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FAGUS SYLVATICA HABITAT SUITABILITY IN THE APUSENI MOUNTAINS

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Abstract

The Fagus sylvatica L., or European beech, is one of the valuable and widespread broadleaved trees in Romania and the Apuseni Mountains. There are numerous studies regarding European beech habitat distribution, but these are made on a larger scale, especially at the continental level, and with low resolution. Species distribution models incorporating bioclimatic, topographic, soil properties, geology, and vegetation variables were used as predictors to assess Fagus sylvatica habitat suitability under current conditions. We used data from the National Forest Inventory of Romania (NFI) to model pure and mixt beech habitat stands in the Apuseni mountains using MaxEnt software. The results revealed that the main factors influencing beech spatial distribution in the Apuseni Mountains are elevation for pure beech stands and clay content in the soil for mixt beech stands. The pure beech stand's optimal habitat suitability has a lower extent than mixt stands with beech in composition, but both record highest habitat suitability values between 450 - 1200 m altitude in Apuseni Mountains.

INTRODUCTION

European beech is the most important and widespread broadleaved trees in Romania and covers more than 2 million ha. In Romania, European beech covers about 30.53 % of forest surface and 37.44 % of total wood volume. It is a valuable deciduous tree that can maintain its high growth rate in very different environmental conditions. In Europe, it extends from southern Scandinavia to the south of Italy, from Spain in the west to the Anatolian peninsula in the east (Durrant et al. 2016).

In Romania, it extends outside of its habitat in few areas in Romania plain (Snagov county), to high elevations in the Carpathian Mountains, reaching 1600 m in altitude. The European beech in the Apuseni Mountains records a wide range of environmental conditions according to National Forest Inventory (NFI) observations, making the first appearance in low hills at 125 m altitude near Tinca village, to around 1400 m elevation in Vladeasa Mountains. Though not demanding of any specific soil type, beech prefers a humidity with precipitation well distributed throughout the year and soils with sandy-silty texture. Fagus sylvatica is a challenging species, and it can be founded very often in shady situations (it is one of the most shade-tolerant broadleaved trees in its range) (Praciak et al.2013) so that natural regeneration is possible in forestry systems with continuous crown coverage as the seedlings can survive and grow below the canopy of dominant trees.

The predominance of beech reduce light level in the understorey vegetation, and beech seeds have more survival chances than those of other tree species. European beech is not particularly sensitive to soil-specific soil properties (Walthert et al. 2013) and grows on a wide variety of soils, especially on Cambisols; with a pH range from 3.2 to 8.4 cannot tolerate the most acidic conditions. Beech shows a moderate soil-acidifying ability (Augusto et al., 2013). It prefers moderately fertile ground, calcified or slightly acidic, and is also sensitive to late frosts (Paule, 2002), and it is found more often in soils with a sandy texture. It grows well on drained soils with a sizeable edaphic volume.

Excessive water content and compacted soils negatively influence beech growth (Packham et al. 2012, Gebler 9*et al. 2007). The only limiting factor that influences beech growth is shallow soils and steep slopes. Beech trees conserve the soil's productive capacity better than any other tree species due to the high content of litter provided to the soil. The primary usage of beech wood in Romania is for firewood because it is strong and available in numerous regions and is also used to make furniture or musical instruments.

Another impact on future habitat is competition, dispersal, disturbance, and biotic interaction between different species. Unfortunately, the temperature change degree will significantly impact tree species from the Carpathian Mountains, even in an optimistic scenario. Some tree species will gain new areas in habitat, and others will lose depending on the species adaptability to the new environment. In this paper, we model the habitat suitability of Fagus sylvatica in the Apuseni Mountains.

MATERIAL AND METHOD

Species distribution models (SDMs) project species habitats based on statistical correlations between species presence or abundance and environmental (predictor or covariate) variables thought to influence habitat suitability.

For modeling beech niche and distribution in the Apuseni Mountains, we used Maxent software that uses a machine learning technique called maximum entropy modeling. MaxEnt is usually used for modeling species distributions from presence-only species records. Initially, MaxEnt was used to estimate the landscape's presence (Phillips et al., 2006). Density estimation assumes that individuals have been randomly sampled across the landscape, i.e., samples in rapport to population density. Such models predict the occurrence rate in a cell, defined as the expected number of individuals in that cell (Fithian and Hastie, 2012).

