R9 Species Conservation Assessment
for
Wood Turtle – *Glyptemys insculpta* (LeConte, 1830)

Allegheny National Forest
Chequamegon-Nicolet National Forest
Green Mountain National Forest
Hiawatha National Forest
Huron-Manistee National Forest
Ottawa National Forest
Superior National Forest
White Mountain National Forest

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This Conservation Assessment was prepared to compile published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580, Milwaukee, Wisconsin 53203.

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1. EXECUTIVE SUMMARY

The Wood turtle (*Glyptemys insculpta*) is designated as a Regional Forester Sensitive Species on the Chequamegon-Nicolet, Green Mountain, Huron-Manistee, Ottawa, Superior, and White Mountain National Forests in the Eastern Region of the Forest Service. The species occurrence is documented but not designated as sensitive on the Allegheny and Hiawatha National Forests. The purpose of this document is to provide the background information necessary to prepare Conservation Approaches and a Conservation Strategy that will include management actions to conserve the species.

Wood turtles are medium-sized turtles that inhabit clear, hard-bottomed creeks, streams, and rivers. They prefer forested areas over nonforested, although small openings in the streamside canopy are essential for nesting and feeding. Wood turtles are omnivorous, are aquatic in spring and fall, and are mostly terrestrial in summer. They are dormant and aquatic in winter. Males establish linear dominance hierarchies but are not territorial. Late maturity, low fecundity, high adult survival rates, and low egg and juvenile survival rates characterize Wood turtles. Nesting occurs once a year, usually in June, and clutch size ranges from 3 to 20 eggs. Sandy, exposed, elevated soil with a southerly aspect near the river or stream is a prerequisite for nesting.

Wood turtles are known or suspected to occur in all of the National Forests covered in this report, but to date formal surveys and studies have taken place only in the Huron-Manistee and Hiawatha National Forests. Element occurrences have also been documented in several other National Forests. Potential threats include damming, streambank stabilization, and intensive timber harvesting activities within 300 m of inhabited wetlands. Streambank stabilization may impact populations if affected areas are used for nesting. While Wood turtles appear to prefer woodlands with mixtures of closed and open canopy and forest edges, complete removal of forest and underbrush on a broad scale is likely to be harmful. Other threats are predation of nests, hatchlings, and adults, removal of adults from populations by humans, and human recreation.

There do not appear to be any major research programs involving the Wood turtle in Region 9 at this time. Several National Forests have implemented management guidelines for the Wood turtle, generally focused on protection of nesting habitat. Surveys for Wood turtles should be done in Spring or Fall (before most vegetation emerges) or should concentrate on potential nesting areas during the June nesting season. Research priorities are locating and determining the status of populations, and implementing monitoring programs where feasible. The Wood turtle is in decline throughout its range, and recovery likely depends upon a commitment to education, habitat protection, law enforcement, and predator control.

2. ACKNOWLEDGEMENTS

The authors wish to thank the following people for assistance including (but not limited to) advice, contacts, references, unpublished data and reports, and general information about Wood turtles in specific regions: Scott Anderson, Brian Bogaczyk, Dick Buech, Gary Casper, Brad Compton, James Harding, Janet Kudell-Ekstrum, Rex Ennis, Carl Ernst, Jeff Hines, Ed Lindquist, Brad Nelson, Leighlan Prout, and Raymond Saumure.

3. NOMENCLATURE AND TAXONOMY

The Scientific name of the Wood turtle was recently changed from *Clemmys insculpta* to *Glyptemys insculpta*. This revision is based on both morphological and genetic evidence (Holman and Fritz, 2001; Feldman and Parham, 2002). This change has gained acceptance in the general scientific community, but use of the name *Clemmys insculpta* may still occur.

SCIENTIFIC NAME:	*Glyptemys insculpta* (LeConte, 1830)	
COMMON NAME:	Wood Turtle	
FAMILY:	Emydidae	
SYNONYMS:	*Emys pulchella*	Sweigger, 1814
	Emys scabra	Say, 1825
	Testudo insculpta	LeConte, 1830
	Terrapene scabra	Bonaparte, 1830
	Emys speciosa var. *levigata*	Gray, 1831
	Emys inscripta	Gray, 1831
	Emys insculpta	Harlan, 1835
	Clemmys insculpta	Fitzinger, 1835
	Geoclemys pulchella	Gray, 1855
	Glyptemys insculpta	Agassiz, 1857
	Glyptemys pulchella	Gray, 1869
	Chelopus insculptus	Cope, 1875
	Sculptured Tortoise	
	Red-legged Tortoise/Turtle	
	“Red-legger”	
	“Redleg”	

4. DESCRIPTION OF SPECIES

Glyptemys insculpta is a medium-sized turtle. Adults usually range from 14 to 20 cm in carapace length, with a record of 23.4 cm (Conant and Collins, 1998). The carapace is a brown or grayish-brown color with a low central keel (Harding, 1997). The scientific name translates roughly to “sculptured carved turtle,” and it describes the most unique attribute of the animal’s external anatomy: there are raised growth annuli on the carapacial scutes, which often result in each scute resembling a lopsided pyramid carved from wood (Carr, 1952). The carapacial scutes are crossed by ridges, and vertebral and pleural scutes may have black or yellow lines radiating from the upper corners (Harding, 1997). The posterior marginal scutes are serrated. The plastron is yellow, and both the plastral scutes and the underside of the marginal scutes of the carapace have dark blotches along their rear outer corners (Ernst et al., 1994). The plastron has a V-notch at the tail (Harding, 1997).

Glyptemys insculpta has a black head with a blunt snout and a notched upper jaw (Ernst et al., 1994). The upper surfaces of the neck, legs, and tail are also mostly black, while the undersides will range in color from yellow to orange to red (Harding, 1997).

When mature, males are generally larger than females, with a longer tail (cloaca should be well past carapacial rim in males), a concave plastron, thicker claws, and larger scales on the front of the forelimbs (Carr, 1952; Ernst et al., 1994; Harding, 1997). Males may also have higher, more narrow shells and larger limbs, feet, and head (Harding, 1997). The posterior marginal scutes of females and juveniles flare outward more than those of mature males (Ernst et al., 1994; Harding, 1997).

Glyptemys insculpta hatchlings range in size from 2.8 to 3.8 cm in carapace length, are a tan, brown or gray color, and have a circular carapace that lacks the sculptured appearance of the adult. They also lack the bright coloration on the underside of limbs that is possessed by adults. The tail of a hatchling will appear relatively long compared to that of an adult, and it may be as long as the carapace (Carr, 1952; Harding, 1997).

Glyptemys insculpta can be similar in size and habits to Blanding's turtles (*Emydoidea blandingii*) and Eastern Box turtles (*Terrapene carolina*), but does not have the hinged plastron or domed carapace of those species. Wood turtles may also appear similar to Bog turtles (*Glyptemys muhlenbergi*), but they are much larger when mature and lack the large, bright orange head spots possessed by Bog turtles (Ernst et al., 1994; Harding, 1997).

Summary of Key Characteristics (Figure 1):

- The key characteristics of Genus *Glyptemys* are:
  - small to medium-sized turtle
  - elongate, keeled carapace (Holman and Fritz, 2001)
- The key characteristics of *Glyptemys insculpta* are:
  - carapace with raised growth lines on scutes ("sculptured")
  - strongly serrated posterior carapace
  - plastron lacking hinge
  - plastral scutes yellow with dark blotches along rear outside corners

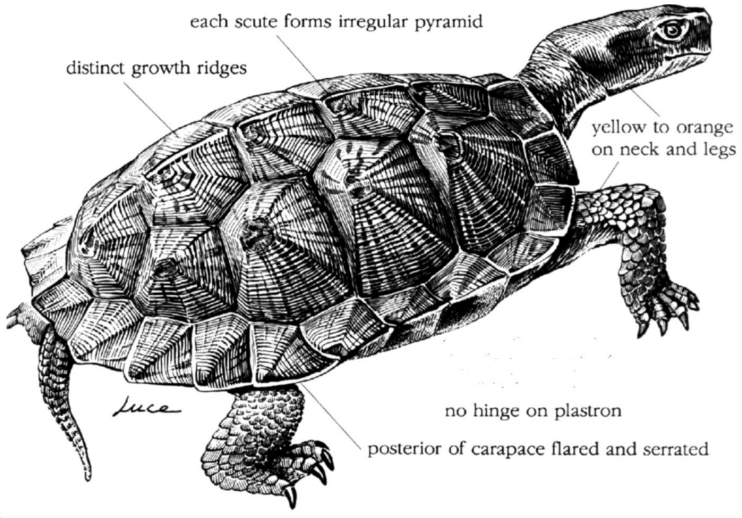

Figure 1. Line drawing of the Wood turtle, *Glyptemys insculpta*, with some distinguishing characteristics noted.

