



Department of Defense Legacy Resource Management Program

Recommended Best Management Practices for the Wood Turtle on Department of Defense Installations

Department of Defense Partners in Amphibian and Reptile Conservation



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Introduction

The wood turtle (*Glyptemys insculpta*) is considered an at-risk species that has been petitioned for federal listing under the Endangered Species Act (ESA); it is currently listed as 'Under Review' by the U.S. Fish and Wildlife Service (USFWS). The Department of Defense (DoD), through its Partners in Amphibian and Reptile Conservation (PARC) network, and the USFWS, have developed Best Management Practices (BMPs) for the wood turtle. The management practices described in this document were developed specifically for DoD installations, but are also suitable for implementation off DoD installations.

The management practices described in this report are intended to serve as guidelines that DoD natural resource managers can use to help plan, prioritize, and implement conservation and management actions that provide a conservation benefit to the wood turtle, while also providing information to comply with regulatory processes such as Environmental Protection Agency's National Environmental Policy Act (NEPA) and associated components (i.e., Environmental Assessments, Environmental Impact Statements). Implementation of these BMPs should not impede military readiness activities, should be documented in installation Integrated Natural Resource Management Plans (INRMPs), and should align with existing efforts among the DoD, federal/state governmental agencies, and non-governmental organizations (NGOs) to prevent this species' continued decline and preclude its listing under the ESA.

Species Profile

Description:

Adults are typically 7 to 9 inches (14-20 cm) in length. Males are larger than females and have a thicker, longer tail and prominent dermal scales on the anterior surface of the forelimbs. Wood turtles have a very rough-textured carapace (top shell) with large scutes (the individual scales covering the shell) consisting of irregular pyramids of concentric grooves and ridges (Figure 1). The plastron (lower shell) is typically yellow with large, often rectangular black markings that fade over time. The plastron is typically concave for adult males and mostly flat for adult females. The posterior edge of the plastron has a large V-shaped notch below the base of the tail (Figure 2). The rear marginal scutes past the hind legs are serrated and adjoin the lower lateral side of the carapace, whereas the front marginal scutes are smooth and form a bridge between the carapace and plastron. The head and neck are brown, yellow, or bright orange, and parts of the face, tail, and limbs may also be orange.



