

ELEVATED MORTALITY OF HATCHLING BLANDING’S TURTLES (*EMYDOIDEA BLANDINGII*) IN RESIDENTIAL LANDSCAPES

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Abstract.—We investigated the relationship between residential development and post-emergent mortality rate in 72 wild Blanding’s Turtles (*Emydoidea blandingii*) at nine separate nesting areas in fragmented and residential landscapes in Massachusetts. Thirteen hatchlings (18%) died during the study, a higher rate than reported by a similar study on a former military base about 10 km away undertaken twelve years previous (0%). Within our study area, we found nests within residential landscapes to have higher mortality rates than nests in nonresidential landscapes. Most observed or inferred mortalities resulted from Eastern Chipmunk (*Tamias striatus*) attacks. Cars, birds, and domestic horses caused the remaining mortalities. Chipmunks are abundant in eastern Massachusetts, especially in residential environments, and depredation of hatchling turtles by chipmunks and possibly other sciurids may be a locally important consideration when developing conservation and management plans for freshwater turtles in New England. Our study provides additional evidence that residential development may result in sink dynamics for freshwater turtles, in which females are attracted to anthropogenic nesting sites, but hatchlings sustain elevated mortality rates.

Key Words.—Blanding’s Turtle; depredation; Eastern Chipmunk; *Emydoidea blandingii*; habitat fragmentation; mortality; *Tamias striatus*

INTRODUCTION

The eastern population of Blanding’s Turtle (*Emydoidea blandingii*) is of conservation concern in each of the five states and provinces in which it occurs: New York; Massachusetts; New Hampshire; Maine; and Nova Scotia (Levell 2000; Grgurovic and Sievert 2005). Eastern populations of Blanding’s Turtle frequently occur in residential landscapes fragmented by roads (Grgurovic and Sievert 2005), although some eastern populations occur in protected wildlife reserves (e.g., Graham and Doyle 1975). In New England, Blanding’s Turtles rely heavily on anthropogenic nesting areas such as land cleared for development, logging, or mining, or in residential areas (Beaudry et al. 2010). These sites may be detected rapidly by nest-searching females and are often accessed via large overland movements (e.g., Congdon et al. 1983; Beaudry et al. 2010). Overland movements to anthropogenic nesting sites may expose females to greater risk of mortality due to roadkill (Steen et al. 2006), but little is known about the fate of hatchlings following emergence from nests in residential areas. Blanding’s Turtles are long-lived and females have been documented reproducing well into their seventies (Congdon et al. 2001). At sites where adult mortality rates are elevated as a result of habitat fragmentation, such as in eastern Massachusetts, juvenile survivorship becomes increasingly important to maintaining population levels. Compared to later life

stages, relatively little is known about the threats to Blanding’s Turtles in their first year of life, although several recent studies have documented habitat selection and movements (e.g., Standing et al. 1997; McNeil et al. 2000). Most previous studies of Blanding’s Turtle hatchling ecology have reported low mortality rates during the study period. For example, Butler and Graham (1995) conducted a study of 63 post-emergent hatchling Blanding’s Turtles at a protected site in central Massachusetts, and did not document any mortality in at least 100 turtle-days of tracking, suggesting that post-emergent mortality was low during their study. We undertook a study of post-emergent movements of Blanding’s Turtles near the site studied by Butler and Graham (1993, 1995), and followed similar protocols. We predicted that hatchling movements in residential landscapes would be similar in distance and duration to those reported by Butler and Graham (1995), but that mortality rates from vehicular collisions and other anthropogenic effects would be higher.

