

Modeling Potential Distribution of Norway Maple (*Acer platanoides*) in Massachusetts, USA

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A comparative assessment of Mahalanobis typicality and ecological niche factor analysis



Predictive distribution modeling

Predictive Distribution Modeling is an innovative GIS method that allows us to create range maps of potential distribution of animals, plant assemblages or target habitats. The probability of distribution is calculated based on the known locations of species presence or absence and underlying environmental characteristics, i.e. precipitation, temperature, elevation, slope, etc. (Guisan and Thuiller 2005). Various predictive models have been developed based on different conceptual considerations, statistical approaches and data availability. Past studies revealed that different methods produce incongruent results (Segurado and Araujo 2004). In this study, we assessed the performance of two models using presence data on *Acer platanoides* in Massachusetts.

Mahalanobis typicality is derived from Mahalanobis distance which expresses the likelihood that a set of environmental variables at a specific location is typical to a known location of the species. The method tells us how typical is the area being analyzed compared to those used as a reference (Sangermano and Eastman 2007).

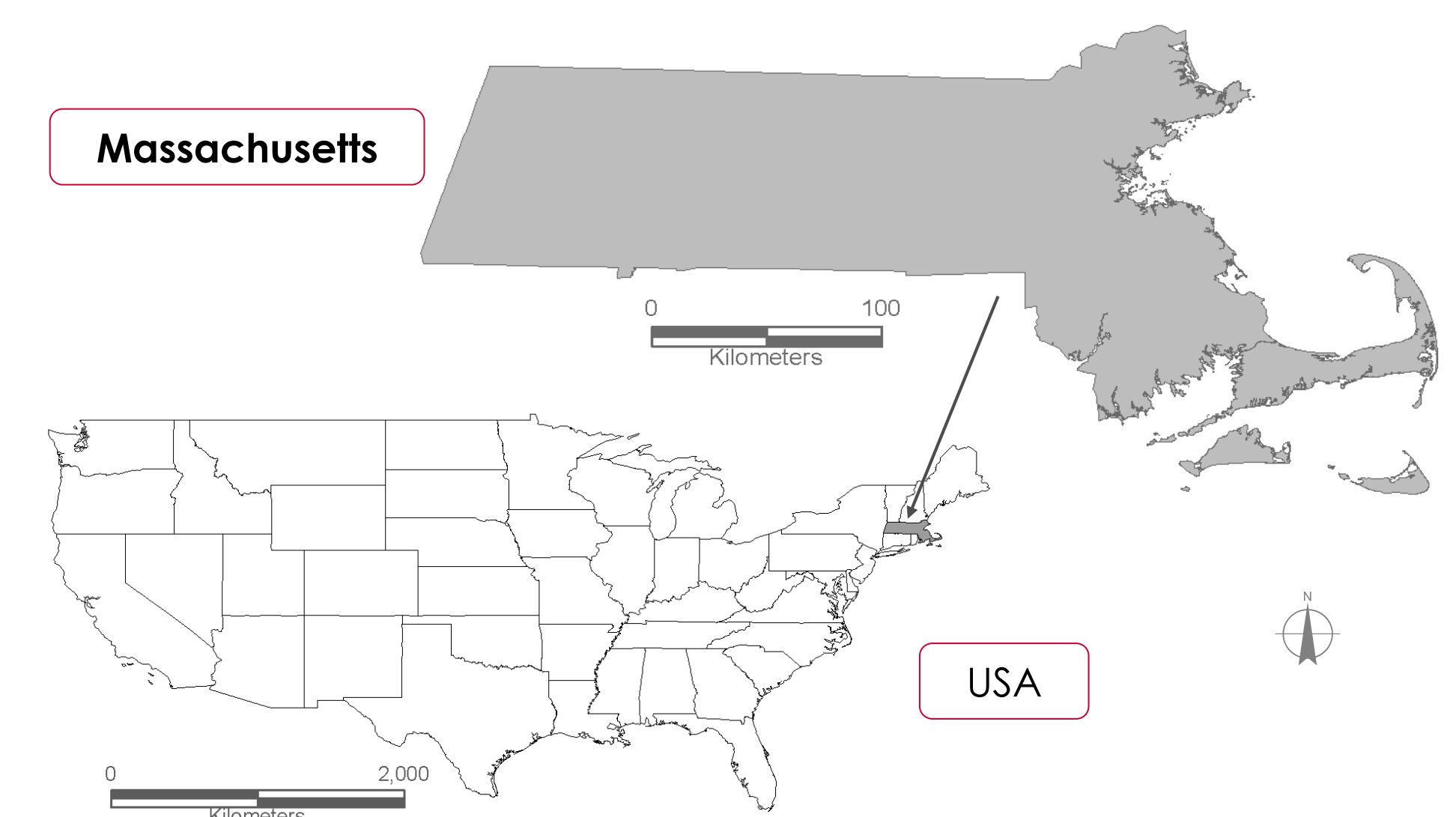
Ecological niche factor analysis compares, in the multidimensional space of ecological variables, the distribution of the localities where the focal species was observed to a reference set describing the whole study area. It computes factors that explain the major part of the ecological variation of the organism. The first factor represents species marginalization, the second describes species specialization (Hirzel et al. 2002).

