Herpetological Conservation and Biology 5(1):1-8.
Submitted: 9 July 2009; Accepted: 22 March 2010.

NESTING MOVEMENTS AND THE USE OF ANTHROPOGENIC NESTING SITES BY SPOTTED TURTLES (*CLEMMYS GUTTATA*) AND BLANDING'S TURTLES (*EMYDOIDEA BLANDINGII*)

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***Abstract.*—Spotted Turtles (*Clemmys guttata*) and Blanding's Turtles (*Emydoidea blandingii*) complete extensive upland movements to use open nesting sites in otherwise forested areas, exposing themselves to risks such as road mortality and poaching. To better understand the risks faced by females of both species, and to inform potential nest site supplementation, we quantified upland movements associated with nesting, determined the extent to which turtles use nest sites of anthropogenic origin, and estimated the number of years the sites had been available. We radio-tracked 23 adult females of each species to identify nesting sites. Blanding's Turtles traveled 1006 m during nesting activities, accounting for 30% of the yearly upland distance traveled by breeding females. Anthropogenic locales constituted 84% of the nest sites, and 58% had been available for 5 y or less. Spotted Turtles moved shorter distances during nesting activities, with a median distance of 148 m, corresponding to 21% of the yearly upland distance traveled by gravid females. Of the nest sites used by Spotted Turtles, 64% were anthropogenic, and 29% were recent. The ability to use newly disturbed areas signals that artificial nesting sites can be detected and used rapidly by turtles, and the quality of artificial sites could be managed to enhance nesting success for these at-risk turtle species. The judicious placement of artificial nest sites could modify or reduce upland movements by adult females during the nesting season, a period when the impact of adult loss is particularly damaging to local population viability.**

***Key Words.*—**Blanding's Turtle; *Clemmys guttata*; conservation; *Emydoidea blandingii*; Maine; nest sites; nesting movements; Spotted Turtles

INTRODUCTION

For freshwater turtles, the habitat characteristics of nest sites directly influence the nest itself (Weisrock and Janzen 1999), with significant consequences for the hatchlings (Wilson 1998). Spotted Turtles (*Clemmys guttata*) and Blanding's Turtles (*Emydoidea blandingii*) in the northeastern United States have evolved in a mostly forested landscape, where open sites suitable for nesting were probably relatively rare. Spotted and Blanding's Turtles are considered at-risk in most states and provinces where they occur, and little data are available on the origin (natural vs. anthropogenic) and recentness of nesting sites. Both species, like all herpetofauna, are assumed to have colonized New England after the Wisconsin glaciation, expanding from southern refugia (Smith 1957; Bleakney 1958; but see Parris and Dauschler 1995). At that time, nesting sites were likely limited to a combination of some enduring features such as river banks and rocky outcrops, and more ephemeral sites such as forest openings created by natural disturbances (e.g., wind, fires). Following colonization by Native Americans, and later Europeans, partial clearing of the forest for agriculture and settlements increased the availability of open canopy localities that could be used by turtles as nesting sites. Knowing the history and characteristics of nesting sites used by these threatened turtles can help inform conservation management, including the creation of artificial nest sites.

Turtle nest site supplementation has been suggested as a management tool to increase nest success and population viability (Marchand and Litvaitis 2003; Moll and Moll 2004), and it has been successful when integrated with reintroduction and habitat restoration projects (Kiviat et al. 2000; Cadi and Maquet 2004). High nest predation rates are frequently reported for natural nest sites (e.g., Thompson 1983; Butler and Graham 1995; Congdon et al. 2000; Horne et al. 2003). Artificial nest sites could be designed to facilitate the manipulation of factors affecting predation risk (e.g., distance to water and forest edge; Kolbe and Janzen 2002). Additionally, the judicious placement of artificial nests sites close to occupied wetlands could theoretically reduce the length of upland trips, thus reducing the risk of road mortality. Road mortality is especially troubling for freshwater turtles: many species are long-lived, have delayed sexual maturity, and attempt numerous upland trips among multiple wetlands every year (Congdon and van Loben Sels 1993; Litzgus and Brooks 1998a; Beaudry et al. 2008). Because of their life-history traits, the loss of only a few adult turtles every year is enough to lead populations of many species to negative growth rates and extirpation (Brooks et al. 1991; Congdon et al. 1993; Heppell 1998).

