# Upper Midwest Riverine Turtle Habitat Improvement and Conservation – Michigan 2014 Progress Report


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Cover photographs:

Top left – Wood Turtle nest enclosure and turtle nesting area along Au Sable River. Photo by Yu Man Lee, Michigan Natural Features Inventory.

Top right – Wood Turtle (*Glyptemys insculpta*). Photo from Wikipedia.

Bottom left – Hatchling Wood Turtles emerged from nest enclosure within Au Sable River project area. Photo by Huron-Manistee National Forests Mio Ranger District staff.

Bottom right – Wood Turtle nest enclosure and turtle nesting along along Au Sable River. Photo by Yu Man Lee, Michigan Natural Features Inventory.

## EXECUTIVE SUMMARY

Wood turtles (*Glyptemys insculpta*) are medium-sized turtles associated with clear, hard-bottomed, sandy creeks, streams and rivers in spring, fall, and winter, and terrestrial habitats in the summer (Harding 1997). They prefer forested areas over open areas, although small openings in the streamside canopy are essential for nesting and feeding. The Wood Turtle is currently listed in a number of states including Minnesota, Wisconsin, and Iowa, and is a species of special concern in Michigan. The Wood Turtle also has been identified as a Species of Greatest Conservation Need (SGCN) by State Wildlife Action Plans (WAPs) in a number of states including Michigan, Minnesota, Wisconsin, and Iowa. The IUCN Red List classifies the wood turtle as a vulnerable species (Hilton-Taylor 2000). Threats to Wood Turtle populations include habitat loss, degradation, and fragmentation due to development, roads, dams, streambank stabilization, and timber harvesting. Other threats include predation of nests, hatchlings, and adults; road mortality; removal of adults from populations by humans; and disturbance from intensive recreational use in and along rivers and streams.

This project is part of a multi-state, multi-year Competitive State Wildlife Grant (CSWG) project that involves four states, Minnesota, Wisconsin, Iowa, and Michigan, and multiple partners within each state. The overall project will improve turtle nesting and riverine habitats, improve turtle nesting success by managing nest sites and reducing nest predation, and reduce adult turtle mortalities along roads and bridges within the study watersheds. In Michigan, efforts have focused primarily on improving nesting success and habitat for the Wood Turtle. This project will also develop and initiate the first landscape-level monitoring approach for the Wood Turtle and other riverine turtle species within the Upper Midwest region to assess the effectiveness of the conservation actions implemented as part of this project. This project will provide examples of conservation actions that can be implemented at other sites to help conserve and manage populations of Wood Turtles and other riverine turtles in Michigan and the Upper Midwest. This project also will benefit other turtle SGCN.

Several conservation actions were implemented as part of this project in Michigan in 2014. These included conducting surveys for Wood Turtles, tracking their movements using radio-telemetry, identifying and mapping flood-safe nesting areas for turtles by identifying and mapping potential areas with suitable turtle nesting habitat and potential turtle nesting areas, visiting these areas in the field to evaluate and verify the presence of suitable nesting habitat and/or nesting turtles/turtle nests, documenting and protecting Wood Turtle nests from predation using nest enclosures, identifying areas that may represent barriers or threats to turtle movements (e.g., road mortality), identifying areas for habitat restoration particularly for nesting and foraging habitat, and assessing the effectiveness of these conservation actions. Project activities in 2014 were conducted mainly in the Au Sable River project area in Oscoda and Alcona counties in northeast Lower Peninsula of Michigan. The project area is located in the U.S. Forest Service Huron-Manistee National Forests (HMNF) Mio Ranger District. Forest Service staff from the HMNF Mio Ranger District and Dr. Tim Lewis and students from the University of St. Thomas in Minnesota are collaborating with the Michigan Natural Features Inventory to implement these conservation actions in the Au Sable River project area.

Visual surveys and radio-telemetry were conducted in the Au Sable River project area from 8 May to 15 August to help document turtle nesting areas and turtle nests and help identify areas that may represent barriers and threats to turtle movements. Visual surveys resulted in the capture of at least

31 Wood Turtles in the project area, of which 27 were new or previously unmarked turtles and 4 were previously marked or recaptured turtles. Of the 27 new turtles, 19 were females, and 8 were males. All 27 new turtles were adults, with minimum ages (i.e., number of annuli) ranging from 10 to 23+ years old and averaging 19.5 years old. Thirteen of the new or recaptured female Wood Turtles were added to the ongoing radio-telemetry study within the Au Sable River project area for a total of about 33 adult Wood Turtles tracked for the telemetry portion for this project in 2014. Based on the visual surveys and radio-telemetry, we were able to identify at least four Wood Turtle nesting areas in the project area. Surveys of these four nesting areas from 9 June to 22 June during the nesting season documented a total of 8 Wood Turtle nests across the four nesting areas, of which 7 were protected with nest enclosures in 2014. Nest enclosures were monitored on a weekly basis throughout the summer until 6 August when they were monitored on a daily basis to check for hatchling turtle emergence. Nest enclosures have been and will continue to be monitored with daily field visits or wildlife cameras until hatchlings from all protected nests emerge or until mid- to late October. To date, none of the protected nests have been predated, and a total of 18 Wood Turtle hatchlings have emerged from only two protected nests at one of the nesting areas.

Areas that may provide suitable nesting habitat and/or may be currently utilized by Wood Turtles and other riverine turtles for nesting were identified within the Au Sable River project area through aerial photograph interpretation, visual surveys in the field, and radio-telemetry. At least four turtle nesting areas and at least two additional areas with suitable turtle nesting habitat and/or evidence of turtle nesting were documented in the field in the Au Sable River project area in 2014. Areas that may represent barriers or threats to turtle movements also were noted based on field observations and turtle locations from the radio-telemetry study. Several turtles were found crossing roads including three live and two dead Wood Turtles and one dead Blanding's Turtle (*Emydoidea blandingii*).

This project has contributed new information that will be important and useful for Wood Turtle management and conservation efforts along the Au Sable River and other sites in Michigan. Information on Wood Turtle habitat use, nesting ecology, and movements will help inform and guide forest and other habitat management activities. Project activities will continue this fall and next year in 2015 including additional analysis and summary of data collected in 2014, continued mapping and evaluation of flood-safe nesting areas and areas that may represent barriers or threats to turtle movements, continued identification and mapping of turtle nesting areas and areas with suitable nesting habitat, continued documentation and protection of nest sites, habitat restoration, and monitoring to assess the effectiveness of these conservation actions. Project activities will continue in the Au Sable River project area, and will also be initiated in one or potentially two additional project areas in 2015.

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## INTRODUCTION

Several studies have documented that many turtle populations inhabiting rivers and streams in eastern North America are declining (Doroff and Keith 1990, Heppell 1998, Daigle and Jutras 2005). The Wood Turtle (*Glyptemys insculpta*) is one such freshwater turtle species that has declined significantly in eastern North America. Wood turtles are medium-sized turtles associated with clear, hard-bottomed, sandy creeks, streams and rivers in spring, fall, and winter, and terrestrial habitats in the summer (Harding 1997). They prefer forested areas over open areas, although small openings in the streamside canopy are essential for nesting and feeding. The Wood Turtle is currently listed in a number of states including Minnesota, Wisconsin, and Iowa, and is a species of special concern in Michigan. The Wood Turtle also has been identified as a Species of Greatest Conservation Need (SGCN) by State Wildlife Action Plans (WAPs) in a number of states including Michigan, Minnesota, Wisconsin, and Iowa. The IUCN Red List classifies the wood turtle as a vulnerable species (Hilton-Taylor 2000).

Threats to Wood Turtle populations include habitat loss, degradation, and fragmentation due to development, roads, dams, streambank stabilization, and timber harvesting. Other threats include predation of nests, hatchlings, and adults; road mortality; removal of adults from populations by humans; and disturbance from intensive recreational use in and along rivers and streams. In Michigan, habitat loss and degradation have occurred in some wood turtle populations, but nest predation and lack of recruitment are probably more of an issue, particularly in the Upper Peninsula (Harding pers. comm.). Road mortality and availability of suitable and sufficient nesting habitat also are limiting factors in some populations.

In addition to the Wood Turtle, the Snapping Turtle (*Chelydra serpentina*), Northern Map Turtle (*Graptemys geographica*), and Eastern Spiny Softshell turtle (*Apalone spinifera spinifera*) inhabit rivers and streams in Michigan, and potentially occur in the same areas as wood turtles. The Blanding's Turtle (*Emydoidea blandingii*) and Eastern Box Turtle (*Terrapene carolina carolina*), which are both special concern species and SGCN in Michigan, also occur in some of the same areas as Wood Turtles. These species also face similar threats as the wood turtle, including habitat loss and fragmentation, nest predation, and road mortality.

This project is part of a multi-state, multi-year Competitive State Wildlife Grant (CSWG) project that involves four states, Minnesota, Wisconsin, Iowa, and Michigan, and multiple partners within each state. The overall project will improve turtle nesting and riverine habitats, improve turtle nesting success by managing nest sites and reducing nest predation, and reduce adult turtle mortalities along roads and bridges within the study watersheds. In Michigan, efforts have focused primarily on improving nesting success and habitat for the Wood Turtle. This project will also develop and initiate the first landscape-level monitoring approach for the Wood Turtle and other riverine turtle species within the Upper Midwest region to assess the effectiveness of the conservation actions implemented as part of this project. If the conservation actions undertaken by this project prove to be successful, this project will provide examples of conservation actions that can be implemented at other sites to help conserve and manage populations of Wood Turtles and other riverine turtles in Michigan and the Upper Midwest. This project also will benefit other SGCN and address conservation issues identified in Michigan's and the other states' WAPs, helping Michigan and the other states' satisfy their major and common goal of stabilizing and increasing populations of SGCNs.

## OBJECTIVES

The following are the specific objectives for Michigan's portion of the CSWG Upper Midwest Riverine Turtle Habitat Improvement project:

1) Improve turtle nesting success by nest site management.
   a) Identify locations of nesting habitats that are safe from frequent normal year flooding events along 2 river stretches considered for this project.
   b) Increase turtle nesting success by reducing the effects of predation using nest cages and/or predator exclusion fences around 30 Wood Turtle nest sites along 2 river stretches (15 nest sites along each river stretch).

2) Reduce adult turtle mortality by increasing connectivity among habitats that turtles use to complete their life cycle.
   a) Identify barriers to movements and pathways that pose a threat to turtle travel needed by Wood, Painted, and Snapping Turtles to complete their normal life cycle along 2 river stretches (or project sites).

3) Improve turtle habitat in river and stream corridors.
   a) Improve the characteristics of potential turtle nesting sites in flood-safe areas to increase their suitability for nesting by riverine turtles. This work would be undertaken at 4 turtle nesting sites/areas.

4) Assess the effectiveness of conservation actions by monitoring turtle use, abundance, and habitat response.
   a) Identify and measure at least 6 parameters that best evaluate the short term response of turtle populations to conservation actions implemented.
   b) Identify 10 population and habitat parameters that would best evaluate the long term response of turtles and describe future habitat conditions at sites where conservation actions have occurred.

5) The lead state will submit a comprehensive report of all activities that address each objective conducted by or on behalf of all States that receive funding to the WSFR Regional office by the required performance reporting period.
   a) Minnesota Department of Natural Resources is designated as the lead state agency for this project.
   b) All participating states (including Michigan) and partners commit to providing the lead state with their project results and necessary information in due time for completion of both the interim and final reports.
   c) The lead state agency commits to completing all interim reports and final report within the specified time lines.

## METHODS

### ***Project/Study Areas***

Project or study areas were selected based on where previous surveys or research on Wood Turtles had been undertaken, and in many cases, where there was information indicating that these sites would be vital to the long term sustainability of the targeted riverine turtle species. In Michigan, Wood Turtle surveys, monitoring, and/or research have been conducted along the Au Sable River and tributaries in Crawford, Oscoda, and Alcona counties, and the Ontonagon River and tributaries in Ontonagon, Gogebic, Houghton and/or Iron counties in Michigan (Figure 1). The Au Sable River project area is located within the U.S. Forest Service's (USFS) Huron National Forest (HNF) Mio Ranger District in Oscoda and Alcona counties (Figure 2). We initially focused the project on these two areas, but we also considered additional project areas as needed and as time and funding allowed or will allow.

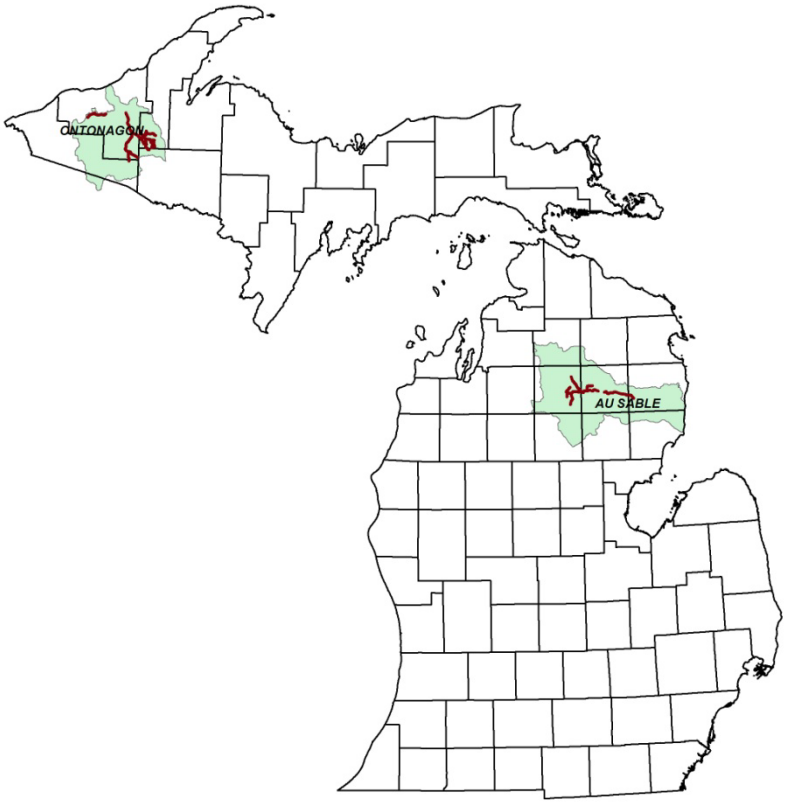


Figure 1. Map of the two project areas for the CSWG Upper Midwest Riverine Turtle project in Michigan, the Au Sable River project area and the Ontonagon River project area.

