Original Research

Using the Non-Parametric Classifier CART to Model Lebanon Cedar (*Cedrus libani* A. Rich) Distribution in a Mountain Mediterranean Forest District

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Received: 19 March 2012
Accepted: 22 October 2012

Abstract

This study was conducted to define indicator species of Lebanon cedar (*Cedrus libani* A. Rich) and to build its potential distribution model in the Yukarigokdere Forest District of Turkey's Mediterranean region. In the study, the data were collected from 119 sample plots. To define indicator species of Lebanon cedar, interspecific correlation analysis (ICA) was employed. The findings obtained from ICA showed that thermo-Mediterranean elements (*Pistacia terebinthus* subsp. *palaestina*, *Quercus coccifera*, and *Styrax officinalis*) are the most significant negative indicator species of Lebanon cedar, while Its most significant positive indicator plants are supra- and mountain-Mediterranean elements (*Acer hyrcanum* subsp. *sphaerocaryum*, *Berberis crataegiana*, *Amelanchier parviflora*, *Fraxinus ornus* subsp. *cilicica*, and *Sorbus umbellate*). By using climatic and topographical data as explanatory variables, visual assessment of the potential distribution probability of Lebanon cedar based on classification and regression technique (CART) was performed. Ten-fold cross validation was run for selection of the optimal tree. The variables building the tree model were elevation, head index, annual precipitation, slope degree, landform category, and topographical position index. Among them, elevation was found to be the most significant factor on the distribution of Lebanon cedar.

Keywords: mediterranean ecosystems, nonparametric methods, potential distribution, spatial modelling, taurus cedar

Introduction

In the context of ecosystem-based management, individual ecology has become more popular compared to community ecology due to the need for more quality information about the ecological properties of each focal species. As focal species, not only commercial tree species but also non-wood products and endemic species are the areas of interest in plant ecology. In ecosystem-based management, the most desired information for field managers and conversationalists is the potential distribution maps of focal species.

Indicator species is particularly important to control the potential distribution maps of the focal species. To define indicator species, interspecific correlation analysis (ICA) is a suitable method. In this analysis, 2 × 2 contingency tables are arranged by using presence and absence data, and chi squared tests are performed between the focal species and each of the other species [1-3].

To generate potential distribution areas for focal species, numerous methods and packet programs are available.

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The essential requirements for modeling potential distribution are based on environmental data at a suitable scale (i.e. altitude, slope degree, aspect, and soil properties) and accurately geo-referenced collection data for a given species [4-6].

Ecological data in plant ecology are often complicated, unbalanced, and contain missing values. Relationships between distribution or productivity of plants and environmental factors may be strongly nonlinear and involve high-order interactions. The commonly used traditional data analysis methods often fail to find meaningful ecological patterns from such data. Classification and regression trees [7-11] are modern statistical techniques ideally suited for both exploring and modeling such data. That is why there has been increasing interest in the use of classification and regression tree (CART) analysis in recent years.

In Turkey, due to the high heterogeneity within the habitats, which influences the spatial distribution of plant species, the Mediterranean region is rich in species diversity and contains a number of endangered endemic floral species [12-14]. High heterogeneity within the habitats of the region is originated from its topographic structure, high altitudinal interval, and complex landform characteristics. Besides, the Mediterranean region has a long human settlement history. For these reasons the region's ecosystems have been subjected to heavy cutting, burning, and overgrazing for hundreds of years [15, 16]. As a result, the majority of the region's forests have become degraded.