5. LIFE HISTORY

5.1 Reproduction

Glyptemys insculpta is characterized by late maturity and relatively low fecundity. Age at maturity ranges from 9 to 20 years depending on the location and the criteria that are used for determining whether or not a turtle is "mature." For example, a male that shows secondary sexual characteristics may not be large or strong enough to mate successfully, and a female that appears to be mature may not yet be nesting. Clutch size ranges from 3 to 20 eggs, usually with an average clutch size of 8 to 10 (Table 1). Walde (1998) estimated that 65 to 70% of the females in a Quebec population were gravid in a given year, and there is no evidence that Wood turtles lay more than one clutch per year (Powell, 1967; Farrell and Graham, 1991; Harding, 1991).

Mating can take place any time during the active season, but is most common in spring and fall (Table 2). The male often initiates courtship, and mating itself often (but not always) takes place in water (Harding and Bloomer, 1979; Kaufmann, 1992a). Courtship is extremely variable among pairs (Harding and Bloomer, 1979), and both Harding and Bloomer (1979) and Kaufmann (1992a) give detailed descriptions.

Nesting activity occurs from late May to early July, but is most common in mid-June (Table 2). Nesting habitat is described in the "Habitat" section of this report. Female Wood turtles may congregate at nest sites, perhaps as a result of a limited number of suitable sites (Harding and Bloomer, 1979; Vogt, 1981; Walde, 1998). In addition, Females may travel long distances to nesting sites (Harding, 1991; Walde, 1998), and may display nest-site fidelity (Walde, 1998). Nesting occurs most frequently in the morning, late afternoon, or evening (Table 2). Pallas (1960), Harding and Bloomer (1979), and Walde (1998) all give descriptions of nesting behavior.

Reported nest predation is often high, and intact nests do not necessarily hatch out all of the eggs (Table 2). Incubation time ranges from 47 to 116 days (Table 2), and is most dependent upon temperature (Harding, 1991; Walde, 1998). Hatchlings emerge from mid - August to early October (Table 2), and emergence of hatchlings from the nest may be staggered over several days (Swanson, 1952). *Glyptemys insculpta* has genetic sex determination (Ewert and Nelson, 1991).

5.2 Ecology

The seasonal activity of *Glyptemys insculpta* generally involves aquatic winter dormancy, a spring aquatic period, a summer terrestrial period, and a fall aquatic period (Table 3). Arvisais et al. (2002) divided the active season of a Quebec population of *Glyptemys insculpta* into four distinct periods. Short distances traveled and large amounts of time spent basking on riverbanks characterize the "prenesting" period (May). The "nesting" (June) period involves the largest movements of the season and movements to nesting sites are an important reason for this. The "postnesting" (beginning of July to end of September) period is defined by smaller movements than the nesting period, use of aquatic and terrestrial habitat, and variable individual movements. The "prehibernation" period is a time when turtles return to and are active primarily in

the river, engage in an autumn mating peak, and eventually cease movement and become dormant.

This division of the active period may be accurate in describing most *Glyptemys insculpta* populations, but it is important to note that the duration and timing of the different periods may change with location and weather patterns. Furthermore, there is some indication that more western populations may be more aquatic (Harding and Bloomer, 1979). There may or may not be sexual differences in seasonal activity. Ernst (2001b) and Arvisais et al. (2002) found no differences between the sexes, but females are more terrestrial than males during the active season in a New Hampshire population (Tuttle and Carroll, 1997). Feeding may be more common during the warmer months (Farrell and Graham, 1991; Ernst, 2001b; Arvisais et al. 2002), and less common during the mating season (Brewster, 1985). Wood turtles may or may not aestivate during the hottest parts of the year (Farrell and Graham, 1991; Kaufmann 1992b; Ernst 2001b).

Wood turtles are primarily diurnal (Brewster, 1985; Ernst, 1986). Ernst (1986) found that Wood turtles are active at cloacal temperatures ranging from 7.5 to 30.0 ^{o}C, with a mean cloacal temperature of 21.01 ^{o}C. In a New Jersey population Wood turtles are active at a mean cloacal temperature of 16.2 ^{o}C and a mean air temperature of 15.2 ^{o}C (Farrell and Graham, 1991). Graham and Dadah-Totsi (1981) found that Wood turtles are 96-97% diurnal at an ambient temperature of 25 ^{0}C, and 100% diurnal at 15 ^{0}C. Nights are spent in water or in shallow depressions on land (Kaufmann, 1992b).

Except for their diurnal tendencies, the daily activity patterns of *Glyptemys insculpta* appear to be quite variable. Wood turtles may be most active in the morning and late afternoon (Harding and Bloomer, 1979; Brewster, 1985), in the middle of the day (1000 to 1500 h; Farrell and Graham, 1991), or may change these patterns seasonally. In Virginia and Pennsylvania populations Wood turtles are active in late morning and early afternoon during the spring and fall. They shift to primarily morning activity in summer (Ernst and McBreen, 1991; Ernst 2001b). Ernst (2001b) gives a complete breakdown of daily activity by month in a Pennsylvania population.

Wood turtles can be long-lived, as evidenced by a 58 year old captive specimen (Oliver, 1955). However, it is likely that most Wood turtles in natural populations do not live this long, and the oldest reported turtle from a natural population was a female of approximately 46 years (Ernst 2001b; Table 5). The reported ages of turtles should be interpreted with caution because counting annuli on the shell of a Wood turtle becomes increasingly difficult once the animal is older than 20 years (Harding, 1991). Populations with a high average age may not be healthy; i.e. there may be a failure in recruitment. Garber and Burger (1995) found that the average age of a Connecticut population increased significantly upon the opening of habitat to human recreation. Within 10 years of opening the area the population was extirpated.

Wood turtle mortality has many potential causes. Eggs and juveniles have a number of natural enemies, while adults may be attacked by raccoons or humans (Harding, 1991). Females may be particularly susceptible to being hit by automobiles when nesting (Brooks et al, 1992; Neiderburger and Seidel, 1999). The "Potential Threats" section of this report gives more detail on both natural and human-caused mortality.

Harding and Bloomer (1979) described the Wood turtle as an "opportunistic omnivore." They listed blueberries, blackberries, raspberries, strawberries, green leaves,

grasses, algae, mollusks, insects, earthworms, tadpoles, dead fish, and newborn mice as among the foods eaten by free-ranging and captive turtles. Harding (1991) suggested that the leaves of strawberry and sandbar willow were the favored "greens," while Walde (1998) observed many individuals eating paper birch leaves. Earthworms are the most commonly consumed food in a West Virginia population (Neiderberger and Seidel, 1999) and in a Pennsylvania population (Ernst, 2001b). Of 51 total observations in Pennsylvania, Strang (1983) found that Wood turtles ate green leaves 31%, flowers or fruit 16%, fungi 37%, and invertebrates 16% of the time. Kaufmann (1995) noted that mushrooms appeared to be a favorite food, and that wood turtles would enter hemlock forest only when mushrooms were emerging. Other notable foods include periodic cicada (Reid and Nichols, 1970), a box turtle egg (Czarnowsky, 1976), eggs and young of low-nesting birds (Harding and Bloomer, 1979), plantain and dandelion leaves (Brewster, 1985), corn (Brewster, 1985; Kaufmann, 1995), avian carrion (Brewster, 1985; Neiderberger and Seidel, 1999), dead mice and toads, and the tips of ferns fronds (Walde, 1998).

There are several other aspects of Wood turtle feeding behavior that deserve mention. Harding (1991) suggested that hatchlings and juveniles are more carnivorous than adults are. Wood turtles in Pennsylvania were not observed to eat when the water and air temperatures were below 17.2 and 23 ^{o}C respectively (Ernst, 1986). Brewster (1985) observed captive individuals, even females, fight and attempt to exert dominance over a food dish. Wood turtles are known to exhibit a foraging behavior called "worm-stomping" in which they repeatedly stomp their feet and slam their plastron on the ground. Kaufmann (1986) observed this behavior in a natural setting, and he noted that when it occurred earthworms often emerged from the soil and were eaten by the turtle. It has since been observed in natural and captive settings in both old and young turtles (Kaufmann et al., 1989; Tuttle and Carroll, 1997).

5.3 Dispersal /Migration

It is often possible to identify home ranges of individual Wood turtles. The home ranges tend to be small, but there is some evidence that home range size may increase with increasing latitude (Arvisias et al., 2002; Table 4). Home ranges are generally centered on a creek, stream or river and may be elongate in shape as a result (Daigle, 1997). Turtles are rarely captured at great distances from their chosen body of water (Harding and Bloomer, 1979; Kaufmann, 1992b; Ernst 2001b; Table 4). Inter-individual variation in home range size can be large (Quinn and Tate, 1991; Daigle, 1997; Arvisais et al., 2002), but it appears that Wood turtles often display site fidelity. Therefore, the home range of a particular animal may change very little from season to season (Harding and Bloomer, 1979; Quinn and Tate, 1991; Arvisias et al., 2002).