MATERIALS AND METHODS

Study site.—From August to October 2002, we undertook a study of Blanding’s Turtle hatchlings in the weeks following their emergence from natural nests at unprotected (privately owned) sites in Middlesex County, Massachusetts, USA. The nesting areas consisted of powerline rights-of-way, residential lawns

and gardens, road shoulders, gravel pits located adjacent to marshes, shrub swamps, vernal pools, and reservoirs in the watershed of the Nashua River, a tributary of the Merrimack River (42.6°N; 71.5°W; Grgurovic and Sievert 2005). Our study followed the field methodology reported by Butler and Graham (1993, 1995), and we attempted to make general comparisons of our findings to theirs. For that reason, we have included a brief description of their study area. Their primary field site is also located in the Nashua River watershed, and approximately 10 km away from our sites. Their site consists of an abandoned sand and gravel pit formerly used for military training operations, currently protected as part of a National Wildlife Refuge. At the time of their study in 1990, most of the nesting area was located > 300 m from the nearest paved public road, and approximately 0.5 to 1.1 km from the nearest residential buildings.

Field methods.—In June 2002, we located 23 Blanding's Turtles nests using the thread-trailing methodology described by Beaudry et al (2010). Nests were protected *in situ* with hardware cloth cages (Standing et al. 1999). From August to October 2002, we studied the terrestrial movements of 72 post-emergent hatchling *E. blandingii* from 11 of these nests that produced multiple live hatchlings. Upon their natural emergence from the nest, hatchlings were tracked overland using a combination of fluorescent powders and ultraviolet lamps (Butler and Graham 1995; Standing et al. 1997). We tracked and relocated hatchlings every 24 hr until we found them dead or we could not relocate them. When we found hatchlings dead or suspected to have died, we attempted to ascertain the cause of death using such physical evidence as footprint patterns in the fluorescent powder and the location of the remains, as well as direct observation of the event.

We determined the number of residential buildings within 125 m (the average distance to permanent water of the 11 naturally-situated study nests) of the nest location using aerial orthoimagery taken between 2001 and 2003 (Office of Geographic and Environmental Information [MassGIS]. 2009. Commonwealth of Massachusetts Executive Office of Environmental Affairs. Available from: <http://www.mass.gov/mgis> [Accessed 10 October 2009]). We compared the mortality rates from among all of our tracked hatchlings to those tracked by Butler and Graham (1995; 0 out of 62) using Fisher's exact test with an alpha level of 0.05 (Quinn and Keough 2002). Because Butler and Graham (1995) do not report the total number of days the turtles were tracked, we also undertook a statistical comparison between the two studies using only the mortality observed during the first day of tracking. We also used Fisher's exact test to compare the mortality rates of

hatchlings from nests within residential landscapes to those from nonresidential landscapes. We compared "nonresidential" and "residential" nests using Fisher's exact test (Quinn and Keough 2002). We defined nests with ≤ 1 residential building within 125 m as "nonresidential" and nests with ≥ 2 residential building as "residential". The number of residential buildings (houses) within 125 m of the nest site was determined using 2001 and 2003 aerial images and direct field reconnaissance. Because hatchlings from the same nests were not strictly independent of one another, we evaluated the mortality rate at the nest level (rather than the individual level as above). We scored nests either "0" if we observed no mortality amongst its tracked hatchlings and "1" if we observed or inferred any mortality. We conducted both analyses using the oddsratio function in the epitools library (epitools: Epidemiology Tools. 2010. R package version 0.5-6. Available from: <http://CRAN.R-project.org/package=epitools> [Accessed 8 January 2011]) in program R (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

We tracked and relocated 72 hatchlings for periods ranging from one to 48 d (average = 4.48 d and median = 2 d), a combined total of 326.9 d. Eighteen hatchlings (25%) were successfully tracked to permanent wetlands. Mean time that these hatchlings spent traveling to water was 88.8 h (median = 153.6 h; range = 10.8–296.5 h). Mean straight-line distance traveled from nest to permanent wetland was 105 m (range = 28.0–435.0 m). We inferred from available evidence that 13 hatchlings died en route to water, a minimum mortality rate of 18.1% in the first weeks, post-emergence (Table 1). These mortalities may be grouped into two levels of confidence: those whose remains were collected ($n = 7$) and those whose remains were not located ($n = 6$). Tracked hatchlings originated from 11 nests averaging 125 m from permanent water, similar to the distances reported by Butler and Graham (1995; i.e., < 200 m). These nests averaged 1,522 UNIT from the nearest other nest used in the study (range = 144–6,900 m).

