A COMPARISON OF TURTLE SAMPLING METHODS IN A SMALL LAKE IN STANDING STONE STATE PARK, OVERTON COUNTY, TENNESSEE

ANDREW S. WEBER AND JAMES B. LAYZER

Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, P. O. Box 5114, Cookeville, Tennessee 38505; Present address: National Park Service, University Park, Pennsylvania 16802 (ASW)
U.S. Geological Survey, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, P. O. Box 5114, Cookeville, TN 38505 (JBL)

ABSTRACT—We used basking traps and hoop nets to sample turtles in Standing Stone Lake at 2-week intervals from May to November 2006. In alternate weeks, we conducted visual basking surveys. We collected and observed four species of turtles: spiny softshell (*Apalone spinifera*), northern map turtle (*Graptemys geographica*), pond slider (*Trachemys scripta*), and snapping turtle (*Chelydra serpentina*). Relative abundances varied greatly among sampling methods. To varying degrees, all methods were species selective. Population estimates from mark and recaptures of three species, basking counts, and hoop net catches indicated that pond sliders were the most abundant species, but northern map turtles were 8× more abundant than pond sliders in basking trap catches. We saw relatively few snapping turtles basking even though population estimates indicated they were the second most abundant species. Populations of all species were dominated by adult individuals. Sex ratios of three species differed significantly from 1:1. Visual surveys were the most efficient method for determining the presence of species, but capture methods were necessary to obtain size and sex data.

Turtle populations are declining worldwide. Habitat loss and over-exploitation for food and the pet trade threaten the continued existence of many turtle species (Klemens, 2000). Adult individuals often dominate populations because of high egg and juvenile mortality (Congdon et al., 2000; Schlaepfer et al., 2005). This high natural mortality of young is compensated for by the long reproductive lifespan of turtles. Consequently, recruitment can be sporadic and still maintain a stable population. Removal of just a few adults, however, can cause population declines (Schlaepfer et al., 2005). There are 16 species of turtles in Tennessee (Scott and Redmond, 2008), but in most waters, only snapping turtles (*Chelydra serpentina*) can be commercially harvested.

In the past, monitoring and assessing turtle populations have received relatively little attention. With the passage of the federal Wildlife Conservation and Restoration Act in 2000 and subsequently the State Wildlife Grants Program, the protection and management of non-game species such as turtles have become priorities for the Tennessee Wildlife Resources Agency (TWRA). On a large spatial scale, the general ranges are known for most turtle species; however, specific location data often are limited. To inventory turtles, TWRA has adopted a sampling protocol which includes the use of hoop nets, traps, and basking surveys (Tennessee Wildlife Resources Agency, 2005). Baited hoop nets and basking traps have been used extensively to capture turtles without harm (Lagler, 1943; Petokas and Alexander, 1979; Pettit et al., 1995; Spencer, 2002). Visual surveys are effective in providing distributional data and relative abundance of species (Lindeman, 1997, 1999; Browne and Hecnar, 2005).

We used all three methods to sample turtles in Standing Stone Lake in north-central Tennessee. The objectives of our study were to compare relative abundance among sampling methods, estimate population size of each species, and describe population attributes.

METHODS

Study Site—Standing Stone Lake is a 28-hectare impoundment in Standing Stone State Park, located in Overton County, Tennessee (Fig. 1). The dam was built in the 1930s by the Works Progress Administration (Tennessee Historical Society, 2002). The park is in the Eastern Highland Rim Province. The geology of the area is composed of Ordovician dolomitic rocks; Silurian limestone, siltstone, and shale; and Devonian and Mississippian limestone, shale, and chert (Hershey and Maher, 1963). Part of the lake had abundant aquatic macrophytes, especially in the three large coves where most sampling occurred. Emergent vegetation was limited to small areas of the lake. Much of the lake is bordered by steeply sloping banks. Fallen trees and limbs, potential turtle basking sites, were abundant in the lake. The surrounding forest consisted mainly of temperate hardwood species, dominated by oaks (*Quercus* spp.). Withers et al. (2004) completed an extensive ecological assessment of Standing Stone State Park and Forest sampling for most faunal groups but not for turtles.

