Macrohabitat models of occurrence for the threatened Cheat Mountain salamander, *Plethodon nettingi*

Lester O. Dillard\(^1\,^2\), Kevin R. Russell\(^1\,^3\) and W. Mark Ford\(^4\)

\(^1\) College of Natural Resources, University of Wisconsin-Stevens Point, 800 Reserve Street, Stevens Point, Wisconsin 54481, USA
\(^2\) Present address: Department of Biology, University of Central Florida, 4000 Central Florida Boulevard, Orlando, Florida 32816, USA
\(^3\) Corresponding author; email: krussell@uwsp.edu
\(^4\) USDA Forest Service, Northern Research Station, P.O. Box 404, Parsons, West Virginia 26287, USA

**Abstract.** The federally threatened Cheat Mountain salamander (*Plethodon nettingi*; hereafter CMS) is known to occur at approximately 70 small, scattered sites in the Allegheny Mountains of eastern West Virginia. We used a comparative modeling approach to explain the landscape-level distribution and habitat relationships of CMS in relation to a suite of biotic and abiotic habitat variables measured across the species’ range. We collected data on 13 explanatory macrohabitat variables at CMS-occupied (\(n = 180\)) and random (\(n = 180\)) sites. We then examined CMS-macrohabitat relationships using a priori, logistic regression models with information-theoretic model selection, classification tree modeling, and discriminant function analysis. Among logistic regression models, a model containing the variables elevation, aspect, slope, and lithology received the strongest empirical support, although a model containing these variables and current vegetation type also received limited support. Variable selection within our classification tree and discriminant function modeling was consistent with logistic regression results. Common variables in all three approaches indicated that the probability of finding CMS across the species’ range increased in areas at higher elevations and underlain by sandstone. Validation of models with empirical support using reserved data indicated that classification accuracy was \(\geq 80\%\) for all three analytical methods. Finally, we linked model outputs from all three methods to GIS coverage maps that predicted CMS occupancy within the study area. Our results indicate that geophysical and ecological characteristics measured at large spatial scales may be useful for quantifying salamander habitat relationships in forested landscapes, and more specifically increase the capacity of managers to locate and plan for the continued persistence and recovery of CMS.

**Key words:** Cheat Mountain salamander; classification tree; discriminant function; distribution; endangered species; GIS; habitat; information theory; landscape; macrohabitat models; *Plethodon nettingi*. 

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Introduction

Conservation of vertebrate diversity increasingly requires elucidating habitat relationships at large spatial scales (Guisan and Zimmermann, 2000; Maurer, 2002). However, habitat relationship studies for most taxa remain focused on characterizing habitats at small, site-level scales. In particular, patterns of amphibian distribution across large spatial scales remain poorly known (Hecnar and M‘Closkey, 1996; Johnson et al., 2002). Because amphibians have limited dispersal abilities and small home ranges (Petranka, 1998), site-specific habitat factors often are assumed to have an overriding influence on patterns of amphibian distribution. However, there is increasing evidence that habitat characteristics measured at broad spatial scales are important predictors of amphibian occurrence and abundance (Gustafson et al., 2001; Welsh et al., 2004; Stoddard and Hayes, 2005; Suzuki et al., 2008). Moreover, development of effective habitat conservation strategies for amphibians may be limited by the historical paradigm that condition of site-level vegetation is equivalent to habitat suitability. Although vegetation composition and structure often exert a strong influence on amphibian distribution and abundance (deMaynadier and Hunter, 1995; Russell et al., 2004a), recent research indicates that the importance of abiotic habitat features such as geology, topography, and climate have not been sufficiently recognized (Diller and Wallace, 1996; Sutherland and Bunnell, 2001; Russell et al., 2004b, 2005).

The Cheat Mountain salamander (Plethodon nettingi; hereafter CMS) is a small terrestrial plethodontid endemic to high-elevation, red spruce (Picea rubens)-dominated forests of the Allegheny Mountains in Tucker, Randolph, Pocahontas, Grant, and Pendleton counties of eastern West Virginia (Green, 1938; Green and Pauley, 1987). The species is restricted to approximately 70 isolated sites distributed across an area of approximately 1800 km² (Pauley and Pauley, 1997; Petranka, 1998). Most (75%) known CMS populations reportedly consist of \( \leq 10 \) individuals and \( \geq 80\% \) of populations occur on the Monongahela National Forest (MNF; USDI Fish and Wildlife Service, 1991).

Cheat Mountain salamanders were listed as a threatened species in 1989 (USDI Fish and Wildlife Service, 1991). Historically, its range possibly was more extensive than the current restricted distribution (USDI Fish and Wildlife Service, 1991). However, intensive logging combined with large wildfires in the region eliminated \( \geq 93\% \) of red spruce forests by 1920 (Clarkson, 1964; Clovis, 1979; Mielke et al., 1986), which in turn was thought to have caused the extirpation of many CMS populations. Although no published studies have directly assessed the impacts of these landscape events on CMS, presumably this species’ response is analogous to that of other woodland salamanders to the microclimatic, vegetational, and structural changes that occur after forest disturbances such as timber harvest (deMaynadier and Hunter, 1995; Russell et al., 2004a; Riedel et al., 2008). Pauley and Watson (2003) found that CMS abundance increased with distance from forest opening edge created by forest regeneration areas, ski trails and roads. In addition to legacy habitat disturbance, recent or ongoing forest management, surface mining,