EMYDINE CONSERVATION SYMPOSIUM

Juniata College
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ABSTRACTS

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ORAL PRESENTATIONS

Ill-effects of Confiscation Events in Box Turtles (*Terrapene* sp.) and Possible Solutions to Combat Disease Events

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Infectious diseases affecting the respiratory system have been associated with significant morbidity and mortality in eastern box turtles (*Terrapene carolina carolina*). Recently, eastern box turtles have experienced population declines due in part to the illegal wildlife trade and its association with the potential spread of infectious diseases, yet the impact of diseases in wildlife confiscations is not thoroughly described. The Association of Zoos and Aquariums' (AZA) Saving Animals From Extinction (SAFE) North American Turtles program with experts in non-profits, academia, government, and zoological institutions partnered to develop a comprehensive plan, including health assessment and disease surveillance with the goal of releasing turtles in a similar plane of health to turtles in the receiving population. During confiscation events, individuals are swabbed for between 4-24 pathogens simultaneously. Fortunately, these procedures were in place because in July 2021, 96 eastern box turtles were confiscated by the US Fish and Wildlife Service while en route to Asia and were relocated to three zoos. From July – August, 40 turtles died from a ranavirus outbreak in which 33 of 36 tested turtles (92%) were qPCR positive for frog virus 3 (FV3), 100% were positive for *Mycoplasma* sp., 80% were positive for Terrapene herpesvirus 1 (TerHV1), and 60% were positive for Terrapene adenovirus. All tested turtles were co-infected with at least two pathogens. The remaining 56 turtles naturally brumated over winter in 2021 and were found dead in May 2022 with remains too autolyzed for informative necropsy. In the fall of 2022, another 19 turtles were confiscated, detected with FV3 on intake, and surviving individuals are currently at the Wildlife Epidemiology Lab to characterize and identify options for long-term survival and viral persistence. The prevalence of a fatal infectious disease within the first 2 years of this program highlights the urgent threat to releasing animals without surveillance in place and has significant implications for long-term confiscation planning.

Wood Turtle (*Glyptemys insculpta*) Site-level Abundances and Demographics in Wisconsin

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Wisconsin contains a substantial portion of the Upper Midwest distribution for the globally endangered Wood Turtle (*Glyptemys insculpta*). However, the current paucity of research and population monitoring statewide has limited our understanding of their status and population trends in the state. Using a Midwest survey protocol, we conducted standardized Wood Turtle population surveys at 50 sites across eight HUC-8 watersheds in Wisconsin from 2018–2023 to estimate adult abundance and population demographic parameters. Across 44 sites we detected 200 unique individuals, consisting of 86 adult females, 60 adult males, and 54 juveniles. We

used *N*-Mixture models to estimate the adult abundance within 0.5-1 km river segments. Site-level estimated adult abundances ranged from 0−22 ($\bar{x}$ = 4 among sites with detected Wood Turtles). Our results provide a foundation for assessing long-term population trends and responses to conservation and habitat management efforts for Wood Turtles in Wisconsin.

Influence of Temporary Emigration on Wood Turtle (*Glyptemys insculpta*) Detection and Abundance Estimates

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Reliable population estimates are critical to making informed management decisions for wildlife species. Standardized survey protocols have been developed for monitoring population trends of the Wood Turtle (*Glyptemys insculpta*), a semi-aquatic freshwater turtle species of conservation concern throughout its distribution. The protocols employ repeated active search surveys of defined areas, allowing for estimation of survey-specific detection probability (*p*) and site-specific abundance. Wood Turtles are highly mobile and the assumption of population closure during the survey period is unlikely to be satisfied, but because the protocols use a single-pass design, they do not allow for separation of availability (p_a) and detectability (p_d). 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 if p_a is random and whether p_a and p_d are influenced by demographic characteristics. We modified the wood turtle survey protocol used in the Midwest portion of their range to include a double-pass design, allowing us to estimate p_a and p_d using a robust design capture-recapture model. The modified protocol was implemented at 14 wood turtle monitoring sites in northeastern Minnesota and northern Wisconsin between 2017 and 2022. Preliminary results indicate that p_a was non-random but not influenced by demographic characteristics, and that capture and recapture probability were strongly influenced by turtle carapace length. The probability of emigrating from the survey area between surveys was 0.63 (CI = 0.52 – 0.73), and probability of emigrants not returning to the survey area during remaining surveys was 0.80 (CI = 0.69 – 0.88). Given availability, the average probability of capture was 0.48 (CI = 0.36 – 0.61), and the probability of recapture during the second pass was 0.25 (CI = 0.19 – 0.32). We will discuss the implications of our study results for abundance estimates using the single-pass survey design and provide modeling recommendations to reduce bias.

Not All Management is Equal: A Comparison of Methods to Increase Wood Turtle Population Viability

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Management generally targets the most tractable life stage to rescue declining populations; however, that stage may not have the largest influence on recovery. Freshwater turtles are declining globally and early stages are frequently targeted for management, although the effectiveness of these actions on population growth are relatively unknown because of incomplete demographic data. We estimated the hatchling yearly survival rate for a freshwater turtle in the field using *in situ* enclosures to collect missing demographic information. We used

these data to develop demographic models to calculate growth rate for a hypothetical, declining population of wood turtles (*Glyptemys insculpta*) in Wisconsin, USA, 2014–2019. We modeled growth for populations across a range of scenarios from no management to combinations of nest protection and head-starting at varying levels of effort. Nest protection alone did not increase population growth rate, while head-starting alone increased population growth by 0.07, with the largest increase in growth rate, 0.11, resulting from combinations of both approaches. No combination of nest protection and head-starting, without an increase in adult survival rate from the observed 0.88 to ≥0.95, led to population stabilization or increase. Populations of freshwater turtles, like the wood turtle, will likely only recover with a multi-faceted approach that targets multiple life stages simultaneously.

Monitoring Wood Turtle (*Glyptemys insculpta*) Movements Using GPS Transmitters in Advance of Bridge and Culvert Upgrades to Facilitate Turtle Passage Under a State Highway in Vermont

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Roads present one of the greatest persistent challenges to freshwater turtle conservation, and mitigation strategies are often prohibitively expensive or are met with resistance by transportation agencies. The Vermont Agency of Transportation (VTrans) has adopted a proactive approach to incorporating more wildlife-friendly designs during routine infrastructure upgrades. A stretch of state highway passing through critical Wood Turtle habitat contains several bridges and culverts that block upstream movement of fish and turtles under the road. In 2025, these structures will be replaced with box culverts that include wildlife shelves/passages for a large range of species, with some specific and innovative accommodations for Wood Turtles (fencing and landscape design to guide turtles toward the culverts). This presents an opportunity to monitor turtle movements pre- and post-construction, assess the extent to which the highway impacts Wood Turtle habitat use and movement patterns, and to collect baseline data so the species' response to the upgrades can be assessed in the future. Working in partnership with VTrans, The Orianne Society conducted preliminary Visual Encounter Surveys and deployed radio transmitters onto turtles at several project locations in 2022 and began using solar-powered GPS transmitters (Ecotone Crex-T Turtle) to monitor turtle movements in 2023. The use of solar powered GPS transmitters allows for fine scale examination of turtle movement patterns and precise road crossing locations with reduced labor and minimal disruption to turtle behavior. This study is ongoing and is expected to continue through 2026. Preliminary results show that solar-powered GPS transmitters are practical for use on Wood Turtles in riparian settings, although care must be taken in programming the units so the batteries are not depleted to critically low levels, which causes permanent battery damage.

Diel and Seasonal Aquatic–Terrestrial Habitat Selection Patterns for a Northern Population of Wood Turtles (*Glyptemys insculpta*)

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Many wildlife species exhibit complex spatiotemporal activity and habitat use patterns to meet their biological needs. Characterizing these patterns and the influence of environmental conditions on movement dynamics can improve our understanding of habitat requirements and inform predictions of how species will respond to environmental changes. Wood turtles (*Glyptemys insculpta*) are unique semiaquatic freshwater turtles that require streams for hibernation and thermoregulation but heavily use terrestrial environments during the active period. Previous wood turtle space use studies have mainly focused on delineating location and size of activity

areas and assessing terrestrial habitat selection during daylight hours. Recent advances in GPS technology allow for tracking spatial dynamics over long periods with fine temporal resolution. The objectives of our study were to characterize diel aquatic–terrestrial habitat selection patterns of adult male and female wood turtles across the active period, and to quantify the influence of air temperature on selection of aquatic, open canopy terrestrial, and closed canopy terrestrial habitat classes. Between 2015 and 2016, we tracked locations of 23 wood turtles in northeastern Minnesota at 10-minute intervals from May to September using GPS loggers coupled with temperature sensors placed on the turtles and in our focal habitat classes, and used these data to assign turtles to a habitat class at each time step. We used binomial generalized linear mixed models and a model selection approach to assess the influence of six predictors of turtle presence on land, and found that day of year, hour of day, and sex were influential predictors. Both sexes showed a strong pattern of using terrestrial environments during the day and aquatic environments at night, with greater nighttime terrestrial activity by females and in mid-summer. Additional analyses will be performed to quantify the influence of temperature on habitat class selection. Our finding that wood turtles routinely return to streams at night in the warmest months of the year was unexpected and furthers our understanding of how this species uses the environment. We anticipate that temperature will have a strong influence on habitat selection and could explain differences in diel activity patterns across the distribution of the species.

Addressing a Critical Conservation Threat with the Collaborative to Combat the Illegal Trade in Turtles

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The illegal collection and trade of North America's native turtles is a serious threat with potentially severe conservation implications. The challenges this issue raises are variable and complex, and confronting them requires a multidisciplinary socio-ecological approach among law enforcement personnel, biologists, legal professionals, social scientists, and other experts. In response to this need, the Collaborative to Combat the Illegal Trade in Turtles (CCITT) was established in 2018 with the goal of advancing efforts to better understand, prevent, and eliminate the illegal collection of North America's native turtles. Currently, the group has over 165 members from across the United States and Canada and is composed of five working groups: Confiscation and Repatriation, Data and Research, Human Dimensions and Communication, Judiciary and Regulations, and Law Enforcement. Here we describe how regional concerns over the illegal collection and trade of native turtles led to grassroots efforts that continue to grow into transnational conversations, broad strategic thinking, and coordinated action across sectors and geographies. We discuss the biological vulnerability of turtles to collection, what is known about the scale of illegal collection, case studies of poaching and trafficking, the structure, function, and recent initiatives of CCITT, and the development of strategies intended to make a meaningful impact in reducing illegal collection and trade.