Trapping—Every other week from May through September 2006, we set hoop nets and basking traps Monday through Friday in Standing Stone Lake. An additional trapping session occurred in October and again in November; these trapping sessions lasted for only two trap nights instead of the usual four. Nine fixed sites were established for setting hoop nets; each week, hoop nets were set at six randomly selected sites. Hoop nets were one-throated, 1.8 m long, and consisted of

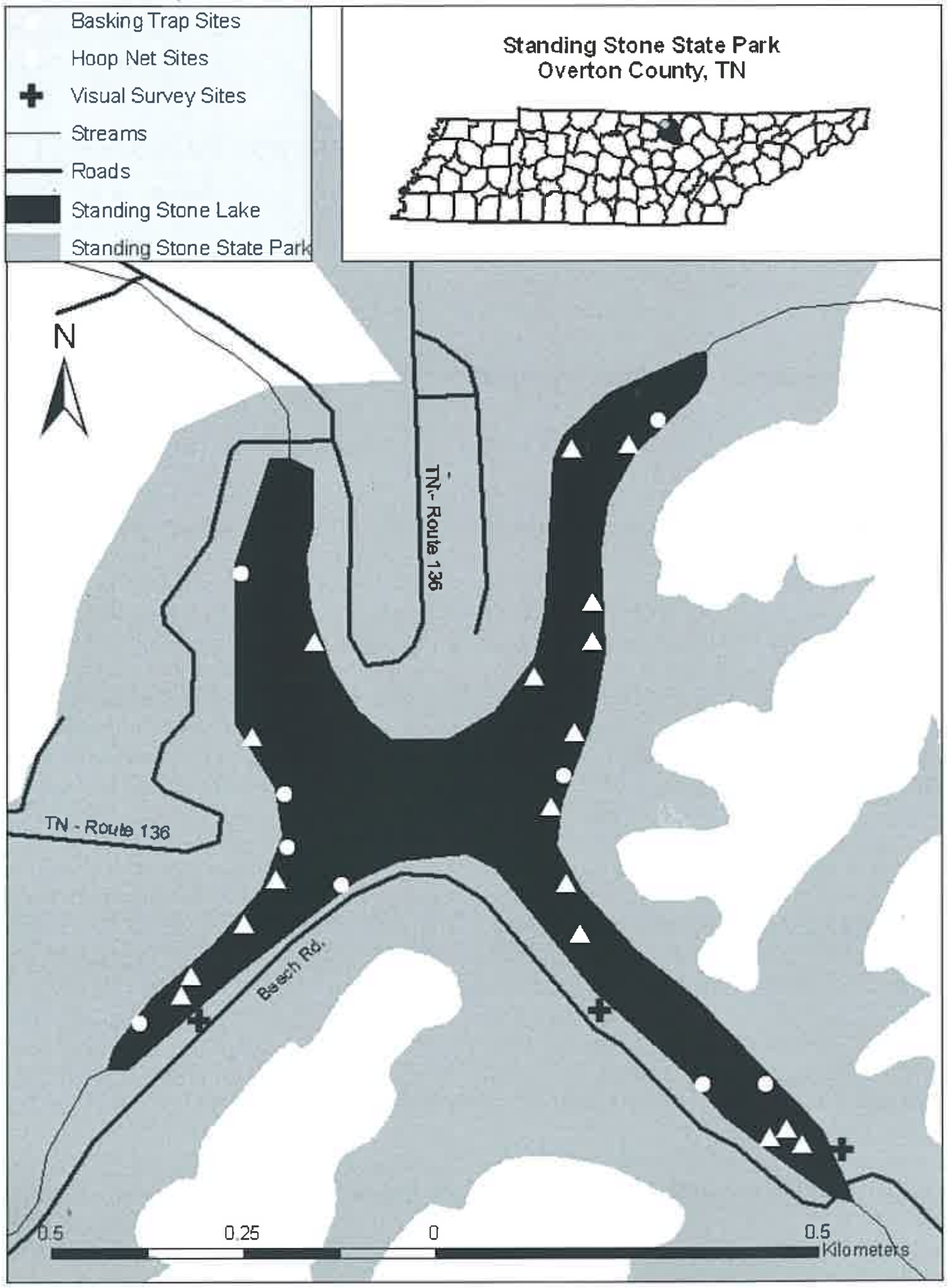

FIG. 1. A map of Standing Stone Lake in Overton County, Tennessee, showing fixed hoop-net and basking trap sites, and visual survey locations around the lake.

three 91.4-cm hoops with 2.54-cm mesh. We set nets in shallow water, partially submerged, and held in place with iron stakes. Thus, turtles captured in hoop nets had ready access to the surface. We baited nets with both chicken parts and canned sardines, and replaced bait every Wednesday or as needed. Traps were removed at the end of the day on Friday. We measured depth and distance to nearest shore from the stake at the open end of the net.

