HABITAT USE AND MOVEMENTS OF A BLANDING'S TURTLE POPULATION IN CENTRAL WISCONSIN

by

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Preface. This thesis consists of 1 technical paper and appendices containing information obtained from a Blanding's turtle (Emydoidea blandingi) population in the Petenwell Wildlife Area, Adams County, Wisconsin during 1982 to 1984. This paper, "Habitat Use and and Movements of a Blanding's Turtle (Emydoidea blandingi) Population in Central Wisconsin", was prepared for the Journal of Herpetology.

I thank my advisor, Dr. Raymond K. Anderson for his interest, support and patience throughout the study and writing of this thesis. I thank my other commitee members, Drs. James W. Hardin and R. David Hillier, for their review of this thesis.

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Gratitude is expressed towards fellow graduate students for fruitful discussions, topical criticisms and the interesting comraderie we experienced. Welcomed moral support was provided by Ellen Barth, Dale Gawlik, Dennis Kent, Karin Kozie, Michael Johnson, Scott Johnson, Dave Mauser, Bob Murphy, Joan Wagner and Faye Weekley.

The desire of my parents, R. Burns and Jane M. Ross, to see me further my education is appreciated as is their partial financial support. I thank my father for introducing me to herpetology at an early age with trips to the Appalachians and numerous natural history texts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

RH: HABITAT USE AND MOVEMENTS OF A BLANDING'S TURTLE (*Emydoidea blandingi*) POPULATION IN CENTRAL WISCONSIN

Key words: Blanding's Turtle Habitat Use and Movements

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ABSTRACT

Eight radio-tagged Blanding's turtles, monitored from June 1983 to January 1984 showed high use of a cattail marsh (101 turtle-days) and a sparsely vegetated pond (88 turtle-days). Most inhabited wetlands were less than 60 cm deep and had summer water temperatures below 28.5 ^{o}C. Five of 8 turtles used different and disjunct habitats between June to September, then moved to 2 adjacent deep ponds for overwintering. Five overwintering sites contained either standing or flowing water, silt bottoms and water depths greater than 0.5 m. Size of activity centers of 2 males (0.57 and 0.94 ha) was not significantly different from that of 6 females (x=0.56 ha). Total range lengths of 2 males (260 m and 635 m) were not significantly different from that of 6 females (489 m). Fourteen of 16 nests (87.4%) nests were in grasslands. Mean nest distance from water and activity centers were 168 m and 620 m, respectively. Striped skunks (<u>Mephitis mephitis</u>) destroyed at least 9 of 16 nests. At least 4 nests were destroyed by predators within 24 hours of completion; all nests were eventually destroyed by predators.

HABITAT USE AND MOVEMENTS OF A

BLANDING'S TURTLE (*Emydoidea blandingi*)

POPULATION IN CENTRAL WISCONSIN

Life history data on Blanding's turtle are scarce (McCoy 1973, Graham and Doyle 1977), possibly due to inadequate sample sizes (Gibbons 1968, Graham and Doyle 1977). Past studies of habitat preferences of aquatic turtles have been based on chance discoveries and qualitative field observations (Bury 1979:591). In a review of habitat selection in reptiles by Heatwole (1977), only 2 studies concerning aquatic turtles [viz, painted turtles (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*)] are listed.

Nesting ecology of Blanding's turtles has been studied in Michigan by Congdon et al. (1983). Snyder (1921), Brown (1927), Bleakney (1963) and Graham and Doyle (1979) provide anecdotal nesting accounts.

Wetland drainage is believed to have destroyed many Blanding's turtle populations (Smith 1961, Minton 1971, Christiansen 1981). Eighty-nine percent of North American vertebrates (excluding fish) are nongame animals and thus have been ignored by wildlife managers in the past (Bury et al. 1980). Identification of critical habitat is essential for the preservation of these nongame animals.

Blanding's turtle is listed as threatened in Iowa, Minnesota, New York, Ohio, South Dakota and Wisconsin. Missouri and Pennsylvania list this species as endangered (Moriarity In press).

The objectives of this study were to determine habitat use, nesting success and movements of a Blanding's turtle population in central Wisconsin.

Study Area. Data were collected from June 1983 to January 1984 on the Petenwell Wildlife Area (PWA), a 291 ha protected wildlife area in Adams County, Wisconsin (T18N, R4E, Sec. 1,4) that is managed by the Wisconsin River Power Company (WRPCo). The PWA is located on the southern edge of an ecologic tension zone (Curtis 1959), an area (about 16 to 48 km wide) of transition between northern and southern vegetation in Wisconsin.

The study area is a complex of wetlands including speckled alder (*Alnus rugosa*) swamps, marshes, small <0.2 ha) ponds and woods (Fig. 1). Marsh-1 and -2 are dominated by bulrush (*Scirpus validus*) and cattail (*Typha angustifolia* x *T. latifolia*), respectively. Stream habitats are bordered by alder and cattail. Elodea (*Anacharis canadensis*) dominated Upper and Lower Ditches. Pond-7 is sparsely covered with algae. Ponds-8 and -9 support dense growths of spiny naiad (*Najas flexilis*) and coontail (*Ceratophyllum demersum*), respectively. The dominant floating plants occurring in

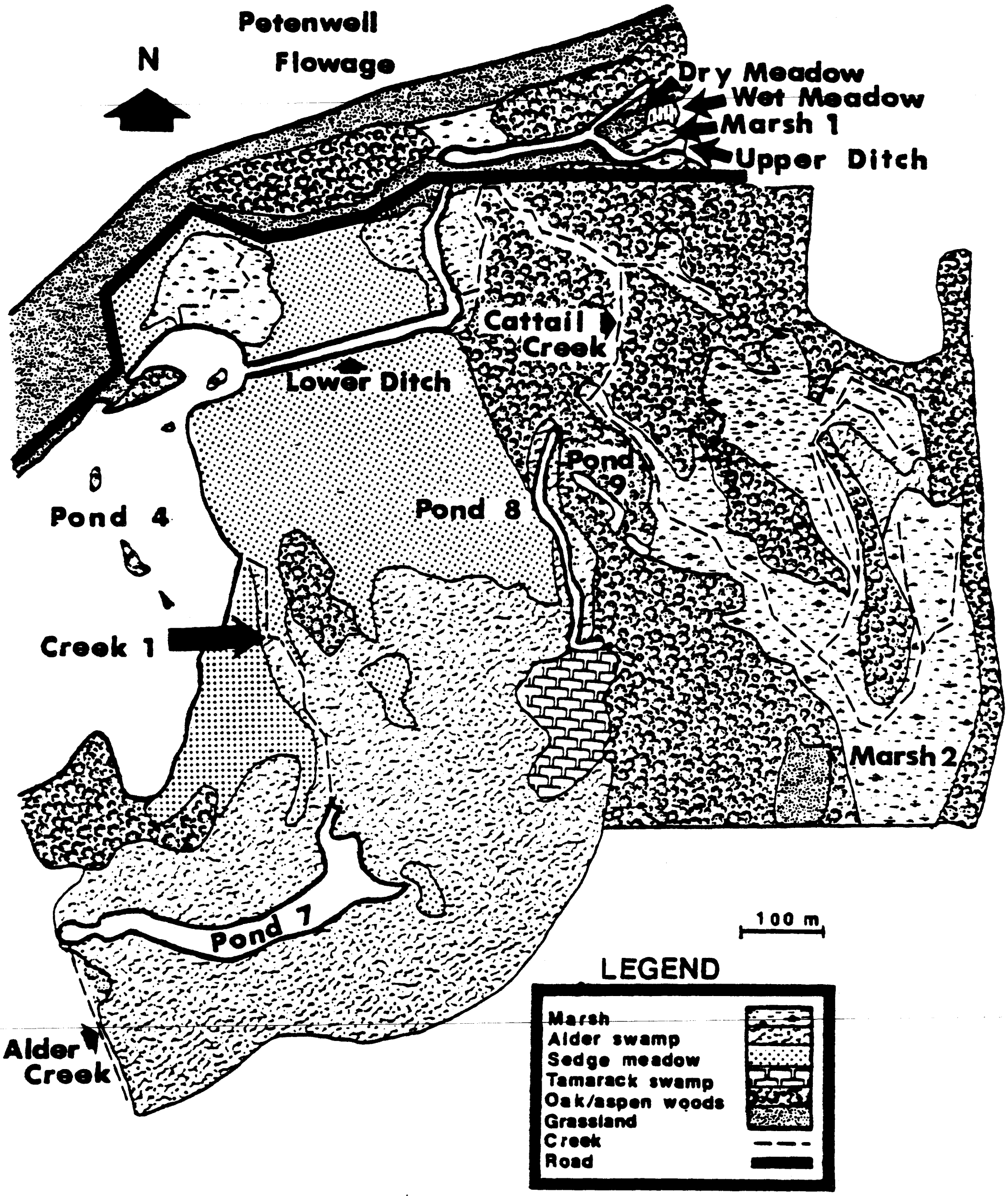

Figure 1. Major habitat types of the Petenwell Wildlife Area study site.