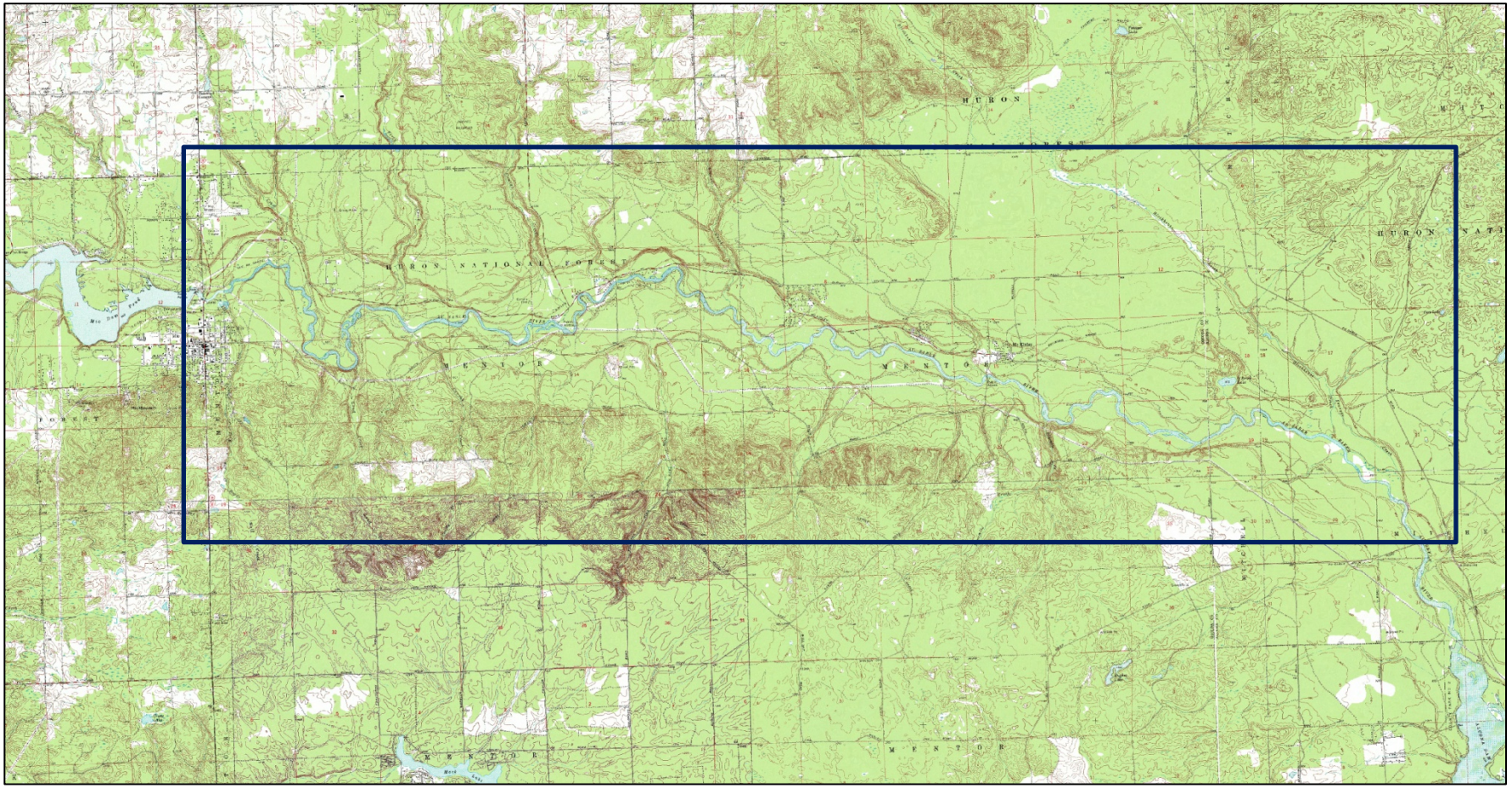


Figure 2. Map of general extent of Au Sable River project area in Oscoda and Alcona counties in the northeast Lower Peninsula of Michigan.

## ***Project Coordination and Planning***

To facilitate project coordination and planning, we participated in discussions with the Michigan DNR and representatives from the partnering agencies in Minnesota, Wisconsin, and Iowa involved with this project through phone calls, conference calls, and/or face-to-face meetings in the fall of 2013 and winter and/or spring of 2014. We also contacted and/or met with the land managers and/or researchers who have been conducting Wood Turtle surveys, monitoring, and/or research in the project areas along the Au Sable River and the Ontonagon River to coordinate and implement project activities. To obtain additional background information on Wood Turtle ecology, particularly nesting ecology, we reviewed the literature and reports on similar projects with Wood Turtles and other turtle species, and consulted with several species experts in 2013 and 2014. We also investigated and applied for approval and permits necessary for conducting project activities including animal care and use approval through Michigan State University's (MSU) Institutional Animal Care and Use Committee (IACUC) and a special use permit from the U.S. Forest Service through the Huron National Forest's Mio Ranger District.

## ***Wood Turtle Surveys and Tracking Turtle Movements***

Radio-telemetry was used to track the movements of turtles at the Au Sable River project area. Information on turtle movements was used to help identify turtle nesting areas and indicate when nesting was about to occur within the project area since this information was not available prior to this project. Information on turtle movements also will be used to assess habitat use before and after habitat improvement work as a way to assess the effectiveness of habitat improvement conservation actions, and to identify barriers to travel and the degree of connectivity among habitats that turtles frequent during their annual cycle.

A sufficient number of wood turtles (20-30) will be tracked at each site where telemetry is undertaken. Prior to the start of this project, a total of 18 Wood Turtles (11 adult females and 7 adult males) had been transmittered and tracked as part of an ongoing, long-term Wood Turtle telemetry research project conducted by Dr. Timothy Lewis with the University of St. Thomas in Minnesota and the USFS Huron National Forest Mio Ranger District. Additional radio transmitters (i.e., 15) were jointly purchased by the USFS Huron National Forest, Dr. Lewis, and MNFI to add additional turtles to the telemetry study in 2014. Visual surveys were conducted in the project area in the spring and early summer of 2014 (i.e., 8 May to 22 June) to capture additional Wood Turtles to add to the telemetry study, following established survey methodologies (Buech et al. 1997, Massachusetts Cooperative Fish and Wildlife Research Unit and the Northeast Wood Turtle Working Group 2013).

Turtles found during visual surveys were captured by hand. Captured turtles were measured, aged, sexed, marked, and examined for general health/condition. For the Au Sable River study area, we recorded the same measurements and used the same methods as those used by Dr. Lewis (Appendix 1). We also recorded additional information and measurements based on what other states or researchers recorded (e.g., Massachusetts Cooperative Fish and Wildlife Research Unit and the Northeast Wood Turtle Working Group 2013, Appendix 1). Measurements included body mass or weight (g), length (cm) and width (cm) of the carapace (upper shell) and plastron (lower shell) along the midline or at the longest or widest point, and shell height (cm, at tallest point). We measured weight with a Pesola spring scale (i.e., 1000 g or 2,500 g capacity)

by placing the turtle in a bag (i.e., pillowcase) and weighing the bag with and without the turtle. We measured carapace width, carapace length, plastron width, plastron length, and shell height (when possible) along the midline or longest or widest points of the shell to the nearest 0.1 cm using a measuring tape or calipers. Age or minimum age was estimated by counting annuli or annular growth rings on the scutes of the carapace or plastron. The annuli on several scutes were generally counted to obtain a more accurate age estimate. For adult turtles (i.e., $\geq$10 years old), plastron concavity and position of the cloaca or anal opening relative to the edge of the carapace were used to determine the sex of individuals. Adult males have concave plastrons, and the cloaca or anal opening on the tail extends well beyond the posterior edge of the carapace (Harding and Bloomer 1979). General health, injuries, scute/shell morphology, and activity or behavior of the turtles also were noted (Appendix 1).

Adult and juvenile Wood Turtles were marked using shell notching which consists of using a triangular metal file to put small, permanent U- or V-shaped notches in the marginal scutes along the outer edge of the carapace following a numbering or lettering system. For the Au Sable River study area, a numbering scheme similar to that of Cagle (1939) that has been used by the USFS and Dr. Lewis within the study area was used (Appendix 2). The equipment used to notch the turtle shells was disinfected prior to use with and between the turtles. Turtles that were already marked (i.e., recaptures) also were documented, and their identification mark or code was noted. Wood Turtles encountered and/or captured in the field were photographed, and located using GPS. They were released at the initial capture site immediately after processing was completed. Processing of each turtle generally took about 25-45 minutes total. Habitat information and survey weather conditions also were recorded (Appendix 1).

A subset of the turtles that were captured in the spring and early summer of 2014 was added to the telemetry study. During processing, radio transmitters were attached to the lower left or left posterior corner of the carapace of these turtles (in front of and to the left of the tail) by gluing the transmitter to the shell using waterproof epoxy. The radio transmitters used for this project were made by Advanced Telemetry Systems (ATS, Isanti, Minnesota, USA) (Model #R1860, 15.9 g, 796-day battery life). Only adult turtles, and primarily adult females, were added to the telemetry study.

Tracking the turtles during the active season from April/May to October will reveal nesting sites and foraging sites as well as hibernation sites. Turtles in the Au Sable River project area were tracked during the active season from 8 May to 15 August 2014, and particularly during the nesting season from late May to late June. Turtles will be tracked in the fall of 2014 to identify hibernation sites. Turtles also will be tracked during the active season in 2015. Turtles were tracked using a telemetry receiver (150-154 MHz) (Communications Specialists, Inc.) and a handheld directional "H" VHF antenna (Telonics, Inc.) or Yagi VHF antenna. Turtles were tracked and located, and visual confirmation of tracked turtles was obtained whenever possible. When tracked turtles were located and visually confirmed, their locations were recorded using GPS, and their activity or behavior and the general habitat in which they were found also were documented.

In addition to tracking turtle movements using radio-telemetry within the Au Sable River project area, visual surveys were conducted to identify and monitor turtle nesting sites and monitor turtle use of enhanced nesting habitat areas. Visual surveys also will be conducted at the Ontonagon

River project area and/or other project areas. We have worked and will continue to work with state and agency partners and university researchers who have conducted telemetry and other research on Wood Turtles to make sure similar, safe, and effective methods are utilized, and consistent and reliable data are collected.

### ***Identifying and Mapping Flood–Safe Nesting Areas*** **(Objective 1a)**

To identify and map flood-safe turtle nesting areas, we first identified and mapped potential areas with suitable nesting habitat for turtles within the study areas by examining aerial photographs of the study areas available online to look for open/non-forested areas along the river and within 500 m from the center of the river channel. Aerial photographs that we examined included low resolution (15-m resolution) and high resolution (30- and 60-cm resolution) World Imagery through the ArcGIS Map Service (http://services.arcgisonline.com/ArcGIS/services) and other statewide imagery publicly available through MSU's Remote Sensing & GIS Office (e.g., NAIP 2012 True Color, NAPP 1998 Color Infrared) ( http://mis.rsgis.msu.edu/ecwp/ecw_wms.dll?MIS?). We mapped potential nesting areas or potential areas with suitable nesting habitat in ArcGIS using ArcMap 10.1. For the Au Sable River project area, the Huron National Forest had identified and mapped erosion sites along the river. We were able to obtain locations of these erosion sites and included them as potential areas with suitable nesting habitat for turtles in the project area.

To evaluate and verify areas that provide suitable nesting habitat for turtles and/or are utilized by turtles for nesting, we visited areas that had been mapped as potential turtle nesting habitat in the field. We assessed and determined habitat suitability for nesting turtles by examining and collecting information on site conditions including substrate composition, tree canopy cover, amount and type of other vegetative cover, soil moisture, slope, and aspect (Appendix 3 and 4). Wood turtles require open, well-drained, elevated, exposed areas of sand and/or gravel for nesting (Akre and Ernst 2006, Ernst and Lovich 2009, Jones 2009), although appropriate nesting areas vary by geographic region. Based on Wood Turtle research in other areas, suitable nesting habitat generally consist of sandy, gravelly, open areas that are generally south facing, have a slope of less than 40 degrees, have little or no ground vegetation (<20% ground cover), are sunlit most of the day, and receive little human disturbance. We also looked for evidence of turtle nesting by surveying for nesting turtles during the nesting season, looking at the telemetry data to see if turtles used the area during the nesting season, and looking for turtle eggshells.