We selected 18 fixed trapping sites in the lake adjacent to potential basking locations (logs). Each week, basking traps were randomly assigned to 12 of these sites and treatments were randomly assigned to traps. Basking traps were attached at these sites with rope or bungee cords. Four traps were set with each of the following treatments: 1) baited (chicken parts and canned sardines), 2) with only decoys, and 3) no bait or decoys (control). Decoys consisted of plastic green sea turtle replicas with flippers trimmed down. We measured water depth, distance to nearest shore, slope of the adjacent log, and width of the log at each site.

We used basking traps similar to those described by Browne and Hecnar (2005). Overall dimensions were 81 × 100 × 33 cm. The 81-cm-long sides were made of 102-mm-diameter PVC pipe capped and sealed on both ends. Metal rods extended from one piece of PVC to the other to make a rectangular frame. The metal rods were screwed into the top of the PVC and sealed. A 33-cm-deep basket made of 12.7-mm

TABLE 1. Numbers of individuals of each turtle species observed or captured with each sampling method in 2006. All recaptures (in parentheses) occurred in the trap type of original capture.

Species	Common name	Sampling method		
		Visual	Hoop nets	Basking traps
Apalone spinifera	Spiny softshell	39	7	0
Chelydra serpentina	Snapping turtle	14	39 (4)	0
Graptemys geographica	Northern map turtle	454	5 (1)	25 (4)
Trachemys scripta	Pond slider	686	40 (3)	3
Total		1193	91	28

wire cloth mesh was placed inside the frame and secured with cable ties. Additional strips of wire cloth mesh were fitted around the edge of the opening to prevent escape. The PVC was spray painted black to give the trap a more natural, mottled appearance. Ramps were approximately 46 × 20 × 2.5 cm. Grooves were cut in the wooden ramps so turtles could grip the ramp and pull themselves out of the water. A wood basking platform (91 × 15 × 2.5 cm) was attached to the ramps with small hinges and fitted across the opening of the basket (Browne and Hecnar, 2005).

Each day, turtles were removed from traps, identified, measured, and sex of mature individuals recorded. We determined sex of snapping turtles > 200 mm in carapace length by the ratio of the precloacal distance to the distance to the posterior lobe of the plastron (Mosimann and Bider, 1960). We used this method unless the penis was extruded, a common behavior of male snapping turtles (De Solla et al., 2001). Male northern map turtles (*Graptemys geographica*) and pond sliders (*Trachemys scripta*) were identified by the presence of thick tails with the cloaca beyond the edge of the carapace (Ernst et al., 1994). Individuals with a carapace length larger than the smallest male and not showing obvious male characteristics were considered female. Individuals with carapace length smaller than the smallest adult male were considered juveniles. Sex of spiny softshells (*Apalone spinifera*) was determined by size and characteristics of the carapace (females are larger and have a smooth carapace while males are smaller and have a rough carapace) (Conant and Collins, 1998).

Dial calipers were used for measurements ≤ 150 mm and Haglof calipers for measurements > 150 mm. Snapping turtles were restrained by placing a PVC pipe over their head as described by Quinn and Pappas (1997) or by using a rope through the mouth and tied behind the carapace (P. Warny, *pers. comm.*).

Each turtle was uniquely marked for later identification. Hard-shelled species were marked by notching the marginal scutes using a variation of the technique described by Cagle (1939) and by injecting wire microtags in soft parts. Snapping turtles were microtagged in the tail; other hard-shelled species were microtagged in the left hind limb. Spiny softshells were marked by microtags only. The first spiny softshell was tagged in the left hind limb; additional ones were tagged in other limbs and the tail in a dorsal clockwise fashion to identify individuals. Double tagging was employed in limbs after the first five spiny softshells. All turtles were then released at the capture site. The Schnabel method (Ricker, 1968) was used to estimate population size of each species. Density was calculated for each species by dividing the final population estimate by the area of the lake.

Basking Surveys—Visual surveys with Bushnell (7 × 35-mm) binoculars and a Trekker (20–60×, 60-mm) spotting scope were conducted from three fixed locations one day every other week from April through September 2006. Most sites where basking traps and hoop nets were set could be seen from these three locations. Aerially basking turtles (turtles resting on an object above the surface of the water) were counted and identified to species if possible. Counts were made every hour from between 0600 and 0800 until 1700. We measured air and water temperatures (°C) at 0800 and recorded any disturbances, as well as whether turtles were basking in sun or shade. Rainfall data were obtained from gauges at Celina and Livingston, Tennessee.

