Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles—An International Conference, pp. 383–391

Identification of Wood Turtle Nesting Areas for Protection and Management

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ABSTRACT: The wood turtle, *Clemmys insculpta*, is a long-lived, semi-aquatic, riverine species that inhabits forested regions of the northcentral and northeastern United States and adjacent regions of Canada. Many states list the wood turtle as "Endangered" or "Threatened," and it is now listed on Appendix II of the Convention on International Trade in Endangered Species (CITES). In this paper, we examine the hypothesis that nesting areas are critical determinants of wood turtle occurrence in northern portions of its range. We measured six habitat variables at 334 nesting sites and used those data to develop criteria that define suitable nesting areas. Our study demonstrated that wood turtles in the Upper Great Lakes Region prefer nesting areas that are near water, very sandy, elevated, bare, and well exposed to solar radiation. Using a geographic information system (GIS), we designed a model that used sandy soil and stream spatial data to locate potential wood turtle nesting areas. The accuracy of the model was evaluated using three methods: aerial photographic interpretation, aerial survey, and ground survey. The ground survey confirmed that all wood turtles and nearly all potential nesting areas meeting the criteria were located near river reaches predicted by the GIS to have potential for producing nesting areas. Aerial photographic interpretation yielded unacceptably poor information, while the aerial survey was acceptable for identifying major nesting areas.

Geologic factors most likely determine the local distribution of wood turtles. In glaciated portions of their range, the historic distribution of wood turtles was probably correlated with the soils from glacial outwash plains. Because these soils occur in isolated patches, wood turtle populations have probably always occurred in disjunct segments. However, human activity has altered the availability of sand and gravel, which in turn may have altered the local distribution of wood turtles. Wood turtles are vulnerable to loss or degradation of their nesting areas from streambank stabilization, channelization, damming, and dredging programs. Thus, it is essential that resource managers identify and protect this element of critical habitat. Because nesting areas are a landscape feature, a partnership of private and public entities is required to effectively manage wood turtles in entire watersheds.

The wood turtle, *Clemmys insculpta*, is a long-lived, semi-aquatic, riverine species that inhabits forested regions of the northcentral and northeastern United States and adjacent regions in Canada. Many states list the wood turtle as "Endangered" or "Threatened," and it is now listed on Appendix II of the Convention on International Trade in Endangered Species (CITES). Numerous hypotheses have been offered to explain the apparent decline of wood turtles: loss of aquatic and riparian habitats through channelization, damming, dredging, streambank stabilization, and general urban and agricultural development; pollution and pesticides; mortality from vehicles; increase in density and/or expansion of the range of important predators such as raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), and opossums (*Didelphis marsupialis*); commercial collection for the pet trade, biological supply houses, and food; and recreationists shooting or taking them for pets (Harding and Bloomer, 1979; Buech et al., 1991; Harding, 1991; Buech, 1992; Kaufmann, 1992; Garber and Burger, this volume).

From a study of the habitat requirements and reproductive success of wood turtles in northeastern Minnesota (Buech et al., 1990, 1991, 1993; Buech, 1992), we obtained information suggesting that wood turtles have very specific nesting requirements: very sandy, elevated, bare sites that were well exposed to the sun. This suggested that we could develop a simple model using only soil and hydrologic factors to predict where suitable nesting areas might occur in a watershed. Physiographic conditions conducive to the creation of suitable nesting areas appear uncommon and unevenly distributed in our region. Appropriate nesting areas may therefore be critical determinants of the occurrence of wood turtles, which would make identification, protection, and management of such areas crucial.

In this paper, we examine the hypothesis that nesting areas are critical determinants of the occurrence of wood turtles in the northern portions of their range. Our objectives were to (1) develop a set of criteria that describes a suitable nesting area for wood turtles in the Upper Great Lakes

Region, (2) develop and test a model that predicts which stream reaches are conducive to creating suitable nesting areas, and (3) compare the efficacy of three methods for locating nesting areas.

METHODS

To describe a suitable wood turtle nesting area, we measured six habitat variables: soil substrate (gravel, sand, sandy loam, etc.), slope (degrees), aspect (16-point compass), elevation above water (meters), distance to water (meters), and vegetative cover (percent cover). We measured these habitat variables at all wood turtle nests encountered during the 1990, 1991, and 1993 nesting seasons on three major nesting areas: an abandoned sand and gravel operation (n = 146), a large cutbank (n = 95), and an abandoned railroad grade (n = 93). Some areas did not provide a full range of conditions for all habitat variables (see Table 1). But collectively, these large nesting areas provided a broad range of possible habitat conditions. Sample sizes for analyses of nest site attributes were always less than the total sample of 334 nest sites because some data were missing for each habitat variable.

