

RETROSPECTIVE ANALYSIS OF EAB SPREAD: UNDERSTANDING THE EFFECT OF LANDSCAPE PATTERN ON INVASION AND PROPAGATION

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ABSTRACT

Spread of emerald ash borer (*Agrilus planipennis* Fairmaire, EAB) in the United States has been rapid and extensive. Nearly 10 years after its initial detection near Detroit, Michigan, EAB is now found in 15 states spanning a radius greater than 500 miles. While human activity has been central to facilitating the spread of EAB over long distances, the role of landscape pattern is not well understood. The purpose of this study was to gain a better understanding of how landscape pattern influences the spread of EAB at a large scale. Specifically, we wanted to: (1) determine how well landscape metrics predict the presence or absence of EAB, (2) provide a means to model the spatial distribution of future infestations, and (3) use spatial statistics to assess the directional trend of EAB occurrence.

A classification regression tree model was created to represent an objective, data-driven analysis of EAB presence/absence in Illinois, Indiana, Kentucky, and Ohio between 2002 to 2011 (as of August 2011). Counties were used as analysis units to match the accuracy of available data and because they are well-suited to regional or statewide planning and mitigation efforts. For each of the 743 counties, data describing landscape-scale factors that could potentially influence the spread of EAB were assembled (see Figure 1 for a list of variables). Metrics for host density (e.g. trees per acre), forest distribution (e.g. proportion of forest edge), and landscape features (e.g. population density) were aggregated by county for model development. Because infestations began to occur more frequently in counties with relatively higher proportions of forest in 2008, detection year was used to split the data into 2 models: period of initial EAB invasion or introduction (INTRO, 2003-2007) and subsequent EAB propagation (PROP, 2008-2011). The Random Forests statistical classification algorithm (Breiman 2001) was used to relate EAB presence/absence to landscape variables for each of the two periods. The models were then used to predict the progression of EAB presence through counties in Iowa, Minnesota, and Wisconsin. Additionally, a standard deviational ellipse was used to determine the directional trend of EAB presence over time across all seven states (IL, IN, KY, OH, IA, MN, and WI).

Landscape variables had a high success rate when predicting EAB presence/absence. In the 4-state study area, accuracy of the classification model was 88% and 83% for the INTRO and PROP time periods, respectively. Human population density and forest pattern metrics, including percentage of core and edge forest, were the most important variables in predicting the presence or absence of EAB (Fig. 1). Urbanized/ highly fragmented landscapes with a low proportion of forest had an initially higher likelihood of EAB presence and relative importance of the explanatory variables varied

from one time to the next. Additional trials were conducted in which spatial information was included in the model, and preliminary results indicate accuracy can be increased by 3-4% by including distance to infestation epicenter as an explanatory variable. Projections of EAB presence for Iowa, Minnesota, and Wisconsin cannot be validated. However, the forecast for the INTRO period resembles the current distribution of EAB presence and provides an indication of future risk and EAB distribution. The directional trend of EAB distribution across the 7-state area shows that the spatial pattern of infestation changed from nearly isotropic during the INTRO period to a SE/NW directional trend in the PROP period (Fig. 2). As human population density has a large influence on EAB presence, the change in directional trend could be a result of movement through the metropolitan area of Chicago, IL and north to Minneapolis/St. Paul, MN. This is an indication that future projections of EAB should not assume simple transmission from one county to the next.

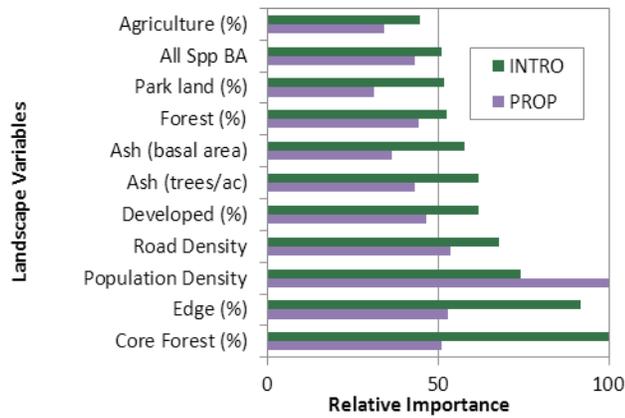


Figure 1. Relative importance of explanatory landscape variables used to model the presence/absence of EAB for the INTRO and PROP time periods. (Note: Importance does not necessarily indicate a positive relationship between the variable and EAB presence.)

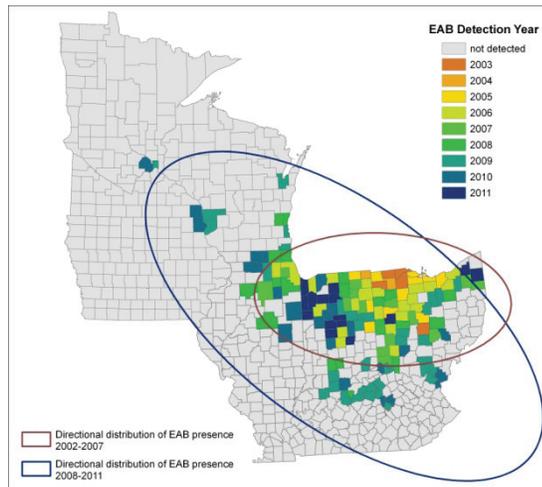


Figure 2. Directional trend (standard deviational ellipse) of EAB occurrence for the INTRO and PROP time periods, MN, WI, IA.

Future work will focus on model enhancements with the aim of accounting for spatial auto-correlation and improving prediction accuracy through better use of spatial or neighborhood information. Climate information will be added to the model to account for the effect of extreme cold weather on EAB propagation. Finally, we will examine strategies for incorporating non-detection probability.

REFERENCES

Breiman, L. 2001 Random forests. *Machine Learn.* 45:5-32.