Data Analysis—Fisher's Exact Test was used to test for differences among capture rates of basking trap treatments. A chi-square test was used to determine if sex ratios differed from 1:1. Pearson correlation analysis was used to determine if hoop net and basking trap capture rates were related to habitat variables recorded at each trap site. Stepwise linear regression was used to determine if the mean number of turtles sighted each day was related to Julian date, air and water temperatures, and rainfall each day. Statistical tests ($\alpha = 0.05$) were performed using Statistical Analysis Systems software (SAS Institute, 2002).

RESULTS

Trapping—In all, we captured 107 individual turtles of four species and recaptured 12 individuals (Table 1). Hoop nets captured all four species: spiny softshell, northern map turtle, pond slider, and snapping turtle. Basking traps captured only pond sliders and northern map turtles. While northern map turtles comprised 89% of the catch in basking traps, they accounted for only 5% of the turtles collected in hoop nets. In contrast, pond sliders comprised 44% of the turtles collected in hoop nets but only 11% of the basking trap catch. Hoop net capture rates exceeded basking trap capture rates in every trapping session (Fig. 2). Overall, hoop nets captured 6.5× more turtles than basking traps. We did not observe any trapping mortality. The presence or absence of decoys or bait did not affect capture rates of northern map turtles in basking

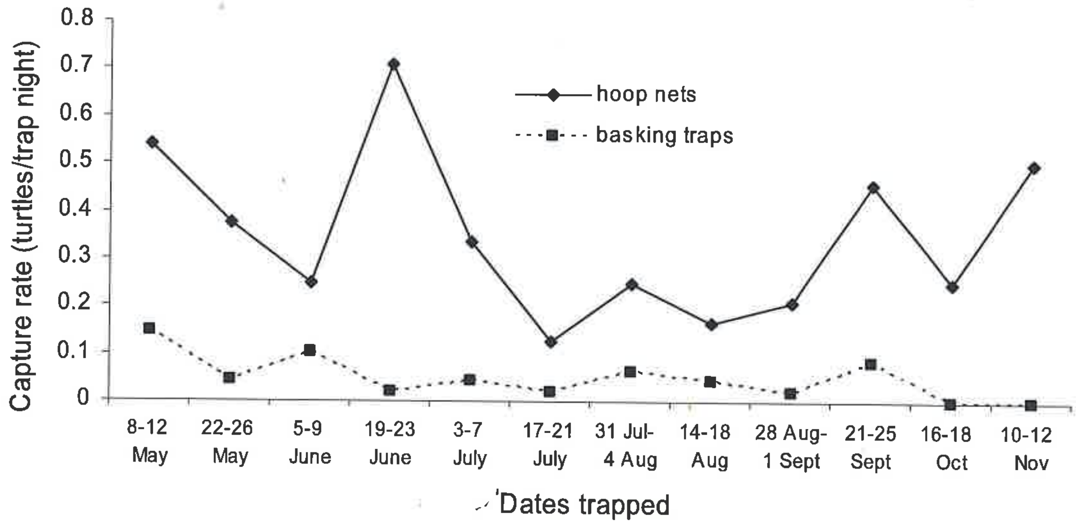

FIG. 2. Capture rates (turtles per trap night) of hoop nets and basking traps for all species in Standing Stone Lake during each trapping session in 2006.

traps (Fisher's Exact Test; $P = 0.9108$). Only three pond sliders were captured in basking traps (two in baited traps and one in a control trap). None of the habitat variables we measured were significantly correlated with basking trap captures. Hoop-net capture rates were positively correlated with distance from shore ($r = 0.73$, $P = 0.0267$) and negatively correlated with bottom slope ($r = -0.72$, $P = 0.0295$).

Population Attributes—Male to female ratios of captured turtles varied greatly among species (Table 2). Male snapping turtles were four times more abundant than females in hoop net catches ($\chi^2 = 12.6$; $P = 0.0004$). Likewise, male pond sliders were twice as abundant as females in hoop-net catches ($\chi^2 = 4.0$; $P = 0.0455$). In contrast, female northern map turtles were four times as abundant as males in basking trap collections ($\chi^2 = 8.0476$; $P = 0.0046$). Too few spiny softshells were collected to determine if the sex ratio differed significantly from 1:1. Sex ratios could not be compared between capture methods because all or nearly all individuals of each species were collected by only one gear type (Table 1).

For the three most frequently captured species, the sex that is known to attain the greater size also had the greater range in carapace length. Male pond slider carapace lengths ranged from 111 to 207 mm, while females ranged from 130 to 269 mm (Fig. 3A). Male northern map turtle carapace lengths ranged from 97 to 116 mm, while females ranged from 98 to 257 mm (Fig. 3B). Male snapping turtle carapace lengths ranged from 148 to 427 mm, while females ranged from 275 to 330 mm (Fig. 3C). Female spiny softshell carapace lengths ranged from 218 to 357 mm and males 169 to 187 mm. We collected juvenile pond sliders and northern map turtles, but we did not collect any juvenile spiny softshell or snapping turtles.

