*Chelonian Conservation and Biology*, 2000, 3(4):602–610


# Occurrence, Habitat Selection, and Movement Patterns of Juvenile Blanding's Turtles (*Emydoidea blandingii*) in Kejimkujik National Park, Nova Scotia

NATALIE L. MCMASTER[1,2] AND THOMAS B. HERMAN[1]

[1]*Centre for Wildlife and Conservation Biology, Acadia University, Wolfville, Nova Scotia, B0P 1X0 Canada;*
[2]*Present Address: Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9 Canada*
*[Fax: 403-492-9234; E-mail: nlm2@ualberta.ca]*

ABSTRACT. – **We examined occurrence, habitat selection, and movement patterns of juvenile (age 1–13 yrs) and subadult (age 17–18 yrs) Blanding's turtles in Kejimkujik National Park, Nova Scotia, Canada, by trapping and radio-tracking 22 juveniles and subadults in summer 1995. Juvenile and subadult density correlated positively with adult density and suitable habitat. Juveniles, subadults, and adults occupied similar macrohabitats; however, juvenile and subadult activity was concentrated in areas with moderately to highly dense *Sphagnum* overlain by sweet gale, leather leaf, and/or sedge. *Sphagnum* appears to be the primary indicator of juvenile and subadult Blanding's turtle habitat. Water depth at turtle location was independent of turtle age. Juveniles tended to be more visible than adults, and young juveniles (age 1–7 yrs) were more visible than old juveniles (age 11–13 yrs) and subadults. Total range, displacements between successive captures, and daily movements increased with age, and correlated positively with the amount of suitable habitat in an area. There was little consistent seasonal movement among juveniles and subadults in this population.**

KEY WORDS. – **Reptilia; Testudines; Emydidae; *Emydoidea blandingii*; turtle; juvenile; subadult; ecology; occurrence; habitat selection; movement patterns; Kejimkujik National Park; Nova Scotia; Canada**

Nova Scotia contains a small, genetically distinct population of Blanding's turtles (*Emydoidea blandingii*) (Mockford et al., 1999) isolated at the northeastern periphery of the species' range. In 1993, this population was designated "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) due to its small size (estimated population ca. 132 adults within Kejimkujik National Park), isolation from other breeding populations (>850 km), and apparently unstable age structure (Herman et al., 1995). Prior to designation by COSEWIC, juveniles and subadults (<25 yrs old) were nearly absent (<7 turtles) in population censuses. The RENEW (Recovery of Nationally Endangered Wildlife in Canada) Recovery Plan for this population emphasized the need to assess the distribution and abundance of sexually immature juvenile turtles (Herman et al., 1999). Juvenile turtles are usually distinguished from adult turtles based on size and/or age, since sexual maturity can be difficult to determine externally. Age at sexual maturity of Blanding's turtles in Nova Scotia is unknown, but in Michigan it ranges from 14 to 20 years and in Wisconsin it occurs at a minimum of 18 years (Ross, 1989; Congdon et al., 1993).

Studies of Blanding's turtles throughout their range note an apparent scarcity of juveniles (Graham and Doyle, 1977; Congdon et al., 1983; Petokas, 1986; Ross, 1989; Power, 1989). Explanations of this scarcity include: (1) juveniles occupy areas not searched by investigators (especially likely if different from those areas occupied by adults) (Congdon et al., 1983; Ross, 1989); (2) juveniles are more secretive than adults (Congdon et al., 1993); and (3) juveniles are truly scarce due to nest failure (Congdon et al., 1983). As a result, few data on juvenile Blanding's turtles exist from anywhere within the species' range. Pappas and Brecke (1992) published a paper solely on juveniles, focusing on the relationship between habitat selection and age. Juvenile growth and body size have been studied in Michigan and Massachusetts (Graham and Doyle, 1977; Congdon and van Loben Sels, 1991). Habitat selection and behavior of neonate Blanding's turtles were studied in Massachusetts (Butler and Graham, 1995) and Nova Scotia (Standing et al., 1997). In both studies, neonates had limited movement and the majority apparently overwintered in shallow waters or in damp groundcover.

The objectives of the present study were to examine occurrence, habitat selection, and movement patterns of juvenile and subadult Blanding's turtles in Kejimkujik National Park, Nova Scotia. Specifically we set out to: (1) search visually and trap in and around areas with known adult populations, nesting beaches, and/or presumed juvenile habitat; and (2) radio-track juveniles to examine movements in relation to season, habitat, and age. Preliminary trapping in August 1994 yielded 5 juveniles, ranging in age from 4 to 12 yrs, that were fitted with radio transmitters and followed into and out of overwintering sites (I. Morrison, *pers. comm.*). In this limited sample, turtles occasionally moved together and congregated in areas with dense *Sphagnum* sp. and moderately dense to dense sweet gale (*Myrica gale*) and leather leaf (*Chamaedaphne catyculata*) (I. Morrison, *pers. comm.*). Morrison's preliminary findings led us to hypothesize that in Nova Scotia: (1) scarcity of juveniles in the population is apparent rather than real; (2) juveniles select habitats with *Sphagnum*, sweet gale, and leather leaf disproportionately to their availability; and (3) turtles' total ranges

