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In Stream, Streamside, and Under Stream Bank Movements of a Bog Turtle, *Glyptemys muhlenbergii*

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ABSTRACT. - Movements of a bog turtle, *Glyptemys muhlenbergii*, outside of characteristic wetland habitat were recorded using radiotelemetry. Data suggest that permit reviewers and park managers should consider the conservation implications of stream use, undercut banks, and streamside habitat in formulating mitigation and management plans within the range of this federally protected species.

Bog turtle *(Glyptemys muhlenbergii*, formerly *Clemmys muhlenbergii)* habitat is typically characterized as spring-fed wetlands with little canopy, flowing water, and soft, mucky substrates (Lee and Norden 1996; Buhlmann et. al 1997; Herman and Tryon 1997; Somers et. al 2000). A number of authors have reported long distance movements of bog turtles outside of characteristic wetlands and into a variety of other habitats both wet and dry (Ernst 1977; Herman and Tryon 1997; Carter et al. 2000; Somers et al. 2000). Noncharacteristic wet habitats utilized include first- and second-order streams, seepages, and restored wetlands. Dry habitats where turtles have been radio-tracked or found include forested uplands, lowland valleys, cultivated areas, roads, and ridges far from known wetlands (Herman 2003; Tryon 2004). The rarity of such reports and the absence of in-stream, streamside, and under stream banks reports makes any new accounts of these movements important in establishing permit review protocols, conservation plans, and management practices for this federally protected species.

In June 2000, a fisherman in a state park in the western Piedmont of North Carolina found a female bog turtle in a rhododendron thicket adjacent to a stream. The age of the animal was estimated at 13 years by counting annuli on the carapace and plastron. Sections of the stream within the park were classified using the Rosgen System as types B4c and C4 moving toward D4 (North Carolina Stream Restoration Institute 2000). In 1977, a bog turtle was also found on a road within the same park, but no characteristic bog turtle wetlands are known within the park. An area of hydric soils, downstream from where the turtle was last seen, may have once been a functioning mountain bog but is now too dry to support a diverse bog community (North Carolina Stream Restoration Institute 2000). The initial capture was intermediate between the closest known confirmed bog turtle wetlands, which are estimated to be at straight-line distances of 3.6 km south, 5.3 km southwest, and 4.9 km northeast.

A transmitter was attached to the turtle (as in Eckler et al. 1990) prior to release at the point of capture. The turtle was radio-tracked 43 days, from 24 June 2000 to 14 August 2000, when the signal was lost. An intensive effort by 8 researchers searching in the vicinity of the last recorded transmission failed to locate the bog turtle.

Tracking occurred during trout season when the park was experiencing periods of high visitor activity in and around the stream. The turtle moved over 800 m downstream using a variety of stream and streamside habitats. Upstream movements to 150 m were recorded within this period of downstream movement. The turtle's activities included swimming along the water's edge, basking on and around small to large-sized rocks and rootstocks, and frequent use of undercut banks covered with root wads (Fig. 1). Movements away from the stream were correlated with periods of heavy rains and evening thunderstorms. While away from the stream the turtle rested under pine debris and in thick vegetation. On one occasion the radio signal was detected coming from the root cavity of a large tulip polar *(Liriodendron tulipifera)* 3.5 m from the stream where the turtle was resting underground. She was also observed several times in very conspicuous locations and could have easily been seen by any fisherman or hiker in the area.

Safeguarding turtles in public areas is a resource protection problem. Throughout this study there were concerns for the turtle's safety because of heavy visitor activity. The fate of the turtle is unknown, and the possibility that a park visitor removed her cannot be ruled out. Garber and Burger (1995) demonstrated that public access to protected areas could result in turtle population declines. Population losses related to human activity include removal and handling of turtles by visitors, turtle mortality on roads, and increased predation resulting from rising predator populations subsidized by human trash and waste. They recommended that public parks take stronger measures to deter the public from disturbing turtle populations. Widner and Roggenback (2000) found that park visitors were less likely to take park relics when informed about park regulations by volunteers in uniform and when parks displayed explicit signs that detailed the park's rules and the legal consequences of breaking them. We support their recommendations that appropriate literature, signage, and programs be developed to educate park visitors about the importance of leaving resources undisturbed.

Figure 1. A transient bog turtle utilized this and other stream bank undercuts and root wads.

Bog turtle populations are often small (Buhlmann et al. 1997; Herman and Tryon 1997) and hence are vulnerable to demographic stochasticity and extinction. The characteristic wetlands of bog turtles are essentially habitat islands; movements between sites likely assist in maintaining genetic variation in the populations and support colonization or recolonization of suitable sites. The probability of population extinction may increase if movement between sites is restricted (Gibbs 1993; Semlitsch and Bodie 1998; Carter et al. 2000). Genetic similarity is greater between bog turtles in the same drainage than between adjoining watersheds (King, in Herman 2003), consistent with extensive use of wet corridors. Although the turtle movement reported here was along a stream corridor, bog turtles clearly use upland routes for dispersal (Herman 2003; Tryon 2004). The diversity of pathways used suggests that landscape-level protection would offer the best opportunity for gene flow between populations.

We are unaware of any reports of bog turtles utilizing undercut banks in streams prior to this account. Permit reviewers should recognize this potential when environmental impact is expected from projects in streams within the range of the bog turtle.

Johnson and Gaines (1990) suggested that studying dispersal and patterns of movement is important in understanding distribution, social behavior, genetic structure, and persistence of populations. Information regarding distance, timing, and proximate cues for movement is essential to further understanding the behavior and ecology of turtles. Bog turtles may make large-scale movements more frequently than suggested by Carter et al. (2000) because their tracking studies averaged only 2 years in duration. Long-term radio-tracking studies, such as those being conducted by Tryon (2004), may reveal that bog turtles move more frequently than previously thought and depend on a diversity of habitats. Knowledge of what motivates turtles to move outside of wetland patches, distances traveled, and how dispersals affect turtle population genetics and demographics will require additional study, as the conservation implications of movement restriction are not well understood at this time.

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