Japanese Honeysuckle, Photo by Missouri Botanical Gardens

Maximum Entropy modeling of invasive plants

In the forests of Cumberland Plateau and Mountain Region

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Introduction

As our influences on the landscape changes the composition of 'natural' areas, it is important that we integrate spatial technology to assist in active management[1] to mediate our impact. This research explores the integration of GIS and remote sensing with statistical analysis to assist in species distribution modeling of invasive species. It is applicable to both native and non-native species and has the ability to assist land managers in identifying both areas of importance and areas of threat[2].

Maximum entropy[3] (MaxEnt) models were used to map the extent of Japanese Honeysuckle (*Lonicera japonica*), Tall fescue (*Lolium arundinaceum*) and Mimosa (*Albizia julibrissin*), three non-native plant species, in the Cumberland and Mountain Region (CPMR). MaxEnt is a non parametric modeling program developed by Philips et al. (2006) that integrates occurrence only data with out the assumptions of some of the more traditional statistical methods.

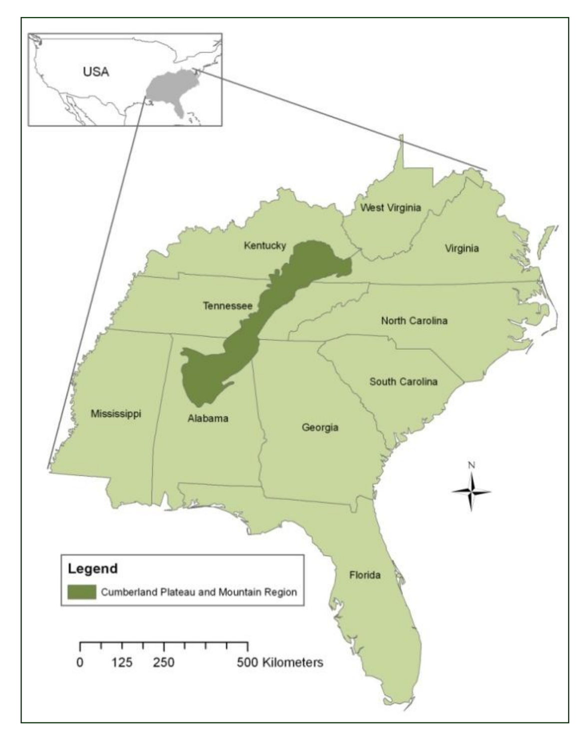
Objectives

1. Model distribution of three invasive species.
2. Assess potential hotspots.

Study Area

The CPMR extends from northern Alabama, through Tennessee, Kentucky and Virginia (Figure 1). It covers a total area of 59 000 km^2 and supports one of the most diverse woody plant communities in the eastern United States[4]. Like many of the forests in the eastern U.S, 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[5]. This may influence the distribution and spread of invasions.

Figure 1 (right): Study Area, Cumberland Plateau and Mountain Region, located in the southeast USA.



Methods

- Information on the invasive species was extracted from the USDA-Forest Service's Forest Inventory Analysis database as absence/presence data.
- Landscape associated variables were derived from digital information.
- Variables were grouped in six categories those derived from remote sensing data, from DEM, from land use, related to climate, 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% were then rerun in final models.
- Accuracy of model output was assessed by using misclassification rates and distance, and with-holding 30% of the data.
- Hotspot analysis was done by mapping models across the region.

