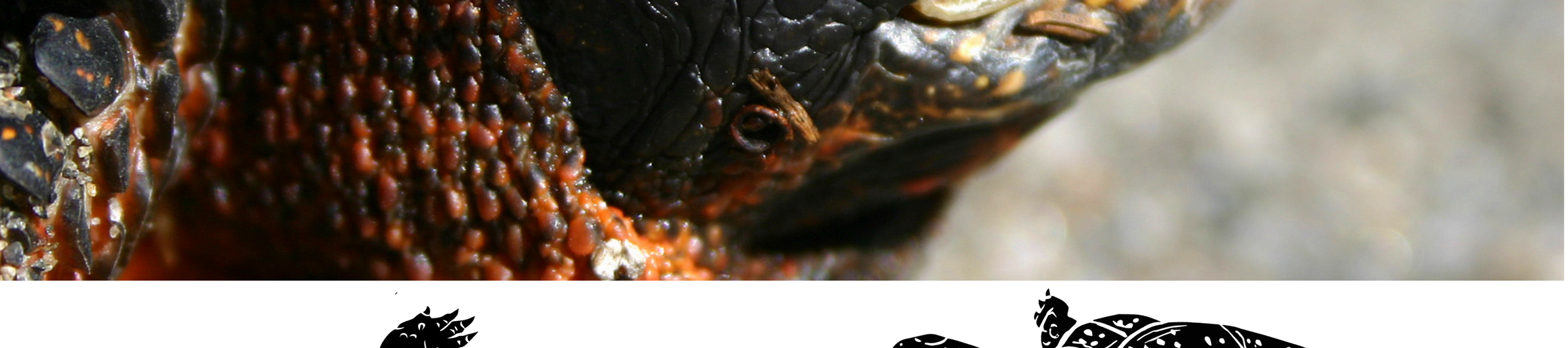
Spotted, Blanding's, & Wood Turtle

Conservation Symposium



2019

November 3–6, 2019
Cacapon Resort State Park, West Virginia

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PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION

Smithsonian Conservation Biology Institute

Program prepared by Mike Jones (MassWildlife)

Agenda
Monday, November 4, 2019

7:30-8:30	Breakfast & Check-in	
	Introduction	
8:30-8:35	Welcome	Kevin Oxenrider
8:35-8:40	West Virginia Division of Natural Resources	Kieran O'Malley
8:40-8:45	Cacapon Resort State Park	Scott Fortney
8:45-8:50	Brief Overview of the 2016 Symposium in Massachusetts	Jessica Meck
8:50-9:50	Introductions (around the room)	Liz Willey & Mike Jones
	Session 1. Regional Updates // Moderator: Kevin Oxenrider	
9:50-10:00	Northeast Region Update	Lori Erb
10:00-10:10	Midwest Region Update	Greg Lipps
10:10-10:20	Canada Updates	Maureen Toner & Mike Jones
10:20-10:30	USFWS Update	Anthony Tur
10:30-10:50	**BREAK**	
	Session 2. Planning // Moderator: Tom Akre	
10:50-11:00	Conservation Plan for Spotted Turtle in the Eastern US	Liz Willey
11:00-11:10	Conservation of Blanding's Turtle in Lake Erie Watershed	Matt Cross
11:10-11:20	Implementing a Conservation Plan for Wood Turtle in the Northeastern USA	Mike Jones
11:20-11:30	Strategic Wood Turtle Conservation in Wisconsin	Andrew Badje
11:30-11:40	Conservation Plan for Blanding's Turtle in the Northeast	Melissa Doperalski
11:40–12:00	**GROUP PHOTO**	
12:00–1:00	**LUNCH and SILENT AUCTION STARTS**	

Agenda
Monday, November 4, 2019

	SESSION 3. Modeling // Moderator: Liz Willey	
1:00-1:10	Combining Historic and Recent Data to Identify Trends in Turtle Distribution	Alvin Breisch
1:10-1:20	An eDNA Approach to Sampling for the Presence and Abundance of Spotted Turtles	Tom Akre
1:20-1:30	Modeling the Projected Population Growth Rate of Wood Turtles	Hardin Waddle
1:30-1:40	Population Viability Analysis and the Role of Head-starting for a Northern Illinois Blanding's Turtle Population	Jason Ross
1:40-2:10	Rapid Demographic Assessments for Freshwater Turtles: Filling in Data Deficiencies	Mike Dreslik
	SESSION 4. Law Enforcement // Moderator: Julie Slacum	
2:10-2:15	CCITT Working Group update	Scott Buchanan
2:15-2:20	Repatriation Working Group Update	Dave Collins
2:20-2:25	USFWS Combating Wildlife Trafficking Update	Dara Satterfield
2:25-2:40	Turtle Commerce: Understanding the Domestic and International Trade of Spotted, Wood, and Blanding's Turtles	Jordan Gray
2:40-2:55	Trends in Black Market Trade in Wood Turtles	Bryce Findley
2:55-3:30	Spotting Illegal Activity: Law Enforcement Meets Management	Mark Cagle & Jeff Hall
3:30–3:45	**BREAK**	
3:45–4:45	**BREAK OUT SESSION 1. Combating Illegal Turtle Trade** Facilitator: Scott Buchanan (with Julie Slacum and Lori Erb)	
4:45–6:15	**POSTER SESSION**	
6:00–7:00	**DINNER**	
7:00–8:00	**Serendipity, Siblings, and Spotted Turtles (KEYNOTE)**	Jackie Litzgus

Agenda
Tuesday, November 5, 2019

7:30-8:30	Breakfast & Check-in	
8:30–8:35	Housekeeping Items	Kevin Oxenrider
	Session 5: Monitoring // Moderator: Jess Meck	
8:35-8:45	Abundance Trends and Vital Rates of Wood Turtle Populations in the Upper Midwest	Donald Brown
8:45-8:55	Population Assessment for Wood Turtles in the Northeast	Patrick Roberts
8:55-9:05	The state of Spotted Turtles in Rhode Island: Occupancy Along a Landscape Gradient and Characterization of Population Genetic Structure	Scott Buchanan
9:05-9:15	Protected is a Verb not an Outcome: Monitoring the Population Trajectory of Spotted Turtle Populations in Protected Habitat over a 30-year Period and Projecting Future Long-term Population Viability	Scott McDaniel
9:15-9:25	Restoring Nesting Areas in Michigan to Reverse Declines in Nest Survivorship That Threaten Population Stability	Roy Nagle
	Session 6. Genetics // Moderator: Tom Akre	
9:25-9:35	Conservation Genetics of Blanding's Turtles: Where Are We Now?	Mark Jordan
9:35-9:45	Impacts of a Highway on the Population Genetic Structure of a Threatened Freshwater Turtle	Alex Robillard
9:45-9:55	Genetic Spatial Structure of the Spotted Turtle, an Endangered Species Facing Rising Sea Levels	Eric Leibgold
9:55–10:10	**BREAK**	
10:10–11:40	**BREAK OUT SESSION 2. Planning, Coordination, Collaboration (by species):** Blanding's Turtle: Melissa Doperalski Wood Turtle: Mike Jones, Lori Erb, Tom Akre, Patrick Roberts Spotted Turtle: Liz Willey, Julie Slacum, Houston Chandler	
12:00–1:00	**LUNCH and SILENT AUCTION ENDS**	

Agenda
Tuesday, November 5, 2019

	SESSION 7: Behavior and Ecology // Moderator: Mike Jones	
1:00–1:10	Grits, Okra, and Spotted Turtles: *Clemmys guttata* Down South	Jonathan Mays
1:10–1:20	Reproductive Output in Southern Populations of Spotted Turtles	Houston Chandler
1:20–1:30	Spotted Turtle use of Mosquito-control ditches in Suffolk County N.Y	Mike Bottini
1:30–1:40	Potential Niche Overlap Between Spotted Turtles and other Turtle Species	Tami Ransom
1:40–1:50	Mortality Risk to Wood Turtle in a Landscape Under Active Agriculture in New Brunswick	Shaylyn Wallace
1:50–2:00	Fine Scale Movement and Dispersal of Virginia and Minnesota Wood Turtle Populations	Jonathan Drescher-Lehman
	SESSION 8: Management // Moderator: Houston Chandler	
2:00–2:10	Habitat Management for Early Successional Forested Wetlands in PA with recommendations for Spotted and Wood Turtles	Roy Nagle
2:10–2:20	Two Decade Study of Blanding's Turtle and Habitat Response to Wetland and Upland Restoration	Erik Kiviat
2:20–2:30	Demographic Response of a Spotted Turtle Population to Multi-year Meso-predator Removal Efforts in a Northeast Ohio Fen	Nicholas Smeenk
2:30–2:40	Managing the Landscape for Wood and Blanding's Turtles at Camp Grayling	Bruce Kingsbury
2:40–2:50	**BREAK**	
	SESSION 9: Population Management // Moderator: Patrick Roberts	
2:50–3:00	Growth and Survival of Wild-born and Head-started Juvenile Blanding's Turtles	Callie Klatt Golba
3:00–3:10	Conservation of Blanding's Turtles in the Chicago region and the Benefits of Head-starting for Size Distributions and Recruitment	Gary Glowacki
3:10–3:20	Evaluating the Effectiveness of a 15-Year Headstarting Program for Wood Turtles	Damien Mullin Semeniuk
3:20–3:30	GPS Tracking, Nest Protection, and Headstarting in Minnesota Wood Turtles	Tricia Markle
3:30–3:40	Habitat Protection, Restoration, and Head-starting: Can These Conservation Strategies Recover an Urban Population of Blanding's Turtle?	Tharusha Wijewardena
	SESSION 10: Conservation Tools // Moderator: Jonathan Mays	
3:40–3:50	Achieving Turtle Conservation on Private Land	Kiley Briggs
3:50–4:00	Working Lands for Wildlife - Northeast Turtles: State Conservation Area Network and Conservation Plans Help Guide on-the-Ground Change on Private Working Lands in NH	Joshua Megyesy
4:00–4:10	Endangered Species Legislation and Decision-making: Case Study of a Quarry Proposal in Blanding's Turtle Habitat	Gabriella Zagorski
4:10–4:30	Symposium Conclusion and NEXT STEPS	Planning Team

ABSTRACTS - Oral Presentations

An Environmental DNA Approach to Sampling for the Presence and Abundance of the Endangered Spotted Turtle (*Clemmys guttata*)

Thomas Akre*, Smithsonian Conservation Biology Institute, Front Royal, VA 22630; akret@si.edu; Ellery Lassiter, Dept. of Biology, University of Arkansas, Fayetteville, AR 72701; Jesus Maldonado and Nancy Rotzel McInerney, Smithsonian Conservation Biology Institute, Washington, D.C. 20008

Environmental DNA (eDNA) technology has emerged over the last decade as animportant method for the detection of species that are difficult to detect in freshwater and marine ecosystems. This rapid adoption is the result of the 1) high selectivity and increased sensitivity of eDNA, 2) overall reduction in sampling time and expenses compared to traditional sampling, and 3) emerging opportunity to determine population and community level processes using metagenomics technology. Yet, challenges remain that have limited the application and ability of eDNA technology to achieve its full potential. The spotted turtle is one of many turtle species that is naturally difficult to sample and rapidly declining. It is considered endangered on the IUCN red list of threatened species and is a candidate for listing on the Endangered Species Act. Therefore, there is an urgent need to improve the knowledge of its distribution and abundance. Our proposed work aims to advance our scientific knowledge in support of conservation of an endangered freshwater turtle species through the use of eDNA to: 1) sample for, recover, and amplify spotted turtle eDNA in a difficult-to-sample aquatic environment; 2) determine spotted turtle presence using eDNA in a detection-corrected framework that employs a hierarchical approach to revealing eDNA detection and its environmental correlates; and 3) to develop a preliminary model of the correlation between a measure of recovered eDNA and spotted turtle relative abundance. Our approach will use adapted methods to filtering water for recovering eDNA and then use a multi-site (N ≈ 20) study with simultaneous trapping and eDNA collection to develop occupancy and detection models. Methods for eDNA extraction, amplification, and quantification will be drawn from protocols developed at the SCBI Center for Conservation Genomics. We will then implement a metabarcoding approach with high-throughput sequencing to improve eDNA detection and enable a preliminary estimate of spotted turtle abundance using an internal standard as a baseline. Using this baseline as reference, we will sample in a similar format at additional sites with relatively high spotted turtle abundance to develop abundance models and then correlate to a measure of recovered eDNA.