Figure 1. Wood Turtle Carapace

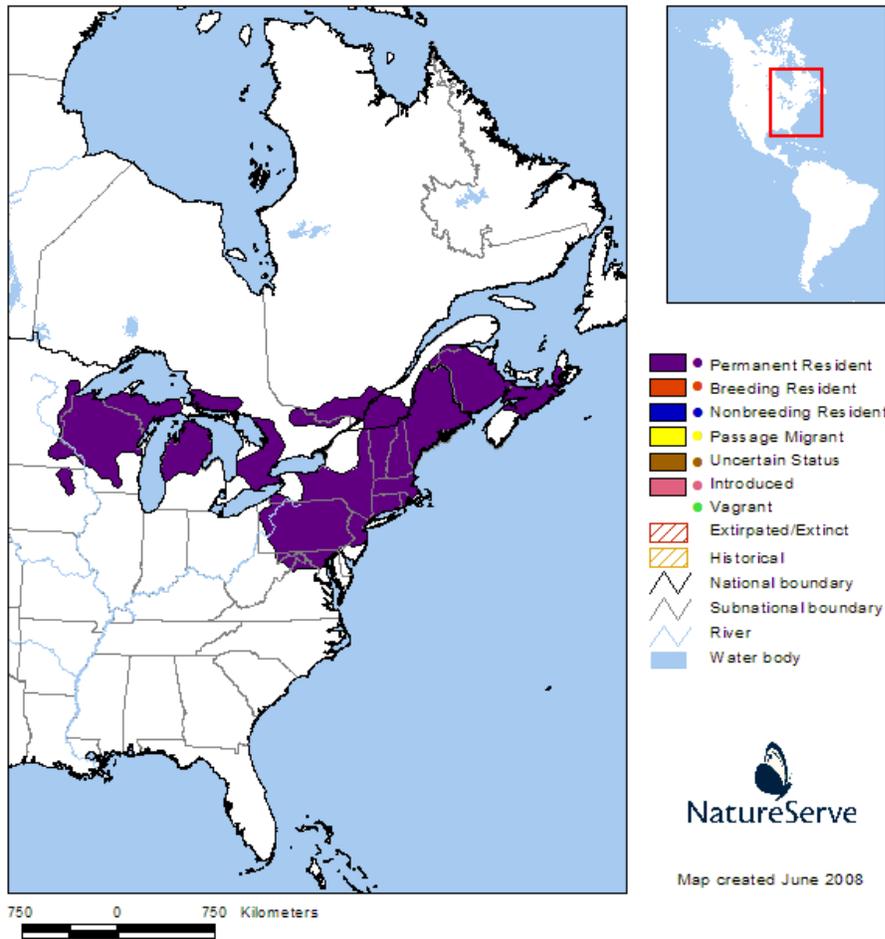


Figure 2. Wood Turtle Plastron (male)

Hatchlings are approximately 1 inch (2.8-3.8 cm) in length and lack the pronounced grooves and ridges, and bright yellow and orange colors of the adults. Furthermore, they lack spots on their other dorsal scutes, distinguishing them from the eastern box turtle for which they are often mistaken. The plastron is not hinged at any growth stage.

Range: The U.S. range of this species includes the states of Connecticut, Iowa, Massachusetts, Maryland, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Virginia, Vermont, Wisconsin, and West Virginia (Figure 3). Their original native range extended as far south as Tennessee and Georgia during the last glacial advance, based on fossil evidence (Ernst and Lovich 2009).

Figure 3. Wood Turtle Range Map (Source: NatureServe 2019).



Distribution on Military Sites: The wood turtle is confirmed present on the following 13 military sites:

- Air Force: Hanscom Air Force Base (Massachusetts); New Boston Air Force Station (AFS) (New Hampshire)

- Army: Camp Grayling Joint Maneuver Center (Michigan); Devens Reserve Forces Training Area (Massachusetts); Fort Belvoir (Virginia); Fort Drum (New York); Fort Indiantown Gap (Pennsylvania); Fort McCoy (Wisconsin); Franklin Armory (Indiana); Letterkenny Army Depot (Pennsylvania); Pembroke Regional Training Institute (New Hampshire); Picatinny Arsenal (Virginia); West Point Military Reservation (New York)

The wood turtle is unconfirmed and potentially present on the following 26 military sites; specimens have been found in the same county as these sites, but not within the boundaries of the installation itself:

- Air Force: Joint Base Andrews (Maryland); Joint Base McGuire-Dix-Lakehurst (New Jersey); Warren Grove Air National Guard (New Jersey); Westover Air Reserve Base (Massachusetts)
- Army: Aberdeen Proving Ground (Maryland); Adelphi Laboratory Center (Maryland); Auburn Training Site (New York); Bangor Army National Guard Base (Maine); Bangor Training Site (Maine); Blossom Point Research Facility (Maryland); Bog Brook Training Site (Maine); Brunswick Training Site (Maine); Camp Smith Training Site (New York); Carlisle Barracks (Pennsylvania); Caswell Training Site (Maine); Ethan Allen Firing Range (Vermont), Fort George G. Meade (Maryland); Gardiner Training Site (Maine); Hollis Training Site (New Hampshire); Plymouth Training Site (Maine)
- Navy: Great Pond Outdoor Adventure Center (Maine); Naval Station Newport (Rhode Island); Naval Computer and Telecommunications Area Master Station Cutler (High Frequency Site, Very Low Frequency Site) (Maine); Naval Support Facility Carderock (Maryland); Naval Weapons Station Earle (New Jersey); Rangeley Survival, Evasion, Resistance and Escape School (Maine)

Habitat: Wood turtles are primarily found near forested streams, in which they hibernate during the winter. They prefer streams with sand, gravel, or rocky bottoms, as opposed to mud and silt (Ernst and Lovich 2009). They are considered semi-aquatic turtles, and will readily leave the water and move to open grasslands, barrens, and sandy shores for nesting and foraging, particularly during the spring. Loose, sandy soils are often their preferred nesting substrate, which makes habitats created by recent disturbance (including construction sites, road berms, bridge embankments, military maneuver areas and ranges, dirt roads and utility right of ways) a primary resource for gravid females. All wood turtles require well-oxygenated and clean water streams for their health and for the abundance of in-stream prey (Kleopfer et al. 2014).

