Spatial Ecology and Seasonal Activity of Blanding’s Turtles (Emydoidea blandingii) in Ontario, Canada

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ABSTRACT.—Understanding the spatial ecology of species at risk is essential for conservation because this information forms the base from which management and recovery plans are delineated. We studied microhabitat selection and evaluated the effect of reproductive class on daily movement patterns, home ranges, and seasonal activity of Blanding’s Turtles in the St. Lawrence Islands National Park, Ontario, Canada. We also consider the potential conservation/management ramifications of differences in habitat use between the reproductive classes. We monitored 38 Blanding’s Turtles (20 males, 13 gravid females, and 5 nongravid females) from April 2008 to August 2009 via radiotelemetry. Reproductive class did not have a significant effect on the mean daily movement of turtles in May, July, and August. In June, however, gravid females moved significantly more (mean = 400 ± 49 m per day) than males (mean = 194 ± 22 m per day). Reproductive class also had a significant effect on turtle home-range size, although high individual variation was observed (range = 1.6–40.6 ha). Gravid females had significantly larger home ranges (mean = 20.3 ± 3.5 ha) did than both males (mean = 8.2 ± 1.8 ha) and nongravid females (mean = 7.3 ± 3.2 ha). At the microhabitat scale, Blanding’s Turtles selected colder water with more submerged and floating vegetation and avoided open water. Our results highlight the importance of stratifying field observations and spatial data by reproductive class and time and including terrestrial habitat in home-range analyses of Blanding’s Turtles.

When preparing management plans for species at risk, conservation practitioners need information on the habitat requirements of those species. Spatial ecology is the study of how landscape configuration influences the community and population dynamics of organisms (Collinge, 2001). Thus, empirical studies in spatial ecology link conservation biology research to practical mechanisms for species management and conservation planning (Collinge, 2001; Whitaker and Shine, 2003). Within the spatial ecology framework, various elements can be evaluated; these include movement patterns, home ranges, and habitat selection. By examining movement patterns, essential habitat types can be identified (i.e., nesting, mating, and overwintering sites), factors limiting distributions or abundance of species can be identified (i.e., spatial configuration of foraging sites in the landscape), and the effects of habitat management can be assessed (Rutherford and Gregory, 2003). In complement to movement patterns, home ranges enable researchers to estimate the size and shape of the area used by an animal, which allows for proper delineation of regions that need to be protected (Burt, 1943; Litzgus and Mousseau, 2004). Finally, habitat selection studies reveal specific habitat types that are used and needed by the species. All these elements, key to conservation, can be stratified by reproductive class, season, and the scale of analysis (Johnson, 1980; Litzgus and Mousseau, 2004; Edge et al., 2010).

For temperate-zone turtles at the northern periphery of their range, the active season (April to late October) (Arvisais et al., 2004; Litzgus and Mousseau, 2004) can be divided into four distinct periods: prenesting (April until late May), nesting (late May/early June until late June/early July), summer (early July until late August/early September), and prehibernation (September until late October). During this time, turtles must acquire energy, thermoregulate, and find refugia to minimize risk of predation (Congdon, 1989; Huey, 1991). In turtles, home-range size, movements, and activity often differ between the sexes (Morreale et al., 1984). Most studies have found that movement and activity are greater in males than in females (e.g., Pluto and Bellis, 1988; Rowe and Moll, 1991), whereas some studies have found the reverse (e.g., Ross and Anderson, 1990; Carrière et al., 2009), and a few found no difference (e.g., Jones, 1996; Carter et al., 1999; Hamernick, 2000). Only a few studies, however, have explored the differences in habitat use between males, nongravid females, and gravid females (Doody et al., 2002; Litzgus and Mousseau, 2004). The goal of this study is to examine differences in habitat use and movement patterns between male, nongravid female, and gravid female Blanding’s Turtles. We also discuss the potential conservation/management ramifications of these differences.