Glyptemys insculpta is not territorial, although a linear dominance hierarchy exists among males in most populations. In a Pennsylvania population, Kaufmann (1992a) found that this hierarchy is positively correlated with age and weight and is often enforced through combat. Several authors have found that there is substantial overlap of individual home ranges despite the apparent aggression of males (Kaufmann, 1995; Daigle, 1997; Tuttle and Carroll, 1997). Home range size may (Daigle, 1997) or may not (Ross et al., 1991; Kaufmann, 1995; Tuttle and Carroll, 1997; Arvisais et al., 2002) differ

between the sexes, and does not appear to be correlated with size or dominance rank (Kaufmann, 1995; Tuttle and Carroll, 1997).

Although Wood turtles often have small home ranges, they can be quite mobile will make occasional long distance movements. Daigle (1997) noted a distance between recaptures (for a male) of 2.8 km, and a male Wood turtle in Virginia moved 1 km between his hibernaculum and summer range (Ernst and McBreen, 1991). Females are also capable of long-distance movements: females looking for nesting sites are known to have moved up to 1 km in Pennsylvania (Ernst 2001b) and 3.7 km in Quebec (Walde, 1998). Brewster and Brewster (1991) noted that a juvenile moved a distance of 500 m. Wood turtles in Ontario make "repetitive seasonal movements" to late summer ranges that are similar to migration (Quinn and Tate, 1991). In concert with their apparent site fidelity, Wood turtles have good homing abilities if they are displaced less than 2 km from their home range (Carroll and Erhenfeld, 1978).

5.4 Obligate Associations

Refer to the following section ("Habitat") for details on obligate associations of *Glyptemys insculpta*. In general, proper nesting habitat may be the most critical requirement of Wood turtles.

6. HABITAT

6.1 Range-wide

Glyptemys insculpta is most commonly associated with forested riparian areas. Clear rivers, streams, or creeks with hard sand or gravel bottoms and moderate current are best. Although Wood turtles are a forest species, they appear to prefer areas in which there are openings in the streamside canopy rather than unbroken forest (Ernst et al., 1994). Wood turtles range-wide tend to be more terrestrial in summer, but there is some evidence that western populations are more aquatic (Vogt, 1981; Harding, 1991). The Wood turtle may occasionally be found in non-riparian habitats such as swamps, bogs, wet meadows, upland fields, and farmland (Harding and Bloomer, 1979).

Winter dormancy takes place in water (Harding, 1997). Some of the hibernacula reported for Wood turtles include muskrat burrows (Bishop and Schoonmacher, 1921; Kiviat, 1978), under overhanging tree roots along banks (Farrell and Graham, 1991; Kaufmann, 1992b; Neiderberger and Seidel, 1999), beaver ponds (Harding and Bloomer, 1979), and the bottom of streams (Bishop and Schoonmacher, 1921; Garber, 1989; Quinn and Tate, 1991; Kaufmann, 1992b; Neiderberger and Seidel, 1999). There are several reports of large numbers of Wood turtles found in the same hibernaculum (Bloomer, 1978; Farrell and Graham, 1991).

Harding (1997) describes preferred nesting habitat as exposed elevated areas with moist sand or sandy soil (Figure 2). Nests are usually close to water (Harding, 1994; Buech et al., 1997). Reported nesting areas include railroad grades, sand/gravel pits, eroding riverbanks, sand bars, and dirt roads (Brooks et al., 1992; Buech et al., 1997; Johnson, personal communication; Walde, 1998; Wusterbarth, 2000). Nesting areas may be the most important facet of Wood turtle habitat. In a comprehensive (334 nests) study

of Wood turtle nesting requirements in eastern Minnesota, Buech et al. (1997) found that suitable nesting sites have sand or gravel substrate, less than 40-degree slope, and low disturbance. Suitable sites are also close to water but at least 1 meter above the normal water level. Vegetation cover must be less than 20%, and the height of woody vegetation should be less than the distance to the southern edge of the nesting area. They also found that if the slope of the nesting area is less than 20 degrees any aspect is acceptable, but if the slope is greater than 20 degrees the aspect is generally East-Southeast or West-Southwest. They emphasize that nesting needs are specific and that sandy soil appears to be the most limiting factor. Harding (1994) suggests that areas receiving full afternoon sun are more likely sites than those not. Human influences on Wood turtle habitat are discussed in the "Potential Threats" section of this report.

Figure 2. An eroded, sandy riverbank: potential *Glyptemys insculpta* nesting habitat.

6.2 National Forests

Several studies of Wood turtle habitat have taken place within National Forest boundaries. In one study, turtles were tracked with radio transmitters along the Au Sable River in the Huron-Manistee National Forest. Turtles were found in lowland conifers 34%, in the river channel 18%, in lowland hardwoods 16%, and on human developments 2% of the time. Analysis suggested that habitat was used non-randomly (Asmus et al., 1999). Turtles along the Manistee River in the Huron-Manistee National Forest nest on unstabilized riverbanks 80% (4 of 5 nests) of the time (Wusterbarth, 2000). Harding (1994) noted six potential nesting areas along the Indian River in Hiawatha National Forest, but did not observe any turtles nesting. A total of seventeen potential nesting areas were identified along the Indian River by Connolly (2002), but no again nesting activity was observed. However, nesting activity was observed along this river the following year (Davis, 2003).

There have been several regional characterizations of Wood turtle habitat that may apply directly to turtles on National Forest lands. In Michigan, Minnesota, and Wisconsin, Wood turtle habitat is made up of three parts. The first is a hard-bottomed river; preferably sand or sandy gravel substrate, with clear or tannin-stained water. The

second is herbaceous forage vegetation. Wood turtles are commonly found on wooded riparian flood plains that possess enough openings in the canopy to support a thick herbaceous understory. This understory is where the majority of foraging occurs. The final component of Wood turtle habitat is sandy nesting substrate, either natural or man-made (Ewert et al., 1998).

Buech and Nelson (1997) used three variables (generalized slope, forest type, texture of soil substrate) and known Wood turtle sightings to describe ideal Wood turtle habitat in eastern Minnesota. They suggested that the areas with the highest suitability for Wood turtles have a generalized slope of 0-2 or 2-6%, Pine, Elm-Ash-Cottonwood, or Aspen-Birch forest, and hard soil substrate texture such as sand and gravel to rock, sand, sand and gravel, or gravel to sandy loam.

6.3 Site-specific

The specific habitat preferences of *Glyptemys insculpta* have been the focus of studies in several locations. In northern Wisconsin, juvenile Wood turtles vary in habitat preference by month. However, the ecotone between Alder thickets and open grassy areas near the river channel consistently has the highest frequency of occurrence of turtles (Brewster and Brewster, 1991). In Maine, Compton et al. (2002) analyzed Wood turtle habitat preference at two scales: within watershed (large) and within activity areas (small) using paired logistic regression. Within the watershed, turtles prefer activity areas that are close to moving water with moderate forest cover and forest canopy over much of the water. Within those activity areas Wood turtles selected nonforested locations close to water with little canopy cover. The authors suggested that the turtles select forest edges as a compromise between thermoregulation and feeding.

Several other authors have quantified the use of particular areas by Wood turtles. In a Pennsylvania population, Kaufmann (1992b) observed Wood turtles in a creek 34%, in an Alder association 25%, in a grass-forb association 20%, in a cornfield 12%, in a Hemlock forest 4%, in a Hemlock swamp 3%, and in a deciduous forest 2% of the time. He stated that Wood turtles seem to prefer areas with a variety of available habitat types rather than unbroken areas of a single habitat type, and that because of this they can be considered an edge species. Quinn and Tate (1991) radio-tracked turtles in an Ontario population. They made 30% of their wood turtle observations in alder swale, 28% in mixed forest, 12% in grassy openings, 8% in upland pine plantations, 7% in deciduous forest, and 5% in lowland conifers. The authors suggested that the apparent preference for Alder might result from a preference for riparian areas. In Connecticut, Tuttle and Carroll (1997) evaluated “habitat units” of radio-tracked Wood turtles and found that 54% of the habitat units were wetland and 46% were upland. Of 5 possible cover types, Wood turtles were found most often in shrub cover (42%).