Behavior: In spring, wood turtles emerge from their aquatic habitat and congregate in small masses along streambanks and marshes to mate and feed. At this time, turtles are highly concentrated and potentially more vulnerable to predation, fire, disease, and poaching. Turtles have a second mating period in the fall. Females may mate with multiple males and delay fertilization, often producing mixed paternity nestlings. Nesting occurs from spring to summer, with nests of 3-20 eggs (typically 5 to 10 eggs) laid in soft soil.

Neonatal turtles may not emerge from their nest during the year in which they hatch (Parren and Rice 2004), but most do between mid-August and early-October, and typically follow the path of least resistance down to the nearest running water. The water provides protection, but the highest mortality rates for the species are incurred from the egg to sub-adult stages. Sexual maturity is reached between 12-18 years, and adults have a roughly 90% or better annual survival rate in sustainable populations. Adults may live beyond 70 years in the wild and may continue to breed well past the age of 45 (Ernst and Lovich 2009).

Wood turtles eat vegetation (both aquatic and terrestrial), mushrooms, invertebrates, carrion, and other food sources. The turtles may have diapause periods during the hottest months in the southern part of its range, returning to cool waters. Active during the fall, cooler nighttime temperatures will drive them back to the streams to brumate under cut banks, debris, rock piles, and other instream features for the cold months from October/November through March (depending on seasonality and location within the range). Turtles may be active during brief periods throughout the winter and have been seen moving slowly down presumably warmer stream channels when surface air temperatures were low, but unseasonably mild.

Threats: Threats to this species include habitat loss and fragmentation, road mortality, subsidized predators (including raccoons and opossum), poaching, invasive plants in nesting habitat, degraded water quality, and subsidized pathogen dispersal (such as ranavirus and upper respiratory disease).

Conservation Status

Wood turtles are designated as a Species of Greatest Conservation Need (SGCN) in the State Wildlife Action Plans of all 17 states in which they occur, considered Endangered by the IUCN, and have been petitioned for federal listing under the ESA as Threatened. Additionally, wood turtles are state-endangered in Iowa and state-threatened in Minnesota, New Jersey, Virginia, and Wisconsin. This species was petitioned for federal listing status as Threatened in 2012 and the USFWS made a 90-day substantial finding in 2015 (USFWS 2015), stating there is “substantial information indicating that the petitioned listing may be warranted,” and the species is scheduled for a federal listing determination in fiscal year 2023 (USFWS 2016). A previous petition for federal listing in 1995 was rejected. Canada listed the species as Threatened under the Species at Risk Act (SARA).

Recommended Conservation Implementation Strategies and Best Management Practices for Wood Turtles on Military Sites

In general, implementation of the specific BMPs listed below should not be performed at the expense of an existing wood turtle population. Habitat management practices, while serving long-term benefits, should be carefully pre-planned prior to their implementation to minimize potentially adverse impacts to turtle activity periods and locations. Make sure to document performance of any of the following BMP’s, whether current or future, in your installation’s INRMP. The USFWS may consider these proactive conservation actions prior to making a listing determination for this species (Kingsbury and Gibson 2012, Mitchell et al. 2006).

1. **Identify and protect wood turtle streams and contiguous upland habitats on military properties.** Review aerial photography and installation Geographical Information System (GIS) data to identify potentially suitable stream channels with unconsolidated bottoms and contiguous upland habitats. Identify exposed sandy and soft soil areas such as alluvial deposits, exposed stream banks, and barrens within 1,000 feet of the channels for potential nesting hotspots. Follow-up by ground-truthing prospective areas, and if they appear to support suitable habitat, or are known to support wood turtles, post as necessary with official signage along roads and other human travel corridors to inform personnel about the actual or potential presence of wood turtles and their vulnerability to military operations and other human activities. This is particularly important on roads with high turtle mortality, or exposed, bare road margins and unpaved surfaces. Include a contact number on signage to report observations of illegal and/or unauthorized operations and activities. If you have concerns the signs will bring attention to sites where wood turtles could be illegally collected, posting generic turtle crossing signs is recommended.
2. **Survey existing wood turtle populations on military sites.** Monitoring existing wood turtle populations is critical to understanding if a population is increasing or decreasing. Survey methods (see inventory and monitoring techniques for wood turtles below) and level of effort are variable and can be tailored to available time and funding constraints. Consider conducting surveys for this species on your military installation if it has the potential to be present, but has not yet been confirmed.
3. **Avoid clearing natural vegetation along stream edges, especially riparian forest buffers.** Maintenance of canopy vegetation over stream riparian zones produces protective cover for entering/exiting turtles, lowers instream temperature, stabilizes erosion and siltation, enhances the diversity of prey items, and produces in-stream features and cover like root tangles and coarse woody debris for turtles.
4. **Retain snags, logs, rocks, and other structures in stream channels and aquatic habitats.** These natural habitat elements provide basking and shelter sites for wood turtles. However, it is recommended that unnatural debris (e.g., tires, trash) be removed.
5. **Prohibit collection of turtles on your installation.** Collection of turtles for commercial or scientific purposes can have negative impacts to local populations due to their longevity and delayed sexual maturity, and is an illegal activity in many states where they occur. Wood turtles can bring high prices on the black market, both domestically and abroad, and poaching should not be considered a minor or harmless activity. Non-target species such as wood and spotted turtles are often disturbed, injured, or killed in the course of trapping for other permitted species. Military natural resource managers