all aquatic habitats are duckweeds (*Lemna minor* and *Spirodela polyrhiza*). Dry meadow consists mostly of sedge (*Cyperus* sp.) and bluegrass (*Poa pratensis*). Wet Meadow dominants are goldenrod (*Solidago canadensis*) and sedge. Plowed fields and grasslands covered by bluegrass and quackgrass (*Agropyron repens*) are adjacent to the wetlands.

METHODS. Individual turtles were captured by hand and with hoop nets (Lagler 1943). AVM (Dublin, CA) SM 1 transmitters, potted in dental acrylic and covered with Plasti-Dip (Jansen 1982), were mounted with brass bolts (#8/32) to anterior marginal scutes of 8 turtles (2 males, 6 females). The packages weighed < 30 g (2.8% of $\bar{x}$ body weight of 1059 g). Radioed turtles were monitored with an AVM Model LA 12 receiver and a hand-held "H" antenna (Telonics Inc., Mesa, AZ). The turtles were located 4-10 times per week ($\bar{x}$=5) until hibernation and monthly from November 1983 to January 1984. Locations were plotted from bearings obtained with a Brunton (Riverton, WY) hand transit through triangulation of 2 or more locations.

Activity centers (Hayne 1949:6; cf. Carpenter 1952, Mahmoud 1969, Reinert and Kodrich 1982) were determined by the minimum polygon method (Mohr 1947), "occasional sallies outside the area" (Burt 1943) were excluded. A minimum of 5 radiolocations within a habitat or adjoining habitats for a minimum of 5 contiguous days constituted an activity center. The resulting area was measured with a compensating polar planimeter. Range lengths were measured as the 2 most distant locations within the activity center (Reinert and Kodrich 1982). Total range lengths were calculated as the distance between the 2 most distant locations among all the activity centers of an individual turtle, thus quantifying the distance moved among these activity centers.

Air, water and cloacal temperatures were obtained with a telethermometer (Yellow Springs Instrument Co., Inc., Yellow Springs, OH). Temperature data were collected at first capture of an individual turtle, subsequent data (except cloacal temperatures) were obtained when information on radiolocations was collected. Daily maximum and minimum air temperatures were obtained from the Necedah Weather Station, about 5 km southwest of the PWA.

Vegetation of each habitat was sampled using a quadrat method (Daubenmire 1959). Random plots were located from a random numbers table. A starting point within each habitat was located randomly and quadrats were placed randomly along a transect from that point. Aquatic vegetation in Pond-9 was sampled with an Eckmann dredge. Terrestrial vegetation densities were determined using a visual obstruction method (Robel et al. 1973). Botanical nomenclature follows Gleason and Cronquist (1963). A compensating polar planimeter was used to determine the area of each habitat type from aerial photographs. Mean water depths were measured with a calibrated rod.

The term "overwintering site" is used herein interchangeably with "hibernacula" (cf. Cloudsley-Thompson 1971, Hutchison 1979, Gregory 1982). Entry into hibernacula was estimated using methods described by O'Pezio et al. (1983); i.e. entry into hibernation for an individual was defined as "the midpoint between the last recorded movement in autumn and the first of a series of stationary signals" indicating it had entered hibernation. Water temperatures at the time of entry into hibernation were interpolated in a similar manner.

Water quality parameters were analyzed by the Research and Development Division of Consolidated Papers, Inc. Methods of analysis followed Am. Public Health Assoc. (1980), except for apparent color which was determined with a Hach color meter. Apparent color was quantified on an increasing scale of 0 to 500 with deionized, distilled water standardized as 0. Water samples were collected monthly from 11 July to 4 December 1983.

Known nesting areas were traversed from 1600 h until 0.5 h after sunset in 1983 during the nesting season to locate nesting females. Nests in 1982 and 1983 that were destroyed by predators were also located. When a nesting female was found, the location was noted and we left the area as inconspicuously as possible to lessen the disturbance. The nesting season was defined as being the first and last day a gravid female was observed on or near the nesting grounds. Females were considered gravid if eggs were felt in the inquinal region or if the posterior half of the plastron would not close fully against the carapace. Nests were checked daily for predation; predators were identified by tracks and other field sign. Distances from nests to nearest water were determined by pacing. Distances to the nearest vegetation 0.5 to 4.5 m in height (shrub) and vegetation greater than 4.5 m in height (tree) were determined with a measuring tape. A 0.5 m square frame was centered on the nest site to visually estimate coverage and frequency of occurrence of vegetation (Daubenmire 1959). Turtles were measured to the nearest 1.0 mm with outside calipers for plastron length (PL), and weighed to the nearest 25 g after marking. Turtles were classified as males if the plastron was noticeably concave and females if the cloacal opening was anterior to the rear carapacial margin (Graham and Doyle 1977). Turtles were marked using a carapace notch technique (Cagle 1939).

RESULTS AND DISCUSSION.

Habitat use. Blanding's turtles used a variety of habitats (Table 1) but mostly shallow marshes, ponds, and ditches (Fig. 2). Habitats receiving the highest use

Table 1. Habitat use by 8 radio-tagged Blanding's turtles, June to October 1983, expressed as the number of turtle-days in each habitat type.

Habitat	Available Habitat (%)	Number of turtle-days
<u>AQUATIC</u>		
Marsh-2	54.0	101
Pond-7	19.3	88
Pond-9	1.1	85
Pond-8	18.1	66
Creek-1	2.2	23
Marsh-1	0.2	18
Upper Ditch	0.2	11
Lower Ditch	2.7	8
<u>TERRESTRIAL</u>		
Wet Meadow	0.4	18
Dry Meadow	1.8	1
Total	100.0	