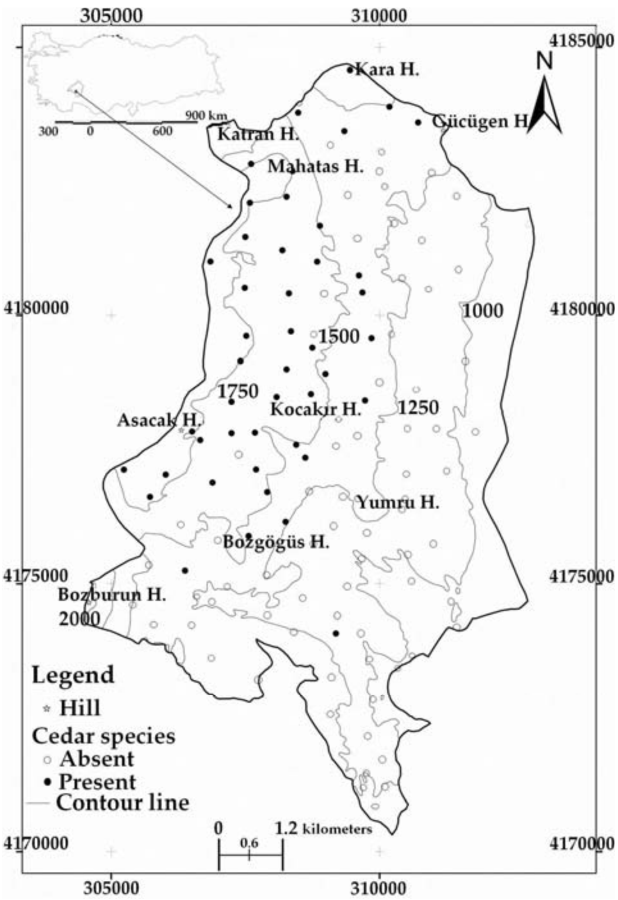

Fig. 1. The study area and the locations of occupied (●) and unoccupied (○) sample points by Lebanon cedar.

Studies concerning mapping of potential distribution areas of the focal species are therefore crucial for preparing accurate management, conservation, and restoration plans for the Mediterranean ecosystems.

Lebanon cedar (*Cedrus libani* A. Rich) is one of the most valuable tree species in Turkey due to its importance from historical, cultural, aesthetic, scientific, and economic points of view. The wood of Lebanon cedar is resistant to decay, insect damage, and climatic conditions. The wood is easily processed by hand on machine tools. Besides, it has a peculiar smell and color. Due to those properties, Lebanon cedar has been in demand for thousands of years. As a result, a considerable portion of Lebanon cedar forests has been destroyed. The destruction has particularly continued in Lebanon cedar forests in the Taurus Mountain of the Mediterranean region. Because of this destruction, there is a comprehensive potential area to be reforested by Lebanon cedar in the region [17]. Therefore, determining the potential distribution areas of the Lebanon cedar is one of the primary matters from an ecological perspective.

This study was carried out to define indicator species of Lebanon cedar by using ICA and to build its geographical distribution model by using CART in the Yukarigokdere Forest District, Mediterranean region, Turkey.

Material and Method

Site Description

Yukarıgökdere Forest District is located in the Lakes subregion of the Mediterranean region, situated between north latitudes of 37º 37' 22.5" and 37º 50' 17" m and east longitudes of 30º 46' 12.4" and 30º 52' 35" m with an area about 8,000 ha (Fig. 1). Limestone is the dominant parent material. Locally, also conglomerates and ophiolitic melanges are present. Elevation ranges between 800 m and 2000 m asl. In the district, a translation climate prevails between Mediterranean climate and continental climate, with an average annual rainfall of 751 mm and an annual average temperature of 13.03ºC. The forest is mainly composed of *Pinus brutia* (Brutian pine), *Pinus nigra* (Crimean pine), *Juniperus exelsa* (Crimean juniper), *Cedrus libani* (Lebanon cedar), and *Ouercus* (oak) species. The district is rich in endemic species, with 61 endemic plant taxa [18, 19].

Data and Statistical Evaluation

The data were collected from 119 sample plots. At each plots the presence and absence data of Lebanon cedar and the other plant species were recorded. In the study, first of all, interspecific correlation analysis (ICA) was applied in order to find the indicator species of Lebanon cedar by using presence-absence data of vascular plants. ICA was applied by considering the plants having a higher frequency value more than 5%. While applying ICA, to find the species having significant association with Lebanon cedar, chi squared tests (χ^2) were applied and, to define signs and values of the associations, correlation coefficients (C) of each species having significant association with Lebanon cedar were calculated [1-3, 20].

$$\chi^2 = \frac{(ad - bc)^2}{(a+b)(a+c)(c+d)(b+d)} \quad (1)$$

$$C = \frac{4(ad - bc)}{(a+d)^2 + (b+c)^2} \quad (2)$$

...where: *a* is the number of common sample plots of Lebanon cedar and a relevant candidate plant, *b* is the number of sample points where Lebanon cedar is present and the candidate plant is absent, *c* is the number of sample points where Lebanon cedar is absent and the candidate plant is present, and *d* is the number of sample plots where both of the species are absent.