Headstarting as a Component of Long-term Recovery in Wood Turtle Populations

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A small relict population of Wood Turtles (*Glyptemys insculpta*) was discovered on a protected area in 2006. Marking of the old founder individuals and radio-tracking helped determine habitat use. Nesting females informed that nesting habitat and nest success was limited due to invasive plants, human landscape alteration, and raccoon depredation. We initiated habitat restoration: mowing in winter, invasive plant removal, and adjacent landowner education. We built a nesting "mound" with loamy soils, which wood turtles readily used, once shown. Hatchlings from protected nests were directly-released 2006-2015, yet only a handful have been discovered in later years. Each year, 2011-2022, some or all of each hatchling cohort were headstarted indoors overwinter for 9 months with a high school. All headstarts from the 2011 cohort, and portions of the 2012-2014 cohorts have been continuously radio-tracked. Headstarted turtles find their own food, establish home ranges, and hibernate communally with founder adults. Subsidized raccoons, lawnmowers, automobiles, flooding events- all human-instigated- are the causes of mortality. In 2017 the first males, and in 2019 the first females from the 2011 headstart cohort reached maturity at age 8-9, younger than expected by 4-5 years. Viable hatchlings (headstarts of headstarts) were produced in 2019 and 2020. Head-starting can pull a relict population out of the nose-dive to extirpation when used in conjunction with habitat restoration practices. It must be conducted with persistence and continuity over at least the number of years it takes for earliest cohorts to reach maturity and begin producing offspring of their own.

Home Range and Movement Patterns in a Central Maine Population of Wood Turtles (*Glyptemys insculpta*)

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We present home range and movement pattern analyses for a population of wood turtles (*Glyptemys insculpta*) in central Maine. We radio-tracked 22 adult turtles for 1–6 years each for a total of 1,813 observations; additional, although limited, data for juveniles is presented descriptively. Using GIS, our goal was to explore the possible effects of (1) individual characteristics (sex, age, and size) against a continuum of home range sizes and distances moved with respect to their overwintering stream and (2) fluctuating annual temperature and precipitation patterns. There was no significant difference between male and female stream emergence dates in the spring; there were, however, differences among years. Analyses of 50% and 95% minimum convex polygons and 50% and 95% kernel density home range sizes between males and females were not significantly different from one another, although maximum occupied stream length distances did differ significantly between males and females. We describe fine scale differences between the sexes in movement patterns and examine potentially important environmental triggers for movement behavior by examining annual fluctuations, such as occur during drought years. Our Maine-based study helps to fill an important geographic gap in the literature, and our results have implications for managing wood turtle populations in changing landscapes.

A Partnership Building the Road from Confiscation to Conservation

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In late 2018, two parallel but separate efforts were underway to address the impact of illegal trade on North American turtles. The Collaborative to Combat the Illegal Trade in Turtles was conceptualized at the 2018

NEPARC meeting in Amherst, Massachusetts. The idea grew rapidly, and the group officially formed that Fall. At the same time, within the Association of Zoos and Aquariums (AZA), a comprehensive Saving Animals from Extinction (SAFE) program plan was being developed to coalesce AZA and non-AZA partners to address these challenges from both ex situ and in situ perspectives. Fortuitously, these efforts merged in Spring 2019 with leaders from the American Turtle SAFE Program and the CCITT joining to co-chair the CCITT Confiscation and Repatriation working group. Initial efforts focused on developing foundation protocols, (Health and Welfare, Disease Screening, Genetics), expanding capacity to hold confiscated turtles, developing a Rapid Response Network to move turtles quickly from law enforcement to dedicated care facilities, and finding a way to pay for it. Extremely high incidence of disease, (particularly ranavirus) in confiscations in 2021 led to continued evaluation of health protocols and an AZA SAFE Grant providing funding to both expand bio-secure quarantine housing at seven SAFE partner facilities and support extended research on ranavirus positive confiscated turtles at the University of Illinois Wildlife Epidemiology Lab. In 2022 a Competitive State Wildlife Grant was awarded for "Addressing Population Declines Due to Loss of Adult and Juvenile Turtles to Illegal Wildlife Trade in the Eastern United States." This grant provides funding for disease screening and genetic analysis of confiscated turtles through 2024. One of the outcomes of a CCITT Northeast Illegal Turtle Trade Workshop held in February 2022 was to develop a State Confiscation Plan Template. The narrative and resources in this document will assist states in developing proactive plans for dealing with turtle confiscations that will provide the best opportunities for positive conservation outcomes.

A Two-Year Study on the Spatial Ecology and Habitat Selection of a Spotted Turtle (*Clemmys guttata*) Population in Southwest Michigan

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Spotted turtles (*Clemmys guttata*) are small, aquatic turtles whose populations have dramatically declined due to habitat fragmentation, poaching, climate change, and subsidized mesopredation. In Michigan, spotted turtles are listed as a threatened species and are currently under review for federal listing under the U.S. Endangered Species Act. We currently lack information about these more imperiled Midwest U.S. populations than the populations across the Eastern U.S. and Southern Ontario. The objective of our study was to investigate home ranges, movement patterns, and habitat selection of spotted turtles in Southwest Michigan to help fill in this knowledge gap. We trapped and marked turtles and used VHF radio-telemetry to track 22 turtles (12 males, 10 females) across two active seasons (May-October 2020 and 2021) in a prairie fen. This allowed us to delineate home ranges, assess habitat selection, and assess influences on their daily movement patterns. Male turtles exhibited larger $wAKDE_c$ home ranges (3.71 ha SE ± 0.52 ha) than females (2.31 ha SE ± 0.38 ha) across the two field seasons. Home ranges of two turtles were compared to previous research within the same site, revealing high site fidelity and recurrent home range patterns. Home ranges were much smaller than those of similar northern latitudes. Smaller home ranges were attributed to easily accessible resources or confinement within the landscape. Precipitation, minimum, and average temperatures significantly influence the turtles' daily movement rates. Habitat selection was evident at both 2nd and 3rd order spatial scales, revealing that emergent wetlands and vernal pools were disproportionately selected out of the seven other habitat types within their population range. We recommend that management agencies conduct analyses of this species habitat selection and spatial ecology at multiple scales. These results can be applied to managing populations in adjacent latitudes that occur in similar habitats.

Associations Between Wood Turtle (*Glyptemys insculpta*) Movement Dynamics and Linear Fragmentation in Allegheny National Forest (PA)

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The wood turtle (*Glyptemys insculpta*) is a species of high conservation concern across its geographic range and is currently under review for listing under the U.S. Endangered Species Act. A primary threat to this species is habitat loss and degradation. Extensive linear forest fragmentation is common across large portions of the range, particularly to facilitate energy extraction and distribution. However, little is known about the influence of linear fragmentation on movement dynamics of wood turtles. Wood turtles are associated with streams and riparian corridors, but individuals often use and move through upland habitats during the summer months. It is possible that wood turtles could use linear forest clearings as movement corridors, resulting in greater movement rates and distances from streams. Alternately, wood turtles could move less or occupy areas closer to streams during the active period due to increased access to open-canopy habitats. To understand how wood turtles respond to linear forest fragmentation, we fitted transmitters to 34 adult turtles (15 male and 19 female) across 16 streams in Allegheny National Forest that represented a gradient of surrounding linear forest fragmentation. We located the turtles approximately three times weekly from April/May through October in either 2021 or 2022. Results will be presented assessing the influence of multiple metrics of forest fragmentation on wood turtle space use dynamics, including core use area sizes, terrestrial and aquatic movement distances, and rate of movement. This information will improve our understanding of how variation and configuration of terrestrial habitat characteristics influence wood turtle space requirements.

Conservation Guidance, Status, Prioritization, and Implementation for the Recovery of the Spotted Turtle, *Clemmys gutatta*, in Illinois

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The Spotted Turtle (*Clemmys gutatta*) has always been a rare species in Illinois and was once thought extirpated. Its historical distribution likely encompassed the former interdunal wetlands along Lake Michigan, now occupied by the greater Chicago metropolitan region. Few populations remained on the landscape post-settlement, and only two remain extant, with one exhibiting severe decline. As such, the Spotted Turtle is protected as an endangered species. The Illinois Department of Natural Resources has instituted a new framework for species conservation consisting of three primary works, a Species Guidance Document, Status Assessment, and Conservation Implementation Plan. In addition to this effort, an Amphibian and Reptile Conservation Strategy was developed using expert solicitation to prioritize conservation actions and delineate threats. Using the information available, I will briefly cover where we are with the recovery of the Spotted Turtle in Illinois.

Genetic Diversity & Structure for the Eastern Portion of the Spotted Turtle (*Clemmys guttata*) Range with Extensions Applicable to Individual Assignment.

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The existing spatial distribution of genetic diversity and structure is a complex stratigraphy of both historical neutral demographic processes as well as interacting evolutionary processes. For species of conservation interest, it is critical to be able to both document the spatial distribution of diversity and structure as well as to be able to uncover the generating forces that have shaped its current distribution prior to developing

comprehensive management plans. In this talk, we present the results of an initial analysis of the standing structure of the spotted turtle *Clemmys guttata*. Sampling 78 unique locales from 16 states along the eastern portion of the species range yielded blood and tissue from 913 individuals. Using ddRADSeq, we developed a *de novo* genome assembly and identified just under 20,000 potential loci for analysis, which were rigorously filtered down to the 926 most informative loci for this particular study. Genetic diversity exhibited no spatial clustering or compartmentalization in this portion of the species range, though did contain a gradual south-to-north reduction in heterozygosity, which is consistent with a relictual post-Pleistocene pattern of range expansion. Estimates of genetic differentiation were low—though consistent with previous studies of this species—for both single ($\theta = 0.029$) and multilocus ($\phi_{ST} = 0.040$) parameters. While these data did not reveal structural clustering or nesting of individual sampling locales, there was a pattern of weak isolation by distance resulting from limitations in dispersal. The multilocus allele frequency spectra for these populations have been used to develop a population assignment tool for the estimation of source allocation for the reintroduction of confiscated animals. The samples from this study are currently being augmented with sampling locales from the remainder of the species distribution as well as the development of a whole genome reconstruction to aid in subsequent population assignment, phylogeographic analysis, and the investigation of putatively adaptive genetic variance for this species.

