IS HOUSING A FACTOR OF INVASIVEPLANTS DISTRIBUTION AT COARSE AND FINE SCALES?

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ABSTRACT

Understanding the factors related to exotic species distribution is important for management because biological invasions are detrimental for many ecosystems. Biological invasions are strongly facilitated by human activities. Housing development is particularly important because disturbed habitats are more easily invaded, landscaping introduces exotic plants, and roads are dispersal corridors. Housing growth is widespread across the globe. Between 1950 and 2000, the proportion of urban area in the conterminous U.S. increased from 1 to 2 percent, while rural low-density housing increased from 5 to 25 percent. Rural growth is particularly strong in areas with natural vegetation, resulting in an increase of the area where natural environments and housing meet, i.e., the Wildland Urban Interface (WUI).

Our goal here was to analyze the relationship between housing and distribution of invasive exotic plants in forested areas at coarse and fine scales. Specifically, we tested how important housing is compared to other environmental and human factors in explaining exotic invasive plant distribution and how this relationship changes with the scale of analysis.

At a coarse scale, we conducted our analysis in New England. We used multiple regression analysis to explain the richness of invasive exotic plants with three sets of explanatory variables at the county level: housing, other human influence, and environmental factors. Two methods were applied to measure the importance of each variable in explaining the richness of invasive exotic plants. Hierarchical Partitioning Analysis measures how much variation is explained by each variable when they are simultaneously included in the regression model. Best Subset Analysis counts how many models out of a set of 20 “better” models included each explanatory variable.

Housing variables were strongly and directly related to the distribution of invasive exotic plants richness. Housing was as important as other human influence and environmental variables in determining richness of invasive exotic plants. Interface WUI (areas where urbanization and natural vegetation meet), low intensity residential area (suburban areas), and change of house units between 1940 and 2004 were the variables that explained most variation of invasive exotic plant richness. All three explained more variation than the human-related or environmental variables, none of which explained more than 18 percent of variation (Fig. 1).

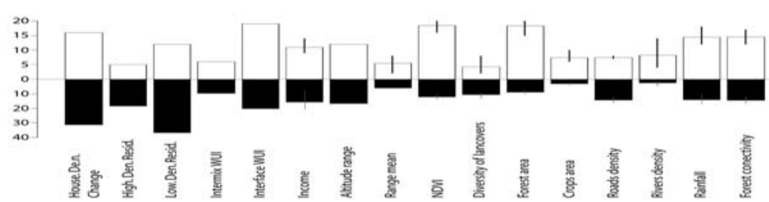

Figure 1.–Summary of multiple regression analysis. White bars represent results of Best Subset Analysis (mean, minimum, and maximum number of times a variable enters 20 models). Black bars represent results of Hierarchical Partitioning Analysis (mean, minimum, and maximum percent of the variability explained by each variable when all variables are included in the model).

Considering the results of Hierarchical Partitioning Analysis and Best Subsets, richness of invasive exotic plants was determined by a positive association with interface WUI, low intensity residential area, change of house units between 1940 and 2000, income, NDVI, rainfall, and altitude and a negative association with forest area and degree of connectivity. Roads were positively related to invasive exotic plant richness but to a lesser extent than the other variables. Area of agricultural land, diversity of landcovers, and density of main rivers were not important variables at the scale of our analysis.

At a fine scale, we conducted the analysis in Baraboo Hills, 30 miles north of Madison, WI. The study area is the largest maple (*Acer* spp.) and oak (*Quercus* spp.) forest remnant in southern Wisconsin, approximately 15 x 30 miles in size. There is a west-east gradient of increasing housing development intensity. We stratified the area according to housing density and set randomly (in numbers proportional to each stratum area) 80 circular sampling plots 20 m in diameter where we recorded presence/absence of eight common invasive exotic plants: garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellate*), bell's honeysuckle (*Lonicera x bella*), white mulberry (*Morus alba*), common buckthorn (*Rhamnus cathartica*), multiflora rose (*Rosa multiflora*), and bittersweet nightshade (*Solanum dulcamara*). We also recorded data on native plants cover and forest structure. Using GIS, we recorded for each plot the distance to the nearest house, road, and forest edge, the number of houses in a 1,000-m-wide buffer around each plot, altitude, and slope.

We used Poisson multivariate regressions to explain richness of invasive exotic plants in each plot and Logistic regression to explain presence of individual invasive exotic plants species in each plot. With Best Subset Analysis, we measured the importance of each explanatory variable as the number of times it was included in 20 best models. The set of explanatory variables included all forest structure ones, distances to houses, roads, and forest edges, and topography.

In the Baraboo Hills, richness of invasive exotic plants increases closer to houses, roads, and forest edges, in plots surrounded with a larger number of houses, and at lower altitude and gentle slope (Table 1). Housing variables, roads, edges, and altitude were the most important determinants of invasive exotic plant richness (Fig. 2). Invasive exotic plants showed two different relationships with the explanatory variables. Buckthorn and honeysuckle were more related to landscape human-related variables, while Japanese barberry, multiflora rose, and garlic mustard were more related to stand condition (Table 2).

Table 1.–Variables explaining richness of invasive exotic plants from four multiple regression Poisson models, each one including a human influence variable (distance to edge, etc). Signs indicate variables included in each model and a direct (+) or inverse (-) effect.

Model	Human influence	Altitude	Slope	Native herbs cover	AIC
Distance to edge	-	-			263
Distance to roads	-	-	-		273
Number of houses	+			-	274
Distance to houses	-	-	-		279

Figure 2.–Importance of each significant variable in explaining richness of invasive exotic plants according to Best Subsets Analysis. Bars represent the number of times each variable entered the 20 best possible models.

Table 2.–Variables explaining presence of the five more abundant invasive exoticplants from Logistic regression models. Signs indicate variables included in each model and a direct (+) or inverse (-) effect.

Species/ variables	Dist. to edges	Number houses	Dist. to houses	Dist. to roads	Altitude	Slope	Shrub cover	Logging
Buckthorn	-	+	-	-				
Honeysuckle	-	+	-	-				
Japanese barberry	-				-	-		
Multiflora rose					-			
Garlic mustard	-						-	-

In conclusion, at broad and fine scales we found consistency in the variables related to the distribution of invasive exotic plants (housing, roads, forest cover and fragmentation, topography). More important, housing variables were as important as other human-related or environmental variables in determining the richness of invasive exotic species both at coarse and fine scales. Plant species showed variation in the association with housing and other factors at fine scales; plants heavily used for landscaping (buckthorn and honeysuckle) were more strongly related to housing and human-created landscape features. Our results have clear management and conservation implications. Housing is expected to continue growing, particularly in rural and natural areas. Areas undergoing housing development should not be located in close contact with natural habitat of high conservation value. Also, housing areas should be a main target for monitoring programs for invasive exotic plants. Regulations should be implemented on species that can be used for gardening in houses located in natural areas.