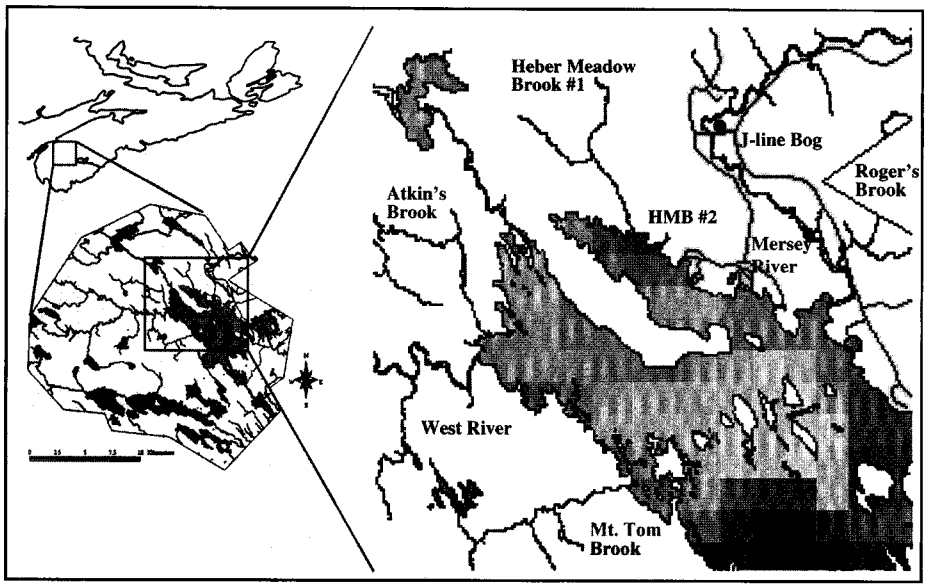


**Figure 1.** Map of the study areas in Kejimkujik National Park, Nova Scotia, Canada: Atkin's Brook, Heber Meadow, J-line Bog, West River, Mount Tom Brook, and three tributaries of the Mersey River, Flowing Waters Brook, Roger's Brook and No-name Brook.

(total area used by turtles through the active season), displacements between captures, and daily distance moved increase with age and amount of available habitat.

## MATERIALS AND METHODS

Data were collected from May to August 1995 in Kejimkujik National Park in south-central Nova Scotia (44°15' – 44°30'N, 65°00' – 65°30'W), Canada. The park is relatively small (381 km$^2$). Its aquatic systems are oligotrophic, acidic, and comprise approximately 20% of the park's area. Adult Blanding's turtle habitat contains abundant aquatic macrophytes, including *Sphagnum, Eriocaulon septangulare, Utricularia purpurea, Scirpus subterminalis, Pontederia cordata, Potamogeton* sp., *Lobelia dortmanna*, and *Utricularia vulgaris* (Power et al., 1994; Herman et al., 1995).

Areas known to contain adult Blanding's turtles, nesting beaches, or presumed juvenile habitat (based on earlier trapping of juveniles in 1994) were trapped: Atkin's Brook, Heber Meadow, J-line Bog, West River, Mount Tom Brook, and three tributaries of the Mersey River, Flowing Waters Brook, Roger's Brook, and No-name Brook (Fig. 1). All areas were trapped with the same intensity but visual searches were concentrated in three locations: Atkin's Brook, Heber Meadow, and J-line Bog.

### Study Areas

*Atkin's Brook.* — This area includes Atkin's Brook and the cove at its mouth. Although Atkin's Brook is approximately 5 km long, only the first 2 km were trapped. Within this 2 km stretch three discrete sections are evident: lower (0–720 m from mouth), middle (720–1300 m), and upper (1300–2000 m). The upper and lower brook sections, which are similar, cut through meadows with steep banks lined with sedge, sweet gale, and leather leaf. *Sphagnum* dominates these sections, lining the edge in large dense mats. The brook ranges from 4 to 8 m wide and 0.5 to 2 m deep, with many small channels created by muskrats or beavers. The lower section is partially dammed by three abandoned beaver dams, and the upper section begins with a large maintained dam. The brook bottom is rich organic mud. The middle brook section differs remarkably from the other two sections. The first 200 m meanders through a meadow with steep banks lined with sedge and the last 480 m cuts under an open and closed forest canopy of *Acer rubrum, Picea rubens,* and *Pinus strobus*. The brook in the middle section has a firm bottom of sand and pebble and is shallow (0.2–1 m) and narrow (1–2 m). Emergent vegetation is absent and sedges dominate the banks. The large cove at the mouth of Atkin's Brook is fringed by cobble stone beach, forest, and meadow. A dense *Sphagnum* mat fills the back half of the cove. The cove's bottom is mud with emergent stands of *Scirpus* sp., *Eleocharis* sp., and *Spartina pectinata.* The shores are lined with sweet gale, leather leaf, and *Rhododendron canadense.*

*Heber Meadow.* — This area includes Heber Meadow Brook, the cove at its mouth, and a smaller brook and cove located immediately to the southeast. Heber Meadow Brook ranges from 3 to 7 m wide and 1 to 2 m deep. The lower part of the brook has steep banks lined with sedge and patches of sweet gale and leather leaf; *Sphagnum,* which occurs in scattered patches, is the dominant aquatic macrophyte. The cove of Heber Meadow Brook is filled with a dense *Sphagnum* mat by early summer. Sweet gale, leather leaf, *Rhododendron canadense,* and *Sphagnum* dominate edges of the two coves and intervening meadow, which flood in spring and fall. The coves changed drastically over the study, due to a drop in water level of approximately 1 m between June and August. The smaller brook east of Heber Meadow Brook is narrow (0.5–1.5 m) except for the first 20 m, which are

approximately 5 m wide. It cuts through a meadow dominated by sweet gale, leather leaf, and *Rhododendron canadense* and then into an open canopy forest of *Acer rubrum, Picea rubens*, and *Pinus strobus* with a floor of sedge and *Alnus* sp.

*J-line Bog.* — This bog is small (ca. 40 x 90 m) and shallow, with a maximum water depth of 70 cm over a thick unconsolidated mud bottom (ca. 40 cm thick). Vegetation in the bog is primarily *Sphagnum fallex, Typha latifolia, Carex* sp., *Juncus* sp., and *Picea mariana*. The bog drains into the Mersey River 150 m to the west.

*West River.* — The first 700 m of West River and the tributary brook on the south side of the river (700 m upstream) were trapped in the study. The river ranges from 20 to 30 m wide and 2 to 3 m deep. The river's steep banks are lined with leather leaf, *Kalmia angustifolia, Rhododendron canadense,* and sweet gale. Aquatic macrophytes, found in scattered patches, are mainly *Sphagnum, Pontederia cordata, Scirpus subterminalis,* and *Potamogeton* sp. The tributary brook is shallow (70 cm) and narrow (2–3 m) and cuts through a sedge meadow with small patches of sweet gale and *Sphagnum* lining the sides.

*Mount Tom.* — This area includes Mount Tom Brook and the cove at its mouth. The brook is short (500 m) and ranges from 3 to 15 m wide and 1 to 2 m deep. The brook has steep banks lined with sedge and patches of sweet gale. *Sphagnum* is the dominant aquatic macrophyte. The cove at the mouth of the brook is filled with a dense *Sphagnum* mat and the shores are lined with sweet gale and leather leaf.