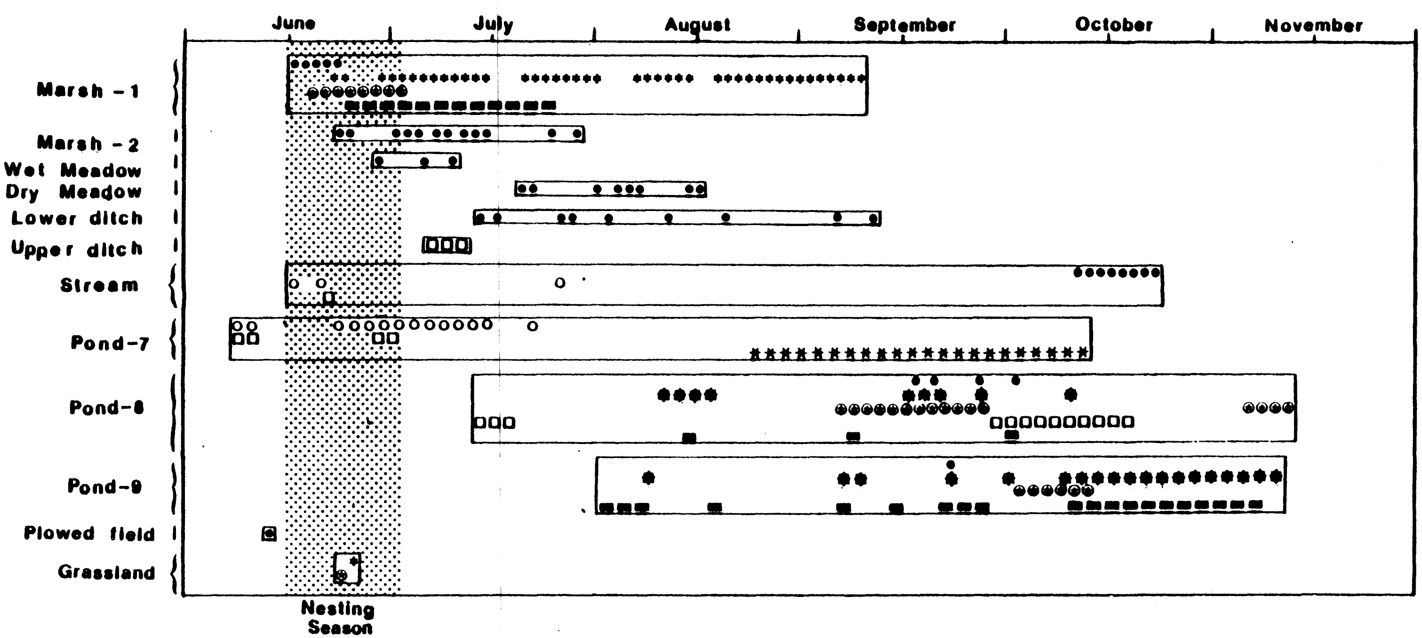

Fig. 2. Habitat use of 8 radio-tagged Blanding's turtles from June to November 1983 on the Petenwell Wildlife Area. Each symbol represents an individual turtle; gaps between symbols indicate times when individuals were not located.

were Marsh-2 (101 turtle-days) and Pond-7 (88 turtle-days). Turtles used habitats generally in proportion to that available (Table 1). Marsh-2 had the greatest use and comprised 54% of the total available habitat. High use of Marsh-2 may be due to 4 females that nested in adjacent fields and traveled through Marsh-2 to return to other wetlands (Fig. 1). Marsh-1 was dominated by dense stands of cattail and forget-me-not (*Impatiens capensis*). Pond-7 had sparse growths of algae and pondweed (*Potamogeton pectinatus*). All other habitats except Pond-4 had substantial growths of either submergent or emergent vegetation. Emergent vegetation included sedges, rushes (*Eleocharis* spp.), bulrush and cattail. Submergent vegetation included coontail, elodea and pondweed. There was no apparent relationship between dominant plant species and habitat use. All wetlands, except Pond-4 and -9, had silt substrates; Pond-4 had a sand substrate and Pond-9 had gravel substrate. Marshes covered by cattail mat were not used but those cattail areas cleared by muskrats (*Ondatra zibeticus*) were used.

Three ponds (Ponds-7, -8 and -9) were occupied during late summer to fall (Fig. 2); 2 of these ponds (Ponds -8 and -9) are relatively deep (Table 2). Selection of deep ponds may be due to a search for food, retreat from high ambient temperatures, or an exploration of overwintering sites. The highest water temperature observed in Ponds -8 and -9 was 26.5 ^{o}C (Pond-8). Water depths of Ponds-8

Table 2. Depths and temperatures of aquatic habitats used by Blanding's turtles June to September 1983 on the Petenwell Wildlife Area.

Habitat	Water Depth (cm)	Water Temperature Range (^{o}C)
Marsh-2	$\bar{x}$=23 Range 6-30	11-25
Marsh-1	$\bar{x}$=12 Range 7-30	12-22
Pond-7	$\bar{x}$=15 Range 0-60	9.5-28.5
Pond-8	$\bar{x}$=70 Range 40-150	12-26.5
Pond-9	$\bar{x}$=110 Range 40-210	12-23
Upper Ditch	$\bar{x}$=30 Range 20-40	12-22
Lower Ditch	$\bar{x}$=40 Range 30-60	15.5-16

and -9 were greater than that of activity centers in surrounding wetlands ($P<0.01$, $t=4.96$, $df=5.0$).

Most wetlands used by Blanding's turtles were < 40 cm in depth. Two ponds (Ponds-8 and -9) with mean water depths of 70 cm and 110 cm, respectively were mostly used in late summer. Use of shallow water may provide more abundant food, access to basking sites, and higher water temperatures. Abundant basking sites, and higher water temperatures would enhance the productivity of the population by allowing the rate of egg development to increase and enable early access to food resources. Water temperatures were similar in most habitats (Table 2) and did not approach the critical thermal maximum for Blanding's turtle of 39.5 ^{o}C identified by Hutchison et al. (1966). The highest water temperatures (up to 28.5 ^{o}C) were present in shallow Pond-7. Three turtles that were marked in Pond-7, were recaptured in Creek-1 during hot, sunny weather in July and August 1983. These turtles may have moved to the shaded creek to escape the higher water temperatures in the pond. Blanding's turtles burrowed into the substrate of Pond-7 during July and August, perhaps to avoid heat stress or to seek subterranean food as do mud turtles (<u>Kinosternon subrubrum</u>)(Moll 1979).

Terrestrial habitat use totalled 19 turtle-days, relatively little compared to that of aquatic habitat. An adult female aestivated in the Wet Meadow for 0.5 to

5 consecutive days on several occasions between 29 June to 7 September. The Wet Meadow is dominated by goldenrod and sedges. This area had greater sampled vegetation densities ($\bar{x}$=2.48, range 1.5-4.0, SD=0.72; N=20). than the adjacent Dry Meadow ($\bar{x}$=1.09, range 0.0-3.0, SD=0.75; N=20)(P<0.01, t=38.33, df=42). Dry Meadow is dominated by sedge, bluegrass and wild rye (Elymus canadensis). In a study of terrestrial box turtles (Terrepene carolina), moisture was found to be the most critical factor in determining habitat use; temperature and vegetative cover were also important (Reagan 1974). We have no evidence that vegetative density was the determining factor in use of terrestrial habitats except perhaps for aestivation. Vegetation density differed significantly among other habitats (P<0.01, t=55.59, df=150) that were used. These habitats were more and less dense vegetatively than the 2 meadow habitats. It seems likely that the turtles occupied these habitats only when moving from 1 site to another.

Four of 8 turtles traversed oak woods and 5 turtles moved through alder swamps when shifting activity centers; 2 turtles moved through meadows when shifting aquatic habitats. Two turtles remained in 1 activity center for 41 and 42 days, a marsh and a pond, respectively. At least 3 turtles used streams to move between activity centers.

These data suggest that Blanding's turtles in central Wisconsin preferred aquatic habitats of < 60 cm in depth, water temperatures < 28.5 °C, and selected deep (up to 2.1 m) ponds with aquatic vegetation for overwintering. Aquatic vegetation provides cover for both turtles and their prey. Terrestrial areas were used as transient habitat. There was no evidence of a relationship between terrestrial vegetation species composition, density, and habitat use.

Water quality. Wetlands with high turtle use (Marsh-2, Pond-7; Table 1) had lower biochemical oxygen demands (BOD's) than those wetlands with little use (Upper Ditch, Pond-4)(Table 3). High BOD's may limit prey densities and thus influence the turtle's habitat selection. pH ($\bar{x}$=6.9) was similar among all wetlands examined (Table 3). Wetlands with more apparent color had less use than those areas with less apparent color. Kofron and Schreiber (1985) subjectively reported that Blanding's turtles in Missouri required "clean, clear" water. Kjeldahl nitrogen and total phosphorus were highest in Pond-4 which received little use; however Marsh-2 and Pond-7, which received high use, also had high concentrations of both parameters (Table 3).

