Geophysical Research Abstracts
Vol. 19, EGU2017-15941, 2017
EGU General Assembly 2017

Modelling tree dynamics to assess the implementation of EU policies related to afforestation in SW Spain rangelands

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In Iberian dehesas and montados, the lack of tree recruitment compromises its long-term sustainability. However, in marginal areas of dehesas shrub encroachment facilitates tree recruitment while altering the distinctive physiognomic and cultural characteristics of the system. These are ongoing processes that should be considered when designing afforestation measures and policies. Based on spatial variables, we modeled the proneness of a piece of land to undergo tree recruitment and the results were related with the afforestation measures carried out under the UE First Afforestation Agricultural Land Program between 1992 and 2008.

We analyzed the temporal tree population dynamics in 800 randomly selected plots of 100 m radius (2,510 ha in total) in dehesas and treeless pasturelands of Extremadura (hereafter rangelands). Tree changes were revealed by comparing aerial images taken in 1956 with orthophotographs and infrared ones from 2012. Spatial models that predict the areas prone either to lack tree recruitment or with recruitment were developed and based on three data mining algorithms: MARS (Multivariate Adaptive Regression Splines), Random Forest (RF) and Stochastic Gradient Boosting (Tree-Net, TN). Recruited-tree locations (1) vs. locations of places with no recruitment (0) (randomly selected from the study areas) were used as the binary dependent variable. A 5% of the data were used as test data set. As candidate explanatory variables we used 51 different topographic, climatic, bioclimatic, land cover-related and edaphic ones. The statistical models developed were extrapolated to the spatial context of the afforested areas in the region and also to the whole Extremenian rangelands, and the percentage of area modelled as prone to tree recruitment was calculated for each case.

A total of 46,674.63 ha were afforested with holm oak (Quercus ilex) or cork oak (Quercus suber) in the studied rangelands under the UE First Afforestation Agricultural Land Program. In the sampled plots, 16,747 trees were detected as recruited, while 47,058 and 12,803 were present in both dates and lost during the studied period, respectively. Based on the Area Under the ROC Curve (AUC), all the data mining models considered showed a high fitness (MARS AUC= 0.86; TN AUC= 0.92; RF AUC= 0.95) and low misclassification rates. Correctly predicted test samples for absence and presence of tree recruitment accounted respectively to 78.3% and 76.8% when using MARS, 90.8% and 90.8% using TN and 88.9% and 89.1% using RF. The spatial patterns of the different models were similar. However, attending only the percentage of area prone to tree recruitment, outstanding differences were observed among models considering the total surface of rangelands (36.03% in MARS, 22.88% in TN and 6.72 % in RF). Despite these differences, when comparing the results with those of the afforested surfaces (31.73% in MARS, 20.70% in TN and 5.63 % in RF) the three algorithms pointed to similar conclusions, i.e. the afforestations performed in rangelands of Extremadura under UE First Afforestation Agricultural Land Program, barely discriminate between areas with or without natural regeneration.

In conclusion, data mining technics are suitable to develop high-performance spatial models of vegetation dynamics. These models could be useful for policy and decision makers aimed at assessing the implementation of afforestation measures and the selection of more adequate locations.