UPPER MIDWEST RIVERINE TURTLE HABITAT IMPROVEMENT

by: Carly Lapin, Tiffany Bougie, and Jim Woodford.
Wisconsin Department of Natural Resources, 107 Sutliff Avenue, Rhinelander, WI 54501

Final Project Report for Period: December 1, 2013 – December 31, 2015

ACROSS ALL FOUR STATES:

PROJECT OBJECTIVE 1: IMPROVE TURTLE NESTING SUCCESS BY NEST SITE MANAGEMENT
Objective 1a: Identify locations of nesting habitats that are safe from frequent normal year flooding events in 10 river stretches considered in this project
Objective 1b: Increase turtle nesting success by reducing the effects of predation using a variety of methods at a minimum of 12 total nesting areas: 10 for wood turtle (*Glyptemys insculpta)* and 2 for smooth softshell turtle (*Apalone mutica*).

PROJECT OBJECTIVE 2: REDUCE ADULT TURTLE MORTALITY BY INCREASING CONNECTIVITY AMONG HABITATS THAT TURTLES USE TO COMPLETE THEIR LIFE CYCLE
Objective 2a: Identify barriers to movements and pathways that pose a threat to turtle travel needed by wood, false map (*Graptemys pseudogeographica*), painted (*Chrysemys picta*), and snapping turtles (*Chelydra serpentina*) to complete their normal life cycle in a minimum of eight river stretches (or project sites).
Objective 2b: Reduce mortality of adult turtles at a minimum of 10 road or bridge crossings by a variety of methods in a minimum of 5 river stretches

PROJECT OBJECTIVE 3: IMPROVE TURTLE HABITAT IN RIVER AND STREAM CORRIDORS
Objective 3a: 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 a minimum of 40 total nesting sites: 36 for wood turtle and four for smooth softshell turtle.
Objective 3b: Restore a minimum of 100 total acres of habitat that could be used for foraging by wood turtle at 3 project sites

PROJECT OBJECTIVE 4: ASSESS THE EFFECTIVENESS OF CONSERVATION ACTIONS BY MONITORING TURTLE USE, ABUNDANCE, AND HABITAT RESPONSE
Objective 4a: Identify and measure at least six parameters that best evaluate the short term response of turtle populations to conservation actions implemented
Objective 4b: 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.

TASKS IDENTIFIED SPECIFICALLY FOR WISCONSIN:

Task 1: Survey, capture, and mark wood turtles on two stretches of the Squirrel and Tomahawk rivers in Oneida County (Study Area 1). Survey, capture, and mark wood turtles on two stretches of the Totogatic[1] and Namekagon rivers in Washburn and Burnett counties (Study Area 2; Fig. 1). Total river distances for Study Area 1 = 41.1 km, and Study Area 2 = 62.3 km.

Project Objectives Addressed: 1a, 2a, 4a, 4b

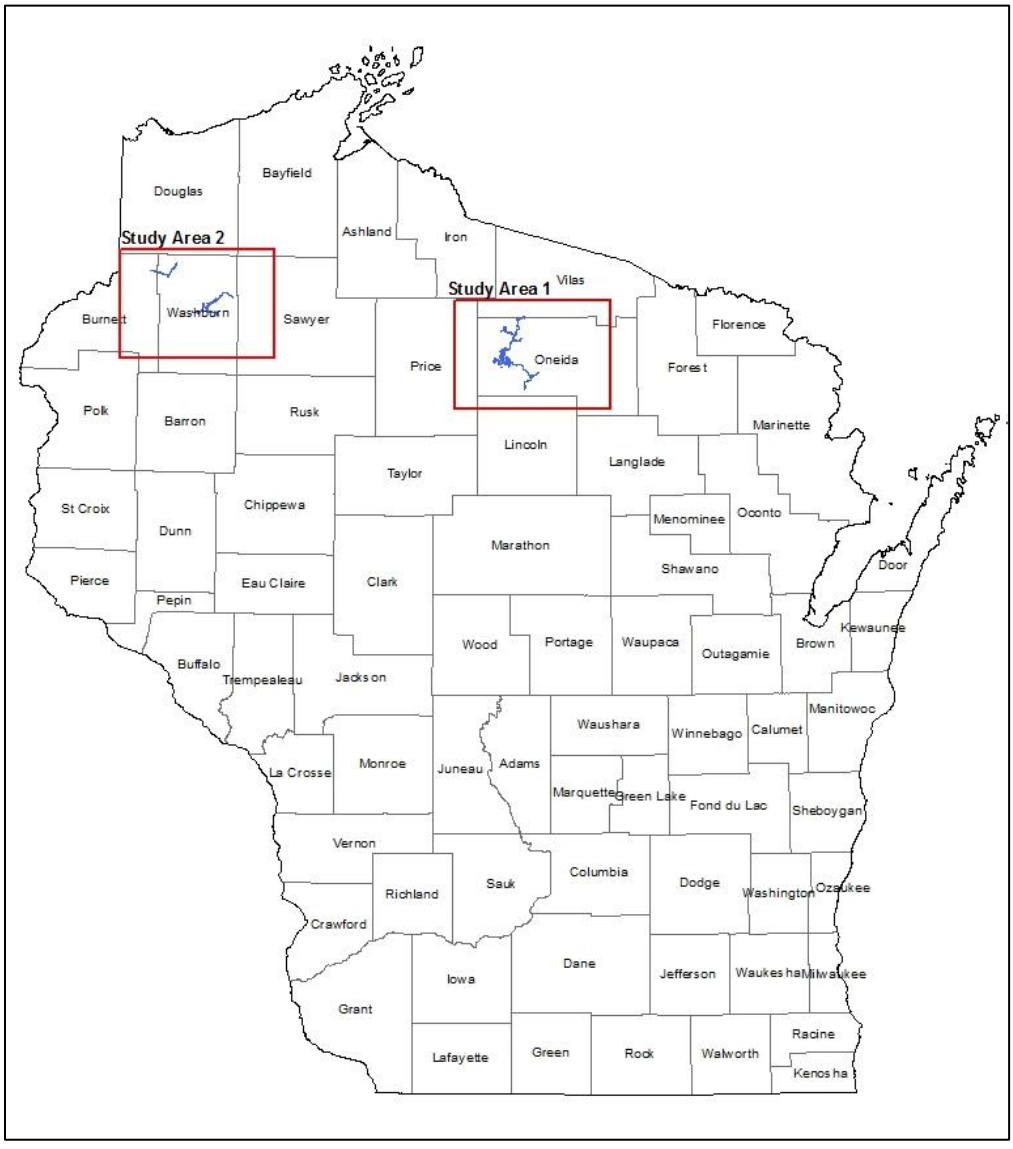

Fig. 1. Locations of riverine turtle project study areas in Oneida, Washburn, and Burnett Counties, Wisconsin, 2014-2015.

[1] Project study site was adjusted from St. Croix River in Washburn and Burnett counties to the Totogatic River for logistical reasons and in response to reports of wood turtle presence on the Totogatic River.

Planning

Preparation for Task 1 began in winter 2014 with a literature review, investigation into survey methodologies, equipment purchase, staff recruiting, schedule planning, and preparation of an Application to Use Animals for Research or Teaching to the Wisconsin Department of Natural Resources (WDNR) Animal Care and Use Committee. Data sheets, protocols, and maps of study areas were prepared for the field season. The National Park Service (NPS) was contacted for permission to conduct work on the Namekagon River, which is a National Scenic Riverway and afforded the same status and protections as a National Park.

Methods

We conducted wood turtle surveys during April and May on sunny days with air temperatures >55°F (13°C), water temperatures from 45-60°F (7-16°C), and prior to leaf-out (Ewert et al. 1998). A survey crew consisted of 2-4 observers paddling by canoes, stopping to search river banks accessible to turtles to look for wood turtles within approximately 10 m of the water (Daigle 1997). Wood turtles were also captured with a net when observed in/near the water or basking on logs (Fig. 2), and they were occasionally observed mating (Fig. 3). Outside of the survey period, wood turtles were also captured and marked opportunistically when observed during nest searching, monitoring, and other field activities.

