these topics and delve into conservation actions needed to protect the species. Over 50 attendees participated in the discussion-based meeting. Break-out sessions tackled some of the complex issues facing

conservation of the Gopher Frog, such as how best to create and restore wetlands, when to apply prescribed fire to the landscape, and protocols for head-starting animals to increase population sizes. The two-day meeting concluded with a field tour of sites on the SRS.

BLADEN LAKES ISOLATED WETLANDS WORKSHOP

In September, NCWRC biologists, in conjunction with The Nature Conservancy, N.C. Forest Service, and NCSU Cooperative Extension, held a workshop focused on management of isolated wetlands in the Bladen Lakes region. The workshop covered two days including a half-day virtual meeting and a full day field tour visiting sites in Bladen County. This was the second in a series of workshops focused on management of isolated wetlands, with the first held in 2019 in the Sandhills. Presentations were given on reptiles and amphibians, plants, natural communities, and management options for both wetlands and uplands. In addition, several case studies were shared of management successes and opportunities for improvement. Although the primary focus was the conservation of reptiles and amphibians, benefits to birds, mammals, plants and invertebrates were also discussed. The virtual day attracted 143 registrants, while the field tour was limited by capacity of vehicles to around 30 participants. Field tour sites included stops at Suggs Mill Game Land, Bladen Lakes State Forest and a private landowner. Participants shared overwhelmingly positive feedback on the value of the workshop, so staff may consider adding a third workshop in the future.



MAMMALS

Eastern Chipmunk Survey Reveals Eight New County Records

by Andrea Shipley, Mammalogist

In March 2021, the NCWRC's statewide mammalogist received an observation of an eastern chipmunk in the southern Coastal Plain. This observation was the first within the central or southern Coastal Plain region of North Carolina. Because she was curious if the observation was due to a one-time anthropogenic event or natural range expansion, she developed a public survey with the NCWRC's Human-Wildlife Interactions (HWI) program and communications team, which used

a press release and an enewsletter announcement for participation in the survey, requesting specific information including address or GPS location of the observation and a clear photo. Observations that included both pieces of information were defined to be "confirmed." The agency began receiving observations in July 2021, most of which were unable to be confirmed. During this quarter, a database of all confirmed observations was developed, the results of which expanded the state range

of the eastern chipmunk in North Carolina significantly. To confirm natural range expansion in the Coastal Plain, staff will continue to survey the public through an observation request using a press release and social media.

Live capture efforts at the confirmed observation sites are planned for fall 2022, to collect museum specimens and genetic samples. A new state range map for eastern chipmunks will be developed based on results of the survey.



Biologists Find Increases in Tricolored and Rafinesque’s Big-eared Bats during Winter Bat Surveys

by Katherine Etchison, Mammalogist

Long-term hibernacula surveys in the mountains detected generally stable count numbers in winter 2022, except at two caves on a property in Macon County. These caves harbored 80 tricolored bats, an increase of 60 from the last count in 2018. Winter counts of tricolored bats in the North Carolina mountains have declined by 95% since the arrival of White-nose Syndrome (WNS) in 2011. The increased numbers at these caves are encouraging, and may be evidence of reproduction by WNS survivors and potential immigration from a nearby cave that experienced a landslide in 2020. Factoring in the bats from the nearby cave, this is still an increase of 47 tricolored bats since 2018.

Rafinesque’s big-eared bats are not known to be susceptible to WNS but are sensitive to human disturbance at winter and summer roosts. Habitat loss is also a threat to the species. Two large hibernacula for this species in Swain County have shown fluctuating, but generally declining counts over the last two decades. This year’s count of 827 Rafinesque’s big-eared bats was the highest since 2009 and continued an increase first noted in 2019. This growth could be an indication that disturbance and habitat loss are not threats to this particular population in the Great Smoky Mountains.

Eight long-term hibernacula in the North Carolina Piedmont were surveyed by Habitat Conservation Division staff, seven of which experienced increases in tricolored bats numbers. One-hundred-forty (140) tricolored bats were counted across all sites, which is an increase of 52 bats from the 2019 survey. The fungus that causes WNS has been detected

in six Piedmont counties, but visible signs of the disease have been encountered in only two hibernacula. It is interesting that the spread of WNS has been much slower and less deadly in the Piedmont and may be due to multiple factors, including lower densities of bats at hibernacula and shorter or more intermittent hibernation periods.



Left photo: A tricolored bat shows visible signs of White-nose Syndrome in a cave in Macon County. Below: Hibernating Rafinesque’s big-eared bats in a mine in Swain County (Katherine Etchison)



Little Brown Bat Tracking Results in Largest Known Colony in State

by Katherine Etchison, Mammalogist

The once common little brown bat has become exceptionally rare in western North Carolina due to impacts from white-nose syndrome (WNS). Mist net captures of this species are down 92% compared to surveys occurring before the arrival of WNS; however, little brown bats are still consistently found at a mist net site in Avery County. NCWRC, NC State Parks, U.S. Fish

and Wildlife Service and Southern Appalachian Highlands Conservancy personnel gathered for the annual mist net survey of this site in August 2022. The team caught five little brown bats and applied radio-transmitters to four of them. The objective of this effort was to locate the bats' roost and begin to learn about the surviving population in the area. Little brown bats

commonly roost in artificial structures like buildings and bridges, which can be subject to modification and become unsuitable over time. It was imperative to find the roost to ensure bats have access to a suitable roost for the future.

One tagged individual was found roosting alone under the wooden siding on a house about 2.8 miles from the mist net site. The other

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Wildlife Diversity Technician Joey Weber searches for a (inset) radio-tagged little brown bat (Katherine Etchison)



MAMMALS

tagged bats were found roosting in a privately owned building about 2.5 miles from the mist net site. An emergence survey on the building resulted in a count of 86 bats exiting the building at sunset, making it the largest known little brown bat roost in the state. Only one

additional little brown bat roost is currently known, and the highest count is five individuals. All other known roosts for this species (six with upwards of 400 individuals) were extirpated in the years since WNS arrival. Efforts are underway to develop a partnership with the

property owner and add bat houses to provide an array of roosting options for the colony. The next step in learning about this surviving population is to plan a second telemetry effort when the bats head to their winter hibernaculum in 2023.



Clockwise from left: NC State Parks Mountain Region Biologist, Sharon Bischof, Southern Appalachian Highlands Conservancy Land Protection Associate, Kyle Shute, and NC State Parks Inventory Biologist, Ed Corey, determine morphological measurements of a little brown bat. A little brown bat caught during a mist net survey in Avery County. A little brown bat found roosting in an Avery County building (Katherine Etchison)

Northern long-eared Bats Elude Capture at Nantahala National Forest Mine

by Katherine Etchison, Mammalogist

NCWRC biologists teamed up with U.S. Forest Service (USFS) staff in an attempt to catch a northern long-eared bat at an inactive Macon County mine in early October. Populations of this species have severely declined due to White-nose Syndrome, which recently caused the U.S. Fish and Wildlife Service to

reclassify the bat from Threatened to Endangered. Nantahala National Forest Wildlife Biologist Johnny Wills acoustically monitored this Macon County mine for the last three years and detected northern long-eared bat calls on multiple occasions. This find is noteworthy because northern long-eared bats

have not been found in a cave or mine in North Carolina since 2014.

