RESEARCH REPORT

Experimental Management of Nesting Habitat for the Blanding's Turtle (*Emydoidea blandingii*)

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ABSTRACT

With the loss, fragmentation, and degradation of natural wetlands, habitat restoration and management are becoming increasingly important tools in the conservation of many turtle species. The rare Blanding's turtle lives primarily in wetlands but requires well-drained and sparsely vegetated soil for nesting. If traditionally used nesting habitat becomes unsuitable due to vegetation overgrowth, females may travel farther with an increased risk of collection, predation, and mortality from cars. At a habitat creation site in Dutchess County, New York, we examined the success and cost-effectiveness of three methods of nesting habitat management—tilling, mowing, and weeding—on replicated 5 m × 7 m plots. Using radiotelemetry, we followed female turtles throughout the 2006 and 2008 nesting seasons. Nesting turtles preferred tilled plots to weeded or mowed plots. Our work suggests that tilling plots can be a successful and cost-effective means of managing nesting habitat.

Keywords: Blanding's turtle (*Emydoidea blandingii*), habitat management, nesting habitat, restoration

Wetland loss, habitat fragmentation, and the degradation of existing habitat by pollution and human encroachment have led to declines in many turtle species in recent decades (Klemens 2000). In fragmented areas, breeding females are at great risk when they travel long distances in search of suitable nesting habitat. Terrestrial movement increases the incidence of collection, mortality from vehicles or construction or agricultural equipment, and predation by foxes, skunks, and raccoons (Kiviat 1997). Many turtle populations nationwide exhibit a male-biased sex ratio, and in regions with higher road density, this bias is significantly more pronounced; the difference is likely due to the mortality incurred by females on overland nesting forays (Steen and Gibbs 2004, Aresco 2005, Gibbs and Steen 2005). Female painted turtles (*Chrysemys picta*) exhibit more injuries than males, likely due to encounters with cars and predators during terrestrial movement (Marchand and Litvaitis 2004). Therefore, reducing terrestrial movements of females may prove vital to the conservation of freshwater turtle species. One strategy for reducing female movements is the restoration and management of turtle nesting habitat near the wetlands in which turtles spend most of their time.

The Blanding's turtle (*Emydoidea blandingii*), a midsized freshwater turtle native to the northeastern United States, the Midwest, and southeastern Canada, is of conservation concern throughout much of its range and is designated as "threatened" in New York by the State Department of Environmental Conservation (DEC 2009). The distance traveled by female Blanding's turtles in overland nesting forays has been reported in the range of 100–2,900 m in various studies (Hartwig 2004, Compton 2007). Females can spend more than seven days searching for a nest site (Congdon et al. 2008) and have been known to spend up to 17 days on land in search of suitable habitat (Rowe and Moll 1991).

Blanding's turtles require nesting habitats with well-drained, sparsely vegetated, sunny, friable (loose) soil for nesting. Reported sites include meadows, cornfields, dirt roads, road shoulders, fire lanes, plowed fields, gardens, piles of cut vegetation, powerline rights-of-way, sandy racetracks, cobble beaches, yards, and abandoned railroad beds (Linck et al. 1989, Ross and Anderson 1990, Kiviat 1997, Standing et al. 1999, Joyal et al. 2001, Congdon et al. 2008). Soil character can vary considerably, although sandy or gravelly soils are used most often (Compton 2007), and soils must be well-drained but not excessively dry or wet (Linck et al. 1989, Bock 2007). Blanding's turtles nest away from trees or shrubs in areas where sunlight raises soil temperatures to levels suitable for egg incubation. However, nests are typically located near some kind of

