Determining habitat suitability of Asian longhorn beetle *Anoplophora glabripennis* in Massachusetts, U.S. using the Mahalanobis typicality approach

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Introduction

The introduction of invasive species to new ecosystems is an unexpected ecological consequence of international trade. Invasive species in the U.S. account for billions of dollars annually in economic and environmental damage and control costs.

Insect pests that target tree species are of particular concern due to extensive forest ecosystems throughout the U.S. that support native biodiversity and regional economies. New England mixed deciduous forests are highly vulnerable to invasive insect species and have already experienced drastic changes in forest structure throughout the region.

Asian longhorn beetle

The Asian longhorn beetle *Anoplophora glabripennis* is a new invasive insect in Massachusetts that is native to China and Korea (Cavey et al. 1998) and was accidentally transported to the U.S. in solid wood packing material (Britton and Nair 2003). Adult female *A. glabripennis* deposit eggs into the bark of the host tree, which develop into larvae and feed on the cambium tissue. Identifying *A. glabripennis* locations and characterizing spread is a critical step in a monitoring and management program.

The objective of this study is to determine habitat suitability of *A. glabripennis* in Worcester using species distribution modeling and a distance operator.

Figure 1. Asian longhorn beetle and evidence of damage in Worcester. *Photos provided by Eric Reynolds courtesy of Michael Bohne, USDA Forest Service*

Species distribution models

Species distribution models (SDMs) determine the current or potential distribution of a target species. Models that use presence only data characterize invasive spread by linking the response variable to the fundamental niche, which is critical to determine the maximum potential range of the target species (Ward 2007). Predictive mapping of *A. glabripennis* is a preventative approach that will identify locations most suitable to future spread.

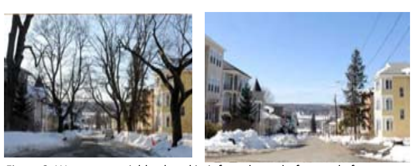


Figure 2. Worcester neighborhood in infested area before and after tree removal. *Photos from Worcester Telegram and Gazette 3/7/09*

Study Area

The study area is composed of ten towns in the center of Worcester County, MA and is approximately 227 square miles. The dominant land-cover is deciduous and mixed forests.

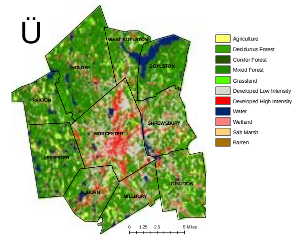
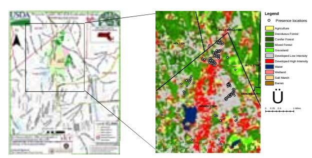


Figure 3. Land cover of study area

Data

Independent predictors include PRISM data for average annual precipitation from 1971-2000, elevation from MassGIS, MODIS temperature data, and an NDVI image. Point data from the city of Worcester denoting presence of infested host trees were not available for this analysis due to privacy of residents. Therefore points were digitized based on a USDA map of outlying infestations using a streets layer as guide. This analysis used 157 presence locations.

Dependent Variable



Independent Variables

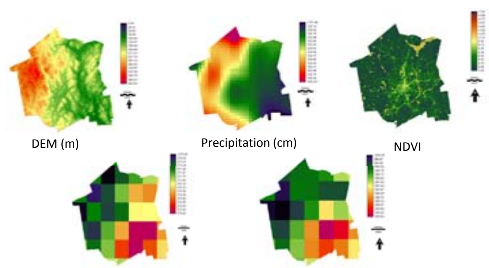


Figure 5. Independent predictor variables used in the study

Methods

Mahalanobis typicality calculates a similarity statistic from 0-1 (Hernandez et al. 2008), where a value of 1 indicates the location has ideal conditions equal to the mean of the data points and decreasing values signify less suitable locations. This analysis used Mahalclass in Idrisi to aggregate the independent variables into a typicality map using a signature file of the dependent data. It also incorporated distance based on an average dispersal rate of 30 meters per day and a beetle life span of 83 days (Smith et al. 2004).

Results

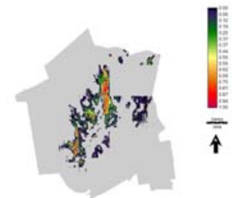


Figure 6. Typicality image using all 5 predictors

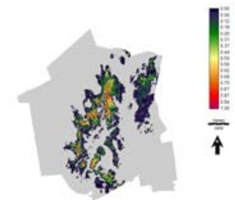


Figure 7. Typicality image without temperature data

Figure 6 illustrates the typicality surface for the study area based on all 5 independent variables. Red areas depict high suitability for *A. glabripennis.* Yellow areas depict moderate typicality and blue-to-grey areas depict low typicality for *A. glabripennis.* Figure 7 shows the typicality output without temperature data. Typicality values for urban Worcester are 0.0001. There are high typicality values clustered around the heavy infestation are and along the western perimeter of urban Worcester.

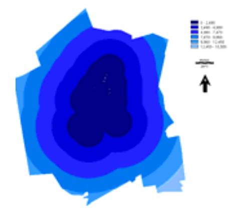
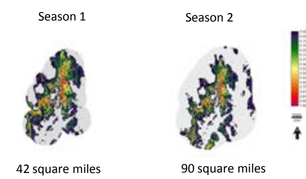


Figure 8. Classified image of distance to current infestation



Discussion

The Mahalclass algorithm determines *typical* species locations using the combined mean value for each independent variable based on all the sites of presence. The coarse temperature and precipitation data somewhat constricted typicality outputs. The NDVI predictor was the most important independent variable for both typicality surfaces. The distance analysis is based on an average rate of dispersal of 2,490 meters per season, however adults are capable of migrating over 1 kilometer per day. The distance image shows baseline projections of how the infestation might spread outward from urban Worcester on a season by season basis.

References

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