Binary (absence/presence) data of Lebanon cedar was taken as a response variable in order to obtain its spatial distribution model. Occupied and unoccupied sample points by Lebanon cedar are given in Fig. 1.

Climatic and topographical variables were taken as explanatory variables. A 30 arc second (0.00083˚ by 0.00083˚) resolution of bioclimatic layers (representing annual trends, seasonality, and extreme or limiting environmental factors) were used for 1950-2000 from the WorldClim data set [21] (downloaded 5 March 2011). All bioclimatic layers were resampled with cubic convolution, the most commonly implemented higher-order resampling technique, to a pixel resolution of 100 m by 100 m grids. Elevation and bedrock geology maps were provided from OGM (general directory of forestry) and MTA (general directorate of mineral research and exploration). Slope and aspect were derived from the elevation-built function provided by ArcGIS. Topographic position index and landform category maps were derived from elevation map by placing "tpi_jen.avx" file into the Arcview extensions directory [22]. These maps were resampled at a resolution of 100 m by 100 m grids by using the nearest neighbour interpolation as the simplest technique for assigning pixel values to the new grid. The resampled bedrock map was composed of 3 main bedrock types (i.e. limestone group including neritic limestone, pelagic limestone and charty limestone with Halobia (a), conglomerate (b), and ophiolitic melange (c). Landform types were composed of 6 classes (i.e. canyons, deeply incized streams (a), midslope and upslope drainage and shallow valleys (b), U-shaped valleys (c), plains and open slopes (d), upper slopes, mesas (f), local ridges/hills in valley, midslope ridges, small hills in plain, and mountain tops or high ridges (g)). Also, heat index (*HI*) and aspect favourability (*AF*) were used in this study as explanatory variables calculated for each pixel following the equations:

$$HI = \cos alpha1 \times \tan alpha2 \quad (3)$$

$$AF = \cos(A\max - A) + 1 \quad (4)$$

...where: *alpha*1 is deviation of aspect from 202.5º (SSW), and *alpha*2 is slope degree. *A* is measured aspect and *A*max is 202.5º (SSW). All environmental layers and their codes are given in Table 1.

Table 1. Environmental variables and their codes (n: continuous data, c: categorical data).

Variables	Codes
Elevation (n)	ELVN
Slope (n)	SLOP
Landform category (c)	LFC
Topographic position index	TPI
Bedrock geology (c)	ROCK
Heat index	HI
Aspect favourability	AF
Radiation index (n)	RI
Annual mean temperature (n)	BIO1
Mean diurnal range (mean of monthly (max temp – min temp)) (n)	BIO2
Isothermality (BIO2/BIO7) (* 100) (n)	BIO3
Temperature seasonality (standard deviation *100) (n)	BIO4
Max temperature of warmest month (n)	BIO5
Min temperature of coldest month (n)	BIO6
Temperature annual range (BIO5-BIO6) (n)	BIO7
Mean temperature of wettest quarter (n)	BIO8
Mean temperature of driest quarter (n)	BIO9
Mean temperature of warmest quarter (n)	BIO10
Mean temperature of coldest quarter (n)	BIO11
Annual precipitation (n)	BIO12
Precipitation of wettest month (n)	BIO13
Precipitation of driest month (n)	BIO14
Precipitation seasonality (coefficient of variation) (n)	BIO15
Precipitation of wettest quarter (n)	BIO16
Precipitation of driest quarter (n)	BIO17
Precipitation of warmest quarter (n)	BIO18
Precipitation of coldest quarter (n)	BIO19

A classification and regression tree technique (CART) was applied to describe potential distribution of Lebanon cedar in the study. CART analysis is a nonparametric tree-building technique. The essential purpose of classification and regression tree technique (CART) is to partition the main data into homogeneous subgroups. In this way, the data is represented by a tree structure. In tree structure, internet nodes denote best split predictor variables. The branches of the nodes denote the criteria values of the split variables. Leaves denote the final response classes. The paths from the root node (top node) to leaf (terminal node) show the decision rules that maximize the distinction among the classes and minimize the diversity in each class. By using this approach, both categorical and numeric response data can be modelled. If the response variable is categorical, then "classification trees"; if it is continuous, "regression trees" are used [7, 23-25]. In this context, since our response variable is categorical data, we used the classification tree technique. The CART method uses the Gini impurity measure to decide the purity for the binary dependent variable.