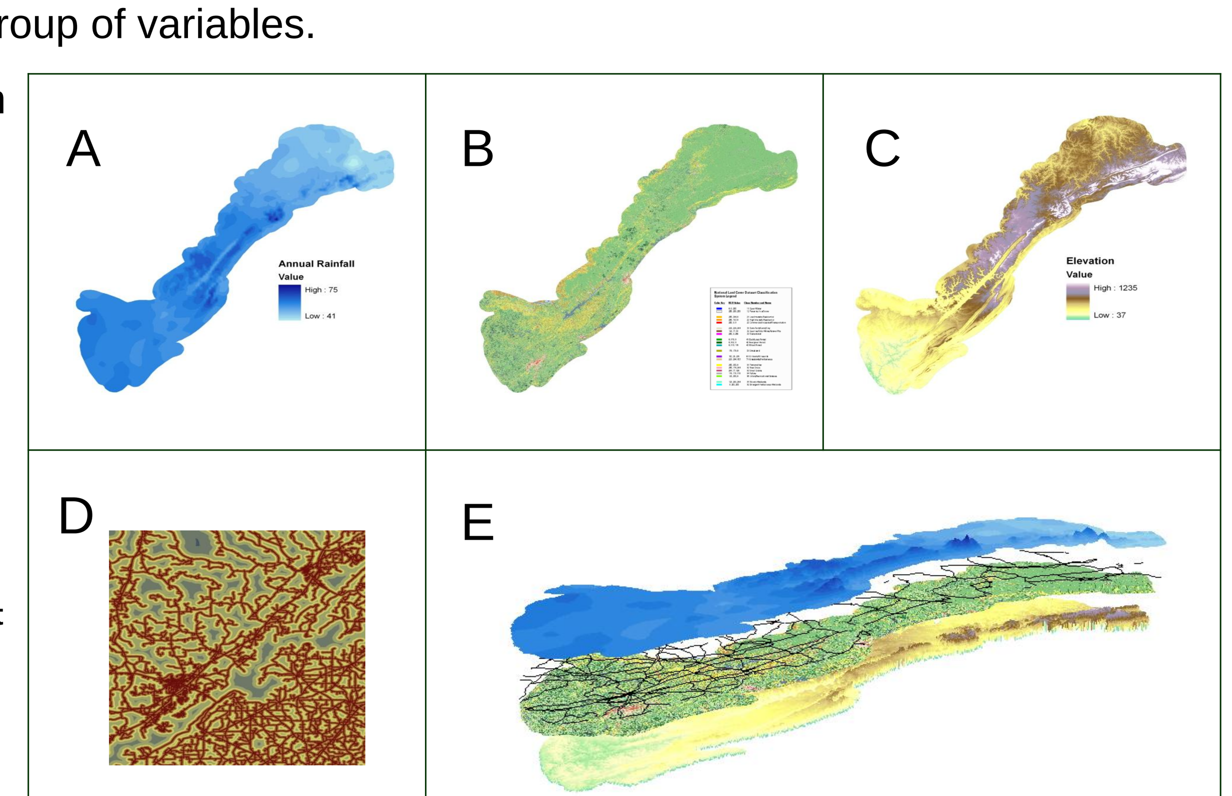


Figure 2 (right): Example of independent variables, A – mean annual rainfall, B – land cover in 1990, C – elevation, D – distance to roads, E – combining layers.

Results

Table 1: Composition and direction of variables used in final Japanese honeysuckle model

	%	Direction
Elevation	58	-
Minimum Temperature	22	+
Amount of forest within 500m	10	-
Slope	6	-
Distance to Main Road	4	U

Table 2: Composition and direction of variables used in final tall fescue model

	%	Direction
Minimum Temperature	58	-
Elevation	22	∩
Disturbance Index in 1990	10	∩
Amount of farming within 500m	10	+

Table 3: Composition and direction of variables used in final mimosa model

	%	Direction
Elevation	49	-
Census	22	+
Road Density	17	+
Water within 500m	11	+

- There were ten variables used in the three models, with elevation used in all three and minimum temperature used in two of the models (Tables 1, 2 & 3).
- Japanese honeysuckle had an AUC of 0.87 and the model showed probable occurrence in 42% of the CPMR.
- Tall fescue had an AUC of 0.84 and the model showed probable occurrence in 11% of the CPMR.
- Mimosa had an AUC of 0.92 and the model showed probable occurrence in 13% of the CPMR.

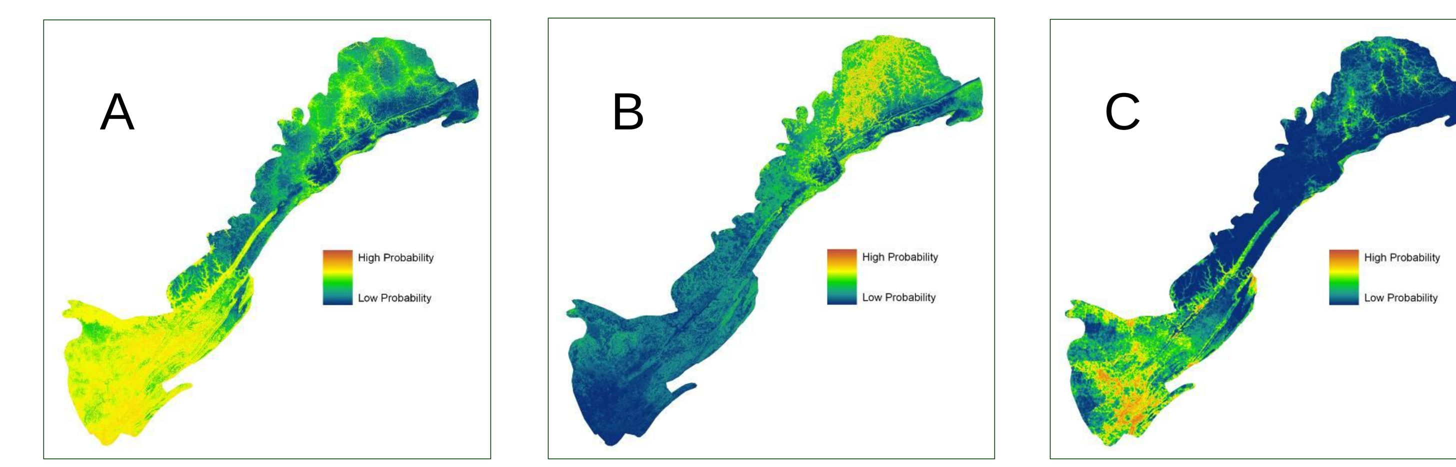


Figure 3: Probability distribution maps of Japanese Honeysuckle (A), **Tall Fescue** (B) **and Mimosa** (C)**.**