*Tributaries of the Mersey River.* — These brooks cut through open sedge meadows, have highly colored water, peaty soils, steep banks, depths of 1 to 2 m, widths of 2 to 5 m, and contain sparse sweet gale, leather leaf, and *Sphagnum*.

## Sampling

Turtles were captured by hand and with baited hoop-traps (3 cm mesh and 30 cm mouth opening). Hand captures were a result of systematic and opportunistic visual searches performed while we were checking traps and radio-tracking turtles in the study areas. Days were spent paddling and looking for juveniles in brooks and floodplains. Traps were set 50 m apart and left in the same location for five consecutive days, for a total of 757 trap days (13 five-day trapping sessions with 14–17 traps). Traps were checked daily and the bait (salmon scraps and canned sardines in soya oil) was changed every second day. Physical characteristics of the trapping areas were recorded and vegetation within a 1 m radius of each trap was classified in one of 15 vegetation categories (Fig. 2). Since traps were evenly spaced and placed independent of habitat and vegetation, their vegetation classification was used to estimate available habitat in the study areas.

All juvenile Blanding's turtles trapped were measured, notched according to the park's turtle identification system (Power, 1989), radiotagged, and released at the site of capture. Growth rings were easily counted with the naked eye. However, a silicone base dental registration paste (Reprosil® R or Regisil® R) was used to take impressions of the costal scutes of the carapace and/or the plastral scutes for later examination under a light microscope.

Sixteen juveniles were outfitted with one of two radio transmitter types: PD-2 (3.8 g) manufactured by Holohil Systems Ltd. (Ontario, Canada) and SM1-H (4 g and 8 g) manufactured by AVM Instrument Company (California, USA). The seven PD-2 transmitters were attached to the margins of the 10th and 11th marginal scutes with nylon line then covered and secured in place with black silicone. The nine SM1-H transmitters were attached to the carapace with

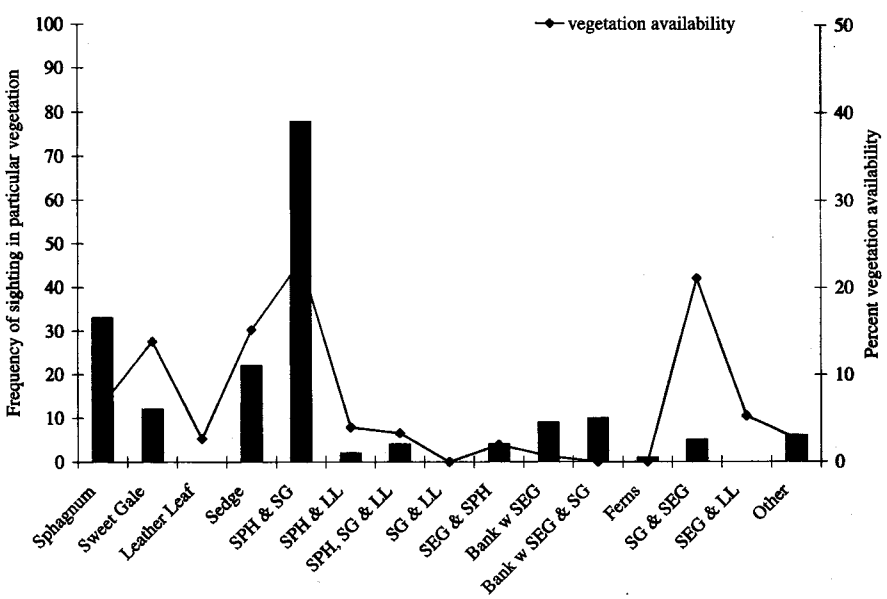


**Figure 2.** Frequency of sightings of juvenile and subadult Blanding's turtles by vegetation type within a 1 m radius of turtle location ($n$ = 186) and percentage of vegetation available at the study sites ($n$ = 152). SPH = *Sphagnum*; SG = sweet gale; LL = leather leaf; SEG = sedge; Bank = steep river bank; other = other species and/or combinations of vegetation.

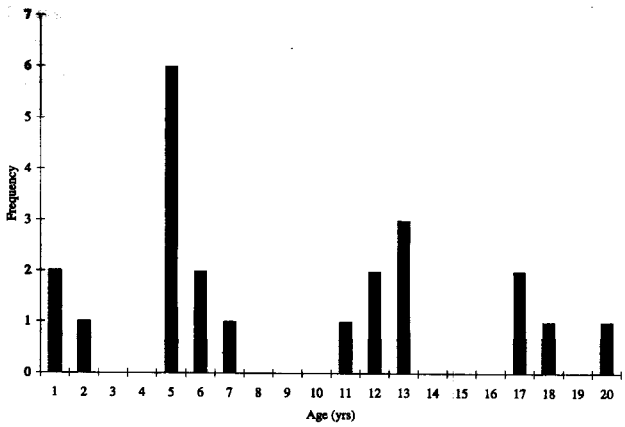


**Figure 3.** Age distribution of 22 juvenile and subadult Blanding's turtles captured in Kejimkujik National Park, summer 1995.

black silicone in a location where the transmitter protruded the least. We believe the transmitters, because of their small size and low weight, did not increase turtle visibility or modify turtle movements.

We attempted to locate all juveniles at least every six days with an AR80000 hand portable radio receiver (AVM Instrument Company) or a TRX-2000S receiver (Wildlife Materials, Inc.). After relocation, most turtles were located visually, and handled when transmitters appeared loose or damaged. The following data were collected at each location: date, time, general weather conditions, water temperature (12 cm below surface), air temperature, water depth, vegetation (within a 1 m radius), distance moved from last location (following the actual stream course and straight line distance in coves and bogs), slope of bank (gradual or steep), bottom substrate, and initial behavior at time of location. Turtle locations were placed in four categories: telemetry visual (located with telemetry and sighted), telemetry nonvisual (located with telemetry but not sighted), sighting (sighting without telemetry), or in trap. These capture data

Table 1. Juvenile, subadult, and mean adult Blanding's turtle measurements. The adult means are based on 15 adults measured over the summer of 1995. CL = Carapace length, CW = carapace width, PL = plastron length, PW = plastron width.

