



Turtles All the Way Down

COLLABORATING TO INFORM WOOD TURTLE CONSERVATION EFFORTS IN THE UPPER MIDWEST

By Donald Brown, Andrew Badje, Gaea Crozier, Tricia Markle, and Jeff Tamplin

At first glance, wood turtles may look like any other aquatic turtle—but they’re actually quite unique. Their carapace features elevated, concentric rings, resembling growth rings associated with trees. Unlike most other turtles, this semi-aquatic, freshwater species spends a substantial amount of time in terrestrial environments where it’s found in the upper midwestern and northeastern portions of the U.S. and southeastern Canada. Wood turtles are found predominantly in river systems with clean, highly oxygenated and medium- to fast-flowing streams for brumation—similar to hibernation in mammals—thermoregulation and other facets of their life history. They are also facing declines across much of their geographic distributions.

▼ A juvenile wood turtle encountered during a standardized population survey in Wisconsin.

In response, all 17 U.S. states where wood turtles (*Glyptemys insculpta*) occur consider it a Species of Greatest Conservation Need (SGCN). Many

states also consider wood turtles to be threatened or endangered. The species is considered threatened by the Committee on the Status of Endangered Wildlife in Canada, and it is currently under review for listing under the federal Endangered Species Act.

State natural resource agencies are charged with implementing management actions to promote recovery of declining species like the wood turtle. To do so, they develop and use [State Wildlife Action Plans](#) and species recovery or conservation plans—when available—that serve as roadmaps for conservation efforts. However, information needed to guide species-specific management actions is often limited. And while many agencies are required to conduct periodic status reviews to evaluate the status of a species, sometimes population responses to implemented actions aren’t assessed, resulting

in uncertainty about the efficacy of recovery efforts. In order to successfully conserve at-risk species, interlaced research, surveillance, monitoring, management and policy efforts are often necessary ([Olson and Pilliod 2024](#)).

That’s where knowledge coproduction comes in. Knowledge coproduction is the creation of formal collaborations between scientists and managers that directly link management information needs to research activities ([Beier et al. 2017](#), [Naugle et al. 2020](#)). This method is in contrast to a linear approach, where scientists independently produce products that may or may not have direct or immediate value for management. An approach that is increasingly being used to address time-sensitive information needs for natural resource management ([Grimm et al. 2022](#), [Caro et al. 2023](#)), knowledge coproduction promotes increased



Credit: Donald Brown



interactions between researchers and managers and the timely creation of products to guide management decisions and activities.

Here, we describe outcomes of using a knowledge coproduction approach for wood turtle conservation in the midwestern portion of their geographic distribution, including Iowa, Michigan, Minnesota and Wisconsin.

Turtle threats

As with many declining wildlife species, habitat loss and degradation are the largest threats to wood turtle populations. Habitat conservation and restoration, however, is challenging for this species due to their use of multiple habitat types, including riverine, riparian and upland environments; their reliance on natural or anthropogenic disturbances to maintain important habitat features; and the vagile nature of the species.

Wood turtles typically remain within 300 meters of streams, but individuals often have multiple terrestrial activity areas that are used for foraging and thermoregulation along streams, which can be separated by several kilometers. In addition, females have been documented traveling over 3 kilometers from streams in search of nesting sites (Willey et al. 2022a). Wood turtles often use forest edges and canopy gaps, where food resources are abundant, and the turtles can easily move from sun to shade for thermoregulation.

Because of this thermoregulation need, protecting occupied forest patches from natural or anthropogenic disturbances that create canopy gaps could result in terrestrial habitat degradation over time. Similarly, dams, culverts and other control structures that alter natural streamflow dynamics can negatively affect wood turtles through reduction in disturbances that create or maintain sandy, open canopy banks that the species uses for nesting and potentially creating barriers for dispersal and migration. On the other hand, broad-scale conversion and fragmentation of forests for agriculture and human development can result in direct habitat loss, as well as degradation of their stream and terrestrial habitats. Population declines may further result from flooding and invasive plant growth along streams, as well as increased terrestrial mortality from mesopredators, motor vehicles and heavy machinery (Jones et al. 2021).