In southern Maine, human population density and growth are high and rates of exurban sprawl are among the fastest in the region (Plantinga et al. 1999). The turtles' numerous upland movements, combined with southern Maine's extensive road network and high traffic rates, are endangering their populations through road mortality (Beaudry et al. 2008), and potentially through poaching as well. An unknown, but potentially important proportion of all upland movements is related to nesting.

To understand better the exposure to upland risks faced by nesting female Spotted and Blanding's Turtles, and to inform potential nest site supplementation efforts, data on nesting decisions were needed. First, we quantified upland movements associated with nesting and estimated the proportion of annual upland travel that these movements represent. Secondly, we determined the extent to which Spotted and Blanding's Turtles use nest sites of anthropogenic origin. Finally, we estimated the number of years the nesting sites had been available in order to further inform the possible creation of artificial nest sites. We predicted that nesting movements by these species constitute a significant proportion of all upland movements and that turtles would predominantly use nest sites of recent anthropogenic origin because of the limited availability of suitable natural locations.

Materials and Methods

Study site.—We conducted fieldwork at six study sites located in York County, Maine, (43°N, 70°W). The area was dominated by low-elevation (< 100 m), uneven terrain with shallow soils, rocky outcrops, and a high density of small scrub-shrub and forested wetlands. Land cover was mostly mixed broadleaf and coniferous secondary or tertiary growth forest interspersed with low to moderate density residential developments. Common wetland types were wet meadows, vernal pools, Red Maple (*Acer rubrum*) swamps, and scrub-shrub swamps dominated by High Bush Blueberry (*Vaccinium corymbosum*), Buttonbush (*Cephalanthus occidentalis*), and Winterberry (*Ilex verticillata*). Average minimum/maximum temperatures for 1 April and 31 October in Sanford, Maine (≤ 30 km from the study sites) are -2°C/7°C and 0°C/10°C, respectively, while the average maximum temperature peaks at 25°C in early August (National Oceanic and Atmospheric Association, National Climatic Data Center. Available from http://www.ncdc.noaa.gov/oa/ncdc.html [accessed 23 April 2010]).

Field methods and analyses.—We radio-tracked Spotted and Blanding's Turtles between April and November in 2004, 2005, and 2006. We captured turtles by hand or with baited hoop-net traps starting at spring thaw in early April. We tracked 23 adult females of each species for a maximum of one year per individual. We fitted each female with a radio-transmitter (Lotek Wireless Inc., models NTB-6_2 [4.5 g] and MBFT-6 [10 g], Newmarket, Ontario, Canada and Holohil Systems Ltd., model RI-2B [10 g and 15 g], Carp, Ontario, Canada) affixed with Biocryl rapid-curing dental acrylic (Great Lakes Orthodontics Ltd., Tonawonda, New York, USA). To avoid interference with mating activities, we positioned radio-transmitters near the posterior carapace margin, and off to the side. Expected battery life was 242–448 d depending on model. Average transmitter mass, including acrylic, was 15.6 g for Spotted and 39.9 g for Blanding's Turtles (3–6% of body mass). We released turtles at the site of capture the same day. Each radio-tagged individual was tracked for a single active season, generally 5–7 mo.

We located each radio-tagged turtle at least every 3–4 d with a hand-held, 64-cm two-element antenna (Telonics Inc., Mesa, Arizona, USA) and a digital receiver (Communication Specialists Inc., Orange, California, USA). Relocation frequency increased to at least once daily for gravid females during the nesting season. We recorded locations with a hand-held eTrex Venture GPS (Garmin Inc., Olathe, Kansas, USA), or on a 30-cm resolution digital orthorectified quadrangle image (DOQ) acquired in May 2003 (Maine Office of GIS. 2004. GIS Data Catalog. Available from http://megis.maine.gov/catalog/ [Accessed 9 December 2004]).

We determined whether females were gravid by palpating their abdomen through the posterior leg cavities. Starting in early June, we collected telemetry relocations more frequently. To avoid disturbing turtles during the nesting period, we limited our radio-tracking to triangulations confirming which wetland was occupied. When the weather conditions and turtle location made imminent nesting possible, we captured gravid females early in the day and affixed a modified 250-m (for Spotted Turtles) and 400-m (for Blanding's Turtles) thread bobbin to the posterior edge of the carapace. We used conduit tape to attach the bobbins (Komar Apparel Supply LLC., Chicago, Illinois, USA), which were wrapped in plastic food wrap and then dipped in liquid plastic that hardens when exposed to air (Plasti Dip International, Blaine, Minnesota, USA). Once the bobbin was installed, we tied the loose end of the thread to vegetation and released the turtle. This operation was done rapidly and with minimum handling to minimize disturbance. We later followed the thread (generally 12–36 h later) through the uplands in search of the nesting site. Nesting was confirmed by directly observing the female nesting or by identifying where the thread disappeared into the ground as it was buried in the nest chamber with the eggs. After the nest location was identified, we removed all thread from the area, except for the buried section which was cut near the surface, and removed the bobbin from the turtle. We marked the location of the nest with flagging tape positioned at least 5 m away, and revisited the nest site weekly to determine fate.