To meet our second objective, we tested the nesting area hypothesis on a relatively little-known segment of the St. Louis River between Seven Beavers Lake and Cloquet, Minnesota, a distance of 253 km. Using a geographic information system (GIS), the model was constructed with two digital sources of information: a U.S. Geological Survey (1: 250,000) topographic map of the St. Louis River watershed and a draft geomorphology map of St. Louis County created by the U.S. Natural Resources Conservation Service. The hydrology component of the model was based on the following premise: We assumed that under historic conditions, wood turtles nested on sandy points on inside turns of streams or on cutbanks on outside turns. Such features are usually created and maintained during episodic flooding in medium-size or larger stream reaches. Thus, we considered only stream orders (Horton, 1945; Strahler, 1957) size 3 or larger as likely to have sufficient hydraulic force to create wood turtle nesting areas. We considered the following characteristics as desirable for the geomorphic component of the model: glacial outwash plain, high sand content, and some topographic relief. Based on these attributes, we classified "Big Rice Outwash Plain" and "Brimson Outwash Plain" as having high potential of producing wood turtle nesting areas; "Upper St. Louis Valley Outwash," "Leora Lake Outwash Plain," and "Upham Basin Till Plain" as medium; "Lake Upham Sands" as low; and the remaining geomorphic classes as having low to zero potential for producing suitable nesting areas. A simple overlay of these hydrology and geomorphology data layers produced a map that predicted the nesting potential of various reaches of the St. Louis River.

The next step was to field test the model predictions. If our hypothesis is correct, we should find both potential nesting areas and wood turtles themselves in direct relation to habitat quality class; the higher the class, the more nesting areas and wood turtles we could expect to find. To meet the third objective, we evaluated the model using three methods: aerial photographic interpretation, aerial survey, and ground survey.

Aerial Photographic Interpretation

This method used aerial photographic interpretation of black-and-white infrared photos (1:15,840) to identify potential nesting areas on the test segment of the St. Louis River. The interpreter searched stereoscopic photo pairs for potential nesting areas on cutbanks (outside bends), sandy points (inside bends), islands, road beds (both railroad and highway) and utility rights-of-way at crossings, and gravel or borrow pits. Each potential nesting area was labeled on a map and classified by type (bank, point, island, gravel pit, and highway, railroad, or utility rights-of-way) and size (small, medium, and large) classes. A small nesting area was defined as having an area of 5–50 m² (in aerial views, size appears to be between that of a car and a two-car garage), a medium nesting area was 51–200 m² (between that of a two-car garage and 1⅓ times the size of a standard 7.3 × 14.6 m ranch style home), and a large nesting area was >200 m² (size appears larger than 1⅓ times the size of a standard ranch style home).

Aerial Survey

In this method, a pilot, navigator, and observer in a fixed-wing plane identified potential nesting areas on the same test segment of the St. Louis River. The observer was responsible for spotting potential nesting areas, classifying those that met minimum standards by type and size (using the same definitions given above), and assigning them identification numbers. The navigator was responsible for locating and labeling potential nesting areas on a map. The aerial survey was conducted 16 October 1992, timed so that it occurred after leaf fall when water levels were normal, and during the period 9 A.M. to 3 P.M. so as to minimize strong shadows. The observer had not participated in the ground survey.

Ground Survey

The ground survey served as the control. Two-person crews canoed the test segment of the St. Louis River to locate potential nesting areas. Each area was assigned an identification number and classified using the same type and size classes as in the two aerial methods. We also recorded soil substrate (silt, fine sand, coarse sand, gravel), slope (nearest 10 degrees), aspect (16-point compass), minimum and maximum elevation above water (meters), vegetative cover (percent cover by class in 10% increments), and presence of wood turtle nests destroyed by predators.

Wood turtles occur in both aquatic and terrestrial habitats, depending on seasonal, diurnal, and weather-related factors (Harding and Bloomer, 1979; Farrel and Graham, 1991; Kaufman, 1992). We recorded the following data on any wood turtle captured: identification number, new or recapture, sex, age, location (in water or on land), and distance from shoreline (Table 2). We conducted a systematic search for wood turtles in both aquatic and terrestrial habitats. The search was conducted on the side of the river that seemed to have the better basking habitat (less tree cover, sunnier). One person searched terrestrial habitat between 0 and 20 m from the river's edge, for a distance of approximately 160 m. The second person searched aquatic habitat along the same 160 m of shoreline. The search was conducted at regular intervals: every 0.8 km in high- or medium-quality habitat and every 3.2 km in low-quality or unlikely habitat. To increase the chance of encountering turtles, we conducted the ground survey when wood turtle activity is concentrated in and along riverine habitat, from 16 September to 1 October (1991). Unfortunately, we encountered cold and cloudy weather while canoeing reaches predicted to have high or medium-quality wood turtle habitat. We therefore resurveyed the much longer, medium-quality habitat segment in spring (18–22 May 1992), when the chance of encountering wood turtles should be even greater than in fall.

