MAXIMUM ENTROPY MODELING OF INVASIVE PLANTS IN THE FORESTS OF CUMBERLAND PLATEAU AND MOUNTAIN REGION

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ABSTRACT

As anthropogenic influences on the landscape change the composition of 'natural' areas, it is important that we apply spatial technology in active management to mitigate human impact. This research explores the integration of geographic information systems (GIS) and remote sensing with statistical analysis to assist in modeling the distribution of invasive species. It is applicable to both native and nonnative species and can help land managers to identify areas of conservation importance and areas of threat.

In this study, maximum entropy (MaxEnt) models were used to map the extent of Japanese honeysuckle (*Lonicera japonica*), tall fescue (*Lolium arundinaceum*), and mimosa (*Albizia julibrissin*), three nonnative plant species, in the Cumberland and Mountain Region (CPMR), which extends from northern Alabama through Tennessee, Kentucky, and Virginia. MaxEnt is a nonparametric modeling program that integrates occurrence-only data without the assumptions of some of the more traditional statistical methods. The objectives of this study were to model distribution of three invasive species and assess potential hotspots.

The CPMR covers 59,000 km^2 and supports one of the most diverse woody plant communities in the eastern United States. Like many of the forests in the eastern United States, the native deciduous hardwood forests of the CPMR have a long history of land-use change driven by agricultural conversion, timber extraction, and more recently, urban sprawl and large-scale conversion to intensively managed pine plantations. These human activities may influence the distribution and spread of invasives.

Information on the invasive species was extracted from the U.S. Forest Service's Forest Inventory Analysis (FIA) database as absence/presence data. Landscape-associated variables were derived from digital information and grouped in six categories: those derived from remote sensing data, elevation, land use, those related to climate, those related to anthropogenic disturbance, and water. Correlation within groups was assessed, and those with high correlation (>0.80) removed. MaxEnt models were run for each group of variables. Variables that contributed more than 5 percent were then rerun in final models. Accuracy of model output was assessed by using area under the curve (AUC) of the receiver operating characteristic, and withholding 30 percent of the data. Hotspot analysis was done by mapping models across the region.

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Ten variables were used in the three models, with elevation used in all three and minimum temperature used in two of the models. Japanese honeysuckle had an AUC of 0.87 and the model showed probable occurrence in 42 percent of the CPMR. Tall fescue had an AUC of 0.84 and the model showed probable occurrence in 11 percent of the CPMR. Mimosa had an AUC of 0.92 and the model showed probable occurrence in 13 percent of the CPMR. To assess similarities between species and possible hotspots of invasions, the 'best' MaxEnt models for each species were compared. In comparing the three species, we found that Japanese honeysuckle has the widest distribution; both Japanese honeysuckle and mimosa are concentrated in the south. By adding the model values together, we can assess areas where both invasives have a low chance of occurrence or both show a high chance of occurrence.

MaxEnt modelling successfully predicted occurrence for all three species (AUC 0.84 to 0.92), regardless of species prevalence (mimosa 2 percent, tall fescue 5 percent and Japanese honeysuckle 30 percent). All models had a mix of environmental and anthropogenic variables, suggesting species distribution is related to both environmental niche and spread through human activities. Overall elevation had the greatest impact on the models. Not only was it selected in all models in which it was entered, but it was also the dominant variable in most models. Elevation influences temperature, rainfall, and soils in the region, and these have been shown to be a controlling factor for many species worldwide. The hotspot analysis identified areas at greatest risk of invasion. This work will be continued to examine the distribution of 11 nonnative species and assess how climate change may influence their distribution.

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