We recaptured 12 individuals: four snapping turtles, five northern map turtles, and three pond sliders. All recaptured individuals retained the microtag at the site of the original insertion; the shell notch was also visible on all recaptured turtles. We did not capture any notched turtles that lacked a microtag. The maximum amount of time that had passed between original tagging and recapture was 139 days. Population estimates were 147 snapping turtles, 71 northern map turtles, and 253 pond sliders. No spiny softshell turtles were recaptured. Based on these population estimates, densities were 5.25 snapping turtles, 2.54 northern map turtles, and 9.04 pond sliders per hectare.

Basking Surveys—During our visual surveys, we made 1,235 sightings of basking turtles. Undoubtedly, many of these sightings were of the same individuals. Pond sliders and northern map turtles accounted for 96% of the turtles observed basking. All species captured in hoop nets and basking traps were observed basking, but snapping turtles were observed basking only on 2 of 16 days sampled, once in May and once in June. Spiny softshells were observed basking on 9 of 16 days and in every month except November. Only 3% of basking turtles could not be identified because of distance or poor light conditions, but they were either pond sliders or northern map

TABLE 2. Observed sex ratios of each species and results of chi-square goodness-of-fit tests to determine if sex ratios differed from 1:1 ($\alpha = 0.05$).

Species	Trap type	Males	Females	Sex ratio (m:f)	χ^2	P
Snapping turtle	Hoop	28	7	4:1	12.6	0.0004
Northern map turtle	Basking	4	17	0.24:1	8.04	0.0046
Pond slider	Hoop	24	12	2:1	4.0	0.0455
Spiny softshell	Hoop	2	5	0.4:1	–	–