An Overview of Strategic Wood Turtle (*Glyptemys insculpta*) Conservation Measures in Wisconsin

Andrew Badje*, Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation, Madison, WI 53707; andrew.badje@wisconsin.gov; Carly Lapin, Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation, Rhinelander, WI 54501

The Wood Turtle (*Glyptemys insculpta*) is listed as a Threatened species in Wisconsin due to habitat loss (e.g., human development, reduction of natural disturbances that create/maintain nesting habitat), adult removal from populations (e.g., road mortality,

illegal collection), and nest failures (e.g., predation, flooding, and cool/wet summers). In 2016, the Wisconsin Department of Natural Resources (WDNR) created a Wood Turtle Status Assessment and Conservation Strategy to serve as an assessment of the effectiveness of current conservation actions and guide future conservation actions. The WDNR has also participated in two United States Fish and Wildlife Service Competitive State Wildlife Grants focusing on wood turtle conservation, which have included telemetry, road mortality reduction, and nest site creation/restoration, protection, and monitoring. In addition, the WDNR has initiated a statewide long-term abundance monitoring program for the species (developed by West Virginia University) and is collaborating with on-going regional landscape genetics and hatchling survival research studies. This presentation will describe how all the WDNR's Wood Turtle specific efforts work in cohesion as part of a constantly adapting conservation strategy to keep Wood Turtles a viable component of Wisconsin's natural heritage.

Spotted Turtles' Use of Mosquito-Control Ditches in Suffolk County, NY

Michael Bottini*, Long Island Nature Organization, East Hampton, NY 11937;
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Over the years 1996–1999, a mark-recapture study of Spotted Turtles on eastern Long Island by John Behler of the Wildlife Conservation Society compiled information on 59 turtles in a 30-acre ditched wetland. During the winter of 1999-2000, Suffolk County Vector Control conducted ditch maintenance operations in a portion of the study area to improve drainage and tidal flow. During the following spring and summer 2000 trapping season, a significant number of marked turtles were not found. Behler hypothesized that the missing turtles were overwintering in the ditches where they were vulnerable to direct damage and mortality from ditch maintenance equipment and indirect mortality via damage to hibernacula and exposure. From 10/21/2004–9/5/2005, a radio telemetry study was undertaken at the site and the movements and locations of between 8 (4 males and 4 females) and 17 (7 males and 10 females) Spotted Turtles were mapped and habitat type was noted. Spotted Turtles showed a strong preference for mosquito-control ditches throughout the year, accounting for 97% of Spotted Turtle telemetry locations during the fall and winter, 92% during the spring, and 61% in summer. They also exhibited a strong preference for ditches containing emergent vegetation (*Typha latifolia*, *T. angustifolia*, *Phragmites communis* and *Scirpus americanus*) or those filled with leaves and twigs. These are the types of ditches that are targeted for maintenance cleaning by Vector Control. Turtle use of these areas throughout the year poses a management challenge for the Suffolk County Department of Vector Control to ensure that mosquito-control programs and maintenance work do not conflict with turtle conservation efforts. The study also revealed that the turtles did not enter a prolonged state of hibernation or inactivity during the winter, nor did they show signs of prolonged estivation, or summer dormancy. Both behaviors are thought to be strategies designed to cope with adverse temperatures: avoidance of subfreezing temperatures during winter and 30+˚C during summer. It appears that mosquito-control ditches, a man-altered habitat that intersects the groundwater table, provides a micro-environment in which critical temperature extremes (0˚C and 30˚C) are not reached.

Combining Historic and Recent Data to Identify Trends in Turtle Distribution

Alvin R. Breisch* (retired) and John W. Ozard (retired), Division of Fish and Wildlife,
New York State Department of Environmental Conservation, Albany, NY 12233

We compiled records of all turtle species for two time periods, pre-1990 and 1990 to 1999, the period during which the New York Amphibian and Reptile Atlas Project (Herp Atlas) was conducted. Over 64,000 species reports were contributed by 1,800 Herp Atlas volunteers with more than 7,700 of these reports being turtles. Sixteen native and two non-native turtle species have been documented as occurring in the wild and reproducing in the state with Blanding's Turtle accounting for 101 records, Wood Turtle 467 records, and Spotted Turtle 488 records. An additional 35,000 pre-1990 records (dating back to the mid-1800s) were compiled from museum records, published papers, theses, and agency reports, which included nearly 2,200 reports of turtles. Blanding's Turtle accounted for 154 records, Wood Turtle 205 records, and Spotted Turtle 254 of these records. Spatial data were mapped by USGS 7.5-minute topographic quadrangle (atlas block), for each of the 979 atlas blocks in the state. Comparing number of atlas blocks verified before and after 1990, both Spotted and Wood Turtle had much greater distribution than previously believed. Since 1999, Blanding's Turtles were found in two new disjunct populations, but overall the number of atlas blocks has not significantly changed. Analysis of the spatial data provides us with more detailed information on individual species distribution within the state, but can also be used to identify areas of high herpetofaunal diversity and will provide a basis for identifying areas with the highest turtle species richness. Southeastern New York has the highest overall herpetofaunal diversity and the highest diversity of turtle species. Spatial and temporal data was combined to give us a more detailed picture of seasonal patterns for observing turtle activity. An unexpected finding was that even in north temperate New York State, Wood and Spotted Turtles were observed by volunteers every month of the year. The annual peak in number of turtle observations, nesting, and roadkills occurred in mid-June. Nearly 10% of all turtle reports were of road killed turtles. However, the pattern of road killed turtles across the state does not coincide with high areas of development or road density.

Achieving Turtle Conservation on Private Land

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As conservation biologists, we often view land management through the lens of our target species, however the majority of land inhabited by Wood and Blanding's Turtles is privately-owned and landowners often perceive conservation as being at odds with their management objectives. In many cases, by doing targeted outreach and listening to landowners about what they need from their land, it is possible to find a conservation strategy that balances those needs with turtle habitat protection and restoration. Sometimes turtle conservation will affect a landowner's bottom line, but many programs exist that can provide financial incentives to landowners, especially in cases where working land is taken out of production. Every property is different, what each landowner needs from their land is different, and how turtles use each property varies from site to site, so a one-size-fits-all approach is not appropriate. Finding the best way to incorporate turtle conservation on private land should be approached with an open mind on a case-by-case basis and with an understanding that you may need to work around conflicting management objectives. How a landowner is approached and how those conversations are framed can make the difference between a contentious relationship that will be difficult to repair and forming a long-term partnership resulting in habitat restoration.

Abundance Trends and Vital Rates of Wood Turtle (*Glyptemys insculpta*) Populations in the Upper Midwest

Donald J. Brown*, West Virginia University, Morgantown, WV 26506, and U.S. Forest Service Northern Research Station, Parsons, WV 26287; donald.brown1@mail.wvu.edu; Ron A. Moen and Maria Berkeland, Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, MN 55811; Carly N. Lapin, Wisconsin Department of Natural Resources, Rhinelander, WI 54501; Jeffrey W. Tamplin, University of Northern Iowa, Cedar Falls, IA 50614; Madaline M. Cochrane, University of Montana, Missoula, MT 59812

Wood Turtle (*Glyptemys insculpta*) populations are thought to be declining throughout much of their geographic distribution. However, few published studies have quantified Wood Turtle population trends or demographic vital rates, and thus information available to inform species status decisions is limited. We have completed several studies in the Upper Midwest states of Minnesota, Wisconsin, and Iowa to improve our understanding of the status of Wood Turtle populations. These studies include collection and analysis of population survey data to quantify abundances and population growth rates, nest site monitoring to determine reproductive success, individual-level monitoring to estimate adult annual survival across populations and years, and modeling to improve our understanding of the sensitivity of Wood Turtle populations to changes in survival and recruitment. Multi-year population survey data indicates that some Wood Turtle populations in the Upper Midwest are likely declining. Over 95% of monitored unprotected nests were flooded or depredated. Estimated average adult annual survival in all states was <0.9, which our models indicate is likely below what is required to maintain stable populations. We will present a synthesis of these multi-state research projects, and discuss implications for management and future research needs.

The State of Spotted Turtles (*Clemmys guttata*) in Rhode Island: Occupancy Along a Landscape Gradient and Characterization of Population Genetic Structure

Scott Buchanan*, Rhode Island Division of Fish and Wildlife, West Kingston, RI 02892; scott.buchanan@dem.ri.gov; Bill Buffum, University of Rhode Island, Kingston, RI 02881; Jason J. Kolbe, University of Rhode Island, Kingston, RI 02881; Johanna E. Wegener, University of Rhode Island, Kingston, RI 02881; and Nancy E. Karraker, University of Rhode Island, Kingston, RI 02881

Spotted turtles (*Clemmy guttata*) are a species of increasing conservation concern throughout their range. Habitat loss, fragmentation, road mortality, subsidized predators, and illegal collection all contribute to increased pressure on populations. To better assess the distribution, abundance, and demography of spotted turtles in Rhode Island, three-years of systematic surveys were carried out along a landscape gradient in which 88 hydrologically isolated, non-riparian wetlands were trapped throughout the activity season. Occupancy was modeled using a suite of landscape and within-wetland variables. Spotted turtle occupancy was low, occurring in 8% of wetlands, and they exhibited a strong association with forested, shallow, natural (i.e., not manmade or heavily modified) wetlands. Blood samples were opportunistically collected from wetlands containing spotted turtles for population genetic analysis. We genotyped 148 individual spotted turtles from 11 populations, at 17 microsatellite loci. We found evidence of modest inbreeding, as well as tentative evidence of recent population declines. However, genetic diversity and differentiation among sites gave no indication of compromised populations.

As our results do not suggest any major signals of genetic degradation in spotted turtles, the southern region of Rhode Island may serve as a regional conservation reserve network, where the maintenance of population viability and connectivity should be prioritized.

Spotting Illegal Activity: Law Enforcement Meets Management

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Through changing demographics, heightened officer awareness and a new direction demonstrated through our agency strategic plan, we have made numerous key reptile and amphibian cases on the State and Federal levels. Incorporating law enforcement techniques normally used in game animal violator apprehension paired with cooperation from the U.S. Fish and Wildlife Service, subjects involved in the illicit reptile trade in North Carolina have been successfully prosecuted. Cases involving spotted turtles and pigmy rattlesnakes highlight our success; however, other species are also being collected for the international food and pet trade. With an estimated 80% of the 90 freshwater turtle and tortoise species in Asia currently threatened, the market has moved here. Some of the major reptile cases we have made, along with training highlights, will be presented. Cooperation between management biologists and law enforcement officers has been key to the success of these cases and important in decision-making about final disposition of confiscated animals.

Reproductive Output in Southern Populations of Spotted Turtles (*Clemmys guttata*)

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Reproductive output is a key aspect of population ecology that is important for long-term population viability. Spotted Turtles (*Clemmys guttata*) are generally considered to be declining across much of their expansive range that stretches from southeastern Canada to the southeastern United States. However, little research has been conducted in southern populations, despite evidence that various aspects of their ecology, including reproductive output, vary across a latitudinal gradient. During 2018, we measured female fecundity and identified nesting sites in two Georgia populations of Spotted Turtles. We attached radio transmitters to 17 female Spotted Turtles at the beginning of the active season and monitored these turtles throughout the breeding season. We located turtles approximately once a week, weighing each individual and palpating for shelled eggs. When shelled eggs were detected, we x-rayed turtles to determine clutch sizes. We then used a combination of telemetry and thread spooling to locate nesting sites and monitored whether or not nests survived until hatching. Over the course of the breeding season, 15/17 females (88%) produced at least one clutch, 11/17 females (65%) produced at least two clutches, and 6/17 females (35%) laid three clutches. At least 32 clutches were produced by these 17 turtles, accounting for between 65 and 77 total eggs. Clutch sizes ranged from 1–4 eggs (mean clutch sizes ± SE: 1st = 2.3 ± 0.2, 2nd = 2.5 ± 0.2, 3rd = 1.5 ± 0.3). We located a total of 16 nests, approximately half of which survived until hatching. The majority of the other nests were predated before hatching, although we did observe some eggs that failed to hatch for other reasons. Our results demonstrate that multiple clutching is common in these Spotted Turtle populations and that total reproductive output can exceed that of Spotted Turtles in other parts of the range. These

results have important implications for future population modeling and viability analysis in the southern portion of the Spotted Turtle range.

Conservation Status of Blanding's Turtles in the Lake Erie Watershed

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With Blanding's Turtles currently under consideration for listing under the U.S. Endangered Species Act, many states have initiated monitoring and conservation programs to determine the species' status throughout its range. To contribute to these large-scale efforts, Michigan and Ohio, states generally lacking coordinated Blanding's Turtle surveys, partnered to assess the distribution of this species in the Lake Erie Watershed using a combination of multi-technique field surveys, genetic analyses, and spatially explicit models to inform and prioritize future management efforts. It is our goal to determine the status of Blanding's Turtles in Michigan and Ohio, and identify high-priority sites to implement adaptive conservation and management actions as necessary. We will present the results from our first season of trapping, which resulted in over 4,000 turtle captures, including 274 unique Blanding's Turtles, and discuss protocol modifications and plans for the next two years.

A Regional Conservation Strategy for Blanding's Turtle in the Northeastern U.S.