TABLE 1

Range of habitat conditions found on three nesting areas of *Clemmys insculpta*. Six habitat variables were measured to define a suitable wood turtle nesting area. SM = an abandoned sand and gravel operation; CB = a large cutbank; RR = an abandoned railroad grade.

Habitat variable	Nesting areas SM n = 146	CB n = 95	RR n = 93
Substrate (gravel, sand, sandy loam)	All	All	All
Slope (degrees)	0–45	0–50	0–40
Aspect (16-point compass)	All	ESE-SW	All
Elevation above water (m)	0–9	0–6	0–5
Distance to water (m)	0–100+	0–9	0–100+
Vegetative cover (%)	0–100	0–100	0–100

TABLE 2

Wood turtles captured during ground surveys of the St. Louis River in northeastern Minnesota in fall 1991 and spring 1992. Wood turtles were found either during systematic searches (Yes), or while we were casually canoeing (No). Distance class to shore when the turtle was first seen in the water is given within parenthesis. Distance class to shore when the turtle was first seen on land is given without parenthesis.

Date	I.D. No.	Sex	Age (years)	Systematic search zone?	Location	Distance to shore (m)	Temperature Air °C	Water °C	Cloud cover (%)
F 91	127	F	20+	No	Water	(2–0)	15	16	81–100
F 91	*	?	?	Yes	Water	(2–0)	14	16	81–100
F 91	200	M	20+	Yes	Land	2–10	11	16	81–00
F 91	125	M	20+	Yes	Water	(2–0)	16	18	0–20
S 92	129	F	20+	Yes	Land	2–10	23	17	0–20
S 92	128	?	4	Yes	Land	0–2	24	16	0–20
S 92	130	?	4	Yes	Land	2–10	25	17	0–20
S 92	131	F	20+	Yes	Land	2–10	26	17	0–20
S 92	134	?	2	Yes	Land	2–10	26	19	0–20
S 92	133	?	3	No	Land	0–2	26	19	0–20

* This turtle avoided capture.

RESULTS

Criteria for Suitable Nesting Areas

The substrates of 331 nests were evenly distributed between sand and sandy gravel. A contour plot of the density distribution of 270 nest sites with respect to slope and aspect (excluding nests where slope and aspect were zero) revealed an interaction (Figure 1). Where slope was low, aspects were distributed in all compass directions. However, at slopes equal to or exceeding 20°, southerly aspects within the range ESE–SW dominated (150 of 164 nests on slopes ≥20°). The greatest slope we encountered at any nest site was 40°.

Elevation above water also seemed important (Figure 2). Of 329 nests, none was located less than 1 m above water, and few (7%) were located <2 m above water. Most nests (86%) were located 2–5 m above water at a point where bank-full water level was about 1 m above the base-flow level.

Distance from the main river channel for 247 nests was skewed to shorter distances (Figure 3). Half of the nests were located 0–10 m from the main channel, and approximately one fourth were located more than 40 m away. This pattern is further exaggerated if distance is measured simply to the nearest open water. Using this measure, we found that 84% of 330 nests were located 0–10 m from the nearest open water, while only 5% of nests were located 50 m or more away. We found only six nests 100 m or more from water—the most distant at 151 m. Nesting sites on the cutbank, created by natural processes, were available only within 10 m of water. Thus, we analyzed nest sites on human-created nesting areas separately to determine whether females actually preferred sites close to water (these areas provided a full range of distances from water). Still, 78% of 236 nest sites were located within 10 m of water (Figure 4). A contingency table analysis of the distribution of nest sites with respect to distance from water by 10 m categories yielded highly significant differences when compared to a uniform distribution. We obtained $X^2 = 493.5$, $P = <0.001$ for a 2×5 table and $X^2 = 71.6$, $P = <0.001$ for a 2×2 table, e.g., 0–10 vs. >10 m. These data strongly suggest that females prefer to nest close to water.