The soil samples and data regarding the beech stand characteristics were collected based on a systematically designed grid of sampling plots during the first National Forestry Inventory (NFI) cycle, undertaken in Romania between 2008 and 2012. The NFI survey was done on a sampling grid with cells measuring 4x4 km, forested sites located in the hills or mountains, and 2x2 km in the plain. The larger sampling density was established according to the smaller forest vegetation cover in the low land area. At the end of the first NFI cycle, 28.204 sample plots with forest were visited in the field, and 15.734 soil samples had been collected. For better modeling of beech habitat, we divided the database into two components, plots with pure beech stands and beech plots in their composition.

Our goal was to create a high-resolution distribution model of beech habitat, and with this, in mind, we used a high-resolution covariates map. Bioclimatic variables were generated from the ROCADA (a gridded daily climatic dataset over Romania) made for nine meteorological variables for 1961–2013 (Dumitrescu and Barsan, 2015). Twenty bioclimatic (bio1-bio19+bio4a) variables were modeled using DEM as a predictor at a resolution of 100x100m, with a random forest algorithm. The relief covariates were generated from the DEM of Romania using SAGA GIS software (System for Automated Geoscientific Analyses - is a Geographic Information System software for geodata processing). The parent material information was taken from the 1:200.000 geologic map of Romania. Soil properties maps were generated from NFI soil sampling plots using an RF algorithm.

RESULTS AND DISCUSSION

The prediction accuracy of Fagus sylvatica shows an excellent prediction for pure beech stands (AUC = 0.915) and for forest stands where beech appears in composition with other species having a good prediction (AUC = 0.887). Among the fifty environmental variables used, the contribution of the first eleven variables, that have a contribution more significant de 2 %, accounted for almost 83.5% of the model prediction in the case of pure beech stands (PBS) and 88.1 % in the case of all beech stands (ABS) (Fig.1).

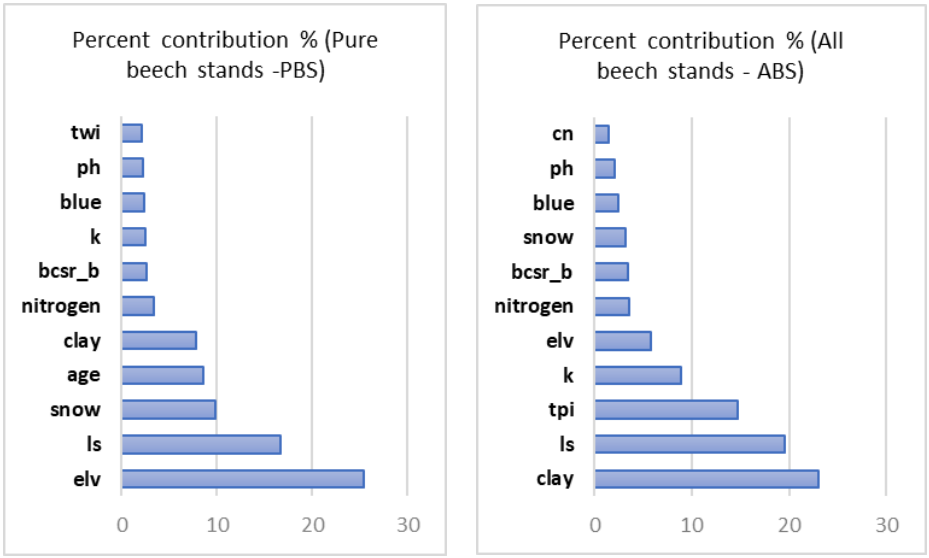

Fig.1. - Variables contribution to the model

The influence of predictor variables is different for pure beech stands than mixt beech forest stands. Except for age (geologic age), TPI (topographic position index), TWI (topographic wetness index), and C/N (the ratio between Carbon and Nitrogen), both models have common predictors. In the ABS model, the soil and relief factors (ls - length of slope and TPI) have a greater contribution mainly due to other species in composition with beech, and they are more soil specific forest stands. The PBS model is a subsample from the larger beech habitat and where more site-specific influence gains greater importance than general influences. From the soil perspective, clay (clay content %), K (Potassium), and BCSR (base cation exchange ratio), and pH(potential of hydrogen) have an impact on beech distribution. Beech stands prefer soils with a relatively low clay concentration, around 20 %, well-drained, and a moderate concentration in BCSR. Using ArcGIS 10.3, the potential distribution of Fagus sylvatica in the Apuseni Mountains based on observed occurrences and current environmental conditions projected by the MaxEnt model is shown in Fig. 2. We divided de legend in Marginal/no presence < 5%, colored in grey, Low presence 5% - 10%, Mid-low presence 10% - 30%, Medium presence 30% - 50%, Mid-high presence 50% - 70%, High presence 70% - 90% and Very-high presence > 90%.