We classified nesting habitat as natural (e.g., rocky outcrop) or anthropogenic (e.g., road side, lawn). Recentness, estimated from field observations and local inquiries, expresses how long the nesting site has been available: high for ≤ 5 y, medium for 6–60 y, and low for > 60 y. We chose the threshold for low recentness to include sites that likely have been available as nesting sites through most of the maximum breeding life of both turtle species (65–110 y for Spotted Turtles, Litzgus 2006; and 60–75 y for Blanding's Turtles, Brecke and Moriarty 1989; Congdon et al. 1993). As a measure of nest site isolation from wetland habitat, we recorded distance to water as the linear distance to the edge of the closest body of water detectable from a 30-cm resolution, 1:24,000 DOQ. We also report nesting travel, which corresponded to travel to a nesting area and back, whether or not nesting occurred during a particular foray, and whether or not the trip back was made to the wetland of origin. Total upland distance traveled included both nesting travel and inter-wetland movements during the entire annual activity period. All upland travel estimates assumed straight-line movements between successive radio-locations. We provide the range and midpoint values for the estimated number of days that included upland travel related to nesting.

RESULTS

Blanding's Turtles.—We found 19 Blanding's Turtle nests, four of which could only be assigned to a general location (due to the thread running out before the nest was built). Two of 19 were found incidentally as they were being dug by turtles not equipped with radio-transmitters, so no data on movements were available for those turtles. Across all three years, Blanding's Turtles nested during the period of 15–30 June (accounting for the leap year, Table 1). The median length of nesting travel was 1,006 m (SD = 1,181 m, n = 17; Table 1), which on an individual basis was 30% (SD = 23%, n = 17) of the total annual upland distance traveled by breeding females (median: 4,197 m, SD = 1,516 m, n = 17). The median distance between the nest site and the closest wetland was 99.5 m (SD = 94 m, n = 14), based on a reduced sample size that excluded nests for which a

TABLE 1. Nesting events and site characteristics for Blanding's Turtles (*Emydoidea blandingii*) in southern Maine, 2004–2006. Nesting travel was defined as all upland movements related to nesting: travel to a nesting area and back, whether or not nesting occurred during a particular foray. Distance to water was defined as distance to closest wetland. No estimate could be calculated when only the general location of the nest was known. Time upland was defined as time spent upland during the course of nesting travels. Recentness expressed how long the nesting site has been available: high for ≤ 5 y, medium for 6–60 y, and low for > 60 y.

Turtle ID	Laying date	Site description	Nesting travel (m)	Distance to water (m)	Time upland (days)		Site origin	Recentness	Fate
Exact location determined					Range	Midpoint			
29	6/15/2004	Borrow pit	386	59	1-3	2	anthropogenic	high	destroyed
34	6/29/2004	Dredge pile by dug out wetland	2585	19	14-16	15	anthropogenic	high	unk
35	6/23/2004	Abandoned vineyard	1521	121	7-10	8.5	anthropogenic	medium	depredated
75	6/20/2004	Large gravel quarry	1478	165	4-7	5.5	anthropogenic	medium	unk
115	6/25/2004	Cleared land for quarry[1]	4461	365	14-16	15	anthropogenic	high	unk
119	6/17/2004	Cleared land for quarry[1]	1360	111	5-7	6	anthropogenic	high	hatched
21	6/30/2005	Selection cut (1-2 yr old)	1432	202	1-10	5.5	anthropogenic	high	hatched
37	6/23/2005	Cleared land for development	737	215	2-8	5	anthropogenic	high	unk
42	6/28/2005	Rocky outcrop	1050	83	5-12	8.5	natural	low	depredated
83	6/22/2005	Land cleared for a house	548	64	6-8	7	anthropogenic	high	unk
114	6/17/2006	Selection cut (<1 yr old)	100	35	3-6	4.5	anthropogenic	high	depredated
129	6/21/2006	Selection cut (1-2 yr old)	575	88	4-7	5.5	anthropogenic	high	unk
134	6/15/2006	Road embankment	1006	208	4-5	4.5	anthropogenic	high	Hatched[7]
144	6/22/2006	Road shoulder	173	57	1-3	2	anthropogenic	medium	depredated
unk	6/15/2006	Backyard lawn	unk	unk	unk	unk	anthropogenic	medium	hatched
General location determined									
116	6/18/2004	Cleared land for quarry[1]	unk	unk	unk	unk	anthropogenic	high	unk
101	6/16/2005	Backyard lawn	100	unk	1	1	anthropogenic	medium	unk
112	6/26/2005	Rocky outcrop	605	unk	2-4	3	natural	low	unk
142	6/17/2006	Rocky outcrop	3190	unk	8-12	10	natural	low	unk