To identify turtle nesting areas or areas with suitable nesting habitat that are safe from flooding, we examined conditions in the field and consulted with local land managers and other site experts. We also will utilize hydrological models such as the U.S. Army Corps Models, HEC-GeoRAS (http://www.hec.usace.army.mil/software/hec-georas/) and the HEC-RAS (http://www.hec.usace.army.mil/software/hec-ras/), to identify flooding zones for any river stretch based on digital elevational models and river flow metered at gauging stations within or closest to that river stretch . Hydrological models will be used to map flood prone areas. Areas within 500m from the center of the river channels that are most secure from flooding, that could provide suitable nesting habitat, and that are well connected to the river channel and to potential foraging habitat will be delineated and mapped in GIS.

***Protecting Nests against Predation*** (**Objective 1b)**

Two main methods were initially proposed to reduce the effects of predation on turtle nests. One method consisted of placing wire cages or enclosures over individual nests shortly after turtles have laid their eggs (Standing et al. 2000, Linck and Gillette 2009). This method requires the close monitoring of nests at the time turtles are nesting, and then again at hatching time. A second method to protect against nest predation consisted of fencing an area that allowed turtles to enter but excluded larger predators such as raccoon and fox. This method has successfully increased turtle nest success by 74% in one study in southern Wisconsin (Geller 2012). Additional methods to reduce nest predation may be considered and utilized. A minimum of 30 nests (15 at each project area) will be protected by cages and/or predator exclusion fences. Protected and unprotected nests will be monitored to assess effectiveness of the nest cages and predator exclusion fences.

In 2014, our nest protection efforts focused on the Au Sable River project area, and we only utilized wire cages or enclosures to protect individual turtle nests. Our goal was to locate and protect up to 15 Wood Turtle nests, and locate and monitor an additional 15 nests nearby to use as control sites. Control sites would not be protected from predators so that we could compare nesting, hatching, and emergence success between protected nest sites and control sites to evaluate the effectiveness of nest protection efforts. We propose to repeat these efforts in 2015, and protect up to 15 turtle nests and monitor an additional 15 nests for control sites, with an option to potentially protect more than 15 nests in 2015 if needed.

Because the locations of turtle nesting areas had not been identified and were not known within the Au Sable River project area prior to this project, we used several different methods to locate Wood Turtle nests for the nest protection effort. One method consisted of identifying and surveying several areas (i.e., 3-5 areas ideally) with suitable nesting habitat for Wood Turtles in the Au Sable River project area during the nesting season. We identified areas with suitable nesting habitat for Wood Turtles based on aerial photo interpretation, available information from Dr. Tim Lewis and biologists from the USFS Mio District Office, and field reconnaissance. We primarily looked for open, well-drained, elevated, exposed areas of sand and/or gravel along the river, based on Wood Turtle nesting habitat requirements identified in the literature (Harding and Bloomer 1979, Akre and Ernst 2006, Ernst and Lovich 2009, Jones 2009). Based on Wood Turtle research and suitable nesting habitat in other areas, we looked for sandy, gravelly, open areas that were generally south facing, had a slope of less than 40 degrees, had little or no ground vegetation (<20% ground cover), were sunlit most of the day, and received little human disturbance. Nests also are usually placed within a few dozen meters and always within a few hundred meters from the river (Ewert et al. 1998), and are well connected to the river (e.g., not separated by a road or ATV trail). Remsberg et al. (2006) found that over 90% of his Wood Turtle telemetry locations, which were located within the Au Sable River project area, were within 200 m of the river. As a result, we focused our surveys on areas with suitable nesting habitat along or within 200m of the river.

Other methods that were used or considered for identifying Wood Turtle nesting areas within the Au Sable River project area included radio-telemetry and substrate inspection. We worked with Dr. Tim Lewis and his students from the University of St. Thomas in Minnesota and the USFS Huron National Forest's Mio Ranger District to track and locate adult female turtles that were

part of the telemetry study during the nesting season to try to locate additional nesting areas and turtles. In Minnesota, researchers have found Wood Turtle nests by smoothing over the surface of the sand or substrate with hand tools in selected areas with suitable nesting habitat in late afternoon or early evening, and returning to these areas early the next day to look for small depressions, scrapings, disturbed soil, or other evidence of nesting to locate turtle nests. We decided to not use this method in 2014 because of the disturbed nature and high recreational use of the potential nesting areas within the Au Sable River project area.

We tracked female turtles and conducted visual surveys in selected areas with suitable nesting habitat every 1-3 days starting in late May (i.e., 23 May 2014) to look for evidence of nesting activity. This included movement to and spending time in areas with suitable nesting habitat (i.e., pre-nesting or staging behavior). We also palpated some of the female turtles to determine if they were gravid and how close they were or might be to nesting (i.e., hardness of eggs).

Once the nesting season started (i.e., first day a female was seen attempting to nest), we surveyed selected nesting areas daily during the day and in the evening to see if any female Wood Turtles were present and/or nesting until the nesting season ended (i.e., last day nesting was observed), or until we located our goal of 30 nests (15 protected and 15 control nests). We conducted surveys for nesting turtles from 9 June to 22 June in 2014. Surveys for nesting turtles were conducted during the day generally from 0700 hrs to 1600 hrs, and in the evening from about 1700 hrs to 2100 hrs. Once we located a nesting turtle, we watched and monitored the turtle from a distance (e.g., using binoculars from about 5-8 m), to minimize disturbance to the turtle, until nesting was completed (i.e., generally until 2400 hrs to 0100 hrs). Once the turtle was no longer visibly disturbed once egg-laying had begun, we tried to move closer to the turtle and tried to position ourselves so that we could count the number of eggs laid either directly or indirectly (i.e., head retractions, Harding and Bloomer 1979). Nesting was completed when the nest was completely covered and the female began to move away from the nest. At this point, we approached the turtle to confirm its identification. For new or unmarked turtles, we captured, measured, and marked the turtles before they left the nesting area. We also recorded weather conditions and other turtles observed at the nesting area during the survey (Appendix 5). For nests that are located by smoothing over the substrate and looking for signs of nesting, we will confirm that these are Wood Turtle nests by gently and carefully excavating the nests to confirm that they are Wood Turtle nests and to count the number of eggs in the nest. Eggs will be excavated within a day of being laid, and will be reburied in their nest cavity within 15 min of excavation. After the turtle completed nesting and left the area, we marked the location of the nest using GPS. The exact location of each nest also was marked in the field with four small wooden stakes placed 1 m from the nest in each cardinal direction.

For the turtle nests that were protected from predators, nest cages or nest enclosures were placed over individual Wood Turtle nests after the turtles had completed nesting and had left the area. If turtles completed nesting late in the evening after nightfall, which was the case for most of the turtle nests we documented, a 61-cm L x 30-cm W (2 ft L x 1 ft W) sheet of galvanized wire mesh (mesh size 1.3 cm x 1.3 cm / 0.5 in x 0.5 in) was placed over the turtle nest to temporarily protect it from predators during the night, and a standard nest enclosure was installed the following morning. Nest enclosures were constructed from wood and galvanized wire mesh with mesh size of 1.3 cm x 1.3 cm (0.5 in x 0.5 in) (Figure 3). Nest enclosures were about 61 cm L x 61 cm W x 30 cm H (24 in L x 24 in W x 12 in H), with a 1.3-cm (0.5-in) galvanized wire mesh

cover attached with zip ties (Figure 3). This design was based on nest enclosures used successfully by USFS and Michigan State University researchers and volunteers who have been protecting Eastern Box Turtle nests in and around the Manistee National Forest and Ft. Custer State Recreation Area (see Appendix 6 for photos of nest enclosure design developed and used by Patrick Laarman in the Manistee National Forest). Nest enclosures were placed over the turtle nest with the nest centered within the enclosure. Nest enclosures were partially buried into the substrate (~8-10 cm / 3-4 in) and staked in to prevent predators from moving the nest cages or digging underneath them (Figure 3).

To compare nesting and hatching success between protected nests and control or unprotected nests, protected nests and control/unprotected nests were monitored 1-2 times a week throughout the summer to document nest predation and any disturbances to the nests and nest enclosures by predators and other sources. Predated nests were documented based on the presence of turtle shell fragments around the nest site. Nest enclosures that were disturbed or removed for some reason were repaired or replaced.

Starting in early to mid-August (i.e., 6 August 2014), nests/nest enclosures were monitored daily to document when hatchlings start to emerge. Hatchling emergence was characterized by a hole in the substrate approximately 3 - 4 cm (1 - 1.5 in) in diameter and/or presence of hatchlings within the enclosure. Cover objects (e.g., leaf litter, dead vegetation, moss, wood, and/or wet sponges) were placed in the nest cages/enclosures to provide cover for the hatchlings that emerge while they are in the enclosure before they are released. Cover objects within the nest cages were sprayed with water during daily nest checks to keep them moist. For control nests that had not been destroyed by predators by this time, modified nest cages/enclosures (i.e., nest cage/enclosure without a top or cover) were placed over control nests. These cages were not meant to protect the eggs and/or hatchlings from predators but to temporarily hold the hatchlings that emerge for up to 12-24 hrs so that we could count the number of hatchlings that emerge and mark them.

Once hatchlings started to emerge, protected and control nests were monitored once or twice a day to look for emergence of hatchling turtles. We documented, measured, and marked the turtle hatchlings that emerged from the protected and control nests using the methods described earlier for adult and juvenile turtles except hatchlings were notched using small scissors or nail clippers. Turtle hatchlings were photographed and released from the nest enclosures after they were processed and marked. Nest enclosures were left in place and nests were checked for 2-3 days after the first hatchlings were observed to ensure that all hatchlings had emerged from the nest. Nest cages were removed after all turtle hatchlings had emerged and had been processed and released. After 3-5 days after the last hatchling emerged from a nest, the nest was excavated to look for eggshell fragments, any failed eggs (i.e., undeveloped or infertile eggs), and/or any dead hatchlings. Undeveloped eggs were defined as eggs enclosing a dead embryonic turtle, whereas infertile eggs did not contain an embryo (Walde et al. 2007). The number of eggs and hatching success were calculated by adding together the number of hatchlings that emerged from the nest, plus the number of failed eggs and/or dead hatchlings in the nest cavity. The number of eggs that hatched was compared with the number of eggshell fragments and the appearance of these shell membranes. Eggshell membranes from which hatchlings emerged are white, soft, and leathery compared to those of eggs that had rotted, which are brownish, hard, and brittle (Walde et al. 2007).

Figure 3. Photos of nest enclosures protecting Wood Turtle nests at various locations within the Au Sable River project area in Michigan. Vegetation was placed in nest enclosures in early August to provide cover for hatchlings upon emergence.

All protected nests (and control nests over which modified nest cages were placed) have been and will continue to be monitored daily until hatchlings emerge from all the nests or as long as project funding will allow. If hatchlings do not emerge by mid-October, the nests (or a subset of the nests) may be gently dug up to determine the fate of the nest. If eggs appear to be viable or live hatchlings are found, nests will be covered back up and revisited later in the fall or in the spring. Nest cages/enclosures over remaining protected nests will be removed by mid- to late October. Wildlife cameras may be installed at or near a subset of these nests to try to monitor and document hatchling emergence. If hatchling emergence is documented in the fall after nest enclosures are removed, nests will be excavated to determine or estimate the number of eggs and/or hatchlings that emerged from the nest. Nests from which hatchlings do not emerge by late October/early November will be left undisturbed, marked, and checked and monitored or excavated in early spring to determine if the hatchlings were able to successfully overwinter in the nest cavity and if they emerge from the nest in the spring. If no hatchlings emerge from a given nest, the number of eggs in the nest will be determined by a direct count following excavation. If a single hatchling emerged, the nest will be considered successful. When no hatchlings emerge, nest failure was evaluated based on characteristics of the destroyed nest, the appearance of the eggs, and/or shell fragments.

***Identifying Barriers and Dangerous Road Crossings*** (**Objective 2a)**

This effort will assess the threat from road mortality in the project areas and identify locations where efforts to reduce road mortality and enhance connectivity may be implemented in the future. We will look at known Wood Turtle occurrences in Michigan's Natural Heritage Database and maps of roads and other barriers to movement. The Natural Heritage database will be checked for locations of reported dead turtles that fall within the project area. For the Au Sable River study area, we will work with Dr. Lewis and the USFS Huron National Forest Mio District staff to identify barriers to movement and pathways that may pose a threat to Wood Turtle movement, assess the threat of road mortality, and identify locations where efforts to reduce road mortality and enhance connectivity could be implemented in the future. The tracking of turtle movements using radio telemetry will indicate how they are negotiating barriers and road crossings. For the Ontonagon River and other potential project areas, we will consult with the local USFS and/or MDNR wildlife biologists and other site experts (i.e., MDOT staff) to identify barriers and pathways that pose threats to Wood Turtle movement.
Road and trail layers superimposed on turtle travel routes and/or turtle locations will reveal locations where turtles could be encountering the greatest road mortality risks within the project areas. Roadside surveys and field inspection will be conducted in areas that may represent barriers or threats to Wood Turtle movements and locations where road mortality may be an issue. These surveys will be conducted during the Wood Turtle active season in 2014 and 2015 (and potentially 2016), particularly in the spring and early summer and in the fall when turtles are moving to and from their overwintering sites and nesting habitats.