The Blanding’s Turtle, Emydoidea blandingii, is a medium-sized freshwater turtle that is considered at risk in 17 of the 18 state/provincial jurisdictions across its range (NatureServe, 2009). A large portion of its global range (~20%) is contained within southern and south-central Ontario (COSEWIC, 2005), and the Great Lakes/St. Lawrence population is designated as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2005). The primary threat to Blanding’s Turtles is habitat loss and degradation (Van Dam, 1993; Harding, 1997). Adult Blanding’s Turtles use a variety of wetland habitats, including vernal pools, bogs, marshes, and impoundments dominated by cattails, water lilies, and duckweed (Rowe and Moll, 1991; Hartwig and Kiviat, 2007). In addition to aquatic habitats, terrestrial habitats are also used frequently as travel corridors between wetlands (Joyal et al., 2001) and for aestivation (Ross and Anderson, 1990; Joyal et al., 2001). Thus, upland habitats that are not fragmented by developments are essential (Grgurovic and Sievert, 2005).

Regional differences in temporal and spatial movement patterns and habitat use are apparent in Blanding’s Turtles (Rowe and Moll, 1991; Hamernick, 2000; Piepgras and Lang, 2000; Edge et al., 2010). Sexual differences in movement are usually attributed to different reproductive strategies (Morreale et al., 1984; Ernst, 1986; Gibbons et al., 1990). Males tend to maximize their reproductive success by maximizing the number of eggs they are able to fertilize. Hence, increased movement should increase chances for copulation with several females and maximize fertilizations (Morreale et al., 1984; Parker, 1984; Ernst, 1986). Although Blanding’s Turtles do not have a defined mating season, two studies report a high number of observed copulations prior to and following overwintering events (Newton and Herman, 2009; Edge et al., 2010). Thus, we expected that the distance moved by males in May, following overwintering, would be greater than that of females. On the other hand, gravid female turtles maximize their fitness by selecting optimal nesting sites. Blanding Turtle females are known to make long-distance journeys outside of their wetlands of origin to reach preferred nesting sites (Joyal et al., 2001). For this reason, we expected gravid females to move greater distances in June than would nongravid females and
males. These greater distances moved and the forays outside of wetlands should also result in gravid females having larger home ranges.

Reptiles are ectothermic and must obtain heat from their environment. Because all physiological processes are temperature dependant, variation in the body temperature of reptiles greatly affects their development, physiology, and behavior (Dawson, 1975; Huey, 1982; Congdon, 1989; Peterson et al., 1993). Most reptiles have a narrow range of preferred body temperatures and thermoregulate by adjusting habitat selection, body posture, and timing of activity (Huey et al., 1989). In temperate regions, the task of thermoregulating can be particularly challenging because of the low average and high seasonal variability in environmental temperatures (Blouin-Demers and Weatherhead, 2001). Thus, with respect to microhabitat selection, we expected turtles to select sites of high thermal quality: sites with high solar radiation (as measured by air and water temperatures). We also expected turtles to select higher percentages of emergent vegetation and floating vegetation because Blanding’s Turtles are wary and these cover types provide refuge (Hamernick, 2000; Sajwaj and Lang, 2000).

### Materials and Methods

**Study Area.**—We conducted this study from May 2008 to August 2009 on Grenadier Island in the Thousand Islands Ecosystem. Grenadier Island is located in the St. Lawrence River directly south of Mallorytown, Ontario, Canada. It is one of the largest islands (approximately 522 ha) in St. Lawrence Islands National Park and harbors several beaver ponds and wetlands that are used by Blanding’s Turtles.