7. DISTRIBUTION AND ABUNDANCE

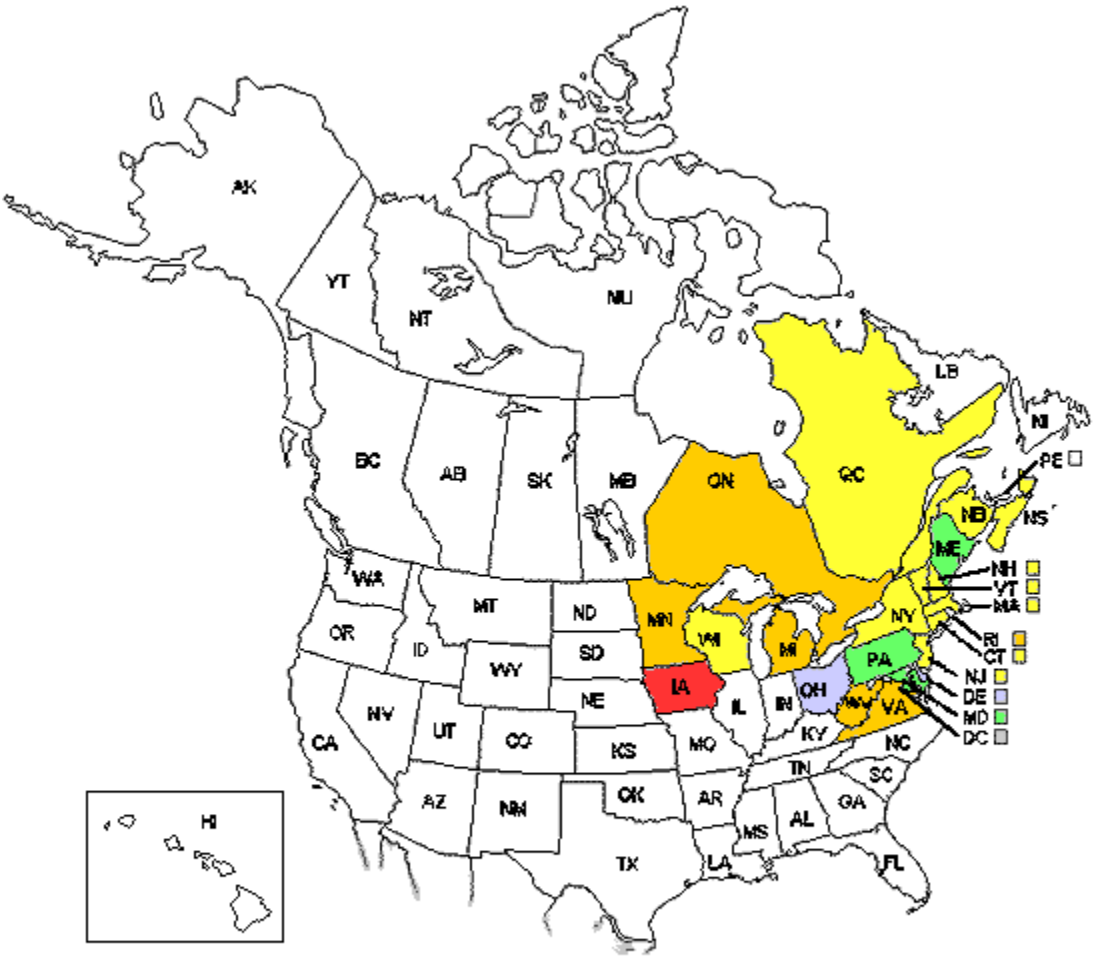

Figure 3. Range-wide distribution of the Wood Turtle, *Glyptemys insculpta*. Shaded states and provinces indicate presence of the Wood Turtle (from NatureServe, 2003).

7.1 Range-wide Distribution (Figure 3)

The range of the Wood turtle extends from Nova Scotia and New Brunswick south along the eastern seaboard into northern Virginia, Western Maryland, and northeastern West Virginia. It extends west through southern Quebec, New York and Pennsylvania into southern Ontario, northern Lower Michigan and Michigan's Upper Peninsula, northern and central Wisconsin, eastern Minnesota and northeastern Iowa (Ernst et al. 1994). Some populations, such as those in southern Ontario and northeastern Iowa, may be disjunct. At one time the Wood turtle ranged as far south as Tennessee (Parmalee and Klippel, 1981) and Georgia (Holman, 1967). It is likely that its range

contracted northward with a warming climate after the Pleistocene (Ernst, 1972; Parmalee and Klippel, 1981).

Ewert et al. (1998) state that "very nearly all Wood turtle habitat was once glaciated." Because Wood turtles require sandy soil for nesting, the occurrence and fine-scale distribution of these animals may be limited by geologic factors. Historically, Wood turtles have likely been concentrated in areas where rivers or streams flow through glacial outwash plains. These geologic features are distributed in a heterogeneous fashion in the upper Great Lakes, and hence so are Wood turtles (Buech et al., 1997). The need for sandy soil combined with the linear nature of Wood turtle habitat may explain why *Glyptemys insculpta* appears to occur naturally in disjunct, isolated populations (Buech et al., 1997; Ernst, 2001a).

Perhaps because of the heterogeneous nature of Wood turtle habitat and distribution, relatively little is known about the distribution and abundance of *Glyptemys insculpta* in many parts of its range. A number of authors have called for studies of Wood turtle distribution and status/abundance, notably in Connecticut (Garber, 1989), Virginia (Ernst and McBreen, 1991), Minnesota (Buech and Nelson, 1997), Maine (Compton, 1999), New Brunswick (McAlpine and Gerriets, 1999), and Michigan (Asmus et al., 1999; Wusterbarth, 2000). Although many populations appear to be declining, Wood turtles can still be locally common where there is suitable habitat and the animals are relatively undisturbed (Harding, 1997). Human influences on distribution and abundance are discussed in the "Potential Threats" section of this report.

7.2 Region-wide Distribution

There are a number of state and regional herpetological field guides and atlases that give county occurrences for *Glyptemys insculpta*. To date, however, there is little published or unpublished information on the distribution and abundance of Wood turtles within National Forests (Table 6). There is evidence of reproduction in the Chequamegon National Forest (Vogt, 1981), Nicolet National Forest (S. Anderson, personal communication), Manistee National Forest (Wusterbarth, 2000), Huron National Forest (Asmus et al, 1999; Wilson et al., 2000), and Hiawatha National Forest (Davis, 2003). Wood turtles are present with evidence of reproduction at numerous sites in Ottawa National Forest (B. Bogaczyk, personal communication), and are present but uncommon in Allegheny (B. Nelson, personal communication) and White Mountain (L. Prout, personal communication) National Forests.

8. RANGE WIDE STATUS

The Global Heritage Status Rank for *Glyptemys insculpta* is G4, the United States National Heritage Status Rank is N4, and the Canada National Heritage Status Rank is N3 (NatureServe, 2003). *Glyptemys insculpta* is listed under Appendix II in CITES (Buhlmann, 1993) and is considered vulnerable by the IUCN (NatureServe, 2003). State rankings and listings vary (NatureServe, 2003; Table 7). As stated in the "Distribution and Abundance" section of this report, relatively little is known about the status of Wood turtle populations in most parts of its range. However, the available evidence suggests that the species is declining range wide (G. Casper, personal communication).

9. POPULATION BIOLOGY AND VIABILITY

Estimates of population size and density vary across the range of *Glyptemys insculpta*. In concordance with the observation that home ranges appear to increase in size with latitude (Arvisias et al., 2002; Table 4), population density appears to decrease with increasing latitude (Table 8). Most populations appear to be either biased toward females or to have an even sex ratio (Table 9). However, comparisons of this type between populations should be interpreted with caution, as different capture methods may yield different population parameters for turtles (Ream and Ream, 1966). It is interesting to note that many populations seem to have a high proportion of adults (Table 9), which may indicate unhealthy populations (Garber and Burger, 1995; Compton, 1999).

Like most turtle populations, the viability of Wood turtle populations is dependent upon adults. As stated in the "Life History" section of this report, Wood turtles have delayed maturity, low fecundity (small clutch size and one clutch per year), high nest predation, and high juvenile mortality rates. As a result, recruitment in most populations is quite low. This low recruitment is balanced by high adult survival rates, and therefore stable populations depend on stable numbers of adults reproducing at fairly constant rates (see also Harding, 1991; Harding, 1997). Combining an increase in adult mortality rate (even a very small increase) with a high juvenile mortality rate can lead to rapid decline and extirpation (Congdon et al., 1993; Congdon et al., 1994; Compton, 1999).

It is also important to note that given the importance of available nesting habitat to Wood turtle distribution and occurrence (Buech et al., 1997; "Habitat" and "Distribution and Abundance" sections of this report), a high adult survival rate does not guarantee a stable population. A given population may in fact be a "ghost population" in which adults are surviving from year to year but there is no successful reproduction. Therefore, when attempting to determine viability it is important to look for evidence of recruitment in addition to high adult survival rates. Such evidence might be the presence of hatchlings and juveniles or a population age structure that is not heavily biased toward older animals (Compton, 1999).