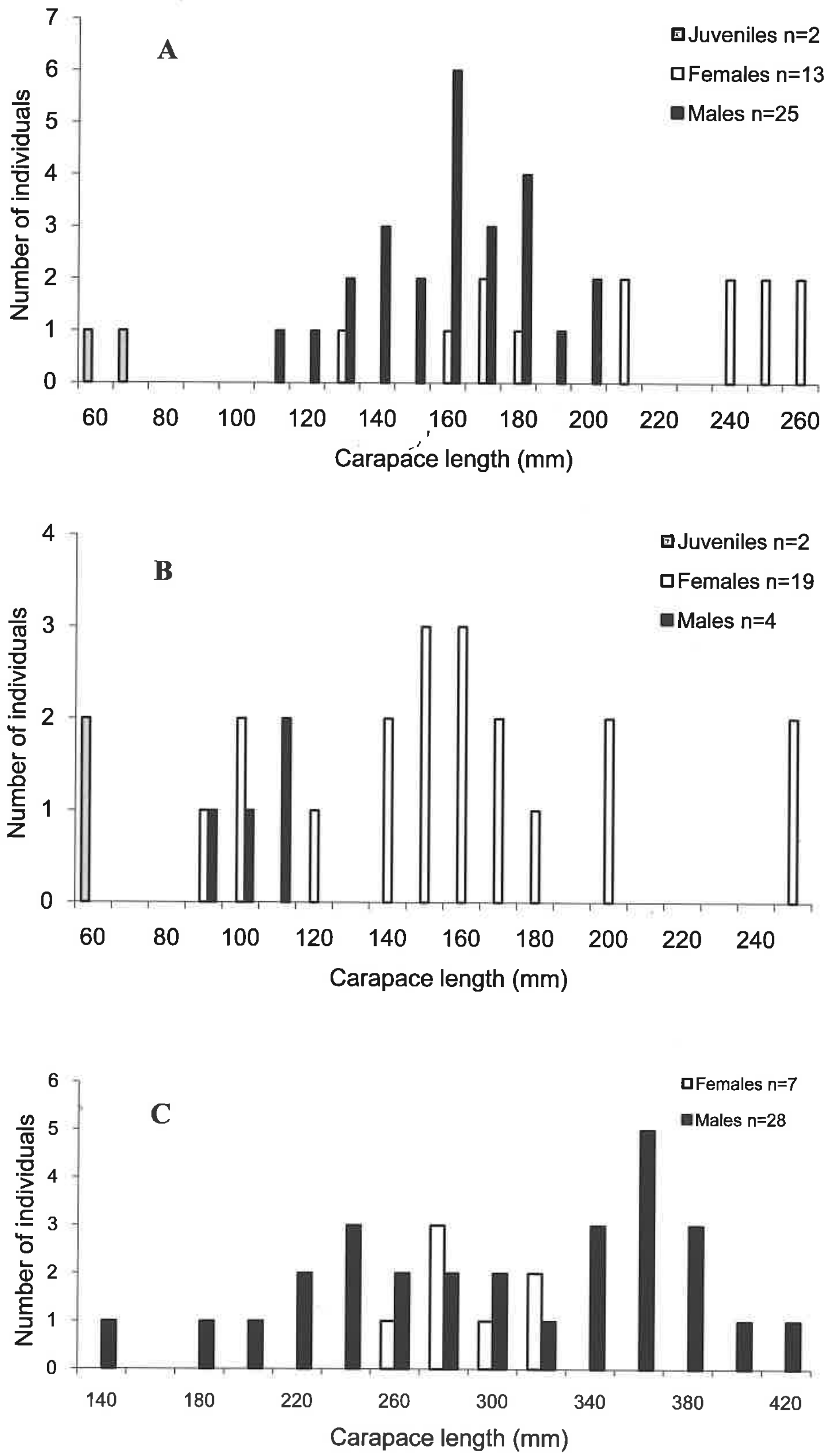

FIG. 3. Length frequency distributions of (A) pond sliders, (B) northern map turtles, and (C) snapping turtles captured in Standing Stone Lake in 2006.

turtles. Incidental sightings of all four species near the surface were also made, but they were not included in our basking counts. We observed that disturbances such as a boat in the area or the presence of potential predators—mink (*Mustela vison*) and great blue herons (*Ardea herodias*)—caused basking turtles to return to the water. No other habitat variable measured was related to the number of turtles sighted each day.

Discussion

We collected four species of turtles in Standing Stone Lake. Relative abundance and species composition varied greatly among sampling techniques. It is difficult to judge which sampling technique provided the most accurate data on relative abundance of species. Population estimates, basking turtle sightings, and hoop net catches indicated that pond sliders were the most abundant species in the lake. Although visual surveys indicated that pond sliders were about 1.5× as abundant as northern map turtles, population estimates indicated there were about 3.5× more pond sliders than northern map turtles in the lake. Hoop nets and basking traps were clearly species selective. We collected all four species in hoop nets but only two species in basking traps. Further, hoop nets captured 8× more pond sliders than northern map turtles, but basking traps collected 8× more northern map turtles than pond sliders. Browne and Hecnar (2005) also reported higher capture rates of northern map turtles in basking traps compared to hoop nets. The snapping turtle was the second most abundant species based on population estimates, but we saw few individuals basking. We often saw snapping turtles moving in the water, but we did not count them because they were not basking. According to Cagle (1944), snapping turtles usually bask by resting in shallow water or floating at the surface; Moll and Legler (1971) referred to this habit as aquatic basking. Snapping turtles however, have been observed aerially basking in some locations (Ewert, 1976; Obbard and Brooks, 1979; and our study). Basking counts likely underestimated the abundance of snapping turtles because this species tends to be crepuscular (Smith and Iverson, 2004). In the northern part of their range, snapping turtles have been known to be primarily diurnal (Obbard and Brooks, 1981), basking with greater frequencies than in the southern part of their range (Obbard and Brooks, 1979). Obbard and Brooks (1981) speculated that there could be geographic variation in their daily activity cycle (which could also account for the higher basking frequencies, at least in part), but indicated that more data are needed to draw conclusions.

Ream and Ream (1966) suggested that the presence of turtles on basking sites or in nets attracted other individuals. Although Mansfield et al. (1998) reported higher capture rates of spotted turtles in traps containing turtle decoys, the decoys did not significantly affect capture rates of basking traps in our study. Perhaps capture rates would have increased if decoys were painted to resemble pond sliders and northern map turtles.

Sex ratios of all species in Standing Stone Lake differed (three species significantly) from 1:1. The causes and ecological significance of skewed sex ratios in turtle populations are unknown. Deviations from a 1:1 sex ratio for snapping turtles are thought to be due to sex-biased sampling methods (Ernst et al., 1994). Similarly, Thomas et al. (1999) found that sex ratios of pond sliders varied seasonally and between hoop nets and basking traps. Sex ratios, however, of northern map turtles collected in basking traps have been reported to be skewed towards males (Gordon and MacCulloch, 1980) or towards females (Browne and Hecnar, 2005; and our study).