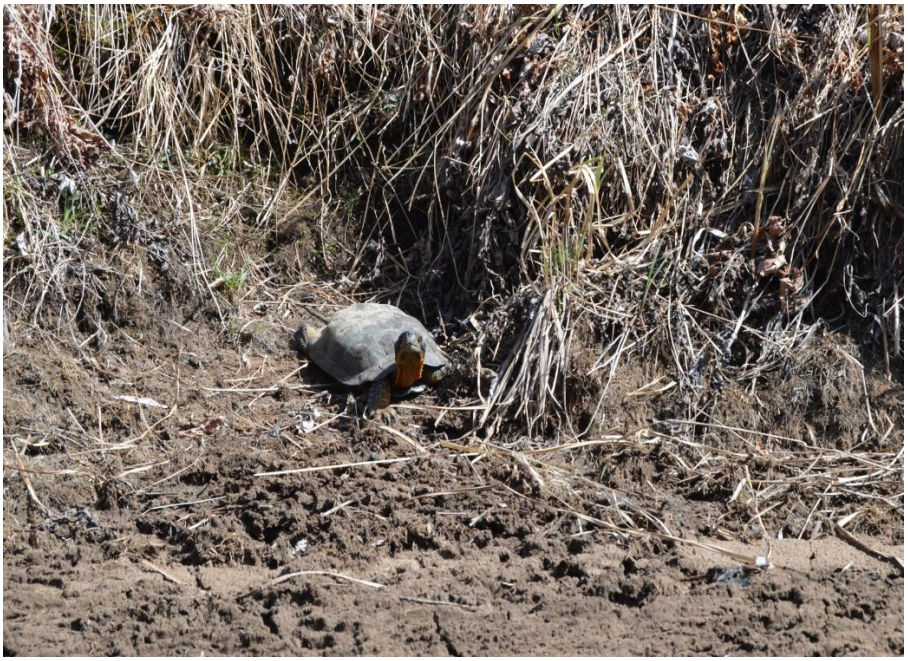

Fig. 2. An adult male wood turtle basks on a stream bank in northern Wisconsin, 2015. Photo by Donald Brown.

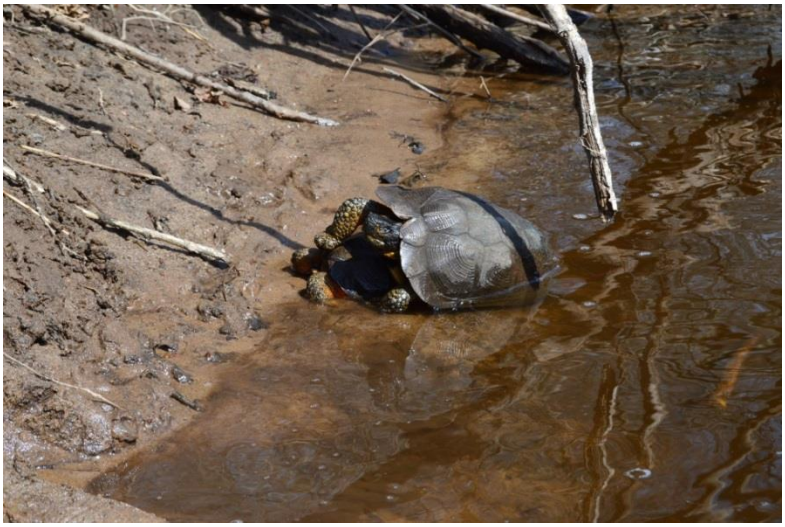

Fig. 3. Wood turtles observed mating in northern Wisconsin, 2015. Photo by Donald Brown.

Upon capture, we processed and marked the turtles (Fig. 4). Processing involved recording general location and habitat data as well as a number of physical measurements. For each turtle, we recorded age, sex, gravidity, weight, straight carapace and plastron length, straight carapace and plastron width, injuries or other identifying marks, general health comments, and took photos of the turtle's carapace, plastron, and head. With the exception of very small juvenile turtles (hatch-year), all turtles captured and processed were marked with a passive integrated transponder (PIT) tag (Biomark, Inc., Boise, Idaho) placed intraperitoneally in front of the right rear leg (Donald J. Brown, *pers. communication*). In addition, all turtles were temporarily marked with a spot of brown paint on the rear carapace for easy field identification during future encounters. Detailed field protocols and data sheets are provided in the appendices of this report.

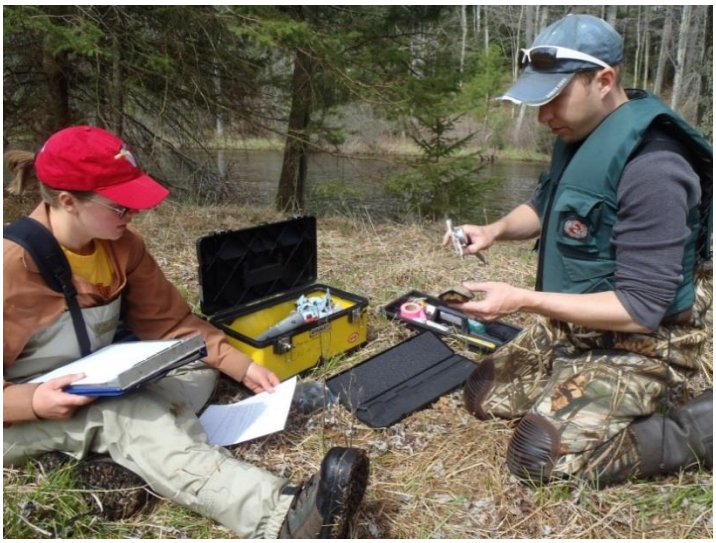

Fig. 4. Processing a captured wood turtle in northern Wisconsin, 2014. Photo by Donald Brown.

We estimated adult turtle population numbers for each of the study areas using the Lincoln-Petersen mark-recapture estimator used by Chapman (1951) with variance and 95% confidence intervals (Seber 1982). Our initial mark period included the 2014 river surveys and active nesting periods (May 14 – June 30, 2014). The recapture period included surveys in the same areas, conducted from April 15 – June 20, 2015. New individuals encountered during the recapture surveys were also marked with PIT tags. No turtles with transmitters left their respective study areas during the mark-recapture period. If no adult turtles were captured in a river stretch in either 2014 or 2015, the population abundance is a minimum count for that stretch of river (mark-recapture not possible).

Signs of turtle activity began a bit later than anticipated in 2014 due to an unusually cool and prolonged spring, which was then followed by an almost immediate switch to warm, summer-like weather and rapid leaf-out during the week of May 26. This resulted in a limited window of favorable conditions for conducting wood turtle surveys; turtles were very difficult to find in the warm air temperatures during the second week of scheduled surveys. Conditions in 2015 were much more suitable for conducting wood turtle surveys, with wood turtle activity starting approximately a month earlier (mid-April) than in 2014 and weather patterns holding steady and spring-like for over a month.

Results

Study Area 1: In 2014, we surveyed both river stretches in Study Area 1 once from May 14 – May 28; wood turtles were found on both river stretches. A total of 37 wood turtles (11 males, 19 females, and 7 juveniles) were processed and all were marked with a PIT tag before release (Table 1). In 2015, we surveyed both river stretches in Study Area 1 twice between April 15 and May 17; wood turtles were once again found on both river stretches. A total of 36 wood turtles (14 males, 18 females, and 4 juveniles) were processed and all but 2 juveniles were marked with a PIT tag before release. Painted and snapping turtles were also observed during surveys.

The minimum population count for adult wood turtles on the Squirrel and Tomahawk rivers [redacted] was five. The population estimate for adult wood turtles on the Tomahawk River [redacted] was 105 with a 95% confidence interval of 73 to 138 in 2015.

Study Area 2: In 2014, we surveyed both river stretches in Study Area 2 once from May 21 – May 30. No wood turtles were found on the Totogatic River. A total of 14 wood turtles (2 males, 9 females, and 3 juveniles) were captured and processed on the Namekagon River and all but one juvenile were marked with a PIT tag before release (Table 1). In 2015, we surveyed both river stretches in Study Area 2 twice from April 28 to May 16; wood turtles were found on both river stretches. A total of 12 wood turtles (2 males, 9 females, and 1 juvenile) were processed and all were marked with a PIT tag before release. Painted and spiny softshell (*Apalone spinifera*) turtles were also observed during surveys.

The estimated population size for adult wood turtles on the Namekagon River was 44 with a 95% confidence interval of 20 to 68 in 2015. The minimum adult wood turtle count was four for the Totogatic River stretch of our study.

Table 1. Results of wood turtle surveys by sex and age for two study areas in northern Wisconsin, 2014-2015.