Melissa Doperalski*, Josh Megyesy & Michael Marchand, New Hampshire Fish and Game Department; Lisabeth Willey, Antioch University New England and American Turtle Observatory; Michael T. Jones, Massachusetts Division of Fisheries and Wildlife; Glenn Johnson, State University of New York Potsdam; Angelena Ross, New York Department of Environmental Conservation; Derek Yorks & Phillip DeMaynadier, Maine Department of Inland Fisheries and Wildlife; Kathy Gipe & Chris Urban, Pennsylvania Fish & Boat Commission; Mark Grgurovic, Parker River Clean Water Association; Bryan Windmiller, Grassroots Wildlife Conservation; Steph Koch, US Fish & Wildlife Service

The Northeast Blanding's Turtle Working Group (www.blandingsturtle.org), a collaborative group of state and federal agencies, non-profits, universities, and independent biologists, has been working since 2004 to conserve the Blanding's turtle throughout its range in the northeastern US, including portions of Maine, New Hampshire, Massachusetts, New York, and Pennsylvania, where it occurs in disjunct populations. Following a regional status assessment in 2007, with support from a Competitive State Wildlife Grant, the NEBTWG developed a Conservation Plan in 2014. As part of the planning process, we undertook standardized monitoring to establish a baseline of distribution and abundance in order to track change over time, rank and prioritize sites, assess the effects of habitat and landscape characteristics on population size and structure, and identify covariates that influence detection. The monitoring strategy has two, nested tiers: intensively trapped sites that provide site-specific population estimates using mark-recapture models and rapid assessment sites that are

analyzed using mixture models. Across the Northeast in 2012–2013, we captured 1,178 Blanding's turtles (including recaptures) at 156 sites over 20,342 trap nights. The Conservation Plan incorporated these empirical data, habitat models, and population models to identify priority sites and actions. With support from a second Competitive State Wildlife Grant, we are currently implementing the highest priority actions identified in the Plan including land protection, habitat management and restoration, and head-starting and nest protection. We are also continuing standardized sampling, which will be used to evaluate the effectiveness of actions and to adaptively modify the conservation strategy going forward.

Long-distance and Fine-scale Movements of Wood Turtles (*Glyptemys insculpta*) in Virginia and Minnesota

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Little is known about long-distance dispersal movements in freshwater turtles, despite the probable importance of such movements for gene flow between populations. There is a pressing need to better understand these movements, especially within the context of an increasingly fragmented landscape. This study aimed to look at these and other long-distance movements by tracking wood turtles (*Glyptemys insculpta*) using miniaturized GPS units attached to their shells. The data were also used to estimate home range sizes and movement speeds, as well as to analyze the shift in these metrics throughout an active season. In total, 61 wood turtles (38 females, 23 males) were tracked for one to three years each, with hourly or sub-hourly locational fixes recorded for the duration of the active seasons. Two datasets, one from Minnesota (n=25) and one from Virginia (n=36), were combined for a total of over 140,000 GPS locations. Our results show that traditional measures of home range significantly underestimate actual home range sizes for wood turtles. In Virginia, home range area and movement speed both increased significantly and peaked for females during the nesting season, while male movement was more consistent throughout the year. We also captured numerous long-distance nesting movements, two long-distance relocation movements following flood displacement events, and two long-range dispersal events by young male turtles. Our data demonstrate the magnitude (>13 km) and the danger of these dispersal movements. They also indicate the potential of modern GPS technology for studying turtle movement and points toward the need for further studies with more individuals over longer timeframes.

Rapid Demographic Assessments for Freshwater Turtles: Filling in Data Deficiencies

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Freshwater turtles are one of the most imperiled vertebrate groups and their conservation and recovery are often complicated by life history traits such as extreme longevity, late maturity, and limited reproductive capacity. Such life history traits make freshwater turtle populations particularly susceptible to anthropogenic disturbances such as habitat loss, collection, and roads. Extreme longevity can allow declining populations to persist on the landscape for decades, perhaps giving the appearance of population stability even when recruitment is minimal or non-existent. Chronic or severe perturbations which increase adult mortality can cause rapid population declines. Even when threats are mitigated, freshwater turtle populations may take decades to rebound due to their life histories. Nearly a third of the 357 recognized turtle species are ranked as endangered or worse. Unfortunately, basic life history and demographic data for many freshwater turtle species are either lacking or are represented from disparate geographical sources. Without basic life history and population-specific demographic information, it is difficult to determine the magnitude of declines, identify specific threats, target conservation actions, or monitor recovery success. We propose a three-part program consisting of capture-mark-recapture, radiotelemetry, and x-radiography to assess vital rates and life history characteristics rapidly. We also provide an estimate of program cost and potential sources of funding, at least in the United States. Although there are inherent caveats with the breadth of the data collected, we identify objective analyses to inform initial actions in the current conservation climate

Trends in Black Market Trade in Wood Turtles (*Glyptemys insculpta*)

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Recent investigations by the United States Fish and Wildlife Service, Office of Law Enforcement have provided insight into the trends concerning the black market trade in wild caught turtles, including wood turtles. These trends include the continued if not increasing commercial trade in turtles unlawfully captured from wild populations. Investigations revealed that persons engaged in capture and transport of turtles from the wild continue to adapt techniques to avoid detection. Reptile dealers were found to continue using schemes to “launder” these wild caught turtles to avoid suspicion during sale and export. Increasingly, the ultimate destination for turtles was found to be China, which drives up the wholesale market value and thus increases the trade in wild caught turtles in the United States. The detection rate by law enforcement during the unlawful capture of turtles from the wild was low. Law enforcement primarily relied upon information provided by individuals who are associated with the reptile trade to initiate these investigations. The use of the CSWG-funded wood turtle DNA database assisted with prosecution of defendants and repatriation of turtles to the wild in these cases.

Conservation of Blanding’s Turtles in the Chicago Region and the Benefits of Head-starting for Size Distributions and Recruitment

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Blanding’s Turtle populations in the Chicago region have suffered range-wide declines largely due to habitat loss and fragmentation, increased levels of predation, poaching and

the associated decrease in both juvenile and adult survivorship. In response to these declines, the Forest Preserve Districts in DuPage and Lake Counties both initiated formal recovery programs that have utilized innovative conservation strategies such as meso-predator control, nest protection, habitat restoration and public outreach to mitigate threats. However, the focus of both programs is on increasing juvenile survivorship and recruitment through head-starting. Since recovery efforts began, the Forest Preserve District of DuPage County and Lake County Forest Preserve District have released of over 1,400 and over 800 turtles, respectively, into 2 focal conservation areas. We found that head-starting resulted in significant shifts in Blanding's turtle population body size distributions. Prior to intervention, size distributions were strongly skewed toward large adults at both sites, a pattern sometimes interpreted as arising from elevated egg and hatchling mortality and a lack of juvenile recruitment. Currently, population body size distributions include a wide range of juvenile and adult size turtles. Importantly, formerly head-started individuals have begun reproducing in both counties and this strategy shows promise for increasing recruitment in existing populations.

Growth and Survival of Wild-born and Head-started Juvenile Blanding's Turtles

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Blanding's Turtles (IUCN Endangered) are long-lived reptiles with delayed sexual maturity. Anthropogenic landscape changes have increased threats to juvenile turtles, resulting in unnaturally low recruitment. Head-starting has become a popular conservation strategy that aims to increase juvenile recruitment by avoiding the increased predation of the vulnerable nest and hatchling age-class. However, there is still debate about whether or not it is an effective management tool. In particular, information is needed on how head-starts fare compared to wild-born turtles. The Lake County Forest Preserve District (LCFPD) in northeastern Illinois initiated a long-term capture-mark-recapture (CMR) project in 2004. As of 2018, 127 wild-born juvenile turtles have been captured, 59 of which have been captured in multiple years. Since 2010, LCFPD has released 879 head-started turtles, including 491 released during the year following hatching, 138 of which have been recaptured during successive years. We used van Bertalanffy growth analysis to compare growth trajectories and Cormack-Jolly-Seber (CJS) modelling techniques to compare survival rates of wild-born and head-started turtles. At release, head-started turtles were about the size of 2-year old wild-born turtles and grew in parallel to their wild-born counterparts. The top ranked survival models demonstrated that survival increased with age for both wild-born (71%-98%) and head-started turtles (63-90%) with overlapping confidence intervals. These results suggest that head-started juveniles perform similarly to wild-born juveniles. A more complete assessment of the success of head-starting awaits information on the reproductive success of head-started turtles. Together with other demographic information from this population (adult survival, fecundity), we anticipate more accurate population projections that will aid in evaluating conservation strategies for this population and potentially for Blanding's Turtles elsewhere.

Turtle Commerce: Understanding the Domestic and International Trade of Spotted, Wood, and Blanding's Turtles

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The globalization of the trade in wildlife has increased species demand and quantity, adding to the multitude of anthropogenic pressures already impacting wild populations. Although protected by local, regional, national, and international legislature, agreements, and treaties, a dynamic global marketplace utilizing new and evolving market technologies continues to circumvent these conservation measures. Among the herpetofauna traded in this marketplace, *Testudines* represent the most commonly kept order. Of the 469 terminal taxa of chelonian, representing 94 genera, the emydid turtles remain a commonly traded group of turtles in the United States and internationally. Of this family, the Spotted Turtle (*Clemmys guttata*) and North American Wood Turtle (*Glyptemys insculpta*) continue to maintain global popularity in the pet trade, while the Blanding's Turtle (*Emydoidea blandingii*) experiences little demand in this marketplace. The trade in all three species is governed by Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and are protected from commercial collection in every state and province in which they are native. Of the three, the Spotted Turtle may be at greatest threat from poaching at the species level due to inconsistencies in its protection status. However, unique populations of Wood Turtle may experience a high level of threat on account of their natural history involving obligatory aqueous brumation. The dynamic trade in chelonians poses an extirpation threat to local and regional populations, places an increased burden on wildlife agencies and their cooperating organizations and private contractors, and undermines protective environmental legislation. New stop-gap and long-term solutions must be devised, coordinated, and implemented to ensure the survival of these taxa at the local, regional, and national population levels.

Conservation Plan for the Wood Turtle in the Northeastern United States

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The Wood Turtle (*Glyptemys insculpta*) has experienced widespread population declines in recent decades and is currently listed as Endangered by the IUCN and included in the State Wildlife Action Plans of all 13 states in the northeastern United States. In 2015, the Massachusetts Division of Fisheries and Wildlife and the Northeast Wood Turtle Working Group — a collective of Wood Turtle experts and conservationists from academic institutions, non-profit organizations, and state and federal agencies — were awarded a Competitive State Wildlife Grant from the USFWS to develop a Conservation Plan for the Wood Turtle in the northeastern United States. This multi-year effort involved intensive region-wide population sampling with a total of 2,141 standardized surveys conducted, resulting in 4,611 Wood Turtle detections and 1,895 tissue samples collected across all 13 states in the Northeast and the District of Columbia. These data

were used to conduct regional assessments of population structure and population genetics, which in turn informed the development of a spatially-explicit, empirically-derived, and expert-informed regional Conservation Area Network (CAN). The Northeast Wood Turtle CAN represents the most robust, representative, and resilient Wood Turtle subpopulations (based on the best available information) and was designed with the intention of providing a structured framework for prioritizing limited management resources. The CAN is accompanied by a multi-scale Conservation Action Plan and implementation framework modeled upon other regional conservation planning efforts including that for Blanding's Turtle (Emydoidea blandingii) in the Northeast. The resulting document, entitled Conservation Plan for the Wood Turtle in the Northeastern United States, can be found at northeastturtles.org. Spatial CAN layers are managed by respective state agencies.

Conservation Genetics of Blanding's Turtle [*Emys (=Emydoidea) blandingii*]: Where Are We Now?

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Understanding the distribution and level of genetic variation is fundamental to making conservation decisions to prioritize populations, develop strategies for population augmentation, and maintain adaptive diversity. There has been considerable activity on several of these fronts for Blanding's Turtle over the past two decades but with minimal synthesis for the species as a whole. In this presentation, a review of patterns of genetic diversity will be presented, and this will be used to identify knowledge gaps and suggest opportunities for action using current information. Taxonomically, there is agreement in the delineation of the species but some debate on whether it should be one of four species of *Emys* or remain monotypic (*Emydoidea*). Intraspecific analyses on a rangewide scale using several different marker types suggests that there are two and possibly three lineages that could be considered evolutionary significant units. Finer scale analyses within regions have also uncovered a fair amount of structure among populations and decent levels of genetic variation within populations. Population structure is most likely to result from pre-settlement processes, but there is beginning to be evidence that contemporary landscape change is reducing gene flow. From a conservation perspective, Blanding's Turtle looks to have maintained considerable genetic variation within populations in spite of habitat loss and fragmentation. This is likely due to a combination of factors including long reproductive lifespan, multiple paternity, and relatively large home ranges. However, low population size and reduced corridors for dispersal are expected to have made potential mates more difficult to encounter and loss of genetic variation should become increasingly apparent in populations as older individuals age out. Overall, these patterns suggest that assisted gene flow should help to maintain genetic diversity. In doing so, conservation practitioners should take care to recognize the hierarchical nature of population structure revealed by range-wide and regional analyses. Greater genetic resolution and geographic coverage, along with description of adaptive genetic variation, are needed to refine knowledge of population structure for guidance on translocation.