***Restoration of Nesting and Foraging Habitat*** **(Objective 3a)**

Habitat restoration efforts in Michigan will focus on nesting habitat. Nesting sites/habitat will be improved by removing encroaching woody vegetation, grass, and other vegetation. Sites of ¼ to ½ an acre that are south facing, have sandy soil, are well connected to river (no roads or ATV

trails), and have a lower risk of flooding will be selected for habitat improvement. Encroaching vegetation will be removed mechanically or through the use of prescribed fire. Ideally, restoration of nesting sites will be done in early spring before turtles emerge or late September to early October to lessen the likelihood of turtles being on land. Habitat restoration will primarily occur in the second and/or third year of the project. We will be collaborating with the Huron-Manistee National Forest, Ottawa National Forest, and/or local MDNR field staff on the habitat restoration efforts. Habitat restoration will occur on U. S. Forest Service, MDNR, and/or privately-owned lands within the project areas. We plan to seek additional funding to provide additional match and support for habitat restoration efforts.

Potential sites for habitat improvement/restoration were identified and inspected during field surveys in 2014. These included areas currently used by Wood Turtles for nesting as well as areas that provide suitable nesting habitat but may or may not be used by Wood Turtles for nesting, particularly areas that are in close proximity to known Wood Turtle nesting areas. For the Au Sable River study area, we have consulted and worked with USFS Huron NF Mio Ranger District's wildlife biologists and other staff and Dr. Lewis to identify 2-4 sites for habitat improvement/restoration by mid-late summer or fall of 2014. We also have discussed with USFS staff and Dr. Lewis management needs at these sites to improve nesting habitat for Wood Turtles and other riverine turtles.

Once the sites for habitat improvement/restoration have been selected and agreed upon by MNFI and local landowner(s) and partner(s), we will work with the landowner(s)/partner(s) to implement habitat improvement and restoration efforts. Habitat improvement and restoration efforts at selected sites will ideally be conducted in the fall, winter, and/or early spring of 2015 prior to Wood Turtle emergence in the spring of 2015. If this is not possible, then habitat improvement and restoration efforts will be completed by late fall of 2015 or winter/early spring of 2016 prior to turtle emergence in spring of 2016. We will work with the local landowner(s), land manager(s), and/or partner(s) to determine the approach, timing, and implementation of nesting habitat improvement/restoration efforts so that these efforts avoid or minimize adverse impacts to Wood Turtles and other riverine turtles as well as other sensitive natural and cultural features that occur/may occur at these sites. We also will work with them to determine the logistics for how the habitat restoration work will get done, if needed.

***Assessing the Effectiveness of Conservation Actions.*** **(Objective 4)**

Plans to measure the effectiveness of implemented conservation actions over the short- and long-term have been discussed and will continue to be refined with state project partners and researchers at universities. Control sampling units will be paired with sampling units that will undergo a conservation action. In some cases, a before and after- treatment condition will apply. Parameters will be measured that best indicate the effect(s) that each conservation action is targeting. For example, the number of hatchlings produced from protected nest sites could measure the effectiveness of nest protection. The feasibility of measuring particular parameters will be discussed with researchers who have previously utilized similar techniques. The final list of parameters for monitoring the effectiveness of the conservation actions and methods for data collection and analysis will be developed in conjunction with the other state and project partners. Methodologies will be coordinated among the 4 states to insure that the results can be validly

compared. Volunteers and/or seasonal field staff will assist with surveys and monitoring to assess the effectiveness of implemented conservation actions. Volunteers and staff working on the project will be trained on study methods before working on the project.

We have worked with the MDNR and the other states and partners involved with the multi-state riverine turtle project to identify and measure at least 6 parameters that best evaluate the short-term response of turtle populations to conservation actions implemented as part of this project. Table 1 provides a summary of initial parameters and associated approaches that have been identified to evaluate the short-term response of turtle populations to conservation actions implemented as part of this project. These parameters and approaches will be refined as needed based on discussions with the other state and local partners and other researchers and managers that have worked with this species and/or have conducted similar work (e.g., Northeast Wood Turtle Working Group).

We will work with the MDNR and the other states and partners involved with the multi-state riverine turtle project to identify and measure 10 population and habitat parameters that would best evaluate the long-term response of turtles and describe future habitat conditions at sites where conservation actions have occurred (i.e., nest protection and habitat improvement/ restoration sites). We will consult and work with the USFS, Dr. Tim Lewis, and other interested partners to help identify and develop and provide recommendations for these population and habitat parameters and describe future habitat conditions at sites that have been managed. These population and habitat parameters and future habitat conditions will be developed and finalized in 2016.

Table 1. Summary of initial parameters and associated approaches that have been identified to evaluate the short-term response of turtle populations to conservation actions.

| **Conservation Actions/ Objectives** | **Parameters to Evaluate Short-term Response** | **Approaches** |
|---|---|---|
| Identifying flood-safe nesting areas | • Monitor whether areas identified as flood-safe nesting areas flood during the nesting season during the project period in 2014 and 2015. | • Visit sites in the field during the active/nesting season, particularly when flooding may be likely.<br>• Consult with project partners and other local site experts. |
| Reducing nest predation by protecting nests | • Monitor and compare *predation rate* (i.e., number of nests that are predated) between protected nest sites and control nest sites<br>▪ Monitor and compare *nesting success* (i.e., number of nests that are successful in terms of having at least one hatchling emerge) between protected nest sites and control nest sites<br>▪ Monitor and compare *hatching success* (i.e., number of eggs that hatch and/or hatchlings that emerge) between protected nest sites and control nest sites<br>• Monitor and identify *nest predators* around protected or control nest sites, if possible | • Monitor protected and control nests from nesting/when eggs are laid throughout the summer to hatchling emergence in 2014 and 2015 following methods outlined under Objective 1b<br>• To monitor and identify nest predators, use track and/or visual surveys. If the site is appropriate (i.e., not visited or used by people very much, evidence of nest predation), wildlife cameras may be installed to try to get information on nest predators. |
| Identifying barriers to movements and pathways and road crossings that pose threats to turtle travel | • Monitor areas identified as potential barriers to movements and pathways and road crossings that pose threats to turtle travel throughout the project period to document turtle use/mortality | • Visit and monitor turtle use and mortality in these areas during the active season in 2014 and 2015 (and 2016 if needed).<br>• Radio-telemetry and tracking turtle movements during the active season<br>• Consult with local partners and site/species experts. |
| Improving nesting and foraging habitat | • Assess and monitor habitat condition prior to and after habitat improvement/restoration<br>• Monitor presence and/or number of Wood Turtles and other turtles using the site for basking, foraging, staging and/or nesting prior to and after habitat improvement.<br>• Monitor presence and/or number of turtle nests prior to and after habitat improvement/restoration. | • Collect pre-habitat improvement/restoration data on these measures in the field in 2014 and 2015.<br>• Collect post-habitat improvement/restoration data on these measures in the field in 2015 and 2016.<br>• Consult and work local partners to obtain these data on these measures. |

## RESULTS

### ***Project Coordination and Planning***

To facilitate project coordination and planning, we participated in discussions with the Michigan DNR and representatives from the partner agencies in Minnesota, Wisconsin, and Iowa involved with this project through phone calls, conference calls, and/or face-to-face meetings. We participated in three conference calls and had email exchanges with the partner agencies in Minnesota, Wisconsin, and Iowa in the fall of 2013 and winter, spring, and summer of 2014 to get the project started and coordinate project approach, activities, timeline, and data collection. We met several times with Lori Sargent, the Michigan DNR's sponsor and main contact on this project, to discuss and develop the project's approach and methods, and provide updates on the project's progress in 2013 and 2014. We also met and worked with Christine Hanaburgh, the MDNR Wildlife Division's Federal Aid Coordinator, in the fall of 2013 to develop Michigan's application to the U.S. Fish and Wildlife Service and the Competitive State Wildlife Grant Program for Michigan's portion of the multi-state grant/project.

We contacted and/or met with the land managers and/or researchers who have been conducting Wood Turtle surveys, monitoring, and/or research in the proposed project areas along the Au Sable River and the Ontonagon River. The Wood Turtle is a Regional Forester Sensitive Species (RFSS) of the Huron-Manistee National Forest. The Mio District of the Huron National Forest has been collaborating with Dr. Timothy Lewis with the University of St. Thomas in Minnesota to conduct Wood Turtle population surveys, monitoring, and research (i.e., radio-telemetry) in the project area on the Huron National Forest for at least the past 15 years. We contacted and met with the USFS wildlife biologists in the Mio District Office (i.e., Kimberly Piccolo and Eric O'Neil) and Cadillac-Manistee District Office (i.e., Philip Huber) of the Huron-Manistee National Forest and Dr. Tim Lewis in the winter and spring of 2014 to review and discuss the project. The USFS staff and Dr. Lewis agreed to share information and collaborate with the MNFI and MDNR on this project. This included working together to track and locate existing Wood Turtles with radio-transmitters and survey for additional turtles within the project area; jointly purchasing additional transmitters to add turtles to the telemetry study for this project; helping to hire, support, and supervise two student researchers to assist with field work for this project during the summer; providing assistance with identifying Wood Turtle nests, turtle nesting areas, areas with suitable turtle nesting habitat, and potential areas for habitat restoration; and/or providing assistance with checking and maintaining turtle nest enclosures. We also developed and submitted an application for a special use permit and was able to obtain a permit from the USFS Huron National Forest Mio Ranger District Office to conduct the project on the Huron National Forest within the Au Sable River study area.

For the Ontonagon River project area, we contacted and discussed the project with the Ottawa National Forest (NF), specifically with the wildlife biologist (i.e., Jeffery Soltesz) from the Bessemer Ranger District of the Ottawa NF who has been coordinating and conducting the Wood Turtle research, monitoring, and management efforts. These efforts have included identifying Wood Turtle nesting areas; working with researchers (e.g., Gary Casper from WI and Richard Buech from MN) and volunteers to document and monitor Wood Turtle nests, nest predation, and nesting success; habitat restoration/improvement; and installing fences along portions of roads (mainly around bridge crossings) to reduce turtle road mortality (Casper and

Buech 2007, Soltesz pers. comm.). We had discussed the project with the Ottawa NF staff during the development of the proposal, and they had expressed interest in collaborating with us on the project. In our discussions in the winter of 2014, the Ottawa NF staff still expressed interest in collaborating with us on this project, but only on the habitat restoration and identification of barriers and dangerous road crossings/road mortality components of the project. While nest predation is an issue for the Wood Turtle population in the Ontonagon River project area, the Ottawa NF staff was concerned that nest protection efforts might bring attention to the Wood Turtle nesting areas and nests within the project area which might make the turtles and nests more vulnerable to illegal collection and/or human disturbance. They also felt that nest predation was not as significant of a threat to the Wood Turtle population in the project area compared to other threats such as road mortality. As a result, we discussed potential options for collaborating on this project including habitat restoration, potentially installing fences along roads to prevent or reduce Wood Turtle mortality, and monitoring responses of the turtle population to these management activities. We were not able to initiate any of these activities in the Ontonagon River project area in the Ottawa NF in 2014. Further discussions with the Ottawa NF staff and potentially other local partners are needed, and will be pursued in the fall of 2014 and winter of 2015. Thus, all conservation actions implemented as part of this project in 2014 were conducted in the Au Sable River project area.

***Wood Turtle Surveys and Tracking Turtle Movements***

Visual surveys were conducted in the Au Sable River project area from 8 May to 22 June 2014 to capture additional Wood Turtles to add to the ongoing radio-telemetry study conducted by Dr. Tim Lewis and the USFS Huron National Forest Mio Ranger District for the telemetry portion of this project. These surveys resulted in the capture of at least 31 Wood Turtles in the project area, of which 27 were new or previously unmarked turtles and 4 were previously marked or recaptured turtles. All new turtles captured in 2014 were examined, measured, weighed, sexed, marked, photographed, located using a GPS unit, and released at initial capture site. Of the 27 new turtles, 19 were females, and 8 were males. All 27 new turtles were adults, with minimum ages (i.e., number of annuli) ranging from 10 to 23+ years old and averaging 19.5 years old. All the recaptured turtles were adult females. With the new and recaptured turtles combined, a total of 23 adult females were found during the surveys in 2014. Of these, at least 13 were believed to be gravid in 2014 based on palpation, occurrence in suitable nesting habitat, and/or observation of nesting during the nesting season. Additional females may have been gravid, but were captured and/or palpated before eggs could be felt or before or after they had nested.

A total of about 33 adult Wood Turtles were tracked for the telemetry portion for this project in 2014. Prior to the start of this project, a total of 18 Wood Turtles (13 adult females and 5 adult males) had been transmittered and tracked as part of an ongoing, long-term Wood Turtle telemetry research project conducted by Dr. Timothy Lewis with the University of St. Thomas in Minnesota and the USFS Huron National Forest Mio Ranger District. Additional radio transmitters (i.e., 15) were jointly purchased by the USFS Huron National Forest, Dr. Lewis, and MNFI to add additional turtles to the telemetry study in 2014. We added 13 new turtles, which were all adult females, to the telemetry study, and replaced the transmitters on two of the previously transmittered turtles. This resulted in a total of about 28 adult females and 5 adult males with transmitters that were tracked as part of the telemetry study.