Norway maple

Acer platanoides is a deciduous tree native in continental Europe. It was introduced to the United States in the 18th century as an ornamental tree. It has naturalized to nearby woods, forest edges and fragmented forests, and from there has moved on to less disturbed habitats. *A. platanoides* is considered an invasive species in New England since it changes the original vegetation structure and out-competes native trees in forest canopy. Thus, it represents a threat to native species and forest habitats diversity (Anderson 1999).



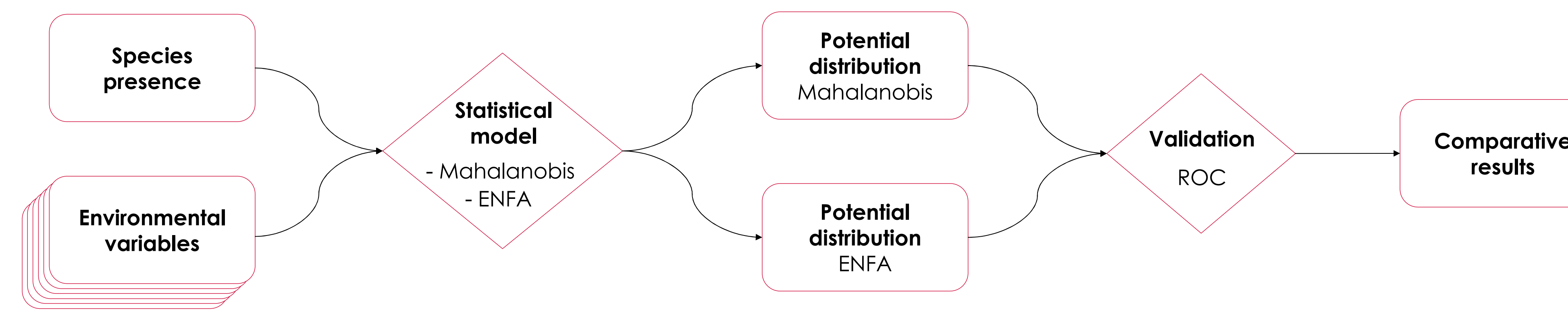
Study Area



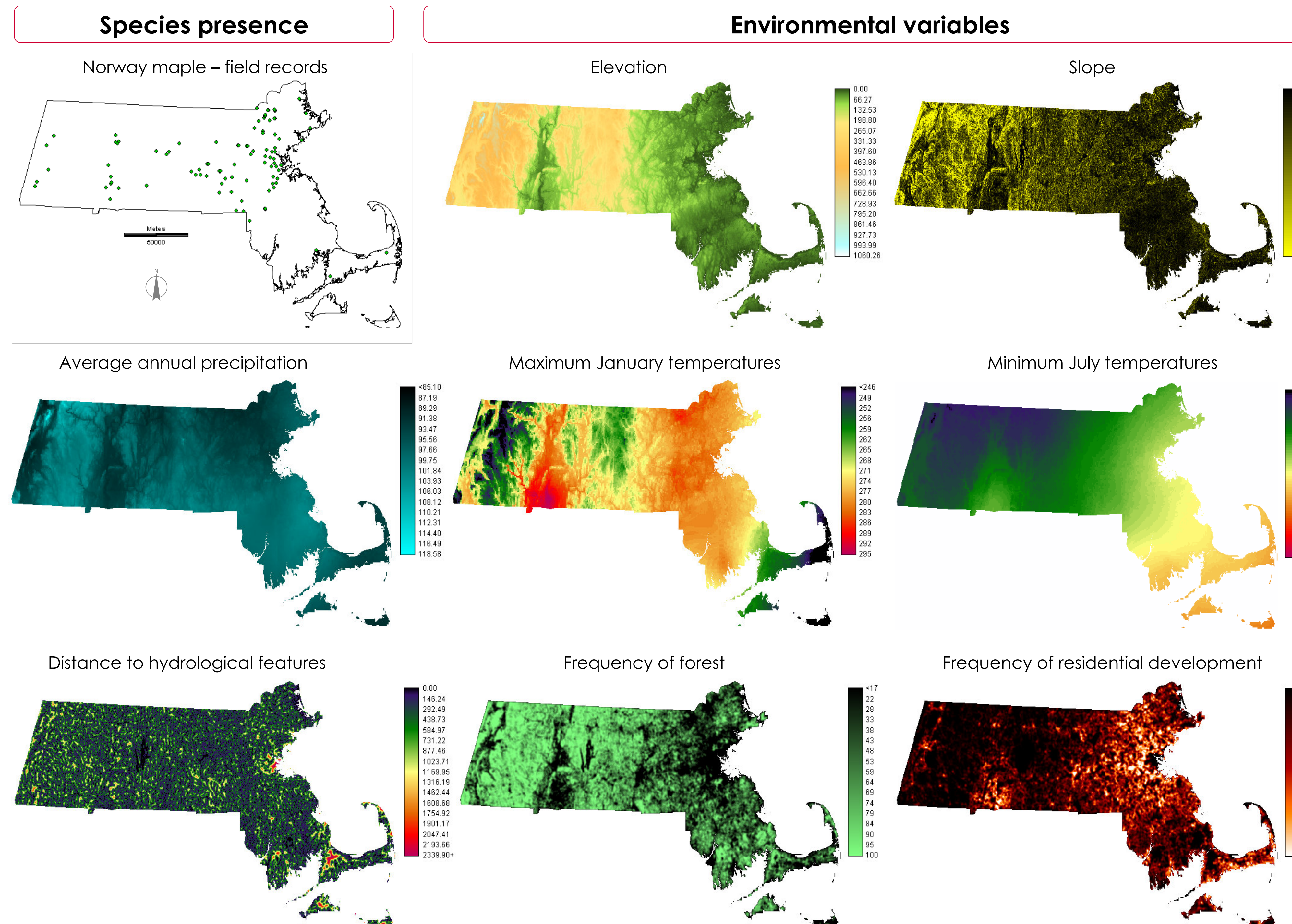
Objectives

1. Create potential distribution maps of *A. platanoides* in the state of Massachusetts using two different statistical models (Mahalanobis and ENFA).
2. Compare the performance of both predictive models using Relative Operating Characteristics (ROC) assessment.