Managing the Landscape for Wood and Blanding's Turtles at Camp Grayling

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Camp Grayling, located in the northern lower peninsula of Michigan, is the largest National Guard training center in the United States, and contains extensive areas of wildlife habitat. As is the case at many such facilities, staff are committed to conserving natural resources, and this is good for resident Wood and Blanding's Turtle populations. We have begun a multi-year study of these species on Camp Grayling, with the principle intentions of better understanding the distribution and ecology of the turtles and informing conservation efforts for these species on base. We are using telemetry, surveying, and GIS habitat modeling to investigate habitat use, identify critical habitat, and clarify the known and predicted local extent of both species. Habitat use in both species has been linked to rivers and streams, but Blanding's Turtles have also used bogs, lakes, marshes and scrub-shrub wetlands, while Wood Turtles have used nearby upland forest and shrub-dominated habitats. Additionally, both species have made regular upland movements between wetlands, highlighting the need to extend conservation attention beyond wetlands alone. Large as Camp Grayling is, individuals of both species also regularly moved in and out of Camp boundaries. Management for the species will thus require consideration of an even larger landscape.

Two Decade Study of Blanding's Turtle and Habitat Response to Wetland and Upland Restoration

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Habitat ecology often receives little attention in turtle research. From 1996-1997, in central Dutchess County, New York, Hudsonia designed replacement (mitigation) habitats for Blanding's turtle (*Emydoidea blandingii*) constituting constructed wetlands, nesting berms, and a one-way barrier fence. The regional population uses core habitats that are deep-flooding, shrubby wetlands bordered by coarse-textured soils. The site is dominated by gravelly glacial outwash with high-pH groundwater. We studied turtle, vegetation, and hydrology responses intensively through 2008 and less thereafter. A 0.7 ha "donor" wetland provided much of the soils and vegetation for 3 constructed wetlands, with large translocated sods placed in a checkerboard pattern to jump-start ecosystem development. Biogeochemical activity per unit area in constructed wetlands quickly approached that of the 3 nearby reference wetlands (total 1.4 ha constructed, 6 ha reference). The overall vegetation communities (59 non-rare vascular species) of constructed and reference wetlands differed and did not converge, although the woody component of the constructed wetlands gradually became denser. We radio-tracked adult Blanding's turtles which quickly used constructed wetlands the first season. Turtles used warmer water in constructed wetlands for thermoregulation. All wetlands drew down in summer, the constructed wetlands drying faster. Turtle use each season correlated with declining water levels. Compared on a habitat-area basis, turtle use of constructed and reference wetlands did not differ during May-September. However, early spring use of constructed wetlands was minor and overwintering use minimal. Wetland use patterns were similar through at least 2009. Nesting females avoided the 1 m high constructed nesting berm tops, and nested elsewhere near constructed wetlands. Nests were dug where vegetation was relatively sparse; nests were in sandier soil in drier years and more gravelly soil in wetter years. The 1.5 km barrier fence allowed one-way movement of turtles into the wetlands, but turtles sometimes circumnavigated the fence to leave the restoration area. In sum, constructed wetlands were well used in late spring-summer but not in winter and early spring, perhaps due to insufficient depths of water and organic soil; nesting habitats were easily created and required frequent maintenance; the one-way barrier is maintenance-intensive.

Genetic Spatial Structure of the Spotted Turtle, *Clemmys guttata*, an Endangered Species Facing Rising Sea Levels

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In species of conservation concern with small populations, genetic connectivity can alleviate the negative effects of low genetic diversity, which can be associated with further population declines. The endangered Spotted Turtle (*Clemmys guttata*), typically persists and breeds in freshwater wetlands with low population numbers. However, they are semi-terrestrial turtles with the potential to disperse long distances. Understanding genetic connectivity and whether habitat loss and fragmentation limits connectivity is important to predict future population trends of this species. We used buccal swabs to collect tissue samples and analyzed 12 microsatellite DNA loci in 164 spotted turtles across five populations on the Atlantic Coastal Plain in Maryland and Delaware. We found that spotted turtles typically dispersed long distances between populations, as far as 18 km. However, as most populations were > 47 km apart, we found small, but significant, genetic differentiation (F_{ST}) between some populations. Notably, a population found a barrier island was genetically differentiated from even proximate populations. We then used regressions to test which of three distance measures (linear distance, > 1 km water-avoidance distance, and weighted resistance distance) best explained F_{ST} between populations. We found that pathways between populations that included avoidance of large flowing bodies of water may best explain F_{ST}. We conclude that predicted sea level rise along this part of the Atlantic Coastal Plain may negatively affect spotted turtle populations although this process will likely be slowed by retention of genetic variability due to the extreme longevity of spotted turtles.

Serendipity, Siblings, and Spotted Turtles

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I have had the rare privilege to turn my childhood fascination into a career. My older brother inspired my passion for catching toads, snakes and turtles while toting me up and down the creek and into the woods by our house. Eventually my brother and I become biology instructors at a canoe-tripping camp and there discovered old mark-recapture records for Spotted Turtles; that treasure trove of data became the basis of my career. You can't predict how one life event or decision will impact your career path: my path has followed this population of Spotted Turtles for decades, and such long-term data are essential for elucidating patterns in population parameters for long-lived species. Despite the study site being relatively pristine, the numbers of turtles captured during spring surveys has declined to approximately half of former numbers, and I don't know why; such are the challenging questions that inspire research. My students and I have been visiting various Spotted Turtle populations in Canada and the USA for more than 25 years, and I am frequently amazed by the differences among sites. Our observations have

revealed two facts: on a global scale, the species is a habitat generalist, but at the local scale, individual populations are specialists in terms of their activity cycles. We have found populations in cypress and gum swamp forests, alder and sphagnum swamps, open-canopy fens, flowing streams, beaver ponds, man-made ditches, and even small pools on rocky islands. Such diversity for a rare species makes it difficult to predict habitat preferences. Locally, Spotted Turtles display predictable seasonal shifts in activity and habitat use, and show temporal fidelity to specific sites. Protection of endangered species requires description of critical habitats, and this generalist-and-specialist dichotomy in Spotted Turtles presents an obvious challenge for creating and implementing conservation plans that focus on habitat protection. The data suggest that each population must be treated separately, which in turn can present financial and logistical obstacles for management agencies. These obstacles must be overcome because both site-specific and range-wide data are essential to maintain the global population of Spotted Turtles. (**Keynote Speaker**)

GPS Tracking, Nest Protection, and Headstarting in Minnesota Wood Turtles (*Glyptemys insculpta*)

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The Minnesota Zoo and Minnesota Department of Natural Resources have partnered to evaluate mechanisms to mitigate wood turtle declines in the state. As recruitment is critical to long-term population viability, our primary research objective is to evaluate methods that improve egg and hatchling survival. To identify nesting sites and other critical wood turtle habitat, we tracked 17 adult and 5 juvenile turtles from multiple watersheds in southern Minnesota between 2017 to 2019 using GPS or VHF transmitters. We are also using the data to determine home range size and potential threats. To protect nesting sites, we installed predator exclusion fences at two sites in the spring of 2019 and monitored activity with trail cameras. Fence structures consist of electric netting, and the simple design is meant to keep predators out but permit turtles to enter. We have found the predator exclusion fences to be partially effective, with trail cameras indicating some protection, but raccoons still entering the enclosures on occasion. The fence design is currently being modified to improve effectiveness, and additional sites will be constructed in 2020, along with control sites to better quantify success. Nest site monitoring will continue through 2021. Further, a headstarting program was initiated after the discovery of multiple wood turtle nests in vulnerable areas (e.g. a corn field, low to the river in cutbank). Headstarting of wood turtle eggs and young is being done at the Minnesota Zoo, and 11 of 17 viable eggs from three clutches have hatched successfully to date. Young will be raised in captivity until release in spring 2020 and will be tracked to learn more about juvenile habitat needs. Past headstarting efforts of wood turtles have been successful in Minnesota, with one of the three current clutches coming from a headstart female. We anticipate that local and state management authorities will be able to use the results of this project to devise and implement effective management strategies that benefit the conservation of wood turtles.

Grits, Okra, and Spotted Turtles: *Clemmys guttata* Down South

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The spotted turtle (*Clemmys guttata*) exhibits an extensive latitudinal distribution extending from southern Canada and Maine south to central Florida. Despite occupying a large geographic range, the species is listed as "Endangered" in Canada and a Species of Greatest Conservation Need (SGCN) in all 21 states in which they occur. Previous studies have focused mostly on northerly spotted turtle populations, with little information available on the natural history and ecology of spotted turtles in the Southeast. Beginning in 2014, we incorporated radio telemetry and mark-recapture techniques to investigate the spatial ecology, phenology, and population dynamics of four populations of spotted turtles in southern Georgia and northern Florida. We also incorporated protocols (e.g., standardized trapping and visual encounter surveys) from a multi-state assessment led by the Spotted Turtle Working Group to assess the population status from Maine to Florida. In addition to our 4 established long-term monitoring sites we conducted 48 rapid assessments around historic records or potentially suitable habitats in Georgia and Florida. Despite what appears to be an abundance of suitable wetlands in both states, turtles proved elusive at most all but our long-term study sites where knowledge of occupied habitat was high due to radio-telemetry efforts. A total of 115 individual spotted turtles were captured in Georgia during this study, 94 from the 2 long-term monitoring sites and 21 via rapid assessments (30% of sites surveyed). Similarly, in Florida a total of 73 individual spotted turtles were captured, all but 3 from the 2 long-term monitoring sites (only 4% of sites surveyed). While trapping and visual encounter surveys appear to be successful in detecting spotted turtles throughout most of their range, these methodologies proved less effective at our more southerly sites, especially in Florida where it appears the species occurs at lower densities and is difficult to detect due to habitat and behavioral differences. Results from this study suggest southern populations of spotted turtles are both uncommon and cryptic, favoring a highly aquatic lifestyle and rarely basking or spending time in upland habitats. Activity is dictated more by water levels than seasonality, and unlike more northern climes, turtles can remain active most of the year resulting in faster overall growth rates, quicker time to sexual maturity, and potentially higher fecundity with production of multiple clutches.

Protected is a Verb Not an Outcome: Monitoring the Population Trajectory of Spotted Turtle Populations in Protected Habitat over a 30-Year Period and Projecting Future Long-Term Population Viability

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Long-term studies on wildlife populations are necessary to track population abundance and shifts in demography over time, yet such studies are difficult to plan, fund, and conduct and are therefore rarely undertaken. Such studies are especially important for long-lived species that can persist for long periods of time with little to no reproductive output or recruitment. We conducted two population studies spanning a thirty-year time frame on the globally endangered Spotted Turtle (*Clemmys guttata*) on protected land in

the center of their range. Spotted Turtles are endangered in Canada, listed as globally endangered on the IUCN red list, and declining throughout their range. However, there has only been one previous long-term study tracking their long-term population trajectory. Here, we use mark-recapture data collected over a 30-year timeframe, and report that the estimated population size of Spotted Turtles has decreased by 49% at our study site despite the habitat residing with a protected area. This decline was concurrent within a significant increase in the proportion of larger individuals within the population, indicating a lack of recruitment into the sub-adult stage class. In addition to monitoring the change in population size over a 30-year period, we used a population viability analysis to both quantify the impact that road mortality has on this population and assess the future fate of this population. The baseline model for the North Wetland Complex (NWC) population predicted a probability of quasi-extinction within 150 yr of 20%. The baseline model for the South Wetland Complex (SWC) predicted a probability of quasi-extinction within 150 yr of 24%. Including an estimate of road mortality (modeled as a reduction in adult survival through annual catastrophic events) into the models, the probability of quasiextinction within 150 yr changed to 93% for the NWC and 94% for the SWC. Our results highlight the critical importance that anthropogenic additive adult mortality has on small populations of turtles and the necessity of detailed demographic studies to detect potential declines in populations of long-lived species.

Working Lands for Wildlife – Northeast Turtles: State Conservation Area Networks and Plans Help Guide On-the-Ground Change on Private Working Lands in NH

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Working Lands for Wildlife (Northeast Turtles) led by the USDA's Natural Resources Conservation Service (NRCS) is a model of partnership with USFWS, States, and conservation groups, that incentivizes voluntary landowner participation to help sustain populations of wood, spotted, and Blanding's turtles. Like the New England Cottontail WLFW initiative, it relies on voluntary management and/or land protection by private landowners in key areas. For turtle conservation, protecting parcels within intact landscapes using best management practices and habitat management are the primary goals. The New Hampshire Fish & Game Department's (NHFG) Nongame and Endangered Wildlife Program has provided on the ground assistance, priority and focal core areas, as well as Best Management Practices that have been developed through regional Competitive State Wildlife Grants. The challenges to making rapid progress include the time commitment for site visits and planning, aligning the goals of landowner, NRCS, and NHFG, and how to share and use sensitive data. In New Hampshire, the two agencies have identified ways to best communicate, share information, and use an existing NRCS programs such as the WREP (Wetland Reserve Easement Program) and EQIP (Environmental Quality Incentives Program) to benefit turtles. NHFG and three state land trusts and organizations were awarded a grant from the National Fish and Wildlife Foundation to directly fund assistance and land acquisition through the Working Lands for Wildlife partnership. The products and results from these efforts will be discussed, as well as lessons learned and options for overcoming data sensitivity issues.