Two hatchlings were killed by automobiles while crossing a lightly-traveled road (estimated average daily traffic = approx. 200 cars per day; Executive Office of Transportation [MassEOT]. 2009. Office of Transportation Planning – Roads [shapefile]. Available from: <http://www.mass.gov/mgis/eotroads.htm> [Accessed 10 February 2011]). One sibling crossed the same road without being struck by a car. One turtle was apparently killed by a bird after eight days of terrestrial movement. In this instance, clearly defined bird tracks measuring 2.5 cm in length were visible between powder patches. We were unable to identify the species of bird. At another site, a single hatchling was apparently crushed to

TABLE 1. Data for 72 hatchling Blanding’s Turtles (*Emydoidea blandingii*) tracked from 11 natural nests. “Chipmunk,” “bird,” “vehicle,” and “horse” indicate the mechanism of fatal injury to the hatchling. The “number of hatchlings lost” column reports hatchlings that were not tracked to either death or wetland entry and were essentially censored from the tracking experiment because of limitations associated with the tracking method. The asterisk (*) denotes an instance of nonlethal chipmunk depredation.

Nest number	Distance to nearest nest (m)	Distance to permanent wetland	Residential buildings within 125 m	Number of hatchlings tracked	Number of mortalities observed	Chipmunk	Bird	Vehicle	Horse	Number tracked to wetland	Number of hatchlings “lost”	Total turtle-days
HN1	2,132	205	3	4	1	1	0	0	0	0	3	5.34
SN1	301	13	0	3	0	0	0	0	0	3	0	15.92
SN3	301	20	0	10	0	0	0	0	0	7	3	79.53
TMN1	6,900	98	0	2	0	0	0	0	0	0	2	2.50
TN1	2,399	125	1	7	0	0	0	0	0	0	7	33.75
TN3	2,399	148	2	3	2	1	0	0	1	1	0	45.98
UN1	526	256	3	4	2	2	0	0	0	0	2	32.23
UN2	144	74	3	12	5	5	0	0	0	1	6	18.23
UN3	971	146	2	12	1	0	1	0	0	1	10	32.75
UN4	144	99	6	9	0	*	0	0	0	4	5	26.56
UN6	526	197	3	6	2	0	0	2	0	1	3	34.12

death in a horse pen while buried in a shallow grass form. The remaining nine hatchling mortalities (61.5% of mortalities, 11.1% of all hatchlings) were apparently killed and eaten by Eastern Chipmunks (*Tamias striatus*). Chipmunk depredation occurred at five nests. Seven of these recorded mortalities occurred within 1 m of a rock wall and one occurred at a lawn/forest ecotone. In the instances in which we located remains of tracked hatchlings, we found only carapacial fragments. “Processing sites” at stonewalls were surrounded by chipmunk tracks in fluorescent powder. We observed chipmunks processing acorns at several of the kill sites, and found acorn fragments at most sites. Chipmunks appeared to use the same processing sites repeatedly. One hatchling was killed and partially eaten along a gravel driveway in a wooded residential area. Remains collected at the scene included most of the posterior portion of the carapace and plastron and most of both bridges. The remains were consistent with previous chipmunk kills, but no chipmunk tracks were found, and the predator could have been another small rodent or an insectivore.

In addition to the 13 mortalities we have already listed, we observed an additional instance of chipmunk depredation attempt. One hatchling survived a chipmunk attack while en route to water and subsequently walked nearly 100 m to its point of wetland entry, where we re-located it. Evidence at the site suggests that the hatchling was interrupted by a chipmunk in red pine plantation about 100 m from its previous form, carried several meters, and partially eaten (the hatchling was missing parts of its feet and marginal bone) before escaping.