Site	2014			2015			Total		
	Male	Female	Juvenile	Male	Female	Juvenile	Male	Female	Juvenile
Study Area 1[a]	**11**	**19**	**7**	**14**	**18**	**4**	**25**	**37**	**11**
Squirrel/ Tomahawk Rivers	1	3	1		1		1	4	1
Tomahawk River	10	16	6	14	17	4	24	33	10
Study Area 2[b]	**2**	**9**	**3**	**2**	**9**	**1**	**4**	**18**	**4**
Totogatic River				1	3		1	3	
Namekagon River	2	9	3	1	6	1	3	15	4
Project Total	**13**	**28**	**10**	**16**	**27**	**5**	**29**	**55**	**15**

[a] Oneida County, Wisconsin
[b] Washburn and Burnett counties, Wisconsin

Future Work

Ideas for future efforts include re-surveying Study Areas 1 and 2 for annual population estimates (mark-recapture). In addition, these survey strategies could be applied to any watershed in the state for a better understanding of wood turtle populations statewide.

Currently, the state of Wisconsin lacks sufficient data to complete robust regional wood turtle population models or viability assessments. Due to the species' listed status in the state, it is important to have a sound understanding of its distribution and population status. We are planning a Phase 2 Upper Midwest Riverine Turtle Habitat Improvement Project, which will promote conservation actions of this task in new areas of the state. Phase 2 will focus primarily on nest site restoration and conservation (see Tasks 3 and 4), but wood turtle surveys will be conducted first, using the methods developed here, in new watersheds to confirm the species' presence. The project areas will be surveyed again in the second year of the study for mark-recapture analysis (using the PIT tags described above) to develop population estimates for other watersheds in the state. We are hoping that by regionally expanding on the work that we began with this project, we will contribute to science-based wood turtle conservation efforts in Wisconsin.

Task 2: Conduct telemetry on 20 wood turtles per year in Study Areas 1 and 2.

Project Objectives Addressed: 1a, 2a, 3b, 4a, 4b

Planning

Preparation for Task 2 began in winter 2014 with a literature review, investigation into transmitter and GPS unit types and technology, attachment techniques, equipment purchase, staff recruiting, schedule planning, and preparation of an Application to Use Animals for Research or Teaching to the Wisconsin Department of Natural Resources (WDNR) Animal Care and Use Committee. Data sheets, protocols, and maps of study areas were prepared for the field season. A plan for the number, size, and gender of turtles to be tracked in each study area, as well as the frequency of monitoring was determined. The National Park Service (NPS) was contacted for permission to conduct work on the Namekagon River.

Methods

We used ultra-high frequency (UHF) radio-transmitters (*n* = 30), model A1-2FM (Holohil Systems Ltd., Carp, Ontario, Canada) that weighed approximately 35 g each. We attached the transmitters to the right rear edge of the turtle's carapace using epoxy PC-7 (Protective Coating Col, Allentown, Pennsylvania; Fig. 5). Turtles were held overnight to allow the epoxy to cure, and released the following day. Transmitters were only attached to adult wood turtles that were ≥730 g in weight so that the combined weight of the transmitter, antenna, and epoxy would not amount to more than 7% of an individual animal's weight (Anonymous 2004). We attempted to distribute the transmitters evenly between the two study areas and at a ratio of approximately 1:2 male to female wood turtles. The transmitters were deployed during spring surveys and opportunistically as female wood turtles were captured following nesting. Due to the overnight holding period required to attach a transmitter, no gravid females were held for transmitter attachment to avoid causing undue stress.

We also attached GPS Geolocating Tags (GPS Bugs hereafter; *n* = 10) from Lotek Wireless Fish & Wildlife Monitoring (Newmarket, Ontario, Canada) that weighed approximately 12 g. These tags were designed to collect a GPS location (i.e., latitude and longitude) for tagged turtles every 4 hours under favorable conditions (i.e., good satellite reception). The GPS Bugs were attached to the left rear edge of the turtle's carapace using epoxy PC-7 (Fig. 5). The GPS Bugs are data loggers only, so they were attached to turtles that were already carrying UHF radio-transmitters so we could retrieve the locational data. GPS Bugs were only attached to adult wood turtles that had all four limbs and were ≥1,020 g in weight so that the combined weight of all equipment and epoxy would not amount to more than 7% of an individual animal's weight (Anonymous 2004). Ten GPS Bugs were deployed in Study Area 1 in 2014 and the remaining five functional units were deployed in Study Area 2 in 2015. DNR Staff intended to use the units to locate wood turtle nesting sites, so most GPS Bugs were deployed on female wood turtles. As with the transmitters, no gravid females were held overnight for GPS Bug attachment to avoid undue stress.

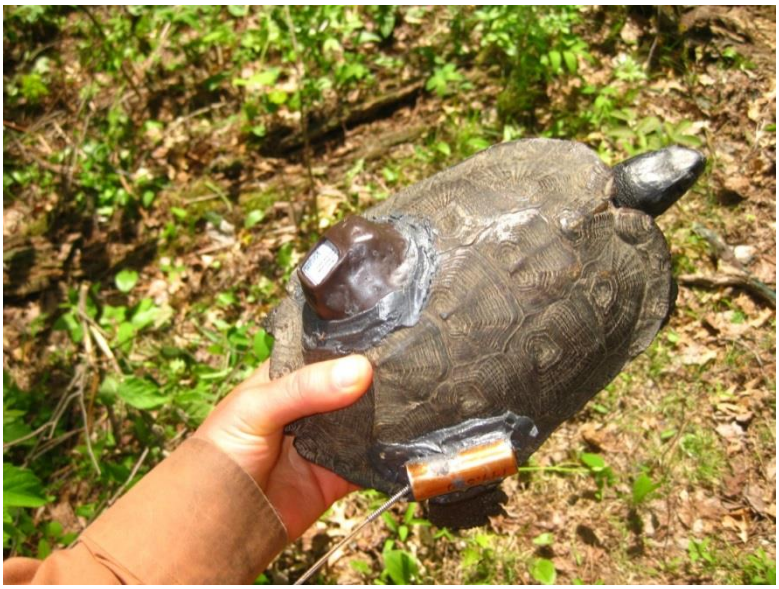

Fig. 5. An adult female wood turtle with a transmitter (right rear carapace) and GPS Bug (left rear carapace) in northern Wisconsin, 2015. Photo by Carly Lapin, WDNR.

During the wood turtle active season (approximately April – October) in 2014 and 2015, we attempted to find transmittered wood turtles one or more times per week. If time and property access permitted, we attempted to visually locate the turtle's position in the field; if that was not possible, then turtles were triangulated using radio telemetry. Throughout the course of the study, we documented wood turtle mortalities as soon as they were observed. During the inactive season (approximately October – April), we attempted to locate the monitored turtles once per month using telemetry from nearby roads or by flying decreasing concentric circles via fixed-wing aircraft. Turtle monitoring concluded in September 2015, and all transmitters and GPS Bugs were removed from study animals.

We conducted telemetry on 12 transmittered turtles (4 males, 8 females) in Study Area 1 in 2014 (Table 2). GPS Bugs were deployed from June 4 – June 5 on male turtles and from June 20 – June 21 on female turtles[2] in Study Area 1. From May 20 – October 30, all individuals were located as many times as feasible given staff availability and obligation to other project components, and a total of 1,576 wood turtle locations were recorded (including GPS Bug data) in Study Area 1 in 2014 (Table 3). The GPS Bugs were attached to turtles in Study Area 1 through September 5, 2014, at which time they were retrieved from the field. Turtle overwintering locations were documented using telemetry during the last week of October 2014, and monthly monitoring continued over the course of the winter.

In 2015 we monitored 11 turtles that were transmittered in 2014 plus two additional adult female wood turtles (Table 2). From April 10 – September 25, all individuals were located as many times as feasible

[2] GPS Bugs did not arrive in time to attach during initial capture, resulting in rather late (mid-June; post-nesting) deployment on female wood turtles

given staff availability and obligation to other project components, and a total of 160 wood turtle locations were recorded in Study Area 1 in 2015 (Table 3).

Wisconsin DNR and NPS staff monitored 10 transmittered turtles (2 males, 8 females) in Study Area 2 in 2014 (Table 2). From June 12 – October 30, all individuals were located as many times as feasible given staff availability and obligation to other project components, and a total of 159 wood turtle locations were recorded in Study Area 2 in 2014 (Table 3).