Attempts to access the mine for visual confirmation of hibernating northern long-eared bats have been abandoned because the mine's deteriorating condition makes human entry unsafe. This early October mistnetting survey was the next best

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Wildlife Diversity Technician Joey Weber and Wildlife Diversity Biologist Katherine Etchison prepare to set up a mistnet at a mine entrance. (Johnny Wills/USFS)

method to confirm northern long-eared bat presence in the mine. Bats move to their winter hibernation sites in early autumn and tend to forage for insects outside the site on warm nights. This behavior presents a key opportunity to catch bats at the entrances of caves or mines to determine which species hibernate in the site.

NCWRC and USFS biologists blocked off the entrance to the mine with a tarp and mistnet in an attempt to funnel entering or exiting bats into the net. Though weather and other conditions were favorable, no bats were caught during the survey. Additionally, tricolored bat calls were recorded on the nearby acoustic detector, but no northern long-eared bats were detected that night. It's uncertain whether northern long-eared bats use the mine and simply were not present that night or whether they're using the mine at all. For now, the mystery of northern long-eared bat presence in the mine continues.



The final mistnet and tarp set up at the mine entrance (Katherine Etchison)



The vertical shaft at the mine entrance (Katherine Etchison)



Populations of the northern long-eared bat have declined severely due to White-nose Syndrome. (Katherine Etchison)

Staff Team with U.S. Forest Service and Specialists to Repair Gates at Caves and Mines on the Nantahala National Forest

by Katherine Etchison, Mammalogist

The NCWRC and the U.S. Forest Service (USFS) worked collaboratively to restore working order to three gates in caves and mines on the Nantahala National Forest in April. These sites serve as bat hibernacula during winter, so preventing unauthorized human entry is key to conservation. Human disturbance often causes bats to wake from

hibernation, which can deplete vital fat reserves needed for surviving white-nose syndrome infection.

At a Macon County mine, a new gate was created because the mine has records of hibernating northern long-eared bats and is currently used by hibernating tricolored bats. Populations of these species have undergone severe

population reductions because of white-nose syndrome. The NCWRC and USFS worked alongside a team of cave gate specialists over three days to repair and fabricate these gates. Staff from the Land and Water Access Division and the Wildlife Diversity Program provided much of the labor for this effort.



Nantahala National Forest Wildlife Biologist, Johnny Wills, Conservation Technician, Brandon Allen, and Franklin Depot Team Leader, Mike Parks, prepare to cut steel for a mine gate. (Katherine Etchison)



A Macon County mine entrance on the Nantahala National Forest after gate installation (Johnny Wills/USFS)



A tricolored bat documented the winter before gate installation in the Macon County mine (Katherine Etchison)

FISHES

Sicklefin Redhorse Conservation

by Luke Etchison, Western Region Aquatic Wildlife Diversity Coordinator

It was a successful year for Sicklefin Redhorse monitoring and egg collection in the Little Tennessee River Basin. Western Region Aquatic Wildlife Diversity biologists teamed up with colleagues from the U.S. Fish & Wildlife Service, Eastern Band of Cherokee Indians,

Duke Energy and Tennessee Valley Authority to capture this state threatened sucker species that is endemic to the Little Tennessee and Hiwassee river basins in western North Carolina and Northern Georgia. The Sicklefin Redhorse can only be caught in high numbers

during its spring spawning run, when males and females congregate in shallow, swift shoals. The spawning period is very brief, so biologists must attempt to time their sampling efforts when temperatures and water levels are just right.

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This year, biologists used boat electrofishing surveys to collect 146 Sicklefin Redhorse from the Little Tennessee River Basin. Survey locations included the Little Tennessee River downstream from Lake Emory Dam, the Oconaluftee River downstream from Ela Dam, the Tuckasegee River near Cullowhee, and the Tuckasegee River between the Oconaluftee River and Bryson City. The Little Tennessee River ended up being the most productive site and biologists were able to collect an estimated 12,000 eggs from just one female. The eggs were fertilized on site before being transported to Warm Springs National Fish Hatchery in Georgia. After hatching there, the propagated Sicklefin Redhorse will be fed until they reach sizes suitable for stocking. Stocking efforts will take place later in the summer/fall 2022 and will focus on areas in their native range where dams currently prohibit the Sicklefin Redhorse from occupying.

Biologists are also conducting a long-term Mark/Recapture study, which requires each fish to be implanted with a unique Passive Integrated Transponder (PIT) tag. This monitoring effort provides additional insights into some of the Sicklefin Redhorse's basic biology such as population size, movement patterns and lifespan. Fifteen of the fish captured in 2021 had been caught and tagged in previous years.



Sicklefin Redhorse collected from the Little Tennessee River (NCWRC)



Partners with the Eastern Band of Cherokee Indians measuring a Sicklefin Redhorse (NCWRC)

Staff Conduct Least Brook Lamprey Surveys in the Tar and Neuse Basins

by Michael Fisk, Eastern Aquatic Wildlife Diversity Coordinator

The Wildlife Diversity Program Staff surveyed for Least Brook Lamprey for the second year in a row to collect data on the distribution and life history of this unique fish. The objectives of these surveys were to update the known distribution of the species and describe spawning habitat. In February and March, staff visually surveyed streams in the Tar and Neuse Basins by walking stream banks, searching for spawning individuals. Surveys were restricted to shallow streams with good visibility.

A total of 97 Least Brook Lamprey were observed from 7 unique sites. Of these, 47 Least Brook Lamprey were collected from Bens Creek, Bear Swamp, and Little Shocco Creek in the Tar Basin. In the Neuse Basin, 50 Least Brook Lampreys were collected from Pearl Creek, Beddingfield Creek, and two unnamed tributaries that flow into Middle Creek and the Little River.

On average female Least Brook Lamprey were slightly larger than males and ranged from 103–145 mm and averaged 127 mm compared to males that ranged 100–143 mm and averaged 124 mm. Least Brook Lamprey were found excavating nests and actively spawning in the crests of riffles and runs with moderate flows. Mean nest depth was 10.2 cm (range 2–26 cm) and water temperature ranged from 11.3 C°–17.3 C° during observed lamprey activity.



Least Brook Lamprey (Michael Fisk)

Additional surveys were conducted in the Roanoke Basin to document lamprey spawning during the same time frame. These efforts were based on 2021 observations from a local Halifax County resident, Rufous Johnson, who provided video of spawning lampreys in the Quankey Creek watershed around Halifax. A group including Mr. Johnson, NCWRC staff and Bryn Tracy and Fritz Rhode with NC Fishes, documented American Brook Lamprey in this watershed in an unnamed tributary of Quankey Creek and in Little Quankey Creek. The American Brook Lamprey, listed as a species of Special Concern, is known to occur in the upper Roanoke Basin in Virginia, however, these are the first records of the species in this basin in North Carolina. It also expands the range

of the species within North Carolina where previous records were restricted to Western North Carolina in the French Broad Basin in Madison County. A total of 17 individuals were observed. Mean total length for females was 153 mm (range = 143–159 mm). Male mean total length was slightly larger at 156 mm (range = 139–165 mm). American Brook Lamprey were observed actively excavating nests and spawning as well as migrating upstream to spawning habitats.

Future surveys will target spawning individuals in February and March of 2023 and this summer staff will survey for juvenile lamprey throughout their range in the Eastern Region. Information collected from juvenile surveys will help gain a better understanding of the life history of these cryptic species.