For a node t, the Gini index of impurity, $g(t)$, is defined in the following way:

$$g(t) = \sum_{j \neq i} p(j \mid t) p(i \mid t) \tag{5}$$

...where: i and j are categories of the target variable. Since our response variable is binary data (occurrence or non-occurrence of Lebanon cedar), the equation for the index reduces to:

$$g(t) = 2p(1 \mid t) p(2 \mid t) \tag{6}$$

The index equals 0 since all recodes in the node belong to only one category, which means the node is purity. To select the best predictor variable of a node, every possible variable is scored and one with the best score that represents the greatest reduction in impurity is selected. For any node t, suppose that there is a candidate split s of the node, which divides it into the left division t_L and the right division t_R.

The score is defined in the following way:

$$\phi(s,t) = g(t) - p_L g(t_L) - p_R g(t_R) \tag{7}$$

...where: P_R is the proportion of cases of child node t sent to the right, and P_L to child node on the left. It can be defined as a candidate set S of binary s at each node. When it starts at the root note t_1, it looks for the division s^* among all possible S, with a greater reduction value of impurity.

$$\phi(s^*, t_1) = \max_{s \in S} \phi(s, t_1) \tag{8}$$

The dataset is divided into two subgroups by a perfect split s, which causes $g(t_L) = g(t_R) = 0$. The recursive partitioning algorithm loops until it is impossible to continue, (i.e. when only one case remains or when all the cases belong to the same class). A maximum tree will be produced when it grows until all terminal nodes are perfect purity. The maximal tree is generally over-adjusted because of the random or noisy cases in the learning dataset. The CART uses an "overgrowing and prune back" procedure to get an optimal tree that is fitted to signal rather than noise [26]. In this study, due to fact that our sample size is small, all data were used for training purposes by using 10-fold cross-validation, i.e. the data were divided into 10 subgroups, and 10 separate models fit. The first model used subgroups 2-10 for training, and subgroup 1 for testing. The second model used groups 3-10 and 1 for training, and group 2 for testing, and so on. In all cases, an independent test subgroup was available. Misclassification error rates were then calculated for each subset. This process was performed for each size of tree, and the tree with the smallest misclassification error rate based on the independent test set was then chosen as the optimal tree [7, 24, 27, 28]. S-Plus software was used to build classification trees [29].

After performing CART, *if-then* rules were written for each path of tree graph in an Excel file to calculate the predicted values of the response variable. The following formulas were used for continuous explanatory variables (formula 9) and categorical explanatory variables (formula 10) to find predicted values (B_n) being the leaf value of n. terminal node.

$$=IF(AND(X_{L1ij} \# Nd_1; X_{L2ij} \ldots\ldots X_{Lnij} \# Nd_n) \tag{9}$$

$$=IF(AND(OR(X_{LC1ij}=c_1; X_{LC1ij}=c_2; \ldots X_{LC1ij}=c_n) \tag{10}$$

...where: $X_{L1ij} \ldots . X_{Lnij}$ denotes divisor explanatory variables for i-th column and j-th row from the first level ($L1$) (top node) to the last level (Ln) (terminal node) of a given path, Nd represents the criteria value of a divisor explanatory variable at each level of the relevant branch, X_{LC1ij} denotes the categorical deviser variables, and c_n denotes categories provided from *if-then* rules in a given categorical variable.

Finally, the predicted values were calculated at each grid (100×100 m) (totally for 6,273 grids). All grids were digitized in order to form the potential distribution maps of response variables.