Nesting Ecology of Spotted Turtles (*Clemmys guttata*) at an Anthropogenic Site in Massachusetts

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Characterizing reproductive parameters for imperiled species is fundamental to assessing conservation status and creating locally informed management recommendations. Spotted Turtles (*Clemmys guttata*) are a species of conservation concern that utilize a variety of habitats for nesting. We conducted visual surveys for nesting females throughout May and June 2021 and 2022. We protected nests from depredation using cages and monitored them throughout the incubation season until emergence. Our objectives were to (1) Characterize nesting phenology, including nesting and hatchling emergence dates and incubation period; (2) Describe mean clutch size and percent hatch success (3) Describe nest site preferences on a macro and micro habitat scale; and (4) Compare the microhabitat of observed nests with random points using conditional logistic regression. During our 2–yr study, we located 18 Spotted Turtle nests and observed nesting between 30 May–28 June, with a median nesting date of 8 June. Hatchlings emerged during August and September after a mean incubation period of 80 ± 8 days. Clutch size ranged from 3–6 eggs per clutch, with a mean clutch size of 4.31. 66.7% of nests successfully hatched, 22.2% failed to hatch, and 11.1% became destroyed. We observed nesting along trail edges and clearings. Nests were associated with herbaceous vegetation, dead vegetation, bare soil, and gravel, though differences between nest sites and random points were insignificant. The results of this study have several applications for the management and creation of nesting sites and can be used to inform other studies in this region.

Mass Mortality of Multiple Species of Freshwater Turtles in a Protected Urban Wetland Complex in Ontario, Canada

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Turtles are one of the most imperiled taxonomic groups, locally and globally. Their greatest threats are habitat loss and fragmentation, road mortality, subsidized predation, and poaching. These threats, individually or in combination, can lead to mass mortality events (MMEs) which are rapidly-occurring events that result in the death of a large proportion of individuals in a population. MMEs are expected to increase in frequency with increases in environmental stochasticity associated with climate change. Turtles exhibit slow life histories and long generation times, traits that result in a limited ability to compensate for MMEs through density-dependent mechanisms, and recovery of turtle populations after decline requires decades. We describe an MME that affected multiple species, including Blanding's turtles (*Emydoidea blandingii*) that are part of a reintroduction program in the Rouge National Urban Park in Ontario, Canada. Our observations represent a unique scenario in which turtle mortality has been documented within the largest urban centre of Canada, where anthropomorphic stresses are greatest, and the population of Blanding's turtles is skewed towards juveniles as a result of previous population declines and subsequent reintroductions. From 2014–2022, we documented 306 turtle mortalities including Blanding's, midland painted (*Chrysemys picta marginata*), and common snapping (*Chelydra serpentina*) turtles. We detail the species and demographics of the carcasses, and discuss the implications of the MME for the remaining populations. In 2020 alone, the number of mortalities was similar to the number observed in the previous six years combined. The majority of carcasses found in 2020 were juvenile headstarted Blanding's turtles and adult female painted turtles. Most mortalities resulted from predation (with Muselids as the suspected predators), but instances of road mortality and winter-kill were also observed. Mortalities were highest in locations used as release sites for headstarted Blanding's turtles, likely resulting from the higher abundance of individuals and our more frequent monitoring in these areas. Ours is not the first report of MME in turtles, and to fully understand the consequences and effective recovery actions, further research into population vital rates and viability is critical.

Can We Mitigate the Damage Poachers Have Done? Repatriation as a Possible Outcome for Confiscated Turtles

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As we increase efforts to combat the illegal trade in turtles, wildlife managers are increasingly left with collections of confiscated turtles that require expensive captive care with uncertain futures. In the interest of restoring the natural condition of these individuals and mitigating the poaching damage, the PA Fish and Boat Commission recently opted to release nine confiscated Wood Turtles (*Glyptemys insculpta*) that had been transferred to our care from a confiscation by law enforcement. Established concerns with introducing captive turtles to areas with existing populations include threats of outbreeding depression or disease transmission. The nine captive turtles had previously been genotyped to specific Pennsylvania watersheds based on a range-wide study that developed a genetic library of the species. Release sites were thus chosen to match those watersheds as well as having protected habitat with an already monitored resident population. The turtles were subsequently tested for disease and found to be negative for 18 known turtle pathogens. At each of three study sites, repatriated turtles were released with radio transmitters, and an equal number of resident turtles were outfitted with transmitters (N=9 repatriated and N=9 resident). Five turtles at two sites were released just prior to brumation (October 2021), and four were released the following spring (May 2022) at a third site. Locations were checked at least twice a month during the active season. One site was monitored for one year, while monitoring at the other two sites is ongoing through a second year. Three of the repatriated turtles were lost from the study; one killed on a road, one died of unknown causes and one to a dropped transmitter. The nine resident turtles remained present for the duration of the study. To date, home range and maximum distance traveled vary widely by individual and do not indicate significant differences between repatriated and resident

turtles. Given the large resource investment in this project and the loss of 1/3 of the repatriated turtles to date, there remains much to be debated about ideal outcomes for confiscated turtles.

What Matters for the Survival of Head-Started Blanding's Turtles?

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Head-starting is a popular conservation intervention used for many turtle species that involves collecting eggs from the wild, hatching and rearing the turtles in captivity, and releasing them back into the wild once they have reached a specified age or size. The goal is to protect vulnerable life stages (eggs, hatchlings), increase juvenile recruitment, and re-establish self-sustaining populations. Analyses of survival, spatial ecology, and growth of head-started Blanding's Turtles demonstrate the potential utility of head-starting for increasing recruitment. However, replicated studies using consistent head-starting and monitoring methods are lacking, so the generality of single-population studies is uncertain. To determine best practices for head-starting as a management tool, we conducted a replicated study of head-start survival at 7 sites in Northern Illinois from 2020-2023. A total of 304 turtles (up to 35 turtles per site per year) were released and tracked using radio-telemetry for 1-3 active seasons post-release and for 1-3 overwintering periods. Head-starts varied in size and age at release and sites varied in size, predator management, and Blanding's Turtle population status. Initial analysis using Cox regression shows that active-season survival was highly variable among sites, ranging from about 40% – 90%. Overwinter survival, estimated directly from the number of transmitter-equipped turtles that survived, averaged 94% across sites and years. These results will be combined with Population Viability Analysis and estimates of economic costs to develop recommendations of best practices for Blanding's turtle head-starting. This will include site-by-site management considerations (i.e., predator removal), release size or age, follow-up monitoring, and adaptive management guidelines.

Ten Years of START, the Saving Turtles at Risk Today Project in Central Ontario

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Since 2013, the Saving Turtles at Risk Today (START) project has conducted landscape scale conservation and research efforts for central Ontario's six turtle species, with a particular focus on Blanding's and spotted turtles. Activities have included wetland surveys to fill knowledge gaps and monitor populations, road surveys to assess and reduce road mortality, long term mark-recapture, radio-telemetry, boosting recruitment through captive incubation and headstarting, public education and community engagement. START has grown into Canada's largest freshwater turtle conservation project. Results, lessons learned, and questions for the future from the project's first decade will be shared.

Nesting Dynamics and Environmental Heterogeneity in a Population Complex of Blanding's Turtle in Nova Scotia

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Based on a long-term dataset, this presentation is part of a series exploring the influence of environmental heterogeneity in space and time on reproduction, recruitment, survival, and movement of Blanding's turtles in Nova Scotia. This population complex comprises four geographically discrete and genetically distinguishable subpopulations that vary in morphology, reproduction, and behaviour. These differences reflect different local evolutionary histories and underscore the importance of understanding ecological scale(s) to ensure that we adopt appropriate management scale(s) for this endangered species. In this paper we compare the dynamics of females and their nests from our 20+ year nest protection program in three of the subpopulations.

Patterns of Standing Genetic Variation and Effective Population Size in Blanding's Turtle Populations

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The level of genetic variation in a population is fundamental to reducing the risk of inbreeding depression in the short term and maintaining its ability to respond to evolutionary forces over the long term. A benchmark for the viability of populations over these two timescales is the 50/500 rule, where the effective population size should be >50 to avoid inbreeding and >500 to maintain evolutionary potential. A recent population viability analysis in Blanding's Turtle suggested that >200 adults are required to maintain 95% of genetic variation over 100 years in the presence of stochastic disturbance, a population size thought to be larger than most extant populations throughout geographic range but at a level with conservation risk relative to the benchmarks above. There are now several studies of genetic variation within populations using microsatellite loci across the geographic range of Blanding's Turtle but direct comparisons of this information among studies has not been investigated. I will present estimates of allelic richness and expected heterozygosity range-wide using a resampling method that calibrates values relative to a reference population even when different sample sizes and microsatellite loci are used. In addition, I will estimate effective population size from single sample linkage disequilibrium models using populations where sample sizes are sufficient. Although such estimates are known to be biased downward in long-lived species with overlapping generations, they will provide a relative picture of population status throughout the range. Collectively, populations at risk will be identified and a framework for using within population genetic variation as a metric for population status will be established for the species.

PVA-based Assessment of Blanding's Turtle Resiliency, Redundancy, and Representation

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Conservation decisions benefit from projections about the future condition of a species as generated using population viability analysis (PVA) or other analytical techniques. For listing decisions made under the US Endangered Species Act, future projections contribute to the Species Status Assessment process and are evaluated using the concepts of resiliency, redundancy, and representation (the three Rs). Although the use of PVA is widespread, explicit linkage of PVA outcomes to the three Rs is rare. To demonstrate this linkage, the status of the Blanding's turtle (*Emydoidea blandingii*), an endangered species in Illinois, was evaluated using the three Rs. PVA was used to evaluate resiliency using the conservation target that, in the absence of

catastrophes, projected population extinction risk be ≤ 5% over 100 years. By this criterion, populations of ≥ 50 adults, occupying ≥ 100 ha of protected habitat, and possessing demographic characteristics consistent with stable or increasing numbers have high resiliency. PVA was used to evaluate redundancy based on the conservation target that, in the presence of catastrophes, metapopulations were projected to retain ≥ 95% of initial genetic diversity over 100 years. By this criterion, regions with intermediate and high resiliency subpopulations totaling ≥ 200 adults have high redundancy. Information from genetic analyses, natural division and watershed boundaries, and the historic distribution of Blanding's were used to identify five representation units in Illinois. Currently, there are few high resiliency populations, only one high redundancy unit, and statewide Blanding's turtle representation is low. PVA projections using current estimated population sizes indicate that without effective management, resiliency and redundancy will continue to decline and resiliency will remain low. The methods used here hold promise for evaluating the three Rs in species of conservation concern more generally.