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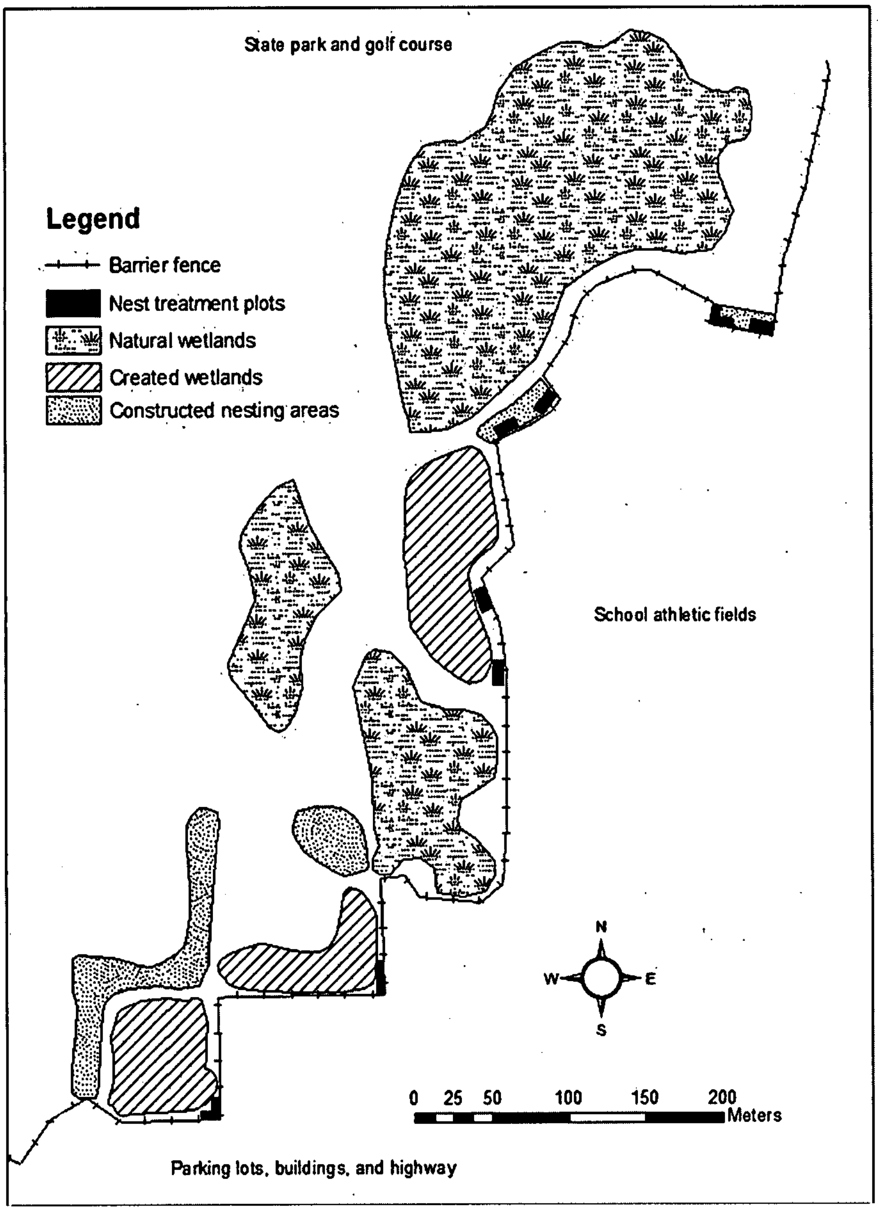

Figure 1. Map of the Blanding's turtle habitat restoration project in the Town of LaGrange, Dutchess County, New York. The entire sanctuary is 12 ha; the wetland area is 7.4 ha.

herbaceous cover such as sedge or grass (Ross and Anderson 1990).

In 1996–1997, Hudsonia Limited designed and monitored the construction of Blanding's turtle habitat at a site in the Town of LaGrange, Dutchess County, New York, to replace wetland and nesting habitat destroyed for the expansion of a public school (Kiviat et al. 2000). The site was located in a rapidly developing area with heavily traveled roads, so the design for the site included upland nesting habitat adjacent to wetlands. Based on the known nesting criteria, Hudsonia designed nesting habitat in the form of berms and flats of sandy or gravelly loam soil on sunny southern or southeastern exposures (Kiviat et al. 2000). During initial construction, these sites were seeded with native grasses and forbs in an attempt to create sparse, tufted, herbaceous vegetation interspersed with bare soil (Kiviat et al. 2000). After several years, however, the constructed nesting habitats were densely overgrown with coarse herbs, rendering them unsuitable for the nesting turtles. In previous years, selected plots were hand-weeded approximately 90% clear of vegetation to provide bare ground for nesting. This form of management was inefficient in terms of time and resources, though turtles did nest on the weeded plots. Our aim was to determine whether more efficient methods of clearing plots could create suitable nesting habitat for Blanding's turtles.