Statistical comparison of the mortality rates (binarized to 0 or 1 based on any observed mortality) between “nonresidential” (n = 4) to “residential” yielded significant differences (Fisher’s exact test; $P = 0.015$). This result remained significant even after the removal of one nonresidential nest that had only 2.5 d of tracking recorded (TMN1, see Table 1; Fisher’s exact test, $P = 0.033$).

DISCUSSION

Although Blanding’s Turtles may be attracted to residential landscapes as nesting areas (Beaudry et al. 2010), and previous studies have suggested that nest-depredation rates are lower in residential landscapes (Marchand and Litvaitis 2004), our findings suggest that residential landscapes are suboptimal nursery habitat for Blanding’s Turtles in the first weeks of life because of elevated mortality from multiple sources, especially chipmunks. Several previous studies have documented mammalian depredation of post-emergent hatchling turtles, including Blanding’s Turtle (e.g., Lefevre and Brooks 1995; Standing et al. 1997; Tuttle and Carroll 2005), but none of the previous studies examining post-emergent hatchling freshwater turtle behavior in the northeastern U.S. and Canada (e.g., Butler and Graham 1995; Standing et al. 1997; McNeil et al. 2000; Castellano et al. 2008) have reported a mortality rate due to chipmunk depredation comparable to that reported in this paper, suggesting that the prevalence of this phenomenon may exhibit high spatial and temporal variability. Notable because of the proximity of their study site to ours (10 km), Butler and Graham (1995) did not observe or infer any mortality among the 63

hatchling *E. blandingii* they followed at a protected site, not fragmented by public roads, and on average 800 m from the nearest residential area. Using Fisher's exact test to compare their observed rate of zero mortalities amongst a sample of 63, their findings suggest a significantly lower mortality rate (Fisher's exact test, $P < 0.001$) lower than our observed rate of 13 out of 72. However, this test assumes that both studies tracked hatchlings for comparable periods of time, which may not be true, as Butler and Graham indicate that a subset of 62 hatchlings were only followed to their first-night form. Comparing only first-day mortality events (zero out of 63 and two out of 72, Butler and Graham 1995 and this study, respectively) does not yield a significant result (Fisher's exact test, $P = 0.500$). However, several statements by Butler and Graham (1995), including the fact that nine hatchlings were tracked for an average of 2.9 d each and that one turtle was tracked for 24 d, suggests that their sample included at least 100 turtle-days. In this case, we feel that the direct comparison of observed mortality events is appropriate, in which case the highly significant result suggests there is a meaningful difference between the mortality rate at the protected, isolated study site of Butler and Graham (1993, 1995) and our fragmented study area. It must be noted again, however, that this effect could be due in part to temporal variation in predator densities, as the Butler and Graham study occurred twelve years prior to the present study. It should also be noted that subsequent to the original study by Butler and Graham (undertaken in 1990), evidence of depredation by chipmunks and bullfrogs has been observed at this study site (Brian Butler, pers. comm.)

The overall effect, however, is further demonstrated within our sites. More specifically, residential development appears to be associated with elevated mortality rates of hatchling Blanding's Turtles. Although the total sample is small ($n = 11$), significant P -values ($P < 0.05$) suggest that there is a relationship between the amount of residential development within 125 m of the nest site and the survivorship of hatchling turtles. Future studies could shed additional light on this hypothesis by designing a telemetry-based experiment with adequate replication, focusing on quantifiable metrics of fragmentation and residential development, distance of nest from water, and proximity to roads. Future studies should also investigate the relationship between specific landscape characteristics such as stonewalls and roads and hatching mortality.

Chipmunk depredation of hatchling turtles outside of an experimental set-up may be under-reported because of the difficulty of detection. Other omnivorous native sciurids, such as Gray Squirrel (*Sciurus carolinensis*) (e.g., Allen 1982) and Red Squirrel (*Tamiasciurus hudsonicus*) may also feed opportunistically on hatchling turtles. In Massachusetts, chipmunks are common near

stonewalls and debris piles in a variety of residential and wooded environments (Ryan and Larson 1976). Chipmunks are well-documented omnivores known to feed on invertebrates, plants and fungi (e.g., Wrazen and Svendsen 1978), bird eggs (Maier and DeGraaf 2000), birds (e.g., Murray et al. 1983), and other animal matter (Forbes 1966). Belzer et al. (2002) reported chipmunk attacks on two captive yearling Eastern Box Turtles (*Terrapene carolina*) in Pennsylvania.