Robust Redhorse Sampling and Population Monitoring Continue

by Brena Jones, Central Aquatic Wildlife Diversity Research Coordinator

Staff continued annual cooperative sampling and population monitoring for Robust Redhorse in the Pee Dee River downstream of Blewett Falls dam, alongside partners in the Yadkin-Pee Dee Technical Working Group, including Duke Energy, S.C. Department of Natural Resources (SCDNR) and S.C. Aquarium. During targeted spring surveys, there were 58 Robust Redhorse captures in 20.3 hrs of electrofishing, a catch rate of 2.85 fish per hour.

These captures represent:

- 50 unique individuals of which 25 were previously untagged fish
- 16 recaptures from previous years, a recapture rate of 32%
- 8 Phase II juveniles, spawned in spring 2015, stocked in November 2016
- One Phase III individual, spawned in spring 2015, stocked at age 5 in March 2020

Fish ranged in size from 17 to 29 inches (425 to 748 mm) in total length (TL), representing multiple age classes. Continued successful recruitment of captively reared fish into the wild population was documented once again this year. Eggs from two females were crossed with one male for captive propagation this year. The resulting fry will be grown out in ponds at the NCWRC's McKinney Lake Fish Hatchery and the SCDNR's Dennis Center for population augmentation stocking.

Duke Energy biologists had 12 more captures near Blewett Falls dam, including four previously untagged fish. This brought the total number of Robust Redhorse captured in North Carolina in 2019 to 60 fish.

Fin clips were collected from all animals in North Carolina, and genetic analysis conducted by SCDNR this summer will determine whether the new fish are products of previous augmentation efforts.



Brena Jones collects a fin clip from a sedated adult male Robust Redhorse. (NCWRC)

Staff Collect Cape Fear Shiner Broodstock from Deep River

by Brena Jones, Central Aquatic Wildlife Diversity Coordinator

The Cape Fear Shiner is federally listed as endangered. This minnow species is endemic to the upper portion of the Cape Fear River basin, living in complex run/riffle/pool habitats found across the North Carolina Piedmont region. In May 2022, staff collected 39 Cape Fear Shiners from the Deep River, which were then transported to the U.S. Fish & Wildlife Service Edenton National Fish Hatchery. These animals will be allowed to spawn in captivity, to maximize the survival of their eggs and offspring. The resulting juveniles will then be stocked back into portions of the species' range where population levels are lower, with the goal of augmenting numbers and increasing chances of future reproductive success in the wild. The USFWS and NCWRC will continue to work in partnership to produce multiple year-classes of Cape Fear Shiners in the future.



Cape Fear Shiners (Brena Jones)

Staff Find No Broadtail Madtoms during Surveys this Quarter

by Katharine DeVilbiss, Central Region Aquatic Wildlife Diversity Biologist

Staff conducted site visits in the Lumber River and two tributaries, Shoe Heel Creek and Joes Creek, for the state listed special concern Broadtail Madtom a rare, undescribed native catfish. Staff checked 42 small, artificial cover structures, informally named "madtom motels" that were previously deployed at four localities for occupancy. They also deployed additional motels to replace lost units. No Broadtail Madtom were detected. Several other fish found utilizing the motels were juvenile native catfish species: Margined Madtom and Snail Bullhead. During the most recent visit in June, individuals of these species were found occupying 11 of 42 motels. One non-native species, the Red Swamp



These madtom motels made suitable housing for other aquatic species, including juvenile native catfish like the Snail Bullhead (Katharine DeVilbiss)

Crayfish, was found occupying a motel. Staff will continue to check motel occupancy for this ongoing project and additional future deployments and surveys are planned.

Sucker Translocations in the French Broad River

by Dylan Owensby, Western Region Aquatic Wildlife Diversity Biologist

Efforts have begun to reintroduce three sucker (Catostomidae) species to portions of the upper French Broad River. Biologists with the Western Region of the Aquatic Wildlife Diversity Program captured Smallmouth Buffalo, Black Buffalo and Smallmouth Redhorse from the French Broad River near Marshall and transported them approximately 55 river miles upstream to the French Broad River near Etowah. These sucker species are just a few of many fish species that are found in the lower French Broad River that are currently unable to occupy their former native range farther upstream. A combination of past water quality issues and three dams on the mainstem French Broad, all of which are located downstream of Asheville, has prevented the fish from returning to large portions of the watershed that they once inhabited.

During three days in June, biologists used boat electrofishing to capture 85 suckers for the translocation (36 Smallmouth Buffalo, 10 Black Buffalo and 39 Smallmouth Redhorse). Each fish was weighed, measured, photographed and given a unique PIT tag before being transported in a fish hauling tank to their new home upstream. Finclips were also taken from a subset of fish for genetic records.

Biologists are hopeful the PIT tags will provide useful information if the fish are captured during later monitoring efforts. One of the translocated Smallmouth Buffalo has already been picked up by a passive PIT antenna located at the mouth of a restored slough near Mud Creek that was created with the help of NCWRC staff in 2020. Biologists are planning to continue with the translocation efforts of these species for the next few years and will be adding more native species to the upper French Broad fish community in the near future.



Smallmouth Buffalo caught in the lower French Broad River (Dr. Luke Etchison)



Dr. Luke Etchison and Hans Lohmeyer measuring and PIT tagging a Smallmouth Redhorse just downstream from Redmon Dam on the French Broad River near Marshall (Dylan Owensby)



Hans Lohmeyer tempering the suckers to the local water conditions in the upper French Broad River prior to being released (Dylan Owensby)

Staff Conduct Fall Survey for SGCN in Lake Mattamuskeet Prior to Large-scale Carp Removal in 2023

by Michael Fisk, Eastern Region Aquatic Wildlife Diversity Coordinator

Aquatic Wildlife Diversity staff surveyed Lake Mattamuskeet in Hyde County in October for fish and mussel Species of Greatest Conservation Need (SGCN). Historically, Lake Mattamuskeet has provided suitable over-wintering habitat for waterfowl because of abundant submerged aquatic vegetation (SAV) in the lake. Due to impacts

of the non-native Common Carp, degraded water quality, and other factors, SAV is at an all-time low. The objective of these surveys was to collect baseline data for the lake before a large-scale carp removal is initiated in 2023. The carp removal is part of a long-term aquatic vegetation management plan to restore SAV in the lake. Thirteen species of

fish were collected in the lake, and several fish species associated with SAV were absent from these collections. Mussel surveys found only the Rangia clam, a species associated with brackish water present in the lake. Future surveys after the carp removal will be conducted to document changes in diversity, abundance and SAV.



