

ECOSYSTEM URBANICITY AS A POTENTIAL FACTOR FOR ALIEN SPECIES INVASIONS

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ABSTRACT

One of the major challenges we face in relation to invasive species is to understand and incorporate the complexity of the human dimension in our preparedness to minimize the risk and impacts of invasions. The challenge is not actually to achieve a high level of understanding, but rather to increase our understanding fast enough so we can help managers in the short term to implement measures that mitigate the potential for invasions or reduce their impacts. To this end we began analyzing past and current human-mediated invasions by alien forest pests. The goal was to detect patterns that would allow us to develop potential indicators of future invasions. We made the assumption that most factors linking humans and invasive species were related to urban areas. After all, urban areas are hubs of acquisition, processing, and distribution of international and domestic goods. In addition, urban areas are the places where most international passengers arrive. Thus, it follows that the intensity of the interactions between forest ecosystems and urban centers would contribute to risk of accidental introductions of alien forest pests. Using this rationale, we developed the concept of “ecosystem urbanicity,” which we define as the degree of potential exposure by ecosystems to urban-driven interactions. In developing a quantitative approach to this concept, we considered two factors as the main drivers of ecosystem urbanicity: (a) the proximity of forest ecosystems to urban areas, and (b) the size of the neighboring urban populations.

For this study we assessed the usefulness of the ecosystem urbanicity concept in relation to alien invasive species in forest ecosystems. First, we quantified the ecosystem urbanicity of county-level forest land in the contiguous U.S. Then we analyzed the patterns of ecosystem urbanicity for those counties where selected alien forest pests were reported in recent years. For this study, we focused on four invasive species: the Asian longhorned beetle (*Anoplophora glabripennis* (Motschulsky)), the emerald ash borer (*Agrilus planipennis* Fairmaire), the Sirex woodwasp (*Sirex noctilio* Fabricius), and the sudden oak death pathogen (*Phytophthora ramorum* S. Werres, A.W.A.M. de Cock). The areas considered for the analysis are shown in Figure 1.

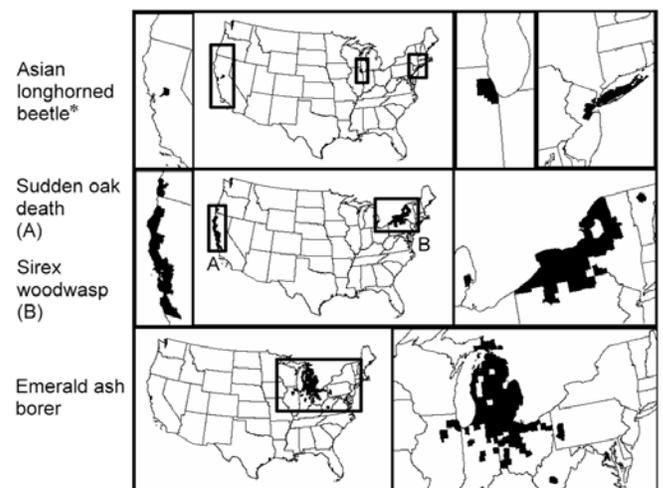


Figure 1.— County detection reports (black) for four invasive species in the contiguous U.S. as of December 2007.

The equation used to quantify ecosystem urbanicity or more specifically forest urbanicity was as follows:

$$FUI_i = \log_{10} \left(1 + k^{-1} \sum_{j=1}^k \frac{P_j}{D_j} \right)$$

where FUI_i is an index of forest urbanicity for the i^{th} county, k was the number of urban areas adjacent to the i^{th} county, P_j was the population size in the j^{th} adjacent urban area, and D_j was the shortest distance between the forest centroid in the i^{th} county and the j^{th} adjacent urban area.

The population numbers and locations of urban areas were obtained from the U.S. Census Bureau. Forest ecosystem centroids were determined based on the concentration of forest land within a county. The location of forest land was obtained after combining the deciduous, evergreen, and mixed forest classes of the 2001 National Land Cover Data (Homer et al. 2007).