Turtles were tracked during the active season from 8 May to 15 August 2014, and particularly during the nesting season from 23 May to 22 June. Turtles that were tracked and located in early May appeared to have only recently emerged from their overwintering sites based on their proximity to their overwintering sites and the river, and presence of mud and leeches on the turtles. This was likely due to the extended winter and late spring we had in 2014. Female turtles that were tracked and located in late May and June were often tracked to or near areas with suitable nesting habitat. Female turtles that were tracked to areas with suitable nesting habitat and spent several days to a week in these areas were closely monitored during the nesting season to try to document nesting. Several females that had transmitters and had been part of the telemetry study prior to 2014 appeared to make significant movements within the project area, potentially moving from the west end of the project area to the east end of the project area, although this needs further analysis. Several of the transmittered turtles also were missing or were not able to be tracked or located within the project area in 2014. The telemetry and movement data will continue to be compiled and analyzed this fall and winter, and more complete results will be provided at a later time.

### ***Identifying and Mapping Flood–Safe Nesting Areas*** **(Objective 1a)**

To identify and map flood-safe turtle nesting areas, we examined aerial photographs of the study areas and mapped 103 potential areas with suitable nesting habitat or potential nesting areas along the Au Sable River within the extent of the project area (Figure 4). These areas were basically areas that looked open from the aerial photographs. The Huron National Forest also has identified and mapped 22 erosion sites along the river within the project area, which we included as potential areas with suitable nesting habitat for turtles in the project area (Figure 4).

A subset of the areas that have been mapped as potential nesting areas or areas with suitable nesting habitat as well as additional areas were visited and evaluated in the field in 2014 to determine if these areas provide suitable nesting habitat for turtles and/or if they are currently or recently being utilized by turtles for nesting based on substrate composition, vegetative cover, aspect, slope, and observations of nesting turtles, old turtle nests, and/or turtle eggshell fragments. These data are still being compiled and analyzed, but at least 4 areas were identified as turtle nesting areas based on observations of nesting turtles and/or eggshell fragments in 2014, and 2 additional areas were identified with suitable turtle nesting habitat based on field evaluations (Figure 4). Most of these areas are erosion sites and/or sites actively used and managed for recreational use (e.g., fishing, boat launches). Several of these areas are particularly steep (i.e., slope over 40-50 degrees).

To identify turtle nesting areas or areas with suitable nesting habitat that are safe from flooding, we examined conditions in the field and consulted with local land managers and other site experts. Based on field evaluations, particularly during the spring of 2014, and consultations with the Huron National Forest Mio Ranger District staff and Dr. Tim Lewis, most of the areas that have been verified as turtle nesting areas or areas with suitable turtle nesting habitat are or should be safe from flooding, particularly on the upper slopes of these areas. According to USFS Mio Ranger District staff, the Au Sable River was particularly high in early spring of 2014 compared to most other years. Even with the higher than normal water level in the river, most of the turtle nesting areas, areas with suitable nesting habitat, and all of the Wood Turtle

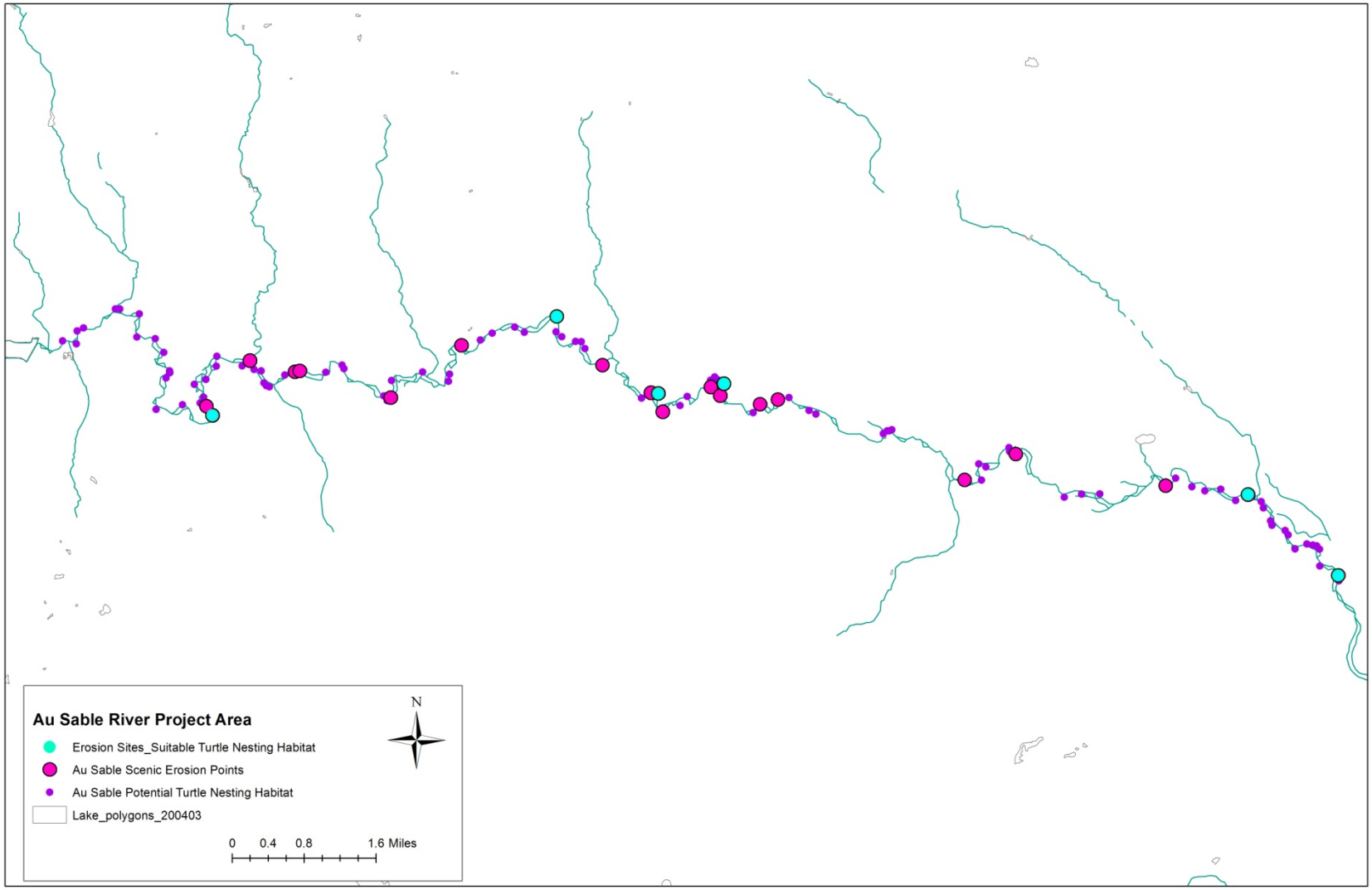


Figure 4. Map of potential areas with suitable turtle nesting habitat based on aerial photo interpretation (small purple circles) and USFS identified scenic erosion sites (pink circles) and areas with confirmed suitable nesting habitat to date (light blue circles) within the Au Sable River study area.

nests documented in 2014 were located above the high water level/mark, and generally quite a distance above the high water level (i.e., at least 5 – 10+ m in some cases), especially in the middle and upper portions of the slopes in these areas. The local USFS Mio Ranger District staff and Dr. Lewis also have indicated that flooding does not appear to occur or be a significant issue for the Wood Turtle population and turtle nesting within the Au Sable River project area.

We will examine and utilize hydrological models such as the U.S. Army Corps Models, HEC-GeoRAS (http://www.hec.usace.army.mil/software/hec-georas/) and the HEC-RAS (http://www.hec.usace.army.mil/software/hec-ras/), if possible, to identify flooding zones and map flood-prone areas within the project areas. Turtle nesting areas and/or areas with suitable turtle nesting habitat will be evaluated in relation to flood-prone areas within the project areas to identify or confirm flood-safe nesting areas. Areas within 500m from the center of the river channels that are most secure from flooding, that provide or could provide suitable nesting habitat, and that are well connected to the river channel and to potential foraging habitat will be delineated and mapped in GIS this fall and winter.

### ***Protecting Nests against Predation*** **(Objective 1b)**

A total of seven Wood Turtle nests were identified, located, and protected at four nesting areas within the Au Sable River project area during the nesting season in 2014 (Table 2). We tracked female turtles and conducted visual surveys in primarily these four areas and a couple other areas from 23 May to 22 June to document nesting. We conducted surveys for nesting turtles at one or two of these areas every day, primarily in the evening, from 9 June to 22 June. The first Wood Turtle nest was documented in the evening on 10 June, and the last nest was documented in the evening on 19 June. Nesting surveys were conducted on 20-22 June, but no nesting turtles were observed. All but one of the protected nests were documented during nesting surveys. One of the nests that were protected (i.e., the one at ASDRS) was identified and reported to us by a member of the general public who had observed a Wood Turtle nesting at that location earlier. We excavated the nest and confirmed that it was a Wood Turtle nest prior to placing a nest enclosure over it. Four of the six female turtles we observed nesting during the surveys nested in the evening (generally between 2000 and 0100 hrs), and two of the females nested during the day (between 1100 and 1600 hrs). One additional Wood Turtle was observed nesting at the ASHO nesting area in the morning on 15 June, but we were not able to locate the nest after nesting was completed and the female left the area.

It is important to note that a large number of female Wood Turtles were observed at these nesting areas during the surveys even though only a small number of turtle nests were actually documented, particularly earlier in the nesting season. For example, on the evenings of 9 and 10 June, 8 to10 turtles (presumably all females) were observed walking around and occasionally digging at the ASHO and ASRPSB nesting areas during the nesting surveys. However, only one female was observed nesting on the night of 10 June. It was interesting to note that female turtles that did not end up nesting in the evenings usually returned to the river or left the nesting area by around 2100 hrs.

Table 2. Summary of Wood Turtle nests that were documented and/or protected in the Au Sable River project area in 2014.

| **Date** | **Wood Turtle ID #** | **Nesting Area**[1] |
|---|---|---|
| 06/10/2014 | Unknown | ASHO |
| 06/11/2014 | 5204 | ASHO |
| 06/11/2014 | 5117 | ASRPSB |
| 06/14/2014 | 5142 | ASHO |
| 06/15/2014 | 5051[2] | ASHO |
| 06/18/2014 | 5210 | ASTE |
| 06/19/2014 | 5212 | ASRPSB |
| - | Unknown | ASDRS |

[1]A key to the abbreviations for the nesting area locations will be provided separately.
[2]Nesting was documented, but nest was not protected in 2014.

Because such a small number of turtle nests were documented during the nesting season in 2014, we decided to protect all the nests instead of leaving some of them unprotected and designating them as control nests. We did continue to survey these areas for predated turtle nests during the summer, and plan to use this information to provide an estimate of nest predation in the four nesting areas. Since we now know the locations of several turtle nesting areas and have better information on the timing and behavior of nesting Wood Turtles, we will hopefully be able to document a larger number of nests in 2015 so that we can monitor protected and control nests to evaluate the effectiveness and impact of nest protection efforts.

In addition to continued surveys for predated nests throughout the summer, Wood Turtle nest enclosures were monitored on a weekly basis from mid-late June through early August to ensure the nest enclosures were still in place and to record any disturbances to the nest or nest enclosures or evidence of nest predation. Three of the nest enclosures were disturbed or became dislodged for some reason and had to be replaced during the summer. Two of the nest enclosures were replaced within a day or several days. One of the nest enclosures was replaced after a couple of weeks because the nest which the enclosure was protecting could not be relocated at first. All three of these nests did not appear to be disturbed during the time they were unprotected, and were carefully excavated a little and reburied to confirm the presence and location of the nest/eggs before replacing or re-installing the nest enclosure over the nest.

Starting on 6 August, we started checking the nest enclosures and nests daily (1-2 times/day) to document hatchling emergence. We started checking the nests in early August for hatchling emergence based on information in the literature and from a species expert in Michigan which indicated that Wood Turtle incubation periods in Michigan should be about 55-60 days. No hatchlings were observed emerging from 6 August to 20 September. Hatchling emergence was first documented at one nest on 21 September. This nest was the first one documented during the nesting surveys, and was laid on 10 June. The incubation period for this nest was 103 days. A total of 9 hatchlings emerged from this nest, of which 8 emerged and were processed and released on 21 September, and an additional hatchling was found in the nest on 22 September and emerged and was released on 23 September. A failed egg also was found in this nest, resulting in a total of 10 eggs in this nest. A second nest had hatchlings emerge on 27-28 September. This nest was the second nest documented during nesting surveys, and was laid on

11 June. The incubation period for this nest was 108 days. A total of 9 hatchlings emerged from this nest as well, with 5 hatchlings found emerged in the nest enclosure in the morning on 27 September, 2 additional hatchlings found in the evening of 27 September, and 2 additional hatchlings found on 28 September. Both these nests were located at the ASHO nesting area.

Surveys to check for hatchling emergence are continuing. The USFS Huron NF Mio Ranger District staff have been assisting with checking the nest enclosures. To date, hatchling emergence has not been documented at the remaining five protected nests. Due to time constraints, the nest enclosure at the Trail's End nesting area/erosion site was removed on 24 September even though hatchlings have not emerged from that nest. A wildlife camera was installed within 2 m of the nest and was set to take a photograph every 5 minutes to continue to monitor this nest site and hopefully document hatchling emergence (assuming it does not get stolen, removed, or disturbed). The wildlife camera will remain at this site and will be checked on a weekly basis until mid-October.