Results

In total 137 vascular plant species were recorded from 119 sample plots. Among them, 72 species have more than 5% frequency value. Thirty six species (nineteen positive and seventeen negative) are significantly associated with Lebanon cedar according to χ^2 results. The plants that have the most significant positive association with Lebanon cedar are *Acer hyrcanum* subsp. *sphaerocaryum*, *Berberis crataegiana*, *Coteneaster nummuleria*, *Amacella parfiniflora*, *Fraxinus ornus* subsp. *cilicica*, *Quercus vulcanica,* and *Sorbus umbellata*. The most significant negative indicators of Lebanon cedar are *Creatagus monogyna*, *Pistacia terebinthus* subsp. *palaestina*, *Quercus coccifera*, and *Styrax officinalis,* as well (Fig. 2).

With respect to CART results, Fig. 3 shows the optimal classification tree, with a 5% misclassification error rate. The tree model produced 8 terminal nodes and 7 splits. The predictor variables used in the splits were ELVN, HI, BIO12, SLOP, LFC, and TPI. Among those environmental variables, the most significant environmental factor on the distribution of Lebanon cedar is ELVN. According to the tree model, Lebanon cedar prefers particularly above approximately 1,300 m and precipitation greater than 600 mm in the district (Fig. 3). This result is meaningful

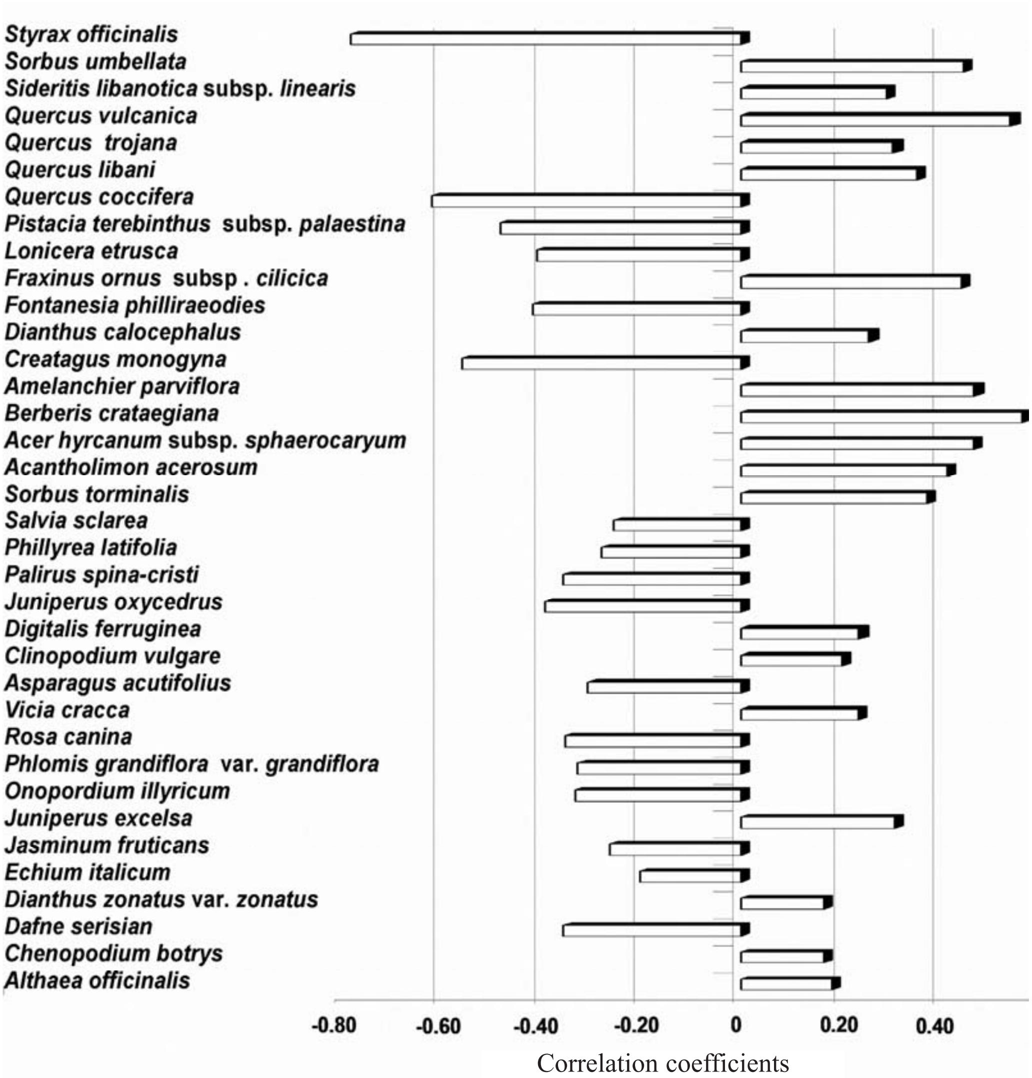

Fig. 2. Plants having significant associations with Lebanon cedar at the level of 0.05 according to χ^2 results and their interspecific correlation coefficients.