Overwintering sites. Blanding's turtles first entered overwintering sites on 20 September 1983; the last radiotagged turtle entered its overwintering site on 22 October 1983 (Table 4). Blanding's turtles were active

Table 3. Ranges of water quality parameters of 4 wetlands in the Petenwell Wildlife Area, 1983.

Location	BOD (ppm)	pH	Color (Arbitrary Units)	TKN (ppm)	TP (ppm)
Marsh-2	1.3-2.4	6.1-7.3	20-120	0.2-3.3	0.038-0.125
Pond-7	1.3-3.4	6.4-8.2	13-85	1.0-1.8	0.075-0.163
Upper Ditch	1.1-3.5	6.4-7.2	150-310	1.0-4.2	0.470-0.157
Pond-4	2.2-7.7	6.4-7.1	110-550	2.0-6.4	0.120-1.313

Table 4. Characteristics of Blanding's turtle overwintering sites on the Petenwell Wildlife Area, 1983.

	Overwintering Site				
	Cattail Creek	Pond 9	Pond 8	Pond 7	Alder Creek
Turtle No.[a]	F1	M2, F2	F4, F6	M1	
Date entered	19 Oct.	M2- 20 Sept. F2- 7 Oct.	F4-22 Oct. F6-7 Oct.	7 Oct.	After 1 Oct.
Within summer activity center?	No	Yes	Yes	Yes	Yes
Habitat type	Creek	Excavated pond	Excavated pond	Pond	Creek
Specific site	Muskrat burrow	Deepest part			Pool[b]
Water depth (m)	0.5	1.8	0.9, 0.6	0.6	0.8[c]
Total No. of turtles observed[d]	1	3	10	1	2

[a] Fx indicates female, Mx indicates male.

[b] Overwintering location probable, but unconfirmed.

[c] Maximum depth.

[d] Minimum number observed in overwintering areas, 18 September to 5 October.

until 4 November in Indiana (Evermann and Clark 1916) and possibly all year in Ohio (Ernst and Barbour 1972). Ponds and creeks, both previously reported as hibernacula for Blanding's turtle (Cahn 1937), were also used as overwintering sites in this study (Table 4). All sites on the PWA had silt bottoms and standing or flowing water. One torpid female used a muskrat burrow in a creek for overwintering. Cahn (1937) also reported winter use of muskrat burrows by Blanding's turtles. These burrows may provide protection agaist freezing since they commonly extend beneath the frostline. We did not observe winter activity during this study. Conant (1938) and Kofron and Schreiber (1985) reported Blanding's turtles being active during the winter months.

Water depth of overwintering sites ($\bar{x}$=0.87 m, range 0.5-1.8 m, SD=0.517) was not different from that of summer activity centers ($\bar{x}$=0.46 m, range 0.1-1.3 m, SD=0.420)($P>0.05$, $t=1.71$, df=10) even though deeper water should provide more protection against low winter temperatures. Two overwintering sites in creeks were ice-free on 25 January 1984 and had flowing water (Table 4).

Evidence for aggregate overwintering was provided when at least 2 of 4 turtles were found within 10 m of one another in Pond-9 for up to 31 days from 6 September to 5 November (Fig. 3). This may be due to a scarcity of

Figure 3(A-H). Activity centers, nest, aestivation and overwintering sites of 8 radiotagged Blanding's turtles on the Petenwell Wildlife Area, 1983. Fx indicates female, Mx indicates male.

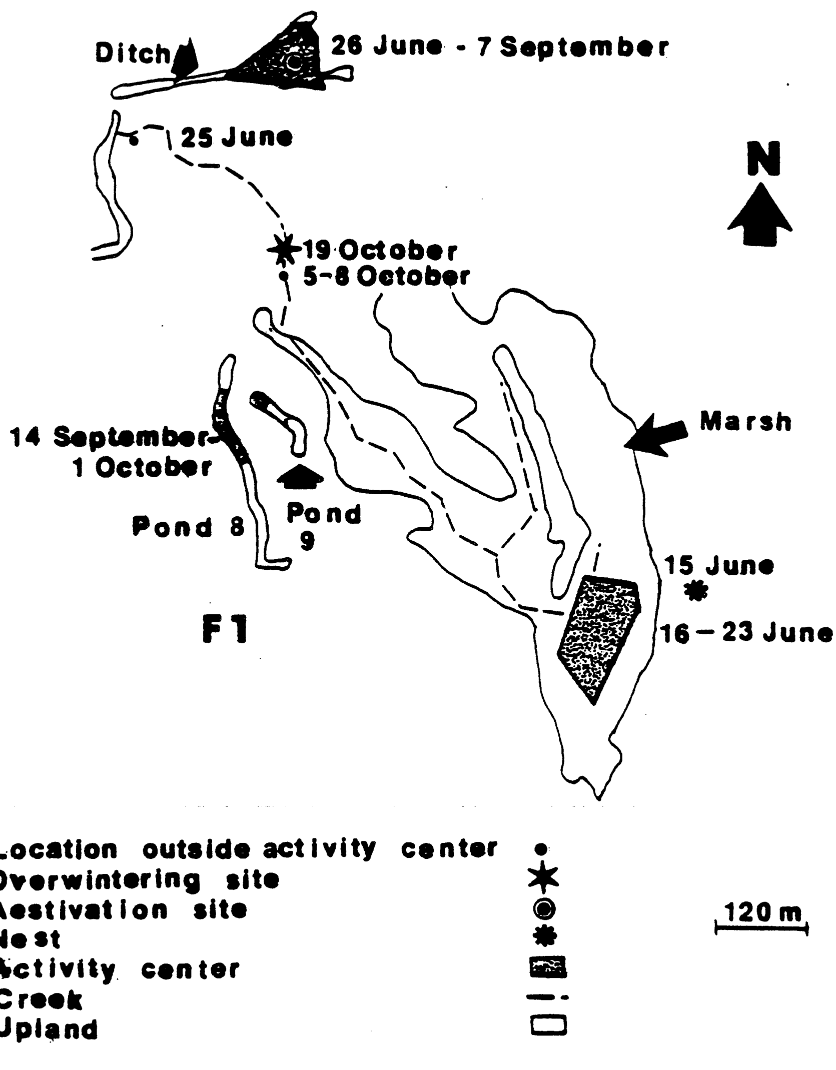

Fig. 3A. Female-1 (F-1).

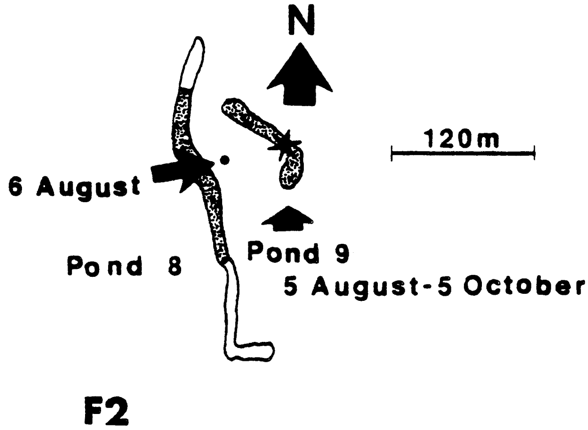

Fig. 3B. Female-2 (F-2).

