Water Colour as a Predictor of Local Distribution of Blanding's Turtles, *Emydoidea blandingii,* in Nova Scotia

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The distribution of *Emydoidea blandingii* in Kejimkujik National Park, Nova Scotia, closely parallels the distribution of highly (darkly) coloured acidic waters and peaty soils. Mark-recapture and radio-tracking data, as well as observations of reproductive activity, showed that turtles maintained three discrete centers of activity within the park, each associated with highly coloured rivers or streams. At most of these locations, summertime activity of turtles was concentrated near the outflow into associated lakes. Individual selection for highly coloured waters was demonstrated by home range shifts of three males from one highly coloured water body to another, involving minimum movements of 5, 8.5 and 11.5 km overland.

Key Words: Blanding's Turtle, *Emydoidea blandingii*, distribution, water chemistry, Nova Scotia.

Blanding's Turtle, *Emydoidea blandingii* (Holbrook), is a northern freshwater species with a distribution centered in the Great Lakes region (Bleakney 1958; McCoy 1973; Gilhen 1984; Herman et al. *in press*). The species' main range extends from extreme southern Quebec and Ontario south and west to central Nebraska including parts of Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, and South Dakota. The species occurs patchily and at low densities over much of this range. Distinct local populations occur further east in New York, Massachusetts, New Hampshire, Maine and Nova Scotia. The most isolated of these is confined to the vicinity of Kejimkujik National Park in southwestern Nova Scotia (Bleakney 1958; Herman et al. *in press*).

The Nova Scotia population is restricted to an inland plateau characterized by summer temperatures higher than elsewhere in the province. It is considered to be a relict from a warmer climatic period and may have been spatially isolated for several thousand years (Bleakney 1958; Gilhen 1984). The status of this population in Nova Scotia has been designated "Threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1993 (Herman et al. *in press*).

The ancestral habitat of the species is believed to have been prairie marsh (Cahn 1937; Smith 1961), but modern macro-habitats vary, and include lakes, ponds, marshes, low fields, ditches, creeks, river sloughs and bogs (see references in Herman et al. *in press*). Cahn (1937) suggested that the increased variety of habitat presently used by *E. blandingii* may have resulted partly from destruction of habitat in its primary range. Despite this variety of macro-habitats, in most populations the species is associated with shallow, vegetated water (Conant 1938; Pope 1949; Carr 1952; Adams and Clark 1958; Ernst and Barbour 1972; Gilhen 1984; Kofron and Schreiber 1985), often with deep organic sediments (Ernst and Barbour 1972; Graham and Doyle 1979; Ross 1989; Ross and Anderson 1990).

As part of a study initiated by Environment Canada–Canadian Parks Service to determine the status of the Blanding's Turtle population in Nova Scotia, we examined physical and chemical habitat parameters associated with individual turtle captures. In this paper we examine the possible link between distribution and movements of turtles and distribution of highly (darkly) coloured acid waters in the Park.

Methods

An intensive mark-recapture and radio-tracking project was begun in the Park in 1987 (Power 1989). Lakeshore and riverine habitats throughout the park were sampled visually for hand-collection of turtles in 1987 and 1988 (approximately 1600 km by canoe, approximately 400 km on foot, approximately 2700 person hours). Additionally, habitats traditionally used by turtles (based on data of previous observers) were sampled with basking traps (MacCulloch and Gordon 1978) and baited hoop traps. As well, during waterfowl surveys of all water bodies in the Park during May and June 1988 (approximately 300 person hours) and 1989 (approximately 540 person hours) all observations of Blanding's Turtles were recorded. All turtles were assigned a unique set of marginal scute notches (Cagle 1939), in keeping with the system previously used in the Park. Temporary numbers painted on the carapace facilitated field identification.

Eight females and seven males from three areas in which turtles appeared most abundant were outfitted with radio transmitters. In order to describe seasonal movement patterns, these animals were tracked throughout the active season. In addition, turtles were periodically monitored at their overwintering sites. Data on forty-five turtles, captured throughout the Park and individually marked but not fitted with transmitters, provided additional information on movements and activity throughout the season.

The Aquatic Resources Inventory (1970-1973) and Kejimkujik Calibrated Catchments Program (1978-present) conducted in the Park (Kerekes 1986*) have provided extensive data on spatial and temporal patterns in water chemistry, including water colour and pH (Kerekes et al. 1986*, 1988; Kerekes 1973a*,1973b*, 1986*). In addition those waterbodies most heavily used by turtles were sampled for watercolor analysis during the present study.

Results

During the study 60 individual turtles were identified. Of the 1572 total captures and recaptures, 217 were made during visual surveys and 1291 were radio locations. Sixteen sightings were made during systematic waterfowl surveys of all waterbodies in the park. The most highly coloured waters in Kejimkujik occurred in small streams and lakes draining extensive and/or peaty catchments (Figure 1, Table 1). In general, Kejimkujik Lake and its tributaries were more coloured than the headwater lakes along the southern border of the Park. Water colour within individual water bodies increased with lake levels and/or discharge rates, but water colour varied consistently among water bodies (Kerekes 1986*; Kerekes et al. 1986; Kerekes and Freedman 1988*).