Wire microtags have been used to mark a variety of animals ranging from fish (Oven and Blankenship, 1993) to freshwater mussels (Layzer and Heinricher, 2004). Numbered microtags can be used to identify individual turtles, but the tags would require surgical removal or sacrificing individuals to be read. We used unnumbered tags inserted in a combination of locations to identify individual spiny softshells. Because the number of locations was limited to five, there was a limited number of combinations that could be used. Thus, for large sample sizes this method would not be suitable for identifying individuals, but it would be suitable for studies that do not require recognition of individuals. Alternatively, a larger number of individuals could be identified by varying the number, size, and location of tags, and reading them with a handheld imaging scope (Downes, 2000). The fact that all turtles recaptured in Standing Stone Lake retained the microtags suggests that this marking technique would be useful in future studies of softshell turtle species.

Conclusions

Visual surveys were the most efficient method for obtaining distributional data for turtles. This method is easy, inexpensive, and requires less time than setting and tending nets and traps; however, the observer must be able to identify turtles from a distance. Surveys can be conducted from the shore as long as access points provide an unobstructed view of potential basking sites such as logs. We observed all four species basking, but snapping turtles basked infrequently. Because we often saw snapping turtles moving in the water, future visual surveys should include those individuals rather than restricting counts to basking individuals. Visual surveys may be less effective where boat traffic or predators are common. Also, turtles moving in the water or basking are less apt to be seen in areas with dense growths of emergent aquatic macrophytes, wind-swept waters, or in turbid conditions.

While visual surveys are the most efficient method of determining the presence of a species, surveys of this type cannot provide detailed information such as lengths, weights, sex ratios, injuries, and parasite loads of turtles. In order to obtain this information, some type of capture must take place; however, we found hoop nets and basking traps were species selective. Chaney and Smith (1950) also reported that these trapping methods were species selective. Additionally, Thomas et al. (1999) reported that these trapping methods were sex selective. Long-term monitoring of populations by unbiased sampling methods is critical for management and conservation of turtles. We think that intensive comparisons of hoop nets and basking traps are needed to determine the least biased sampling method. One of the challenges faced by conservation and management agencies is the ability to identify adult dominated populations that are stable and those that are unstable or declining. Since average recruitment of turtles is normally low, the sizes of stable populations and exploited populations may differ, but their length frequency distributions may be similar (i.e., dominated by adults).

Acknowledgments

We thank J. Thomasson, J. Helton, K. Moles, B. Davis, V. Mengel, E. Dyer, E. Rahm, J. Damer, T. Black, N.

Jamison, and K. Raper for their assistance in the field. P. Warny provided advice, and S. Hughes and the staff of Standing Stone State Park provided logistical support. C. J. Tzilkowski and J. R. Brown provided valuable comments on an earlier draft of this paper.

Literature Cited

Browne, C. L., and S. J. Hecnar. 2005. Capture success of northern map turtles (*Graptemys geographica*) and other turtle species in basking vs. baited hoop traps. Herpetol. Rev., 36:145–147.

Cagle, F. R. 1939. A system of marking turtles for future identification. Copeia, 1939:170–173.

———. 1944. Home range, homing behavior, and migration in turtles. Miscellaneous Publications of the Museum of Zoology, Univ. of Michigan, 61:1–33.

Chaney, A., and C. L. Smith. 1950. Methods for collecting map turtles. Copeia, 1950:323–324.

Conant, R. C., and J. T. Collins. 1998. A field guide to reptiles and amphibians: eastern and central North America. Houghton Mifflin Company, New York.

Congdon, J. D., R. D. Nagle, O. M. Kinney, M. Osentoski, H. W. Avery, R. C. van Loben Sels, and D. W. Tinkle. 2000. Nesting ecology and embryo mortality: implications for hatchling success and demography of Blanding's turtles (*Emydoidea blandingii*). Chel. Cons. Biol., 3:569–579.

De Solla, S. R., M. Portelli, H. Spiro, and R. J. Brooks. 2001. Penis displays of snapping turtles (*Chelydra serpentina*) in response to handling: defensive or displacement behavior? Chel. Cons. Biol., 4:187–189.

Downes, S. 2000. The use of wire microtags to identify small individual prey in snakes. Amphibia-Reptilia, 21:126–131.

Ernst, C. H., J. E. Lovich, and R. W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, DC.

Ewert, M. A. 1976. Nests, nesting and aerial basking of *Macroclemys* under natural conditions, and comparisons with *Chelydra* (Testudines: Chelydridae). Herpetologica, 32:150–156.

Gordon, D. M., and R. D. MacCulloch. 1980. An investigation of the ecology of the map turtle, *Graptemys geographica* (Le Sueur), in the northern part of its range. Can. J. Zool., 58:2210–2219.