Eight additional transmitters were attached to adult female wood turtles in Study Area 2 in 2015, and GPS Bugs were attached to 4 adult female wood turtles from June 12 – August 5 (Table 2). From May 1 – September 22, all individuals were located as many times as feasible given staff availability and obligation to other project components, and a total of 1,129 wood turtle locations were collected in Study Area 2 in 2015 (Table 3).

Table 2. Wood turtles monitored using transmitters and GPS Bugs in two study areas in northern Wisconsin, 2014-2015.

Site	2014 Turtles with Transmitters		2015 Turtles with Transmitters[a]		2014-2015 Turtles with GPS Bugs[b]		Total Monitored Turtles	
	Male	Female	Male	Female	Male	Female	Male	Female
Study Area 1[c]	**4**	**8**	**0**	**2**	**3**	**5**	**4**	**10**
Squirrel/ Tomahawk Rivers	1	1			1	1	1	1
Tomahawk River	3	7		2	2	4	3	9
Study Area 2[d]	**2**	**8**	**0**	**8**	**0**	**4**	**2**	**16**
Totogatic River				3		1		3
Namekagon River	2	8		5		3	2	13
Project Total	**6**	**16**	**0**	**10**	**3**	**9**	**6**	**26**

[a] Turtles outfitted with transmitters in 2014 continued to be monitored in 2015. These numbers reflect only new turtles outfitted with transmitters in 2015.
[b] GPS Bugs were used in Study Area 1 in 2014 and Study Area 2 in 2015.
[c] Oneida County, Wisconsin
[d] Washburn and Burnett counties, Wisconsin

Table 3. Results (number of locations) of wood turtle monitoring using telemetry and GPS Bugs in two study areas in northern Wisconsin, 2014-2015.

Site	2014 Number of Location Records[a]		2015 Number of Location Records[a]		Total Location Records	
	Male	Female	Male	Female	Male	Female
Study Area 1[b]	**325**	**1,251**	**17**	**143**	**342**	**1,394**
Squirrel/ Tomahawk Rivers	137	313	5	5	142	318
Tomahawk River	188	938	12	138	200	1,076
Study Area 2[c]	**33**	**126**	**28**	**1,101**	**61**	**1,227**
Totogatic River			0	195	0	195
Namekagon River	33	126	28	906	61	1,032
Project Total	**358**	**1,377**	**45**	**1,244**	**403**	**2,621**

[a] Higher location record numbers correspond with the use of GPS Bugs, which were programed to record location every 4 hours.
[b] Oneida County, Wisconsin
[c] Washburn and Burnett counties, Wisconsin

We estimated adult turtle survival using both the Mayfield (Mayfield 1975) and Kaplan-Meier (Pollock et al. 1989) methods. We used Systat version 10 (SPSS, Inc., Chicago, IL) to calculate Kaplan-Meier survival estimates, and to examine the effects of the covariates sex and age on survival.

Home Range: Many turtle locations acquired during this study included visuals of the study animals. Locations determined by telemetry included $\geq$3 bearings that were $\geq 45^0$ apart by compass and collected within 30 minutes of each other. We used an Excel program (University of Wisconsin, Madison, Wisconsin) to calculate each turtle location and error ellipse. We only used one location per 24hr period for home range development, and censored all nesting period locations for females. We developed 95% adaptive kernel home ranges for each turtle using ArcView 3.3 with the Animal Movement Extension (Hooge and Eichenlaub 2000) for animals with a minimum of 20 locations that had error ellipses $\leq$20 ha.

Results

We monitored 22 and 30 adult wood turtles with radio-transmitters in 2014 and 2015, respectively.

Study Area 1: There was one adult wood turtle mortality (male) and 4 adult wood turtle mortalities (1 male, 3 females) in 2014 and 2015, respectively. Although several carcasses were too decomposed to determine cause of death, one necropsy was conducted, and the cause of death was determined to be predation. All mortalities were assumed to be from natural causes (i.e., drowning, exposure, or predation) based on the condition and locations of the carcasses. During surveys, we observed that 28% (*n*= 7) of adult male wood turtles were missing whole or partial limb or limbs. These injuries were completely healed and the turtles did not appear limited. Our hypothesis is these injuries were due to encounters with mammalian predators. We also sampled several living study animals (*n* = 7) from the Study Area 1 population in 2015 to test for ranavirus and herpes virus; all tests were negative.

Study Area 2: In Study Area 2, there was 1 adult wood turtle mortality in each of the 2 years of the study. In 2014, an adult female wood turtle died after being hit by a car near a bridge crossing on the Namekagon River. In 2015, another adult female wood turtle was found dead. Although the carcass was too decomposed to determine the cause of death, this mortality was assumed to be from natural causes (i.e., exposure or predation) based on the condition and location of the carcass.

Survival and Home Range Size: Our study included two full nesting periods (2014 and 2015) for wood turtles in northern Wisconsin. Most wood turtle mortalities occurred during the summer months. All of the female mortalities (n = 5) occurred during or immediately after the nesting period (mid-June to early July). There were two male mortalities; one occurred during the winter of 2014-2015, and the other occurred in July 2015. Weekly survival, based on the Mayfield analysis, was 0.997 in 2014 and 0.994 in 2015. Annual Mayfield survival probabilities in 2014 (n = 22) and 2015 (n = 29) were 85% and 75%, respectively. The covariates sex and age had no statistically significant effect on adult turtle survival, so we pooled all data for additional K-M analyses. The overall K-M survival probability for the entire monitoring period of 494 days was 0.734 (*SE* = 0.046). Annual K-M survival probabilities were 0.844 (*SE* = 0.084) and 0.762 (*SE* = 0.0940) for 2014 and 2015, respectively.

During project surveys, we found that 28% (n= 8) of adult male and 4% (n=2) of adult female wood turtles were missing whole or partial limb or limbs. These injuries were completely healed and the turtles did not appear limited. Our hypothesis is these injuries were due to encounters with mammalian predators and/or snapping turtles.

Average home range size for adult male wood turtles in Study Area 1 was 17.3 ha (range = 14.8–21.1; n = 3). We did not have enough locations to determine home range size for adult males in Study Area 2. Average home range sizes for adult female wood turtles were 7.4 ha (range = 4.0–12.4; n = 7) and 20.5 ha (range = 1.8–87.6; n = 6) for Study Areas 1 and 2, respectively.

Future Work

We plan to use the locational data and home range estimates to investigate wood turtle movement patterns and habitat use in northern Wisconsin. In addition, these methods could be applied to other watersheds in wood turtle range to provide a better understanding of wood turtle ecology.

As described above, we are planning a Phase 2 Upper Midwest Riverine Turtle Habitat Improvement Project, which will include activities described in tasks 1, 3, and 4 of this report. However, the planned project will not include telemetry. The intent of telemetry in this project was to use the information gained from detecting wood turtles regularly to identify nesting sites, but over the course of the project, we discovered that it is relatively easy to find nest sites using pre- and post-season reconnaissance of project areas, as well as intensive monitoring of the project areas during the nesting season. Telemetry is very costly in terms of equipment and staff time, and we don't believe it is required to accomplish the conservation objectives of the Phase 2 project (i.e., nest site habitat restoration, nest protection, improved recruitment, and reduced adult mortality).

Task 3: Install predator exclusion devices on 15 wood turtle nests in Study Area 1 and another 15 wood turtle nests in Study Area 2.

Project Objectives Addressed: 1b, 4a

Planning

Preparation for Task 3 began in winter 2014 with a literature review, investigation into methods of turtle nest protection, equipment purchase, and consultation with other agency personnel that had installed protective devices at wood turtle nest sites in northern Wisconsin. Data sheets, protocols, and maps of study areas were prepared for the field season.

Methods

We used two different types of predator exclusion devices during the course of the project: individual nest cages (Fig. 6) and electric fencing around entire nest sites (Fig. 7). Nest cages were constructed using 1x2 in (2.5x5 cm) mesh wire fencing cut down and assembled to 16x16 in (41x41 cm) wide and 7 in (18 cm) tall, open on the bottom. These cages were placed over individual wood turtle nests and secured at all four corners using 6 in (15 cm) metal tent spikes. The wire mesh gauge for these cages was large enough to allow hatchling turtles to escape while still protecting the nests from depredations. Electric fence exclosures were constructed at known turtle nest sites using 5x5 in (13x13 cm) mesh wire fencing installed around three sides of the nest site furthest from the water. Two strands of electrified wire were placed to completely encircle the fenced area and powered by a solar-powered electric fencer (Fi-Shock, Woodstream Corp., Lititz, PA, USA). The two electrified wires were hung at approximately 15 and 30 in (38 and 76 cm) above ground level. We also installed time-lapse and motion activated trail cameras (PC900 Hyperfire, Reconyx, Holmen, WI, USA) at six restored nesting areas to document predator activity and nest hatching success.