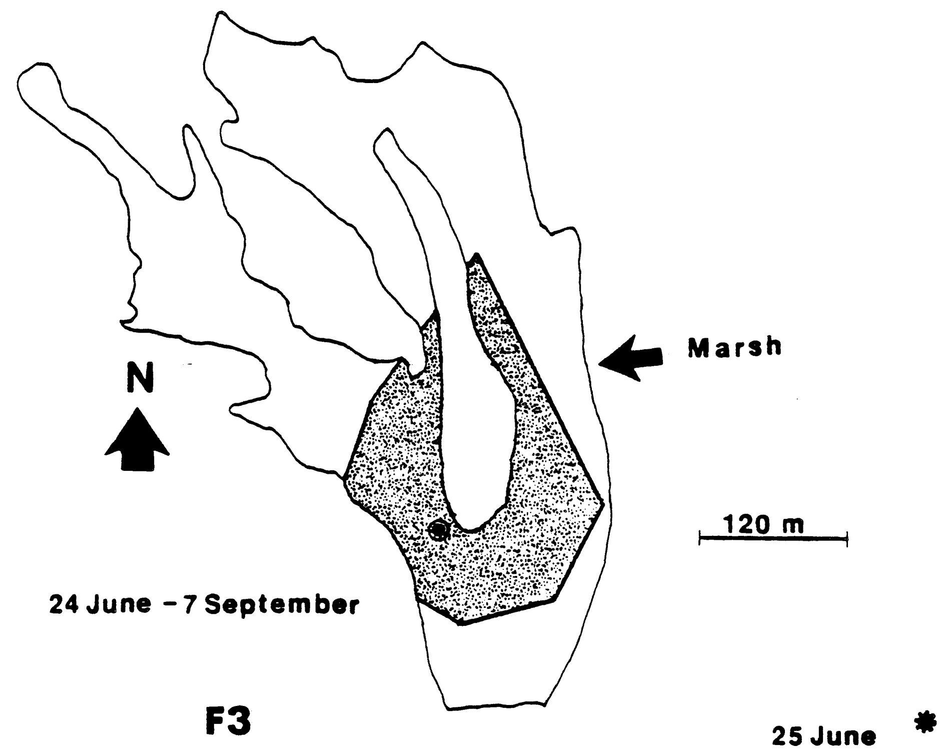

Fig. 3C. Female-3 (F3).

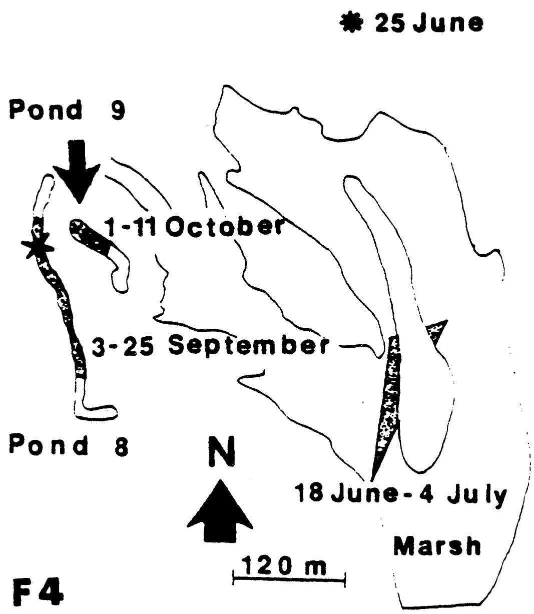

Fig. 3D. Female-4 (F4).

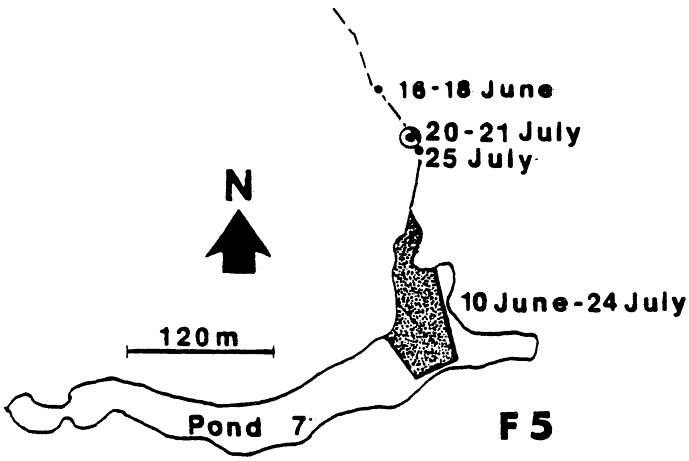

Fig. 3E. Female-5 (F5).

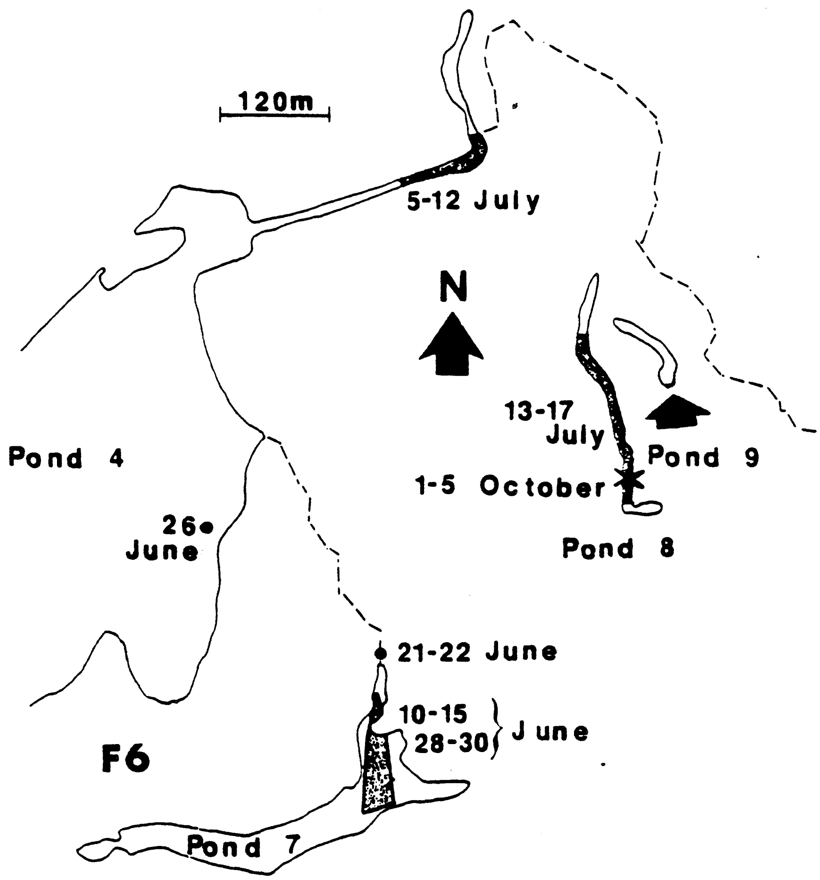

Fig. 3F. Female-6 (F6).

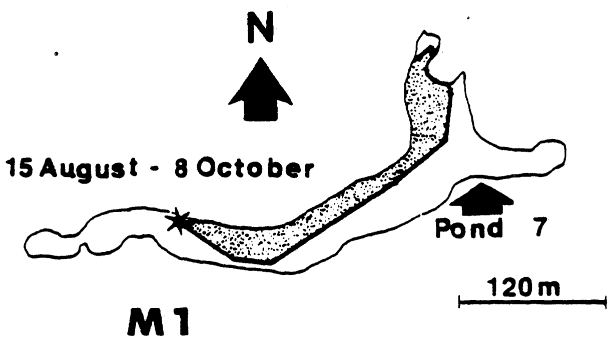

Fig. 3G. Male-1 (M1).

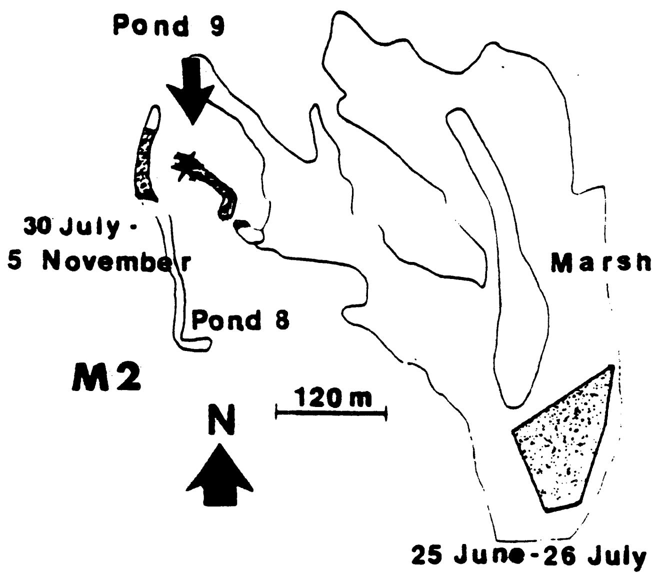

Fig. 3H. Male-2 (M2).

suitable hibernacula (Gregory 1982:132). containing stable water depths > 0.5 m. Winter aggregation may facilitate mate-finding which could increase mating success. We believe that stable water depths are an important criterion for selection of overwintering sites.