| Turtle ID | Age (yrs) | Weight (g) | CL (cm) | CW (cm) | PL (cm) | PW (cm) |
|---|---|---|---|---|---|---|
| 9-9,10 | 2 | 53.0 | 7.1 | 5.7 | 6.4 | 3.6 |
| 9-1,11 | 5 | 138.3 | 10.1 | 6.9 | 9.7 | 5.1 |
| 9-1,8 | 5 | 152.7 | 10.3 | 7.4 | 9.9 | 5.4 |
| 9-3,4 | 5 | 114.9 | 9.6 | 6.7 | 9.0 | 5.0 |
| 9-1,10 | 5 | 120.7 | 9.6 | 7.0 | 9.2 | 5.0 |
| 9-1,4 | 5 | 130.4 | 9.9 | 6.6 | 9.7 | 5.0 |
| 9-1,9 | 5 | 91.0 | 8.8 | 6.2 | 9.2 | 4.6 |
| 1,9-1 | 6 | 195.0 | 11.4 | 8.6 | 11.0 | 6.0 |
| 8-2,11 | 6 | 163.7 | 10.4 | 7.3 | 10.2 | 5.8 |
| 9-1,2 | 7 | 360.0 | 13.4 | 10.0 | 13.3 | 7.3 |
| 10-1,10 | 11 | 447.0 | 15.5 | 11.2 | 14.9 | 7.9 |
| 10-1,3 | 12 | 580.0 | 16.6 | 11.7 | 16.2 | 8.9 |
| 10-1,2 | 12 | 500.0 | 15.3 | 11.0 | 15.4 | 8.3 |
| 9-4,10 | 13 | 360.0 | 13.8 | 9.9 | 13.9 | 7.4 |
| 9-1,3 | 13 | 520.0 | 15.3 | 10.6 | 15.6 | 8.1 |
| 10-1,9 | 13 | 642.0 | 16.3 | 12.0 | 16.2 | 8.5 |
| 9-2,11 | 17 | 912.1 | 19.4 | 13.4 | 19.3 | 10.2 |
| 9-2,8 | 17 | 768.5 | 18.1 | 12.1 | 17.9 | 9.4 |
| 9,10-0 | 18 | 970.0 | 19.7 | 13.5 | 18.8 | 10.4 |
| 9-2,4 | 20 | 1199.4 | 21.1 | 14.9 | 19.1 | 10.4 |
| Adult Mean | | 1295.1 | 21.6 | 14.8 | 20.1 | 10.9 |
| Adult S.D. | | 210.8 | 1.7 | 1.1 | 1.3 | 0.6 |

were used to calculate ratios of sightings to trappings and of visual to nonvisual locations of telemetered turtles. If the likelihood of trapping is independent of age, both ratios should provide a reliable measure of visibility of different aged turtles. If not, the latter should still be reliable.

## RESULTS

Twenty-two juveniles and subadults were encountered in the study; 5 had been marked in 1994 and 17 were first captured in 1995. Ages ranged from 1 to 20 yrs (Fig. 3). For the remainder of this paper 'juvenile' refers to turtles aged 1–

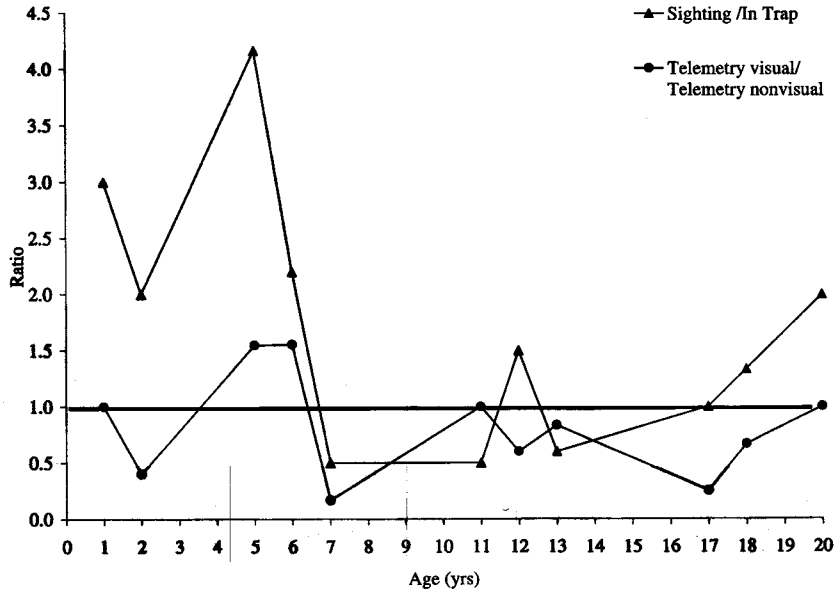


**Figure 4.** Ratio of sightings to trapped Blanding's turtles and ratio of visual to non-visual locations of telemetered turtles, with age.

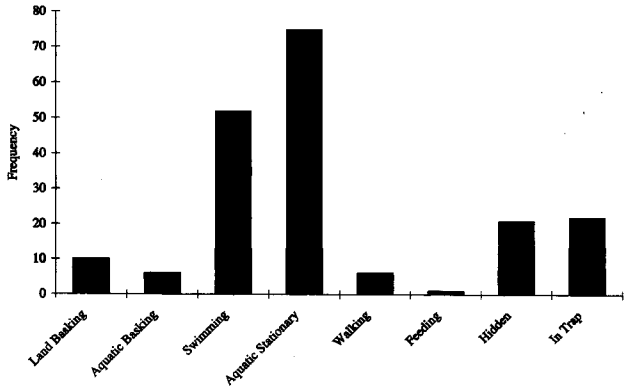


**Figure 5.** Activities of juvenile and subadult Blanding's turtles upon initial contact during each sighting. 'Aquatic stationary' refers to basking on *Sphagnum* mats or floating with head at the surface. $n = 193$.

13 yrs and 'subadult' to turtles aged 17–18 yrs. Juveniles encountered were further divided into young (1–7 yrs) and old (11–13 yrs), based on differences in size, behavior, and habitat use. All juveniles and subadults were distinctly smaller and lighter than 15 adults encountered during the study (Table 1).