[1] Blanding's Turtles 115, 116, and 119 shared the same general nesting location

posteriori measurements of distance to water could not be made. Blanding's Turtles spent a considerable amount of time upland for nesting purposes, with an average midpoint of 6 d (Table 1). Some notable nesting sites included an incipient quarry where trees and topsoil had been removed (three nests), woodlots where recent selective logging of various intensity had been conducted (three nests), and rocky outcrops within forested areas (three nests). Anthropogenic locales constituted 84% of the total nest sites observed for Blanding's Turtles, and 58% of the sites were of high recentness (≤ 5 y). Combining our results with those of a previous study with an overlapping study site (Joyal et al. 2000), 80% of Blanding's Turtles nested at anthropogenic sites (n = 25 nests). Of the nine known-fate nests, four (44%) hatched, all from anthropogenic sites (Table 1). The eggs of four nests were eaten by unknown predators, three of them within hours after they were oviposited. One nest, located in a borrow pit, was destroyed by earth-moving machinery.

Spotted Turtles.—We found 14 Spotted Turtle nests, eight of which could only be determined to an approximate location. Across all three years, nesting occurred during the period 12–29 June (Table 2). The median length of nesting travel was 148 m (SD = 306 m, n = 13; Table 2), which on average was 21% (SD = 17%, n = 13) of the total annual upland distance traveled by breeding females (median: 1,026 m, SD = 1,050 m, n = 13). The median distance between the nest site and the closest wetland was 7.5 m (SD = 87 m, n = 10) when including all nest locations, and 21.5 m (SD = 108 m, n = 6) when only considering nests placed in upland sites. On average, Spotted Turtles completed upland movements related to nesting over 2.6 d per season (Table 2). For Spotted Turtles, most nest sites (64%) were anthropogenic in nature (75% when combined with a previous Maine study with spatial overlap: Joyal et al. 2001; n = 28 nests), and 29% were of high recentness (≤ 5 y). Five turtles nested in backyards and two in agricultural settings (a hay field and a horse pasture). Among natural settings, four turtles nested in S*phagnum* moss within wetlands, with three turtles nesting on floating sphagnum in the same 28-ha marsh, and the fourth in a sphagnum hummock within a 1-ha fen. Only one Spotted Turtle nested in a natural upland site, a rocky outcrop near the top of a forested hill (~ 135 m above sea level, 60 m above last used wetland). Among Spotted Turtle nests of known fate, 33% (2 of 6) hatched, both at anthropogenic sites (Table 2). We observed a single case of failure from each of the following causes: predation by unknown predator, ant predation, trampling by horses, and deliberate exposing of the eggs by the landowner. One gravid Spotted Turtle was killed by a car while traveling towards a potential nesting site.

DISCUSSION

Both Spotted and Blanding's Turtles used anthropogenic nest sites more than natural nest sites. Road sides, backyards, and quarries, which were all used

TABLE 2. Nesting events and site characteristics for Spotted Turtles (*Clemmys guttata*) in southern Maine, 2004–2006.. Nesting travel was defined as all upland movements related to nesting: travel to a nesting area and back, whether or not nesting occurred during a particular foray. Distance to water was defined as distance to closest wetland. No estimate could be calculated when only the general location of the nest was known. Time upland was defined as time spent upland during the course of nesting travels. Recentness expressed how long the nesting site had been available: high for ≤ 5 y, medium for 6–60 y, and low for > 60 y. For Fate, numbers in parentheses correspond to the proportion of eggs that hatched, when known.