should consider prohibiting collection of all native turtles on military sites, even in the few states where collection is not prohibited.

6. **Distribute fact sheets and outreach tools.** Educational fact sheets and pamphlets (e.g., <http://northeastparc.org/wood-turtle-brochure/>) can be shared with military and civilian personnel to inform them about this at-risk species.
7. **Control subsidized predator populations.** Subsidized predators are species whose populations have increased in part due to enhancement of food and habitat provided directly or indirectly by humans. Raccoons, foxes, coyotes, and corvids are well-known natural predators of wood turtles and their nests. Installation residents should limit access to food, garbage, and shelter for subsidized predators. In addition, pets such as cats and dogs can also be predators of wood turtles. Installation residents should limit pet access to wood turtle habitats, where they might prey upon nests and turtles, and keep pets leashed near these habitats. Secured trash disposal and waste and debris cleanup can limit the expansion and concentration of these predator populations. Discourage residents from feeding outdoor animals or from feeding pets outside.
8. **Establish dismantled stream buffers around permanent channels and wetlands.** If possible, avoid use of military and all other vehicles (including all-terrain vehicles) in wetland habitats, and establish a vehicle-free buffer zone of at least 30 to 100 meters around the edges of permanent streams and wetland structures (Jones et al. 2018). Install barriers in areas where unauthorized stream crossings or wetland incursions occur to minimize wetland and channel damage and stream sedimentation. Operation of vehicles in the soft soils around or in aquatic habitats can cause significant rutting damage to the ground, kill sensitive vegetation, and lead to serious erosion issues. Any area that is impacted as such should be restored towards its natural condition. The use of tracked equipment for mechanical wetland restoration projects during dry conditions is preferred.
9. **Control or remove invasive and non-native species.** Invasive species may include various plants that grow at unnaturally high densities, particularly in the absence of fire and in both wetlands and uplands, thereby changing physical habitat structure and overcrowding basking and nesting opportunities, both of which adversely impact the turtles. Non-native aquatic plants such as Japanese knotweed, *Hydrilla*, *Phragmites*, and purple loosestrife, can have negative impacts to aquatic habitats by outcompeting native wetland plants. Invasive species may also include animals such as feral hogs and red-eared sliders (*Trachemys scripta elegans*) that deplete or compete with wood turtles for resources. The best procedures for controlling invasive species are those that both effectively limit their proliferation, as well as minimize potentially harmful impacts to turtles, and will vary according to the invasive species in need of control, and numerous criteria specific to each

installation. Therefore, consult your natural resources staff for invasive species control guidelines for your installation.