Capture data show that young juveniles were more easily sighted (hand captured) and old juveniles and subadults were more easily trapped ($\chi^2 = 37.3, p < 0.01$) (Fig. 4). When located using telemetry, young juveniles were again more easily seen than old juveniles and subadults ($\chi^2 = 105.7$, $p < 0.01$). The difference in visibility between age classes was evident in the field. In most cases, young juveniles were located visually without the receiver, while old juveniles and subadults were difficult to locate visually even with the receiver. Most frequently observed behaviors upon sighting were "swimming at the edge of vegetation" or "aquatic stationary" (basking on *Sphagnum* mats or floating with head at the surface) (Fig. 5).

*Habitat Selection.* — Juveniles and subadults were found predominantly in tributaries of Kejimkujik Lake in four main areas: Atkin's Brook, Heber Meadow Brook, J-line Bog, and Mt. Tom Brook. The three brooks supporting juveniles were similar in habitat and vegetation. They cut through open sedge meadows with varying combinations of sweet gale and leather leaf lining the brook's edge. The brooks had highly colored water, peaty soils, steep banks, depths of 1 to 2 m, widths of 2 to 5 m, and *Sphagnum* as the dominant macrophyte. The brooks all flowed into coves with bog-type flood plains with peaty soils, *Sphagnum* as the dominant macrophyte, and sweet gale and leather leaf lining the cove's edges. Water depth at turtle location was independent of turtle age ($r^2 = 0.034$).

Turtles used vegetation disproportionately to its availability ($\chi^2 = 68, p < 0.0001$). Overall, juveniles and subadults were sighted primarily in mixed *Sphagnum* and sweet gale (Fig. 2). Pure *Sphagnum* and sweet gale made up approximately 7% and 14% of the vegetation in study sites, respectively. Mixed *Sphagnum* and sweet gale made up approximately 23% of the vegetation in the study sites. Use of vegetation by juveniles varied with age (Fig. 6). Subadults used a wider range of vegetation types, without spending the majority of time in any one type. Old juveniles spent the majority of time in *Sphagnum* and sweet gale. Young juveniles similarly spent the majority of time in *Sphagnum* and sweet gale but also used a range of other vegetation types.

Habitat and vegetation varied slightly among the four locations that supported juveniles. Atkin's Brook (with 12 known juveniles) was lined with *Sphagnum* over 70% of its length, and patches of sweet gale bordered over 74% of its length. Leather leaf lined less than 1% of Atkin's Brook. In contrast, Heber Meadow (with 4 known juveniles) had equal amounts of sweet gale (44%) and leather leaf (33%). Here, juveniles used the two meadows more than the brooks. *Sphagnum* lined only 28% of Heber Meadow Brook and only one juvenile was recorded in the brook over the summer. The small brook east of Heber Meadow Brook, 70% of

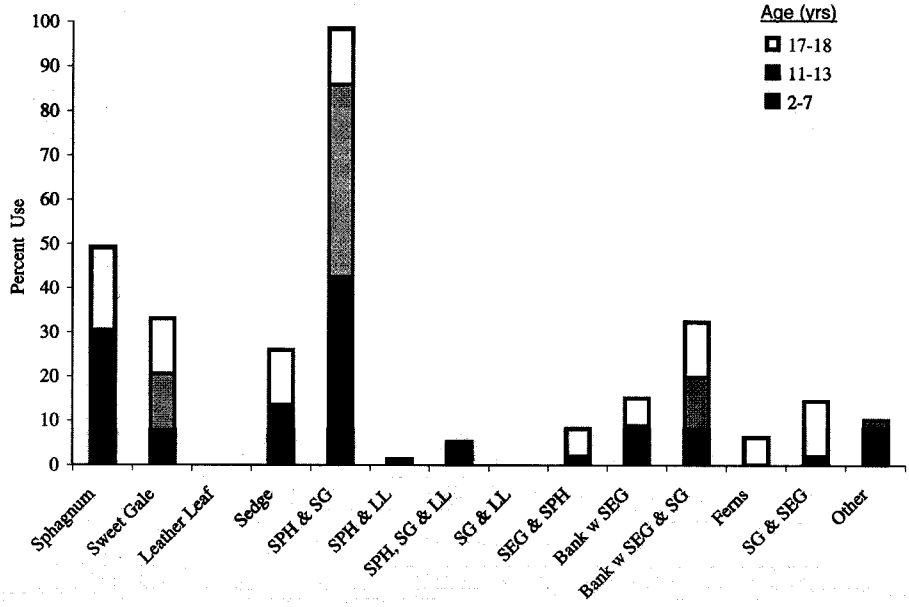


**Figure 6.** Percentage of vegetation type within a 1 m radius of a juvenile Blanding's turtle location, by age class ($n = 194$). SPH = *Sphagnum*; SG = sweet gale; LL = leather leaf; SEG = sedge; Bank = steep river bank; other = other species and/or combinations of vegetation.

**Table 2.** Total range size of juvenile Blanding's turtles during the active season (May–October), 1995. Ranges were only calculated for turtles with more than six locations. Ranges of Atkin's Brook turtles represent the length of brook used and those of Heber Meadow and J-line Bog turtles represent the area in the cove/flood plain occupied. Range of turtle 9-2,11 incorporates linear lakeshore movement during July and August. Flood refers to the flood plains located west of the mouth of Atkin's Brook.

| Turtle | Location | Age | Seasonal Range |
|---|---|---|---|
| 9-1,4 | Atkin's Brook | 5 | 600 m |
| 9-1,8 | Atkin's Brook | 5 | 750 m + Flood |
| 9-1,11 | Atkin's Brook | 5 | 550 m |
| 8-2,11 | Atkin's Brook | 6 | 440 m + Flood |
| 9-4,10 | Atkin's Brook | 7 | 1500 m + Flood |
| 9-1,2 | Atkin's Brook | 13 | 1300 m + Flood |
| 9-1,10 | Heber Meadow | 5 | Two 40 $m^2$ |
| 9-3,4 | Heber Meadow | 5 | 3000 $m^2$ |
| 9-2,11 | Heber Meadow | 17 | 2500 m |
| 9-9,10 | J-line Bog | 2 | 30 $m^2$ |
| 1,9-1 | J-line Bog | 6 | 40 $m^2$ |

which is lined with *Sphagnum*, was frequented by juveniles more often. J-line Bog (with 2 known juveniles) is a small area (ca. 40 x 90 m) with muddy *Sphagnum* and sparse sedge overhead. Mt. Tom Brook (with 2 known juveniles) is a short brook (ca. 500 m) with *Sphagnum* and sweet gale lining 25% and 63% of its length, respectively. Areas known to support adult Blanding's turtles but that apparently lacked juveniles (West River, Flowing Waters Brook, Roger's Brook, and No-name Brook) did not have sweet gale, leather leaf, or *Sphagnum*.