**Radiotelemetry and Data Collection.**—We captured Blanding’s Turtles by hand, dip-net, and submerged hoop nets baited with canned sardines. We determined the sex of turtles by presence or absence of male secondary sexual characteristics (concave plastron and longer preanal tail length in males; Ernst and Lovich, 2009). We determined female reproductive status by palpation during the egg bearing period (May to early July). We fitted 38 Blanding’s Turtles (20 males, 13 gravid females, and 5 nongravid females) with radio-transmitters (Holohil SL-2FT 17 g; battery life of 36 months). We bolted transmitters to the rear marginal scutes of the carapace using stainless steel screws, washers, and nuts. We used marine silicone to cover screws and transmitter edges, thus preventing detritus and macrophytes from catching on the transmitters. Transmitters (including screws, nuts, and silicone) represented at most 5% of the turtle’s body mass and were removed at the end of the study. We released turtles at their site of capture the following morning, and we relocated each individual every 3–4 days in 2008 and every 1–2 days in 2009 with a telemetry receiver and a directional antenna. At each location, we recorded the Universal Transverse Mercator (UTM) coordinates (3D differential receiver status, NAD83 datum) using a GPSmap72 (Garmin International Inc., Olathe, KS) with an estimated accuracy of ≤ 6 m. We also noted the behavior of the turtles.

**Movement Patterns.**—We analyzed movement data from 13 individuals (four gravid females, three nongravid females, six males) (800 relocations) radio-tracked daily for four consecutive months during the 2009 active season (May to August). To calculate the distance moved between radio-locations, we used the Animal Movement Extension 2.0 (Hooge and Eichenlaub, 2000) in ArcGIS 3.2 (ESRI, 1995–2010). We measured movements as straight-line distances between relocations. If more than one day had elapsed between relocations, the daily distance moved was calculated by dividing the distance moved between relocations by the number of days elapsed since the last location. We also determined the total distance traveled in aquatic and terrestrial habitats by males, nongravid females, and gravid females in May, June, July, and August. To examine the effects of reproductive class and month on the daily distance moved by turtles, we used a two-way repeated-measures ANOVA. Movement data from 2008 were not used for statistical analyses of the daily distance moved because of the longer intervals between relocations.

**Home Ranges.**—We calculated the home range for each individual turtle using the 100% minimum convex polygon method (MCP). MCPs are calculated by creating the smallest possible convex polygon that encompasses all known locations for an individual. MCPs provide a robust estimate for maximum home-range size for herpetofauna (Row and Blouin-Demers, 2006) and are the most commonly used method to estimate animal home ranges (Powell, 2000). MCPs were calculated using Hawth’s Tools (Beyer, 2004), an animal movement extension for ArcMAP 9.0 (ESRI, 1995–2010). We also determined the proportion of aquatic and terrestrial habitat in the home ranges of males, nongravid females, and gravid females.

To assess the robustness of our home-range estimates, we ran an asymptote analysis with the ABODE.mxt tool (Laver, 2005). Past studies have shown that the estimates of home-range area converge as the number of relocations increases.
Microhabitat Analysis.—We quantified habitat directly at the locations used by the turtles. Habitat was not quantified during nesting forays and, to keep sampling manageable, was only characterized at every second telemetry location. We quantified seven habitat variables within a 50-cm radius around each turtle location (Table 1). The percentage of open water, emergent vegetation, floating vegetation, and submerged vegetation was determined visually. Also, air temperature was measured using a mercury thermometer 30 cm above the surface of the water; water depth was measured using a meter stick; and water temperature was measured 15 cm below the surface of the water using a digital thermometer.

To measure habitat availability, a random location was immediately characterized after the turtle location to ensure that no temporal or environmental changes affected the measured variables. Random locations were identified by selecting a direction from the characterized turtle location at random and moving a distance of 40 m (an approximation of the daily distance moved by Blanding’s Turtles during our pilot study in 2007). Such a distance ensures that the random location selected was available to the turtle.

To examine habitat selection within the turtles’ home ranges, we used matched-pairs logistic regression. In the paired design, each turtle location is compared to its paired random location, thus controlling for changes in environmental conditions through time and ensuring that each random location was available to the individual being radio-tracked (Compton et al., 2002). We collected data on microhabitat use for 11 adult females and 12 adult males. Because of the small number of observations for each sex, data from both sexes were pooled. We ran univariate analyses for each habitat variable and selected variables with P-values less than 0.25 for subsequent multivariate analyses (Hosmer and Lemeshow, 2000). We fitted candidate models using a backward stepwise regression, and we selected the model with the lowest Akaike’s Information Criterion (AIC) score (Boye et al., 2002). Finally, we evaluated the fit of the each model using the likelihood-ratio statistic (Hosmer and Lemeshow, 2000).