This bowfin was one of 13 species staff collected in Lake Mattamuskeet during a survey in October. (Photo: Michael Fisk)

Staff Continue Robust Redhorse Stockings into Pee Dee River

by Brena Jones, Central Region Aquatic Wildlife Diversity Coordinator

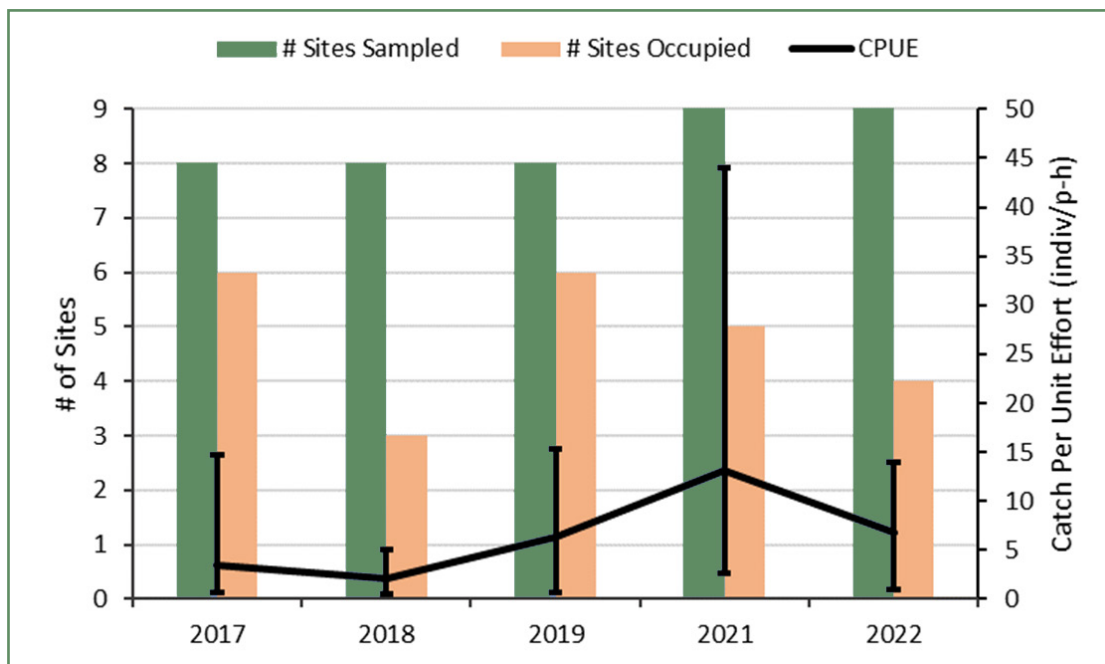
In November, 7,404 Phase I (6 months old) Robust Redhorse fingerlings raised at the South Carolina Department of Natural Resources Dennis Center and the NCWRC’s McKinney Lake Fish Hatchery were stocked into the Pee Dee River in North Carolina. These fish were the progeny of adults collected in the Pee Dee River spawning shoals in North Carolina in spring 2022. Another 915 were held back at McKinney Lake Hatchery to grow out to Phase II (18 months old), which will be stocked in the winter 2023.

Staff Continue Carolina Pygmy Sunfish Monitoring in Southeastern NC

by Brena Jones, Central Region Aquatic Wildlife Diversity Coordinator

Staff continued annual monitoring surveys for the Carolina Pygmy Sunfish, a State Threatened species endemic to Columbus and Brunswick counties in North Carolina and small portions of the coastal plain in South Carolina.

Of nine previously occupied localities sampled in October, Carolina Pygmy Sunfish were collected at four locations. Carolina Pygmy Sunfish are persisting and catch per unit effort (CPUE) ranged from 1 to 14 individuals per person hour.



Carolina Pygmy Sunfish monitoring results by year. Black line indicates average CPUE values, with vertical black bars indicating maximum and minimum CPUE for each year. 2018 sampling was conducted two months after Hurricane Florence.

MOLLUSKS

Staff Conduct Host Fish Surveys for Tar River Spiny mussel

by Michael Fisk, Eastern Region Aquatic Wildlife Diversity Coordinator

In May and June, Wildlife Diversity Program staff in the Eastern Region conducted host fish surveys for the Tar River Spiny mussel. Mussels have parasitic larvae called glochidia that they attach to the gills

and fins of fish for several weeks before they drop off into the substrate. Although lab studies have identified several fish species as suitable hosts, determining host fish under natural conditions can help

gain a better understanding of the Tar River Spiny mussel's life history, which will lead to enhanced conservation strategies. A long-term augmentation site in Little Fishing Creek (Halifax County), a tributary

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Rachael Hoch

of the Tar River, was used for this project. Staff used a combination of seining and backpack electro-fishing to collect host fish in the vicinity of the augmentation site. White Shiner, Pinewoods Shiner, Bluehead Chub and Satinfin Shiner were targeted based on previous lab and hatchery trials where Tar River Spiny mussel glochidia successfully attached and transformed into juvenile mussels.

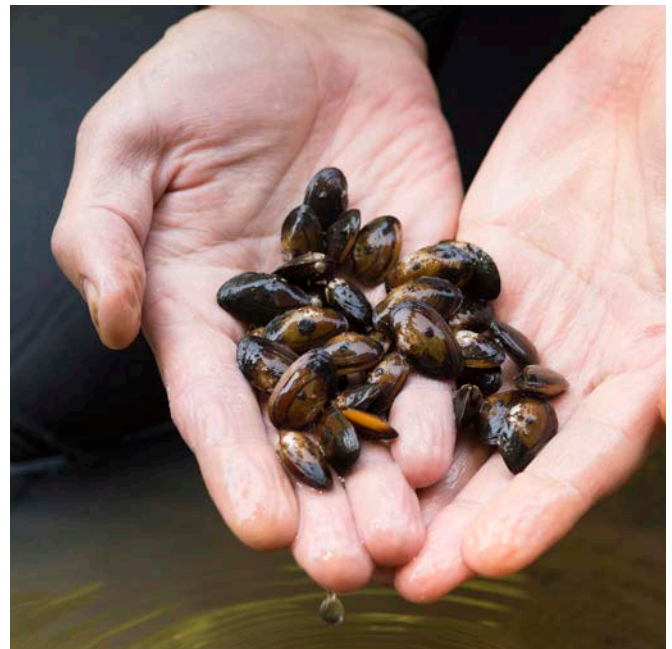
From the first collection in May, staff found glochidia on four of the

13 White Shiners and five of the 44 Pinewood Shiners collected. No glochidia were collected on the Bluehead Chubs. Two White Shiners held two glochidia each while all other fish only had single individuals. Four of the 10 glochidia collected were preserved and appear to be Tar River Spiny mussels based on visual assessments. The other glochidia collected may be common *Elliptio* species and one glochidia from the federally listed Atlantic Pigtoe. To confirm the

identity of each species, staff will measure, photograph and genetically analyze the glochidia. Host fish collections were completed in June, and the fish are currently being processed. The results of this study will help identify host fish for the Tar River Spiny mussel as well as other native mussels within Little Fishing Creek. These findings will help gain a better understanding of native mussel life history and lead to more informed conservation strategies.



Above: Tar River Spiny mussel conglutinates. Conglutinates are packages of glochidia that the female mussel releases. Often, the conglutinates will mimic prey and food items to attract host fish and increase the likelihood of infestation = attachment to the host. Host fish will attempt to eat the conglutinates, and the glochidia are expelled and attach to the gills of the host fish.
(Sierra Benfield)



Tar River Spiny mussels (NCWRC)

Staff Continue Mussel Surveys for Unknown, New-to-Science Species

by Katharine DeVilbiss, Central Region Aquatic Wildlife Diversity Biologist

NCWRC staff continued mussel surveys from May through June for an unknown, new-to-science species in the Little River and tributary waters of the Pee Dee River drainage, to supplement surveys performed since the species discovery in May 2019. The undescribed species is known to be a narrow-ranged North Carolina endemic, located in only 8 km (~5 mi.) of the Little River mainstem in Randolph County to date. Twelve surveys were performed in the Little River at previously surveyed localities as part of an occupancy

and detection study. This was the third visit to these repeat sites. Six individuals of the undescribed species were detected over four sites, all of which were untagged and not found during previous visits. Those four sites were within the known range. Search effort totaled 46 person-hours (p-h), for an average catch per unit effort of 0.13 individuals per p-h. In other words, it took over 7.5 hours to locate one individual of this unknown species.