Evaluating the Effectiveness of a 15-Year Headstarting Program for Wood Turtles (*Glyptemys insculpta*)

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Two adjacent populations (PopA, PopB) of endangered Wood Turtles were studied extensively beginning in 1988. By the mid-1990s, both populations declined by 70% as the result of a suspected poaching event. A population viability analysis (PVA) determined that extirpation of both populations was inevitable if no intervention was undertaken, and so a headstarting program was initiated in 2003 and the first cohort was released in 2005. Our objective was to quantitatively assess the effectiveness of the 15-year headstarting program by modeling population-specific demographic parameters to evaluate recovery efforts to date, and determine the next phase of recovery. PopA has continued to decline despite the release of 123 headstarts and now has an estimated population size of 18 turtles (11 adults, 7 juveniles). PopB has slowly increased with the release of 330 headstarts and now has a population size of 117 turtles (31 adults, 86 juveniles). PopA and PopB experience relatively high adult annual survivorship (89%, 93%) but low 1-year post-release survivorship of headstarts (36%, 52%). Our PVA projected that PopA will continue to slowly decline whereas PopB will slowly recover, and that both populations would recover if a predator-management strategy was implemented. Six headstarted turtles have reproduced suggesting both populations may become self-sustaining. Since 2015, subsidized predators have killed 11 adult turtles and we have detected three diseases (mycotic shell disease, ranavirus, herpesvirus) in the headstarts. Headstarting alone is not enough to save the populations from local extinction as they face multi-faceted problems for which management is challenging.

Restoring Nesting Areas on the E.S. George Reserve, Michigan, to Reverse Declines in Nest Survivorship That Threaten Population Stability of Painted, Blanding's and Snapping Turtles

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When we initiated our study of turtles on the University of Michigan E.S. George Reserve in the mid-1970's, potential problems from forest succession and invasion by the introduced shrub Autumn Olive (*Elaeagnus umbellata*) were not of remotest concern. By the 1990's, almost all old field nesting areas were reduced in size and three nesting areas had been entirely abandoned by turtles. From the early period prior to loss of major nesting areas (1976-1989) to the period of substantial nesting area loss (1990-2003), nest densities increased markedly in the remnant habitats, and nest survivorship decreased from 24% to 7% for Painted Turtles (N= 455/1249), and from 19% to 2% for Blanding's Turtles (N =148/83), yet remained constant at 14% for Snapping Turtles (N=309/318). Analysis of life-history traits of Blanding's Turtles indicate that no reasonable combination of increased juvenile survivorship, clutch size or frequency, or decrease in age at maturity can compensate for reduced nest success (i.e., the Blanding's Turtle

population is decreasing). In 2016-2018, we found that nesting areas were totally restricted to anthropogenic habitats such as lawns, roads, and remnants of fire lanes; no old field nesting areas remained. We initiated restoration by removing trees, shrubs, and other vegetation from five nesting areas using a BobCat with a tree masticator or a toothed bucket attachment, chain saws, a disc harrow, and a PTO-driven tiller. We observed use of the restored areas by both older and younger females of all three species during 2016, and we monitored nest survivorships in all reclaimed nesting areas during 2017-2018. Both older and younger (naïve) turtles used all five reclaimed areas during all three years, yet nest mortality rates remained high for Painted and Blanding's Turtles. Ultimately, creation of more, isolated, and larger restored nesting areas, and perhaps predator control, will be required to maintain viable turtle populations.

Habitat Management for Early-Successional Forested Wetlands in Pennsylvania, with Recommendations for the Conservation of Spotted Turtles and Wood Turtles

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Over a decade ago, the Pennsylvania Game Commission published *Management for American Woodcock in Pennsylvania* (Palmer, 2008), with the stated goal of creating 783,150 acres of early successional forest habitat on moist soils in Pennsylvania by 2017, a total area larger than the size of Rhode Island. Similar habitat management programs have been embraced by a variety of government agencies and non-profit entities, and are underway in many other U.S. States. These programs are often advertised as benefitting biodiversity, including long-lived turtles that utilize forested wetlands, yet long-term data supporting that assertion are lacking. Although there is little doubt that vegetation modification or removal benefits some vertebrate ectotherms under some conditions, widespread implementation of early successional forest management programs is in some ways an experiment in progress, and it may be detrimental to some non-game, non-target species. Development of management guidelines should take into consideration the unique aspects of spatial ecology and life histories of non-target species such as amphibians and reptiles to minimize potential negative impacts. We discuss our current collaborations with state agencies in Pennsylvania aimed at enhancing both game and non-game species, including Spotted Turtles and Wood Turtles, and at protecting overall biodiversity. We also provide specific management recommendations for selecting and creating early successional forests, and discuss relevant aspects of turtle ecology and life histories.

Potential Niche Overlap Between the Spotted Turtle (*Clemmys guttata*) and Other Turtle Species

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Resource partitioning is an important factor in determining community structure and may allow species with similar habitat or dietary requirements to co-exist. Our goal was to look at possible factors influencing the local distribution of the spotted turtle, *Clemmys*

guttata, by examining potential habitat and resource competition between spotted turtles and three other fresh water turtle species on the Delmarva Peninsula. We first compared the use of water bodies by spotted turtles with those of other turtle species and measured pond-level characteristics (e.g., pH, dissolved oxygen, pond depth) where turtles were found. We also collected samples of turtle claw keratin, which were then analyzed to determine if similar $\delta^{13}C$ and $\delta^{15}N$ isotopes were found among different turtle species. Finally, we used structural equation modeling (SEM) to test which parameters might impact spotted turtle numbers. These complimentary methods allowed us to determine whether the turtle species were potentially competing for a) habitat resources (based on cohabitation and pond use overlap) and b) food resources (by comparing stable isotope profiles). We found that niche overlap is potentially occurring among these turtles. Dissolved O_2 and pH were negatively correlated with spotted turtle abundances whereas they were positively correlated with painted turtle abundance. We found differences in $\delta^{13}C$ signatures for spotted turtles among sites, but general similarities in $\delta^{13}C$ values between spotted turtles and mud turtles across sites indicated that these two species were feeding on isotopically similar food items. Ecological communities are complex and it is especially important to understand the factors influencing the distribution of threatened or endangered species such as the spotted turtle.

Collaborative Monitoring Reveals Factors Influencing Wood Turtle Demographics Across the Northeastern United States

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Despite the decline of turtle species worldwide, large-scale population monitoring programs remain rare due to a lack of standardized protocols as well as logistic and monetary challenges associated with sampling cryptic reptiles. Moreover, low and variable detectability exhibited by many species often necessitates large sample sizes in order to reveal environmental relationships. Although threatened throughout its global range, very little is known about the factors influencing Wood Turtle (*Glyptemys insculpta*) population demographics. Through a collaborative effort using a single standardized sampling protocol, we conducted a large-scale population monitoring effort for the Wood Turtle throughout the northeastern United States. Our objective was to identify the factors and relevant scales influencing Wood Turtle abundance, age structure, and sex ratio. From 2012 to 2017, we conducted 983 spring stream surveys at 293 sites across 12 states from Maine to Virginia. Riparian (90 m), annual movement (300 m), and landscape (5500 m) scales appeared in at least one set of top models of abundance, age structure, and sex ratio. Of the factors examined, Wood Turtle abundance was most strongly influenced by proportion of agriculture at multiple scales. Juvenile proportion displayed strong positive relationships with stream characteristics and urbanization metrics at varying scales. Sex ratios were more likely to be male-skewed with more forest cover near streams as well as higher traffic rates and lower levels of undeveloped land on the landscape. This study highlights the important role that collaborative population monitoring programs can play in conservation efforts for cryptic species.

Impacts of a Highway on the Population Genetic Structure of a Threatened Freshwater Turtle (*Glyptemys insculpta*)

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Genetic partitions for members of the family Emydidae often correspond with both natural and anthropogenic landforms. For semi-terrestrial turtles, there are clear negative impacts associated with habitat fragmentation via roadways such as loss of breeding individuals, increased inbreeding and decreased migration. The wood turtle is a Species of Special Concern in New York and native to the central portion of the state, where Interstate Highway 88 was constructed in the 1970s. To examine possible impacts the highway had on local populations, we utilized a museum collection of wood turtles that predate road construction. Specifically, we used microsatellite markers to compare historic (n = 38) and contemporary (n = 26) wood turtle DNA from opposite sides of the highway. We measured inbreeding (F_{is}), differentiation (F_{st}), number of breeding individuals (N_e), migration (m) and overall population genetic structure. We predicted that the populations on either side of the highway would become more differentiated and inbred over time. We also predicted that migration would decrease over time. Overall, we found that populations on either side of the interstate were historically a single population, had a greater number of breeding individuals and were less differentiated. We found no change in inbreeding across time. Findings suggest there is more migration, running north to south between the two populations, likely attributable to the directionality of flow associated with local creeks. Further research examining these two separate populations within the context of the entire state is necessary to determine whether they should be treated as separate Conservation Units.

Population Viability Analysis and the Role of Head-starting for a northern Illinois Blanding's Turtle Population

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The Blanding's Turtle (*Emydoidea blandingii*) is a long-lived species once common in the prairies and wetlands of northern Illinois, but now only occurs in scattered populations. To aid the recovery of Blanding's Turtle populations, the Forest Preserve District of DuPage County (FPDDC) maintains a head-starting and release program to alleviate high mortality in younger age-class turtles and increase population size. We previously conducted trapping and analysis at the main release site to determine basic demographic parameters under the current head-starting program. We found moderately high head-start survival, fairly high adult female survival, and an increasing population size suggesting head-starting was working as a conservation strategy. To investigate future population trajectory and the outcome of continued head-starting we conducted a population viability analysis (PVA) using the program VORTEX incorporating updated demographic data from surveys in 2018. Updated models continue to indicate moderately high head-start survival which may increase with body size. Though population size continues to increase, the PVA indicates some form of ongoing management is necessary to avoid a negative stochastic growth rate. Ceasing head-starting could result in

extinction (within 100 years) if no natural recruitment is occurring. Head-starting 50 eggs/year did not result in extinction for any of the scenarios modeled, and head-starting 100 eggs/year would maintain or increase population size. Head-starting 200 eggs/year would increase population size even if no natural recruitment is occurring or juvenile mortality is higher than current estimates indicate. Alternatively, maintaining high natural age 0-1 survival would increase growth rate, but may be difficult because current egg and hatchling mortality are unknown (but likely high based on few juveniles present prior to head-starting). Maintaining high adult survival will be important regardless of other management practices. We conclude the best management strategy for this population is to head-start at least 100 eggs/year until threats can be alleviated and other management can demonstrate adequate natural recruitment.

Demographic Response of a Spotted Turtle (*Clemmys guttata*) Population to Multi-year Meso-predator Removal Efforts in a Northeast Ohio Fen

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Meso-predators, including raccoons (*Procyon lotor*), are primary predators of turtles and may obtain unnaturally high densities due to human subsidies. Predation by such predators may be more prevalent for turtle nests, and this can be especially detrimental when nesting sites are concentrated. Persistent nest predation often results in a skewed population structure dominated by large adults due to reduced recruitment. Meso-predator control efforts during the nesting season have occurred yearly since 2011 at several important turtle sites in northern Ohio. At a northeast Ohio fen, we compared size distribution and sex ratios of Spotted Turtles among survey efforts from 2007 to trapping efforts in 2017–2018 to assess the demographic response of Spotted Turtles to removal of meso-predators. We used a Lincoln-Peterson population estimate with a Chapman modifier to estimate the turtle population size and density in 2017–2018. From 2011–2016, 115 raccoons and 7 Virginia opposums (*Didelphis virginiana*) were removed along a railroad bed where turtles frequently nest. While the turtle sex ratio did not differ, we found a significant shift in the size distribution between the two time periods resulting from the capture of juveniles in 2017–2018, but not in 2007. A similar size distribution was observed in Painted Turtles (*Chrysemys picta*). We estimated the population size to be 28 individuals (95% CI: 19–37), resulting in a density estimate of 22 individuals/hectare. The shift in size distribution and similarity to a conspecific turtle species, suggests that meso-predator control efforts have mitigated predation of nests and/or young, resulting in increased recruitment in the population examined in this study. Further, the estimated population density is high relative to other populations. These results suggest a healthy population with yearly recruitment and evolutionarily stable sex distribution as a result of continued predator control efforts during the nesting season.