The distribution of nests with respect to vegetative cover was strongly skewed to the low-cover categories (Figure 5). Approximately 35% of 327 nests had no vegetative cover in the vicinity of the nest, 72% had 0–10% vegetative cover, and 93% had 0–20% vegetative cover. Only two nests had more than 50% vegetative cover. Combining the above information, we produced a minimum set of criteria for defining a suitable nesting area for wood turtles in the Upper Great Lakes Region (Figure 6).

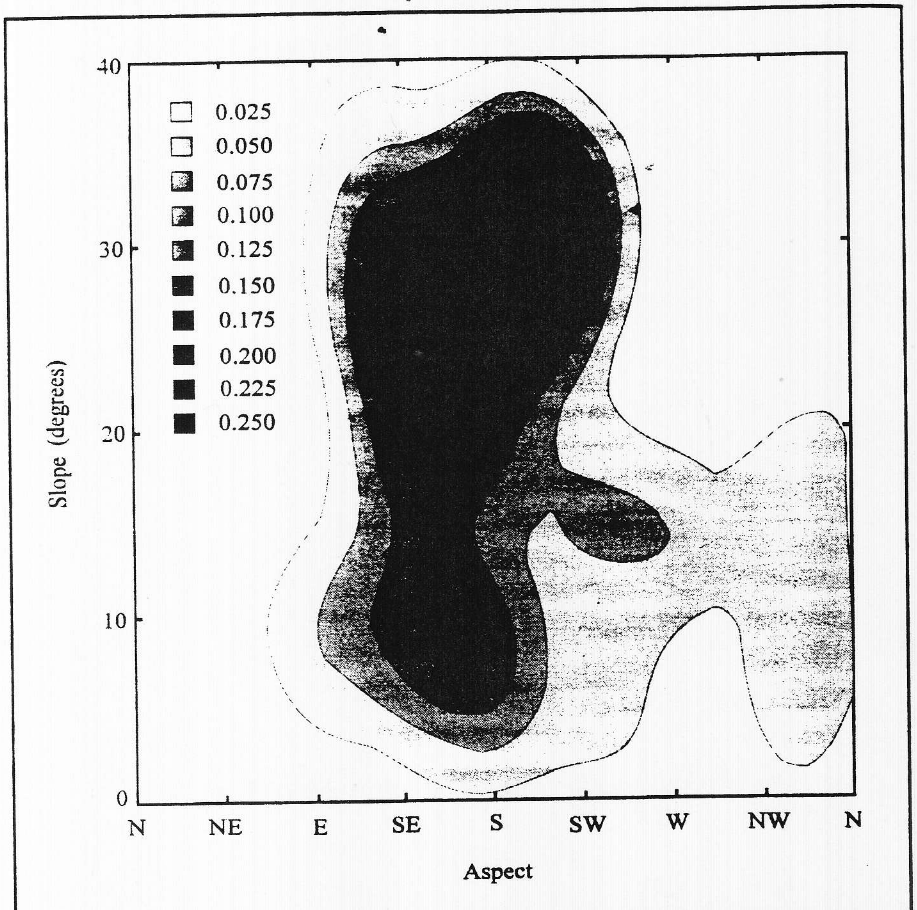

Figure 1. Contour plot of the density distribution of 270 wood turtle nest sites classified by slope and aspect. Nest sites with a slope and aspect of 0 were excluded. Density estimation used the bivariate nonparametric kernel (Silverman, 1986). Shading indicates nest site density; the darker the shading, the greater the proportion of total observations found in that nest site density class.

Evaluation of Nesting Area Model

The GIS model classified 3.2 km of the test segment of the St. Louis River as having high potential value for producing wood turtle nesting areas, 75.6 km as medium, and the remaining 173.8 km as having low or insignificant potential value. The ground survey identified 24 potential wood turtle nesting areas. About 90% of these nesting areas (21 of 24) were found in medium-quality habitat. A Fisher's Exact Test ($P < .0001$, df = 2, FI = 28.8) rejected the null hypothesis expectation that nesting areas would be distributed in proportion to the availability of habitat by class. The three nesting areas found in habitat classified as having unlikely potential were located about 5,13, and 19 river km