10. **Maintain or improve water quality.** Prevent input of sediment and chemicals (fertilizers) in surface water to maintain or improve water quality. Where feasible, minimize soil disturbance when using heavy equipment near wetlands. Use native wood chips or hay bales to slow or prevent intrusion of sediments into wetlands at construction sites. Use the minimum amount of fertilizers, herbicides, and pesticides necessary to achieve management objectives, especially on lawns and golf courses.
11. **Minimize road mortality.** Roads can fragment wood turtle habitat, create barriers to dispersal, and increase the potential of road mortality. When possible, minimize the construction of new roads and use existing roads and trails for military training activities. Consider installing turtle crossings/culverts under established roads and trails wherever and whenever feasible to lessen vehicular mortality (e.g., between stream and nesting habitat).
12. **Encourage unpaved trail surface cohesion with tackifiers and emulsions.** Unconsolidated trail surfaces provide ill-fated nesting opportunities for female wood turtles. Hardening this surface makes the area less attractive and deters turtles from lingering on the trail or attempting to excavate a nest. The surface will also be less erodible, preserving surface water quality and saving maintenance costs for resurfacing.
13. **Mow in ways which reduce direct mortality.** If possible, mow roadsides and bivouac fields with agricultural tires and decks at least 8 inches or higher and during hot times of the day when turtles avoid the most exposed habitats. Mow fields from inside-out to avoid trapping turtles. Use single-annual dormant-season treatments if possible when turtles are in their streambed habitats in late fall, through the winter, and while the ground is still frozen in early spring. For hayed areas, do first cutting after turtle nesting season (generally safe after mid-July).
14. **Avoid creating incised streams and steep banks, and placing rip-rap along shorelines.** Turtles will readily attempt to, but rarely successfully navigate across these obstacles, leading to mortality in hatchling turtles on long/steep drops as they attempt to move towards the stream, and critical energy loss in adult turtles as they attempt to move away from the stream. All scenarios can lead to drownings, a significant mortality factor even in this semi-aquatic species.
15. **Consider restricting recreational fishing in wood turtle-occupied waters.** Fishermen can detrimentally remove food sources for wood turtles such as amphibians, eggs, and large invertebrates. They also apply pressure by

releasing their unused bait into the water such as exotic frogs, rusty crayfish, and invasive earthworms, which may compete for the same food source as the turtles.

16. **Dispose of uncontaminated dredge spoil in areas that would benefit nesting turtles.** Although dredging degrades habitat quality for some species, spoil piles that are high in sand content can serve as important turtle nesting habitat if deposited above the high-water mark along the shore or as islands within waterways. Consider creating wood turtle nesting habitat using dredge spoil materials.

Benefits of Wood Turtle Best Management Practices to Military Training Operations

1. Identification of wetland sites enables military planners to consider these sensitive habitats when developing and/or scheduling training and maneuvering activities.
2. Management of invasive species lessens the damage they may cause to training and maneuver area conditions and provide natural, realistic training environments.
3. Minimum setbacks ensure long-term stability of military training areas.
4. Proper erosion control and stream management provides a suite of species protections, while also reducing cost and burden on immediate and downstream features and structures, including maneuver trails, dams, reservoirs, recreational lakes, and amphibious training sites.
5. High-quality wood turtle habitat provides excellent cover and concealment for bivouaging, and shade for work-rest ratios, and breaks up the landscape for trainers to introduce multiple objective scenarios.
6. Wood turtle habitat enhancements can be used for establishing mitigation banks for several candidate and listed species with comparable habitat requirements, including the spotted turtle, Northern red-bellied cooter, Blanding's turtle, and bog turtle.
7. Training in wood turtle habitats can be harsh on vehicles, equipment, and personnel. Avoidance of these habitats may prevent unnecessary vehicle and equipment repair costs and loss of training time by military personnel.

Military Points of Contact

Contact your Military Service headquarters natural resources personnel with questions regarding wood turtle management and conservation actions:

Navy: Tammy Conkle (tamara.conkle@navy.mil; 202-685-9203)

Marine Corps: Jacque Rice (jacqueline.rice@usmc.mil; 571-256-2796)

Army: Steve Sekscienski (steven.sekscienski@us.army.mil; 571-256-9725)

Air Force: Kevin Porteck (kevin.porteck@us.af.mil; 210-925-4259)

Species Experts

Tom Akre: AkreT@si.edu; 540-635-0466

David McNaughton: david.k.mcnaughton@navy.mil; (619) 532-4403

Mike Jones: mtjones@bio.umass.edu; (508) 389-7863

For additional experts on wood turtles, search the Partners in Amphibian and Reptile Conservation (PARC) [Expert Partner Database](#).

Inventory and Monitoring Techniques for Wood Turtles

Wood Turtle Assessment Protocol

The American Turtle Observatory and the Northeast Wood Turtle Working Group (see <http://americanturtles.org>) put together the Wood Turtle Assessment Protocol (Attachment A) for sampling wood turtle populations throughout the species' range. The assessment can be performed for one season for a rapid assessment, or continued for several years for a long-term assessment (Jones and Willey 2014). Assessments are meant to take about an hour each, for a total of three surveys per season, walking one kilometer of stream (sinuous, not straight-line distance) with one to five observers.