Five of 6 individuals in this study overwintered within their summer habitats (Table 4). However, most (4 of 6) Blanding's turtles moved from marshes, shallow ponds, and ditches and selected deep ponds. A population of Blanding's turtles in Michigan (Congdon et al. 1983) evidently overwintered within marshes they inhabited during the summer (J. Congdon pers. commun.). Aquatic turtles, as well as other reptiles, may use the area immediately surrounding the hibernacula prior to entry into the overwintering site (Gregory 1982). The presence of 10 Blanding's turtles in Pond-8, and 3 in Pond-9 indicates a preference for deep water for overwintering. These ponds probably provide cooler water temperatures in late summer and stable water levels during the critical overwintering period.

Water temperatures between 10 and 13° C may have stimulated winter torpidity. Three individuals overwintered in Pond-9 where water temperatures at the onset of hibernation were 13° C, 13° C and 12.5° C, respectively; 4 turtles hibernated in 3 separate habitats where water temperatures at the onset of hibernation were between 10 and 12°C. Gregory (1982) states that a difficulty in determining stimuli for hibernation in reptiles is that ambient temperature may be correlated with other external cues (i.e., photoperiod, food supply or rainfall) that may induce hibernation. The last overland movement occurred when F4 moved from Pond-9 to Pond-8 between 11 and 22 October 1983; the highest daily maximum and lowest minimum air temperatures during this period were 14°C and -5°C on 12 and 13 October, respectively.

<u>Aestivation sites.</u> Three individuals aestivated (F1, F3, and F5); 1 in terrestrial and 2 in wetland habitats. Aestivation time ranged from 0.5 to 5 days during 21 July to 28 August 1983. F1 aestivated terrestrially 15 times for a mean duration of 2.2 days (Range 0.5 to 5 days). She partially buried herself beneath leaf litter, goldenrod and sensitive fern (<u>Onoclea sensibilis</u>) cover in the Wet Meadow. When she was not aestivating, she was in Upper Ditch; water temperatures there ranged from 12°C to 15.5°C during late July and August. The ambient temperatures during aestivation ranged from 18°C to 33°C. F3 buried herself to a depth of 0.3 m beneath a sedge clump in cattail matting and was found in the same location 13, 14 and 19 August. F5 aestivated, partly buried, in silt substrate of Creek-1 beneath overhanging alders on 21 July 1983. Daily maximum air temperatures during these aestivation periods ranged from 27 to 37.5°

C ($\bar{x}$=31.0 °C). Water temperatures within wetlands used by aquatic-aestivating individuals ranged from 18 to 28.5 °C.

Water temperatures of ponds nearest to, and frequently used by terrestrially-aestivating individuals were low (Range 12-18 °C). Cool water temperatures may slow physiological processes, e.g., digestion. Terrestrial aestivation would allow body temperatures to rise, thereby increasing the rate of such physiological processes. Higher body temperatures of terrestrially-aestivating turtles may be selectively advantageous over turtles in cooler environments. Basking individuals would be at a disadvantage because of exposure to predators as well as high summer temperatures. Daily maximum air temperatures during aestivation approached the critical thermal maximum this species, and may be the stimulus for aestivation.

MOVEMENTS.

Activity centers. There was no significant difference between the size of activity centers of 2 males (0.57 and 0.94 ha) and that of 6 females ($\bar{x}$=0.56 ha, range 0.12-0.94 ha). Size differences among activity centers may reflect variability in habitat as shown in previous studies (Bury 1979:595) or the proximity to feeding areas (Cagle 1941). Habitat variability or food-searching may be why several individuals moved to deep ponds in late summer. Six females had a mean of 2.3 activity centers (Range 1-4, Fig. 3A-F). Multiple activity centers suggest a search for suitable habitat to fulfill changing seasonal requirements (e.g., temperature or food). Seven non-radiotagged Blanding's turtles were marked and recaptured within 100 m of their original capture site in Pond-7; recapture dates ranged from 3 days to 2 months during 18 June to 28 August.

Movements between activity centers. Blanding's turtles made relatively long movements between activity centers; total range lengths (between activity centers) of 2 males (260 and 635 m) did not differ significantly from that of 6 females ($\bar{x}$=489 m, range 145-990 m), Range lengths, within activity centers, of 2 males (15 and 635 m) were not significantly different from that of 6 females ($\bar{x}$=213 m, range 25-425 m). These relatively long movements between activity centers are in contrast to Gibbons (1968) observation of "no indication of extensive travel" in the population he studied. Gibbons' observations were based on the recapture of 4 individuals from relatively large (>6 ha) continuous habitats which probably provided most life requisites for Blanding's turtles.

Distances between activity centers of 2 males ($\bar{x}$=213 m, N=6) was not significantly different from that of 6 females ($\bar{x}$=159 m, N=16). Activity centers of turtles often overlapped during the same period (Fig. 3).

Territoriality in freshwater turtles has not been documented (Bury 1979:598). One juvenile (F5) had 1 activity center whereas juvenile F6 had 3 activity centers. Movement between activity centers was first observed on 15 June when F6 moved from a shallow pond via Creek-1 to a deep pond (Fig. 3F.). F1 traveled 900 m via Cattail Creek on 23 June, arriving at the north end of the Cattail Creek on 25 June; by 26 June she had traveled 110 m to Marsh-1. This is relatively rapid travel by an animal commonly considered to be relatively sedentary. Movements of 4 females (Figs. 3A, 3C, 3D and 3H) from Marsh-2 to adjacent wetlands represents post-nesting movements as these females were radio-tagged while leaving nesting areas. Three of the 4 females nested (Fig. 3) and a fourth was not gravid when radio-tagged.

Blanding's turtles in this study had well-defined activity centers which were separated by relatively long distances and often changed over time. These shifts were probably attempts to locate mates or suitable habitat, incuding overwintering sites.

<u>Nesting Ecology.</u> Sixteen Blanding's turtle nests were located during 1982 and 1983 (Table 5). Twelve (75%) of the nests had been destroyed by predators when first located. The nesting season lasted from 12 June until 1 July in 1982 and from 14 June until 2 July in 1983,

Table 5. Nest sites of Blanding's turtles on the Petenwell Wildlife Area, 1982-1983.

	Plowed Ground	Grassland	Dirt Road	Total
N	1	14	1	16
%	6.3	87.4	6	100.0

similar to those reported for lower Michigan by Congdon et al. (1983). Females were most commonly seen on nesting grounds in the evening ($\bar{x}$=1741 h, range 1030-2045). Gravid females appeared on nesting grounds earlier in the day, during or immediately after a rainfall.

Nests were relatively long distances from the nearest water ($\bar{x}$=168 m, range 33-420 m) and established activity centers ($\bar{x}$=0.62 km, range 0.31-0.83 km, N=3). Desirable nest site characteristics may include high soil moisture, little predator use or proximity to dispersal routes for hatchlings (e.g., ditches and streams). In Michigan, Blanding's turtles are known to nest up to 2.4 km from their home marsh (J. Congdon, pers. commun.). Suitable nesting sites were present in closer proximity to water in this study and Congdon et al.'s (1983) study, but turtles bypassed these and chose more distant sites. A suitable nesting site is considered to be an open sunny field with sparse and widely scattered woody vegetation that is <6 m high. Females may be exhibiting nest site fidelity or they may have been imprinted on their natal site when they made extended movements to nest sites.