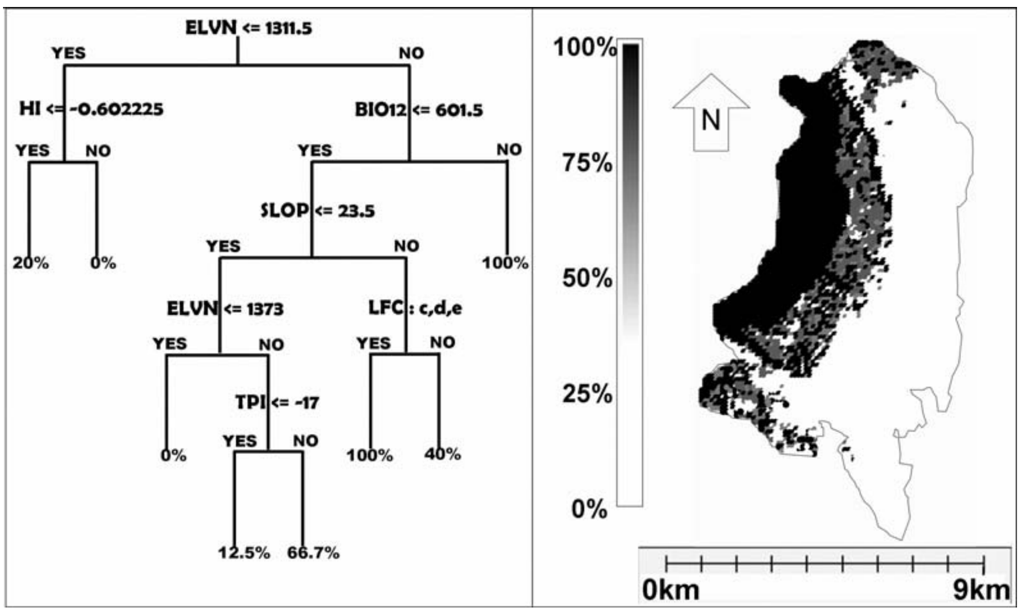

Fig. 3. Classification tree model and distribution probability map of Lebanon cedar in the Yukarigokdere Forest District of the Mediterranean region, Turkey.

because Lebanon cedar prefers wetter and cooler climatic conditions. That is why Lebanon cedar is often present between 1,200-1,900/2,000 m asl. in the Tauros Mountains of the Mediterranean region, Turkey. In the Yukarigokdere Forest District, the most favourable sites for Lebanon cedar begin at 1,500 m (Fig. 3).

Discussion and Conclusion

Thermo-Mediterranean, euro-Mediterranean, supra-Mediterranean and mountain-Mediterranean communities are distributed from lower sites to the upper sites, respectively, in the Yukarigokdere district [17]. As expected, Lebanon cedar showed negative associations with many thermo-Mediterranean elements such as *Pistacia terebinthus* subsp. *palaestina*, *Quercus coccifera*, and *Styrax officinalis*. Those findings are meaningful because Lebanon cedar is often present in the supra-Mediterranean or mountain- Mediterranean communities [12, 13, 15, 30-33]. That is why Lebanon cedar also has a highly positive association with well-known supra-Mediterranean and mountain-Mediterranean elements such as *Acer hyrcanum* subsp. *sphaerocaryum*, *Berberis crataegiana*, *Amelanchier parviflora*, *Fraxinus ornus* subsp. *cilicica*, and *Sorbus umbellata*. Those results confirmed the tree model results as well. Thermo-Mediterranean communities are dominant at elevations between 900-1,100 m while supra-Mediterranean and mountain-Mediterranean communities are found above approximately 1,300 m, where the site conditions are the most favourable for the distribution of Lebanon cedar [19].