We also were able to collect information about the location and habitat characteristics of the Wood Turtle nest sites that were documented during the surveys in 2014. All but one of the nests (i.e., nest at ASDRS) are located in open, sandy/gravelly substrates. The amount of vegetative cover varies among the nest sites/nesting areas. The three nests at the ASHO nesting area are in very open, sandy/gravelly areas with little to no tree canopy and vegetative cover. The two nests at the ASRPSB nesting area are in open sandy/gravelly substrates but there are some trees along the river and scattered around the nesting area, which do provide or cast some shade on the nest sites. The nest at ASTE is located in a fairly open, sandy/gravelly area but there is some vegetative cover in terms of scattered forbs, herbaceous plants, and small shrubs and tree seedlings. The nest at ASDRS is adjacent to a parking area, and the substrate is more gravelly and loamy with plants. There were grass and forbs growing in the nest enclosure right in/over the nest, and the nest also was shaded by a thick stand of autumn olive until early September. All but two of the nests are located towards the upper portions of the bank or slope within the nesting areas, with one nest located in the lower slope and one nest located towards the lower or middle portion of the slope. Additional habitat analysis will be conducted.

### ***Identifying Barriers and Dangerous Road Crossings*** **(Objective 2a)**

A small number of live and dead Wood Turtles was found crossing roads or on roads at several locations within the Au River project area while driving around the project area in 2014 (Figure 5). Four observations of three different Wood Turtles were documented crossing a paved road at two locations and a dirt road at a different location (Figure 5). An additional Wood Turtle was found on the other side of a paved road from where it had been located several times prior to this, and was assumed to have successfully crossed the road in this area. These four turtles were adult females. Two dead Wood Turtles were found on paved roads at two different locations within the project area in June (Figure 5). A Blanding's Turtle also was dead on a paved road in the project area. The radio-telemetry data need to be analyzed to examine and identify potential barriers and pathways or road crossings that pose threats to Wood Turtles in the Au Sable project area. But at this time, given the small number of Wood Turtles observed crossing roads or found dead on roads in 2014, road mortality may not be a significant threat to the Wood Turtle population in the Au Sable project area, but this should continue to be monitored and assessed.

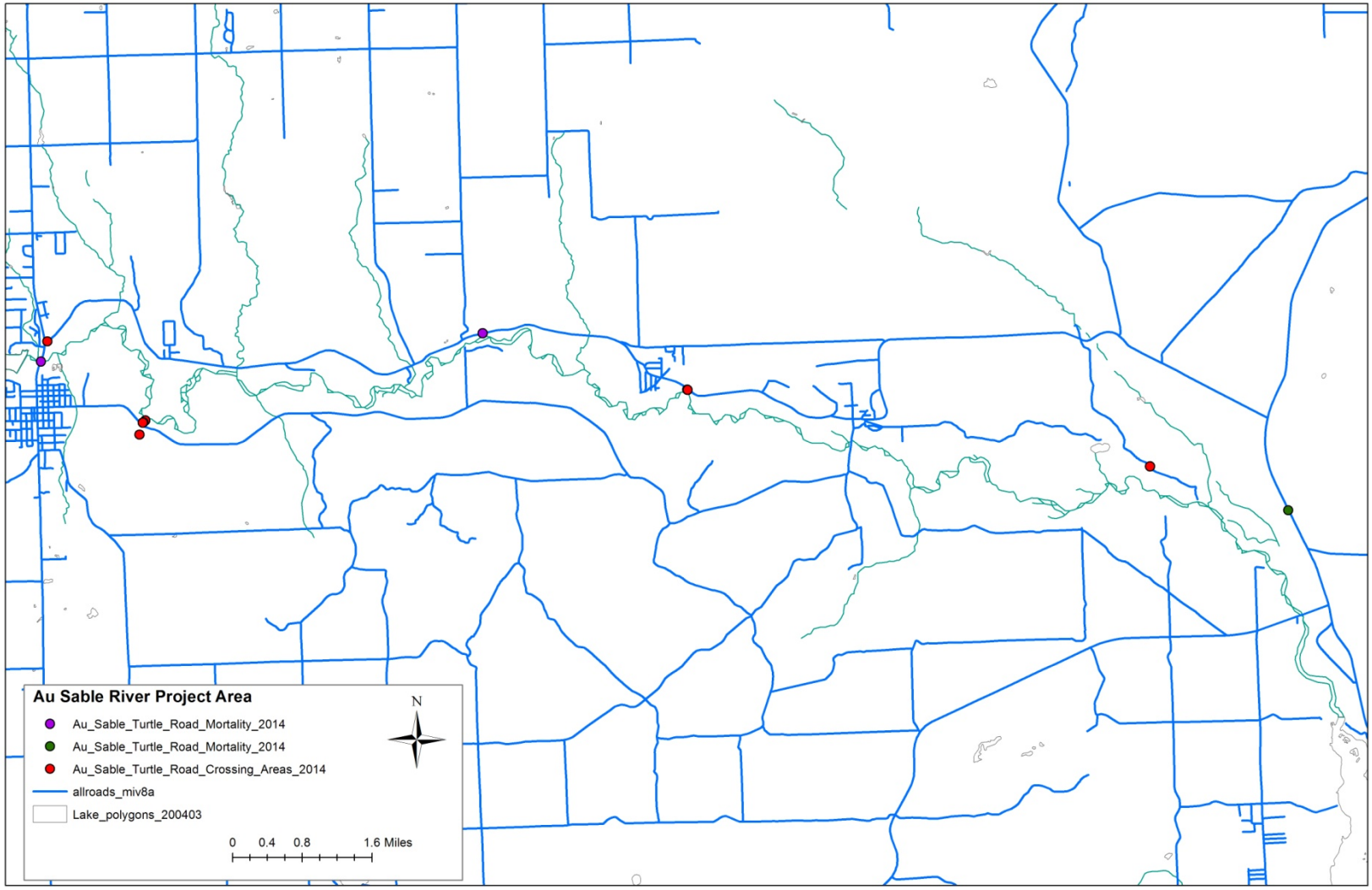


Figure 5. Map of locations where Wood Turtles and other turtles were found crossing roads, presumed crossing roads, or dead on roads in the Au Sable River project area.

***Restoration of Nesting and Foraging Habitat*** **(Objective 3a)**

Based on documentation of Wood Turtle nesting areas and/or areas with suitable nesting habitat within the Au Sable project area, we have initiated discussions with the USFS Huron NF Mio Ranger District regarding several potential areas for habitat restoration, particularly restoration of nesting habitat. These include small areas adjacent to or near three of the four Wood Turtle nesting areas identified in 2014. Habitat management needed at these sites primarily include removal of some trees and clearing of ground vegetation. These areas already have sandy/gravelly substrates. The USFS staff are interested in doing some habitat restoration to provide additional nesting habitat for Wood Turtles and other turtles in the project area as part of this project, and are considering these options. We will continue discussions with the USFS Huron NF Mio District staff and Dr. Lewis regarding these opportunities for habitat restoration. If they agree to do some habitat restoration, these activities will hopefully be conducted in the fall of 2014 and/or winter or early spring of 2015 after the Wood Turtles have returned to their overwintering sites this fall and prior to their emergence next spring.

***Assessing the Effectiveness of Conservation Actions*** **(Objective 4)**

We started to assess the effectiveness of the conservation actions implemented as part of this project using some of the identified short-term parameters and approaches. Table 3 summarizes the results of our assessment. We will continue to assess the effectiveness of our conservation actions as we continue to implement the project and as we complete analysis of data collected this year.

Table 3. Summary of parameters evaluated to date to assess the effectiveness of conservation actions implemented in 2014 in the short-term.

| **Conservation Actions/ Objectives** | **Parameters to Evaluate Short-term Response** | **Approaches and 2014 Results** |
|---|---|---|
| Identifying flood-safe nesting areas | • Monitor whether areas identified as flood-safe nesting areas flood during the nesting season during the project period in 2014 and 2015. | • Three of the four nesting areas identified in 2014 were visited and monitored in the spring and summer, and no flooding of these areas was observed. These and other turtle nesting areas/areas with suitable nesting habitat should continue to be monitored in 2015.<br>• Project partners/local site experts for the Au Sable River project area were consulted in 2014, and they indicated that flooding is not an issue for the Au Sable River project area. This makes sense given the dams/water control structures located upstream and downstream of the project area. Flooding also may not be an issue given the steepness of some of the nesting areas. |

| | | |
|---|---|---|
| Reducing nest predation by protecting nests | • Monitor and compare *predation rate* (i.e., number of nests that are predated) between protected nest sites and control nest sites<br>• Monitor and compare *nesting success* (i.e., number of nests that are successful in terms of having at least one hatchling emerge) between protected nest sites and control nest sites<br>• Monitor and compare *hatching success* (i.e., number of eggs that hatch and/or hatchlings that emerge) between protected nest sites and control nest sites<br>• Monitor and identify *nest predators* around protected or control nest sites, if possible | • Only protected nest sites were available in 2014. No control nest sites were designated due to the small number of nest sites documented in 2014.<br>• *Predation rate of protected nest sites* = 0% at this point in time; none of the protected nests were predated as far as we can tell but we will have to wait until the fate of all protected nests have been determined before final result. *Predation rate of control nest sites* = Not available but did survey and document predated nests in the nesting areas with protected nest sites so will be able to get an estimate of number of predated nests once data have all been compiled.<br>• *Nesting success of protected nest sites* = 2/7, or 29%, at this point in time, but only 2 of the 7 nests have had hatchlings emerge. Will need to determine fate of all protected nests before final result. *Nesting success of control nest sites* = Not available b/c no control nest sites in 2014.<br>• *Hatching success of protected nest sites* = This will be determined after the fate of all protected nests have been determined. *Hatching success of control nest sites* = Not available b/c no control nests in 2014.<br>• Nest predators were not identified or monitored in 2014. Wildlife cameras were installed in the fall of 2014 to try to document hatchling emergence, and may be used in 2015 to try to get information on nest predators. |
| Identifying barriers to movements and pathways and road crossings that pose threats to turtle travel | • Monitor areas identified as potential barriers to movements and pathways and road crossings that pose threats to turtle travel throughout the project period to document turtle use/mortality | • Turtle use of roads and mortality on roads in the Au Sable project area were documented incidentally while driving around the study area doing field work. A small number of live and dead Wood Turtles were found on the roads in 2014 – see results for Objective 2a.<br>• Radio-telemetry and tracking turtle movements during the active season – 2014 data need to be analyzed.<br>• Local partners and site/species experts were consulted in 2014 for the Au Sable River project area. They indicated that they have not documented a significant number of Wood Turtle road crossings or road mortality in the area historically. |

| | | |
|---|---|---|
| Improving nesting and foraging habitat | • Assess and monitor habitat condition prior to and after habitat improvement/restoration<br>• Monitor presence and/or number of Wood Turtles and other turtles using the site for basking, foraging, staging and/or nesting prior to and after habitat improvement.<br>• Monitor presence and/or number of turtle nests prior to and after habitat improvement/restoration. | • Collect pre-habitat improvement/restoration data on these measures in the field in 2014 and 2015 – Data from visual surveys, nesting surveys, nest area/predated nest surveys, and radio-telemetry in 2014 will provide some data and insight into this.<br>• Collect post-habitat improvement/restoration data on these measures in the field in 2015 and 2016 – These data were not collected yet as habitat improvement/restoration activities have not been conducted yet.<br>• Consult and work local partners to obtain these data on these measures. |

## DISCUSSION

Studies and information on Wood Turtle nesting ecology in Michigan are limited. This project will provide additional information and enhance our knowledge and understanding of Wood Turtle nesting ecology in the project areas and in Michigan in general. Prior to this project, information was lacking on Wood Turtle nesting ecology in the Au Sable River project area in terms of the locations and habitat characteristics of their nesting areas, turtle movements to and from nesting areas, timing and duration of the nesting season and hatchling emergence period, nesting and hatching success, nest predation rates, site fidelity to nest sites, etc. This project was able to start obtaining information to answer a number of these questions. This information will be important for management and conservation of the Wood Turtle population in the Au Sable River project area.

Wood Turtle nesting habitat in the Au Sable River project area was for the most part similar to nesting habitat requirements identified in the literature and at other study sites, but there were some interesting characteristics that were slightly different. Wood turtles require open, well-drained, elevated, exposed areas of sand and/or gravel for nesting (Akre and Ernst 2006, Ernst and Lovich 2009, Jones 2009), although appropriate nesting areas vary by geographic region. Based on Wood Turtle research in other areas, suitable nesting habitat generally consist of sandy, gravelly, open areas that are generally south facing, have a slope of less than 40 degrees, have little or no ground vegetation (<20% ground cover), are sunlit most of the day, and receive little human disturbance. The four Wood Turtle nesting areas that were documented in 2014 generally consisted of sandy, gravelly, mostly open areas although the amount of ground vegetation and tree cover did vary among the sites. One of the nesting areas did have quite a few trees growing in it, and two of the nesting areas did have some ground cover and shrubs growing in or adjacent to the nest (>20% cover). Three of the turtle nests in these nesting areas were shaded/partially shaded part of the time by vegetation growing in or adjacent to the nests, which may have impacted nest/egg incubation and delayed hatchling emergence. The four Wood Turtle nesting areas in the project area also were different in that only one of them is south-facing, while the other three nesting areas are west-facing, which is probably the next best alternative to south-facing in terms of receiving warm afternoon sun. Three of the four nesting areas are erosion sites,

and two of them are very steep, with slopes close to or greater than 40 degrees. All four of the nesting areas are recreational areas (i.e., fishing sites, river access sites, and boat launch sites) and receive moderate to high levels of human disturbance or use. Many of the areas along the river that provide open, sandy/gravelly habitat suitable for turtle nesting are erosion and/or recreational sites. While Wood Turtles do seem to nest in some of these areas and no obvious adverse impacts to turtle nests were observed at the four nesting areas, the disturbance levels and steepness of some of these areas may impact Wood Turtle nesting and/or nesting success. However, the steep nature of some of these sites also may deter or reduce nest predation. Wood Turtle nesting ecology at these sites need further investigation.