The American Turtle Observatory has have been accepting data collected during the usage of the Wood Turtle Assessment Protocol for several years and can include your data at no cost into the national dataset, to be used for the listing decision in 2023. This venture was originally formed to guide conservation actions, build partnerships, and avoid federal listing, if possible, and it has been guiding state conservation policy throughout the range of the turtle.

Mark-recapture

Mark-recapture is still the most widely-used method to census turtle populations. This technique involves making permanent marks on the shell, such as notching or drilling the lateral scutes to provide long-term, distinctive visual indicators of individual turtles. Use of Passive Integrated Transponders (PIT) can also be used to identify individuals for confirmation or for law enforcement purposes. Blood, nail, or tissue sampling taken during these surveys can also provide the material basis for a genetic mark-recapture based on mitochondrial DNA diversity, or to be used as eDNA bioassays for surveys of stream habitats for turtles. Researchers can perform these surveys annually or as time and funding allows. Genetic mark-recapture gives a better long-term analysis and physical mark-recapture provides a better immediate or annual picture of the status of a population.

Basking Surveys

Visual surveys of artificial or natural basking sites (i.e. logs, banks and sandbars, etc.) can be conducted with speed, efficiency, and a much shorter duration than other ground survey methods. This method is not ideal for quantification, but it requires much less effort than other survey methods such as mark-recapture. Optimum survey periods are early spring through the nesting season of early summer (D. McNaughton, pers. obs.).

High Priority Research Questions

Confirmation of Wood Turtles at Unconfirmed Military Sites

Many DoD installations (see Distribution on Military Site above) throughout the range of the wood turtle have the potential to have populations of this species, however, their presence is unconfirmed. It is recommended that surveys be conducted to confirm the presence or absence of the species on those military lands. The generally secretive habits of wood turtles frequently precludes the reliable detection of live individuals. Thus, if a dead (e.g., road-killed) specimen (or even just a shell) is opportunistically encountered on an installation, it should be photographed, its location recorded, and the information passed along to your Military Service headquarters natural resources personnel for proper documentation and confirmation.

Connectivity Between Populations and Long-term Implications

Illegal collection and poaching, stream channel modification and urbanization have led to declines and local extirpations of wood turtles causing fragmentation and isolation of once contiguous populations. Studies/surveys that focus on how populations of wood turtles interact among each other, the degree of gene flow among populations, and the impacts of long-term isolation of populations are needed.

Population Size and Trends

Most turtle species, and especially wood turtles, live long lives and do not reproduce until an advanced age. These characteristics make turtle populations extremely vulnerable to even low levels of adult mortality (Congdon et al. 1993). Therefore, the stability of a population on a military installation is influenced by population size (number of turtles present), demography (sex and age ratios), and population trajectory (rate of increase or decrease). Surveys that focus on population size and trends are needed on DoD sites.

Upland Habitat Use Patterns

On DoD sites where occupied wood turtle streams are adjacent to maneuver areas, factors such as activity buffers, soil compaction and exposure, and vegetation management procedures may all affect turtle usage and mortality. Research is necessary on DoD sites to determine how these factors affect turtle usage and mortality, and to further determine how to minimize mortality, while potentially enhancing survival.

Biosecurity

Those who train on military sites many bring equipment from distant locations. The movement of potential viral and fungal pathogens represents a threat to wood turtle health, as ranavirus and other outbreaks can cause catastrophic loss in a single season. Effective equipment decontamination and isolation measures may be the best protective measures for the long-term health of the population. Additionally, biosecurity for installations is rarely mentioned in INRMPS and other long-term planning documents. This is a necessary inclusion in species conservation plans for vulnerable taxa such as turtles.

Additional Sources of Information on Wood Turtles

[American Turtle Observatory](#)

[Chelonian Research Foundation](#)
[IUCN](#)
[NatureServe](#)
[New Hampshire Wildlife Action Plan \(Appendix A\)](#)
[Virginia Herpetological Society](#)

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Literature Cited

Congdon, J. D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. *Conservation Biology* 7(4): 826-833.

Ernst, C.H., and J.E. Lovich. 2009. *Turtles of United States and Canada*. John Hopkins University Press, USA.

Graeter, G.J., K.A. Buhlmann, L.R. Wilkinson, and J.W. Gibbons (editors). 2013. *Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians*. Partners in Amphibian and Reptile Conservation Technical Publication IM-1, Birmingham, AL. 321 pp.