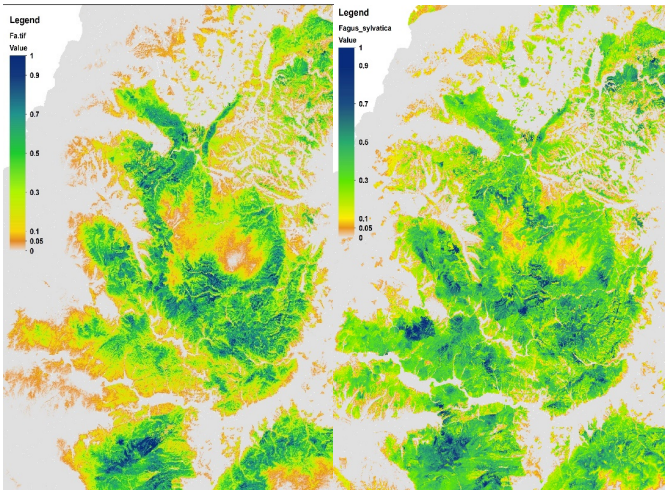

Fig.2. - Maxent model for Fagus sylvatica in Apuseni Mountains, left PBS model and in the right the ABS model

There are many similarities between the models, but we can notice that the PBS model has a lower extent in high occurrence as a function of altitude than the ABS model. The models' differences can be explained by the fact that Fagus sylvatica can extend in mixture with other species beyond his natural habitat, mainly on lower altitudes in association with *Quercus petraea* and higher altitudes with *Picea abies.* The High presence (> 0.7) in the PBS model fallows to a reasonable extent a specific range of elevation (Fig.3) with greater density than the ABS model in 300 – 1200 m altitude range.

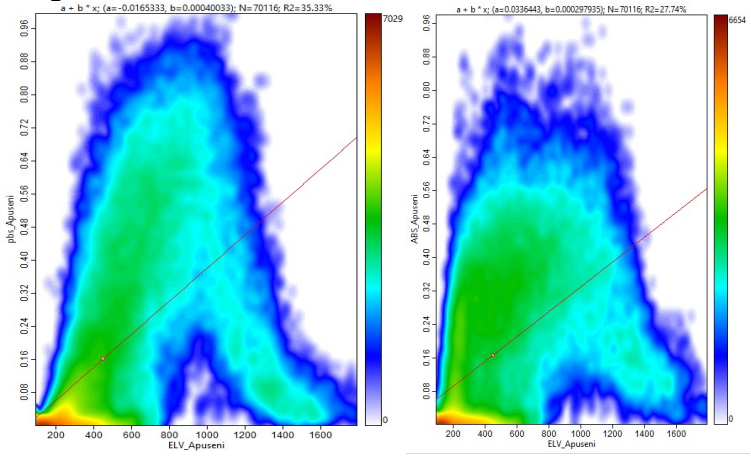

Fig. 3. – Scatterplot between Elevation and PBS model (left) and ABS model (right)

PBS model has a better correlation with elevation (R^2 = 0.35) than the ABS model (R^2 = 0.22), and from de density scatterplot, we can observe a lack of low values in habitat susceptibility, especially in the PBS model in the range of 800 -1200 m. The main advantage of high-resolution maps can be that it can surprise local influences like slope, parent material, soil type, aspect in habitat sustainability.

CONCLUSIONS

Fagus sylvatica is not a very demanding tree species and has many habitats in the Apuseni Mountains. The habitat is influenced mainly by elevation that affects other bioclimatic factors and the slope or soil properties like the clay content and base cation exchange ratio. Pure beech stands have a smaller extent in elevation than mixt beech stands, but in their optimal range of 500 -1200 m, records highest values of habitat susceptibility than mixt beech forest stands. The resulted high-resolution habitat susceptibility map can be used in forest management practices.

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