*Movement Patterns.* — Turtle movement patterns, described as total ranges (total area used by turtles through the active season), displacements (distance between successive captures), and daily distances (displacement between successive captures divided by the number of days between successive captures) varied by age and location (Tables 2–5). Total range and displacement increased with age and amount of available habitat. Among old juveniles and subadults, 17.6% and 15.4% of displacements exceeded 500 m, respectively. In contrast, only 0.7% of displacements of young juveniles exceeded 500 m, and 68.7% were less than 100 m. Displacements were greater in Atkin's Brook than in Heber Meadow and J-line Bog. Fifty percent of displacements of Atkin's juveniles and subadults ($n = 91$) exceeded 100 m; in contrast only 15% of Heber Meadow ($n = 47$) juvenile and subadult displacements exceeded 100 m. No displacements of J-line Bog ($n = 15$) juveniles exceeded 50 m. Lower sample sizes at J-line Bog and Mt. Tom ($n = 6$) resulted from late captures of juveniles and small number of individuals (two each). Mt. Tom juveniles were not considered in the comparison due to low sample size. Displacements of juveniles were smaller than those recorded from adults in this population (Power, 1989) ($\chi^2 = 24.4, p < 0.005$) (Table 5). Comparison is possible because numbers of days between successive captures are similar for these two data sets (juvenile mean = 7, SE = 0.54; adult mean = 6.4, SE = 0.15). Daily distances did not differ significantly between young and old juveniles (Mann-Whitney Test, $z = 1.22 < 1.96$, $p = 0.05$). Daily distances decreased from Atkin's Brook (41.6 x 55.1 m) to Heber Meadow (12.3 x 18.1 m) to J-line Bog (4.8 x 6.4 m) (Kruskal-Wallis test). Again, Mt. Tom juveniles were excluded from analysis due to their small sample size.

Seasonal shifts were apparent in Atkin's Brook and Heber Meadow juveniles. Three of five juveniles that were followed throughout the active season in Atkin's Brook moved into the flood plains in mid-June, and at the same time a juvenile located in the brook moved into the forest. Three of the four young juveniles returned to the brook by 1 July and the other on 22 July. Old juveniles in Atkin's Brook disappeared in July and August and were found in upper Atkin's Brook at the end of August. By October, young juveniles in Atkin's Brook (which had been tracked since the

**Table 3.** Displacement between successive captures based on age categories of juvenile and subadult Blanding's turtles.

| | Age Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1–7 yrs | | 11–13 yrs | | 17–18 yrs | | Total | |
| Displacement (m) | *n* | % | *n* | % | *n* | % | *n* | % |
| 0–10 | 31 | 23.1 | 2 | 11.8 | 2 | 15.4 | 35 | 21.3 |
| >10–50 | 34 | 25.4 | 4 | 23.5 | 2 | 15.4 | 40 | 24.4 |
| >50–100 | 27 | 20.2 | 6 | 35.3 | 1 | 7.7 | 34 | 20.7 |
| >100–500 | 41 | 30.6 | 2 | 11.8 | 6 | 46.2 | 49 | 29.9 |
| >500 | 1 | 0.7 | 3 | 17.6 | 2 | 15.4 | 6 | 3.7 |
| Total | 134 | | 17 | | 13 | | 164 | |

**Table 4.** Displacement between successive captures based on the location of juvenile and subadult Blanding's turtles.

| | Location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Atkin's Brook | | Heber Meadow | | J-line Bog | | Total | |
| Displacement (m) | *n* | % | *n* | % | *n* | % | *n* | % |
| 0–10 | 6 | 6.6 | 20 | 42.6 | 8 | 53.3 | 34 | 22.2 |
| >10–50 | 18 | 19.8 | 10 | 21.3 | 7 | 46.7 | 35 | 22.9 |
| >50–100 | 21 | 23.1 | 10 | 21.3 | 0 | 0.0 | 31 | 20.2 |
| >100–500 | 44 | 48.4 | 5 | 10.6 | 0 | 0.0 | 49 | 32.0 |
| >500 | 2 | 2.2 | 2 | 4.3 | 0 | 0.0 | 4 | 2.6 |
| Total | 91 | | 47 | | 15 | | 153 | |

**Table 5.** Displacement between successive captures of 14 radiotagged adult Blanding's turtles, 1 May – 15 November 1987 (Power, 1989).

| Displacement (m) | Male ($n=7$) | | Female ($n=7$) | | Total | |
|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* | % |
| 0-10 | 35 | 23.5 | 28 | 18.5 | 63 | 21.0 |
| >10-50 | 22 | 14.8 | 35 | 23.2 | 57 | 19.0 |
| >50-100 | 27 | 18.1 | 21 | 13.9 | 48 | 16.0 |
| >100-500 | 47 | 31.5 | 46 | 30.5 | 93 | 31.0 |
| >500 | 18 | 12.1 | 21 | 13.9 | 39 | 13.0 |
| Total | 149 | | 151 | | 300 | |

previous year) returned to overwintering sites used the year before (I. Morrison, *pers. comm.*). Heber Meadow juveniles showed no seasonal movements. Although turtles were located together (within 30 cm) on fifteen occasions, these assemblages appeared random. Four juveniles in Atkin's Brook (aged 5–6 yrs) were followed all summer and their movements appeared independent of one another.