To this end, we created plots of mowed, tilled, and weeded ground within the created habitat in areas known to have had successful nests in previous years. In two nesting seasons, we followed female turtles throughout the nesting season, and in one season, we also monitored the overland movements of gravid females using thread-trailing. This allowed us to identify both which plots females initially explored and which they eventually nested in.

Methods

This study was carried out at a 12 ha Blanding's turtle habitat creation site (hereinafter, the sanctuary) located in the Town of LaGrange, New York (Figure 1; Kiviat et al. 2000). The site consists of 1.4 ha of artificially created wetland, 6 ha of natural wetland, and 1 ha of created nesting areas interspersed with forest, scrub, and herb-dominated areas. Blanding's turtles nest on both the created nesting areas and other forb-dominated areas. It is bordered to the north and west by woods and a golf course, to the southwest by houses and yards, and to the east and southeast by school grounds and playing fields, with parking lots and roads beyond. A 1.5 km fence with one-way "turtle curbs" (to allow turtles entry into the site but to discourage exit from it) runs along the boundary between the school and restoration area but does not completely encompass the sanctuary. For a complete description of the area and habitat construction, see Kiviat and others (2000).

We selected eight sites within the sanctuary in areas along the fence known to have had successful nests in previous years (Figure 1). The turtles had not recently nested in the two southern constructed nesting areas; therefore we did not place treatment plots in these areas. Sites were chosen for similarity of vegetation composition and cover. At each location, we created three 5 m × 7 m plots. In 2006 and again in 2008, at each site we created one plot each of mowed, hand-weeded, and tilled treatments, in random arrangement, for a total of 24 plots in each year. Treatments were rotated at random between 2006 and 2008. In mowed plots, vegetation was cut to a height of 5 cm with a high brush mower; in tilled plots, soil was completely tilled to a depth of 15 cm (typical nest depth) with a front-tine tiller; in weeded plots, about 90% of vegetation was pulled with hands or hand tools, leaving some plants for cover as in previous years. Preference for what plants to leave standing was given to the grass little bluestem (*Schizachyrium scoparium*) because it is a native species and because it forms the low tufts of vegetation adjacent to bare ground that turtles may prefer for nesting (T. Hartwig, pers. obs.). Where no bluestem was present, we left other dominant species, usually spotted knapweed (*Centaurea biebersteinii*) or crown vetch (*Coronilla varia*). Treatment sites were selected in mid-May. All habitat manipulations were completed by one week prior to 25 May, the start of nesting season. We determined the start of nesting season as the earliest day a female had moved toward nesting grounds during nine years of radiotelemetry at this site.

We caught turtles and outfitted them with radio-transmitters either during hoop trap surveys (1 May to 15 May) or during visual surveys for nesting turtles (25 May to approximately 20 June). From 25 May through most or all of June of 2006 and 2008, we radio-tracked female turtles every afternoon and through the night until the turtle either nested or was located in a wetland or on land in a resting spot, generally under dense vegetation. In 2006, whenever a gravid female was found on land and did not appear to be actively nesting (examining the ground for a spot to nest, or actually digging), we attached a reverse-spool bobbin to the posterior portion of the female's carapace and attached the end of the thread to adjacent vegetation (Boonstra and Craine 1986). Bobbins were replaced whenever females were located on land. Trails of females were traced the afternoon following bobbin attachment. All treatment plots visited in that 24-hour period were recorded.

In 2006, when a turtle was found beyond the sanctuary perimeter fence, it was moved to within the sanctuary to protect both adult and eggs. These turtles were released on a nesting treatment plot selected at random. In 2008, we did not return turtles to the sanctuary unless they were moving to a dangerous area, for example, a road, athletic field, or parking area.

For turtle nesting preferences, we used two exact tests (Fisher's and mid-*P*) on turtle site selection based on treatment (mowed, tilled, or weeded). Because we were working with a threatened species and therefore had small sample sizes, we determined the statistical power for each of our tests; when power was low (< 50%), we raised the alpha level to 0.10. First, we performed the test pooling data for all turtles that nested on the plots in 2006 and 2008, assuming that the turtles were independent data points. Because some of the individual turtles were the same in the two years, we conducted another test of the data in which we analyzed the data for first captures only. Finally, we analyzed the data for 2006 only. All data were analyzed using WINPEPI software (Abramson 2009).