Conservation Implications for Movements Large and Small: for Wood Turtles and Blanding's Turtles in Michigan

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Since 2018, we have been studying movement in Wood and Blanding's Turtles in central Michigan, using radiotelemetry and GPS data loggers. In this presentation, we will highlight observations of movements of conservation importance from multiple life stages. Understanding larger movements across the landscape, and the barriers to such moves, continues to inform us about population structure, which has implications for local demography. Large moves routinely take individuals out of protected areas onto private lands and into contact with more people, and roads, sometimes with lethal consequences. Using GPS to track gravid females has helped clarify not only where they are nesting, but how they get there, which is not necessarily the most direct, or least risky way. We will comment on where the females are coming from on their way to nest, and where they go afterwards. Interestingly, where they came from and where they go afterwards are not always the same. We also tracked a small number of hatchlings and will examine early movements post-hatching.

Mitigating Turtle Road Mortality

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Road impacts including direct mortality and habitat fragmentation are a leading threat for freshwater turtles. Further, the unique life histories, slow population growth, and physical attributes of turtles make them particularly vulnerable to vehicle strikes. While roadway mitigation for wildlife is becoming more common, it is often expensive, and effectiveness for small animals remains largely unstudied. The Minnesota Zoo, in partnership with the Minnesota Department of Transportation and Twin Cities metro counties, spent four years testing and evaluating the effectiveness of barriers and warning signs in reducing small animal road mortality with a focus on turtles. Our goal was to redirect turtles and small wildlife away from roadways and to existing under-road infrastructure where practicable. We implemented a before-after-control-impact (BACI) study at 25 sites from 2018 to 2021. Starting in 2019, modified chain-link fences, 8-inch corrugated pipe barriers, and wildlife warning signs were installed across 12 different sites. Our results show that chain-link fencing (with the addition of trenching and wrap-around end treatments) can effectively reduce mortality of adult turtles. However, this design did not decrease mortality of juvenile and hatchling turtles. After retrofitting fences with ½-inch wire mesh, we documented a substantial reduction in mortality of all age classes (up to 91% over pretreatment), thereby demonstrating its utility as an effective mitigation strategy. Although our sample size

was limited, 8-inch diameter drainage pipe also appears to have potential in preventing turtles from accessing the roadway. While not as effective as chain-link fencing, it still reduced mortality by over 50% and was installed for a fraction of the cost. The value of wildlife warning signs, however, remains less clear, as preliminary data suggest significant variability in effectiveness among sites. This study provides a framework for measures that can be implemented across the U.S. to mitigate the mortality of turtles and small animals on roadways, thereby benefiting wildlife conservation.

Creating Landscape-Appropriate Habitat Restoration Strategies: Success of a Turtle Nest Habitat Design for Rock Barren Landscapes

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Turtle nesting habitat can be created or enhanced as a strategy to increase habitat availability or provide suitable habitat away from urban threats. The traditional approach to nest habitat construction is to create nesting mounds using a mix of sand and gravel. However, nesting mounds do not resemble natural turtle nesting habitat in a rock barren landscape where turtles nest in crevices and cracks in the bedrock which have filled with soil and are covered with lichen (*Cladonia* spp.) and/or moss (*Polytrichum* spp.). Furthermore, a sand nesting mound will easily erode and dissipate off an open, rocky landscape. Therefore, our objective was to design and evaluate the success of novel turtle nesting habitat for a rock barrens landscape. Based on detailed nest habitat assessments, we designed and constructed turtle nesting sites to better represent natural nesting habitat in the landscape. To evaluate success of the nest habitat design, we assessed the (1) survival of transplanted moss and lichen cover on created nest sites, (2) ecohydrological and physical conditions at created and natural sites, and (3) turtle egg hatching success at created and natural sites using a split-clutch experiment. Initial results indicate that hatch success was higher at the created nest sites compared to natural sites. In general, created habitat tended to have a more stable thermal and moisture regimes compared to natural sites. We also found no difference in productivity between lichen transplants and natural sites, indicating that in-tact lichen transplants were successful. Moss transplant success was more variable likely due to heat and/or moisture stress because transplants were conducted during nesting season. Overall, the initial success of our nest habitat design suggests that this landscape-appropriate strategy will be useful for creating and enhancing turtle nesting habitat in rock barren landscapes.

Recovery of a Blanding's Turtle Population through Nest Protection and Headstarting

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A regionally significant population of the rare Blanding's turtle (*Emydoidea blandingii*) at Great Meadows National Wildlife Refuge (GM) in Massachusetts had declined from an estimated 135 individuals of >110mm CL in 1973 to fewer than 60 in 2004, when we began a long-term conservation management program for this population. In the early years of our efforts, the majority of females in the population were old individuals, mostly marked as adults in the 1970s, and juveniles were scarce. We began protecting Blanding's turtle nests at GM in 2003 and began regularly headstarting hatchlings and releasing them back into the population regularly in 2008. By the end of 2022, we had released 667 headstarted juveniles into the GM wetlands. Using a combination of known fates data from more than 430 turtle-years of radiotelemetry of both adults and headstarted juveniles, we estimate that the Blanding's turtle population at GM approximately quadrupled in size between 2004 and 2021, with a 2021 population of approximately 240 individuals of >110mm CL. Trapping data support our conclusion that headstarting has greatly augmented the GM Blanding's turtle population, demonstrating that the majority of individuals captured in recent years are formerly headstarted juveniles, which greatly outnumber both adults and non-manipulated juveniles in the population. We use Kaplan-Meier survival

estimates from radiotracking together with data on clutch size and hatching rate to examine population models of the GM Blanding's turtle population, perhaps allowing us to estimate when and to what degree current headstarting efforts may be reduced while still sustainably maintaining population of Blanding's turtles at Great Meadows.

Sexual Dichromatism of Tomia in Blanding's Turtles (*Emydoidea blandingii*) in central Ontario

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Variation in upper tomia (upper beak) colouration has been observed in Blanding's turtles (*Emydoidea blandingii*), however, there is very little reference to this in the literature. This variation was examined for sexual dichromatism in a central Ontario population. A guideline was created which suggests adult males present a solid, dark upper tomia, while adult females present a cream to yellow tomia with black banding. Upper tomia photographs of 179 Blanding's turtles were taken and presented to 13 observers to assess the accuracy of the guideline in determining turtles' sex. Following the guideline, observers were able to correctly identify the sex of Blanding's turtles 97% of the time. Given this result, Blanding's turtle upper tomia colouration appears to be sexually dichromatic and the guideline can be a useful sex-determination tool for field and conservation applications. At this point there is no clear understanding as to why this dichromatism occurs in Blanding's turtles, and further research is recommended.

Predicting the Effect of Forest Harvest on Wood Turtle Habitat Suitability

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Sustainable forest management aims to maintain environmental, social, cultural, and economic values and benefits over time. Included is protecting species-at-risk such as the endangered Wood Turtle (*Glyptemys insculpta*). The Wood Turtle is a challenging species for forest management as females may travel 500+ meters perpendicular from rivers into forested habitats. Forestry occurs in approximately 40% of the Wood Turtle's Canadian range making it a widespread threat to the species, however the magnitude of the threat is unknown. Our research objective is to determine the effects of commercial forest harvest on Wood Turtle habitat suitability to better delineate critical habitat. We outfitted 20 female Wood Turtles with VHF transmitters and Lotek PP240 GPS loggers and collected four years of fine resolution spatial data. We combined this occurrence data with environmental predictor variables collected both on-site and via remote sensing (LiDAR, forest inventory) in a step selection function to quantitatively inform a habitat suitability model. We then applied our habitat suitability model to chronosequence forest harvest blocks aged 1-35 years, and late successional forests, to predict the effects of forest harvest on Wood Turtle habitat suitability. Analyses are on-going but comprehensive results will be presented. This study will provide important data to better manage Wood Turtles in working forested landscapes.

Creating Nesting Habitat for Freshwater Turtles

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Over the past two decades, we worked with state and federal agencies and university staff to create nesting habitat for freshwater turtles in central Pennsylvania and southeast Michigan. Our major goals included replacing and restoring lost nesting habitat, mitigating turtle road mortality, and providing nesting habitat away from roads to reduce future mortality. Habitat was created for Blanding's, Wood, Northern Map, Painted, and Snapping Turtles. We worked with the Pennsylvania Department of Transportation and US Silica Corp. to create large nesting mounds of sand and shale along the Juniata River, and with the US Army Corps of Engineers and Pennsylvania Game Commission to create similar mounds near other rivers, streams, and lentic wetlands in Huntingdon County. On the E.S. George Reserve in Michigan, we worked with staff to restore nesting habitats that had been lost due to shading from forest succession and invasive shrubs. We review our experience for land managers and provide guidance beginning with determining the need for turtle nesting habitat, then selection of a site, construction and materials, monitoring, and protecting nests to increase hatchling recruitment. Our projects highlight the value of long-term partnerships and educational opportunities between academic research teams and local conservation agencies and institutions.

Law Enforcement: Challenges and Needs of Enforcing the Turtle Trade from a State's Perspective

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The North American freshwater turtle and tortoise trade is astounding to observe due to its scope and scale, and the wide variety of native and exotic species that one can encounter in legal and illegal commerce. To the casual observer or uninformed consumer, an encounter with a wild turtle or a turtle in commercial captivity can be equally awe-inspiring. Unfortunately, experience in wildlife law enforcement quickly reveals the fundamental risks to wild populations and the difficulty in regulating collection, possession, and sale that is inherent in the trade. Limited available resources to confront the enormous scale of the problem, as well as navigating the different state and federal laws and regulations are leading challenges. This presentation will highlight and focus on the roles and responsibilities of law enforcement, the challenges they are presented with, and their needs to assist in maintaining healthy and thriving populations.