Statistical Analyses.—We performed all statistical analyses with JMP version 8.0 (SAS Institute Inc., Cary, NC, 2005–10) and R version 2.7.2 (R Development Core Team, Vienna, Austria, 2008). We report all means ± SE, and we considered tests significant at α = 0.05. Daily movement data and home-range estimates were log transformed to meet the assumptions of homogeneity of variance, normality, and sphericity.

RESULTS

We captured 91 Blanding’s Turtles (51 males and 40 females) and radio-tracked 38 individuals for at least three consecutive months during the 2008–09 active seasons (1,589 relocations).

Movement Patterns.—Most terrestrial movements occurred in May and June (Fig. 1). In May, males and nongravid females traveled more than gravid females, but the distance traveled in terrestrial habitat was similar across all reproductive classes (Fig. 1). Gravid females traveled more than males and nongravid females in June and 21% of the total distance traveled by gravid females in June was in terrestrial habitat (Fig. 1). The total distance traveled by turtles in July and August was similar across all reproductive classes with males traveling only slightly more than females in August (Fig. 1).

A one-way ANOVA revealed that reproductive class had no effect on the annual mean daily distance moved ($R^2 = 0.07$, $F_{2,18} = 0.61$, $P = 0.55$). A two-way repeated-measures ANOVA revealed a significant interaction of month and reproductive class ($F_{6,30} = 2.533$, $P = 0.042$) on the monthly mean daily distance moved. Mauchly’s test indicated that the assumption of sphericity was met ($\chi^2 = 9.08$, $P = 0.11$). Four separate ANOVAs testing for the effect of reproductive class on mean daily distance moved during each month revealed no significant effect of reproductive class in May ($R^2 = 0.22$, $F_{2,12} = 1.37$, $P = 0.30$), July ($R^2 = 0.17$, $F_{2,12} = 1.01$, $P = 0.40$), and August ($R^2 = 0.11$, $F_{2,12} = 0.64$, $P = 0.55$; Fig. 1). In June, however, reproductive class had a marginally significant effect ($R^2 = 0.44$, $F_{2,18} = 5.4$, $P = 0.05$). A Tukey-Kramer HSD test
indicated that gravid females moved significantly more (mean \(= 400 \pm 49 \text{ m per day}\)) than did males (mean \(= 194 \pm 22 \text{ m per day}\)) (Fig. 2).

Sixteen nesting forays, defined here as movements to and from nesting areas, occurred between 4 and 25 June in 2008 and between 29 May and 27 June in 2009. Thirteen females were radio-tracked to their nesting sites, and four of the six gravid females in 2008 were also gravid in 2009. Furthermore, two nongravid females in 2008 were gravid in 2009. Nesting sites were located 150 to 1,850 m (mean of 919 \(\pm 129 \text{ m}\)) from the wetland of origin. During these nesting forays, females traveled a total distance of 650 to 3,479 m (mean of 2,095 \(\pm 285 \text{ m}\)) to and from nesting sites, staying up to 15 days around the nesting area before traveling back to their wetland of origin. Three communal nesting areas were used by six radio-tracked females in 2008 and 2009. One of these nesting sites had been identified previously by Petokas in 1986. Finally, one female successfully tracked to her nesting site in 2008 and 2009 used the same nesting site both years.

**Home Ranges.**—Home-range size varied between individuals, ranging from 1.6 to 40.6 ha with a mean of 12.0 \(\pm 1.8 \text{ ha}\). The mean home-range size was 8.2 \(\pm 1.8 \text{ ha}\) (11.1 \(\pm 3.2\% \text{ terrestrial}\)) for males, 7.3 \(\pm 3.2 \text{ ha}\) (15.9 \(\pm 10.1\% \text{ terrestrial}\)) for nongravid females, and 20.3 \(\pm 3.5 \text{ ha}\) (42.1 \(\pm 7.6\% \text{ terrestrial}\)) for gravid females. A one-way ANOVA revealed that reproductive class had a significant effect on home-range area \((F_{2,36} = 8.21, P = 0.0012)\). A Tukey-Kramer HSD test indicated that gravid females had significantly larger home ranges than did both males and nongravid females (Fig. 3). The larger home ranges of gravid females were largely a result of their greater use of terrestrial habitats.