## DISCUSSION

Until 1994, only 7 juvenile Blanding's turtles had been recorded in Nova Scotia. Now, distribution, preferred habitat, and movements of juveniles are better understood. Based on age distribution of known juveniles, recruitment to the juvenile cohort appears to vary from year to year in the Kejimkujik population, but overall may be higher than previously suspected (Herman et al., 1995). There was no evidence of reproductive activity or physical traits associated with maturity in any of our subadult turtles. Turtles between ages 16–20 yrs have reproduced elsewhere in the species' range (Graham and Doyle, 1977; Congdon et al., 1983). Juveniles in our population were smaller and lighter than the 15 adults encountered during the study. Assuming maturity is dependent on size (Ross, 1989), age at maturation in this population is later than in most other populations. The Nova Scotia population experiences a shorter growing season and cooler temperatures than most other populations, with a resultant decrease in cumulative heat units, so later maturation might be expected. With continued monitoring of this population, actual age and size at maturity can be determined when individuals first marked as juveniles first nest (females) or develop their plastral concavity (males).

*Habitat Selection.* — Distribution of juveniles appears to be related to adult density and suitable habitat. Atkin's Brook and West River have the highest known density of adult turtles in the park, followed by Heber Meadow Brook and a section of the Mersey River (Herman et al., 1995). Juvenile densities were similar, with Atkin's having the highest, followed by Heber Meadow, J-line (near the Mersey River), and Mt. Tom. Species protection is simplified if juveniles and adults use the same areas in the park.

All areas that supported juveniles shared certain features: steep banks, darkly colored, slow moving and shallow water (1–2 m), peaty soil, and varying densities of sweet gale, leather leaf, sedge, and *Sphagnum*. In fact, *Sphagnum* appears to be the most important feature and could be considered characteristic of juvenile Blanding's turtle habitat. For example, Atkin's Brook, where 10 juveniles were found, has large dense mats of *Sphagnum* lining 70% of the brook's edges. However, only one juvenile was found in Heber Meadow Brook, where only 28% of the brook is lined with *Sphagnum*. The presence of *Sphagnum* provides a protective cover and shallow foraging area for juveniles. Juveniles were most frequently located beneath some type of cover, e.g., sweet gale, leather leaf or sedge. Overhead cover, along with *Sphagnum*, appears to provide optimal habitat. Results from a controlled laboratory experiment on captive hatchlings also showed their affinity for dense *Sphagnum* when equal amounts of open water, sparse *Sphagnum*, and dense *Sphagnum* were available (McMaster, 1995). Hatchlings were found three times as frequently in dense *Sphagnum* as in sparse *Sphagnum*, and seven times as frequently in dense *Sphagnum* as in open water.

Slow flowing, darkly colored acidic streams with peaty soil are primary habitat for Blanding's turtles of all ages in Kejimkujik National Park. Juveniles in Nova Scotia generally remain in streams throughout the year, but adults move temporarily into lakes in early to mid-summer (Power, 1989). The streams, despite increased acidity, have higher secondary productivity than clearer water (Power et al., 1994). A combination of high secondary productivity with *Sphagnum* as a refuge from predators may account for the year-round presence of juveniles in these areas.

Congdon et al. (1992) found that mean water depth at point of capture of juvenile snapping and painted turtles in Michigan was positively correlated with age. We did not find such a correlation, however, the difference may be attributed to the type of habitat used. Turtles in Michigan occurred in a marsh, while juveniles in Nova Scotia occurred mainly in streams with steep banks.

*Movement Patterns.* — Total range size increased with age and amount of available habitat. Two turtles (ages 2 and 6 yrs) in J-line Bog stayed within a 40 $m^2$ area, which coincided with the total area of apparently suitable habitat (*Sphagnum* with sedge and tree over-story) at that site. The 2-yr old used a slightly smaller area (30 $m^2$). Similarly, two juveniles (both age 5 yrs) at Heber Meadow used relatively small strips representative of apparent suitable habitat. The 18-yr old juveniles at Heber Meadow moved greater distances (up to 2 km) in short periods (5 days) through apparently unsuitable habitat along the shores of Kejimkujik Lake. Juvenile activity in Atkin's Brook was limited to upper and lower sections of the brook. Juveniles aged 5 yrs used segments of the lower section ranging in length from 440 m to 720 m. Juveniles aged 7, 12, and 13 yrs not only used the lower section of the brook (720 m long) but ventured up through 580 m of apparently unfavorable habitat to the upper section (700 m long) in mid-August. In one case, three of the juveniles moved into the flood plain in early June and returned to the brook by 27 June. The increasing size of total ranges with increasing age may

explain the age-related differences in vegetation use. These may in part arise simply from a difference in 'grain' with which different age animals experience their environment. With larger total ranges, old juveniles should encounter more heterogeneous vegetation, including unsuitable or less preferred habitat. Young juveniles, which have smaller total ranges, can remain in smaller areas of more homogeneous vegetation. Therefore, young juveniles should yield more accurate data on habitat preference.

Although movement patterns are best represented visually, they can also be analyzed based on displacement between successive captures and daily distance moved. Displacement varied with age and location. As expected, old juveniles, whose larger size enhances motility, had larger displacements than young juveniles, independent of location. Old juveniles were not located every seven days due to increased movement, so the numbers of extensive displacements are possibly underestimated. Displacements of both age classes depended on the amount of suitable habitat. The total amount of suitable habitat increased from J-line Bog to Mt. Tom to Heber Meadow to Atkin's Brook. Excluding the Mt. Tom data (due to limited sample size), turtle displacements correlated positively with the amount (spatial extent) of suitable habitat. As suspected, juvenile displacements between successive captures were smaller than adult displacements in the same population. The lack of significant differences between young and old juveniles in daily distance moved likely reflects movement of old juveniles out of radio range, which increased days between successive capture and probably reduced daily distance estimates. Similar to the displacement of turtles, daily distance increased from J-line Bog to Heber Area to Atkin's Brook, again suggesting constraints placed on movement by the amount of suitable habitat. Continued monitoring of juvenile distribution and movements is needed before a clear pattern of seasonal movement, if it exists in this population, can be described.

*Scarcity.* — The nature of scarcity of juveniles in this population is now better understood. Scarcity in previous censuses was probably not due to juveniles occupying areas (macrohabitats) not searched or different from those occupied by adults. Juveniles and subadults in the present study occupied areas that have been searched in the past, but traps used in this study were modified to exclude larger turtles (larger snapping turtles in particular may inhibit young and smaller juvenile Blanding's turtles from entering a trap). They were also placed closer to the margins of brooks and coves than in past studies and as a result probably sampled a slightly different microhabitat. Although macrohabitats of juveniles and adults overlap extensively, there are important differences, particularly in temporal use. Areas in Atkin's Brook and Heber Meadow, used throughout the active season by juveniles, were visited by adults primarily during transit to and from overwintering and mating areas (Power, 1989). Adults were only found in J-line Bog immediately before and after nesting.