10. POTENTIAL THREATS

10.1 Present or Threatened Risks to Habitat

Ernst (2001a) stated that habitat destruction and alteration is the major threat now facing *Glyptemys insculpta*. Many other authors appear to agree with this assertion. In the eastern part of its range, urbanization is responsible for destroying much Wood turtle habitat (Harding and Bloomer, 1979; Ernst and McBreen, 1991). The building of roads through Wood turtle habitat can also be harmful. Populations of turtles such as *Glyptemys insculpta* cannot remain viable in the face of the additional adult mortality caused by road-kill (Gibbs and Shriver, 2002). Because of its need for clear, flowing water, the Wood turtle can be considered "pollution intolerant" and may be affected by pesticide use (Harding and Bloomer, 1979; Burger and Garber, 1995). Damming and channelization of rivers and streams is destroying Wood turtle habitat across its range (Harding and Bloomer, 1979; Harding, 1991; Buech and Nelson, 1997). However, Wood

turtles can be tolerant of mild habitat alteration such as small-scale opening of the streamside canopy that may create feeding and nesting areas (Harding, 1991). The benefits of any such activity could in some cases be offset by side effects of harvest machinery such as compaction of soil and destruction of nesting habitat (B. Nelson, personal communication).

Nesting habitat is of primary importance to Wood turtle population viability, and it can be destroyed or created by human activity. Man-made structures that may provide nesting habitat include building gravel roads, railroad beds, gravel pits, agricultural fields, and utility fields (Buech et al., 1997). However, some of these structures and activities may also harm Wood turtle populations. Road-kill is one example, and intense agriculture can result in decreased growth and recruitment and increased adult mortality (Saumure and Bider, 1998). Streambank restoration, dams, dredging, channelization, and recreation (Buech et al., 1997) can destroy nesting habitat. For example, Compton (1999) found that damming and subsequent flooding through water release destroyed 25% of nests in Maine. Wusterbarth (2000) found that Wood turtles appeared to prefer unstabilized rather than stabilized banks for nesting along the Manistee River.

Even when habitat is left intact, it may be degraded through human recreation. Increased numbers of humans often lead to increased numbers of Raccoons (Engeman et al., 2003 and references therein), which are an important predator of nests and adults (Harding and Bloomer, 1979; Wusterbarth, 2000). Garber and Burger (1995) observed two Wood turtle populations decline to extinction once they were exposed to large numbers of human recreationists. Burger and Garber (1995) stated that humans find Wood turtles "irresistible" and generally remove them or at least displace them when they are found. The collection of females when they are congregated for nesting is a threat (B. Bogaczyk, personal communication). Wood turtles may face threats from litter such as plastics and fishing gear (Burger and Garber, 1995; Wusterbarth, 2000; Ernst 2001b). They may also be shot by human vandals (Harding, 1991).

10.2 Overutilization

In the past, collection of *Glyptemys insculpta* by biological supply houses was an important issue and may have led to population declines and extirpations, particularly in Wisconsin (Harding and Bloomer, 1979; Vogt, 1981). Collection for food was at one time a threat in the eastern part of the range of *Glyptemys insculpta* (Harding, 1991), and may be responsible to some extent for current population conditions. Presently, illegal collection of Wood turtles for the pet trade is a cause for concern (Harding, 1991; Ernst et al., 1994). Collection and removal of Wood turtles has certainly resulted in population declines, as it is the adults that are easiest to find and most often captured (Ernst et al., 2001a). As previously stated Wood turtle populations will become unstable if even a few adults die or are removed (see "Population Biology and Viability" section of this report). Levell (2000) suggested that trade in Wood turtles is not necessarily a major concern and that allowing captive propagation and trade might alleviate problems. Ernst (2001a) disagreed with these suggestions and postulated that allowing trade in Wood turtles would increase poaching. Collectively, the current evidence suggests that illegal collection is still an issue.

10.3 Disease or Predation

Wood turtles can fall prey to humans as well as to a number of natural predators. Death and injury rates may be high in some areas (Table 10). Nest predation is generally high (Table 2) and Raccoons and Striped Skunks are believed to be the most common nest predators. Ravens, crows, and Coyotes may also consume Wood turtle eggs (Harding and Bloomer, 1979). Hatchlings and juveniles have many potential predators including Raccoons, Skunks, Opossums, birds, other turtles, and fish (Harding and Bloomer, 1979). Adults may also fall victim to predatory attacks and Raccoons are often implicated (Harding, 1985; Farrell and Graham, 1991). However, any opportunistic predator might attack an adult Wood turtle (Walde, 1998). Harding (1985) noted that a large rodent had apparently gnawed upon two turtles, causing extensive shell damage. Predator-related injuries commonly include limb amputations, bobtails, and damaged shells. Limb loss may significantly affect survivorship (Harding, 1985). Almost all human-caused deaths and injuries result from automobile collisions, although in one population a number of turtles were shot (see Table 10 and references therein).

Leeches are often noted on *Glyptemys insculpta*. Infestation rates may be as high as 90% of captured turtles (Farrell and Graham, 1991). Peaks of infestation may be seasonal in nature, and if so they usually correspond to spring and fall when the turtles are spending large amounts of time in the water (Koffler et al., 1978; Hulse and Routman, 1982; Brewster and Brewster, 1986; Farrell and Graham, 1991). Most infestations are by the leech *Placobdella parasitica*, although *Placobdella ornata* has also been found (Saumure and Bider, 1996). To date there is no data on the effects that leeches may have the well being of Wood turtles (Harding, 1991). Wood turtles may become infected by roundworms (Harding and Bloomer, 1979), and the trematodes *Spirorchis innominata* and *Telorchis corti* may also infect them (Hughes et al. 1941).

10.4 Inadequacy of Existing Regulatory Mechanisms

Given the fact that most Wood turtle populations appear to be in a state of decline, there is at present no reason to conclude that current regulations are sufficient. The summary for the CITES listing of the Wood turtle contains the following statement: "reviewers concur that protective legislation at state and provincial levels in the United States and Canada appears to have done little to curb collection of this species" (NatureServe, 2003). Although most states have granted the Wood turtle some level of legal protection, enforcement and education rarely occur. Furthermore, Wood turtles are not always considered in conservation and development planning (Harding, 1991).

10.5 Other Natural or Human Factors

As previously stated, Wood turtles occur naturally in disjunct, isolated populations. In addition, their life history makes them particularly vulnerable to disturbance and increased mortality rates (particularly adult mortality rates). In their own way these factors can be considered a threat to the survival of Wood turtle populations.

11. SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

In a recent faunal survey of Ottawa National Forest, it was suggested that Michigan's Western Upper Peninsula possesses one of the best remaining concentrations of Wood turtles within their range (G. Casper, personal communication). This area is therefore focused upon in this section of the report. The Western Upper Peninsula is a mosaic of federal, state, and private land. Ottawa National Forest makes up a sizable portion of this area, and it is contiguous with Nicolet National Forest in Wisconsin, which may also contain healthy populations (J. Hines, personal communication). Notable state land includes the Porcupine Mountains Wilderness State Park, Copper County State Forests and various County Forests. Potentially important private land includes the L'Anse Indian Reservation, Ontonagon Indian Reservation, and a number of ski resorts.

12. SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Consideration of Wood Turtles is a part of conservation planning in the Huron-Manistee National Forest (R. Ennis, personal communication) and the Hiawatha National Forest (J. Kudell-Ekstrum, personal communication), and may be in others (documentation was not reviewed). In the past, Hatchling Wood turtles have been incubated and released in Huron-Manistee National Forest (T. Wusterbarth, personal communication).

In Massachusetts, habitat of "rare wetland fauna" such as *Glyptemys insculpta* was involved in 3,300 timber-harvesting operations or 5.3% of the total. The Massachusetts Natural Heritage and Endangered Species Program recommended actions such as timing of harvest, buffer zones around water bodies, prevention of siltation, and improved stream crossing. These measures were incorporated where necessary (Kittredge, 1996). Compton (1999) estimated that in Maine, the Maine Shoreland Zoning Ordinance and Champion International Corporation's (a large landholder) Riparian Management Guidelines would protect 80-85% of turtle locations from intensive forestry. However, the Riparian Regulations of the Land Use and Regulation Commission (responsible for the less populated western portion of Maine) would protect only 17% of turtle locations. He suggested that buffer zones 300 m from large wetlands, rivers, and streams would enclose 99% of turtle locations.

Small-scale opening of streamside habitat may be important to create Wood turtle foraging and nesting areas (Harding, 1991).

The following guidelines are listed in the Indian National Wild and Scenic River Decision Notice and Management Plan, Appendix D, Hiawatha National Forest.