Jones, M.T., H.P. Roberts, and L.L. Willey. 2018. *Conservation Plan for the Wood Turtle in the Northeastern United States*. Report to the Massachusetts Division of Fisheries & Wildlife and the U.S. Fish & Wildlife Service. 259 pp.

Jones, M.T. and L.L. Willey. 2014. Standardized assessment protocol for wood turtle populations. Northeast Wood Turtle Working Group. Available from: <http://www.northeastturtles.org/wood-turtle-conservation-plan.html> (Accessed 20 SEP 2019).

Kingsbury, B.A. and J. Gibson (editors). 2012. *Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States*. Partners in Amphibian and Reptile Conservation Technical Publication HMG-1, 2nd Edition. 155 pp.

Kleopfer, J.D., T.S.B. Akre, S.H. Watson, and R. Boettcher. 2014. *A Guide to the Turtles of Virginia*. Bureau of Wildlife Resources Special Publication Number 4. Virginia Department of Game and Inland Fisheries, Richmond, VA. 44 pp.

McNaughton, D.K. Personal observations and unpublished data. Pennsylvania Amphibian and Reptile Survey, Mid-Atlantic Center for Herpetology and Conservation.

Mitchell, J.C., A.R. Breisch, and K.A. Buhlmann. 2006. *Habitat Management Guidelines for Amphibian and Reptiles of the Northeastern United States*. Partners in Amphibian and Reptile Conservation Technical Publication HMG-3, Montgomery, AL. 108 pp.

NatureServe. 2019. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VA. Available from: <http://explorer.natureserve.org> (accessed 20 SEP 2019).

Parren, S.G. and M.A. Rice. 2004. Terrestrial overwintering of hatchling turtles in Vermont nests. *Northeastern Naturalist* 11:229-233.

Pearse, D.E. and J.C. Avise. 2001. Turtle mating systems: behavior, sperm storage, and genetic paternity. *Journal of Heredity* 92(2): 206-211. Available from: <https://doi.org/10.1093/jhered/92.2.206> (Accessed 20 SEP 2019).

USFWS. 2015. Endangered and threatened wildlife and plants: 90-day findings on 25 petitions. FR 80(181): 56423-56432.

USFWS. 2016. National Listing Workplan: 7-Year Workplan (September 2016 Version). Available from: <https://www.fws.gov/endangered/esa-library/pdf/Listing%207-Year%20Workplan%20Sept%202016.pdf> (Accessed 22 January 2019).

Appendix A

Wood Turtle Assessment Protocol
April 5, 2014

Standardized Assessment Protocol for Wood Turtle Populations

Developed by the Northeast Wood Turtle Working Group

(Draft April 5, 2014)



Summary.—This document outlines a simple and standardized sampling methodology for wood turtle populations. Two levels of assessment are described: Rapid (RA) and Long-Term/Reference (LTR). This protocol was developed in 2012 and 2013 by a regional team of researchers working from New Brunswick to Virginia. Results are compiled and analyzed annually by a team at the University of Massachusetts. The protocol is as follows: Designate one kilometer of meandering stream using Google Earth. Stream segments may be either those known to support wood turtles, or randomly generated stream segments (for random segments, contact the project coordinator). Permanently record the Start and Stop locations of your study segment in decimal degrees and flag them in the field; these locations remain fixed throughout the project. With one or more experienced observers, survey the designated segment three times in the Spring or Fall Season, when wood turtles are expected to be in or immediately adjacent to the overwintering stream in your region. For Rapid Assessments, simply conduct three surveys in any Spring or Fall season. For Long-Term Assessment, repeat the three surveys per season in at least four consecutive seasons (e.g., Spring-Fall-Spring-Fall). During each survey, record the Start and Stop Times and record the number of minutes that were NOT spent surveying (so they may be removed from analysis). Using a calibrated thermometer, record the air and water temperature and sky conditions at the beginning and end of the survey. The methodology outlined in this document is designed to be simple, flexible, to fit within existing research programs, and to accommodate regional differences in research priorities and wood turtle behavior. The success of the effort is tied to the number of sites sampled throughout the region, and so broad regional participation is encouraged, although the project is primarily a volunteer effort. Data collected through the regional effort are maintained in a centralized, web-based data repository at the University of Massachusetts in Amherst, Massachusetts.