The location or placement of individual nest sites seems to be similar to what other researchers or studies have found. Wood Turtle nests are usually placed one to three meters above the water line so that they are not subject to flooding, and usually within a few dozen meters and always within a few hundred meters from the river (Ewert et al. 1998), and are well connected to the river (e.g., not separated by a road or ATV trail). This was certainly the case with the Wood Turtle nests documented in the Au Sable River project area in 2014. However, we did not survey for nesting turtles, predated nests, or areas with suitable nesting habitat in areas that were not immediately adjacent to the river. Survey sites in 2015 should include some areas with suitable nesting habitat that are not immediately adjacent to the river.

Also, as in other studies, the Wood Turtle nesting period in the Au Sable River project area was primarily in early to mid-June, from at least 10 June to 19 June. Although we first documented nesting on 10 June, it is likely that nesting started a little earlier than this. We did not feel hard eggs when we palpated several female turtles between 2- 4 June but did feel hard eggs in some females on 9 June and potentially as early as 5-6 June. So nesting may have started as early as 5-6 June. Harding and Bloomer (1979) report that most Wood Turtle populations nest in June. Jones and Willey (2014) also report that Wood Turtles generally nest in June throughout the Northeast region and adjacent areas, although observed nesting dates range from mid-May to mid-July (Harding and Bloomer 1979, Compton 1999, Walde et al. 2007, Akre 2010). Brooks et al. (1992) observed Wood Turtles in Ontario nesting between 7-19 June, and Walde et al. (2007) reported nesting dates between 9–28 June in Quebec, which closely mirrors nesting dates from 12–29 June reported by Harding and Bloomer (1997) for Wood Turtles in Michigan. Based on results from this year and other monitoring studies or protocols, we plan to start intensively tracking and checking female turtles in late May (i.e., around Memorial Day) and starting nesting surveys in late May or early June in 2015.

The length of the nest/egg incubation period and delayed hatchling emergence were particularly surprising and unexpected. The incubation periods for the two nests that have had hatchlings emerge were 103 and 108 days, and the other five protected nests have not had hatchlings emerge yet to date. The extended incubation period and delayed hatchling emergence are likely due to the cool, wet summer we had this year. The incubation time for Wood Turtle eggs is variable and depends on environmental factors such as temperature (Harding and Bloomer 1979). Most nests emerge in August, but emergence ranges from July to October (Jones and Willey 2014). Harding and Bloomer (1979) reported an incubation period of 47 to 65 days (mean=58.9 days) for Wood Turtle eggs collected in Michigan and hatched in the laboratory at room temperature. Walde et al. (2007) reported hatching dates of 17 August to 7 October, and incubation periods ranging from 60 to 116 days, with average incubation periods of 77.5 and

86.8 days for Wood Turtle nests in Quebec. Compton's (1999) degree-day models based on data from field-hatched (n=4) and lab-hatched (n=7) nests from Maine and other reported studies predict that a wood turtle egg will hatch when it has received 788 (SE=10.1) degree-days above a threshold of 12.5°C (54.5°F). Incubation time of the Maine nests ranged from 67 days (at a mean temperature of 24.5°C/76°F) to 113 days (with a mean temperature of 19.5°C/67°F) with a median (n=11) of 89 days.

If the remaining four protected nests do not have hatchlings emerge by the end of this week (i.e., 4 October), we will likely have to remove the nest enclosures over these nests due to lack of time and funding remaining on this year's project budget. We will try to continue to monitor a subset of these nests using wildlife cameras, and will continue to monitor these nests on a weekly basis through mid-October. It is possible that hatchlings will not emerge from some of these remaining nests this year. Compton (1999) suggested that, in northern latitudes, nest failure is likely to occur in some years because of low summer temperatures. It's possible that some of the protected nests may have failed due to the cool, wet summer we had this year. Additionally, successful overwintering of eggs and/or hatchlings has not been documented or confirmed in Wood Turtles (Harding and Bloomer 1979, Walde et al. 2007). Nests that do not have hatchlings emerge this fall will be checked and monitored or excavated in the spring to determine if the eggs and/or hatchlings were able to successfully overwinter.

Although we did not have control nests designated to directly compare with protected nests, we did find some evidence of nest predation at some of the nesting areas, and we were able to demonstrate that Wood Turtle nests could be protected with wire mesh nest enclosures and have hatchlings successfully emerge from them. Our goal or plan in 2015 is to document more Wood Turtle nests so that we can designate and compare nesting success and other parameters between protected nest sites and control nest sites. In order to do this, we will expand the length or duration of our nesting surveys by starting earlier in June, and we will need to have additional surveyors so that we can survey multiple nesting areas per evening. We are going to work with Dr. Lewis try to recruit some student and other volunteers to assist with nesting surveys next year. We also will continue to primarily conduct our nesting surveys in the evenings but may add some early morning nesting surveys as well.

We will continue to make progress on the other project objectives and tasks including identifying flood-safe nesting areas, identifying barriers and pathways that pose threats to turtle movements, and restoring nesting and foraging habitat. To identify flood-safe nesting areas, additional examination of aerial photographs of the Au Sable River project area and other project areas will be conducted to identify areas along the river and within 500m from the center of the river channel that may provide suitable turtle nesting habitat or may represent turtle nesting areas. We also will examine and utilize hydrological models such as those developed by the U.S. Army Corps, if possible, to identify flooding zones and map flood-prone areas within the project areas. Turtle nesting areas and/or areas with suitable turtle nesting habitat will be evaluated in relation to flood-prone areas within the project areas to identify or confirm flood-safe nesting areas. Areas within 500m from the center of the river channels that are most secure from flooding, that provide or could provide suitable nesting habitat, and that are well connected to the river channel and to potential foraging habitat will be delineated and mapped in GIS this fall and winter. Additional analysis of the Wood Turtle survey and telemetry data from 2014 will be conducted this fall and winter to identify barriers and pathways that pose threats to turtle movements in the

Au Sable River project area. We will continue working with the USFS Huron NF Mio Ranger District staff to implement habitat restoration within the project area. We also will continue discussions with the Ottawa National Forest staff to determine if and how some of the project activities can be implemented in the Ontonagon River project area.

Finally, we are considering potentially adding a project area or replacing the Ontonagon River project area if they are no longer interested in collaborating on this project and if the USFWS, MDNR, and Minnesota DNR, the lead agency on this project/grant, approve of this change. The project area we are considering is along the Muskegon River in Osceola and Clare counties. Jim Harding with Michigan State University who has studied and monitored Wood Turtles in Michigan for over 30 years has done some Wood Turtle surveys and monitoring along the Muskegon River, and suggested this area or stretch of the river. Harding (pers. comm.) reports that nest predation is a significant issue along this stretch of the river as well as habitat loss, particularly loss of nesting habitat due to streambank stabilization efforts. The proposed project area primarily occurs on private land although there is some public/state land along the river farther upstream. We will look at the project budget and continue to work with Jim Harding to investigate and evaluate the feasibility of adding this area to the project. We also will consult with the USFWS, MDNR, and the Minnesota DNR regarding this matter.

## LITERATURE CITED


Akre, T. and C. Ernst. 2006. Population dynamics, habitat use, and home range of the wood turtle, Glyptemys (=Clemmys) insculpta, in Virginia. Unpublished report to the Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 257 pp.

Buech R.R., L.G. Hanson and M.D. Nelson. 1997. Identification of wood turtle nesting areas for protection and management. Pages 383-391 in: Proceedings: Conservation, Restoration and Management of Tortoises and Turtles: an International Conference, Abbema et. al. (eds) July 11-16, 1993, SUNY, Purchase NY.

Brooks, R.J., C.M. Shilton, G.P. Brown and N.W.S. $uinn. 1992. Body size, age distribution, and reproduction in a northern population of wood turtles (Clemmys insculpta). Canadian Journal of Zoology 70: 462–469.

Compton, B.W. 1999. Ecology and conservation of the wood turtle (*Clemmys insculpta*) in Maine. Unpublished. M.S. thesis, University of Maine.

Daigle, and Jutras. 2005. Quantitative evidence of decline in a southern Quebec Wood Turtle (*Glyptemys insculpta*) . Journal of Herpetology 39:130-132.

Doroff, A.M., and L.B. Keith. 1990. Demography and ecology of an ornate box turtle (*Terrapene ornate*) population in south-central Wisconsin. Copeia 1990:387-399.

Ernst, C. H. and J. E. Lovich. 2009. Turtles of the United States and Canada. Second edition. Johns Hopkins University Press; Baltimore.

Ewert, M., D. Premo, J.H. Harding, and K. Premo. 1998. Wood turtles and their habitat in Michigan. Report by White Water Assoc., Inc. 11 pp. + cover.

Geller, G.A. 2012. Reducing predation of freshwater turtle nests with a simple electric fence. Herpetological Review. 43:398-403.

Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press. Ann Arbor. 378 pp.

Harding, J.H. and Bloomer, T.J. 1979. The wood turtle, *Clemmys insculpta*. . .a natural history. Herp – Bulletin of the New York Herpetological Society 15:9–26.

Heppell, S.S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia 1998:367-375.

Hilton-Taylor, C. (Comp.). 2000. 2000 IUCN Red List of Threatened Species. Gland, Switzerland: IUCN, 61 pp.

Jones, M.T. 2009. Spatial ecology, population structure, and conservation of the wood turtle (*Glyptemys insculpta*) in central New England. Unpublished. Ph.D. dissertation, University of Massachusetts.

Jones, M. T. and L. L. Willey. 2014. Status and conservation of the Wood Turtle in the Northeastern United States. Draft. University of Massachusetts, Amherst, MA. 273 pp + appendices.

Linck, M. and L.N. Gillette 2009. Post-Natal Movements and Overwintering Sites of Hatchling Blanding's Turtles, *Emydoidea blandingii*, in East-Central Minnesota. Herp Review 40: 411-414.

Massachusetts Cooperative Fish and Wildlife Research Unit and the Northeast Wood Turtle Working Group. 2013. Coordinated monitoring strategy for Wood Turtles (*Glyptemys insculpta*) in the Northeastern United States. Draft. University of Massachusetts, Amherst, MA. 13 pp.

Remsberg, A.J., T.L. Lewis, P.W. Huber, and K.A. Asmus. 2006. Home ranges of Wood Turtles (*Glyptemys insculpta*) in Northern Michigan. Chelonian Conservation and Biology 5(1): 42-47.

Standing, K.L., T.B. Herman, M. Shallow, T. Power, and I.P. Morrison. 2000. Results of the nest protection program for Blanding's turtle in Kejimkujik National Park, Canada: 1987-1997. Chelonian Conservation and Biology 3:637-642.

Walde, A.D., J.R. Bider, D. Masse, R.A. Saumure, and R.D. Titman. 2007. Nesting ecology and hatching success of the wood turtle, *Glyptemys insculpta*, in Québec. Herpetological Conservation and Biology 2: 49–60.

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# APPENDICES

Appendix 1. Wood Turtle observation data sheet for recording observations of and associated information on Wood Turtles found during visual surveys on land and in the river.