Turtle ID	Laying date	Site description	Nesting travel (m)	Distance to water (m)	Time upland (days)		Site origin	Recentness	Fate
Exact location determined					Range	Midpoint			
137	6/18/2004	Exposed soil in backyard	205	12	2-5	3.5	anthropogenic	high	destroyed
163	6/18/2004	In young (3 yrs old) clear cut	260	55	1-3	2	anthropogenic	high	depredated
182	6/14/2004	On paved road shoulder	115	3	3-5	4	anthropogenic	medium	failed
149	6/12/2005	In horse pasture	902	283	4-9	6.5	anthropogenic	medium	failed
227	6/29/2005	On grassy backyard	641	18	3-5	4	anthropogenic	medium	hatched (5/5)
292	6/16/2006	Mowed field with exposed soil	62	25	1-3	2	anthropogenic	medium	hatched (4/5)
General location determined									
16	June 2004	Sphagnum mat[1]	0	0	0	0	natural	low	unk
152	June 2004	Sphagnum mat[1]	0	0	0	0	natural	low	unk
156	June 2004	Sphagnum mat[1]	0	0	0	0	natural	low	unk
58	June 2005	Backyard lawn[2]	148	unk	0	0	anthropogenic	high	unk
296	June 2005	Sphagnum hummock	0	0	0	0	natural	medium	unk
59	6/26/2005	Backyard lawn[2]	665	unk	3-5	4	anthropogenic	high	unk
189	6/26/2005	Rocky outcrop	493	unk	4-6	5	natural	low	unk
238	6/28/2005	Backyard lawn	unk	unk	4-8	6	anthropogenic	medium	unk

[1] Spotted Turtles 16, 152, and 156 shared the same general nesting location
[2] Spotted Turtles 58, 59 shared the same nesting site

in this study, were widely available in much of our study area, offering sun-warmed ground. The specific substrate at these nesting sites was variable, from loose organic matter (e.g., a dredge pile) to consolidated soil with an organic layer (e.g., lawn) to sand or gravel with almost no organic matter. In our study, Blanding's Turtles nested in a substrate of exposed mineral soils, such as those found in quarry and borrow pits, more often than Spotted Turtles (eight of 19 nests for Blanding's Turtles compared to zero of 14 for Spotted Turtles). Our results are consistent with a prior study in Maine, where most nests of both species (Spotted: 86%, n = 14; Blanding's: 67%, n = 6) were found in human-altered sites such as yards, roadsides, and pastures (Joyal et al. 2000; 2001). If in their evolutionary history these turtle species relied on natural disturbances to open the forest canopy (e.g., Litzgus and Mousseau 2004), these patterns of anthropogenic site use are not surprising as humans are now the dominant agents of disturbance in our study area. The use of anthropogenic sites by Blanding's Turtles is common in other parts of their range; such sites include clear-cuts, burns, military exercise areas, yards, mulch piles, old fields, road sides, fire lanes, and railway embankments in Massachusetts, Michigan, Minnesota, and Nebraska, USA (Butler and Graham 1995; Congdon et al. 2000; Piepgras and Lang 2000; Grgurovic and Sievert 2005; Ruane et al. 2008). Naturally open nesting sites were extensively used in Minnesota (stabilized dunes, Pappas et al. 2000), Wisconsin (grasslands, Ross and Anderson 1990), and Nova Scotia, Canada (lakeshore cobble beaches, Standing et al. 1999). Spotted Turtles have been reported nesting in disturbed areas such as roadsides, yards, pastures, fields, and powerline right-of-ways (Joyal et al. 2001; Milam and Melvin 2001; Litzgus and Mousseau 2004; Ernst and Lovich 2009), but also in natural locations. In a study area with little human disturbance in Ontario, nesting occurred on rock outcrops, dug into the soil and lichen accumulated within cracks (Litzgus and Brooks 1998b), a behavior also observed in Maine (Joyal et al. 2001; this study). The habit of Spotted Turtles nesting within wetlands has been observed in this study, as well as elsewhere, with nesting observed in root hummocks in a Red Maple swamp, and in marshy pastures (Joyal et al. 2001; Ernst and Lovich 2009).

Blanding's Turtles used recently disturbed sites more often than Spotted Turtles. Only on three occasions did we observe Blanding's Turtles nesting in a site that has been available for longer than 60 y. Meanwhile, 11 Blanding's Turtles nested at sites that had been available for less than 5 y, taking advantage of recently disturbed areas such as logging operations and land clearing for quarries, house sites, or a new road. Though less frequent, this behavior is also demonstrated by Spotted Turtles, as we observed one nesting in a recent clearcut, and another one nesting in garden soil that had been freshly overturned. The use of recently cleared sites has also been observed in South Carolina, where Spotted Turtles have been observed nesting in five year-old clearcuts (Litzgus and Mousseau 2004). It is unclear whether the use of recent sites for nesting is beneficial; further investigations are needed to determine if higher nest success rates favor the use of new sites, perhaps via better soil conditions or lower predation pressure.