Wood Turtles and Stream Restoration: Opportunities for Enhancing Conservation Outcomes

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Stream restoration is a widespread practice across the United States, and the primary objectives of this work include water quality improvement and the creation of fish habitat. In many cases, these projects overlap with known or potential wood turtle habitat, although it is unknown how wood turtles are impacted by stream construction project. A review of the stream restoration literature reveals that wood turtles are not a focal species for this work, despite being a stream obligate that co-occurs with many target taxa such as trout. In this study, stream restoration practitioners active in PA were given a web-based survey that assessed their knowledge and conservation attitudes on the wood turtle in the context of their work. Additionally, known stream restoration project locations in PA were used to quantify restoration effort and expenditures that have occurred in watersheds occupied by the wood turtle across the state. In total, 44 practitioners completed the survey. Practitioners expressed a high willingness to include the wood turtle in project design and implementation, as long as these could be cheaply and easily integrated into existing protocols. The mapping analysis revealed that over $100,000,000 have been spent on stream restoration projects in watersheds occupied by the wood turtle over the past 20 years in PA. These results highlight a significant opportunity to integrate

wood turtle habitat restoration with ongoing stream restoration by connecting with practitioners directly. Monitoring wood turtle response to stream restoration will be a key step in developing beneficial designs and practices that can be incorporated into existing practices. Creating and leveraging new partnerships with the stream restoration community has the potential to deliver broader benefits to the wood turtles than could be done alone.

Assessing the Use of Repatriation for Woodland Box Turtles (*Terrapene c. carolina*) Acquired through Confiscation from the Illegal Trade

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Woodland box turtles (*Terrapene c. carolina*) are regularly confiscated by law enforcement during turtle trafficking busts. These confiscations leave state fish and wildlife agencies with multiple turtles in their care that absorb monetary resources typically not set aside for such events. Repatriation is an option for confiscated turtles, though several risks, including disease and foreign genetic introduction, have kept most natural resources managers from using the method. Beginning in 2022, the West Virginia Division of Natural Resources initiated a study to assess the use of repatriation for box turtles acquired from confiscation events in 2016-2020. Repatriated turtles were released onto a state-owned Wildlife Management Area (WMA) in Randolph County, WV. Biologists used radio telemetry to track repatriated box turtles (N=8) and wild-caught box turtles (N=1) weekly to determine movements, behaviors, and survival. One month prior to release, repatriated box turtles were placed in soft-release pens constructed on the WMA in areas determined to be suitable box turtle habitat. Shortly after release, repatriated box turtles were observed performing behaviors typical of their wild counterparts, including foraging, basking, and aestivating during storm events and excessive temperatures. Overall, repatriated box turtles had an apparent survival rate of 87.5% with 7 of the 8 box turtles surviving and entering brumation. We present preliminary results of this repatriation project and recommendations for future repatriation endeavors. Biologists will continue radiotracking box turtles during 2023 to determine and assess post-brumation survival throughout the active period.

Reassessment of Blanding's Turtles in the Northeast using Coordinated Regional Sampling Data

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The Northeast Blanding's Turtle Working Group (NEBTWG) has worked cooperatively since 2003 to assess the status of populations of Blanding's Turtles in the Northeast (ME, NH, MA, NY, PA). In 2011, with funding from a Competitive State Wildlife Grant (C-SWG), the NEBTWG began a comprehensive planning process and long-term, field-based, monitoring effort to assess distribution, prioritize sites, and develop a baseline to evaluate change over time and assess effectiveness of conservation actions. As a result, "The Conservation Plan for the Blanding's Turtle and Associated Species of Conservation Need in the Northeastern United States" was developed which identified conservation targets. In 2016, a second C-SWG was awarded for a five-year regional reassessment which focused on conservation targets at the highest priority sites identified in the region. Using both field data and remotely collected data, we examined changes in turtle abundance, landcover, land protection, and habitat suitability within 36 high priority sites. Despite relatively stable population parameters in the short term and a comparatively high rate of land protection, continued habitat loss at the rate observed during the sampling period would likely result in population decline, and therefore the NEBTWG recommends that we redouble our efforts, focusing on habitat protection at key sites throughout the region.

Post-release Dispersal and Space Use of Soft and Hard-released Translocated Long-term Captive Eastern Box Turtles (*Terrapene carolina carolina*) Relative to Sympatric Resident Turtles

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Translocation is a conservation tool with the potential to help mitigate some of the largest issues facing emydid turtles, including habitat destruction and collection for the illegal pet trade. While translocation is a common technique in wildlife management, subsequent monitoring efforts, which are essential to evaluate success, are often lacking. Soft-release methods are often employed as an attempt to improve translocation outcomes by increasing site fidelity, but effectiveness can vary among species. In 2021, we released 35 long-term captive eastern box turtles (*Terrapene carolina carolina*) that had been surrendered to South Carolina Department of Natural Resources in compliance with new laws governing herpetofauna. We translocated these turtles to the Savannah River Site in west-central South Carolina, where we soft-released 25 individuals after nine months of penning and simultaneously hard-released 10 individuals to examine the efficacy of soft-release. We radio-tracked 26 translocated turtles (16 soft-released and 10 hard-released) for one year following their release, and radio-tracked 10 sympatric resident turtles as a control group. We will compare settling time and dispersal distance, along with space use metrics (including home range) among the three groups. Our results will aid emydid turtle conservation by examining the suitability of releasing long-term captive turtles into wild populations, and by examining the efficacy of soft-release methods in future turtle translocations.

Effects of Landscape Structure and Land Use on Turtle Communities Across the Eastern United States

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Landscape context is integral to population ecology, affecting a range of life history parameters, yet very little is known about how landscape structure influences many taxa. We sampled wetlands at 531 sites across 16 states in the eastern U.S. to examine the influence of landscape heterogeneity and anthropogenic land use on the relative abundance of freshwater turtles. Specifically, we aimed to understand how two components of landscape structure — compositional heterogeneity (wetland diversity) and configurational heterogeneity (wetland aggregation) — influence turtles with varying life history traits. Our results suggest that wetland configuration can modulate the relationship between relative abundance and anthropogenic land use. For example, spotted turtle (Clemmys guttata) was negatively associated with hay/pasture cover when wetlands were less aggregated, but this relationship subsided as aggregation increased. Notably, the way wetland aggregation modulated land use relationships varied across species. These results suggest that some anthropogenic cover types may not be strictly positive or negative for certain species, but instead context-dependent. Relative abundance also generally increased with higher wetland diversity. We report a range of responses to roads that did not strictly correspond with well-established predictions related to body size and terrestrial activity patterns. Overall, our study supports the use of context-driven approaches to land use-related conservation and management decisions rather than blanket prescriptions, and further emphasizes that effective conservation of freshwater systems requires a landscape-level perspective.

Reproductive Ecology and Conservation of Spotted Turtles (*Clemmys guttata*) in South-Central Pennsylvania

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From 2020-2022, we monitored reproductive female spotted turtles (n=7) at two sites in south-central Pennsylvania. We tracked turtles using radio telemetry to examine nesting ecology and protect nests with wire-

mesh cages. Females nested from 13-24 June, primarily in disturbed habitat during the evening, with some turtles nesting throughout the night. Average clutch size was 4.3 (range 3-5) and average incubation time was 72 days**.** A total of 22 hatchlings were released from 6 individual nests. Females produced a maximum of one clutch per year, and three females did not reproduce in some years. Two of the five (40%) adult reproductive females in one small population were killed by predators during our study. We discuss collaborative conservation efforts with government agencies and private landowners to manage for biodiversity and identify and protect critical spotted turtle habitat.

Wood Turtle (*Glyptemys insculpta*) Abundance-Habitat Relationships in the Laurentian Mixed Forest Province of Wisconsin and Minnesota

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The wood turtle (*Glyptemys insculpta*) is a species of conservation concern throughout its distribution in the Upper Midwest region. While several studies have investigated individual-level habitat selection patterns in the region, the influence of habitat characteristics on abundance is not well understood. This research is needed to inform landscape-level habitat management and conservation initiatives for the species. The purpose of our study was to identify important aquatic and terrestrial habitat characteristics and quantify their influence on wood turtle abundance dynamics in the Laurentian Mixed Forest Province ecoregion of Wisconsin and Minnesota. We collected or obtained standardized population survey data for 57 sites within the ecoregion. We used N-Mixture models with a multi-stage model selection procedure to assess the influence of a wide range of aquatic and terrestrial predictors on abundance, including several horizontal and vertical forest structure metrics derived from airborne LiDAR. We found that several aquatic and terrestrial habitat characteristics were important predictors of wood turtle abundance. Preliminary results suggest that stream velocity and stream width were the strongest aquatic predictors, with maximum abundance at moderate velocities and comparatively smaller streams. Preliminary results suggest that relative canopy height and vertical variation in leaf area density were the strongest terrestrial predictors, with relationships indicating that sites with higher proportions of young forest or canopy gaps were optimal. The results of our study will assist managers with locating potentially robust populations in under-surveyed areas and identifying management actions that could improve habitat quality for wood turtles.

The Use of Habitats by the Wood Turtle (*Glyptemys insculpta*) on Three Working Farms in the Hudson Valley and its Implications for Management and Conservation

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Agriculture in the Hudson Valley and elsewhere in the northeastern states is undergoing a reevaluation with regard to optimizing farm production with the dovetailed concerns of water resources, carbon sequestration, and biodiversity conservation. In recent years, turtle populations in farmscapes have become an important issue for research, conservation, and management. Farming provides both benefits and detriments to turtles. Farms create non-forested habitats, ponds, and nesting areas, and help keep land out of more intensive uses such as residential development. However, in general, farms grow crops that shade turtle nests and disorient hatchlings, use pesticides and fertilizers toxic to turtles and their invertebrate foods, yield silt and nutrients in storm runoff, and "subsidize" predators of turtle eggs especially raccoons and striped skunks. Most importantly, farm machinery can accidentally injure and kill turtles. Because turtles are long-lived, slow-reproducing organisms, the loss of small numbers of adults can strongly affect population dynamics. The wood turtle (*Glyptemys*

insculpta), which typically uses a combination of habitats in and near streams, is known to be particularly at risk from encounters with farm machinery. To better understand how wood turtles make use of varying agricultural landscapes (i.e., conventional vs organic; pasture vs crops) and explore how the impacts of farm equipment and cultivation practices on wood turtles can be reduced or mitigated, we radio-tracked adult wood turtles at three farms in the Hudson Valley, including a 600-ha reduced-till, organic grain and vegetable farm (2019-2022), a 160-ha no-till, organic vegetable and hay farm that also raised beef (2019-2020), and a 55-ha farm that grew conventional field corn (2021-2022). In this presentation, we discuss wood turtle habitat preference and farming-related turtle mortalities at the three farms, and demonstrate how some *regenerative* farming practices, including cover-cropping, may ironically be more deleterious to wood turtles than conventional techniques. We also present data on the influence of streamflow, river size and morphology, and riparian vegetation on turtle-farm interactions and their implications for managing wood turtles on working farms.