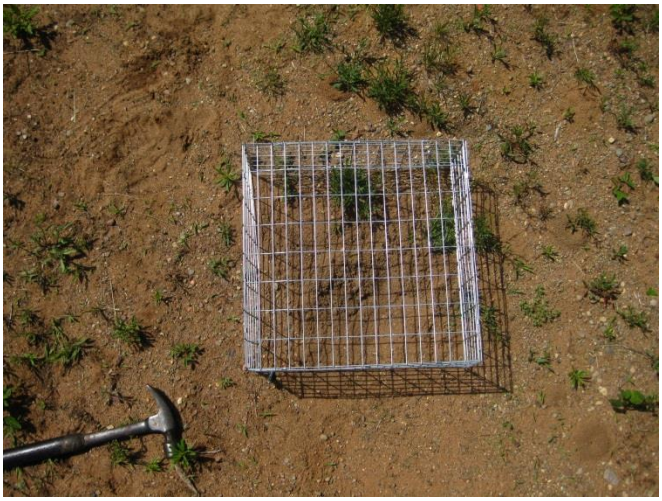

Fig. 6. Nest cage installed over a wood turtle nest. Photo by Carly Lapin, WDNR.

Fig. 7. Electric fence exclosure installed at wood turtle nest site. Photo by Michele Woodford, WDNR.

During turtle nesting seasons in 2014 and 2015, we searched for wood turtle nests by checking known and likely nesting areas and observing the behavior of monitored turtles. Nesting areas were monitored in the mornings and evenings throughout the nesting period so that individual nests could be documented. Turtles that were observed in a nesting area and exhibited nesting behavior (i.e., searching, digging test holes, or actively laying eggs) were left alone and observers stayed a respectful distance away (>10 m) to not disturb them during the laying process. Upon the completion of a nest (i.e., eggs covered and female turtle left the area), the location was recorded and the nest marked with a pin flag. Nests with eggs were confirmed by observing eggs being laid with binoculars or partially uncovering the nest to confirm that eggs were present.

We installed nest protection devices (i.e., nest cages, electric fence exclosures, or both) for approximately half of the documented nests. It was not possible to install nest cages on individual wood turtle nests that were laid on road shoulders due to their susceptibility to shoulder mowing equipment and potential danger posed to vehicles on the road. In Study Area 1, some wood turtle nests were excavated and moved from road shoulders to nearby restored nesting areas (see Task 4; Fig. 8), to decrease predation events and hatchling road mortality.

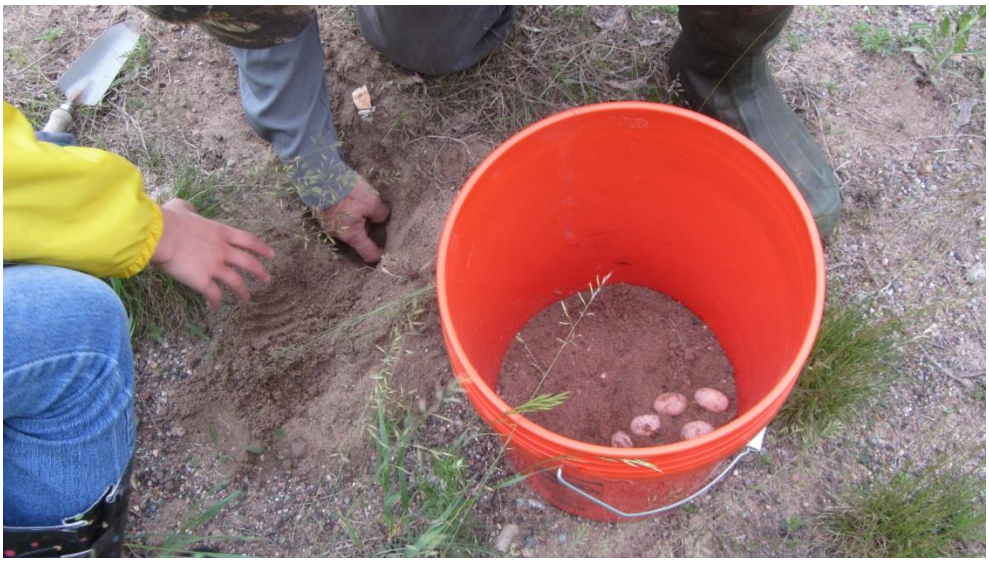

Fig. 8. WDNR staff move a wood turtle nest from a roadside location to a restored, riverside nest area in northern Wisconsin, 2014. Photo by Michele Woodford, WDNR.

Documented nests were visited two or more times per week throughout the summer to check for predation events. Nest predation was observed during every month of the nesting period, May through September. When the time of expected hatching approached (approximately 65-70 days of incubation), documented nests were visited several times per week to check for predation and/or evidence of hatching. During this time period in both field seasons, trail cameras were used to photograph nests at 3-minute intervals to observe any hatchlings leaving the nests. Nest monitoring continued until fall when temperatures dropped below freezing and wood turtles returned to the water for the winter. After this time, many of the documented nests were excavated to record hatching success rates. No viable embryos or eggs were found during these checks, and there were no documented occurrences of wood turtle hatchlings overwintering in the nest.

Results

Overall we documented 69 individual wood turtle nest during the two field seasons. Of these, 17% (6/36) of protected nests and 52% (17/33) of unprotected nests were depredated. All depredations appeared to be caused by mammals.

Study Area 1: We documented seven wood turtle nests initiated from June 12 to June 21 in Study Area 1 in 2014 (Table 4). Of these, five nests were moved from roadsides to restored nesting sites and protected from predation with nest cages, electric fence exclosures, or both. None of the protected nests were predated. Unpredated nests were monitored through early October as described above, but no nests were documented to have hatched. In addition to these 7 nests, 16 additional nests from wood turtles and other species (primarily snapping turtle) were depredated on a number of roadside shoulders in the study area. No turtle eggs were found to have hatched in Study Area 1 in 2014. We attributed this complete nesting season failure to an unusually cool and prolonged spring, followed by a

relatively cool summer in 2014. We hypothesize the nesting phenology delay and insufficient ground temperatures did not provide enough heat to fully develop the turtle embryos.

We documented 27 wood turtle nests initiated from May 29 to June 8 in Study Area 1 in 2015. Of these, 11 nests were moved from roadsides to restored nesting areas and protected from depredation. Three of these protected nests were predated despite nest protection strategies, and all three depredations occurred within a day or two of egg hatching. In all three cases, we documented that some eggs hatched prior to the depredation. Nest predators included raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and other unknown mammals. Six other, unprotected wood turtle nests were predated over the course of the summer. Unpredated nests were monitored through early October as described above, and 18 nests were documented to have hatched (i.e., at least one hatchling emerged) from August 18 – September 14, producing 146 hatchlings.

Study Area 2: We documented 12 wood turtle nests initiated from June 12 to June 17 in Study Area 2 in 2014 (Table 4). Of these, 6 nests were protected with nest cages, none of which were predated; 4 other known nests were predated by raccoons or other mammals. Unpredated nests were monitored through early October as described above, and only one nest hatched, producing 11 hatchlings from August 27 – August 28. Again, the high rate of hatching failure in 2014 was attributed to a later than normal nesting period, followed by a relatively cool summer.

We documented 23 wood turtle nests initiated from May 29 to June 15 in Study Area 2 in 2015. Of these, 15 nests were protected with nest cages, electric fence exclosures, or both. Three of the protected nests were predated when a badger (*Taxidea taxus*) entered the electric fence exclosure on August 6, near the time when some nests were beginning to hatch. Six additional, unprotected wood turtle nests were predated over the course of the summer. Unpredated nests were monitored through early October as described above, and 12 nests hatched (i.e., at least one egg successfully hatched) from August 12 – September 22, producing 93 hatchlings.

Table 4. Results of wood turtle nest monitoring in two study areas in northern Wisconsin, 2014-2015.