**Microhabitat Analysis and Behavior.**—Microhabitat data from 187 turtle locations (76 female locations, 111 male locations), with the 187 corresponding random paired locations, were used for analysis. The model with the lowest AIC value (AIC = 231.751) had the variables \(\%\text{FLOAT\_VEG}\), \(\%\text{SUB\_VEG}\), and \(\%\text{OPEN\_H2O}\) and was statistically significant (log ratio = 35.5, \(R^2 = 0.091\), \(P < 0.0001\)) (Table 2). Based on the odd ratios, Blanding’s Turtles selected colder waters where both floating and submerged vegetation are abundant. A 1°C increase in water temperature resulted in a 16% decrease in the probability of selection; a 25% increase in submerged vegetation resulted in a 70% increase in the probability of selection; a 25% increase in floating vegetation resulted in a 28% increase in the probability of selection; and a 25% increase in open water resulted in a 31% decrease in the probability of selection (Table 3, Fig. 4).

Pearson Chi-square analysis revealed a significant difference in behavior at telemetry location between reproductive classes \((\chi^2_{10,1561} = 64.36, P < 0.0001)\) and between months \((\chi^2_{15,1561} = 158.11, P < 0.0001)\). Turtles were most often found immobile underwater, usually under bog mats or floating vegetation (45%). Gravid females were located underwater less often than were nongravid females and males, and the frequency of underwater turtle observation was higher in August than any other month (Fig. 5). Furthermore, gravid females were found basking at the surface of the water and on land more often than males and nongravid females (Fig. 5). Basking behavior was most often observed in May, thereafter decreasing in frequency (Fig. 5).
Table 2. Matched paired-logistic regression models explaining microhabitat use by Blanding’s Turtles on Grenadier Island, St. Lawrence Islands National Park, Ontario, Canada. The models with the lowest AIC scores and highest Akaike weights (ω) have more substantial support. The number of parameters (k) is also indicated.

<table>
<thead>
<tr>
<th>Model</th>
<th>k</th>
<th>AIC</th>
<th>ΔAIC</th>
<th>ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2O_TEMP, H2O_OPEN, %FLOAT_VEG, %SUB_VEG, %EMERG_VEG</td>
<td>5</td>
<td>233.274</td>
<td>1.5230</td>
<td>0.1809</td>
</tr>
<tr>
<td>H2O_TEMP, H2O_OPEN, %FLOAT_VEG, %SUB_VEG</td>
<td>4</td>
<td>231.7509</td>
<td>0.0000</td>
<td>0.3873</td>
</tr>
<tr>
<td>H2O_TEMP, H2O_OPEN, %FLOAT_VEG</td>
<td>3</td>
<td>231.7882</td>
<td>0.0373</td>
<td>0.3801</td>
</tr>
<tr>
<td>H2O_TEMP, H2O_OPEN</td>
<td>2</td>
<td>235.7767</td>
<td>4.0260</td>
<td>0.0517</td>
</tr>
</tbody>
</table>