Four additional surveys were conducted in tributary waters of the Uwharrie Mountain region in

Hannahs Creek and Barnes Creek. No individuals of the undescribed species were located. Species of Greatest Conservation Need (SGCN) species detected in these surveys included Brook Floater (state endangered), Carolina Creek-shell (state endangered), Notched Rainbow (state threatened), and Savannah Lilliput (federal species of concern, state endangered). Staff biologists plan to continue surveys and studies to further their understanding of this undescribed freshwater mussel species.



Undescribed mussel species from Little River, Pee Dee basin (Katharine DeVilbiss)

Staff Continue Mussel Surveys in the Pee Dee River

by Brena Jones, Central Aquatic Wildlife Diversity Coordinator

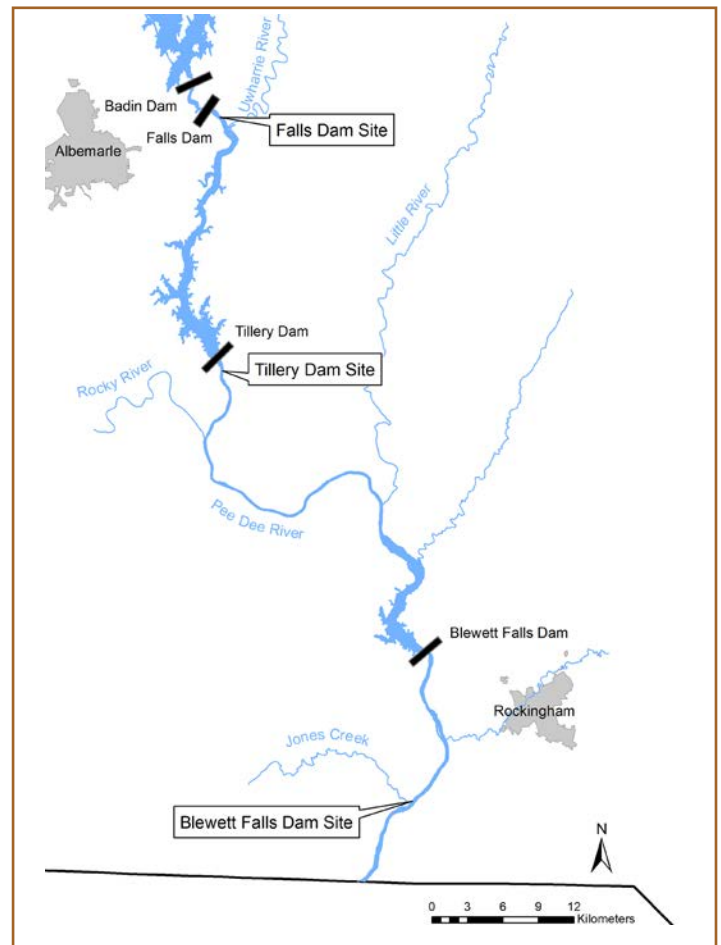
Beginning in 2009, three long-term mussel population monitoring sites were established in the lower Pee Dee River, near the state border in south-central North Carolina. In 2022, with help from partners including Duke Energy/Progress, staff conducted the seventh biennial survey for priority mussel species downstream of Blewett Falls and Tillery dams. Monitoring at the third site, below Falls Dam, has been turned over to Cube Hydro as part of its Federal Energy-Regulatory

Commission (FERC) license requirements. These data provide an opportunity to document the potential changes in mussel diversity and abundance due to the improved dissolved oxygen levels and minimum flows downstream of these dams implemented under new FERC licenses for Duke Energy/Progress. In addition, this long-term dataset may provide insights into population responses to other events such as extreme floods from large hurricanes.

Data analysis from this survey is ongoing. There was an increase in species richness, with 13 detected in 2022, up from 11 in 2019, but neither “new” species was new to the site. Species richness at the Blewett Falls site remained at 10, unchanged from 2019. Mussel Species of Greatest Conservation Need collected were the Yellow Lampmussel, Eastern Lampmussel, Creeper, Eastern Pondmussel, Carolina Creekshell and Eastern Creekshell.



Top photo: Female Yellow Lampmussel (Brena Jones); Right illustration: Mussel Monitoring Area Map – Pee Dee River, NC



Dwarf Wedgemussels Released into Swift and Little Shocco Creeks to Augment Populations

by Michael Fisk, Eastern Region Aquatic Wildlife Diversity Coordinator

Aquatic Wildlife Diversity staff released 500 federally endangered, Dwarf Wedgemussel into Swift Creek in the Neuse River basin and in Little Shocco Creek in the Tar River basin in November. These efforts were to augment existing populations of Dwarf Wedgemussel in Swift Creek in Johnston County and Little Shocco Creek in Warren County. All mussels were tagged with Hallprint (alpha-numeric) and passive integrated transponder (PIT) tags to aid in relocating and identifying individual mussels. Habitat types were characterized for each mussel released to help gain a better understanding of habitat impacts on overall success. Additional Dwarf wedgemussels will be released in these sections in spring 2023. Each augmentation reach will be evaluated each year to determine growth, survival and movement.



Some of the 500 Dwarf Wedgemussels released into Swift and Little Shocco creeks (Michael Fisk)

Staff Continue Lake Waccamaw Fish and Mussel Monitoring Surveys

by Brena Jones, Central Aquatic Wildlife Diversity Coordinator

NCWRC staff, in partnership with NC State Parks, has conducted annual standardized surveys since 2009 for three fish Species of Greatest Conservation Need (SGCN) at multiple sites in Lake Waccamaw, including the endemic, federally Threatened Waccamaw Silverside. The mean number of Waccamaw Silversides collected per minute of seining (catch rate) at all sites combined has been highly variable over nine sampling years and was 11.8 fish/minute (fpm) of seining in 2022. This value has ranged from 1.82 fpm in 2017 to 23.5 fpm in 2009; it was an increase from the catch rate of 3.6

fpm in 2021. Variability is likely due to the fish's schooling behavior, preference for open waters of the lake, and varied sampling conditions, such as very warm water (exceeding 33 C), which causes fish to move out into deeper habitats that cannot be seined. The highest catch rate at a single site in 2022 was 21.1 fpm. The Waccamaw Killifish and Waccamaw Darter were also successfully collected, showing that populations persist within Lake Waccamaw.

Staff also conducted quantitative mollusk surveys in Lake Waccamaw, which are completed biennially since 2009. Data

analysis from this survey is ongoing, but the Waccamaw form of *Elliptio congarea* and Tidewater Mucket remain the most abundant mollusk species, composing over 90% of the individuals at each study site.