Based on our observations and those of the waterfowl surveyors (including the first author), the distribution of Blanding's Turtle in the Park closely parallels the distribution of these highly coloured acidic waters (Figure 1; Tables 1 and 2). Turtles occurred on ten rivers and streams, and occupied the margins of at least four associated lakes. All of these water bodies, with the exception of Grafton Lake, exceeded 60 Hazen units (H.u.) in colour (Table 1). At most of these locations turtles moved downstream to the lake inflow area in late spring, coincident with increasing water temperature, and moved back upstream in late summer. Three concentrations were apparent: (1) combined area of Atkin's Brook and West River drainages; (2) Heber Meadow Brook; (3) a small section of upper Mersey River (Figure 1).

TABLE 1. Water colour (Hazen units) and pH of waters used by Blanding's Turtle in Kejimkujik National Park, Nova Scotia.

Site[a]	Sample Date	Water Colour (H.U.)	pH[b]
1. Rogers Brook	16 VIII 88	210	–
2. Mersey River	11 VIII 88	110	5.4
3. Jeremys Bay	11 VIII 88	70	5.2
4. Heber Meadow Bk	11 VIII 88	400	–
5. West River	7 VIII 88	210	4.6
6. Atkins Brook	7 VIII 88	240	4.5
7. West River Brook #1	7 VIII 88	210	–
8. West River Brook #2	7 VIII 88	180	–
9. West R. Bay	7 VIII 88	200	–
10. Frozen Ocean L.	23 VIII 88	120	5.1
11. Inness Brook	21 VIII 88	160	–
12. Stewart Brook	21 VIII 88	200	–
13. Cannon Brook	14 VIII 88	220	–
14. Lake #28	14 VIII 88	240	5.1
15. Grafton Lake	24 VIII 88	5	6.0

[a]See Figure 1 for location of sites (by number).
[b]pH-based on data from various sampling dates.

Discussion

The three general areas of turtle concentration had previously been identified during a marking program in the park between 1969 and 1982 (Weller 1971-72*; Thexton and Mallet 1977-79*), but since observers relied on visual sightings primarily during the nesting season, the picture of turtle distribution was incomplete. In particular, early observers failed to recognize the extent to which turtles used smaller, highly coloured streams.

Some of these early observations associated turtles with water bodies that were not used outside the nesting season. Grafton Lake, which is relatively clear (Table 1), was long considered an important habitat for Blanding's Turtle (Bleakney 1958, 1963). However, most sightings at this location were of nesting females on nearby roadways or on the dam at the lake outlet (Bleakney 1958, 1963, 1976*; Thexton and Mallet 1977-79*; Weller 1971-72*). Sightings on the lake itself were limited (Dobson 1971; Brownlie, personal communication; Hope personal communication; Swain, personal communication; this study), and most were adjacent to the highly coloured inflow from Little Kempton Lake (220 H.u.; Number 16, Figure 1).

Although turtles concentrated their activity in the three areas described above, some individuals moved from one highly coloured water body, through less coloured waters, to another highly

*Citations marked with an asterisk are unpublished documents and are listed separately following the Acknowledgements and before the Literature Cited sections.