Blanding's turtle nests were located relatively long distances from shrub ($\bar{x}$=18.6 m, range 1-70 m) and tree vegetation ($\bar{x}$=36.4 m, range 6-70 m). Fourteen (87.4%) nests were in grasslands (Table 5). Nesting areas included plowed fields and grasslands dominated by bluegrass and quackgrass which were often adjacent to the wetlands (Fig. 3). Another species of turtle, e.g., diamondback terrapins (*Malaclemys terrapin*), distribute their nests with no apparent regard to vegetation (Burger and Montevecchi 1975).

Bare soil comprised 23.9% of the total percent cover of 9 Blanding's turtle nests on the PWA (Table 6). Sheep sorrel (*Rumex acetosella*), grasses and a sedge (*Carex pensylvanica*) comprised 56.5% of the total percent cover of the nests. All nest sites were in sandy soil. Blanding's turtles in Michigan nest in similar sitles (Congdon et al. 1983).

Nine of 16 (56%) PWA nests were destroyed by striped skunks (*Mephitis mephitis*); the remaining 7 nests were destroyed by unknown predators. Other potential predators occurring in the are include red fox (*Vulpes vulpes*), gray fox (*Urycyon cinereoargenteus*) and raccoon (*Procyon lotor*). Congdon et al. (1983) found raccoons to be the most common predator of Blanding's turtle nests in Michigan where only 22% of 73 nests were successful. All Blanding's turtle nests that we found were destroyed by predators. The 4 active PWA nests were subsequently destroyed by predators within 24 hours following nest completion. Congdon et al. (1983) found a range of 42 to 93% ($\bar{x}$=67%) nest predation over a 6-year period.

Table 6. Percent cover and frequency of occurrence of vegetation at 9 Blanding's turtle nests on the Petenwell Wildlife Area, 1983.

Species	Percent Cover	Percent Frequency of Occurrence
Rumex acetosella	11.9	88.0
Cenchrus longispinus	10.0	25.0
Panicum oligosanthes var. *scribnerianum*	8.6	50.0
Agropyron repens	7.8	50.0
Carex pensylvanica	6.8	38.0
Poa pratensis	6.7	13.0
Poa compressa	4.7	63.0
Lespedeza capitata	3.3	13.0
Moss	2.9	38.0
Phleum pratense	2.3	38.0
Achillea millefolium	2.2	25.0
Potentilla recta	1.8	50.0
Euphorbia corollata	1.3	38.0
Sporobolus cryptandrus	1.1	25.0
Panicum capillare	1.1	25.0
Plantago purshii	1.1	50.0
Unidentified grass	1.1	13.0
Dead plant material	1.0	13.0
Solanum sp.	0.6	13.0
Lichen	trace	trace
Rhus glabra	trace	trace
Bare soil	23.9	100.0

Blanding's turtles on the PWA preferred shallow water wetlands with standing water, usually with some aquatic vegetation and a silt substrate. These wetlands commonly had water depths and temperatures <40 cm and 25 ^{o}C, respectively. Wetlands with low BOD's and less apparent color were used more often than wetlands with high BOD's and more color, respectively. Open upland nesting areas were usually present within 200 m of permanent water. Hibernacula were deep (>0.5) wetlands with silt substrates; these factors may increase overwinter survival.

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Appendix A. Cover and frequency of occurrence of plants in wetland habitats used by Blanding's turtles.

Location	Species	Coverage	Frequency of Occurrence
Creek 1	*Hydrodictyon reticulatum*	0.44	0.53
	Elodea spp.	0.42	0.30
	Lemna minor	0.08	0.13
	Spirodela polyrhiza	0.03	0.10
	Eleocharis spp.	0.02	0.03
	Unidentified grass	0.01	0.10
	Potamogeton pectinatus	trace	0.07
Upper Ditch	*Elodea occidentalis*	0.75	0.95
	Hydrodictyon reticulatum	0.20	0.95
	Potamogeton crispus	0.05	0.45
	Ceratophyllum demersum	trace	0.10
Lower Ditch	*Elodea occidentalis*	0.74	0.24
	Potamogeton crispus	0.25	0.12
	P. zosteriformis	0.01	0.04
Pond 4	Algae: *Cladophora* sp., *Cymbella* sp., *Maugeotia* sp., *Vaucheria* sp.	<0.01	0.16
Pond 7	*Lemna minor*	0.27	1.00
	Algae: *Cladophora* sp., *Cymbella* sp., *Maugeotia* sp., *Synedia* sp., *Vaucheria* sp.	0.23	0.15
	Potamogeton pectinatus	0.19	0.50
	Spirodela trisulca	0.14	0.96
	Hydrodictyon reticulatum	0.08	0.69
	Unknown A	0.08	0.12
	Unknown B	0.01	0.23
	Ceratophyllum demersum	trace	0.04
Pond 8	*Najas flexilis*	0.69	1.00
	Ceratophyllum demersum	0.18	0.60
	Elodea nuttalli	0.10	0.44

	Hydrodictyon reticulatum	0.03	0.36
	Algae	trace	0.01
Pond 9	*Ceratophyllum demersum*	0.96	0.90
	Utricularia vulgaris	0.04	0.07
Marsh 1	*Lemna minor*	0.29	0.76
	Scirpus validus	0.14	0.48
	Carex spp.	0.11	0.40
	Myosotis scorpoides	0.10	0.68
	Equisetum arvense	0.07	0.64
	Glyceria grandis	0.06	0.28
	Epilobium spp.	0.06	0.44
	Impatiens capensis	0.04	0.44
	Rumex orbiculatus	0.03	0.32
	Cyperaceae	0.03	0.28
	Mentha sp.	0.03	0.24
	Galium asprellum	0.02	0.16
	Lycopus virginicus	0.01	0.08
	Hydrodictyon reticulatum	0.01	0.16
	Cicuta bulbifera	trace	0.08
Marsh 2 (Cattail Marsh)	*Lemna minor*	0.42	0.92
	Typha angustifolia x *T. latifolia*	0.39	0.76
	Impatiens capensis	0.05	0.60
	Galium asprellum	0.03	0.44
	Cyperaceae	0.03	0.48
	Cicuta bulbifera	0.02	0.52
	Scutellaria gallericulata	0.01	0.12
	Sagittaria latifolia	0.01	0.16
	Myosotis scorpoides	0.01	0.12
	Calamagrostis canadensis	0.01	0.08
	Lycopus spp.	0.01	0.04
	Hydrodictyon reticulatum	0.01	0.04
	Bidens frondosa	trace	0.16
	Polygonum persicaria	trace	0.12
	Rumex orbiculatus	trace	0.12
	Leptodictyon trichopodium	trace	0.04
	Scirpus validus	trace	0.04
	Mushroom	trace	trace

Appendix B. Cover and frequency of occurrence of plants in terrestrial habitats used by Blanding's turtles.