1) Do not stabilize or revegetate sites having all of the following characteristics:
    a. Full sun exposure to afternoon and evening sun (SW aspect). Sites that receive only morning sun are not suitable.
    b. Slope less than 40 degrees. Usually the nest site is located at least five feet higher than the water surface elevation.
    c. Sand or sand-gravel substrate with little or no ground vegetation (less than 20% ground cover).
2) Maintain turtle access to known or suspected sites. Treatment of a bank that is unsuitable for nesting should not preclude turtle access to adjacent suitable

habitat. Use of a low-profile wood structure with sod capping is preferable large rock or other material that results in a rough or slippery surface.

3) Where stabilization of erosion caused by ongoing human use is desirable but nesting activity is known or suspected, it may be possible to create suitable habitat nearby. The created habitat must have all the essential characteristics listed above and must be visible to turtle exiting the river. A person familiar with nesting habitat requirements should be consulted before attempting this.

13. PAST AND CURRENT CONSERVATION ACTIVITIES

The Wood turtle is listed in a number of states (NatureServe 2003; Table 7), receives legal protection in most states within its range (Harding, 1991), and is a CITES Appendix II species (Buhlmann, 1993). It is a Regional Forester Sensitive Species in 6 of the 8 National Forests covered by this report. A number of authors have suggested steps and guidelines for the conservation of *Glyptemys insculpta*. These include Harding and Bloomer (1979), Harding (1991), Buech and Nelson (1997), Buech et al. (1997), and Ernst (2001a). In general these authors suggest protection of habitat, particularly nesting habitat, and allowing populations to remain undisturbed.

14. RESEARCH AND MONITORING

14.1 Existing Surveys, Monitoring, and Research

There are a number of statewide reporting programs that catalog Wood turtle sightings. Several state herpetological atlas projects continue to catalog occurrences of *Glyptemys insculpta* and other herpetofauna. Relevant to this report are the Wisconsin Herpetological Atlas Project (Casper, 1996), the Vermont Reptile and Amphibian Atlas Project (Andrews, 2002), the Pennsylvania Herpetological Atlas Project (Hulse et al., 2001), and the New Hampshire Fish and Game Reptile and Amphibian Reporting Program (Taylor, 1993; Taylor, 1997). The Minnesota Natural Heritage and Nongame Research Program and the Michigan Natural Features Inventory catalog occurrences in those states. Recently, the Michigan DNR started a Michigan Herpetological Atlas project.

Small-scale surveys and research programs appear to be uncommon at this time. Surveys for Wood turtles in portions of Hiawatha National Forest took place in 1994 (Harding, 1994), 2002 (Connolly, 2002), and 2003 (Davis, 2003). Surveys also took place in the Huron-Manistee National Forest from 1994 to 2001 (C. Schumacher, personal communication). Currently, occurrences of the Wood turtle are documented in Nicolet National Forest and are then reported to the Wisconsin Herpetological Atlas Project (S. Anderson, personal communication). Long-term studies of *Glyptemys insculpta* by C. Ernst in Pennsylvania and R. Buech in Minnesota have recently come to an end (C. Ernst and R. Buech, personal communication). J. Harding continues his long-term (over 30 years) study in Schoolcraft County, Michigan (J. Harding, personal communication). The only other active research program that consistently involves Wood turtles appears to be that of R. Saumure and J. Bider in southern Quebec.

14.2 Survey Protocol

This portion of the report suggests ways in which to find Wood turtles once potential habitat has been identified. Descriptions of ideal Wood Turtle habitat and classification schemes that can be used to identify such habitat can be found in the "Habitat" section of this report, as well as in Buech and Nelson (1997), Buech et al. (1997), Ewert et al. (1998), and Compton et al. (2002). The best time to search for Wood turtles is in spring and early fall because they are concentrated near rivers and streams at these times. Spring (before complete "leaf-out") is most preferable because the vegetation is less dense and Wood turtles are easier to see (Daigle, 1997; Ewert et al., 1998). Gravid turtles may concentrate in available nesting areas (Ewert et al., 1998). Refer to Table 2 and references therein for the best times for finding nesting females.

Vegetational cues can be used for beginning Wood turtle surveys. In Michigan, surveys should begin when ostrich ferns have early to mid-sized fiddleheads, maples and other hardwoods are half to nearly fully leafed out, and ash species are early in leafing out. Although Wood turtles may be active earlier in the season than this, cold spells may send them back into temporary dormancy (Ewert et al., 1998). There is a general consensus in the literature that once Wood turtles enter their terrestrial phase they become increasingly difficult to find. Davis (2003) states that in Northern Michigan the blooming of the flowers Yellow Hawkweed (*Hieracium caespitosum*) and Bergamot (*Modarna fistulosa*) are indicators of the beginning of the nesting season. Because late springs or cold spells can delay or halt Wood turtle activity, survey schedules should be made as flexible as possible.

One potential way to search for *Glyptemys insculpta* is to use three people, one on each bank of the river or stream and one walking or canoeing down the center (Daigle, 1997). This method would increase the possibility of locating turtles and would make it more difficult for them to escape once located. Except possibly for nesting females, Wood turtles are active only during the day so night surveys would not be useful (see "Life History" section of this report). Surveys can also be done in winter or early spring before turtles emerge, and would involve searching potential hibernacula (Bishop and Schoonmacher, 1921; Farrell and Graham, 1991; "Habitat" section of this report). Once Wood turtles are captured, age, size, and sex measurements are probably the most important preliminary data to gather. A relatively young average age for a population, combined with other evidence of recruitment such as nesting females and the presence of hatchlings and juveniles may suggest a healthy population (Garber and Burger, 1995; Compton, 1999). A sex ratio that approximates 1 to 1 would also be an indicator of population health.

In Hiawatha National Forest surveys were done during the first two weeks of June on sunny afternoons (starting at 4-5 pm and ending at dusk). A canoe was used rather than walking. All eroded streambanks that had potential as nesting areas were recorded and mapped. For each site the aspect, slope, and amount of erosion were also recorded (J. Kudell-Ekstrum, personal communication).

14.3 Research Priorities

Although there are a number of aspects of Wood turtle biology that remain to be explored, the increasing rarity of this animal suggests several important directions:

1) The small-scale distribution and abundance of the Wood turtle needs to be assessed throughout its range. Information in this area is sorely lacking, making it the top priority. Although ground-based surveys by biologists or students would probably be best, it might also be helpful to use tools such as the internet to locate turtles/populations (McAlpine and Gerriets, 1999).

2) Determining the status and viability of Wood turtle populations once they are located is also a priority. Recording data such as survival rates, average age of the population, presence of hatchlings and juveniles, and number of nest sites and nesting females would be critical to such an endeavor. It is possible that there are other indicators of population health. In-depth studies of key populations, such as those in northwestern upper Michigan, might help to uncover such indicators.

3) Once populations have been located and their status determined, it would be advisable to set up monitoring programs for those populations that appear to be healthy.

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17. LIST OF CONTACTS

17.1 Information Requests

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Brian Bogaczyk,	Ottawa National Forest
Richard Buech,	USDA Forest Service North Central Forest Experiment Lab
Gary Casper,	Milwaukee Public Museum
Bradley Compton,	University of Massachusetts
James Harding,	Michigan State University
Kenneth Ennis,	Huron-Manistee National Forest
Carl Ernst,	George Mason University
Jeff Hines,	Minnesota DNR
Janet Kudell-Ekstrum,	Hiawatha National Forest
Ed Lindquist,	Superior National Forest
Brad Nelson,	Allegheny National Forest
Leighlan Prout,	White Mountain National Forest
Raymond Saumure,	McGill University

17.2 Review Requests

Brian Bogaczyk,	Ottawa National Forest
Tom Callison,	Grand Traverse Band of Ottawa and Chippewa Indians
Matt Cole,	Huron-Manistee National Forest
Sean Dunlap,	Ottawa National Forest
Daniel Eklund,	Chequamegon-Nicolet National Forest
Kenneth Ennis,	Huron-Manistee National Forest
Bob Evans,	Ottawa National Forest
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Chris Schumacher,	Huron-Manistee National Forest
Paul Thompson,	Huron-Manistee National Forest

Table 1. Reproductive output and age and size at maturity for the Wood turtle, *Glyptemys insculpta*, across its range. The data are arranged loosely from south to north in descending order. Values for age at size at maturity should be interpreted with caution. These parameters may vary temporally and spatially, and the methods used to estimate them may vary among studies. Where possible, plastron lengths are reported because plastron shape is less variable among animals than carapace shape. An asterisk (*) denotes that data is from captive animals, and the symbol ~ denotes that the data are approximate. An "n" denotes sample size, "m" denotes male and "f" denotes female.