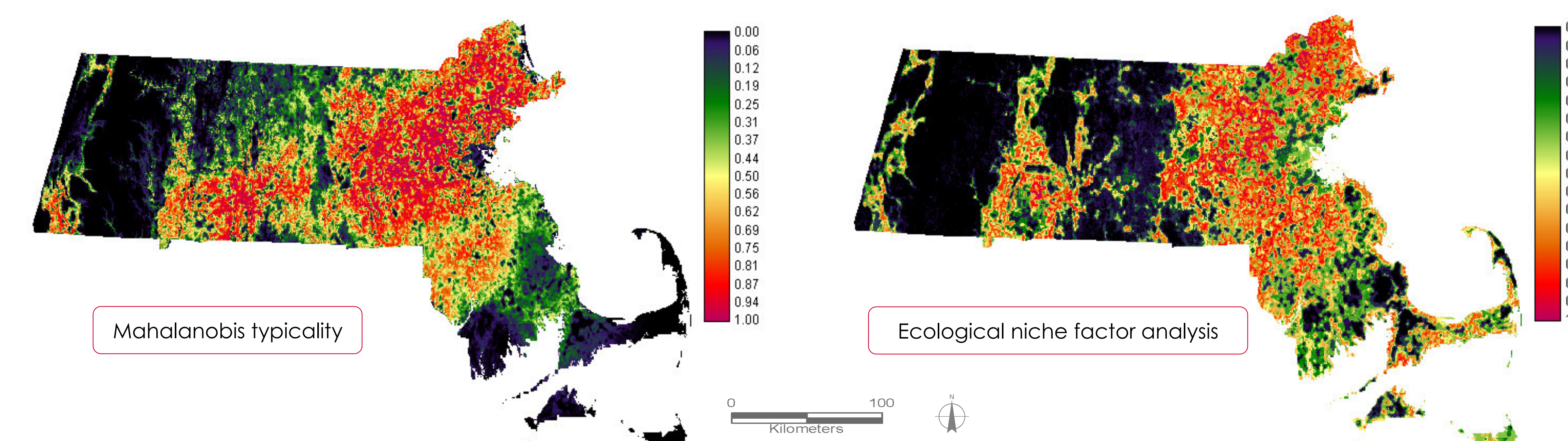
Methods: work-flow diagram



Models inputs



Models outputs

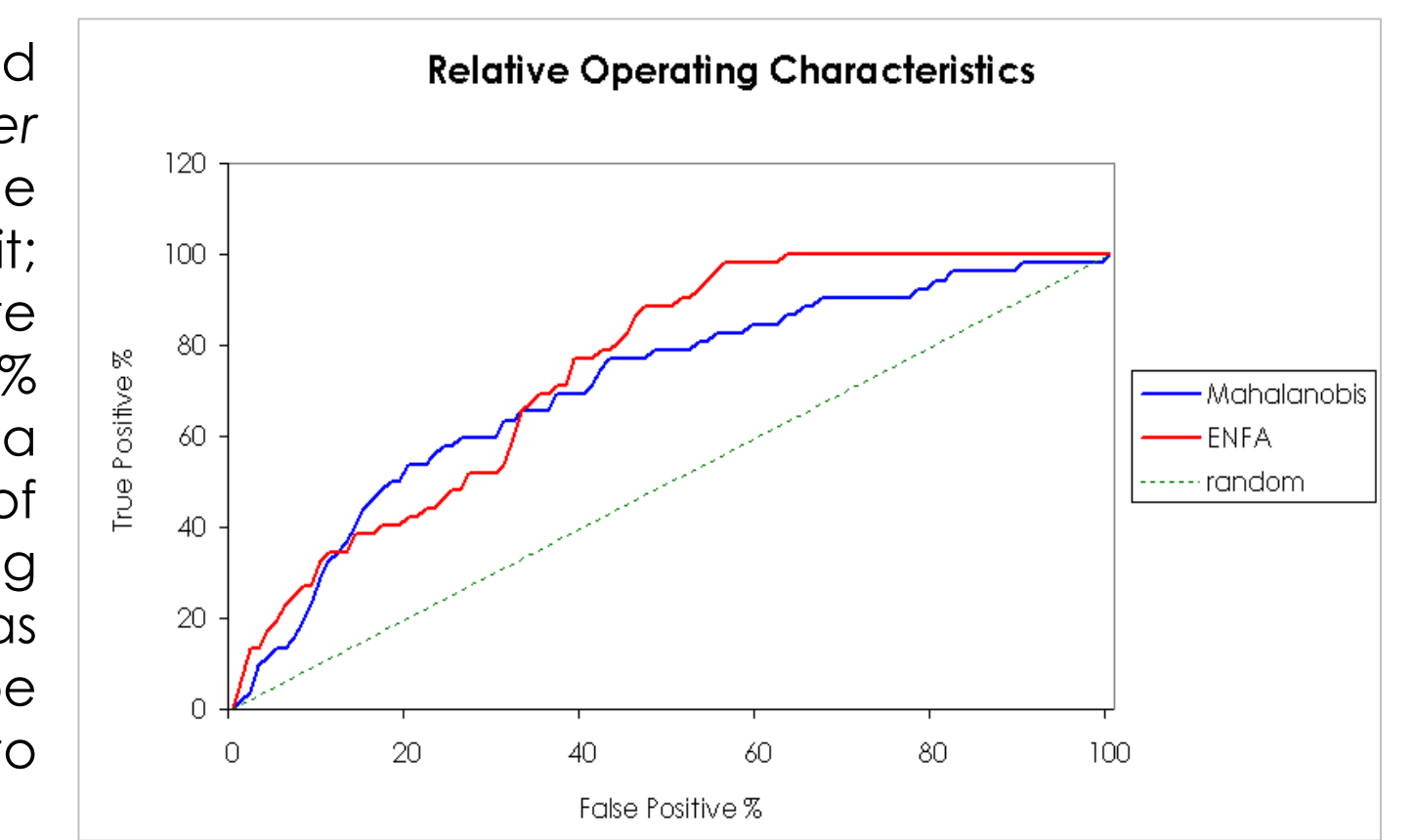


Data and software

Data on *Acer platanoides* presence (104 points) were downloaded from the Invasive Plant Atlas of New England [http://nbi-nin.ciesin.columbia.edu/ipane/index.htm]. Environmental variables of elevation and slope were derived from DEM obtained from the Clark University HERO database. Climate data used in the analysis were downloaded from the Worldclim database [http://www.worldclim.org]. The precipitation map represents the annual average precipitation for the period 1950-2000. The temperature data include average maximum July and minimum January temperatures for the same period. The source of hydrology and land cover data is MassGIS [http://www.mass.gov/mgis]. The distance to water bodies and frequency of forest and residential land cover categories were considered in the analysis. All the data were formatted to the resolution of 90x90 meters. IDRISI 15 Andes Edition was used for data processing and Mahalanobis typicality analysis. Biomapper version 3.2 was employed for the ENFA analysis and the land cover frequency calculation.

Results

Both models produced suitability maps for *Acer platanoides*. The presence data were randomly split; 50% was used to calibrate the models, the other 50% to validate them. The Area Under the Curve (AUC) of the Relative Operating Characteristic (ROC) was calculated and the shape of the curve interpreted to compare both models.



The Mahalanobis results provided **ROC = 0.709**, ENFA results **ROC = 0.749**. The first and last 30% of the curve suggests that ENFA performs better in predicting the presence of *A. platanoides* as well as its absence within the study area. Mahalanobis provides better results in the mid-range of the predicted suitability.

Discussion and conclusions