Hershey, R. E., and S. W. Maher. 1963. Limestone and dolomite resources of Tennessee. State of Tennessee Dept. of Conservation and Commerce, Division of Geology, Bull. 65. Nashville, Tennessee.

Klemens, M. W. 2000. Turtle conservation. Smithsonian Institution Press, Washington, DC.

Lagler, K. F. 1943. Methods of collecting freshwater turtles. Copeia, 1943:21–25.

Layzer, J. B., and J. R. Heinricher. 2004. Coded wire tag retention in ebonyshell mussels *Fusconaia ebena*. N. Am. J. Fish. Mgt., 24:228–230.

Lindeman, P. V. 1997. A comparative spotting scope study of the distribution and relative abundance of river cooters (*Pseudemys concinna*) in western Kentucky and southern Mississippi. Chel. Cons. Biol., 2:378–383.

———. 1999. Surveys of basking map turtles *Graptemys* spp. in three river drainages and the importance of deadwood abundance. Biol. Conserv., 88:33–42.

Mansfield, P., E. G. Strauss, and P. J. Auger. 1998. Using decoys to capture spotted turtles (*Clemmys guttata*) in water funnel traps. Herpetol. Rev., 29:157–158.

Moll, E. O., and J. M. Legler. 1971. The life history of a neotropical slider, *Pseudemys scripta* (Schoepff), in Panama. Bull. Los Angeles Co. Mus. Nat. Hist., 11:1–102.

Mosimann, J. E., and J. R. Bider. 1960. Variation, sexual dimorphism, and maturity in a Quebec population of the common snapping turtle, *Chelydra serpentina*. Can. J. Zool., 38:19–38.

Obbard, M. E., and R. J. Brooks. 1979. Factors affecting basking in a northern population of the common snapping turtle, *Chelydra serpentina*. Can. J. Zool., 57:435–440.

———. 1981. A radio-telemetry and mark-recapture study of activity in the common snapping turtle, *Chelydra serpentina*. Copeia, 1981:630–637.

Oven, J. H., and H. L. Blankenship. 1993. Benign recovery of coded wire tags rainbow trout. N. Am. J. Fish. Mgt., 13:852–855.

Petokas, P. J., and M. M. Alexander. 1979. A new trap for basking turtles. Herpetol. Rev., 10:90.

Pettit, K. E., C. A. Bishop, and R. J. Brooks. 1995. Home range and movements of the common snapping turtle, *Chelydra serpentina*, in a coastal wetland of Hamilton Harbour, Lake Ontario, Canada. Can. Field-Natur., 109: 192–200.

Quinn, H., and T. Pappas. 1997. Restraining and marking method for snapping turtles, *Chelydra serpentina*. Herpetol. Rev., 28:196–197.

Ream, C., and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in painted turtles. Amer. Midl. Natur., 75:325–338.

Ricker, W. E. 1968. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications, Oxford, England.

SAS Institute. 2002. SAS 8.2 for Windows SAS Institute. Cary, North Carolina.

Schlaepfer, M. A., C. Hoover, and C. K. Dodd. 2005. Challenges in evaluating the impact of the trade in amphibians and reptiles on wild populations. BioScience, 55:256–264.

Scott, A. F., and W. H. Redmond. 2008 (latest update: 10 February 2010) Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee, Available from http://apsu.edu/reptatlas/ (accessed 18 February 2010).

Smith, G. R., and J. B. Iverson. 2004. Diel activity patterns of the turtle assemblage of a northern Indiana lake. Amer. Midl. Natur., 152:156–164.

Spencer, R. J. 2002. Growth patterns of two widely distributed freshwater turtles and a comparison of common methods used to estimate age. Aust. J. Zool., 50:477–490.

Tennessee Historical Society. 2002. The Tennessee Encyclopedia of History and Culture, Standing Stone State Rustic Park. Available from. http://tennesseeencyclopedia.net/imagegallery.php?EntryID=S089 (accessed 27 July 2010).

TENNESSEE WILDLIFE RESOURCES AGENCY. 2005. Tennessee's comprehensive wildlife conservation strategy. Nashville, Tennessee.

THOMAS, R. B., N. VOGRIN, AND R. ALTIG. 1999. Sexual and seasonal differences in behavior of *Trachemys scripta* (Testudines: Emydidae). J. Herpetol., 33:511–515.

WITHERS, D., C. BAILEY, K. CONDICT, AND R. MCCOY. 2004. An ecological assessment of Standing Stone State Forest, Overton and Clay Counties, Tennessee. Tennessee Department of Agriculture and Tennessee Division of Natural Heritage, Department of Environment and Conservation. Nashville, Tennessee.