To reach nesting sites, both species cover considerable distances upland, but Blanding's Turtles averaged more than six times (median: 1,006 m) the distance covered by Spotted Turtles (median: 148 m). These extended upland movements included non-direct, meandering movements to potential nesting sites, which were sometimes abandoned after false nest starts. These travels translate to long periods of time upland for nesting purposes, with some Blanding's Turtle individuals observed upland for up to two weeks. Upland forays during the nesting season have been reported to last 2–7 d for Blanding's Turtles in the U.S. Midwest (Congdon et al. 1983; Rowe and Moll 1991). Of significance to conservation, nesting movements are more complex than simple straight-line trips from a wetland to a nest site: the majority of Blanding's Turtles in Michigan nested 2–400 m from the nearest water, but females covered much more actual ground overall in selecting nest sites (Congdon et al. 2000). Similarly, to reach nesting sites only an average of 541 m from their resident wetland, Blanding's Turtles from Minnesota meandered for 931 m (Piepgras and Lang 2000). Nesting movements may only comprise a modest proportion of the total annual upland movements for both species (21% for Spotted, 30% for Blanding's Turtles), but along with post-nesting movements, they can have important conservation consequences: their length, the fact that they are completed by a large proportion of the adult females, and their coincidence with seasonally high traffic volumes substantially increase the overall risk to population viability (Beaudry et al. 2010).

Disturbed habitats can potentially have negative consequences for freshwater turtles in some locations, due to increased predation rates and to altered vegetation that can change nest temperature and introduce sex ratio biases (Kolbe and Janzen 2002). However, the ability to use newly disturbed areas signals that artificial nesting sites can be detected and used rapidly by turtles and the location and quality of artificial sites could be managed to enhance nesting success. Canopy openings could be made and nesting substrate added to create an artificial nesting site. Furthermore, and most importantly, nest predation pressure and exposure to road crossings may be reduced by controlling spatial factors such as distance and direction from staging wetlands, vegetation edges, and lawns (Marchand and Litvaitis 2003). Along with direct nest protection through the installation of nest cages, artificial nesting sites could be used to increase local population recruitment. Nest site fidelity could in theory impede the discovery and use of artificial nesting sites, but fidelity appears to be variable, at least for Blanding's Turtles: of three females radio-tracked in two successive years in Maine, two used the same area twice, but another used areas 1,500 m apart (Joyal et al. 2000). Similarly, three of 11 females in Michigan nested up to 1,300 m from previous sites (Congdon et al. 1983). We conclude that the absence of absolute nest site fidelity combined with frequent use of anthropogenic sites of relatively recent origin suggest that artificial nesting sites could be attractive to these and other turtle species of conservation concern. Furthermore, the judicious placement of artificial nest sites could steer movements by adult females away from roads during the nesting season, thus reducing exposure to high-risk, demographically valuable individuals (adult females; Congdon et al. 1993; Heppell 1998; Litzgus 2006) during high-risk times (the nesting and post-nesting periods; Beaudry et al. 2010).

Acknowledgments.—This project was supported financially by the Maine Department of Inland Fisheries & Wildlife (Nongame and Endangered Wildlife Fund), the Maine Agricultural and Forest Experiment Station, the Maine Department of Transportation, the U.S. Environmental Protection Agency, the Maine Outdoor Heritage Fund, the U.S. Fish & Wildlife Service, The Nature Conservancy, the A.V. Stout Fund, and the Maine Association of Wetlands Scientists. Housing for the field work was generously provided by John Brissette, U.S. Forest Service Northern Research Station. All turtles were captured and handled under State of Maine permits 04-247 and 06-377 and following a protocol approved by the University of Maine Animal Care and Use Committee (protocol A2004-02-01). We thank Jaime Haskins, Mark Ward, Jami MacNeil, Ben Wasserman, William Hoffman, Nicole Munkwitz, Laura Leighton, and David Scarpiti for field assistance. Chad Rittenhouse provided helpful comments on this manuscript. Maine Agricultural and Forest Experiment Station Publication No. 3092.

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