Modeling the Projected Population Growth Rate of Wood Turtles

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The Wood Turtle (*Glyptemys insculpta*) is a highly terrestrial medium-sized turtle that occurs in the northeastern and upper midwestern United States and in southeastern Canada. The Wood Turtle faces several threats throughout its range including habitat loss, road mortality, and illegal collecting. Currently the species is undergoing a status assessment to evaluate the species' needs and current condition. To assist with the status assessment, we have developed a population model that can be used to better understand the influence of the various life history parameters on the overall population growth rate. We have used preliminary information from the available scientific literature to develop estimates with associated precision to attempt to account for parametric uncertainty. Our model is age-based, including uncertainty in parameter estimates for the age at first reproduction, clutch size, proportion of breeding females per year, and annual survival rates of hatchlings, juveniles, and adults. This preliminary analysis suggests that populations of Wood Turtles are likely declining. As is typical for a long-lived species with delayed maturity, the parameter with the highest elasticity (proportional sensitivity) was adult survival. There are several important limitations to our analysis, and therefore our preliminary results should be interpreted with caution; for instance, environmental stochasticity, temporal autocorrelation, immigration, spatial structure and transient dynamics are not considered. Our next step is to use a formal elicitation approach to improve estimates of the life history parameters for Wood Turtles from experts with direct knowledge or unpublished data. We are especially interested in how parameters might vary geographically across the range of the species. We would also like to elicit more information about threats to the species and how they might directly affect one or more life history parameters. With this information, we hope to better model the likely future population conditions for Wood Turtles for inclusion in the status assessment.

Mortality Risk to Wood Turtle in a Landscape under Active Agriculture in New Brunswick

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Agricultural land and improved agricultural machinery present an ecological trap for some species. The threatened wood turtle (*Glyptemys insculpta*) inhabits riparian buffers and forests but will use agricultural fields if close to nesting habitat, as these fields can provide adequate basking temperatures and feeding grounds. In actively farmed fields, agricultural machinery can present a mortality risk for the species. Mitigation of this risk is difficult, as there is limited information on the effects of agricultural practices on wood turtles. We sought to quantify how different agricultural practices affect wood turtles at levels ranging from individual movement behaviour to population demographics. From May to October of 2017 and 2018, we studied wood turtles in central New Brunswick along a second-order stream surrounded by hayfields and forest. We located 50 wood turtles along a 2-km section and radio-tagged 23 to monitor their habitat use and relative risk from agricultural practices. In July and August of 2017 and 2018, we monitored the movement response of wood turtles approached by agricultural machinery. Results varied, but none of the turtles successfully escaped the mower during harvest. We recorded a total of 993 relocations in 2017 and 2018, and from 15 June to 15 July, approximately 50% of relocations were within a hayfield. Females used the fields more often and for a longer period than males. In June, 86% of turtles in the field were within 30m from the field edge and 80% in July. We also sought to quantify how different agricultural machinery affects wood turtles at multiple life stages through experimental

trials using two mower types using cantaloupes as proxies. In general, we found that rotary disc mowers resulted in a significantly greater injury to all size classes at low blade heights compared to sickle cutter bar mowers. This information will help fill several critical knowledge gaps for this species-at-risk and provide management recommendations to land managers attempting to mitigate agricultural impacts.

Habitat Protection, Restoration, and Head-starting: Can These Conservation Strategies Recover an Urban Population of Endangered Blanding's Turtle (*Emydoidea blandingii)*?

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Habitat loss and fragmentation are major drivers of population decline for many freshwater turtles, especially in urban areas. Several conservation strategies, including habitat protection and restoration, and head-starting, have been used to improve population recovery, with varying success. However, few studies have investigated the success of these strategies when implemented simultaneously. Our study investigates individual and population health of head-started Blanding's Turtles (*Emydoidea blandingii*) released into a restored wetland complex in the Rouge National Urban Park (RNUP) in Ontario, Canada. We conducted a mark-recapture study to measure: 1) population size; 2) age distribution; 3) sex ratio; 4) somatic growth rate; 5) body condition (mass vs. body length); and, 6) survivorship of each head-started cohort. In the 2018 and 2019 field seasons, using baited hoop traps and walking transects, we captured 36 Blanding's Turtles (1 wild female, 1 wild male, 34 head-start juveniles; 20 recaptures). The sex ratio was 0.03 male: 0.03 female: 1 juvenile, and the age distribution confirmed that juveniles are the most common demographic class in the population. These results are not surprising given that only 5 adult wild Blanding's Turtles have been historically found at the study site. Preliminary results also indicated that at least 47% of head-started Blanding's Turtles display relatively poor body condition, and a growth rate of 7 mm/year, which is slower than that of wild Blanding's Turtles of similar age in southeastern Michigan, USA. Our study will indicate whether several conservation strategies implemented together can initiate recovery of an endangered turtle population in a highly disturbed habitat where multiple threats persist.

Conservation Planning for Spotted Turtles in the Eastern U.S.

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Spotted turtles (*Clemmys guttata*) are of conservation concern throughout their range in the United States and Canada, and they are identified as SGCN in all 21 states in which they occur, Endangered by the IUCN and have been petitioned for federal listing under the Endangered Species Act. With support from a U.S. Fish and Wildlife Service Competitive State Wildlife Grant award to the Virginia Department of Game and Inland Fisheries in 2017 and a Northeast Regional Conservation Needs (RCN) Grant, the eastern U.S. states (from Maine to Florida) are undertaking a comprehensive, collaborative conservation planning effort for the spotted turtle. As part of this effort, we are quantitatively assessing the distribution and status of spotted turtles and evaluating effects of climate change and habitat fragmentation in order to guide and prioritize future management. We have developed and are implementing a standardized monitoring program to identify high priority sites and management actions across the region and are engaging in a broad-scale assessment to quantify genetic structure and identify genetically unique and diverse populations. In 2018, teams across the region sampled over 50 sites in 10 states over 8000 trap nights and captured over 700 spotted turtles. Population estimates from that sampling effort ranged from 7 to 188 turtles/50-ha site. Teams continued to sample in 2019, and we will present our current progress to date and next steps in the planning process.

Endangered Species Legislation and Decision-making: Case Study of a Quarry Proposal in Blanding's Turtle Habitat

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Mining practices can negatively impact turtles through degradation of wetlands and surrounding upland habitat, alteration of movement corridors, direct mortality, and increased risk of nest and turtle predation. These impacts, in turn, can cause changes in patterns of energy allocation, skewed sex ratios and changed demography, which may ultimately lead to population declines. Using radio-telemetry, GPS data loggers, and capture-mark-recapture surveys over two field seasons, we described the demography of, and identified critical habitat for, a population of globally-endangered Blanding's turtles (*Emydoidea blandingii*) inhabiting an area of interest for development of a trap rock quarry in Ontario, Canada. We captured 56 turtles and estimated population size to be 80 +/- 18 turtles, and density to be 1.84 turtles/ha, which is among the highest reported densities for the species. Daily distances moved and home range sizes were generally smaller than conspecific values reported in the literature, suggesting that habitat quality was high as turtles did not need to move much to acquire necessary resources. We identified 15 nest sites and 12 wetlands that housed overwintering turtles, both considered critical habitats with lowest tolerance to destruction. We mapped our spatial data based on the application of legislated provincial and federal recovery guidelines, and the results clearly indicate that the quarry proposal should be rejected if the spirit of the law is upheld.

ABSTRACTS - Poster Presentations

Influences of Temporary Emigration and Demographic Structure on Wood Turtle Visual Encounter Survey Results using the Midwest Protocol

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Standardized Wood Turtle (*Glyptemys insculpta*) survey protocols have been developed and implemented for both Eastern USA and Midwest USA populations. For both protocols, repeated surveys are completed using a single pass through defined areas, allowing for estimation of survey-specific detection probability (p) and site-specific abundance. However, because the protocols use a single-pass design, they do not allow for separation of p into the components of availability (p_a) and detectability (p_d) given availability. During the active season Wood Turtles move within and among stream, riparian, and upland habitats, and are not always visible to observers even when present in the survey area, and thus it is unlikely that all individuals will be available for detection in all surveys. If there are systematic influences on p_a or p_d that are not accounted for in the survey design or data analysis, then resulting abundance estimates could be highly biased. The objectives of this study were to determine whether demographic structure is a strong factor influencing Wood Turtle population survey results, and to quantify p_a and p_d using the Midwest survey protocol. To accomplish these objectives, we modified the protocol to include a double-pass design, allowing us to separately estimate p_a and p_d using an open robust design capture-recapture model. In spring 2017, we conducted 6 double-pass surveys at 8 monitoring sites in Minnesota. To provide additional insights into p_a, we also examined high temporal resolution location data for 7 Wood Turtles that occupied the monitoring sites within the seasonal and daily survey time frame in 2016. Preliminary capture-recapture analyses indicate strong support for presence of temporary emigration, with estimated average p_a per survey being ca. 0.2. There was little support for p_a varying based on age class or sex, but some support for p_d varying by age class (0.75 and 0.65 for adults and juveniles, respectively). For the 7 monitored turtles, the estimated proportion of time spent within the survey areas was 0.35, and of this time, 86% was spent on land. The results of this study will assist with future refinements of Wood Turtle monitoring protocols to maximize reliability of population inferences.

The Use of Inexpensive GPS Loggers as a Conservation Tool for the State Threatened Blanding's Turtle (*Emydoidea blandingii*) in New York

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We evaluated the use of inexpensive GPS loggers to track the movements of Blanding`s turtles in the St. Lawrence River Valley ecoregion of New York State. We conducted

limited tests on the use and efficacy of these devices in 2017 and affixed units to 12 telemetered gravid females to identify potential nesting areas at several key sites in 2018. In 2019, we conducted a more comprehensive application of these devices to identify and document nesting areas of gravid females at key sites as well as evaluate movement patterns to and from nesting sites. We waterproofed and affixed loggers to 18 gravid females by attaching them to a mounting plate, which facilitated swapping out loggers with depleted batteries. The average battery life was 10 days on a 4-hour charge recording at 5-minute intervals. Probable nesting sites of 12 females were located based upon successive examinations for gravidity and duration of time spent at a single location. Centroids of point clusters were calculated for each individual and the average distance from each point in a cluster was used to delineate a radius around the centroid in which the potential nest could occur. However, in no case could the exact location of a nest be determined. We also placed loggers on five radio-tagged gravid females that were translocated to protected, artificially-created nest sites to introduce them to the new nesting location. None of the introduced females nested within the artificial sites and all moved to nearby wetlands or moved in the direction of travel prior to translocation. The present study demonstrates a practical application of inexpensive GPS loggers as a valuable conservation tool that makes large-scale tracking of target individuals with minimal effort possible. The potential use of these GPS loggers may be applicable to a wide range of ecological investigations involving other wildlife with reduced human effort. The data we collected in the present study will be valuable in informing regional conservation planning for Blanding's turtles in New York and these methods can be applied to gather similar information on the species across a larger geographic region.

Demographic Changes in a Wood Turtle Population Over Four Decades

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A population of wood turtles (*Glyptemys insculpta*) in Schoharie County, New York was studied extensively from 1973 through 1977. These investigations addressed home range, habitat use and demographics. During the course of this work 96 turtles were marked and a total of 1712 captures of these turtles was recorded. This study area was resurveyed during spring and fall of 1995 and 1996 to evaluate the status of this population and the habitat. A total of 40 wood turtles was captured during 13 survey days. These included 11 individuals that were previously marked between 1973 and 1977 and 29 new captures. The new captures included 13 juvenile to young-adult individuals less than 20 years of age and 16 turtles greater than 20 years old. The three groups may represent three distinct demographic elements: surviving residents, new recruits born into the population since last work, and immigrants or transients. This population was surveyed again in the spring and fall of 2018 and 2019. During these visits a total of 41 wood turtles was captured during 31 survey days. These included 7 individuals that were previously marked and 34 new captures. These recaptures included two individuals marked during 1973-77 period, documenting ages in excess of 60 years, and five turtles marked during the 1995-96 surveys. The new captures included 12 juvenile to young-adult individuals less than 22 years of age (the interval between visits) and 22 turtles greater than 22 years old. Again possibly representing surviving residents, new recruits and immigrants of transients. These elements are discussed in relation to previous knowledge of this population especially in light of the potential impact on this population by severe flooding of this site caused by Hurricane Irene in 2011.

Comparing Seasonal Activity Ranges and Macrohabitat Use by Wood Turtles and Blanding's Turtles in Michigan

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Estimates of seasonal activity range and macrohabitat use are informative tools for understanding wildlife populations**.** Wood Turtles and Blanding's Turtles are found throughout the state of Michigan, where they are both listed as Special Concern. We conducted a study of both species at a National Guard training center where they had not previously been studied. The site is made up of a network of aquatic and upland habitats, which are intersected by anthropogenic structures at varying degrees. We radio-tracked 14 Wood Turtles and 24 Blanding's Turtles during the 2018 and 2019 active seasons to compare how each species interacts with their environment. We used Minimum Convex Polygons to estimate seasonal activity ranges for 18 Blanding's Turtles and 12 Wood turtles. Estimations for both species ranged widely but were larger on average for Wood Turtles than for Blanding's Turtles. We used compositional analysis to examine macrohabitat use and compared results between species and sexes. Our results show which areas of the base turtles occupy and which habitat features they are most associated with, so these areas can be adequately protected. Research conducted on populations which occupy military training centers serve an important role in furthering the understanding of habitats with unique conditions and potential barriers. This study will contribute to efforts at protection in such environments.