Discussion

Daily Movements.—The daily movements of Blanding’s Turtles on Grenadier Island were almost three times longer than those documented in past studies (Table 4; Ross and Anderson, 1990; Rowe and Moll, 1991; Piepgras and Lang, 2000; Innes et al., 2008; Edge et al., 2010). The higher annual mean daily movements of gravid females in our study could be associated with the inclusion of nesting forays in the movement analysis, because some studies removed nesting forays and other upland habitat movements from home-range calculation (Rowe and Moll, 1991). All three reproductive classes (males, gravid females, and nongravid females), however, had much higher than average daily movements. Interstudy differences could be attributed to difference in tracking patterns or local environmental factors. We found that differences in time between telemetry locations dramatically influenced the accuracy of daily movement estimates. In 2008, the average daily distance moved (DDM) by turtles in our study was 51 m per day, and turtles were radio-tracked 1–7 times per week. In 2009, however, when turtles were radio-tracked 5–7 times per week, the average DDM was 180 m per day. These results suggest that to estimate the daily movement patterns of Blanding’s Turtles properly, individuals must be radio-tracked every day of the week; otherwise researchers run the risk of grossly underestimating the daily movement of this species. This same pattern is evident in the literature; the highest observed DDM were obtained in studies where turtles were radio-tracked 1–7 times per week. Interestingly, several past studies on Blanding’s Turtles excluded nesting forays and other terrestrial movements from home-range analysis (Ross and Anderson, 1990; Edge et al., 2010). These turtle species aggregate annually around overwintering sites, and it appears that the seasonal movement patterns of aggregate breeders do not follow the predictions of the reproductive strategies hypothesis (Carter et al., 2000; Doody et al., 2002; Litzgus and Mousseau, 2004).

Home Ranges.—In comparison with several other studies, the Grenadier Island population exhibited intermediate home-range sizes (Table 5). The large variation in home-range size estimates among studies can be attributed to several factors, such as methodological differences, turtle age and reproductive class, sample size, and most important local habitat composition (Cagle, 1944; Bury, 1979). Unlike past studies (Hamernick, 2000; Edge, 2010), we observed a significant difference between the sexes in home-range size. Pooling of nongravid females with gravid females for home-range analysis in previous studies could be responsible for these conflicting results. The significantly larger home ranges of gravid females can be explained by the inclusion of long-distance nesting forays in home-range calculations. Interestingly, several past studies on Blanding’s Turtles excluded nesting forays and other terrestrial movements from home-range analysis (Ross and Anderson, 1990; Rowe and Moll, 1991; Innes et al., 2008). Although studying activity centers within a home range might reveal information about a turtle’s daily activity patterns, all terrestrial movements should be included in home-range analysis. Nesting is a normal activity for a gravid female turtle; and because the home range of an animal is, by definition, the area within which an individual moves when performing its normal activities, nesting excursions should be included in home-range estimation (Burt, 1943).

Microhabitat Selection and Behavior.—During the active season, Blanding’s Turtle habitat consisted of muck substrate, water depths of 1–220 cm, cattails, sedges, grasses (predominantly wild rice), water lilies, swamp loosestrife, and various wetlands adjacent to their nesting sites are essential movement corridors, and one

Table 3. Coefficients and odds ratios for the paired-logistic regression model explaining microhabitat use by Blanding’s Turtles on Grenadier Island, St. Lawrence Islands National Park, Ontario, Canada.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>SE</th>
<th>Increase</th>
<th>Odds ratio</th>
<th>95% CI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2O_TEMP</td>
<td>-0.171</td>
<td>0.072</td>
<td>1°C</td>
<td>0.84</td>
<td>(0.73, 0.97)</td>
</tr>
<tr>
<td>%SUB_VEG</td>
<td>0.532</td>
<td>0.433</td>
<td>25% (1 level)</td>
<td>1.7</td>
<td>(0.73, 3.97)</td>
</tr>
<tr>
<td>%FLOAT_VEG</td>
<td>0.246</td>
<td>0.102</td>
<td>25% (1 level)</td>
<td>1.28</td>
<td>(1.05, 1.56)</td>
</tr>
<tr>
<td>%OPEN_H2O</td>
<td>-0.365</td>
<td>0.104</td>
<td>25% (1 level)</td>
<td>0.69</td>
<td>(0.57, 0.85)</td>
</tr>
</tbody>
</table>

*95% CI from odds ratios.
submerged vegetation. This is consistent with past studies showing that Blanding’s Turtles inhabit productive, clean, shallow waters with abundant aquatic vegetation and soft muddy bottoms over firm substrates (Ernst et al., 1994). Microhabitat analysis revealed that Blanding’s turtles on Grenadier Island favored colder water with abundant floating and submerged aquatic vegetation and avoided open water. The wetland complex on Grenadier Island is relatively homogenous and remains largely undisturbed by human activities; thus, the lower predictive power of the model could be because little selection is needed in such a high-quality homogenous habitat (Edge et al., 2010).