Site	Number of Nests Documented		Number of Nests with Protection		Number of Nests Predated (Protected and predated)		Number of Nests that Hatched		Number of Documented Hatchlings[c]	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Study Area 1[a]	**7**	**27**	**5**	**11**	**1**	**9(3)**	**0**	**18**	**0**	**146**
Squirrel/ Tomahawk Rivers	0	3	0	2	0	1	0	0	0	0
Tomahawk River	7	24	5	9	1	8(3)[d]	0	18[d]	0	146
Study Area 2[b]	**12**	**23**	**5**	**15**	**4**	**9(3)**	**1**	**12**	**11**	**93**
Totogatic River		1		1		N/A[e]		N/A[e]		N/A[e]
Namekagon River	12	22	5	14	4	9(3)	1	12	11	93
Project Total	**19**	**50**	**10**	**26**	**5**	**18(6)**	**1**	**30**	**11**	**239**

[a] Oneida County, Wisconsin

[b] Washburn and Burnett counties, Wisconsin

[c] Hatchling numbers derived from count of hatchlings leaving nest and/or number of empty shells left in nest following hatching.

[d] Three nests were counted as both hatched and predated. Some hatchlings emerged prior to predation.

[e] Nest was never relocated after initial documentation; the outcome is unknown.

Future Work

We are planning a Phase 2 Upper Midwest Turtle Habitat Improvement project that will continue the work described here in other watersheds of the state. Included with this proposed project is maintenance of electric fence exclosures described above at restored nest sites in both Study Areas. In the new proposed project, the methods used to complete this task will be adapted to improve their effectiveness (for example, we will try a new electric fence configuration) and used to monitor and protect wood turtle nests in new watersheds in Wisconsin, improving recruitment and conservation of this species throughout the state.

Task 4: Improve eight nesting areas in flood safe areas in Study Areas 1 and 2.

Project Objectives Addressed: 1a, 3a, 4a, 4b

Planning

Preparation for Task 4 began in fall 2013 with inspection of both study areas from the water to identify locations with good potential for nest site creation/restoration. Sites were considered suitable if they were close to (visible from) the water, above flood stage, relatively free of trees, and had south-, southwest-, or west-facing slopes. This was followed in winter 2014 with on-the-ground site visits and mapping and contact with landowners and property managers. Sites were identified on private, [redacted]

Methods

All of the restored nest sites for the project were visible from the water, above flood stage, relatively free of trees, and had accessible south-, southwest-, or west-facing slopes. The sites were prepared by clearing brush and trees by hand, followed by removal of roots and topsoil, either with a rototiller or bulldozer (Figs. 9 and 10, respectively). A strip of vegetation was maintained between the water and the nest site at all locations to prevent erosion and runoff into the waterway. Erosion did not occur at any of the restored nest sites. All sites were monitored and maintained free of vegetation by hand pulling and mechanical means (rototiller and weed whip) throughout the summer months.

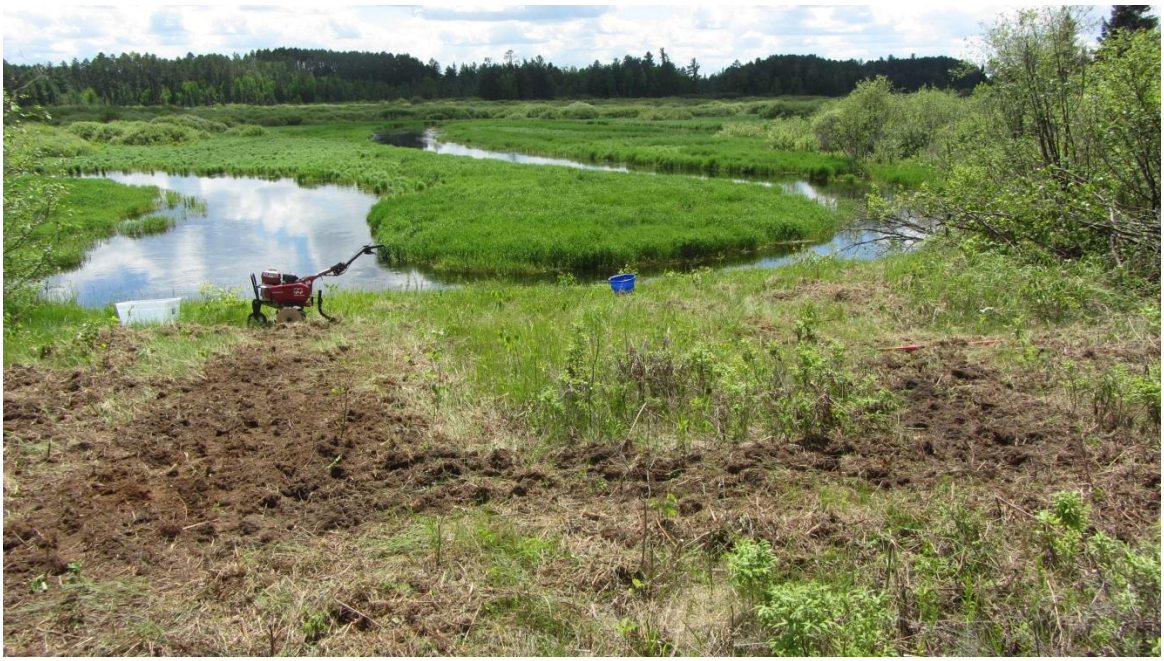

Fig. 9. Restoring a turtle nest site using a rototiller in northern Wisconsin, 2014. Photo by Michele Woodford, WDNR.

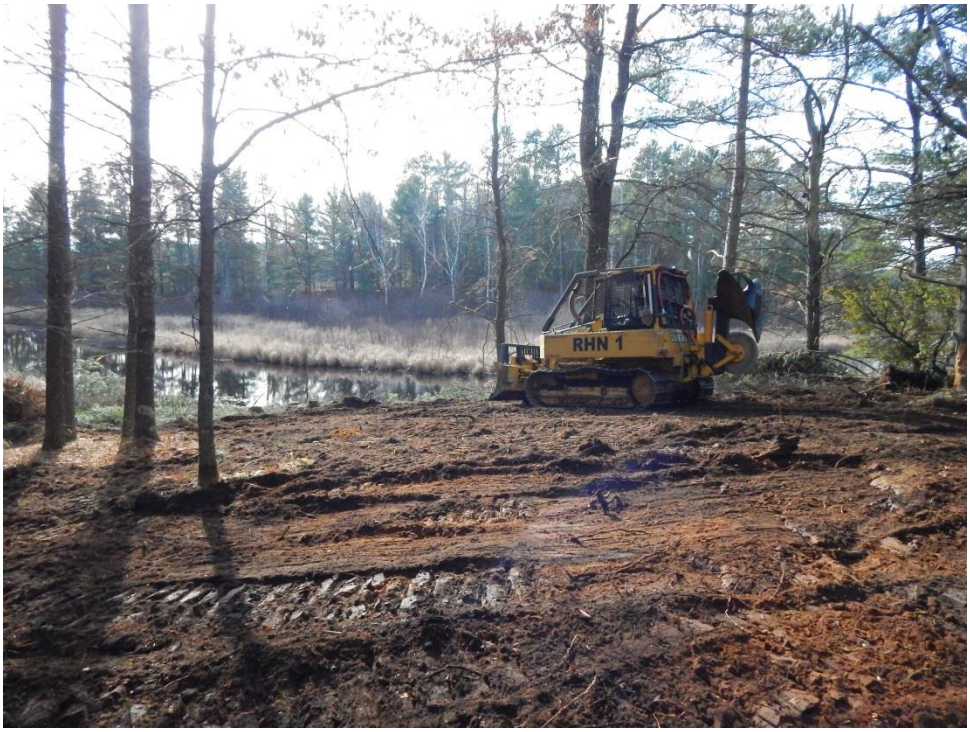

Fig. 10. Nest site restoration using heavy equipment in northern Wisconsin, 2015. Photo by Carly Lapin, WDNR.

Results

We created, enhanced, or restored 10 turtle nesting areas within the study areas in northern Wisconsin.

Study Area 1: We identified 37 locations with good potential for nest site creation on both rivers in Study Area 1. In spring 2014, eight nest sites were created on Wisconsin state property in Study Area 1 by hand-clearing trees and brush and then either scraping with a bulldozer or rototilling by hand to remove roots and seed bed (Table 5). Electric fencing was installed (see "Methods" under Task 3) at two of these sites.