Habitat	Species	Coverage	Frequency of Occurrence
Wet Meadow	*Solidago canadensis*	0.34	0.97
	Cyperus sp.	0.13	0.93
	Achillea millefolium	0.08	0.80
	Thelypteris palustris	0.08	0.20
	Cyperaceae	0.06	0.50
	Potentilla simplex	0.05	0.50
	Equisetum arvense	0.04	0.33
	Onoclea sensibilis	0.03	0.43
	Hieracium aurantiacum	0.03	0.23
	Lactua canadensis	0.02	0.30
	Polytricum sp.	0.02	0.20
	Rosa sp.	0.02	0.20
	Monarda fistulosa	0.02	0.13
	Cirsium arvense	0.01	0.13
	Rumex acetosella	0.01	0.13
	Erigeron strigosus	0.01	0.13
	Gentiana andrewsii	0.01	0.10
	Poa pratensis	0.01	0.10
	Unknown A	0.01	0.10
	Rubus spp.	0.01	0.07
	Agropyron repens	0.01	0.03
	Populus tremuloides	trace	0.13
	Poa compressa	trace	0.07
	Lysimachia lanceolata	trace	0.07
	Viola spp.	trace	0.07
	Polygonum sagittatum	trace	0.07
	Oxalis stricta	trace	0.03
	Boehmeria cylindrica	trace	0.03
	Solidago gramifolia	trace	0.03
	Ambrosia artemisiifolia	trace	0.03
	Hypericum punctatum	trace	0.03
	Viola sagitta	trace	0.03
	Rudbeckia hirta	trace	0.03
	Euphorbia corollata	trace	0.03
	Acer rubrum	trace	0.03
	Alnus rugosa	trace	0.03
Dry Meadow	*Cyperus* sp.	0.29	0.88
	Poa pratensis	0.11	0.60
	Elymus canadensis	0.11	0.48
	Panicum oligosanthes var. *scribnerianum*	0.11	0.44
	Agropyron repens	0.10	0.24
	Poa compressa	0.06	0.16

	Achillea millefolium	0.05	0.32
	Equisetum arvense	0.03	0.52
	Unknown grass	0.03	0.28
	Rumex acetosella	0.02	0.32
	Agrostis stolonifera	0.02	0.08
	Solidago canadensis	0.01	0.12
	Unknown B	0.01	0.12
	Monarda fistulosa	0.01	0.08
	Andropogon gerardi	0.01	0.08
	Rosa sp.	0.01	0.08
	Echinochloa sp.	0.01	0.08
	Antennaria neglecta	0.01	0.04
	Festuca arundinaceae	trace	0.04
	Euphorbia corollata	trace	0.04
	Hieracium aurantiacum	trace	0.04
	Rubus spp.	trace	0.04
Alder swamp 1	*Urtica dioca*	0.76	1.00
	Elymus canadensis	0.09	0.47
	Polygonum arifolium	0.05	0.68
	Cyperus spp.	0.02	0.26
	Galium spp.	0.02	0.21
	Alnus rugosa	0.02	0.16
	Dryopteris sp.	0.01	0.16
	Calamagrostis canadensis	0.01	0.11
	Onoclea sensibilis	0.01	0.10
	Boehmeria cylindrica	0.01	0.10
	Rubus spp.	trace	trace
Alder swamp 2	*Calamagrostis canadensis*	0.45	0.81
	Cyperus spp.	0.34	0.63
	Pilea pumila	0.14	0.50
	Bidens spp.	0.05	0.01
	Dryopteris spp.	0.02	0.19
	Moss	trace	trace
	Onoclea sensibilis	trace	trace
	Impatiens biflora	trace	0.06
Alder swamp 3	Cyperaceae	0.39	0.71
	Calamagrostis canadensis	0.31	0.48
	Urtica dioca	0.13	0.29
	Osmunda cinnamomea	0.09	0.37
	Moss	0.03	0.14
	Impatiens biflora	0.03	0.14
	Dryopteris spp.	0.01	0.10
	Ilex verticillata	0.01	0.10

Appendix B. Continued.

	Fragaria spp.	trace	trace
	Onoclea sensibilis	trace	trace
	Viola spp.	trace	trace
	Oryzopis asperifolia	trace	trace
	Galium spp.	trace	trace
	Ranunculus sp.	trace	trace
Wood edge	*Danthonia spicata*	0.87	0.75
	Poa pratensis	0.13	0.20
	Fragaria sp.	trace	trace
	Quercus sp.	trace	trace
	Populus tremuloides	trace	trace
	Galium spp.	trace	trace
	Rubus sp.	trace	trace
	Prunus serotina	trace	trace
	Unknown	trace	trace
Hayfield edge	*Agropyron repens*	0.72	1.00
	Poa pratensis	0.25	0.60
	Zanthoxylum americanum	0.02	0.10
	Ribes sp.	0.01	0.10
	Ipomoea sp.	trace	0.10

Appendix C. Relationship of cloacal and environmental temperatures (°C) to activity in Blanding's turtle on the Petenwell Wildlife Area, 1982-1983.

					Environmental temperature					
		Cloacal temperature			Air			Water		
Activity	N	$\bar{x}$	($\pm$SD)	range	$\bar{x}$	($\pm$SD)	range	$\bar{x}$	($\pm$SD)	range
Moving in water	25	21.5	(5.84)	11-31	26.6	(5.23)	13-33	20.5	(5.82)	11-28
Moving on land	18				25.0	(4.06)	17-33			
Aestivation	15				25.8	(4.86)	17-33	16.0	(4.99)	11-28.5

Appendix D. A sample of the population structure of the Blanding's turtle population in the Petenwell Wildlife Area, 1982-1983, as determined from hand capture data.

Plastron length (mm)	Number of individuals	Number of males within sample
221-230	2	
211-220	2	
201-210	9	
191-200	10	2
181-190	9	3
171-180	8	3
161-170	3	1
151-160	4	1
141-150	1	
131-140	1	
Total	49	10

Appendix E. Shell dimensions and body weights of Blanding's turtles on the Petenwell Wildlife Area, 1982-1983.

Size class		PL [a] (mm)			CL [b] (mm)			SH [c] (mm)			SH/PL			Weight (gm)		
(PL) (mm)		$\bar{x}$	(±SD)	N	$\bar{x}$	(±SD)	N	$\bar{x}$	(±SD)	N	$\bar{x}$	(±SD)	N	$\bar{x}$	(±SD)	N
131-140	F [d]	137.0		1										475.0		1
	M															
141-150	F	148.0		1				50.0		1				575.0		1
	M															
151-160	F	155.5	(2.89)	4	165.0		1	59.5	(0.71)	2	0.388	(0.001)	2	612.5	(15.00)	4
	M															
161-170	F	167.5	(2.12)	2	175.0		1	69.0		1	0.416		1	760.0	(56.57)	2
	M	169.0		1	179.0		1							625.0		1
171-180	F	175.3	(1.50)	4	181.0		1	71.3	(2.52)	3	0.406	(0.013)	3	882.5	(122.85)	4
	M	173.3	(1.53)	3	187.0		1	63.5	(4.95)	2	0.368	(0.030)	2	881.7	(102.51)	3
181-190	F	184.2	(1.79)	5	194.0	(4.24)	2	75.7	(1.15)	3	0.411	(0.008)	3	1056.0	(113.27)	5
	M	185.0	(3.27)	4				71.0	(4.16)	4	0.384	(0.021)	4	1100.0	(115.47)	4
191-200	F	195.3	(3.35)	7	202.0	(1.41)	2	78.2	(2.57)	3	0.400	(0.011)	3	1049.3	(185.53)	7
	M	192.0	(0)	2				66.0	(1.41)	2	0.344	(0.007)	2	1200.0	(0)	2
201-210	F	204.9	(3.18)	9	212.0		1	81.4	(2.61)	5	0.401	(0.011)	5	1038.9	(525.32)	9
	M															
211-220	F	213.7	(3.06)	3	224.0		1							1433.3	(115.47)	3
	M															
221-230	F	227.0		1				97.0		1				2000.0		1
	M															

[a] PL=plastron length

[b] CL=carapace length

[c] SH=shell height

[d] F indicates female, M indicates male.

Appendix F. Vegetation density of terrestrial habitats used by Blanding's turtle.

Habitat[b]	Vegetation density[a] Mean	(±SD)	Range	No. of radio-locations	No. of density readings
Alder Swamp 1	5.82	(1.52)	3.5-10.0	1	20
Wet Meadow	2.48	(0.72)	1.5-4.0	18	20
Wood Edge	2.18	(0.78)	0.0-3.0	1	20
Dry Meadow	1.09	(0.75)	0.0-3.0	5	20
Alder Swamp 2	1.55	(1.22)	0.0-4.0	3	20

[a] After Robel et al. 1973.

[b] See Appendix B for composition of habitats.