Blanding’s Turtles may select for areas with greater densities of filamentous algae, submerged vegetation, and floating vegetation because they provide food and cover from predators (Ross and Lovich, 1992; Hartwig and Kiviat, 2007). Floating vegetation, submerged vegetation, and filamentous algae are known to harbor high densities of macroinvertebrates (Evans et al., 1999; Gaston, 1999; Yozzo and Diaz, 1999), which are a primary food for Blanding’s Turtles (Lagler, 1943). Because Blanding’s Turtles spent most (>70%) of their time underwater (Fig. 4), it is unsurprising that selection occurred for water column properties (e.g., floating vegetation, submerged vegetation, and water temperature).

Similar to the Blanding’s Turtles in Minnesota (Hamernick, 2000), Blanding’s Turtles on Grenadier Island did avoid some habitat types, most notably open water. The lack of basking sites and refuge from predators in open water could potentially make this habitat unattractive to turtles. Furthermore, open water typically lacks the abundance of potential food sources

![Graphs showing frequency of observed data (histograms) and predicted probability of selection as the percentage of floating vegetation, percentage of submerged vegetation, percentage of open water, and water temperature increases for Blanding’s Turtles (1 = turtle locations, 0 = random locations) followed by radio-telemetry on Grenadier Island, St. Lawrence Islands National Park, Ontario, Canada.](image)

**Fig. 4.** Frequency of observed data (histograms) and predicted probability of selection as the percentage of floating vegetation, percentage of submerged vegetation, percentage of open water, and water temperature increases for Blanding’s Turtles (1 = turtle locations, 0 = random locations) followed by radio-telemetry on Grenadier Island, St. Lawrence Islands National Park, Ontario, Canada.
and complex structural characteristics that habitats with more vegetative biomass contain.

Finally, we expected Blanding’s Turtles to select for warmer shallower water because of their thermoregulatory needs. Contrary to our expectation, Blanding’s Turtles selected sites with colder water. As the active season progresses, water levels fall, and surface water temperatures dramatically increase. During the hot summer months, turtles may select colder water to maintain their body temperatures within an optimal range that maximizes performance and fitness (Christian and Tracy, 1981; Huey and Kingsolver, 1989).

Interestingly, gravid females were more often found basking on floating vegetation and at the surface of the water than males and nongravid females. Basking behavior is often presumed to function in thermoregulation (Boyer, 1965; Crawford et al., 1983; Bulté and Blouin-Demers, 2011), and this trend could be a result of the higher energetic needs of gravid females (Congdon, 1989). Furthermore, accurate thermoregulation may have high reproductive benefits for adult females, such as speeding follicular development (Sarkar et al., 1996). In a study on the Yellow Margined Box Turtle (Cuora flavomarginata), Chen and Lue (2008) found evidence that gravid females maintained significantly higher shell temperatures during the nesting season (May to July). Following the nesting season, however, there were no significant differences in shell temperatures between males and females (Chen and Lue, 2008). Bulté and Blouin-Demers (2010) and Carrière et al. (2009) also found that gravid female Northern Map (Graptemys geographica) and Painted (Chrysemys picta) Turtles spent more time basking than males prior to and during the nesting season (May and June).

In summary, reproductive class and season influenced the behavior and spatial ecology of Blanding’s Turtles. Thus, management plans should take into account these two effects. It is not enough to separate males from females; gravid females must be separated from nongravid females. Furthermore, to meet the goal of conservation and management of this species, movements associated with nesting should be considered.