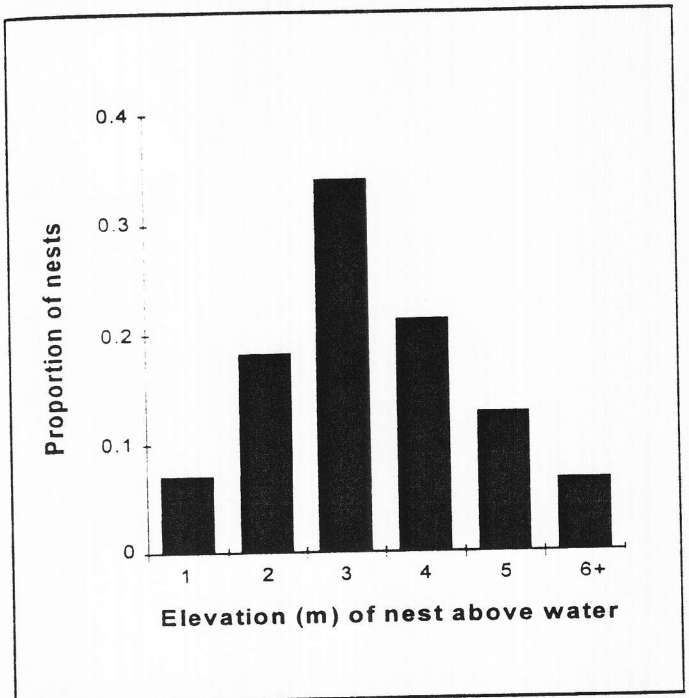

Figure 2. Distribution of 329 wood turtle nest sites classified by elevation above water in 1 m class intervals.

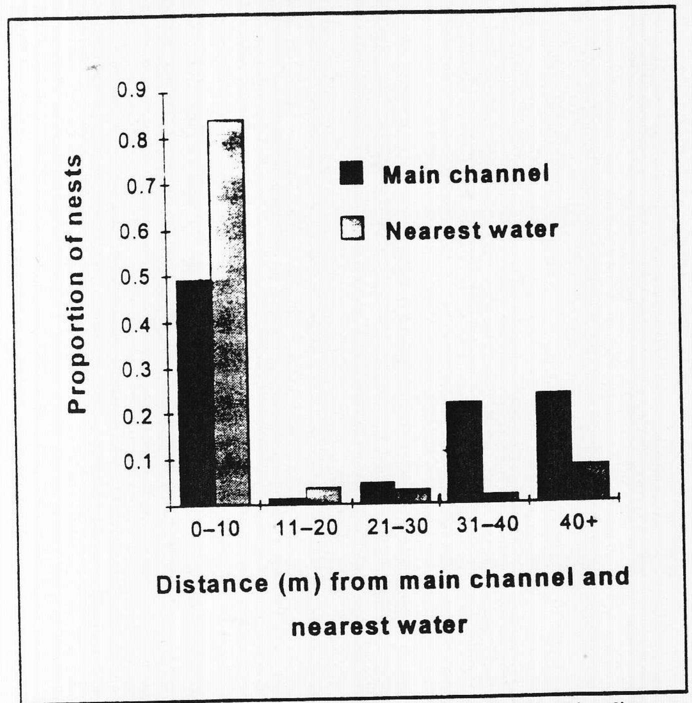

Figure 3. Distribution of wood turtle nest sites classified by distance to the main river channel (n = 247) and distance to the nearest water (n = 330), in 10 m class intervals.

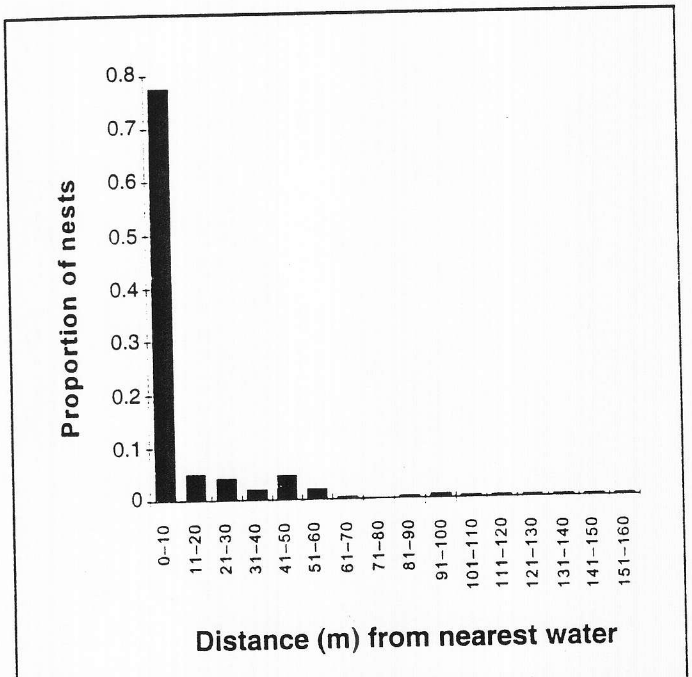

Figure 4. Distribution of 236 wood turtle nest sites on human-created nesting areas classified by distance to the nearest water in 10 m class intervals.