A young Rayed Pink Fatmucket from Lake Waccamaw (Brena Jones)

Several Listed Mussel Species Found During Roanoke River Surveys

by Michael Fisk, Eastern Region Aquatic Wildlife Diversity Coordinator

In September, Aquatic Wildlife Diversity staff with the N.C. Wildlife Resources Commission (NCWRC) surveyed for mussels in the Roanoke River from Hwy. 48 in Roanoke Rapids, downstream to Weldon. Historically, the Roanoke River has been impacted by dam construction, altered flow regimes and water quality issues. This 5-mile reach of river, which forms the border between Northampton and Halifax counties, can be characterized by large shoals and braided complexes of

side channels and islands. Suitable physical habitat for mussels exists in the reach, although no surveys have been conducted throughout most of the area. With improvements in water quality and flow regime over the last 20 years, mussel surveys were needed to determine current species richness and abundance. Historically, the federally threatened Atlantic Pigtoe was documented in this reach. Atlantic Pigtoe populations are fragmented and depressed in the Roanoke

Basin, and updated distribution data will help inform conservation measures moving forward.

Surveys were conducted just downstream of the Hwy. 48 bridge as well as throughout the braided section of river between Roanoke Rapids and Weldon (Figure 1). Mussels were collected, identified, enumerated and released, during timed snorkel surveys. At each site, four to seven species were encountered including several state listed species: the threatened Triangle Floater

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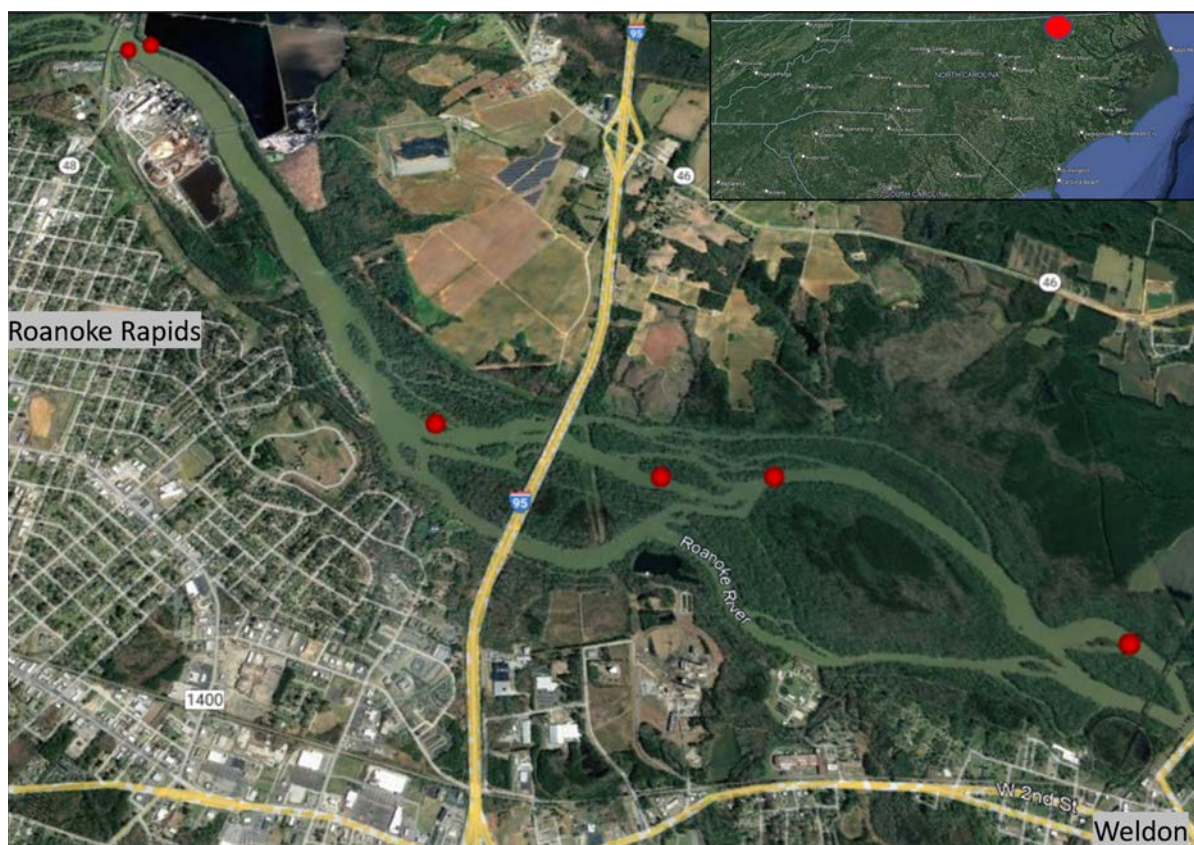


Figure 1: Map of study area in Northampton and Halifax counties. The red circles indicate study area in map inset and where mussel surveys occurred.

and Alewife Floater, as well as the state endangered Green Floater. As the name implies, the Alewife Floater is dependent on river herring (Alewife and Blueback Herring) and American Shad as host fish, and their presence in this reach is likely related to long-term management of anadromous species in the Roanoke River over the last three decades. Other species of interest were the Tidewater Mucket, Eastern Pondmussel and Roanoke Slabshell. The three most common species listed in increasing order were Eastern Lampmussel, Northern Lance and Eastern Elliptio. Multiple size classes and recruitment were documented for each species.

Based on these surveys, this section of the Roanoke River has a thriving mussel community. Although no Atlantic Pigtoes were collected, suitable habitat exists for them — additional surveys are necessary to determine if a contemporary population exists. Although the species may be extirpated from this reach, restoration efforts to re-establish the Atlantic Pigtoe in the Roanoke River has great potential.



A Green Floater collected during surveys in the Roanoke River (NCWRC)



An Alewife Floater collected during surveys in the Roanoke River (NCWRC)

Staff Conduct Mussel Surveys in Randolph and Montgomery Counties

by Katharine DeVilbiss, Central Region Aquatic Wildlife Diversity Biologist



Carolina Creekshell (Michael Fisk)



Notched Rainbow (Michael Fisk)

In July and August, NCWRC staff performed mussel surveys in waterways in Randolph and Montgomery counties — the Little River, Uwharrie River, Barnes Creek and Betty McGees Creek. The objectives of the surveys were to update freshwater mussel distributional records and augment the knowledge base of a new-to-science species that was recently discovered. The undescribed species is a narrow-ranged North Carolina endemic, currently known in only 8 km of the Little River mainstem in Randolph County. These surveys were outside of this core area and no individuals were detected. Search effort totaled 37 person-hours (p-h). Species of Greatest Conservation Need detected in these surveys included another new endemic, an *Alasmidonta* species (description ongoing), Carolina Creekshell (State Endangered) and Notched Rainbow (State Threatened). Staff biologists plan to continue surveys and studies to further their understanding of this undescribed freshwater mussel species.

CRUSTACEANS

Staff Continue Cape Fear Basin Crayfish Surveys in Guilford County

by Katharine DeVilbiss, Central Region Aquatic Wildlife Diversity Biologist

As part of ongoing efforts to update distributional records of native crayfish species, staff biologists visited 13 sites in Guilford County in April, June and July specifically targeting the known geographic area of the Greensboro Burrowing Crayfish (special concern). One reproductively mature male was found in a burrow in an unnamed tributary of South Buffalo Creek. Other species found during the digging efforts included the Carolina Ladle Crayfish, Sickle Crayfish, and the *Cambarus* species *C acuminatus* complex.