Population Genetic Analysis of the Wood Turtle across its US Native Range

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Analyses of genetic structure (genetic variation within and among populations) provide a useful component to conservation planning. As a part of two successive Competitive State Wildlife Grants (CSWGs) for the wood turtle (*Glyptemys insculpta*), we worked with partners to obtain population samples from across the species range. We examined genetic structure for 1,067 individual samples at 15 microsatellite loci. This provides the most spatially comprehensive genetic analysis of this species performed to date. Within-population genetic variation varied considerably. Allelic richness ranged from 3.4 to 6.2 (average 5.1) and mean expected heterozygosity ranged from 0.5 to 0.7 (average = 0.6). Genetic differentiation also varied considerably. Pairwise F_{ST} ranged from 0 to 0.27. At the largest spatial scale, there was strong evidence for two large-scale cohesive genetic groups, corresponding to the Midwest (IA, MN, MI) and the remainder of the US eastern range (from Virginia to Maine). These results are consistent with two Evolutionary Significant Units (ESUs) or Distinct Population Segments (DPSs). Within the more eastern set of population samples, genetic structure followed a stepping-stone or isolation by distance pattern. That is, there was evidence for continuous variation in allele frequencies, likely due to spatially restricted gene flow. Estimation of full-sibling families from the genetic data provided evidence of movement of 50.6 km among one pair of sites and 30.5 km between a second pair of sites. This data set has been used for preliminary assignment of confiscated wood turtles, possibly for repatriation. 'Self-assignment' testing suggests that repatriation to HUC 4 basin will be more accurate (mean 0.76) than assignment to specific collections will be less accurate (mean 0.47). Given the continuous and low-level genetic differentiation among eastern populations, possible repatriation to the correct HUC 4 basin, but incorrect smaller-scale basin, is not expected to have large negative fitness consequences. Our results can be used to help define large-scale conservation units (e.g. ESUs or DPSs), provides a baseline for assignment tests for confiscated animals, and could be used to help guide additional conservation measures such as translocations, if deemed warranted.

Evaluation of Release Techniques of Headstarted Blanding's Turtles (*Emydoidea blandingii*) in an Urban Landscape

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Headstarting is a conservation tool used to recover endangered populations of freshwater turtles. Headstarted turtles sometimes exhibit a behavioural acclimation period that may lead to reduced survival and growth after release into the wild. Enhancing the early release experience could help headstarted turtles acclimate more quickly to the release environment, thereby improving post-release outcomes. A soft-release typically involves temporarily placing headstarted animals in an enclosure at the release site, providing protection from predators, and offering supplemental food. In contrast, a hard-release involves directly placing headstarted animals in the release environment. We investigated whether the early release experience could affect survival, body condition, and somatic growth rate of headstarted Blanding's turtles (*Emydoidea blandingii*) released into Rouge National Urban Park (RNUP) in Toronto, Ontario, Canada. We used two release methods: a type of soft-release in which headstarted turtles spent one week in an enclosure (~25 m^2) to acclimate to the release environment (i.e., delayed-release) but without supplemental feeding or protection from predators; and a hard-release in which turtles were released directly into the wetland. We found that the release method did not affect survival or growth rate. However, body condition declined rapidly in the delayed-release group in the first year after release. Given that delayed-release turtles were not supplemented with food, they had limited opportunities to forage while in the enclosure and likely spent more energy attempting to escape the enclosure which resulted in lower fat reserves. We also compared the body condition of headstarted turtles to that of similar-sized wild juveniles from two populations, one in Algonquin Provincial Park (APP) and one in a coastal wetland near Lake Erie (LE). Body condition of headstarted and wild turtles from APP were similar, but body condition of LE turtles was lower compared to headstarted turtles. Some limitations (e.g., sampling period, habitat type, environmental conditions) apply when comparing turtles from different populations, but such comparisons are necessary when wild juveniles are absent at RNUP. Our results suggest that a delayed-release did not improve post-release outcomes for headstarted turtles. Future research should examine whether a delayed-release could improve habitat use patterns of headstarted turtles.

Schools as Conservation Partners: Lessons Learned from a Decade of Headstarting Turtles

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Headstarting has become an increasingly common tool used by conservationists, especially with herpetofauna. Though the practice is not appropriate for all species in all locations, there are instances in which it has been shown to be an effective conservation management tool. However, attaining meaningful conservation results often entails headstarting large numbers of animals over many years, a significant investment of time, resources, and space. In order to share the burden of the work, and also enable community engagement in the project, some conservationists have partnered with their local schools to raise animals in the classroom. Headstarting in schools has the opportunity to expose participating school children to local conservation concerns and give them an opportunity to make a difference in their community. At the same time, a decentralized headstarting structure can present challenges, such as ensuring that protocols and standards are maintained, communicating with a large group of caretakers, and monitoring the health and growth of animals in different locations. Based on more than 13 years experience in overseeing the raising of nearly one thousand hatchling *Emydoidea blandingii* (Blanding's turtles), *Glyptemys insculpta* (wood turtles), and *Clemmys guttata* (spotted turtles) in classrooms, we present our key lessons learned and best practices for other organizations who may be contemplating similar collaborations with local schools.

POSTER PRESENTATIONS

Population Structure of Three Isolated Northern Illinois Blanding's Turtle (*Emydoidea blandingii*) Populations

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The Blanding's Turtle (*Emydoidea blandingii*) is declining range-wide due to synergistic threats associated with habitat fragmentation, loss, and degradation. In Northern Illinois, Blanding's Turtle populations are often isolated in an urbanized landscape with little chance for interpopulation migration. Thus, it is imperative to monitor populations inhabiting isolated patches because of risks from demographic and environmental stochasticity due to small population dynamics. By collecting data on sex, stage, and morphometrics on all captured individuals, our study will determine if concerning patterns or biases in the size, sex, or stage structure exist in three northeastern Illinois populations. For example, biased sex ratios toward adult males could indicate decreased adult female abundance and impact population growth through depressed recruitment rates. Additionally, a skewed stage structure toward juveniles could indicate decreased adult abundance from unusually low adult survivorship. Our results could aid regional wildlife managers by signaling potential threats to the demography of small, isolated populations.

Population Structure of the Western Pond Turtle (*Actinemys spp.*) Across Twelve Military Installations in California

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Western Pond Turtle (*Actinemys spp.*) populations are currently threatened with habitat loss, predation, and shell disease. The synergies among threats have caused severe population declines whereby they are an endangered species in Washington, a sensitive species in Oregon, and a species of special concern in California. It is imperative to investigate their status in California to determine how prevalent threats are and what level of conservation action needs to be taken to avoid declines. We examined the population structure of the Western Pond Turtle populations at twelve military installations across California through sampling in one-week bouts using 50 aquatic traps at one visit per base. We recorded the body size, life stage, and sex of all individuals. Our study is intended to represent a first pass at determining if there are any immediate conservation concerns, such as biases in stage or sex ratios and population size structure.

Assessing the Influence of Sampling Design on Wood Turtle (*Glyptemys insculpta*) Detection Probability and Population Estimates

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The wood turtle (*Glyptemys insculpta*) is a species of conservation concern due to population declines throughout its range. Two regional, multi-state survey protocols have been developed for standardized monitoring and data collection across the wood turtle's range. The protocols are commonly referred to as the Eastern protocol and Midwestern protocol. It is currently unknown if the sampling designs result in similar abundance estimates or if data from the two protocols are compatible for broad-scale analyses. We assessed two key aspects of the standardized protocols: constrained vs. unconstrained surveys and aquatic-focused vs. terrestrial-focused surveys. Surveys were conducted using all 4 design variations: aquatic-focused constrained, aquatic-focused unconstrained, terrestrial-focused constrained, and terrestrial-focused unconstrained. Between the fall of 2021 and spring of 2023, we completed survey comparisons at 6 sites in West Virginia, 3 sites in Pennsylvania, and 1 site in Maryland as well as recruited collaborators from across the wood turtle's range to perform comparisons of one or more of the survey designs. We will compare total captures, unique captures, detection probabilities, and abundance estimates among the survey designs. This information can be used to maximize flexibility in survey design while maintaining data congruency across space and time.

A Pond of Their Own: Influences of Still Waterbody Use on Wood Turtle Movements

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In the private working forests of Michigan's western Upper Peninsula, wood turtles (*Glyptemys insculpta*) are a focus of collaborative conservation. Wood turtles are currently being considered for listing under the Endangered Species Act of 1973, but little information is available on wood turtle ecology in private working forests. One aspect of wood turtle ecology that is of particular interest to forest managers is the timing and extent of seasonal movements from occupied rivers. Wood turtles spend the fall, winter, and spring in and near these rivers, and move into adjacent uplands during the summer where they may be exposed to risk due to forest management activities. Using VHF radio-telemetry, we collected location data from 10 adult female wood turtles between early May and late October of 2021 and 2022 in two watershed basins of Michigan's western Upper Peninsula. Our analysis indicated that the mean maximum weekly distance traveled by all wood turtles during the post-nesting season in each basin was similar (North basin: 151m, SE=23.58; South basin: 182m, SE=46.24), but distances traveled during pre-nesting were dissimilar (North basin: 20m, SE=5.87; South basin: 116m, SE=44.62). Upon further examination, this discrepancy may be due to two southern basin turtles moving from the river to a temporary pond in early spring. When incorporating this pond into our distance from water analysis, the dissimilarity between basins during pre-nesting was diminished (North basin: 20m, SE=5.87; South basin: 20m, SE=11.6). Currently, seasonally restricted smart buffers are used to reduce risks to wood turtles from forest management activities around flowing water. However, our results suggest that further work is needed to understand the influence of still waterbodies on wood turtle movements and the potential need to account for still waterbodies when incorporating smart buffers into forest management plans.

Baseline Energetic Requirements of Ornate Box Turtles (*Terrapene ornata*)

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Increasing ambient temperatures due to climate change may lead to altered behaviors as turtles attempt to regulate internal body temperatures. Increased efforts to maintain temperatures may result in energetic tradeoffs, leading to reduced individual fitness and, thus, population abundance. Estimation of resting metabolic rates for turtles affords calculation of baseline energetic requirements and the potential to predict costs associated with warming landscapes. Using flow-through respirometry, we will determine the resting metabolic rates (RMRs) of adult Ornate Box Turtles (*Terrapene ornata*) across a temperature gradient to provide information on energetic costs. The baseline estimates will then be used to determine the annual RMR costs on the landscape.