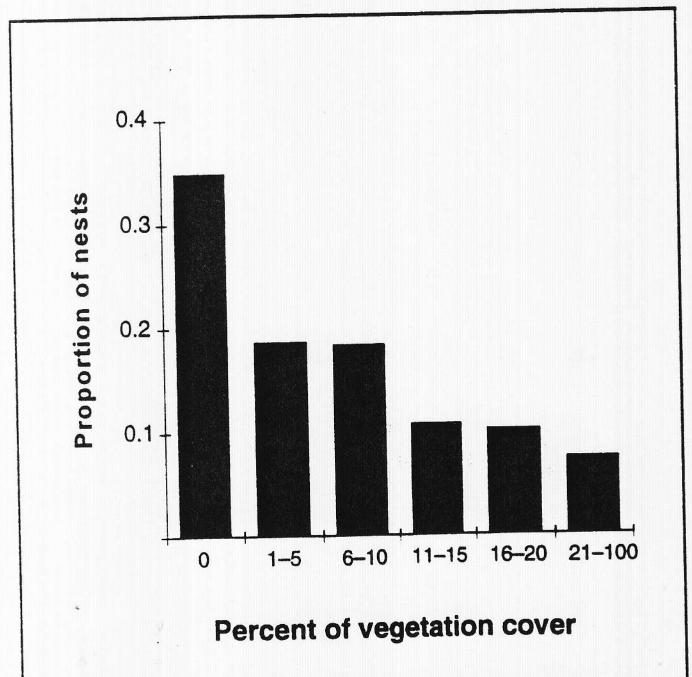

Figure 5. Distribution of 327 wood turtle nest sites classified by cover of vegetation in percent.

from the boundary of medium-potential habitat. However, on a straight-line basis, the 5 km nesting area was located only 1.1 km from the boundary, and the 13 and 19 km nesting areas were located 1.7 and 3.6 km, respectively, from nearby low-potential habitat.

Another measure of the adequacy of the model is the occurrence of wood turtles themselves. We found only four wood turtles during the fall ground survey; all were located in medium-quality habitat. A Fisher's Exact Test ($P < .02$, df = 2, FI = 8.9) rejected the null hypothesis expectation

TABLE 3
Number of potential wood turtle nesting areas classified by type and size using three methods: aerial photo interpretation, aerial survey, and ground survey.

Type and size class of potential nesting areas	Aerial Photo Interpretation: Number of nest areas	Aerial Photo Interpretation: Number correctly classified	Aerial Survey: Number of nest areas	Aerial Survey: Number correctly classified	Ground Survey: Number of nest areas	Ground Survey: Number not identified by other methods
Bank						
Large	11	0	4	1+2*	1	0
Medium	30	0	8	0	3	1
Small	1	0	4	1	2	1
Point						
Large	15	0	1	1	1	0
Medium	56	1*	9	2*	0	0
Small	9	0	6	4	16	9
Island or sand bar						
Large	5	0	0	0	0	0
Medium	12	0	2	0	0	0
Small	3	0	1	0	0	0
Highway right-of-way						
Large	2	0	0	0	0	0
Medium	15	1*	0	0	0	0
Small	0	0	1	1	1	0
Utility right-of-way						
Large	4	0	0	0	0	0
Medium	1	0	0	0	0	0
Small	0	0	0	0	0	0
Gravel pit						
Large	0	0	3	0	0	0
Medium	0	0	0	0	0	0
Small	0	0	0	0	0	0
Total	164	2	39	12	24	11

*Correctly classified by type of nesting area, but size misclassified one class too large.

that wood turtles would be distributed in proportion to the availability of habitat by class. The resurvey of habitat classified as medium the following spring occurred under much better weather conditions but still yielded only six wood turtles. Several points are worth noting about wood turtle observations (Table 2). Of the ten wood turtles found in both fall and spring, only two were found off the systematic search segments. In contrast to the results of the fall survey, four of the six captures in spring were very young turtles. Furthermore, weather in spring was clear and warm, which produced a high contrast in air and water temperatures. With one exception, we found wood turtles on land when the air temperature exceeded water temperature and in the water when the water temperature exceeded air temperature. Wood turtles found in water were all close to shore (0–2 m). Despite our search of terrestrial habitat between 0 and 20 m from the shoreline, all wood turtles found on land were found within 10 m of shore, and half of these were found within 2 m of water. On an area basis, including only habitat where we found wood turtles (0–2 m in water and 0–10 m on land), the capture density of wood turtles was 0.22 wood turtles per ha of habitat for fall 1991 and 0.33 wood turtles per ha for spring 1992.