It is important to address the potential influence of human handling on chipmunk-caused mortality. Because we handled hatchlings up to twice daily without gloves, the implications of human scent on hatchlings is of significant concern. Several nut-removal studies have shown that human handling affects seed removal by squirrels and chipmunks (Duncan et al. 2002; Wenny 2002). Wenny (2002) observed elevated (nearly 50% greater) removal rates of human-handled *Cornus* sp. and *Prunus* sp. seeds in a manipulative experiment in Illinois. Duncan et al. (2002) concluded that human handling encourages removal for a short duration (i.e., several days). The fluorescent powders may also render the hatchlings more visible to chipmunk predators. Future studies using fluorescent powders to study hatchling movements should incorporate a study to evaluate these effects into their study design using nuts as surrogates, or use radiotelemetry as an alternative to powder tracking. We feel that our results and inference are not biased because we make comparisons only amongst data collected using the powder-tracking technique.

In summary, we suggest that residential development can result in suboptimal landscapes for post-emergent hatchling Blanding's Turtles by indirectly elevating mortality rates. It is possible that residential development functions as a population sink for Blanding's Turtles, in which females are attracted to dry, open lawns and gardens to nest, but hatchlings sustain elevated mortality rates at those nesting areas. Sciurid depredation may be a locally important consideration for the conservation of Blanding's Turtles and other freshwater turtle species in the northeastern U.S. and Canada, although this mechanism may exhibit strong temporal variation.

Acknowledgments.—We are indebted to Mark Grgurovic, Liz Willey, Brad Compton, Betty Mobbs, and Tom Jones for assistance in the field, and to several landowners in Groton and Littleton, Massachusetts, USA, who allowed evening property access. This project was supported by grants to Mike Jones from the Howard Hughes Medical Institute (grant to Hampshire College) and New England Wetland Plants, Inc., of Amherst, Massachusetts, and to Paul Sievert by the Massachusetts Natural Heritage and Endangered Species Program. We obtained permission to handle and study Blanding's

turtles from the Massachusetts Division of Fisheries and Wildlife (letter of authorization from Assistant Director Thomas W. French dated 12 April 2001). The University of Massachusetts Institutional Animal Care and Use Committee (Protocol #21-02-08) approved our field methods. Charlene D'Avanzo, John Reid, Brian Schultz, Steve Roof, Liz Willey, Brad Compton, and Brian Butler provided extremely helpful comments on earlier drafts of this manuscript, and Liz Willey provided statistical advice early in the process.

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PAUL R. SIEVERT received a B.S. in Fisheries and Wildlife Biology from Iowa State University (1981), M.S. in Wildlife Ecology from the University of Wisconsin (1984), and Ph.D. in Biology from the University of Pennsylvania (1996). Since 2000, he has been the Assistant Unit Leader for Wildlife in the USGS Massachusetts Cooperative Fish and Wildlife Research Unit at the University of Massachusetts Amherst. Paul’s research interests are in conservation biology, physiological ecology, and biostatistics. His research group studies populations of threatened and endangered species (freshwater turtles, salamanders, butterflies and moths, Short-tailed Albatross (*Phoebastria albatrus*), and Sumatran Tigers (*Panthera tigris sumatrae*)) to better understand, and hopefully reverse, their declines. With respect to physiological ecology, he is interested in how energy and water balance influence the nesting ecology of marine birds, the estivation behavior of turtles, and the establishment of species range boundaries. His quantitative research focuses on methods for estimating survival rates, and the use of population viability analyses in conservation biology. (Photographed by Sean Werle)