Great Lakes Rare Turtles Conservation Efforts through John Ball Zoo

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The John Ball Zoo's (JBZ) conservation strategic plan mandates that 3% of the AZA dues revenue be dedicated to in situ conservation and that more than half of that effort is involved in Great Lakes projects. The Great Lakes are known to harbor a diverse amount of turtle species, in particular rare and endangered turtles within the Emydidae family. There are myriad drivers of the rapid decline for these rare turtles: habitat fragmentation, mesopredation, road mortality, and illicit collection and trade. In order to curb the loss of these species, the JBZ initiated its Great Lakes Rare Turtle program. The program is building towards projects that address key threats to rare turtle species. In collaboration with Michigan Natural Features Inventory, JBZ is conducting research on the distribution and demography of Spotted Turtles (*Clemmys guttata*) throughout Southwest Michigan and Wood Turtle (*Glyptemys insculpta*) nesting ecology and protection in Muskegon County. Both projects are supported by Competitive State Wildlife Grants. In addition, John Ball Zoo has established a Box turtle (*Terrapene carolina carolina*) head start program in collaboration with Pierce Cedar Creek and Grand Valley State University (GVSU). The program aims to increase the survival rate of box turtles and test the efficacy of head starting as a turtle conservation tool. Recently the JBZ and GVSU initiated a community science effort to identify locations that pose a road mortality threat to Blanding's and other turtles. Data will aid in the mitigation efforts towards preventing future road mortalities of Testudines. The research and conservation efforts of John Ball Zoo and its partners are crucial in protecting the rare turtle species in the Great Lakes region. The data collected from these projects will help in developing effective conservation strategies to protect these species and their habitats. The collaboration between John Ball Zoo, Michigan Natural Features Inventory, Pierce Cedar Creek, and Grand Valley State University is a testament to the importance of partnerships in conservation efforts.

Abundance and Detection Probability Estimates for Wood Turtles (*Glyptemys insculpta*) in Three West Virginia Streams

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West Virginia is the southwestern range limit for wood turtles (*Glyptemys insculpta*), a species currently under review for listing under the Federal Endangered Species Act. To date, wood turtle abundance and detection probability estimates have not been reported for the species in West Virginia. We analyzed monitoring data collected from seven 1-km stream survey transects across three streams in West Virginia between 2020 and 2022 using open population models to estimate sex-specific abundance and detection probabilities as well as survival and recruitment for turtles at each stream segment. Candidate models incorporated survey season, Julian day, air temperature, ranked average stream depth and streamflow conditions into models of latent abundance and detection probability. We extrapolated these estimates of density from survey segments to

estimate the current abundance of wood turtles in each stream, representing the first estimate of abundance for wood turtles in West Virginia. These abundance estimates will serve as a baseline for tracking long-term population trends, especially given that habitat suitability at the range limit for wood turtles is expected to decrease with climate change and continued human development.

Minnesota's Wood Turtle Conservation Plan

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The Wood Turtle (*Glyptemys insculpta*) is a state-threatened species in Minnesota and was identified in Minnesota's Wildlife Action Plan (2015-25) as a species in need of a statewide management plan. Minnesota's Wood Turtle Conservation Plan was completed in 2020 and identifies issues, 10-year goals, prioritized strategies, and targeted implementation activities. The Minnesota Department of Natural Resources formed a Wood Turtle Planning Team composed of biologists with Wood Turtle expertise to guide development of the conservation plan. Northeast and Southeast Work Groups were established to address planning and prioritization of implementation activities within each region. Emmons & Olivier Resources, Inc. (EOR) was contracted to coordinate the development of the plan and write the plan with regular meetings and feedback from the Planning Team. This poster provides a broad look at the five conservation issues identified in the plan: 1) Habitat, 2) Adult mortality, removal, and sub-lethal impacts, 3) Juvenile recruitment, 4) Knowledge gaps, and 5) Partnerships. Examples of targeted implementation activities are included in the poster.

Reducing the Risk of Prescribed Burns on Ornate Box Turtles (*Terrapene Ornata)* in Illinois

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Native prairie ecosystems and associated herpetofauna have significantly declined throughout the 21st century. Once common throughout Midwest prairies and grasslands, the Ornate Box Turtle (*Terrapene ornata*) is of conservation concern in multiple states, including Illinois. Notable threats to population persistence include road mortality, illegal harvesting, and increased predation from mesopredators. Unfortunately, prescribed burns present an additional threat. While necessary, there is an increased risk of harming Ornate Box Turtles if burns are conducted between spring emergence and the beginning of winter dormancy. The loss of even a few individuals can drastically reduce population viability. To better understand the timing of dormancy, we used radiotelemetry to monitor 26 Ornate Box Turtles across three Illinois sites. We also collected shell and soil temperatures with data loggers to determine when and under what conditions turtles are at risk from burns. By combining radiotelemetry observations with shell temperature data, we determined when turtles were above ground. We then created a model predicting emergence based on environmental variables, such as air temperature, precipitation, and time of year. The best model to predict above ground activity considered the interaction of day of year and current air temperature. Our results can aid land managers and ecologists in determining the best time to conduct prescribed burns in Ornate Box Turtle habitat.

Home Range Sizes and Habitat Selection of Spotted Turtles (*Clemmys guttata*) in Northern Michigan

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Understanding an animal's spatial ecology is critical to developing effective management plans for the species. In Michigan, the spotted turtle (*Clemmys guttata*) is listed as a state-threatened species and regional studies on its spatial ecology have been limited. Spotted turtles face many of the same threats as other turtle and tortoise species, such as habitat fragmentation, increased adult mortality, and reduced juvenile recruitment. The goal of this study is to provide baseline information on the spatial ecology of spotted turtles in Northern Michigan and inform conservation and management plans for spotted turtles both locally and throughout their northern range. We used radio telemetry to track spotted turtles (n=15) at two study sites across two active seasons (2022, 2023). This location data was used to estimate home range sizes and quantify habitat selection at multiple spatial scales. Home range areas were estimated and compared between sexes and between sites. Habitat selection was quantified at both 2nd and 3rd order spatial scales and compared between sexes and sites. The results of this study are preliminary and data collection will continue through the 2024 active season. Data collected in this study will be used to develop local management recommendations for spotted turtles in the study areas.

Abundance and Demography of the Wood Turtle (*Glyptemys insculpta*) across Two River Systems in Michigan's Lower Peninsula

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The Wood Turtle (*Glyptemys insculpta*), an imperiled North American freshwater turtle, is a semi-aquatic, cryptic species with a disjunct distribution across a broad geographic range. Wood Turtles are plagued by a variety of threats such as: habitat loss and degradation, poaching, and direct mortality due to roads, agricultural machinery, and depredation by mesopredators. Addressing range-wide Wood Turtle population declines requires current abundance and demography data. However, this information is lacking for Wood Turtles in Michigan. Our primary objective was to complete mark-recapture surveys to gather baseline data on the abundance and demography of Wood Turtle populations along two river systems in Michigan's Lower Peninsula. In 2022, we recorded 134 unique Wood Turtle captures across 160 total surveys. We used multinomial N-mixture models with a removal sampling observation process to estimate site-level abundances. Mean estimated abundance for each individual site ranged from zero to nineteen. Likewise, Wood Turtles from all size classes were represented in the northern river sites but hatchlings and smaller juveniles were absent from the southern river sites. Our results will be a significant contribution to the protection and management of this sensitive species and provide a foundation for evaluating the success of future management actions.

Conservation Genetic Analysis of Spotted Turtle Across Ohio, Michigan, and Indiana

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Spotted Turtle (*Clemmys guttata*) populations are declining dramatically across their range primarily due to habitat alteration, fragmentation, and reduction. Fragmented habitats have the potential to affect a specific population's genetic diversity and size through the direct loss of individuals and reduction of gene flow. Understanding genetic variation in spotted turtles can provide insight into population dynamics and conservation needs. I aim to examine genetic variation in spotted turtle populations within the western portion of its geographic range including Ohio, Michigan, and Indiana. Using blood samples collected during the 2022 and 2023 field seasons as well as previously collected tissues, I will genotype over 300 individuals across 15 or more localities using 15 microsatellite loci. Preliminary analyses of levels of genetic variation within and among localities will be presented. This study will provide researchers and managers with the knowledge necessary to assess the vulnerability of spotted turtles to further population declines based on genetic diversity.

Where Will the Turtle Cross the Road?

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Roads pose a major threat to wildlife populations via long-term chronic mortality associated with wildlife-vehicle collisions and habitat fragmentation. Understanding the landscape context where wildlife species are more likely to encounter and cross roads can therefore provide important information that can be applied to mitigation measures and monitoring programs. Turtle populations are especially vulnerable to road mortality as slow moving, long-lived organisms and the potentially higher mortality rates incurred by nesting females. Blanding's Turtle is a semi-aquatic species that often uses a variety of wetland types throughout its active season. These attributes and its status as a widespread species in decline make it ideal for assessing road related risks. We are developing road crossing models for Blanding's Turtle in Manistee National Forest in northwestern Michigan to predict landscape risk along roadways for this sensitive species. We applied a common species distribution modeling (SDM) program Maxent to identify landscape features associated with Blanding's Turtle road records in this region. These models will be compared to road risk models in New York State to determine if similar landscape features are associated with road crossing locations or if road mitigation measures will need to focus on region specific information.

Detection and Occupancy of the Western Pond Turtle (*Actinemys spp.*)

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Low densities, followed by a secretive nature, create challenges for accurately estimating population estimates and site occupancy rates. The Western Pond Turtle (*Actinemys spp.*) faces range-wide declines and is currently a species of special concern in California. Our project aims to determine their status across 12 military installations using an occupancy/detection framework while attempting to maximize captures during one 50

aquatic trap/four trap night sampling session per installation. Because we sampled areas of known occupancy, we could focus on estimating detection rates. We aim to create an MS Excel tool to determine the detection probabilities while accounting for various environmental and habitat-related co-variates.