Reproductively mature Greensboro Burrowing Crayfish
(Katharine DeVilbiss)

HABITAT MANAGEMENT

The Value of Collaboration in Non-Native Invasive Plant Species Management in North Carolina's Mountain Bogs

by Emily Nolan, Wildlife Diversity Technician

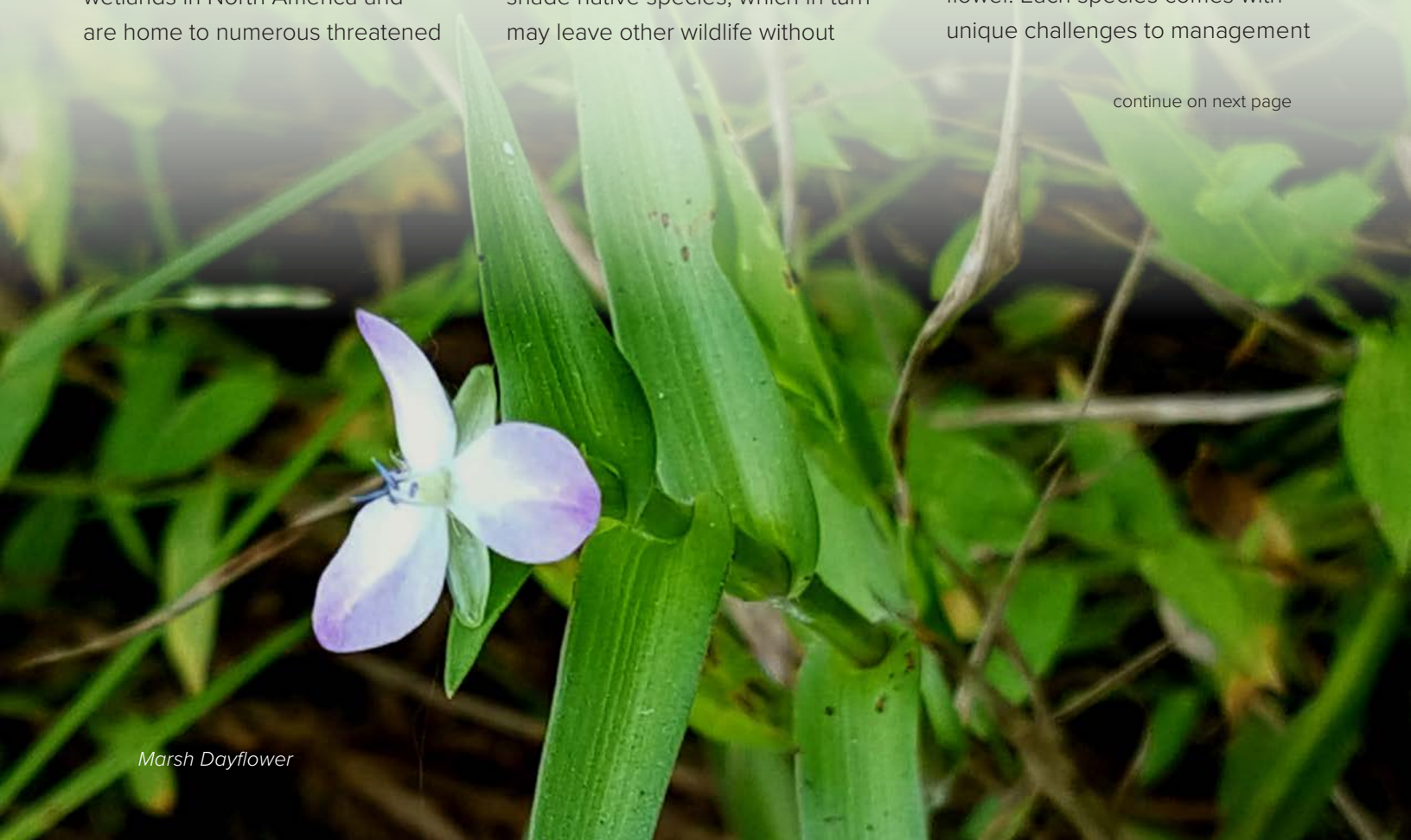
Non-native invasive species (NNIS), particularly plants, are just one of many threats to Southern Appalachian bogs. These bogs are some of the most rare and unique wetlands in North America and are home to numerous threatened

and endangered species. However, mountain bogs are vulnerable to degradation from climate change, habitat loss, and NNIS. Non-native invasive plants can choke out or shade native species, which in turn may leave other wildlife without

proper habitat or food sources. Examples of NNIS commonly found in mountain bogs include Oriental bittersweet, Multiflora rose, Chinese/European privet, and Marsh day-flower. Each species comes with unique challenges to management

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Marsh Dayflower



and removal. There are many different methods available to treat NNIS, including use of hand tools, chainsaws and brush cutters, herbicides, and hand pulling. Deciding which method is best depends on a suite of factors such as the plant characteristics itself, the extent of invasion, the habitat they are found in, and the time and resources available for removal.

In 2021, NCWRC staff found the highly invasive Marsh dayflower in a western North Carolina bog with a known bog turtle population. The qualities that make this plant uniquely invasive are its abilities to reproduce vegetatively, seed dispersal by aquatic wildlife, and formations of large mats that prevent other plant species from growing. Initially, it was thought to be contained to a small section of stream just outside the main bog. However, after further inspection it was found to be much more widespread throughout the bog including a large portion in the main bog turtle nesting habitat. Beginning in spring 2022, NCWRC staff began removing Marsh dayflower in the bog. Although mechanical removal is not advised due the plant's vegetative growth and easy seed dispersal, staff chose to use this method over herbicide treatment to avoid spraying harsh chemicals in sensitive turtle nesting habitat. At least once per month from April-October, NCWRC staff and other volunteers pulled Marsh dayflower by hand, bagged, and disposed of it. With each visit, they found fewer plants, and by the end of fall, they had nearly cleared the main bog of this highly invasive plant. Despite staff making significant progress eradicating Marsh dayflower in 2022, it is likely much will resprout in spring 2023.

In 2023, staff plan to continue to hand-pull again but are also looking to learn more and refine their methods by discussing and sharing information with conservation partners



A mat of invasive Marsh dayflower, taking over a wetland (iNaturalist)



NCWRC Wildlife Diversity Technician Emily Nolan hand-pulls the non-native plant Marsh dayflower in a mountain bog. (NCWRC)

that have dealt with Marsh dayflower in bogs. Fortunately, the Bog Learning Network (BLN), a consortium of scientists and land managers working to advance the restoration and management of Southern Appalachian bogs, is holding a meeting in March 2023 (<https://boglearningnetwork.com>). This in-person meeting will provide an excellent opportunity to share ideas and discuss how best to manage Marsh dayflower in these sensitive wetlands. Staff hope that through the BLN they can tackle what would otherwise be a tremendous task for the NCWRC to accomplish alone in managing Marsh dayflower in this imperiled mountain bog.

Summer Planning for High Elevation Forest Restoration

by Christine Kelly, Western Bird and Carolina Northern Flying Squirrel Biologist

NCWRC staff and partners with the Southern Appalachian Spruce Restoration Initiative (SASRI) planned several high elevation forest restoration projects this summer. The restoration work is intended to connect habitat and to provide food and cover for species like the Carolina Northern Flying Squirrel, Red Crossbill and Northern Saw-whet Owl. SASRI's Black Mountains Sky Island Team designed two resto-

ration projects. The first, on private property, will incorporate "release treatments" that cull competing vegetation to encourage subcanopy Red Spruce to reach the canopy and begin bearing cones. The team, consisting of wildlife biologists, foresters and botanists, met in September for a combined training and workday to lay out the restoration treatments. The second is proposed for Mt. Mitchell State Park property. There,

subcanopy spruce would be managed like the first project to accelerate growth into the canopy, and spruce seedlings will be planted in areas where spruce has not been able to recover on its own. The Plott Balsams Sky Island Team laid out a similar release treatment on William H. Silver Game Land. SASRI's Sky Island Teams provide members with an opportunity to learn from and support one another.