Efficacy of the Three Methods

The number of wood turtle nesting areas correctly classified by aerial methods was low (Table 3). Aerial photographic interpretation identified 164 potential nesting areas, but only two were correctly classified as nesting areas and both of these were misclassified as one size too large. Thus, aerial photographic interpretation yielded a large number of false positives (n = 162) while only correctly identifying two of the 24 nesting areas that met minimum criteria. Accuracy of the aerial survey was better but still poor. It yielded fewer false positives (n = 27) and correctly identified 12 of the 24 nesting areas, but four of the 12 were misclassified as to size. Of the 11 nesting areas located in the ground survey that were not identified by aerial methods, 10 were small.

Cost of the three methods differed greatly. Aerial photo interpretation took 17.5 hours and the aerial survey took even less time: five hours of air time for two persons. The ground survey took the most time: two weeks for four persons in fall 1991. If we assume salaries of $10 per hour and a plane at $125 per hour, the costs are $175 for conducting the aerial photo interpretation, $725 for the aerial survey, and $3,200 for the ground survey. (No costs were incurred for the aerial photographs, which were borrowed for this project.)

CRITERIA FOR SUITABLE NESTING AREA

• SUBSTRATE:	Sand or gravel
• SLOPE:	< 40°
• ASPECT:	If slope < 20°, any aspect is OK; If slope > 20°, aspect is ESE to WSW
• ELEVATION:	> 1 meter above normal water level
• VEGETATION COVER:	< 20% ground vegetation; height of woody vegetation < distance to southern edge of nesting area
• DISTANCE TO WATER	Close
• DISTURBANCE:	Low

Figure 6. Summary of criteria for defining a suitable wood turtle nesting area in the Upper Great Lakes Region.

DISCUSSION

Criteria for Suitable Nesting Areas

Wood turtles have been reported to nest in a variety of habitats including meadows, hay and corn fields, open and sparsely vegetated fields, forest openings, elevated railroad beds, road embankments, and high banks on streams (Carroll and Ehrenfeld, 1978; Harding and Bloomer, 1979; Farrell and Graham, 1991; Harding, 1991; Kaufmann, 1992). In our study we observed wood turtles nesting on natural features such as sandbars, sandy points, and cutbanks along streams as well as areas of human origin including sand and gravel pits, railroad and road beds, and utility rights-of-way (Buech et al., 1991; Buech, 1992; Buech et al., 1993).

Despite the variety of habitats used by wood turtles for nesting, they have some characteristics in common. Characteristics of nesting areas noted in the literature include within 100–200 m of water; sandy loam, sand, sandy gravel, and gravel soils; well-drained workable soil not prone to flooding; areas exposed to direct sunlight; and almost bare soil (Carroll and Ehrenfeld, 1978; Harding and Bloomer, 1979; Tyning, 1990; Farrell and Graham, 1991; Harding, 1991; Kaufmann, 1992). The quantitative criteria we used to characterize wood turtle nesting areas (Figure 6) are consistent with the qualitative descriptions listed above. Our females clearly chose to nest exclusively on sites with sand or sandy gravel soils, with little or no vegetation, and exposed to direct sunlight. They showed a preference for the upper half of southerly aspects on slopes between 20° and 40°. They also chose sites close to water, but at least 1 m above water. In short, wood turtles prefer nesting areas that are generally very sandy, bare, well exposed to solar radiation, and close to water but elevated. These characteristics are consistent with areas likely to be created and maintained by natural disturbance processes operating with riverine habitat. However, well-exposed nest areas occur infrequently on the landscape. Thus, the distribution of wood turtles in northern regions is probably constrained by the availability of nesting areas.

Evaluation of Nesting Area Model

Virtually all areas meeting our criteria were either located on reaches of the St. Louis River classified as having medium potential for producing nesting areas or located near habitat classified as medium or low. Although we anticipated a degree of error, the three potential nesting areas located outside of expected regions appeared near the boundaries of appropriate geomorphic types. The fact that we captured wood turtles only within medium-potential habitat further supports our belief that the nesting area model performed well. Overall, the results for the nesting area model support our contention that in the Upper Great Lakes Region, the occurrence of wood turtles is dependent upon the occurrence of nesting areas, which is dependent upon the juxtaposition of very sandy soils with rivers of appropriate size.