Credit: University of Minnesota-Duluth

Although habitat loss and degradation are major threats to wood turtle populations throughout their geographic distribution, many other challenges have been identified at the local level, such as stream pollution, pesticides, viral and fungal disease outbreaks (e.g., *Ranavirus*), and poaching for illegal trade markets. As one of the most cold-adapted turtle species in North America, rapid contemporary climate change is also a major concern, with a recent study projecting up to a 52% loss in suitable habitat by 2070 (Mothes et al. 2020). Increased prevalence of extreme weather, including droughts, freezing events in spring and summer, and heavy rainfall that results in extreme flooding events, are also impacting the species (e.g., Spradling et al. 2010).

Knowledge coproduction informs conservation

Before 2014, wood turtles had not been a major management focal species for the midwestern states, and scientists had conducted relatively little research on the species in the region. Work on wood turtles slowly increased in the 2000s as agencies gained capacity and local knowledge about the species. Increased levels of grant funding, primarily through U.S. Fish and Wildlife Service, were instrumental in driving the advances in research and conservation for the species. The Center for Biological Diversity's petition for listing under the Endangered Species Act in 2012 also provided momentum for research and conservation.

▲ American badgers investigate caged wood turtle nests in Minnesota.



Credit: Jeff Tamplin

▲ An adult female wood turtle killed by a terrestrial mesopredator in Iowa.

▼ Fencing installed to divert turtles away from a major road in Minnesota.

Although there were many pressing information needs for conservation strategies and actions—since conservation biology is a “crisis discipline” that requires timely decisions and actions (Soulé 1985)—the states were already moving forward with initiating a variety of conservation actions, such as the creation and protection of nesting habitat, installation of fencing along roadways to reduce vehicular mortality, enhancement of foraging habitat and headstarting young turtles.



Credit: Tricia Markle

Assessing the short-term outcomes of those actions was a major information need; but wood turtles are a long-lived species with delayed sexual maturity and low fecundity, meaning it could take decades to fully understand the influence of conservation actions on population health. As a result, states needed help developing methods to track population changes over time. Similarly, defining population number targets required an understanding of abundance and demography for healthy populations within the focal ecoregions. These information needs formed the basis of a strong coproduction relationship that has been continuously active for over 10 years.

A few critical components led to a midwestern wood turtle knowledge coproduction relationship throughout Minnesota, Wisconsin, Michigan and Iowa. One factor was the acquisition of a large multi-state grant funded through the U.S. Fish and Wildlife Service Competitive State Wildlife Grants (CSWG) program in 2013. The other component was the vision of states involved to formally integrate research and management. Minnesota and Iowa provided subawards from the CSWG grant to university scientists, which allowed for the incorporation of graduate student thesis projects. This initial investment created the momentum that has since resulted in an additional two CSWG grants, two Great Lakes Fish and Wildlife Restoration Act grants and several formula-based State Wildlife Grants, among other funding sources. The states of Wisconsin and Michigan also began formally engaging university scientists in these subsequent grants. The continued funding support has undoubtedly been a critical component of sustaining the collaborative relationships over the past decade. While still being conducted on an individual state level, coproduction is now being incorporated on a landscape level between the Midwest range state agencies, federal agencies and universities.

When the coproduction relationship began in 2014, scientists knew that wood turtles had severely declined in the southern part of Minnesota, but the status of northern Minnesota populations was unknown. A research team jointly led by the University of Minnesota-Duluth (UMD) and the U.S. Forest Service Northern Research Station (NRS) tackled this information need first by using historical research and monitoring data in combination with new survey data to compare abundances at focal sites and estimate the population trend over



an 18-year period using historical monitoring data (Cochrane et al. 2018). This study found that wood turtles were still prevalent in the region, but populations appeared to be declining, supporting the need for active management.

After assessing the status of northern Minnesota populations, the UMD-NRS team shifted its focus to tracking short-term responses to active management actions (Cochrane et al. 2019, Berkeland 2020), such as the creation and protection of nest sites and developing a standardized population survey protocol to track longer-term population trends (Brown et al. 2017, Beard et al. 2024). The resulting survey protocol is currently used for population monitoring programs in Minnesota, Wisconsin and Michigan. During this time, independent research and monitoring in the other midwestern states also focused on assessing short-term responses to active management actions, as well as quantifying space-use patterns and improving our understanding of the geographic distribution of the species.