The resulting ecosystem urbanicity index for forest lands in the contiguous U.S. is shown in Figure 2. The closer their proximity to urban areas and the greater the size of the urban populations, the higher the ecosystem urbanicity values. As expected, large portions of the country exhibited low values (less than 0.5), while the highest values clustered around large population centers. When we analyzed the ecosystem urbanicity values of the counties encompassing the areas highlighted in Figure 1, we found that more than 75 percent of those counties had ecosystem urbanicity values above 0.5 (Fig. 3). Moreover, we found that several of the counties where the four selected pests were detected during the first year after initial discovery had ecosystem urbanicity values greater than 1.

There are many practical implications of these findings. Hypothetically, if we had concentrated our monitoring efforts solely in counties within the top 15 percent of the ecosystem urbanicity scale, we would have detected all four of the selected species. The counties in the upper 15 percent of the ecosystem urbanicity scale represent for the contiguous U.S. approximately 10 percent of the forest land, 45 percent of the nursery/floriculture farms, 20 percent of woodland crop farms, 70 percent of foreign cargo tonnage associated with forest pest interceptions,

and 99 percent of the international passengers arriving in the U.S.

Although an ecosystem urbanicity framework may not explain the underlying mechanisms driving human-mediated invasions, this concept appears to capture the influence of those mechanisms. Thus, in the short term, this framework could help managers design and implement monitoring efforts aimed at early detection of invasive forest pests. From a research perspective, this framework facilitates delimitation of geographic areas where human-mediated interactions are occurring (i.e., in areas in close proximity to urban areas). This in turn helps to focus research and enhances our ability to uncover the processes behind human-mediated invasions. More work is underway to refine the measurement of ecosystem urbanicity as used in this paper and to extend its application to invasive species in agricultural and aquatic ecosystems.

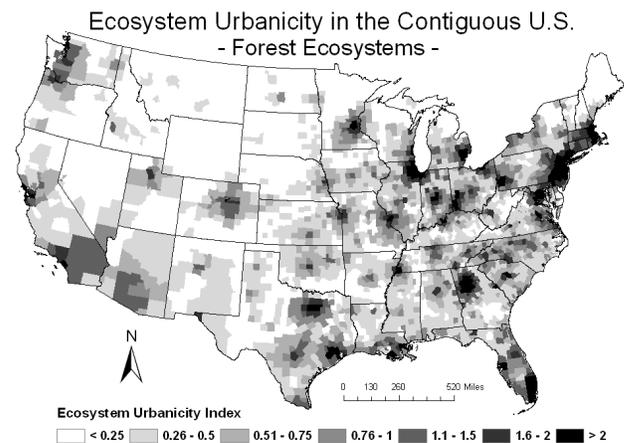


Figure 2.—Ecosystem urbanicity of forest ecosystems in counties within the contiguous United States.

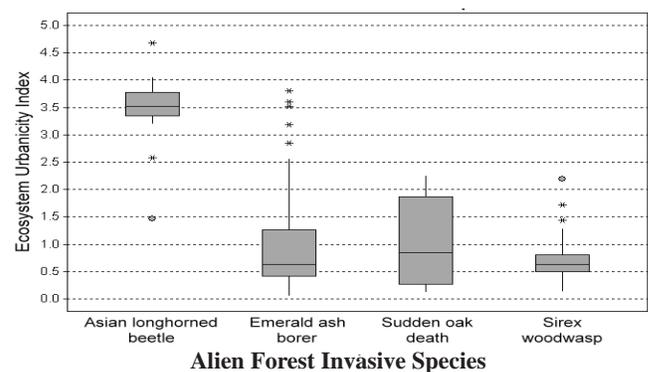


Figure 3.—Box-whisker plots of ecosystem urbanicity values for those counties in the contiguous U.S. where four alien invasive species were detected.

Literature Cited

Homer C.; Dewitz, J.; Fry, J.; Coan, M.; Hossain, N.; Larson, C.; Herold, N.; McKerrow, A.; VanDriel, J.N.; Wickham, J. 2007. **Completion of the 2001 National Land Cover Database for the Conterminous United States.** Photogrammetric Engineering and Remote Sensing. 73: 337- 341.

Acknowledgments

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