In 2015, we continued to maintain all eight nest sites created in 2014 with regular weed cutting, and wood turtles were observed nesting at four of the nest sites. One additional nest site was created on private property in fall 2015.

Study Area 2: We identified 29 locations with good potential for nest site creation along the Namekagon River in Study Area 2. [redacted]

We identified two additional sites on [redacted] the Namekagon River that would be suitable for nest site creation [redacted]. Wood turtles were documented using these locations for foraging and basking throughout the summer months. [redacted]

In an effort to seek alternative locations for nest site creation, we focused on the Totogatic River, a tributary to the Namekagon River with documented wood turtle observations. The Totogatic River is designated a Wisconsin Wild River and this designation legally restricts vegetation management, which would be required for nest site creation, within 150 ft of the river bank. Given the required distance from the water, we did not feel that nest site creation on the Totogatic River would be an effective conservation action.

We were contacted in 2014 by a private landholder on the Namekagon River whose property had regular turtle nesting activity (wood, snapping, painted, and softshell). This landowner expressed an interest in being involved in the project, and an existing turtle nesting site on his property was enhanced in spring 2015 with the addition of sand and installation of electric fence (Table 5). This site was monitored and maintained free of vegetation throughout the summer. Wood and snapping turtles were documented nesting at this site the same year it was enhanced (Fig. 11).

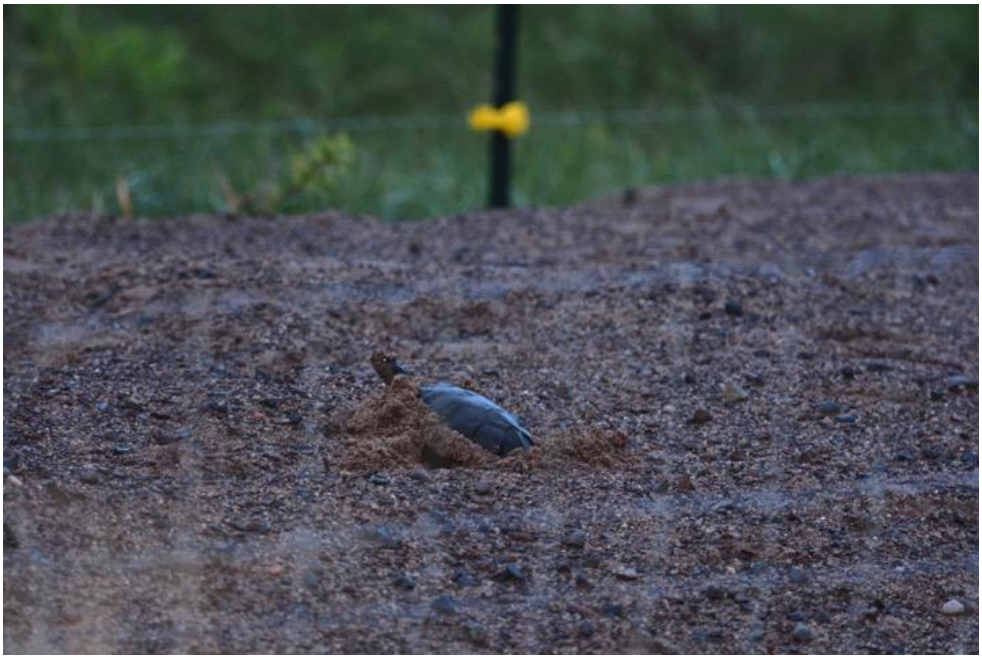

Fig. 11. A wood turtle lays eggs at a restored nest site protected by electric fencing in northern Wisconsin, 2015. [redacted]

Table 5. Wood turtle nest sites restored in two study areas in northern Wisconsin, 2014-2015.

Site	2014 Nest Sites Restored		2015 Nest Sites Restored		2014-2015 No. Sites with Electric Fencing	2014-2015 No. Sites used by Wood Turtles
	No. Sites	Hectares	No. Sites	Hectares		
Study Area 1[a]	**8**	**0.77**	**1**	**0.02**	**2**	**4**
Squirrel/ Tomahawk Rivers	2	0.05	1[c]	0.02	1	1
Tomahawk River	6	0.72			1	3
Study Area 2[b]	**0**	**0**	**1**	**0.02**	**1**	**1**
Totogatic River						
Namekagon River			1[c]	0.02	1	1
Project Total	**8**	**0.77**	**2**	**0.04**	**3**	**5**

[a] Oneida County, Wisconsin
[b] Washburn and Burnett counties, Wisconsin
[c] Restored nest site is on private property; all other sites are on Wisconsin state property.

Future Work

We are planning a Phase 2 Upper Midwest Turtle Habitat Improvement project that will continue the work described here in other watersheds of the state. Included with this proposed project is maintenance of the restored nest sites described above in both Study Areas. Nest sites will be maintained free of vegetation so they continue to be suitable for nesting turtles. Methods of weed control may include mechanical and/or chemical strategies. The methods used to complete this task will be used to create and monitor turtle nesting habitat in other watersheds in Wisconsin, improving recruitment and conservation of this species throughout the state.

Task 5: Map road threats and barriers to wood turtle movement in Study Areas 1 and 2.

Project Objectives Addressed: 1b, 2a

Planning

Preparation for Task 5 began in fall 2013 with inspection of both study areas from the water to identify potential road threats to area turtles.

Methods

Road threats and barriers were located during fall 2013 reconnaissance, turtle surveys, telemetry tracking, and during nest season monitoring. Places where turtle road crossings seemed likely or were observed were recorded and the information was used to place road barriers and turtle crossing signs.

Results

Study Area 1: While conducting telemetry and nest monitoring in 2014, we identified seven road crossings or bridges in Study Area 1 where wood turtles were at risk while looking for nesting sites or otherwise moving through the watersheds (Table 6). No road-killed wood turtles were documented in 2014, but one unmarked gravid female wood turtle was struck by a car and killed in June 2015. No movement barriers were identified in Study Area 1.

Study Area 2: While conducting telemetry and nest monitoring in 2014, we identified five road crossings or bridges in Study Area 2 where wood turtles were at risk while looking for nesting sites or otherwise moving through the watershed (Table 6). One of the study animals, an adult female wood turtle with a transmitter, was struck by a car and killed in June 2014. One other road-killed wood turtle (unmarked) was documented in 2015. No movement barriers were identified in Study Area 2.

Future Work

There is no future work associated with this task, though these methods could be applied to any watershed in the state for a better understanding of road-related threats and movement barriers for wood turtles statewide.

Task 6: Install filter strip barriers to prevent wood turtle access to identified road threats in Study Areas 1 and 2.

Project Objectives Addressed: 2b, 4a, 4b

Planning

Preparation for Task 6 began in summer/fall 2014 and winter 2015 based on a review of wood turtle movements during the 2014 field season. Road threats were identified and local, county, and state municipalities contacted for permission to install turtle crossing road signs and filter strip barriers. Additional planning involved equipment purchase and hiring of contractors to complete some of the work.

Methods

We identified locations that were suitable for filter strip barrier installation during the summer 2014 field season. Sites were considered suitable if wood turtles were documented crossing the roadway in that location and the local terrain was suitable for installing a barrier that would be effective in preventing turtle access to the road. After acquiring the necessary permits, filter strip barriers were installed in spring 2015, prior to the nesting season. Two different designs were used: a buried half-culvert (Fig. 12) and silt fencing (Fig. 13). Turtle crossing signs were installed in spring and fall 2015 at road crossing locations to improve awareness of turtle crossings and reduce road mortality (Fig. 14).