**Wood Turtle Observation Data Sheet** (attach to survey and/or nest form(s) if appropriate)

**Processing Start Time:** _____
**Processing End Time:** _____

**Date:** _____ **Study Area:** _____ **Surveyors:** _____
**Capture Time:** _____ **Site Name:** _____
**Notch ID #:** _____ **General Location Description:** _____ **T, R, S:** _____
**PIT Tag #:** _____ **Status:** Initial Capture / Recapture **Landowner:** _____
**Location of PIT tag:** _____ **Transmittered?** Yes / No **Measured** Yes / No
**Frequency:** _____ **Transmitter?** New / Old / Replaced **Notched** Yes / No
**GPS Unit:** _____ **GPS Waypt.:** _____ **EPE:** _____ **Turtle Photos** Yes / No #'s _____
**Latitude (dd.dddd):** _____ **Longitude (dd.dddd):** _____ **Habitat Photos** Yes / No #'s _____
**Weather:** **Air temp (°F):** _____ **Sky Code:** _____
**Wind Code:** _____ **RH (%):** _____ **Precip. Code:** _____

**Sex:** Male / Female / Gravid / Not Gravid / Not Sure Gravid / Unknown **Age class:** Adult / Juvenile / Hatchling
**CPL (cm):** _____ **CPW (cm):** _____ **Height (cm):** _____ **Age/Visible Annuli:** _____ **Clutch size:** _____
**PL (cm):** _____ **PW (cm):** _____ **Mass (g):** _____ with / without transmitter
**General Health:** Healthy / Scars / Injuries
**Injuries:** Tail / Eye / Limb (specify in comments) / Markings / Deformities / Sores / Lethargy / URT Distress / Parasites / Other
**Activity/Behavior:** Basking / Resting / Traveling (land) / Traveling (water) / Carapace / Plastron / **Scute morphology:** Normal / Irregular
**Detection Method:** Visual Survey / Nesting Survey / River Survey / Telemetry / Mating / Nesting / Foraging / Other (describe)
**Turtle in (circle one):** Sun / Partial Sun / Filtered / Shade

**Macrohabitat (natural community type, dominant canopy, understory, shrub and ground cover, species composition, moisture, etc.) :**

_____

_____

**Substrate:** Sedge / Grass / Herb/Moss / Detritus/Leaf litter / Log / Rock / Bare Ground / Sand / Water / Other / Unkn
**Cover:** None / Shrub / Sedge/Grass / Herb/Forb / Detritus/Litter / Log / Water / Other / Unknown
Other/Unknown: _____
**Soil Moisture:** Inundated / Saturated / Moist (mesic) / Dry-mesic / Dry (xeric)

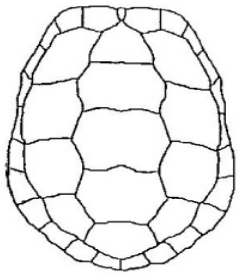
**Habitat Type:** Active / Nesting / Overwintering

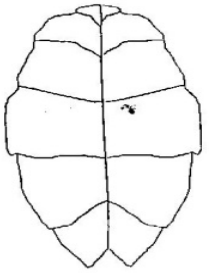
**Tree Canopy:**
___open
___partial
___filtered
___shade

**Position:**
___crest
___upper slope
___mid slope
___lower slope
___bottom

**Slope:**
___flat
___0-10
___10-35
___35+
___vertical

**Indicate notches and record marks or injuries:**

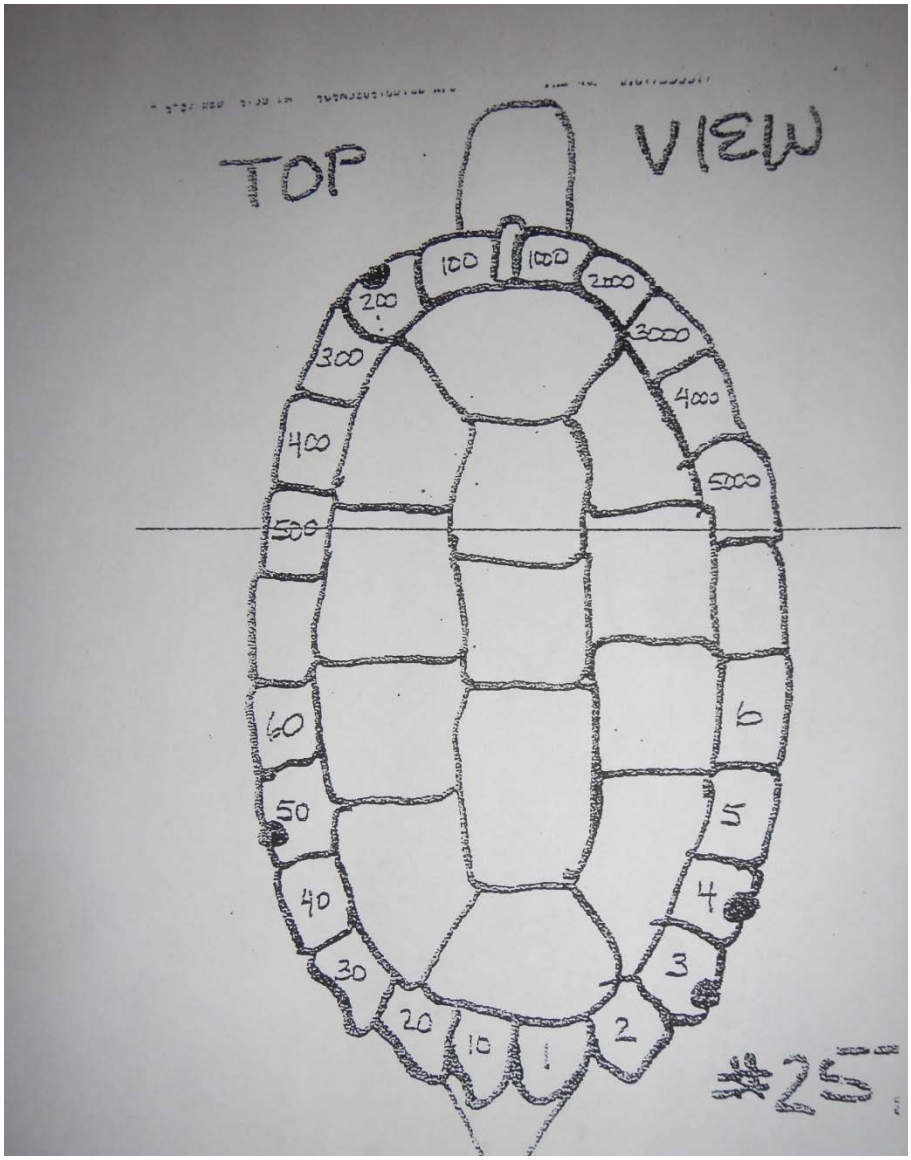




**Comments:**

_____
_____
_____
_____
_____

Appendix 2. Illustration showing turtle notching numbering scheme used for marking Wood Turtles in the Au Sable River project area.



Appendix 3. Wood Turtle Nest Site Form developed by the Huron-Manistee National Forests Mio Ranger District and University of St. Thomas to record information about Wood Turtle nest sites found in the Au Sable River project area.

***Huron-Manistee National Forests Mio RD***
**University of St. Thomas**
**Wood Turtle Nest Site Form**
**(* = required; *italics = biological site only* )**

**Data Entered**
Date _____ Initials_____
**Data in GIS**
Date _____ Initials_____

| *Date: | *Start Time: | *End Time: |
|---|---|---|
| **SITE INFO** *SITE NAME: | | Local ID - Nest Site #: 5_____ |
| *Site Category: admin / bio / use area | *Scientific or Common Name of Survey Species: turtle | |
| ***Nest Site Category is Biological:*** *Site Type: nest* | *Origin Method: direct* | *Origin: natural* *History: new / unk* |
| **Turtle Nest Data** | | |
| GPS Point (in decimal degrees): 44._____ -8__._____ | | |
| Photo (with ruler and labelled bag): Y N | | |
| Slope (%): | | |
| Aspect (degrees): | | |
| Straight line distance to high water mark (meters): | | |
| Vertical distance above stream (m): | | |
| Nest dimensions: shortest axis _____cm, longest axis _____cm, depth _____cm | | |
| Position on Slope: Lower Middle Upper | | |
| Immediate Habitat (5m radius): Sand Gravel Cobble Grass Forbs Shrubs Forested | | |
| Rocks Present: none _____% gravel _____% cobble _____% | | |
| Nest Condition: New Emergent Predated | If emergent or predated, estimated number of eggs: ____ | |
| Shell Sample: Y N | | |
| Soil Sample: Y N | | |
| Nest obliterated after measurements: Y N | | |
| | | |
| *Site Comments: | | |
| | | |

Page 1

Appendix 4. Wood Turtle Nesting Habitat Survey Form developed by MNFI to record information during surveys for areas with suitable nesting habitat.

**Wood Turtle Nesting Habitat Survey Form**

Date: _____ Study Area: _____ Observers: _____

StartTime: _____ Site: _____ T, R, S: _____ GPS Unit: _____

EndTime: _____ Location Description: _____ GPS Waypoint Name: _____

Duration: _____ Survey/ID Method: Canoe/River Survey Visual/Walking Air Photo Other: _____ Latitude: _____

Longitude: _____

General Habitat Description (natural community/forest type, dominant vegetation in/around area, approximate size of area, etc.): EPE: _____

_____ Photos: Yes No

_____ Camera: _____

_____ Photo #'s: _____

Substrate: Sedge Grass Forbs Herb/Moss Detritus/Leaf litter Bare Ground Sand Gravel Silt / Clay Other / Unknown: _____

Cover: None Trees Shrub Sedge/Grass Herb/Forb Detritus/Litter Logs/Wood Water Other / Unknown: _____

Soil Moisture: Inundated Saturated Moist (mesic) Dry-mesic Dry (xeric)

| Tree Canopy: | Position: | Slope: | Aspect: | | |
|---|---|---|---|---|---|
| ___open | ___crest | ___flat | N | S | Height/vertical distance above river: _____ m / ft |
| ___partial | ___upper slope | ___0-10 | NE | SW | Plateau or areas with level ground? Yes No |
| ___filtered | ___mid slope | ___10-35 | NW | SE | Evidence of turtle nesting/shell fragments? Yes No |
| ___shade | ___lower slope | ___35+ | W | E | Potential/likely turtle nesting area? Yes No |
| | ___bottom | ___vertical | | | Explain why/why not? _____ |

Threats: Habitat loss Habitat fragmentation Altered hydrology Incompatible management (mowing, disking, burning etc.)

Invasive species - list spp.: _____ Succession/woody encroachment - list species: _____

Road mortality Human persecution Collection Comments _____

Potential/priority for Habitat Restoration: High Medium Low

Habitat restoration needs/recommendations: _____

_____

_____

_____

Additional comments: _____

_____

Weather: Air temp (°F): _____ Sky Code: _____ Wind Code: _____

Rel. humidity (%): _____ Precipitation Code: _____ Last Rain: _____ Days Ago

**Species Present:** List animal species observed at this site. Note especially listed species and potential turtle/nest predators.

| Species: | Number observed | GPS Waypoint | Photo #'s | Notes, observations, etc. |
|---|---|---|---|---|
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Appendix 5. Wood Turtle Nesting Survey Form (page 1) developed and used by MNFI to record information during surveys to document nesting turtles/turtle nest sites during the nesting season.

Page _____ of _____

**Wood Turtle Nesting Survey Form**

Date: _____ Study Area: _____ Observers: _____

StartTime: _____ Site: _____ T, R, S: _____

EndTime: _____ Location Description: _____

Duration: _____ GPS Waypt.: _____ EPE: _____ Latitude: _____ Longitude: _____

Total Survey Effort (hrs/mins):

| Summary of species: | Wood Turtle | Snapping | Painted | Blanding's | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # Turtles Observed: | | | | | | | | | | | |
| # Nests Observed: | | | | | | | | | | | |

Beginning Weather: Air temp (°F): _____ Sky Code: _____ Wind Code: _____

Rel. humidity (%): _____ Precipitation Code: _____ Last Rain: _____ Days Ago

| Species | Male, NG Female, Nesting Female | Notch ID # | Frequency (if transmittered) | Nesting Activity / Signs | Intact Nest | Predated Nest | # Eggs/ Clutch | # Hatchlings | Signs of Predators/ Disturbance | Photo(s) | GPS Waypoint | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
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Ending Weather: Air temp (°F): _____ Sky Code: _____ Wind Code: _____

Rel. humidity (%): _____ Precipitation Code: _____

*MNFI, 10/01/2014*

Appendix 5. Wood Turtle Nesting Survey Form (page 2) developed and used by MNFI to record information during surveys to document nesting turtles/turtle nest sites during the nesting season.

Page _____ of _____

**Threats:** Habitat loss Habitat fragmentation Altered hydrology Incompatible management (mowing, disking, burning etc.)
Invasive species _____ Succession/woody encroachment - _____
Road mortality Human persecution Collection Comments _____

**Other Species Present:** List additional species observed at this site. Note especially listed species and potential predators. :

| Species: | Number observed | Notes, observations, etc. |
|---|---|---|
| | | |
| | | |
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| | | |

**Directions to survey site and location if first time to site/location:**

_____

_____

**Attach map, air photo or drawing indicating survey area, survey routes and locations of wood turtles and/or suitable nesting habitat.**

**Sky Codes:**
0 = Sunny/clear to few clouds (0-5% cloud cover)
1 = Mostly sunny (5-25% cloud cover)
2 = Partly cloudy, mixed or variable sky (25-50%)
3 = Mostly cloudy (50-75%)
4 = Overcast (75-100%)
5 = Fog or haze

**Precipitation Codes:**
0 = None
1 = Mist
2 = Light rain or drizzle
3 = Heavy rain
4 = Snow/hail

**Wind Codes (Beaufort wind scale):**
0 = Calm (< 1 mph) smoke rises vertically
1 = Light air (1-3 mph) smoke drifts, weather vane inactive
2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face
3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends
4 = Moderate breeze (13-18 mph) moves small tree branches, twigs, and leaves, raises loose paper
5 = Strong breeze (19-24 mph) small trees sway, branches move, dust blows
6 = Windy (> 24 mph) larger tree branches move, whistling

**Macrohabitats:**
**PFO** = Palustrine Forested Wetland: standing water at least part of the year, tree canopy cover exceeds 30%.
**PSS** = Palustrine Scrub-Shrub Wetland: shrub cover exceeds 30%, but tree cover does not.
**SDG** = Palustrine Emergent Wetland dominated by sedges.
**CAT** = Palustrine Emergent Wetland dominated by cattails.
**UFO** = Upland Forest: >30% tree canopy cover, elevated above any potential flooding by sloping topography.
**USS** = Upland Scrub-Shrub: berry bushes, willows, crab apples and hawthorns, typically mid-succession.
**OLD** = Oldfield: fallow fields covered with herbaceous or grassy cover, includes CRP lands.

*MNFI, 10/01/2014*

Appendix 6. Design for turtle nest enclosure developed and used by Patrick Laarman to protect Eastern Box Turtle nests in the Huron-Manistee National Forests Manistee Ranger District in Michigan. Wood Turtle nest enclosures used for this project was based on this design.