The Hobbled vs. the Healthy: Home Range Differences Between Injured vs. Uninjured Spotted Turtles (*Clemmys guttata*)

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Globally, freshwater turtles face many threats, including habitat fragmentation, the pet trade, and road mortality. An additional cause of decline, predation, can also lead to nonlethal injury, with more than 7% of spotted turtles (*Clemmys guttata*) having predator-induced amputation of limbs or tails. Little is known about how injuries affect any freshwater turtle species' movement patterns, let alone freshwater turtles with partially terrestrial lifestyles, or how injuries may affect their survival later in life. We examined the home range movement patterns of injured versus uninjured spotted turtles at a site in Delaware by using radio telemetry transmitters to track movement patterns. In spring and summer 2022, we captured 20 spotted turtles (n = 11 female and n = 9 male) and tracked each individual for approximately one year. Of these 20 *C. guttata*, seven had limb injuries, in which at least one limb had been partially or completely amputated by a predator, and the remaining 13 were uninjured. We compared home ranges of injured and uninjured spotted turtles to assess if limb injuries are affecting their movement patterns or migration from aquatic to terrestrial habitats. We also compared male and female *C. guttata* home range sizes and assessed if carapace length had any effect on home range sizes as well. We found no difference in home range sizes between male and female *C. guttata* and between injured and uninjured *C. guttata* during their breeding season. We did find that injured turtles had smaller home ranges compared with uninjured turtles during their nonbreeding season. This could be cause for concern as predators may be having more of an effect on spotted turtle populations than simple removal of predated individuals.

A Status Assessment and Conservation Plan for the Eastern Box Turtle (*Terrapene carolina carolina*) for the Northeastern United States

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A Status Assessment and Conservation Plan for the eastern box turtle (subspecies woodland box turtle, *Terrapene carolina carolina*) in the northeastern U.S. was completed in February 2023 (northeastturtles.org). The *Status Assessment for the Eastern Box Turtle in the Northeastern United States* provides (1) an overview of the biology and ecology of the eastern box turtle in the northeast, (2) a summary of threats to the species, (3) a standardized sampling protocol, (4) a regional genetic assessment, and (5) an analysis of regional habitat impairment. The *Conservation Plan for the Eastern Box Turtle in the Northeastern United States* compliments the Status Assessment by presenting a regional strategy for conserving the species and addressing key threats. The core of the Conservation Plan is a Conservation Area Network, a collection of priority sites and landscapes important for supporting the long-term persistence and adaptive capacity of the species in the Northeast. The Conservation Plan also provides a Conservation Action Plan that details recommendations to address threats and support the long-term persistence of the eastern box turtle.

Application of Computer Vision for Off-Highway Vehicle Route Detection in Threatened Tortoise Habitat

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Habitat degradation and direct mortality from expanding roads and off-highway vehicle (OHV) networks have been identified as direct stressors to turtle and tortoise populations. To understand the effects of OHVs on Mojave desert tortoise (*Gopherus agassizii*), we developed a computer vision model to identify spatially explicit estimates of OHV route density within the species' range in Arizona, Utah, Nevada and California. Here, we define OHV routes as non-paved, linear features across the desert landscape, including, but not limited to, designated routes. Utilizing National Agriculture Imagery Program (NAIP) geospatial data (n = 1,732 image chips), we trained a Convolutional Neural Network (CNN) using a Resnet101 in Fastai. When tested against a validation set (n = 343 image chips), the model benchmarked at 85% accurate (n = 290 correctly-classified images). We piloted our model on NAIP imagery collected for 23 Open-Use Off-Highway Vehicle Areas (~2,373,004 km^2) in southern California that were deemed important for supporting tortoise habitat connectivity. Across all image chips in the sample area (n = 100,581), we estimated ~19,000 linear km of OHV routes. Approximately 55% of the study area was classified as containing no OHV routes, however, a quarter of the study area had four or more OHV routes present. Single OHV routes were present in 16% of the study area, and 2-3 OHV routes were present in the remaining 4%. As a next step, we are scaling our efforts to the entire range of the species. Estimates of OHV density from such a model can allow stakeholders to evaluate the impact of legal and illegal OHV use within critical tortoise habitat. Our results can be applied as a tool to monitor OHV routes within ranges of other threatened or sensitive species, and offers the potential for mapping additional linear features present within their habitats.

Evidence of Recruitment in Three Adjacent Blanding's Turtle (*Emydoidea blandingii*) Populations in Central Michigan

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Many Blanding's Turtle (*Emydoidea blandingii*) populations are likely functionally extirpated, having only a small number of only mature individuals that are isolated from other such populations, and little to no recruitment. Although Blanding's Turtles can live a long time, recruitment is necessary for viability. As part of a long-term study, we have begun monitoring three adjacent populations of Blanding's Turtles in the vicinity of Grayling, Michigan. Mark and recapture efforts at three sites through four years reveals that all of them have evidence of recruitment. Of 51 female turtles sampled during the nesting season, 21 were gravid at Site 1, 11 at Site 2, and 10 at Site 3. A total of eight females were gravid multiple years, and five confirmed nesting. Juveniles were of all pre-adult ages, suggesting reproductive success in most years. Sites were not the same in terms of the age distribution of individuals. Site 2 had more juveniles in total (10/35), however, Site 1 juveniles made up more of the overall composition of total caught (9/20) and Site 3 was the lowest in either consideration (6/29). One likely reason for the dissimilarity between sites in composition of juveniles is the area we sampled. For Site 1, it is possible we missed some aspect of connectivity so that we are sampling the "nursery" wetlands of a larger population. The lack of juveniles in Site 3 is probably inverse where we were sampling the adult

areas. Overall, it is significant that we found recruitment and different levels of age groups within the three adjacent populations in Camp Grayling. Long-term sampling of recruitment evidence is warranted and would lead to better insight into the stability of these populations.

Investigating Sexual Colour Dimorphism in an Ontario Population of Spotted Turtles (*Clemmys guttata*)

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Spotted turtles (*Clemmys guttata*) are a globally, federally (Canada), and provincially (Ontario) endangered species of small freshwater turtle, currently threatened by illegal poaching for the pet trade. The species displays sexual dichromatism: males bear dark brown chins and eyes, while females bear bright orange chins and eyes. Females bearing conspicuous colours are uncommon in the animal kingdom; typically, the males are more brightly coloured. Spotted turtles may be an example of this sex-role reversal, where males choose a mate among competing females. While sexual dichromatism in spotted turtles has been observed for decades, its functional role remains a mystery. The purpose of our study is to use visual models and behavioural trials to test whether males choose to mate with the brightest-coloured females. Models will be 3D-printed and painted to resemble male (control) and female (effect) spotted turtles. *In situ* and *ex situ* behavioural trials will be conducted, where live males will be exposed to models with differing intensities of orange chins, and their choices scored. Trials will be video-recorded, and behaviours will be catalogued in ethograms. We predict that males will exhibit reproductive behaviours most frequently in response to the brightest-coloured female model, indicating mate preference based on colour. This study will be the first to describe the role of sexual dichromatism in spotted turtles and could provide new insight into turtle evolution and the role of sexual dichromatism in other turtle species. Our work could also reveal a novel aspect to the threat of poaching. If our prediction is supported, this would suggest that removing the brighter-coloured female turtles which are targeted for their beauty by poachers, would coincidentally remove the most fit females from the population, potentially exacerbating population declines resulting from the more common threats of habitat destruction and road mortality.

Proposed Wood Turtle Agricultural Best Management Practices, New Brunswick

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In the province of New Brunswick, 94% of watersheds with wood turtles have agriculture within 200m of the watercourse. Without management strategies to mitigate the threat of agricultural machinery, populations inhabiting agricultural landscapes will likely become ghost populations. Due to ongoing projects throughout the province & new funding streams focused on improving farmer practices for biodiversity, the Government of New Brunswick's goal was to create Best Management Practices (BMP) for wood turtles in agricultural landscapes. BMP's were created based on current research, the ease of farmer implementation and the potential effectiveness of each practice. A total of 11 BMP's were selected, BMP's were categorized by strength of the strategy and given a label for whether an incentive should be provided to a farmer for implementing the strategy. Strategies that had the highest impact & highest ease of implementation were chosen to be of high value and categorized to be incentivized. Based on these factors, BMP's that will be designated as best practices and given financial incentives include leaving an unmowed buffer strip, delaying hay harvest, and converting forages to livestock pasture. BMP's that will not be provided an incentive but will be included as a BMP include raising the blade height, and converting forage crops to late-season crops. These strategies are currently in draft form and will be published on the Government of New Brunswick's website by the end of the year. We

would like to share our reasoning for each BMP and are open to suggestions on how the BMP's could be improved.

Nest Site Selection and Hatchling Success of Wood Turtles (*Glyptemys insculpta*) in Central Maine

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Wood turtles are a Species of Greatest Conservation Need in the 2015–2025 Maine Wildlife Action Plan and are currently up for federal listing through the United States Fish and Wildlife Service. Wood turtles are a long-lived species with delayed sexual maturity. They also have a low nest success rate and reduced early life stage survival. The goal of our study was to observe nesting events, collect microhabitat data and record nest fate to determine what characteristics a female may be selecting as a "quality" nesting location and if those assumptions were confirmed by the nest fate. Specifically, our objectives were to (1) identify nest and test dig site characteristics that influence site selection such as canopy openness, substrate particle size and soil organic matter; and (2) to relate these characteristics to nest fate. Surveys were conducted during peak nesting hours to identify test dig and nest locations. Canopy openness was calculated using Gap Light Analyzer software, particle size by separating grain size using soil sieves, and percent organic matter through loss on ignition. Fate was determined for each individual egg per clutch. In total, 12 nests were identified (n=12), and two nests successfully hatched. Our results show that there is a significant difference between canopy openness, organic matter, and particle size between nests, test digs and control sites. Females appear to be choosing areas with more open canopy, small gravel particle sizes (<0.2mm), and low organic matter in the soil. In total, 83% of our nests were predated (n=10) and out of the two successful nests, two hatchlings emerged naturally per nest. Our data highlights important site microhabitat characteristics that females may be selecting when determining nest locations and gaining valuable insight on pressures facing nests during incubation.

Considering Canines as Collaborators for Wood Turtle Conservation Work

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The Maine Wood Turtle Project and Science Dogs of New England began a partnership in 2019 to evaluate the use of scent detection dogs for enhancing turtle monitoring efforts. Each subsequent field season we have evaluated our training success and looked for new opportunities to integrate the dog into our research. We took a collaborative approach to developing a training strategy and used systematic assessment to further refine these training techniques. Here we describe the potential benefits of these methods for canine assisted turtle research. Our ongoing population demography data and nesting study methods have been influenced by the presence of a conservation dog. We will also report on other potential field applications, such as missing turtle recovery. Our results to date and discussion of the value added to our monitoring efforts, alongside the logistics and limitations we experienced, can inform other turtle programs considering partnering with conservation canines.