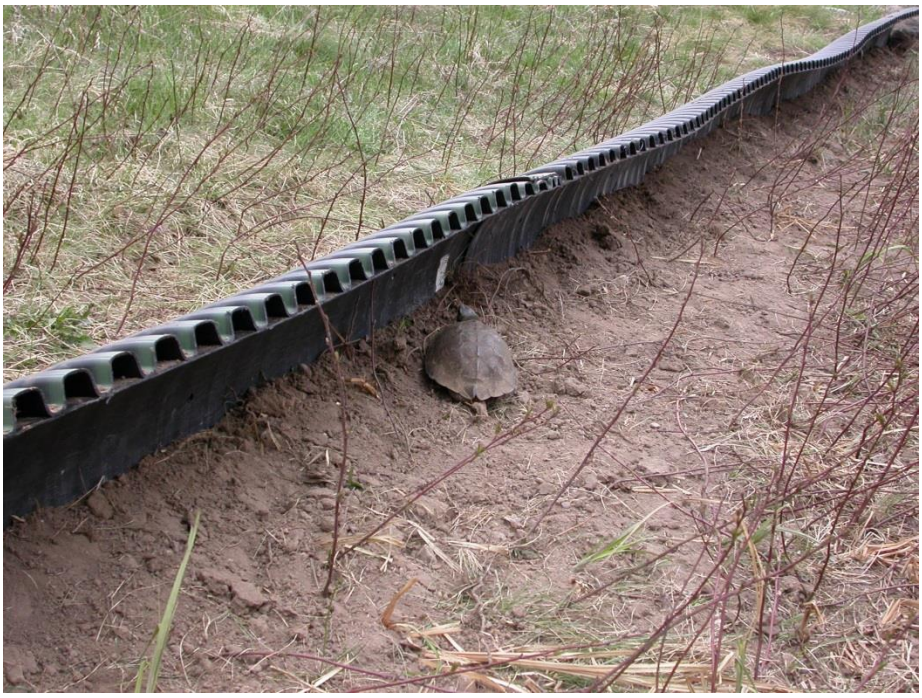

Fig. 12. A wood turtle stopped at a roadside barrier. This design is a plastic road culvert that was cut in half and partially buried, with the interior facing toward the river. Photo by Jim Woodford, WDNR.

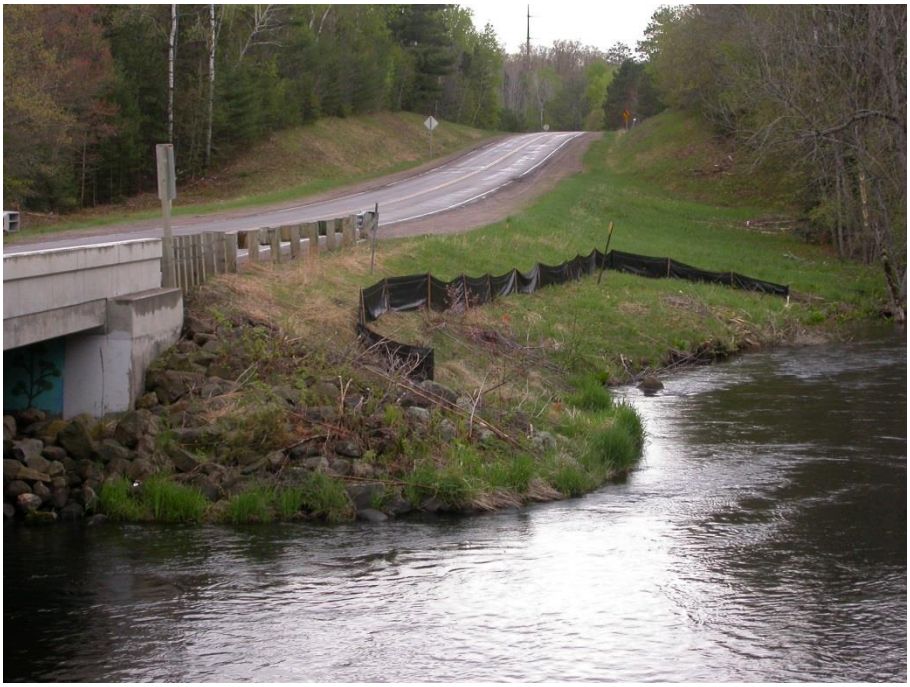

Fig. 13. Filter strip barriers (silt fencing) to prevent road access by turtles. Photo by Jim Woodford, WDNR.

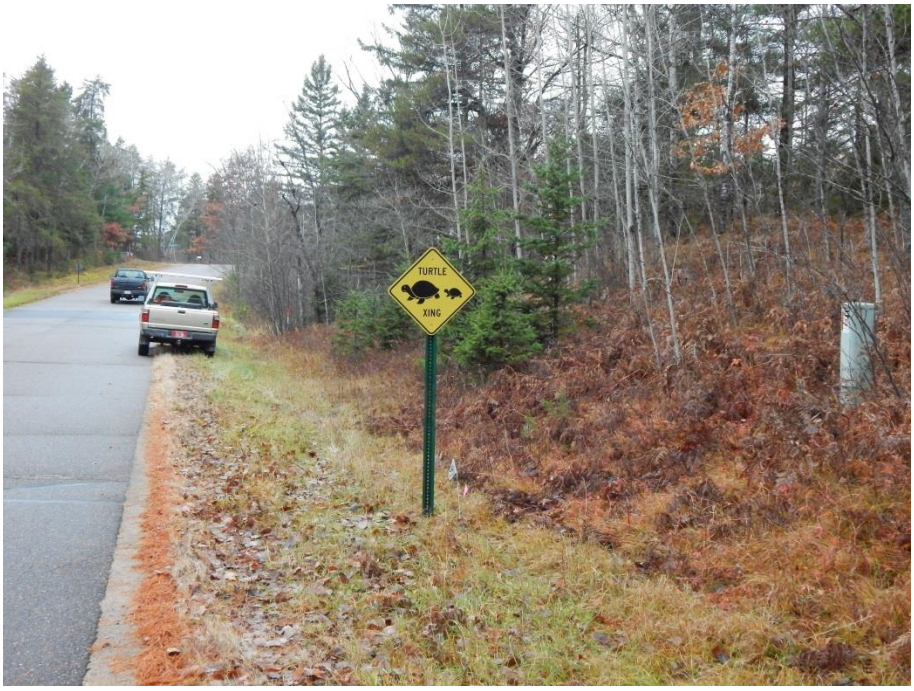

Fig. 14. Turtle crossing sign at identified road crossing location. Photo by Carly Lapin, WDNR.

Results

Study Area 1: We installed 340 ft (104 m) of the culvert type road barrier near a bridge crossing in Study Area 1 in 2015 (Table 6). The cost for this design of barrier was $6.76 per foot. The barriers at this location had mixed results, with observations of turtles being stopped (Fig. 4) as well as a turtle finding a way around them. Turtle crossing road signs were installed at five of the seven crossing locations identified in Study Area 1 in fall 2015.

Study Area 2: Wisconsin DNR staff and road construction contractors [redacted] installed approximately 1,430 ft (436 m) of silt fence barriers at three locations in Study Area 2 in spring 2015 (Table 6). The cost for this design of barrier was $2.50 per foot. The barriers at this location had mixed results, with observations of turtles being stopped as well as turtles finding a way around them. Turtle crossing road signs were installed at two of the five crossing locations identified in Study Area 2 in spring 2015.

Table 6. Summary of efforts to protect wood turtles at road crossing locations in two study areas in northern Wisconsin, 2014-2015.

Site	Road Crossings Identified (No.)	Road Signs Installed (No. of Crossings)	Barriers Installed	
			Number of Locations	Length (feet)
Study Area 1	**7**	**5**	**1**	**340**
Squirrel/ Tomahawk Rivers	3	3		
Tomahawk River	4	2	1	340
Study Area 2	**5**	**2**	**3**	**1,430**
Totogatic River	1			
Namekagon River	4	2	3	1,430
Project Total	**12**	**7**	**4**	**1,770**

Future Work

Future work associated with Task 6 includes maintenance of road-side barriers (annual maintenance for snow loading on silt fence, removing encroaching vegetation, replacing when damaged) and turtle crossing signs so they remain effective. In addition, efforts associated with this task can be used to reduce turtle road mortality in other watersheds in the state.

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Grant Project Budget

The total Competitive State Wildlife Grant amount awarded for The Upper Midwest Riverine Turtle Habitat Improvement Project was $493,903, of which Wisconsin was allotted $99,972; Wisconsin spent its entire allotted amount.

APPENDICES. PROTOCOLS AND DATA SHEETS

Appendix 1-A. Wood Turtle Survey and Capture Protocol
Appendix 1-B. Wood Turtle Nest Survey and Monitoring Protocol
Appendix 1-C. Data Sheet Codes
Appendix 1-D. Wood Turtle Survey Data Sheet
Appendix 1-E. Wood Turtle Processing Data Sheet
Appendix 1-F. Wood Turtle Nest Site Data Sheet
Appendix 1-G. Wood Turtle Individual Nest Data Sheet