State or Province	Clutch size	Age at maturity	Size at maturity	Source
Virginia	maximum of 12	-	-	Ernst and McBreen, 1991
West Virginia	-	9 years minimum	-	Neiderberger and Seidel, 1999
New Jersey	9 eggs (n=1)*	-	-	Combs, 1971
New Jersey (Sussex Co.)	mean = 8.5 +/- 1.7 range = 5-11 (n=21)*	~14 years	minimum PL: 139 mm (m), 143 mm (f)	Farrell and Graham, 1991
New Jersey (Passaic/Sussex Co.)	mean = 8 range = 5-11	-	minimum CL: 160 mm	Harding and Bloomer, 1979
Pennsylvania (Centre Co.)	mean = 8.9 range = 5-12 (n =7)*	13-14 years	-	Kaufmann, 1992a
Pennsylvania (Venango Co.)	10 eggs (n=1)	-	-	Swanson, 1952
Connecticut	-	~14 years	mean =170 mm CL	Garber, 1989
New Hampshire	mean = 7.8 +/- 1.0 range = 6-9 (n=9)	-	-	Tuttle and Carroll, 1997
Nova Scotia	mean = 8.2 range = 4-11 (n=20)	-	-	Powell, 1967
Wisconsin (Black/Wisconsin R.)	mean = 11 (n=11)	~14 years (f) ~20 years (m)	minimum CL: 180 mm (m), 171 mm (f)	Ross et al., 1991
Wisconsin (Elk River)	9 eggs (n=1)	-	-	Vogt, 1981
North Wisconsin	12/15 eggs (n=2)*	-	-	Brewster, 1985
Ontario (Algonquin Park)	mean = 8.8 +/- 2.4 range = 3-13 (n=21)	17-18 years	minimum PL: 170 mm (m), 161 mm (f)	Brooks et al., 1992
Quebec (Sutton River)	-	~15 years	-	Daigle, 1997
Quebec (Mauricie Region)	mean = 10.1 range = 5-20 (n=58)	14 years (f) 15 years (m)	minimum PL: 183 mm (m), 177 mm (f)	Walde, 1998
Michigan (Schoolcraft Co.)	mean = 10.5 range = 5-18	~12-14 years	minimum CL: 160 mm	Harding, 1991

Table 2. Measures of nesting success and the timing of mating and nesting events for the Wood turtle, *Glyptemys insculpta*, across its range. The data are arranged loosely from south to north in descending order. Timing of events, particularly incubation and hatchling emergence, should be interpreted with caution. The timing of these events may vary temporally and spatially with weather. An asterisk (*) denotes that data are from captive animals, and an "n" denotes sample size.

State or Province	Mating season	Nesting season	Nest predation	Nesting time	Incubation/Success	Source
Virginia	Most in spring and fall	June	-	-	52 days*	Ernst and McBreen, 1991
West Virginia	March - April Sept. - December	-	-	-	-	Neiderberger and Seidel, 1999
Pennsylvania (Lancaster Co.)	11 March - 31 May 11 October	4 June - 19 June	-	-	Emergence 14 Sept. to 11 October	Ernst, 2001b
New Jersey	-	June or July	-	Afternoon /evening	-	Combs, 1971
New Jersey (Sussex Co.)	Late March - April Oct. and November	June 31 May - 10 July*	-	Early morning or late evening*	70 –71 days (n=2) Late Aug. emergence	Farrell and Graham, 1991
New Jersey (Passaic/Sussex Co.)	April - May Sept. - November	5 June - 7 July	-	Afternoon or evening	Mid-Aug. to early Oct. emergence	Harding and Bloomer, 1979
Pennsylvania (Centre Co.)	April – mid-May mid-Sept. - October	4 June - 16 June	-	Most common after 1600 h	-	Kaufmann, 1992a
Pennsylvania (Venango Co.)	March* - April September*	-	-	-	6 of 10 hatching (n=1)* from 27 Sept. – 5 Oct.	Swanson, 1952
New Hampshire	-	2 June - 13 June	100% (n=4)	-	66 –82 days (n=8) 77% success	Tuttle and Carroll, 1997
North Wisconsin	1 May - 15 June* Early Sept. – Winter*	Mid-June*	-	Morning (n=1)* Evening (n=1)*	48% hatching (n=2)*	Brewster, 1985
Ontario (Algonquin Park)	-	June 7 - June 18	88% (15 of 17)	Begin excavation near dusk	-	Brooks et al., 1992
Quebec (Mauricie Region)	May - October 77% in fall	9 June - 28 June	0%	Morning or evening	60 –166 days 17 Aug. to 7 Oct. emerg.	Walde, 1998
Michigan (Schoolcraft Co.)	Most common in June and Sept.	10 June - 29 June	Can approach 100%	Late evening	47 –65 days* Late Aug. - Sept. emerg.	Harding, 1991; 1994

Table 3. Active season and terrestrial activity period of the Wood Turtle, *Glyptemys insculpta*, across its range. The data are arranged loosely from south to north in descending order. The duration of activity seasons and terrestrial periods should be interpreted with caution, as they may vary with weather conditions.

State or Province	Active season	Terrestrial period	Source
Virginia	March to January	-	Ernst and McBreen, 1991
West Virginia	March - October	May - September	Neiderberger and Seidel, 1999
Pennsylvania (Lancaster Co.)	Early March to late November	Mid-June to Autumn	Ernst, 1986; Ernst, 2001b
New Jersey (Sussex Co.)	Early March - late November	Mid-May to early October	Farrell and Graham, 1991
New Jersey (Passaic/Sussex Co.)	Late April/mid-May to late Sept./early Nov.	Early June - Late August	Harding and Bloomer, 1979
Pennsylvania (Centre Co.)	Late March/early April to late Oct./early Nov.	Late May - late September	Kaufmann, 1992b
Ontario (Algonquin Park)	-	Most of Spring and Summer	Quinn and Tate, 1991
Quebec (Sutton River)	-	Aquatic most of active season	Daigle, 1997
Quebec (Mauricie Region)	May to October/November	July and August	Walde, 1998
Quebec (Mauricie Region)	May to October/November	End of June to mid-September	Arvisais et al., 2002
Michigan (Schoolcraft Co.)	Late April to early October	Aquatic most of active season	Harding and Bloomer, 1979; Harding, 1991

Table 4. Home range size and maximum distance traveled from water for the Wood turtle, *Glyptemys insculpta*, across its range. The data are arranged loosely from south to north in descending order. Comparisons between locations should be made with caution, particularly when different methods of estimation have been used. An "n" denotes sample size, and MCP refers to Minimum Convex Polygon.

Location	Home range size	Method of estimation	Maximum distance from water	Source
West Virginia	-	-	200 m	Neiderberger and Seidel, 1999
Pennsylvania (Lancaster Co.)	-	-	250 m	Ernst, 2001b
Pennsylvania (Cumberland Co.)	447 +/- 233 m	Greatest recap. distance	-	Strang, 1983
Pennsylvania (Centre Co.)	Male mean: 3.79 +/- 1.40 ha (n=6) Female mean: 2.55 +/- 0.45 ha (n=4)	Quadrat Summation (100%)	600 m (95% within 300 m)	Kaufmann 1992b; 1995
New Hampshire	Male mean: 5.8 +/- 3.3 ha (n=5) Female mean: 3.9 +/- 3.0 ha (n=5) Juv. mean: 6.0 +/- 6.8 ha (n=2)	-	-	Tuttle and Carroll, 1997
Wisconsin (Black River)	Male mean: 0.25 +/- 0.165 ha (n=3) Female mean: 0.54 +/- 0.330 ha (n=4)	MCP (95%)	-	Ross et al., 1991
Wisconsin (Wisconsin River)	Female mean: 1.4 ha (n=2)			Ross et al., 1991
Wisconsin (Wisconsin River)	-	-	40 m (Juveniles)	Brewster and Brewster, 1991
Michigan (Au Sable River)	Male mean: 9.1 ha (n=3) Female mean: 10.4 ha (n=6)	MCP (100%)	-	Asmus et al., 1999
Michigan (Au Sable River)	Overall mean: 7.3 ha (n = 3 male, 5 female, 2 juv.)	MCP (100%)	-	Wilson et al, 2000
Ontario (Algonquin Park)	Overall mean: 24.3 ha (n= 2 male, 6 female)	MCP (95%)	-	Quinn and Tate, 1991
Quebec (Sutton River)	Male mean: 707.5 +/- 191.8 m (n=16) Female mean: 189.0 +/- 61.1 m (n=9)	Greatest recap. distance	-	Daigle, 1997
Quebec (Mauricie Region)	Male mean: 30.3 ha (n=6) Female mean: 27.6 ha (n=14)	MCP (95%)	300 m	Arvisias et al., 2002
Michigan (Schoolcraft Co.)	-	-	150 m	Harding and Bloomer, 1979

Table 5. Average longevity of and maximum age of the Wood turtle, *Glyptemys insculpta*, from across its range. The data are arranged loosely from south to north in descending order. Age estimates should be interpreted with caution as a result of the difficulty in aging turtles older than 20 years. The symbol ~ denotes that the data are approximate.