Above: Pink flagging marks a Red Spruce on William H. Silver Game Land that is targeted for release from overstory hardwood canopy (Chris Kelly); Right: Biologists and foresters from the Black Mountain Sky Island Team discuss how to accelerate growth of target Red Spruce trees while maintaining other habitat components important to the Carolina Northern Flying Squirrel. (Gary Peeples/USFWS)



NEW TECHNOLOGY

Staff Install First Motus Receiver Wildlife Tracking System in Western North Carolina

by: Christine Kelly/ Western Bird and Carolina Northern Flying Squirrel Biologist

Right before the Thanksgiving holiday, the NCWRC installed its first mountain-region Motus receiver station. The Motus Wildlife Tracking system is described by Birds Canada as “an international collaborative research network that uses coordinated automated radio telemetry to facilitate research and education on the ecology and conservation

of migratory animals.” Motus radio technology is an especially good fit for tracking the movements of species such as songbirds, bats, and even insects, whose small size does not allow them to carry larger tracking technologies, such as GPS tags. For these species, Motus supports two types of uniquely coded radio transmitters (often

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Directional antennas atop The Parry Family Tower at The Mountain Retreat and Learning Center (Christine Kelly)

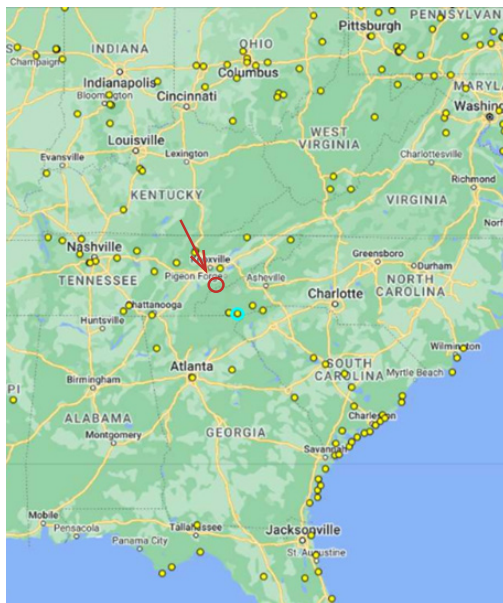
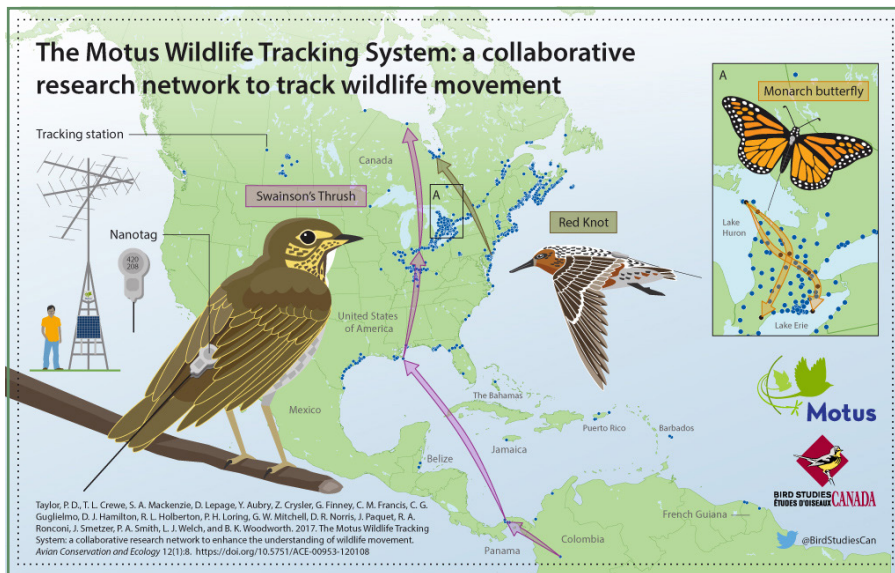
A “dual mode” Motus station. The large yagi antenna (right) is tuned to 166.380 MHz while the smaller yagi antenna (below) is tuned to 434 MHz. (Christine Kelly)



referred to as nanotags) operating on the 166.380 MHz or 434 MHz frequencies. The Motus network is only as strong as the network of receiving stations across the landscape. Western North Carolina, as well as some other parts of the interior Southeastern United States, presents a big gap in coverage that the NCWRC intends to fill! To do this, the NCWRC has

identified locations across the mountain region to install receiver stations consisting of a small computer (receiver) and directional antennas. Ideally, adjacent stations will complement one another in their antennas' coverage span. This is referred to as a Motus Fence. The analogy is that each receiver station is a fence post; the antennas' signal ranges

(up to 15km) are the railings. The first post in the Motus Fence was installed on Little Scaly Mountain in Macon County in November. Highlands Cashiers Land Trust connected NCWRC to The Mountain Retreat and Learning Center. Director Steph Anderson offered the use of the Center's 40-foot Parry Family Tower — a perfect base for our Motus station This new station is a “dual mode” Motus station, meaning its four antennas are listening for signals from both 166.380 and 434 MHz frequency radio tags. The receiver on Little Scaly complements an existing Motus receiver at the Pisgah Astronomical Research Institute in Balsam Grove. Biologists are planning the next posts in the Motus Fence at key points to the west of Little Scaly. We can hardly wait for spring migration to see what tagged birds, some traveling from as far away as South America, ping our new Motus station upon returning to North Carolina!



Clockwise from top left: The NCWRC is on the Motus map. Motus station at The Mountain Retreat and Learning Center on Little Scaly Mountain is circled in red (Motus.org). Kendrick Weeks, Western Wildlife Diversity Program Supervisor solders a connector to a coaxial cable. (Christine Kelly). An infographic from Birds Canada about the Motus Wildlife Tracking System (Motus.org)

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The Wildlife Diversity Program

The Wildlife Diversity Program was established in North Carolina in 1983 to prevent nongame species from becoming endangered by maintaining viable, self-sustaining populations of all native wildlife, with an emphasis on species in decline.

More than 700 nongame animals call North Carolina home. Many nongame species, including mammals, birds, amphibians and reptiles, freshwater mussels and fish, are common and can be seen or heard in your own backyard. Other nongame animals, such as bald eagles and peregrine falcons, were, at one time, considered endangered, but now soar high in the sky, thanks to the work conducted by wildlife diversity biologists.

The staff who work for the Wildlife Diversity Program are dedicated to conserving and promoting nongame wildlife and their habitats through a variety of survey and monitoring programs, species management, and habitat conservation or restoration projects. These programs and projects target nongame animals and their habitats, but game species — such as deer, turkey, mountain trout, and black bass — also benefit because they share many of these same habitats.

You can learn more about the many projects and programs conducted by wildlife diversity personnel on behalf of nongame and endangered wildlife by visiting www.ncwildlife.org/wdp.



Jeff Hall