• **PLANNING PHASE, STEP I: SELECT A STREAM SEGMENT FOR STUDY.**

Identify a reach of stream that is suitable for study. It may either be (a) a stream segment known to be occupied by wood turtles; (b) a stream segment randomly generated by the regional effort; or (c) stream segment in a data-deficient region. You should ensure that access to the property is allowed. Select 1 kilometer of meandering stream habitat using the Path Measurement tool in GoogleEarth or a similar program (e.g., ArcView, ArcMap, USGS topos). See Figure 1, next page. When possible, use GoogleEarth's time machine function to locate "leaf-off" springtime aerial images because it is easier to see details of the riparian corridor in forested areas.

• **PLANNING PHASE, STEP II: PERMANENTLY RECORD THE BOUNDARIES OF YOUR STUDY SITE.**

Record the upper and lower bounds (in decimal degrees) of the study segment using a GPS or GIS (e.g., Arc10; GoogleEarth). For example: **START: 42.3737, -71.1313; END: 42.3685, -71.1221**. In the field, flag your start and stop locations with survey tape. These will remain the fixed bounds of your survey segment for the duration of the study. If the site is not randomly selected, you may position the site bounds so as to maximize homogeneity of land use (e.g., primarily urban, forested, or agricultural).

•**PLANNING PHASE, STEP III: CONDUCT A RECONNAISSANCE SITE VISIT.**

If you have not visited the site already, conduct a reconnaissance visit to make sure that property access is feasible and that the study reach should not be re-situated.

•**SURVEY PHASE, STEP I: ASSIGN “OBSERVER NUMBERS” TO THE SURVEYORS DURING EACH SURVEY.**

For each survey, identify between one and four surveyors, who should be numbered consecutively from 1 to 4. Observer #1 must be allowed to lead the survey. Observers may be assigned different numbers upon each survey, but “Observer #1” must always be designated clearly on the data sheet and must lead the survey team in order to have an independent survey.

•**SURVEY PHASE, STEP II: CONDUCT THREE SURVEYS WITHIN A SINGLE SEASON FOR A RAPID ASSESSMENT.**

Record the Start and Stop Time of your surveys. Record the total number of minutes that you spend NOT searching for wood turtles: processing turtles, eating lunch, etc. Record the air temperature, water temperature, and sky conditions at the start and stop of your survey. **Observers should aim for a pace of 1 km in 1 hour of searching.** Within the stream and adjacent stream-influenced areas (floodplain), search for wood turtles around woody structure and in open clearings. Use polarized lenses and walk upstream. Record ALL wood turtle observations, and note which observer located which turtle. Note the sex and juvenile breakdown of the total wood turtle sample. Measure, weigh (see “Measuring and Weighing Turtles”), photograph (carapace and plastron; see “Photographing Turtles”), and individually mark (see: “Marking Turtles”) all turtles captured. Note the presence of wood turtle tracks in the stream substrate.

•**SURVEY PHASE, STEP III: ENTER YOUR DATA**

In the field, enter your data onto the standardized field forms available at <http://northeastturtles.org/NE/formsGLIN.html>. After completing three surveys in a season, you have completed a **Rapid Assessment**. Hooray! If you are a participant in the regional study, which is ongoing in 2014-2015, enter your survey data into the regional database at <http://northeastturtles.org/NE/GLINsurveys.html>.

•**SURVEY PHASE, STEP IV: REPEAT IN A TOTAL OF FOUR SEASONS (TOTAL OF 12 SURVEYS) FOR A LONG-TERM ASSESSMENT**

The success of this effort relies partly on a strong network of regional “Long-Term” or “Reference” populations, which are sampled more intensively than Rapid Assessment Sites. If you have the resources and interest, consider repeating the three-visit protocol in *three additional consecutive seasons*. After four seasons of sampling, it is often possible to build an open-population estimate of population size during the sampling period, which is useful in determining regional abundance patterns and trends.

Please contact with questions:

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Figure 1. Illustration of study site delineation in GoogleEarth. The yellow lines in both “A” and “B” illustrate one kilometer meandering sections of suitable wood turtle habitat. These are fixed survey segments for either 3 surveys in one season (Rapid Assessment), or twelve over four seasons as outlined above (Long-Term). In both instances pictured, the population is believed to be extirpated. Note that both transects were drawn using leaf-off springtime aerial images taken in April.