Spatial Ecology and Habitat Utilization of Hatchling Blanding's Turtles

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The Blanding's turtle, *Emydoidea blandingii*, is an endangered semi-aquatic freshwater turtle ranging from the upper Midwest to Southeastern Canada, with isolated populations in Eastern states and provinces. Information regarding the spatial ecology and demography of the species is essential to population recovery. Habitat utilization and movement patterns of the adult Blanding's turtle have been well studied across its range. However, little information is known about hatchling movement and habitat usage following nest emergence. At Camp Ripley Training Center, the current management strategy is to escort hatchlings from the nest site to the nearest wetland complex following emergence. A study was established in 2017 to determine whether the current management practice is the most effective strategy. In order to examine the success of this management strategy, transmitters were attached to hatchlings following nest emergence and escorted to wetland complexes frequently utilized for hatchling release. Preliminary data has suggested that escorting hatchlings to wetlands may not be the best management practice, as many hatchlings leave the wetlands and retreat to upland forests. Future work includes releasing hatchlings at the nest site to compare habitat usage and survival. From the results of this project, land management strategies may be adjusted to optimize hatchling survival. This study would not be possible without the joining support of the MN Army National Guard and MNDNR.

Efficacy of Meso-Predator Control on Blanding's Turtle (*Emydoidea blandingii*) Nest Success in Northeastern Illinois

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A growing body of literature strongly suggests that predation on turtle eggs and hatchlings by meso-predators is high and can limit population growth, decrease recruitment and lead to population declines in many turtle species, including Blanding's Turtles. As such, many agencies have utilized head-starting as a tool to increase juvenile recruitment by avoiding this period of increased predation risk. However, head-starting can be expensive, time consuming and there is still debate about whether or not it is an effective long-term conservation strategy. Conversely, meso-predator management is often discussed as a more efficient and less-intrusive alternative to head-starting. In 2013, the Lake County Forest Preserve District began a meso-predator control program, with a focus on raccoons, in order to determine its efficacy in increasing nest success within a focal conservation area in Northeastern Illinois. Raccoon density estimates prior to control efforts ranged from 6-22 (km^2) and, on average, 61% (41%-89%) were estimated to have been removed annually (Leslie catch-per-unit effort removal model). Since control efforts began, Blanding's Turtle nest success has increased from 7.7% to a 6-year mean nest success rate of 66.7%. Although, other factors may be contributing to increased nest success, the data suggests that meso-predator control may be a cost-effective way to increase recruitment and warrants additional study.

Neonate Ecology of Spotted Turtles in Ohio and Michigan

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To develop effective conservation plans for the spotted turtle (*Clemmys guttata*), the ecological requirements of all life stages need to be considered. The adult and nest stages have been the primary focus of spotted turtle research, with the neonate stage receiving very little attention. However, neonate survival and recruitment into the adult population is critical for population persistence. In particular, if habitat requirements of neonates differ from those of adults, different management strategies may be necessary to ensure that appropriate habitat is available for neonate spotted turtles. We investigated the habitat use, movement, and survival of neonate spotted turtles in northwest Ohio and southwest Michigan using radio telemetry. We tracked 18 neonates upon emergence from the nest. One was confirmed dead, five were lost due to transmitter expiration, and we lost transmitter signals for three, which could be due either to predation or transmitter failure. Nine neonates were tracked to overwintering locations, and we continued to radio-track four of those neonates the following spring. Neonates had a mean weekly movement rate of 7.88 and 2.16 meters/week in Ohio and Michigan, respectively. These differences in movements and survival between states might be reflective of the differences in habitat availability. In Michigan, neonates resided in a shallow-water fen and were mainly located in sphagnum moss mounds or in mucky water. In Ohio, neonates used grassland habitat that floods in spring, but which was dry when used by the neonate turtles. Neonates in Ohio spent considerable time sheltered in both sphagnum moss and in substrate beneath grasses. Overall, our results suggest that neonate spotted turtles have moderately high survival, contrary to the theory that turtles generally have low survival early in life. However, longer studies are needed to quantify annual survival of juvenile spotted turtles, and to determine how many neonates are eventually recruited into adult populations. Additionally, because spotted turtles live in a variety of habitats across their geographic range, neonate survival, movement, and habitat use likely differs

among populations, as has previously been found for nesting habitat. Therefore, site-specific research is critical to appropriately protect separate populations.

The Role of Community Involvement in Species-At-Risk Projects: Shawanaga First Nation's Species-at-Risk Project

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Shawanaga First Nation, located on the coast of Eastern Georgian Bay, Ontario, Canada is home to many amazing but unfortunately declining reptiles. In order to help protect and conserve these species, a species at risk program was started in 2019. This program had goals to identify and assess major threats to SAR reptiles, evaluate population sizes and distributions, educate the local community, and develop mitigation and management strategies. We would like to share some of our preliminary results through successes and hardships that were made during the 2019 season as well as be open to suggestions to improve going forward. This project shows how powerful community involvement can be for population level projects.

Habitat Modeling of Spotted Turtles (*Clemmys guttata*) and Blanding's Turtles (*Emydoidea blandingii*) in Indiana

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Many turtle populations are in decline across the United States due to a variety of factors, including habitat loss, urban development, poaching, and road mortality. Population occurrence and habitat extent are critical elements of understanding distributional trends, and thus it is important to approach sampling using effective methods. We conducted visual encounter surveys (VES) and trapping for two state-endangered species of turtles in Indiana, the Spotted Turtle (*Clemmys guttata*) and the Blanding's Turtle (*Emydoidea blandingii*). This data, along with relevant habitat variables, were used to model the distribution of both species in Indiana using a maximum entropy modeling program, MaxEnt. Recent element occurrences (EOs) and other records, as well as observations from our surveys and trapping efforts, were used for presence data. Environmental variables were chosen based on the ecology of both species (e.g. soils, wetlands) and the relationship of habitat with urban development (e.g. roads). We evaluated final models using area under the curve (AUC) and corrected Akaike information criterion (AICc). The best models were successful in identifying known localities from presence data for both species. Blanding's Turtle models were able to predict suitable habitat that reflects its geographic distribution, while Spotted Turtle models were more limited. The Blanding's Turtle models were able to be used for looking at other potential localities or potential sites for focused management or repatriation. Spotted Turtle model performance reflected the need for more samples, but also the likelihood of fewer numbers due to declining habitat availability. Both Blanding's Turtle and Spotted Turtle models argue for the need of more intense survey efforts based on historical occurrences, as well as restoration efforts across the state. Through our modeling efforts, we are able to provide information on habitat distribution and connectivity for enhancing conservation and management strategies for both of these state-endangered species of turtles.

Spotted Turtle (*Clemmys guttata*) Occupancy and Abundance in Massachusetts

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Turtles are among the most threatened group of vertebrates in the world. The freshwater turtle subfamily Emydinae is especially vulnerable to extinction in North America due to multiple anthropogenic threats, including habitat loss, habitat degradation, road mortality, and poaching. *Clemmys guttata* is a small, cryptic turtle that resides in shallow, densely vegetated freshwater wetlands and was once one of the most abundant freshwater turtles in Massachusetts. Spotted turtles were listed as a Species of Special Concern under the Massachusetts Endangered Species Act until 2006, though they are still considered a Species of Greatest Conservation Need, and relatively little is known about their status since delisting. We analyzed data from regional, standardized trapping across Massachusetts in 2018 and 2019. We evaluated sampling results against local and landscape covariates along with climate model layers using a hierarchical modeling framework to assess which covariates best predict relative abundance and detection. Our analysis improves our understanding of *C. guttata* in an important component of its range, and our results will be used to inform conservation needs of this vulnerable and elusive species into the future.

Home Range, Habitat Selection, and Population Abundance of Wood Turtles at Umbagog National Wildlife Refuge and the Nulhegan Basin Division of the Silvio Conte National Fish and Wildlife Refuge

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The Northeast Region of the U.S. Fish and Wildlife Service categorized the wood turtle as a priority “at–risk” species in 2017 in response to widespread population decline reported by the Northeast Wood Turtle Working Group (NEWTWG). In 2018 and 2019, the NEWTWG protocol was implemented at Umbagog National Wildlife Refuge (Umbagog), located in Maine and New Hampshire, and the Nulhegan Basin Division of the Silvio Conte National Fish and Wildlife Refuge (Nulhegan), located in Vermont, to understand the status of this species in two federally protected areas. In 2019, research was expanded to collect habitat and spatial data, and to assess factors limiting long-term survival to inform the implementation of management actions, such as improving nesting site quality or head-starting. Twenty-two turtles were fitted with VHF tags, with 14 turtles also fitted with a GPS tag. Habitat plots were sampled at random locations within a 300 meter buffer to four stream survey transects. Turtles tracked via radio telemetry had habitat plots sampled at their location, as well as, a paired random location to compare habitat use vs. availability. Temperature loggers were deployed at nest sites to evaluate if temperature is a factor limiting reproductive success. Spring emergent and nesting surveys in 2018 and 2019 resulted in finding 57 turtles at Umbagog and 7 turtles at Nulhegan that were notched with a unique code (Ernst et al. 1974). Juvenile turtles too small to notch have been encountered at Umbagog 27 times during the two years. Using initial GPS data, mean home range size was significantly different ($p = 0.003$) between males (4.33 ha, $n = 3$) and females (13.58 ha, $n = 3$). Preliminary population estimates were derived using regional estimates of capture probabilities ($p = 0.10$ to 0.13) and

ranged from 118 to 138 and 47 to 55 turtles at Umbagog and Nulhegan, respectively. Data collection will continue through mid-September 2019.

Home Range and Movement Dynamics of Two Populations of Spotted Turtle (*Clemmys guttata*) at the Southern Extent of Their Range

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The spotted turtle (*Clemmys guttata*) is a Species of Greatest Conservation Need in Florida, where it reaches the southern periphery of its range. This species was recently petitioned for listing under the U.S. Endangered Species Act, citing habitat fragmentation and population declines. Spotted turtles have been documented from 15 counties in Florida, though most records are limited to single specimens found on roads between March and May. Little information exists on the habitat, abundance, distribution, and ecology of spotted turtles in the Southeast, with no previous studies targeting the species in Florida. Since 2014, we've used radio telemetry and mark-recapture techniques to investigate home range, movement, and phenology of two populations of spotted turtles in Florida. We captured a total of 70 individual spotted turtles and tracked 27 using radio-telemetry. Adult home range size varied between sites and individuals, from very small (0.1 ha) to large (43 ha), with an overall mean of 6.6 ha. Both sexes remain active year-round, with males moving greater distances and utilizing larger areas. Shallow water and abundance of woody debris within complex, forested wetlands appear to be the most reliable habitat characteristics for predicting spotted turtle presence in Florida, with roads/high traffic volume negatively impacting populations and constricting movement and dispersal. Population size at occupied sites is small, with known sites scattered and isolated across the landscape. Results from this study indicate spotted turtles in Florida and both uncommon and cryptic, favoring a highly aquatic lifestyle, and rarely basking or spending time upland. Protection of large-scale wetland complexes and preserving connectivity is necessary for the long-term conservation of this rare and secretive species.

Spotted Turtle (*Clemmys guttata*) Distribution and Conservation Status in West Virginia

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Research and management of Spotted Turtle (*Clemmys guttata*) populations has increased since the species was petitioned for listing under the Endangered Species Act. The Spotted Turtle is currently listed as an S1 species (critically endangered) in West Virginia. Spotted Turtles are a cryptic, semi-aquatic chelonian that use a variety of habitat types, such as shallow grassy wetlands, ponds, shallow bays within larger lakes, and forested swamps. In West Virginia, the species is only known to occur in a few wetlands within the eastern panhandle region of the state. However, the northern panhandle and north-central portions of the state also contain potentially suitable habitat. The purpose of this project is to improve our understanding of the distribution and abundance of Spotted Turtles in West Virginia, using population surveys combined with habitat suitability modeling. In spring 2019, we sampled 15 wetlands in the eastern panhandle with known or potential Spotted Turtle populations based on historical records and survey activity. We captured Spotted Turtles at 5 of the wetlands, 3 of which were not known-occupied wetlands prior to this sampling effort. We captured a total of 96

spotted turtles, including 80 unique individuals. We will survey additional wetlands in fall 2019 and spring 2020, including potentially suitable wetlands outside of the documented counties of occurrence. We will construct a regional habitat suitability model to guide future survey site selection, and this model will be refined using results from additional sampling.

Influence of Bait Type on Capture Success of *Clemmys guttata* Using Small Hoop Nets in Shallow Wetlands.