Results

We monitored the nesting preferences of a total of ten individual females in 2006 and 2008. In 2006, all nine radio-tracked females nested within the treatment plots—seven in tilled plots and two in mowed plots (Table 1). In 2008, six females nested within the treatment plots, one nested inside the sanctuary but not in a treatment plot, and two nested outside the sanctuary (Table 1). Of the six females that nested in the treatment plots in 2008, five nested in tilled plots and one in a weeded plot. In all analyses of turtle nesting treatment preference, turtles showed a statistically significant preference for nesting in tilled plots compared to mowed or weeded plots (Table 2).

In 2006, thread-trailing data revealed that every turtle had been placed on, or explored on her own, a plot of each treatment type before choosing her nest site. No turtle nested on a plot it had been placed on without first leaving and coming back. Although turtles were placed on hand-weeded plots, none nested there, suggesting that placement on a plot did not determine where a turtle nested. Mowing and tilling were more efficient than hand-weeding. Weeding took about 2.5 h for one person on one plot; mowing took 0.25–0.33 h, and tilling less than 0.5 h. Including the costs of equipment rental, tilling and mowing were less expensive than hand-weeding due to the high labor costs associated with hand-weeding (Table 3).

Discussion

Based on our small sample sizes, Blanding's turtles nested preferentially on managed (tilled, mowed, and weeded) plots at our sites. Of these managed treatments, turtles nested significantly more often on the tilled plots. Turtles may have preferred the loose soil created by tilling in these plots. Tilling also brought larger rocks to the surface, ensuring that nest excavation would not be interrupted by rocks in the nest cavities. Mowing appears to be an acceptable form of treatment as well, although turtles nested less often in mowed plots (two of nine nests in 2006). The efficacy of mowing may be related to the type of vegetation being mowed; both nests were dug in patches where crown vetch with relatively large tops and slender stems dominated. When mowed,

Table 1. Nesting plot treatments selected by each turtle. Individual females are indicated by their tag numbers. Codes indicate location of nests: T = tilled; M = mowed; W = weeded; O = off the treatment plots. Shading indicates turtles that nested in the same physical location in both years, despite a change in plot treatment.

Turtle	2006	2008
647	T	—
701	M	—
809	T	T
811	T	O
817	M	T
819	—	T
820	T	—
834	T	T
838	T	W
840	T	T

Table 2. Results from analysis of turtle nesting site preferences using nest site locations of all turtles who nested in the plots in 2006 and 2008, all turtles only on their first nesting occasion, and turtles captured in 2006 only. Criteria for adjusting the alpha-level are indicated in the main text. Statistically significant *p*-values are shaded.

	Fisher's exact test	Mid-P exact test
All nests ($n = 16$)		
Power	61%	75%
Alpha level	0.05	0.05
p-value	0.04	0.04
First captures only ($n = 10$)		
Power	42%	44%
Alpha level	0.10	0.10
p-value	0.06	0.05
2006 captures only ($n = 9$)		
Power	35%	43%
Alpha level	0.10	0.10
p-value	0.09	0.06

this growth pattern left small sprouts emerging from otherwise bare ground. In grassy areas, by contrast, a dense sward covered the ground even after mowing, and no turtles nested in this substrate. Only one turtle nested in a weeded plot (one of six nests in 2008); in years prior to our study, turtles nested in weeded plots when no mowing or tilling occurred. Rain during plot treatment may have led to the wet soil being compacted during weeding, rendering these plots less desirable for nesting than tilled or mowed plots.

For the artificial nesting sites within the constructed wetland, mowing was more efficient than tilling, but at this scale tilling was slightly less expensive and therefore more cost-effective (Table 3). Despite the costs of rental equipment, mowing and tilling were less expensive than weeding because of its time-intensive nature and the associated labor costs. Actual costs will vary with local pricing and donated time and equipment, but these estimates demonstrate that tilling can be a cost-effective option, especially as the size of management plots, and therefore labor costs, scale upward.

Because we increased the alpha level to 0.1 to compare management treatments, we increased the chance of a Type I error (finding an effect of treatment when there isn't one). If this occurred, we would have concluded that tilling was the best method when in fact turtles showed no preference between tilled, mowed, and weeded plots. However, turtles obviously preferred to nest in managed areas: 15 of 16 turtles nested in manipulated plots in 2006 and 2008. In our cost analysis, tilling was the cheapest method, suggesting that choosing tilling over mowing or weeding would be an acceptable management decision even if there were no significant differences in turtle preferences among management treatments.