That juveniles are more secretive than adults is also not a likely explanation for their scarcity in past population censuses. Although all juveniles are cryptically marked and undoubtedly some were missed in this study, young juveniles were more visible than old juveniles. This difference in visibility probably reflects behavioral differences between young and old juveniles and subadults. Young juveniles were first located approximately by telemetry, and in most cases after initial approach they were located visually at the surface. Old juveniles were more secretive than young ones; it was an effort to locate these turtles visually. On most occasions the subadults were not visible at first approach. On the few occasions they were seen, they invariably submerged. Juveniles were usually found active in the water and they were hidden only 10% of the time.

Another possible explanation for scarcity of juveniles in past population censuses is nest failure. The large number (22) of juveniles encountered during the present study, although possibly insufficient to sustain the present population (ca. 132 adults), may reflect a real increase in recruitment over the past two decades. This is encouraging, although the reason for it remains unclear.

In summary, scarcity of juveniles is apparent; juveniles select habitats with *Sphagnum*, sweet gale, and leather leaf; and turtles' movements increase with age and the amount of available habitat. Knowledge gained from the present study on habitat selection and movement patterns of young Blanding's turtles can be applied more broadly to address the issue of juvenile scarcity elsewhere in the species' range. In Nova Scotia it can be combined with existing knowledge of nesting requirements and distribution of adults within Kejimkujik National Park to develop predictive models to locate populations and identify critical habitat for protection outside the park. In the face of rapid environmental change, long-term survival of this species at the northeastern periphery of its range requires conservation in both protected and working landscapes.

### Acknowledgments

This work was funded by World Wildlife Fund Canada (ESRF) and Acadia University and initiated by the RENEW Recovery Team for Blanding's turtle (Nova Scotia population). The collaboration of Ian Morrison, Sally O'Grady, and other Parks Canada staff, is gratefully acknowledged. Thanks are extended to A. Rhodin, T. Graham, N. Armstrong, and an anonymous reviewer for comments on the manuscript. S. Boates, G. Daborn, D. Hurlburt, and D. Schindler kindly reviewed earlier drafts. Dave Oickle generously helped with the fieldwork and lent support and encouragement throughout the study.

## LITERATURE CITED

Butler, B.O. and Graham, T.E. 1995. Early post-emergent behavior and habitat selection in hatchling Blanding's turtles, *Emydoidea blandingii*, in Massachusetts. Chelonian Conservation and Biol-

ogy 1(3):187-196.

CONGDON, J.D. AND VAN LOBEN SELS, R.C. 1991. Growth and body size in Blanding's turtles (*Emydoidea blandingii*): relationships to reproduction. Can. J. Zool. 69:239-245.

CONGDON, J.D., DUNHAM, A.E., AND VAN LOBEN SELS, R.C. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

CONGDON, J.D., GOTTE, S.W., AND DIARMID, R.W. 1992. Ontogenetic changes in habitat use by juvenile turtles, *Chelydra serpentina* and *Chrysemys picta*. Can. Field-Nat. 106:241-248.

CONGDON, J.D., TINKLE, D.W., BREITENBACH, G.L., AND VAN LOBEN SELS, R.C. 1983. Nesting ecology and hatchling success in the turtle *Emydoidea blandingii*. Herpetologica 39:417-429.

GRAHAM, T.E. AND DOYLE, T.S. 1977. Growth and population characteristics of Blanding's turtle, *Emydoidea blandingii*, in Massachusetts. Herpetologica 33:410-414.

HERMAN, T.B., POWER, T.D., AND EATON, B.P. 1995. Status of Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia, Canada. Can. Field-Nat. 109:182-191.

HERMAN, T., BLEAKNEY, J.S., BOATES, J.S., DRYSDALE, C., GILHEN, J., MORRISON, I., POWER, T., STANDING, K.L., AND ELDERKIN, M. 1999. National Recovery Plan for Blanding's Turtle (*Emydoidea blandingii*) Nova Scotia population. Report No. 18. Ottawa: Recovery of Nationally Endangered Wildlife Committee, 39 pp.

MOCKFORD, S.W., SNYDER, M., AND HERMAN, T.B. 1999. A preliminary examination of genetic variation in a peripheral population of Blanding's turtle, *Emydoidea blandingii*. Molecular Ecology 8:323-327.

MCMASTER, N.L. 1995. Hatchling *E. blandingii*'s distribution, habitat selection and daily activity cycles. Unpubl. Report, Biology 3413, Centre for Wildlife and Conservation Biology, Acadia University, Wolfville, N.S.

PAPPAS, N.J., AND BRECKE, B.J. 1992. Habitat selection of juvenile Blanding's turtles. *Emydoidea blandingii*. J. Herpetol. 26:233-234.

PETOKAS, P.J. 1986. Patterns of reproduction and growth in the freshwater turtle *Emydoidea blandingii*. Ph.D. Thesis, State Univ. New York, Binghamton.

POWER, T.D. 1989. Seasonal movements and nesting ecology of a relict population of Blanding's turtle (*Emydoidea blandingii*) in Nova Scotia. M.Sc. Thesis, Acadia University, Wolfville, Nova Scotia.

POWER, T.D., HERMAN, T.B., AND KEREKES, J. 1994. Water color as a predictor of local distribution of Blanding's turtles, *Emydoidea blandingii*, in Nova Scotia. Can. Field-Nat. 108:17-21.

ROSS, D.A. 1989. Population ecology of painted and Blanding's turtles (*Chrysemys picta* and *Emydoidea blandingii*) in central Wisconsin. Wis. Acad. Sci. 77:77-84.

STANDING, K.L., HERMAN, T.B., HURLBURT, D.D., AND MORRISON, I.B. 1997. Postemergence behaviour of neonates in a northern peripheral population of Blanding's turtles (*Emydoidea blandingii*), in Nova Scotia. Can. J. Zool. 75:1387-1395.

*Received*: 15 February 1999
*Reviewed*: 24 April 2000
*Revised and Accepted*: 13 June 2000