Location	Average longevity	Maximum known age	Source
Pennsylvania (Lancaster Co.)	Males: 6.82 years Females: 6.47 years	Male: 42 years Female: ~ 46 years	Ernst, 2001b
New Jersey (Sussex Co.)	51 of 36 turtles 20+ years old	Male: 27 years	Farrell and Graham, 1991
Connecticut	Overall: 12.49 +/- 1.4 years (before human interference) Overall: 17.56 +/- 0.80 years (after human interference)	32 years	Garber, 1989; Garber and Burger, 1995
Wisconsin (Black River)	-	Female: 33 years	Ross et al., 1991
Ontario (Algonquin Park)	Males: 21.6 +/- 2.4 years Females: 24.6 +/- 2.2 years	-	Brooks et al, 1992
Michigan (Schoolcraft Co.)	Males: 25 years Females: 24 years	Male: 32 years	Harding, 1991 Harding and Bloomer, 1979;

Table 6. Counties that contain records of the Wood turtle, *Glyptemys insculpta*, and R9 National Forest Lands. It is important to note that a county record for the Wood turtle does not necessarily mean that Wood turtles are present on National Forest lands in that county. Verified records of Wood turtles on National Forest lands within a given county are noted by an asterisk (*).

National Forest	Counties with Wood turtles present	Source
Allegheny	Warren, Forest, Jefferson, McKean, Elk	Hulse et al., 2001
Chequamegon	Bayfield, Sawyer, Vilas, Ashland, Price, Taylor	Casper, 1996
Nicolet	Vilas*, Forest*, Oconto, Oneida, Florence*	Casper, 1996; S. Anderson, pers. com.
Green Mountain	Addison, Rutland*, Windham, Washington, Windsor, Bennington*	Andrews, 2002; C. Grove, personal communication
Hiawatha	Mackinaw, Schoolcraft*, Alger, Delta	Ruthven and Thompson, 1915; Harding and Holman, 1990; Davis, 2003
Huron	Crawford*, Ogemaw, Iosco*, Oscoda*, Alcona*	Harding and Holman, 1990; Asmus et al., 1999; USDAFS Unpub. data
Manistee	Oceana, Muskegon, Wexford, Mason, Newaygo, Mecosta, Lake, Manistee*	Harding and Holman, 1990; USDAFS Unpub. data
Ottawa	Ontonagon*, Iron*, Baraga, Gogebic*, Houghton	Harding and Holman, 1990 B. Bogaczyk, personal communication
Superior	Lake, St. Louis	Oldfield and Moriarty, 1994
White Mountain	Coos*, Grafton*	Taylor,1993; Taylor, 1997; Grove, personal communication

Table 7. Ranking and listing of the Wood turtle, *Glyptemys insculpta*, by state and province. Rankings are as follows: SH: possibly extirpated, SR: reported, S1: critically imperiled, S2: imperiled, S3: vulnerable, S4: apparently secure. All data are from NatureServe (2003).

State or Province	Ranking	Listing
Connecticut	S3	Special Concern
Delaware	SR	-
District of Columbia	SH	-
Iowa	S1	Endangered
Maine	S4	-
Maryland	S4	-
Massachusetts	S3	Special Concern
Michigan	S2/S3	Special Concern
Minnesota	S2	Threatened
New Hampshire	S3	-
New Jersey	S3	Threatened
New York	S3	-
Ohio	SR	-
Pennsylvania	S4	-
Rhode Island	S2	Special Interest
Vermont	S3	-
Virginia	S2	Threatened
West Virginia	S2	-
Wisconsin	S3	Threatened
New Brunswick	S3	-
Nova Scotia	S3	-
Ontario	S2	Rare
Quebec	S3	-

Table 8. Reported population size and density estimates for the Wood turtle, *Glyptemys insculpta*. The data are arranged loosely from south to north in descending order. The data should be interpreted with caution, as methods of estimation vary. "Mean" refers to the fact that separate estimates from several years were averaged, and "95% CL" refers to 95% confidence limits for an estimate.

Location	No. of turtles captured	Population size estimate	Method used	Density estimate	Source
West Virginia	187	337	Schnabel index	19.1/ha	Neiderberger and Seidel, 1999
New Jersey (Sussex Co.)	316	mean = 654	modified Lincoln Index	mean = 10.6 / ha	Farrell and Graham, 1991
New Jersey (Passaic/Sussex Co.)	-	-	-	12.5 / ha	Harding and Bloomer, 1979
Pennsylvania (Lancaster Co.)	88	159 (95% CL = 103 - 215)	Schumacher and Eschmeyer model	4.42 / ha	Ernst, 2001b
New Hampshire	82	-	-	2.6 / ha	Tuttle and Carroll, 1997
Ontario (Algonquin Park)	68	71 (95% CL = 51 - 103)	Petersen	0.24 / ha	Brooks et al., 1992
Quebec (Sutton River)	52	66 (95% CL = 56 - 81)	Schumacher and Eschmeyer model	1.2 / 100 m of river	Daigle, 1997
Quebec (Mauricie Region)	188	238 (95% CL = 191 - 285)	Lincoln - Petersen index	0.44 / ha	Walde, 1998

Table 9. Reported capture results, sex ratios, and percentage of adults in populations of the Wood turtle, *Glyptemys insculpta*, from across its range. The data are arranged loosely from south to north in descending order. Comparisons should be interpreted with caution, as different methods of capture may bias results. The asterisk (*) indicates that values for these populations were documented as unstable (Garber and Burger, 1995).

Location	No. of marked turtles	Sex ratio (m:f)	% Adult	Source
West Virginia	187	1:1	54%	Neiderberger and Seidel, 1999
New Jersey (Sussex Co.)	316	1:0.6	34%	Farrell and Graham, 1991
New Jersey (Passaic/Sussex Co.)	-	1:1.5	-	Harding and Bloomer, 1979
Pennsylvania (Lancaster Co.)	88	1:0.72	76%	Ernst, 2001b
Pennsylvania (Centre Co.)	84	1:1	83%	Kaufmann, 1992a
Connecticut	-	Population 1 = 1:2.4 Population 2 = 1:1.5	63% 56%	Garber, 1989*
New Hampshire	82	1:1.8	56%	Tuttle and Carroll, 1997
Wisconsin (Black River)	58	1:0.6	98%	Ross et al., 1991
Wisconsin (Wisconsin River)	24	1:1.9	96%	Ross et al., 1991
Michigan (Pine River)	82	1:1.8	-	C. Schumacher USDAFS Unpub. data
Michigan (Manistee River)	43	1:0.36	-	C. Schumacher USDAFS Unpub. data
Michigan (Little Manistee River)	32	1:2.6	-	C. Schumacher USDAFS Unpub. data
Michigan (Au Sable River)	29	1:1.8	69%	Asmus et al., 1999
Ontario (Algonquin Park)	101	1:2.7	76%	Brooks et al., 1992
Ontario (Algonquin Park)	48	1:4.1	96%	Quinn and Tate, 1991
Quebec (Sutton River)	52	1:1.2	81%	Daigle, 1997
Quebec (Mauricie Region)	Population 1 = 31 Population 2 = 33	1:1 1:0.8	65% 88%	Saumure and Bider, 1998
Quebec (Mauricie Region)	188	1:0.98	69%	Walde, 1998
Michigan (Schoolcraft Co.)	397	1:1	82%	Harding, 1991

Table 10. Reported human and predator-related deaths and injuries of the Wood turtle, *Glyptemys insculpta*. All human-related deaths were the result of automobile collision except those reported by Harding (1991), which were the result of shootings. Predator-related injury numbers may be misleading in some cases, as turtles with multiple injuries may have been counted more than once. "P1" and "P2" refers to the fact that two different populations were studied.

Location	No. of turtles	Human-related deaths	Predator-related deaths	Human-related injuries	Predator-related injuries	Source
West Virginia	187	1	-	-	-	Neiderberger and Seidel, 1999
New Jersey (Sussex Co.)	316	-	3	-	53	Farrell and Graham, 1991
Pennsylvania (Lancaster Co.)	88	1	1	3	9	Ernst, 2001b
Connecticut	133	4	3	-	-	Garber and Burger, 1995
Michigan (Au Sable River)	29	2	-	1	8	Asmus et al., 1999
Ontario (Algonquin Park)	101	7	2	-	-	Brooks et al., 1992
Quebec (Mauricie Region)	P1 = 31 P2 = 33	-	-	3 8	32 28	Saumure and Bider, 1998
Quebec (Mauricie Region)	188	-	-	-	65	Walde, 1998
Michigan (Schoolcraft Co.)	397	6	1	-	44	Harding, 1985; 1991