Two of the nine turtles that we observed in both 2006 and 2008 returned to the same nesting site location, though the plot treatment for that location had changed (Table 1). In 2005, one of the turtles nested in the same location, showing high nest site fidelity; in 2007, she nested at the other end of the sanctuary. The other turtle nested south of the sanctuary in 2005 and 2007, laying her eggs in the same location both years. Other individual turtles show a wide range of fidelity to nesting sites from year to year (unpub. data; Standing et al. 1999).

In 2006, seven of our nine turtles walked around the fence and left the sanctuary at least once before nesting, after exposure to at least two types of plot. These turtles were recovered and placed on experimental plots. All females did eventually nest in experimental plots and produced successful nests. However, our strategy of managing nesting areas near the turtles' wetlands to prevent long-distance nesting movements was not successful. This raises the question of why turtles would initially reject treated plots before accepting them. The turtles may have specific needs in terms of nesting microhabitat that were not provided at the site, so that they nested there only because they had to. In addition, because this site occurs along an ecological edge, the presence of people (including researchers), predators, and many depredated painted turtle nests may have discouraged turtles from using our plots until they were ready to lay and had no other option. Temple (1987) studied a total of 22 nests of three turtle species in a prairie at a Wisconsin site and found greater depredation of nests by mammals closer to edges, but he did not distinguish between the prairie-marsh edge and the prairie-forest edge.

Table 3. Costs for establishing treatment plots. Time estimates assume 3 h per weeded plot, 0.75 h per tilled plot (0.5 h tilling, 0.25 h moving equipment), and 0.33 h per mowed plot (0.25 h mowing, 0.08 h moving).

	Weeding	Tilling	Mowing
Tools	Shovel: $20 Gloves: $10	Rototiller rental: $50 Delivery: $50 Damage waiver: $4.50 Hard hat: $7 Safety goggles: $3 Ear plugs: $0.50	Mower rental: $75 Delivery $50 Damage waiver: $10.50 Hard hat: $7 Safety goggles: $3 Ear plugs: $0.50
Labor	24 h × $6.75/h = $162	6 h × 6.75/h = $40.50	3.33 h × $6.75/h = $22.48
TOTAL:	**$192.00**	**$155.50**	**$168.48**

Blanding's turtles, like many turtles, are known to nest during periods of rain or soon after. The moist soil is easier to dig in, and the rain is thought to cover the scent of the nest (Burke et al. 1994, Farrar 2003, Bowen and Janzen 2005). The turtles may have been waiting for rain to nest. It is also possible that female Blanding's turtles have to walk and dig test pits until their eggs are ready to be laid, and then there is a brief period of egg retention when nests must be dug before eggs are lost. The turtles may have been reducing the costs of locomotion back to the wetland by continuing nesting forays until they chose a nesting site, as has been observed in snapping turtles (*Chelydra serpentina*, De Solla and Fernie 2004), or the turtles may have been attempting to return to an old nesting area located outside the sanctuary. In either case, the fence, which was intended to protect turtles from potential threats, may be impeding their nesting forays.

Overall, tilling appears to be the best of the three management techniques in terms of both cost and preference by turtles. Turtles did leave the sanctuary in both years of our study in order to explore other nesting habitats. Keeping the turtles within the sanctuary requires a continuous investment of time and resources. Further experiments could explore ways of managing nesting microhabitat to better match turtle preference so as to reduce turtle movements out of the sanctuary, or alternative approaches to providing safe access to nest sites outside of the sanctuary. All nests in tilled plots in 2006 occurred near the edge of the plot, adjacent to vegetation, suggesting that the turtles may have preferred some cover, which could be created by partial tilling of plots, leaving bare ground interspersed with patches of weeds. In larger sanctuaries, more widely spaced plots might allow turtles to encounter a nesting plot under suitably wet conditions or after they have wandered for a longer time. If these or similar efforts do not elucidate the problem of nest site rejection, costs of restoration and management of artificial habitat for turtles should include costs of ongoing monitoring and protection of turtles, particularly during nesting season.

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