Chapter 59
Species Distribution Modeling of American Beech (Fagus Grandifolia) Distribution in Southwest Ohio

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ABSTRACT

The ability to predict American beech distribution (Fagus grandifolia Ehrh.) from environmental data was tested by using a geographic information system (GIS) in tandem with species distribution models (SDMs). The study was conducted in Butler and Preble counties in Ohio, USA. Topography, soils, and disturbance were approximated through 15 predictor variables with presence/absence and basal area serving as the response variables. Using a generalized linear model (GLM) and a boosted regression tree (BRT) model, curvature, elevation, and tasseled cap greenness were shown to be significant predictors of beech presence. Each of these variables was positively related to beech presence. A linear model using presence only data was not effective in predicting basal area due to a small sample size. This study demonstrates that SDMs can be used successfully to advance one's understanding of the relationship between tree species presence and environmental factors. Large sample sizes are needed to successfully model continuous variables.

INTRODUCTION

At one time, a vast deciduous forest covered nearly all of the state of Ohio (Schwartz et al. 2001). American beech (*Fagus grandifolia Ehrh.*) represented the successional climax of this forest in southwestern Ohio (Braun, 1936). In a region with little in the way of major disturbance, beech came to dominate the landscape (Braun, 1936; Runkle, 1990). In fact, beech accounted for 1 in every 2 overstory trees in some

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parts of southwestern (SW) Ohio's pre-European settlement forest (Shanks, 1953; Braun, 1936). Today, beech is much less common in SW Ohio, and there is evidence that beech populations are in decline (Runkle, 1990; Fore et al. 1997; Runkle, 2000; Widdmann et al. 2009). Beech mortality is expected to be exacerbated as beech bark disease (BBD) spreads west across Ohio with an expected arrival in SW Ohio around 2020 (Widdman et al. 2009; Morin et al. 2007). Species distribution modeling has been shown to be an effective tool in advancing our understanding of how site characteristics influence species abundance (Tatsuhara and Antatsu, 2007). Despite the historically prominent role of beech in Ohio forests, its decreasing population, and the threat of BBD, species distribution modeling has not been applied to American beech.

In this study, we investigated the effectiveness of using species distribution modeling to predict the abundance of beech in SW Ohio forests from site characteristic data, and to discern what site characteristics are important in determining how much beech is observed at a given site. Many studies have sought to better understand the interactions between site characteristics and beech presence, but no study has yet tested whether or not these site characteristics can be used to predict beech abundance. By utilizing a geographic information system (GIS) in tandem with a species distribution model (SDM), we tested the ability to predict beech abundance from site characteristic data.

Species Distribution Modeling

Species distribution models (SDMs) use environmental predictor variables and field data to produce a spatially explicit, statistically derived response surface (Guisan and Thuiller, 2005). Generally, accurate prediction of a species' distribution is the primary goal of a SDM. Quantifying relationships between a species and an environmental gradient is typically a secondary concern (Austin, 2002). Predictor variables capture the influence on a species' population distribution from limiting factors, disturbances, or resources (Guisan and Thuiller, 2005). SDMs have a heavy theoretical reliance on the niche concept in ecology (Guisan and Thuiller, 2005). SDMs have been used to investigate a variety of ecological questions (quantifying the environmental niche of a species), as in this study (Austin et al. 1990). Other recent studies have relied on SDMs to better understand how invading non-native species impact native plant populations. For example, Lemke et al. (2011) studied the potential impacts of Amur honeysuckle (*Lonicera maackii*) in the Cumberland Plateau region of Tennessee, USA. Clark et al. (2012) used SDMs to find out how susceptible eastern hemlock (*Tsuga canadensis*) populations are to spreading hemlock woolly adelgid in eastern Kentucky, USA. Weber and Boss (2009) modeled mature forests as part of an effort to assess the value of certain areas to wildlife in Maryland, USA. Many studies have modeled how tree distributions may be altered under various future climate change scenarios. Table 1 summarizes some other uses of SDMs in ecology and biogeography.

Beech Site Characteristics

American beech is a very shade tolerant, late successional species common to the eastern deciduous forest of North America. Beech is found as far north as Nova Scotia and southern Canada and extends south to the panhandle of Florida. It occurs as far west as East Texas and Arkansas and into parts of Illinois (Tubbs and Houston, 1990). Temperature limits the range of beech north (growing season warmth) and south (high summer temperature) while precipitation limits its westerly extent (Fang and Lechowicz, 2006). Because climatic variables are relatively homogenous across SW Ohio, climate variables are