ROC is a statistics frequently used for evaluation of species distribution models (Fielding and Bell 1997). It compares a rank map (e.g. predicted suitability map) against a Boolean map (e.g. species presence/absence). ROC indicates how well the events of the Boolean map falls within the high suitability values in the rank map (Pontius and Schneider 2001). The value of AUC is usually the only baseline to assess how well a model performs. However, it represents a disadvantage for models which use presence-only data, such as Mahalanobis and ENFA. It penalizes models for predicting presences in locations where no data have been collected, assuming species absence to indicate unsuitable habitats. Therefore, the validation should not be based solely on the absolute value of AUC. The shape of the curve needs to be taken into consideration, as it provides valuable information about models behavior (Parmentier, submitted).

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References

Anderson, R. (1999). Disturbance as a factor in the distribution of sugar maple and the invasion of Norway maple into a modified woodland. *Rhodora* 101 (907): 264-273.

Hirzel, A.H., Hausser, J., Chessel, D. and Perrin, N. (2002). Ecological-niche factor analysis: how to compute habitat-suitability maps without absence data? *Ecology*, 83, 2027-2036.

Fielding, A. H. and Bell, J. F. (1997). A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation* 24 (1): 38-49.

Guisan, A. and Thuiller, W. (2005). Predicting species distribution: offering more than simple habitat models? *Ecology Letters* 8: 993-1009.

Parmentier, B. and Pontius, R. (2007). Improvements in the use of the ROC statistic for landscape ecology. Conference proceedings of the World Congress of the International Association for Landscape Ecology. Wageningen, The Netherlands 2p.

Pontius, R. G. and Schneider, L. C. (2001). Land-cover change model validation by an ROC method for the Ipswich watershed, Massachusetts, USA. *Agriculture, Ecosystems and Environment* 85: 239-248.

Sangermano F. and Eastman J. R. (2007). Linking GIS and Ecology. The use of Mahalanobis Typicalities to model species distribution. Proceedings of XI CONFIBSIG (Iberoamerican Conference of GIS). Buenos Aires, Argentina.

Segurado, P. and Araujo, M. B. (2004). An evaluation of methods for modelling species distributions. *Journal of Biogeography* 31: 1555-1568.