Efficacy of the Three Methods

The least expensive method was aerial photographic interpretation, but it produced the least reliable information. The major problem was distinguishing between sand and grass. Numerous grass openings were falsely classified as potential nesting areas, although accuracy could be expected to improve with experience. Another problem with aerial photographs is uncertainty about water levels.. Suitable nesting areas could be missed or rejected if photos were taken at high water levels. Conversely, unsuitable nesting areas could be classified suitable if photos were taken at low water levels. Ground surveys yield the best information, but are most expensive and labor intensive. Aerial surveys provide a compromise; they are intermediate in cost and quality of information (they tend to generate false positives, and to miss small nesting areas).

Management Applications

The performance of the nesting area model demonstrates the ultimate dependence of wood turtles on the occurrence of sand soils. It suggests that geologic factors limit the availability of nesting areas and thus the occurrence of wood turtles themselves. Furthermore, in the Upper Great Lakes Region, glaciation created heterogeneity in the spatial distribution of geomorphic types. Thus, we can expect the occurrence of wood turtles to be similarly distributed. Wood turtle populations in the Upper Great Lakes Region probably occur in short, disjunct river segments. This segmented distribution has implications not only for gene flow but also for our perception of the historic abundance of wood turtles. Because of their dependence on sand soils, wood turtles in the Upper Great Lakes Region were probably never uniformly distributed, but were locally abundant in patches of optimal habitat.

There is a caveat in using this model to predict the current distribution of wood turtles: Human activity has altered the availability of both sand and gravel throughout the region, and it has introduced new disturbance processes that can create or eliminate suitable nesting areas. Prior to human influence, nesting areas were probably created and maintained primarily during high water events on third-order or higher streams that intersected sandy soils. These events create and maintain bare cutbanks on outside turns and sand bars on inside points, some of which would be suitable for wood turtle nesting areas. In recent times, human activity has created additional nesting areas in the form of gravel road or railroad beds, utility rights-of-way, gravel pits, and agricultural fields near streams. However, human activity has also eliminated nesting areas through streambank restoration, dams, dredging, and channelization (Harding and Bloomer, 1979; Harding, 1991; Buech, 1992; Kaufmann, 1992; Buech et al., 1993). This activity has probably changed the current distribution of suitable nesting areas and, ultimately, may have affected the distribution of wood turtles throughout the region.

The relative scarcity of wood turtles and their specific nesting requirements strongly suggest a need to identify and protect their nesting areas. The performance of the nesting area model and the results of our study of the efficacy of aerial and ground survey methods open new opportunities for managing their nesting areas. First, we recommend that managers use soils and hydrology maps to identify stream reaches where wood turtle nesting areas may occur. Attention should be focused on stream reaches that meander, which are far more likely to possess nesting areas than straight reaches. Alternatively, third- or higher-order stream segments that intersect areas of red pine (*Pinus resinosa*) and especially jack pine (*Pinus banksiana*) are good indicators of the potential occurrence of wood turtle nesting areas in our region. Once such segments are identified, they should be checked by air, canoe, and/or ground survey (depending on how much area one has to cover) to confirm whether suitable nesting areas are present. Aerial surveys provide an economical way of rapidly locating reaches containing nesting areas, especially larger nesting areas. Ground surveys can then be used to confirm potential sites identified from the air. We used a fixed-wing plane; a helicopter can be used for greater accuracy but at additional cost.

In our fall and spring ground surveys, we found only two wood turtles in segments not systematically searched (25% and 17% of captures, respectively). This suggests that systematic (rather than casual) surveys are preferable in confirming the presence of wood turtles. The presence of wood turtles may also be confirmed by visiting potential nesting areas in spring, shortly (1–2 weeks) before the nesting season. Adult females tend to stage near nesting areas during that season. The chance of finding wood turtles is increased when surveys are conducted during the spring nesting season, and if done systematically over time, could form the basis of a wood turtle monitoring program.

Conservation of nesting areas begins by identifying their geographic location. We then need to ensure that human activity does not degrade existing nesting areas. Streambank stabilization, channelization, dams, and recreation programs are particularly troublesome because they can severely degrade or eliminate wood turtle nesting areas. Managers should therefore ensure that there is an administrative process to review such programs for potential impact on wood turtle nesting areas. Because nesting areas are a landscape feature, it will require a partnership of private and public entities to effectively manage wood turtles across entire watersheds.

The importance of maintaining suitable nesting areas for this long-lived species must be emphasized. Managers should not be lulled into thinking that because adults are present, the population is doing well. Wood turtles commonly live 30 years or longer. If recruitment is inadequate, many years could pass before attrition would become evident in the population. The viability of wood turtle populations is already a concern because of direct and indirect impacts of human activity. Loss of nesting areas would exacerbate the problem. Thus, nesting areas should be considered an essential element in any management plan for viable wood turtle populations.

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