Following up

In 2016, nine researchers that were a part of this knowledge coproduction convened for a workshop to discuss their initial projects and findings and to identify opportunities for research synergy among the states.

This workshop resulted in a collaborative publication that estimated adult survival rates and mortality threats across Minnesota, Wisconsin and Iowa. They found that adult survival in all three states was likely lower than what is needed to maintain viable populations (Lapin et al. 2019). In response, Wisconsin funded additional research through the University of Wisconsin-Madison (UW) to estimate the importance of survivorship rates in different life stages on long-term population viability, as well as the ability of two management actions—head starting and nest protection—to reverse population declines.

The researchers found that, although both management actions are beneficial, high adult annual survival rates are key to maintaining viable



Credit: Jeff Tamplin

populations for the species (Bougie et al. 2022). In addition, the UW research team conducted a field study that quantified the influence of nest protection on survival to the hatchling stage (Bougie et al. 2020), finding that this management action does result in significantly higher nest survival rates.

▲ Head-started wood turtles released with radio transmitters at seven weeks of age to study habitat selection and survival rates in Iowa.

Scientists continue to monitor population responses to management actions across all four Midwest states, largely funded through additional CSWGs and SWGs and other state grants, including Minnesota's Environment and Natural Resources Trust Fund. Over time, the state agencies have refined their management actions based on this effectiveness monitoring, and information sharing across agencies has been important for accelerating the rate of progress and directing limited resources toward the most effective conservation actions. For example, researchers at the Minnesota Zoo collaborated with the Minnesota Department of Transportation and local counties to test several road mortality mitigation strategies. Wildlife warning signs were not found to be very effective, but a before-after study of modified barriers was shown to direct turtles to safe passages under the roadway and reduce turtle road mortality by up to 90% (Markle and Stapleton 2022).

State and federal agencies have also continued to support conservation-focused research where major



information gaps for the species still exist, such as projects to inform terrestrial habitat management strategies by quantifying abundance-habitat relationships (Staggs et al. 2024), assessing the health of wood turtle populations in working forests (Brockman 2024) and developing a habitat suitability model for the region that was finalized in fall 2024. Researchers from the Minnesota Zoo and the University of Northern Iowa are currently studying habitat selection and survivorship of wood turtles in early life stages, while a research team led by Grand Valley State University is conducting research to better understand adult predation rates for wood turtles in Wisconsin and Michigan.

Products resulting from the Midwest wood turtle knowledge coproduction relationship have served as the scientific backbone for state species guidance documents, such as the Wisconsin Wood Turtle Status Assessment and Conservation Strategy (internal report) and the Minnesota Wood Turtle Conservation Plan (Minnesota Department of Natural Resources 2020). Data and publications resulting from the coproduction relationship were also incorporated into the Species Status Assessment that the U.S. Fish and Wildlife Service conducted to determine if federal listing was warranted.

Maintaining strong connections

In 2021, the Midwest Wood Turtle Working Group formed to help maintain the strong connections that have been developed between wood turtle managers and researchers across the region and to facilitate the integration of new researchers and managers into the wood turtle conservation community. The working group currently includes over 40 members representing state and federal management agencies, nongovernmental organizations, research scientists and graduate students. The working group meets several times annually to share information and discuss research projects and products, management activities and concerns, funding opportunities and potential new research and management collaborations.

Knowledge coproduction has been an extremely valuable approach to wood turtle conservation in the Midwest, with benefits to the management and research communities and, most importantly, to the species. In only ten years, it allowed the research community to quickly address management information needs during initiation of regional conservation actions and to align subsequent

research activities with expanding conservation efforts. Management priorities and funding were promptly channeled into the most effective conservation actions based on research results. This approach has also been used to enhance conservation of several turtle species in the eastern U.S., including wood turtles, with just as much success (e.g., Jones et al. 2018, Willey et al. 2022b, Roberts and Erb 2023).

With passionate people and adequate funding, coproduction relationships can quickly and organically evolve from single project collaborations to regional-scale collaboratives. As the pace of wildlife declines continues to escalate, cultivating and maintaining knowledge coproduction relationships, such as the one described here, could be a key to conservation success for many species. ■



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