**Table 4.** Review of literature on the mean daily distance moved (DDM) by male (M), nongravid female (NGF), and gravid female (GF) Blanding’s Turtles.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>Mean daily distance moved (m/day) ± SE (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>Ontario</td>
<td>M: 199.42 ± 9.76 (9) NGF: 195.32 ± 15.57 (4) GF: 249.50 ± 16.96 (6)</td>
</tr>
<tr>
<td>Edge et al., 2010</td>
<td>Ontario</td>
<td>M: 83.5 ± 39.9 (5)</td>
</tr>
<tr>
<td>Innes et al., 2008*</td>
<td>New Hampshire</td>
<td>M: 27.55 ± 6.89 (4) NGF: 30.08 ± 14.15 (3)</td>
</tr>
<tr>
<td>Sajwaj et al., 1998</td>
<td>Minnesota</td>
<td>M: 22.75 ± 8.34 (4) NGF: 41.75 ± 8.83 (4)</td>
</tr>
<tr>
<td>Rowe and Moll, 1991b</td>
<td>Illinois</td>
<td>M: 48.9 ± 20.85 (4) NGF: 32.4 ± 22.66 (3)</td>
</tr>
<tr>
<td>Ross and Anderson, 1990c</td>
<td>Wisconsin</td>
<td>M: 48.4 ± 8.99 (21) GF: 95.1 ± 10.56 (56)</td>
</tr>
</tbody>
</table>

*The DDM was averaged over April–August to compare with other studies.

bThe DDM was only calculated within activity centers.

cThe minimum DDM was calculated.
Collectively, our results suggest that nesting excursions are primarily responsible for the differences observed between the reproductive classes in activity, movements, and home-range size and composition in Blanding’s Turtles.

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LITERATURE CITED


Table 5. Review of Blanding’s Turtle home-range sizes for males (M), non-gravid females (NGF), and gravid females (GF).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>Method</th>
<th>Mean home range size (ha) ± SE (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>Ontario</td>
<td>MCP</td>
<td>8.5 ± 1.7 (20)</td>
</tr>
<tr>
<td>Edge et al., 2010</td>
<td>Ontario</td>
<td>MCP</td>
<td>57.1 ± 15.3 (5)</td>
</tr>
<tr>
<td>Schuler and Thiel, 2008</td>
<td>Wisconsin</td>
<td>MCP</td>
<td>26.1 ± 9 (9)</td>
</tr>
<tr>
<td>Innes et al., 2008a</td>
<td>New Hampshire</td>
<td>MCP</td>
<td>6.6 (3)</td>
</tr>
<tr>
<td>Innes et al., 2008b</td>
<td>New Hampshire</td>
<td>MCP</td>
<td>3.7 (4) ± 1.5 (3)</td>
</tr>
<tr>
<td>Grgurovic and Sievert, 2005</td>
<td>Massachusetts</td>
<td>Fixed kernel (95%)</td>
<td>27.5 ± 0.10 (14)</td>
</tr>
<tr>
<td>Hamernick, 2000</td>
<td>Minnesota</td>
<td>MCP</td>
<td>38.4 ± 35.4</td>
</tr>
<tr>
<td>Pierrons and Lang, 2000</td>
<td>Minnesota</td>
<td>MCP</td>
<td>94.9 ± 58.4 (8)</td>
</tr>
<tr>
<td>Rowe and Moll, 1991b</td>
<td>Illinois</td>
<td>MPM</td>
<td>1.4 (4) ± 1.2 (3)</td>
</tr>
<tr>
<td>Ross and Anderson, 1990b</td>
<td>Wisconsin</td>
<td>MPM</td>
<td>0.76 ± 0.19 (2)</td>
</tr>
</tbody>
</table>

a Median values instead of averages.

b Measure of activity center size; excludes nesting forays and long distance movements.

c MPM is equivalent to the MCP method.

HAMERNICK, M. G. 2000. Home ranges and habitat selection of Blanding’s Turtles (Emydoidea blandingii) at the Weaver Dunes, Minnesota. Final report submitted to the Nongame Wildlife Program, Minnesota Department of Natural Resources.


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