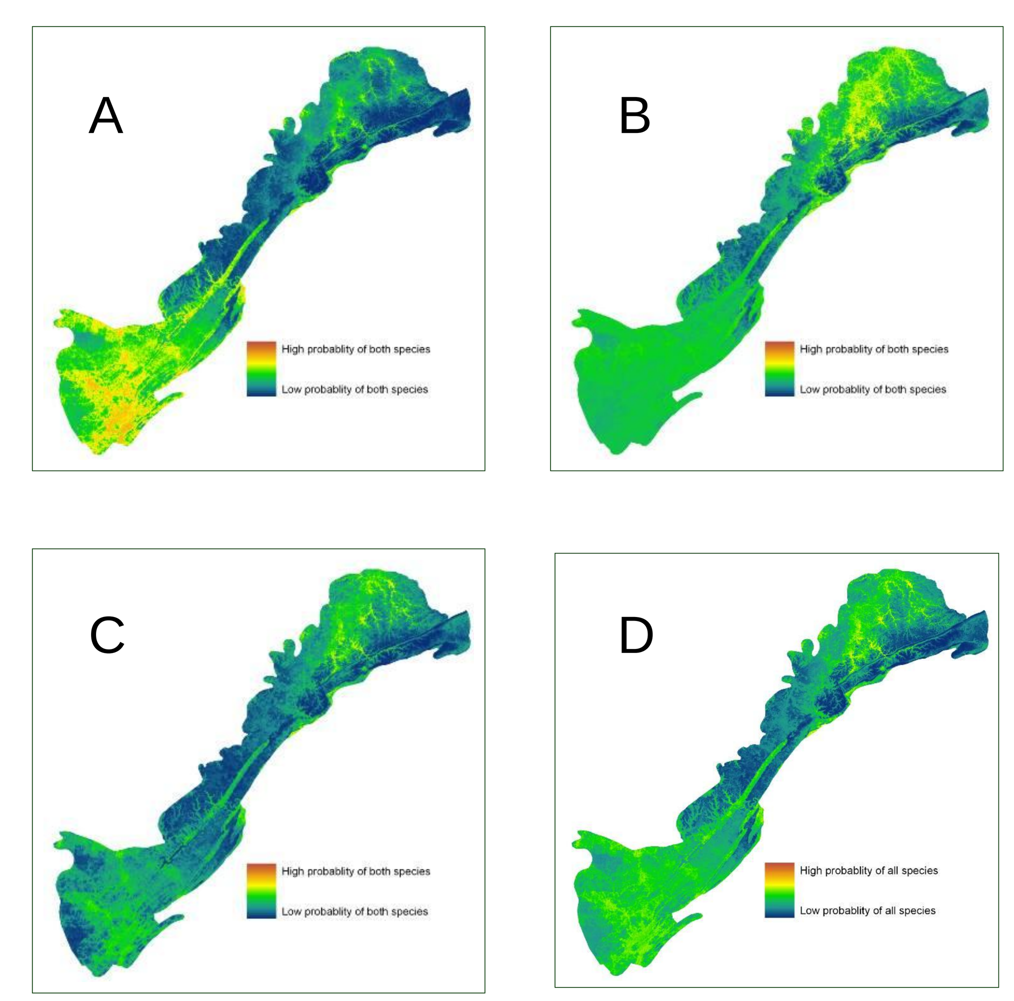


Figure 4: Combine MaxEnt best models for hot spot analysis (A - Japanese and mimosa combined, B - for Japanese and tall fescue combined, C - tall fescue and mimosa combined, D - Japanese honeysuckle, tall fescue and mimosa combined).

- To assess similarities between species and possible hot spots of invasions the 'best' MaxEnt models for each species were compared (Figure 4).
- In comparing the three species Japanese honeysuckle has the widest distribution, both Japanese honeysuckle and mimosa are concentrated in the south.
- By adding the model values together it is possible to assess area where both have low chance of occurrence or both show a high chance of occurrence (Figure 4).

Discussion

- MaxEnt modelling successfully predicted occurrence for all three species (AUC 0.84 to 0.92) regardless of species prevalence (mimosa 2%, tall fescue 5% and Japanese honeysuckle 30%)
- 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 being selected in all models it was entered in, 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 non native species and assess how climate change may influence their distribution.

Acknowledgments

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