Habitat variables influencing breeding effort in northern clade
*Bufo fowleri*: Implications for conservation

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**Abstract.** Local extirpations of the northern clade of Fowler’s toad, *Bufo fowleri*, have been documented in the northeastern United States and Canada. To facilitate conservation of this species, we identified key characteristics of its preferred breeding habitat and adjacent landscape at Cape Cod National Seashore. We conducted calling surveys at 67 wetlands to quantify *B. fowleri* annual breeding effort over three years. The resultant multivariate models were then tested with data collected at 30 additional wetlands. *B. fowleri* choruses were more likely to be detected in permanent wetlands than semi-permanent or temporary wetlands. Predaceous fish and *Rana catesbeiana* did not negatively affect breeding effort. Wetlands used for breeding typically had shallower shores, less emergent vegetation, less canopy cover, fewer organic acids, and were warmer and less acidic than sites with no evidence of breeding choruses. Large choruses of *B. fowleri* typically occurred in wetlands containing < ~33% woody emergent vegetation and adjacent uplands had more bare habitat and less development than sites without breeding. Our results suggest that *B. fowleri* in the northeastern United States will decline as development and post-agrarian reforestation continue and that removal of woody vegetation in and adjacent to breeding ponds may be necessary to maintain some populations.

**Key words:** Amphibian conservation; *Bufo fowleri*; Cape Cod National Seashore; regression tree analysis; species-habitat models.

**Introduction**

Fowler’s toad, *Bufo fowleri* (Hinckley), is a semi-fossorial habitat specialist associated with early successional habitats containing well-drained substrates (Green, 2005). This species is widely distributed, but because of its association with sandy, early successional habitats (Green, 2005), which occur mostly along the coast, it has a patchy distribution, especially in inland New England, USA (Klemens, 1993).
Recent research indicates that its natural range is smaller than previously thought. Masta et al. (2002) identified three genetically distinct clades; northern, central and southern. Some subpopulations of the *B. fowleri* complex are stable in the United States, however the northern clade appears to be declining in some localities in the northeastern United States. In Canada, *B. fowleri* is federally protected as a Threatened species (Oldham, 2003).

Factors affecting *B. fowleri* populations include habitat degradation (Breden, 1988; Klemens, 1993; Mierzwa et al., 1998), pesticides (Lazell, 1976), road mortality (Cook, unpublished data) and hydroperiod alterations (Tupper, 2001). It is likely that the northern clade of *B. fowleri* will continue to decline in the Northeast due to continued urban sprawl along the heavily populated coastal plain where *B. fowleri* primarily occurs (Klemens, 1993). In addition, post-agrarian reforestation (Eberhardt et al., 2003) and resultant extirpations of amphibians dependent on open-canopy wetlands (Skelly et al., 2002) may negatively impact local populations of *B. fowleri*.

Here, we facilitate the conservation of *B. fowleri* at Cape Cod National Seashore, a heavily-visited natural area, by modeling the relationship between abundance (breeding effort) and key abiotic, physical, and biological features of this clade’s breeding wetlands and adjacent landscape. Our main objective was to identify key habitat characteristics that can be used by biologists and land managers to recognize wetlands that likely support large breeding aggregations of *B. fowleri* in the northeastern United States and Canada.

**Methods**

We conducted fieldwork within and immediately adjacent to Cape Cod National Seashore (17 646 ha) in Barnstable County, Massachusetts (for a detailed description of study area see Tupper et al., 2007). We used a stratified-random selection scheme with wetland hydroperiod [i.e. permanent (wetlands that contain water year-round), semi-permanent (wetlands contain plants that require a near permanent hydrology, but water levels fluctuate so wetlands dry occasionally, but not annually) and temporary (wetlands that dry annually)] as the stratifying criterion to select 67 study sites (Tupper, 2006).

**Calling anuran surveys (CAS)**

We sampled *B. fowleri* at these sites with standardized calling anuran surveys (CAS; Weir and Mossman, 2005) in 2003, 2004 and 2005 during the peak vocalization period (between 15 May and 11 July) (Paton et al., 2003; Tupper et al., 2007). We conducted CAS weekly from sunset until approximately midnight and rotated the order sites were sampled to avoid potential temporal sampling biases (Tupper et al., 2007). Each site was sampled 22-25 times over the three seasons. Thirty additional sites (selected with the same stratified-random selection criterion) were sampled in