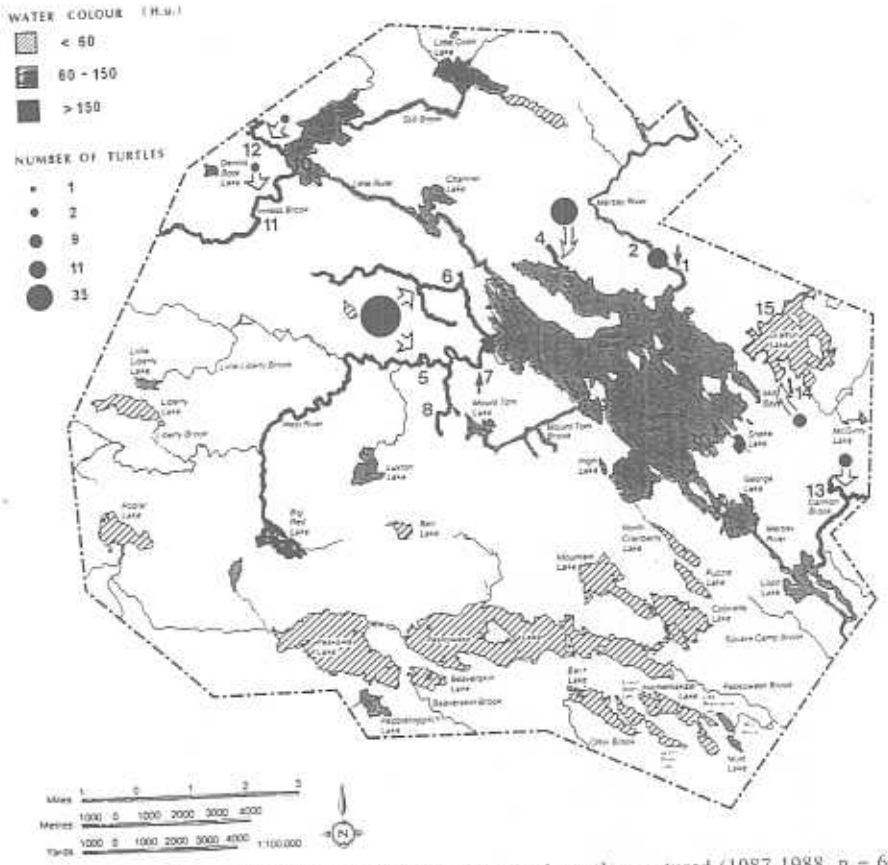

FIGURE 1. Water colour and number of individual Blanding's turtles captured (1987-1988, n = 60) in Kejimkujik National Park, Nova Scotia (see Table 1 for pH and water colour at specific capture locations (1-15)).

coloured water body. Comparison of historical records with our observations show that two males shifted their home ranges among these areas, moving minimum distances of 5 and 11.5 km over their lifetime. Such shifts may occur abruptly. In less than 14 days one radio-tagged male in our study moved a minimum of 3 km overland to establish residency (for at least one year following) in a small unnamed lake (Number 28, Figure 1) with exceptionally dark water (240 H.u.). This lake is approximately 8.5 km from the home range that he used in 1987 as well as in previous years for which there are records. These shifts, involving movements through less coloured waters, indicate active selection of areas characterized by highly coloured waters.

It is unlikely that the parallel between distribution of turtles and highly coloured waters is an artifact of biased sampling. Historical observations did not result from systematic sampling but rather were incidental to other field work. There is no indication that that work was carried out disproportionately in highly coloured waters. As well, the independently conducted survey of breeding waterfowl in 1988 and 1989 revealed no incidental sightings of *E. blandingii* in clear water bodies (Table 2). Blanding's Turtles in Maine also prefer dark waters, particularly those associated with shallow, heavily vegetated, slow-moving streams (Graham 1992).

Why are turtles associated with highly coloured waters and peaty soils in the Park? Blanding's Turtles are primarily carnivorous (Cahn 1937; Conant 1938; Lagler 1943; Carr 1952; Graham and Doyle 1977; Kofron and Schreiber 1985), and in Nova Scotia consume aquatic macro-invertebrates, tadpoles and fish (Bleakney 1963; Weller 1971-72*; this study). If the association is food-related, these areas should be characterized by high secondary productivity. Although secondary productivity in Kejimkujik is not particularly high (Schell and Kerekes 1988), Kerekes

TABLE 2. Incidental sightings of *E. blandingii* during waterfowl surveys in waterbodies of Kejimjujik National Park, grouped according to water colour.

Water colour sightings (Hazen units)	Waterbodies surveyed	Number with turtle sightings			Number of sightings		
		1988	1989	total	1988	1989	total*
<60	16	0	0	0	0	0	0
60 – 150	20	2	2	4	3	2	5
>150	10	4	2	6	6	5	11
Total	46	6	4	10	9	7	16

*Number of waterbodies surveyed vs. total number of sightings: $\chi^2 = 13.75$, $p < 0.001$

and Freedman (1989) showed that macro-invertebrate productivity is significantly greater in highly coloured waters, regardless of acidity, than in water bodies with clear water. Primary productivity is often reduced in highly coloured waters due to rapid attenuation of light, but secondary productivity may be enhanced by the input of organic materials. Allochthonous material is probably greatest on small lakes and first order streams draining organic substrates and at the inflows of these streams on larger lakes. These are precisely the areas most used by *E. blandingii* in the Park.

An analysis of soil maps for the park (Cann and Hilchey 1959; Hilchey et al. 1962; MacDougall et al. 1969) indicates that peaty soils may be even a better predictor of *E. blandingii* distribution than water colour. Within highly coloured waters turtles were concentrated in areas with peaty substrate.

Concentration of summertime activity of turtles near the lake inflows of smaller highly coloured streams is probably associated with feeding, and suggests that secondary production in these areas is relatively higher than elsewhere on the lakes. Other predators, including Painted Turtles (*Chrysemys picta*), Great Blue Herons (*Ardea herodias*), and ducks were also observed in these areas. Throughout the study area, Painted Turtles were more widespread than *E. blandingii* but showed similar patterns of relative abundance. In contrast, Snapping Turtles (*Chelydra serpentina*) may reach their highest densities in the park on clear water lakes (authors unpublished data). Although we have demonstrated an apparent association between *E. blandingii*, peaty soils and highly coloured waters, further work on production and feeding dynamics in these areas, particularly streams, is needed. Improved understanding of this association might allow us to predict the location of additional yet undiscovered populations of this species in Nova Scotia.

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