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Interest in management of spotted turtles (*Clemmys guttata*) has grown since the species was petitioned for listing under the Endangered Species Act. Standardized sampling methods are currently being developed to assess the species status and assist with development of long-term monitoring programs. Passive sampling using baited traps is a common method for spotted turtles. Researchers have typically used canned sardines as bait, but research into the effectiveness and feasibility of other bait types is lacking. A recent study conducted at ponds in Missouri found that wet cat food was equally as effective as sardines at capturing snapping turtles (*Chelydra serpentina*), and six times more effective at capturing painted turtles (*Chrysemys picta*; Richardson et al. 2017). In spring 2018, we conducted a study to determine if wet cat food was an effective bait for spotted turtles inhabiting shallow wetlands in West Virginia, as well as to determine if the findings of Richardson et al. (2017) were consistent when sampling in a different region and different habitat types. Results suggest no significant difference in spotted turtle captures ($p = 0.810$, $N = 58$ paired trap tests), with 31 and 27 unique individuals captured using canned sardines and wet cat food, respectively. We further assessed bait preference by conducting independent surveys in April 2019, and had similar results ($p = 0.256$, $N = 35$). Our study suggests that wet cat food is an effective alternative to sardines for attracting spotted turtles to small hoop nets in shallow wetlands, supporting the findings of Richardson et al. (2017). Our study also indicates potentially strong individual-level bait preferences, given only 3 individuals were captured in traps containing both bait types, but further research is needed.

Factors Affecting the Population Dynamics of Wood Turtles in Oswego County, NY

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This poster reports on ongoing research on a study population of wood turtles (*Gylptemys inscuplta*) in eastern Oswego County, New York in relation to the demographic, life history, ecology, nesting and conservation of this declining species in this portion of its range. Habitat data collected thus far is consistent with findings from the published literature. Observations at one nest site at this location reveal a large amount of nest predation and reduced juvenile recruitment. Age distribution is consistent with the low juvenile recruitment. Overall, the data suggests that this population appears to have a low juvenile survival and reduced recruitment.

Spotted Turtle (*Clemmys gutatta*) Population Analysis and Headstarting Efficacy at Ira Marsh in Cayuga County

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In 2017, a follow-up survey was conducted in a marsh where a spotted turtle headstarting study was initiated in 1985 by Collins and then by Rosenbaum and various students since. In that original 1985 study, 39 resident spotted turtles were initially marked and released followed by subsequent captive rearing of 29 headstarted animals (See Rosenbaum & Collins 2019). 2017 was the most recent re-assessment of this study. Despite deliberate and extensive searching, none of the original resident spotted or any of the headstart release animals could be located. Thirty two years after its initiation and over 20 years since our last reporting on this study, it is not really suprising that none of the initial 1980s animals could be located in a vast wetland complex that is interconnected to many other wetland complexes. In this regard, the results are not surprising. Perhaps what should be surprising is that any spotted turtles were still present over 30 years after their initial study. We thank David E. Collins for help in the field and for initiating this study.

Assessment of Spotted Turtle (*Clemmys gutatta*) Headstart Release Program in Northern New York State

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In 1985, a headstarting study of spotted turtles (*Clemmys gutatta*) was initiated in a large wetland complex in northern Cayuga County, New York. The purpose of this study was to provide information to evaluate the effectiveness of headstarting as a recovery tool. In phase I of this study, 29 resident spotted turtles were captured, marked and released. In Phase II, gravid females from this population were collected and their eggs hatched and reared in captivity. Between 1988-1991 39 headstarters (4 in 1988, 22 in 1989, 4 in 1990 and 9 in 1991) were released into this site after 15-22 months of growth in captivity. Between 1991–1998 surveys were conducted to re-assess the status of residents and headstarted spotted turtles at this site. A total of 11 headstarters (28 %) were recaptured during this period. Findings confounding the assessment of this headstart release program are discussed.

Genetic Diversity of Spotted Turtle (*Clemmys guttata*) Populations in a Fragmented Landscape

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Spotted Turtle (*Clemmys guttata*) is a species that has become rare across a large portion of its geographic range including the Midwest. Habitat loss, fragmentation, and degradation are expected to reduce genetic diversity and increase differentiation among remaining populations. We examined genetic variation in spotted turtles in Indiana and Ohio to assess genetic variation, delineate populations, and investigate potential bottlenecks. Eight microsatellite loci were used to genotype 139 individuals. A sample of 7 or more individuals was obtained from four sites that represent three counties in Indiana. Two sites from Ohio had a sufficient number of samples to be included at this level. Additional localities with fewer individuals were included to see where they fit into the population structure. We detected three genetic clusters within the sample using Bayesian and ordination based cluster analyses. Individuals from one Ohio locality were largely clustered alone and had a significant degree of differentiation from all of the Indiana sites. Two sites in the same county in northwest Indiana, were not differentiated in cluster analyses but had several private alleles and weak differentiation estimated with F_{ST} and Jost's *D*. Two of the six sites had detectable bottlenecks, even though levels of allelic diversity and heterozygosity were relatively high and comparable to populations investigated in other studies. Overall, population structure was identified among localities in Indiana and Ohio that may warrant independent management. Populations where the bottlenecks were detected may be of special concern in the future as they continue to be subjected to isolation.

Into the Weeds: A Comparison of Microhabitat Use by Wood and Blanding's Turtles in Northern Michigan

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Camp Grayling Joint Maneuver Training Center is a military training base located in northern Michigan, which includes large areas of relatively undisturbed wildlife habitat. Both Wood and Blanding's Turtles are among the species found on base, and in some areas they have been found to use the same water bodies. The fact that these species coexist at Camp Grayling provides an opportunity to compare microhabitat use between them within the same landscape. To investigate this question, we used VHF radio telemetry to collect microhabitat data on both species (14 Wood Turtles and 24 Blanding's Turtles) throughout their active season in 2018 and 2019. 14 microhabitat variables were collected once per week, with the aim of representing the physical and vegetative structure of the immediate environment where the turtle was located. Repeated measures MANOVA tests were used to test for microhabitat selection in both species by comparing microhabitat values at used versus random points, and to test for differences between the two species. Understanding how these species differ in habitat use and whether interactions between them change how they use their habitat has important implications for the conservation and management of these species.

Wildlife Forensic Science: Bridging the Gap between Conservation Research and the Courtroom

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The 2019 Spotted, Blanding's and Wood Turtle Conservation Symposium's goal is to "convene experts…to network and share ongoing research and conservation efforts". Conservation efforts often require regulatory intervention, which in turn often leads to legal considerations. Bridging the gap between science, conservation, and law enforcement, is wildlife forensics. Wildlife forensics applies scientific data to legal investigations in a manner that will withstand judicial scrutiny. Over 24 major wildlife laws and 3 international treaties deal exclusively with the protection of thousands of endangered species across the globe. The development of methods to identify species, individualize members of a single species, and determine population origin of individuals has become an overwhelming task. It is therefore crucial for wildlife forensic scientists to be able utilize the efforts of conservation researchers to accomplish their shared goal, the protection of endangered species. A recent case involving wood turtles at the U.S. Fish and Wildlife Forensics Laboratory highlights the importance of shared research data when a conservation management issue becomes a legal issue. In this example, data provided by key conservation genetic researchers was crucial to providing a straightforward and efficient response to the criminal investigations by law enforcement. This partnership provides an excellent framework for future conservation researchers to model the presentation of their data when working with threatened and endangered species with respect to the use of that data in a legal context.

Drivers of Communal Overwintering Behaviour of Blanding's Turtle (*Emydoidea blandingii*) in a Restored Wetland Complex in the Rouge National Urban Park, Ontario, Canada

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Freshwater turtles in northern temperate areas spend more than half their lives overwintering and must tolerate prolonged periods of submergence at cold temperatures under ice, and hypoxic conditions. For at-risk turtles, successful winter hibernation is crucial for their long-term conservation. Winter aggregations are common for northern populations of turtles, such as the Blanding's Turtle. Environmental factors identified to influence overwintering site selection include dissolved-oxygen content, pH, water temperature, water depth, substrate type, vegetation cover, and duration of ice cover. Interestingly, this species overwinters communally even when overwintering habitats are not limited, and the reason for communal overwintering behaviour has not been well studied. Our study focuses on four hypotheses that may explain communal overwintering behaviour in head-started Blanding's Turtles in the Rouge National Urban Park (RNUP): habitat limitation; predator avoidance; site fidelity to reduce energy costs; and non-random spatial affiliation by siblings. Given that the head-started Blanding's Turtles are juveniles, the mate-selection hypothesis will not be investigated. We will conduct this study from September 2019 to April 2020 using radio telemetry and visual surveys. Genetic relatedness of turtles will be estimated using known clutch histories: Blanding's Turtles hatched from the same clutch will be considered closely related (i.e. siblings). The findings from this study will identify the potential drivers of communal overwintering behaviour of juvenile Blanding's Turtles and provide a better understanding of which behaviours will maximize their chances of survival during winter.

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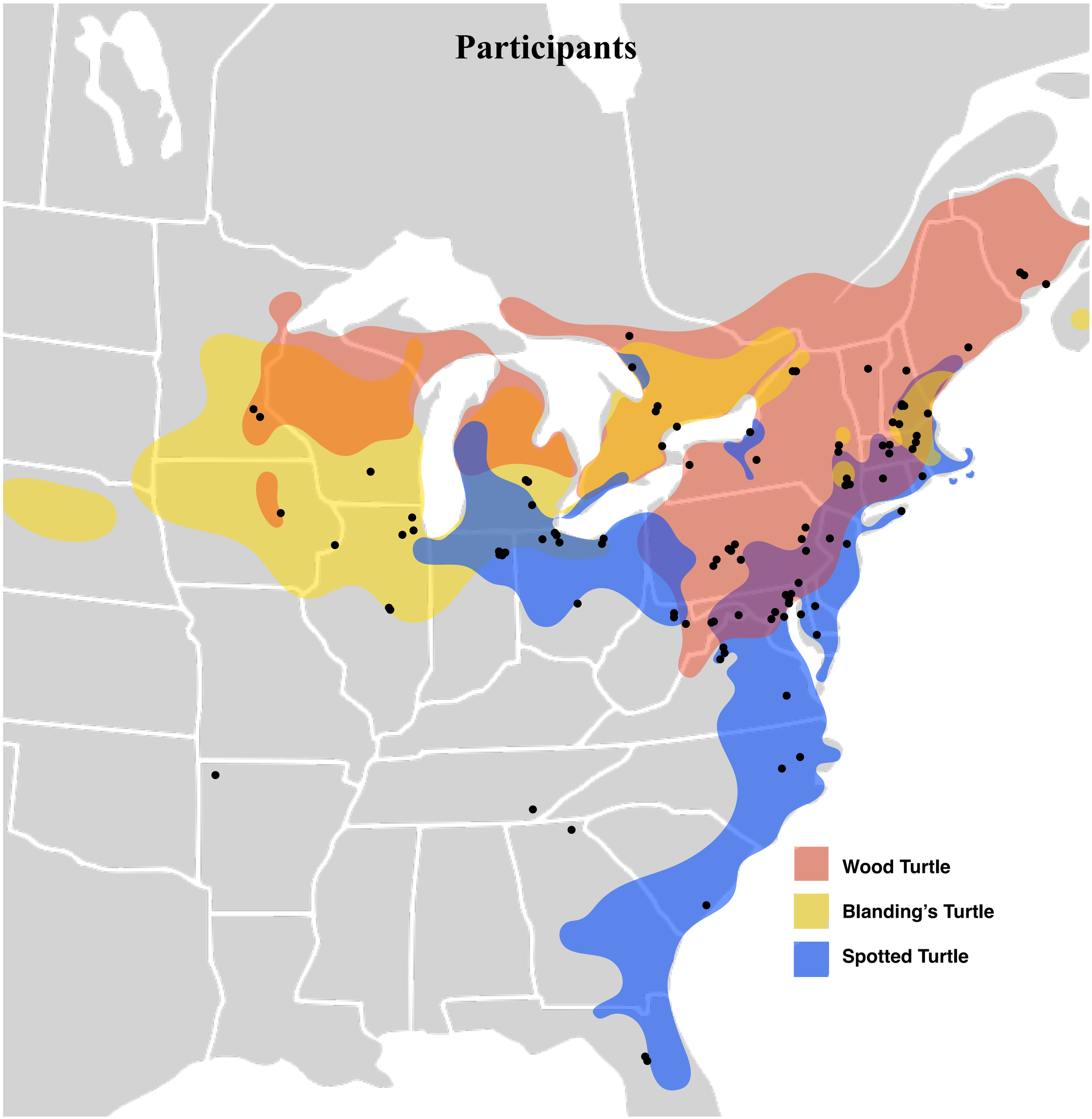

Above: Participants in the 2019 Spotted, Blanding's and Wood Turtle Conservation Symposium are marked as dots. Below: Group photo taken November 4, 2019.

Adult female Spotted Turtle from northern Florida.
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