The Mediterranean region has a vast and rich forest potential. In the region, several valuable forest tree species such as Brutian pine (*Pinus brutia*), Crimean pine (*Pinus nigra*), and Crimean juniper (*Juniperus exelsa*) are widespread as well as Lebanon cedar. The region also is rich in endemic diversity with more than 700 endemic species [34-36]. However, the majority of the Mediterranean forests have been degraded. That is why mapping the potential distributions of focal species is crucial to prepare essential management and conservation plans for the Mediterranean region ecosystems.

More recently modeling spatial distribution of organisms has become a popular topic due to numerous packet programs [4-6, 37-39]. Of various statistical approaches in modeling studies, CART has been increasingly used in resent years due to the fact that it can model complex and nonlinear ecological relations much better than traditional techniques [27].

Spatial distribution models can also be applied to digital maps of climate change scenarios. This is particularly important for the Mediterranean region, because human-induced climate change is seriously threatening Mediterranean ecosystems [40, 41].

Even though numerous studies have already focused on the relationships between plant distribution and environmental factors, a considerable study has not been carried out about the spatial distribution modelling of plant species in the Mediterranean region of Turkey so far. That is why this present study also is important as an essential reference for further studies, which will be carried out about species distribution modelling of the species in the Mediterranean region of Turkey.

References

1. COLE L.C. The measurement of interspesific association. Ecology **30**, (4), 411, **1949**.
2. POOLE R.W. An introduction to quantitative ecology. McGraw- Hill, Inc., New York, **1974**.
3. ÖZKAN K. The measurement of interspecific association by interspecific correlation analysis. Suleyman Demirel University, Faculty of Forestry Journal **2**, 71, **2002** [In Turkish].
4. CARPENTER G., GILLISON A.N., WINTER J. Domain: a flexible modelling procedure for mapping potential distributions of plants and animals. Biodiversity & Conservation, **2**, 667, **1993**.
5. SKOV F. Potential plant distribution mapping based on climatic similarity. Taxon, **49**, 503, **2000**.
6. VARGAS J.H., CONSIGLIO T., JØRGENSEN P., CROAT T.B. Modelling distribution patterns in a species-rich plant genus, Anthurium (Araceae), in Ecuador. Diversity and Distribution, **10**, 211, **2004**.
7. BREIMAN L., FRIEDMAN J.H., OLSHEN R.A., STONE C.G. Classification and Regression Trees. Wadsworth International Group, Belmont, California, USA, **1984**.
8. CLARK L.A., PREGIBON D. Tree-based models. In: Chambers JM, Hastie TJ (Eds) Statistical models in S. Wadsworth and Brooks, Pacific Grove, California, USA, pp 377-420, **1992**.
9. RIPLEY B.D. Pattern recognition and neural networks. Cambridge University Press, Cambridge, UK, **1996**.
10. ROBERT J., WARREN R.J. An experimental test of well-described vegetation patterns across slope aspects using woodland herb transplants and manipulated abiotic drivers. New Phytologist **185**, 1038, **2010**.
11. HEIKKINEN R.K., LUOTO M., ARAÚJO M.B., VIRKKALA R., THUILLER W., SYKES M.T. Methods and uncertainties in bioclimatic envelope modelling under climate change. Progr. Phys. Geogr. **30**, 1, **2006**.
12. ATALAY I. The ecological conditions of the natural occurrence areas of cedar (*Cedrus libani* A. Rich.) and regioning of seed transfer of cedar in Turkey. Forest Ministry Press, Turkey, **1987**.
13. KANTARCI M.D. The Site Classification of Mediterranean Region, Turkey. Forest Ministry Press, 668/64 Ankara, Turkey, p 150, **1991** [In Turkish].
14. OZKAN K., GULSOY S., MERT A., OZTURK M., MUYS B. Plant distribution-altitude and landform relationships in karstic sinkholes of Mediterranean region of Turkey. J. Environ. Biol. **31**, 51, **2010**.
15. FONTAINE M., AERTS R., OZKAN K., MERT A., GULSOY S., SUEL H., WAELKENS M., MUYS B. Elevation and exposition rather than soil types determine communities and site suitability in Mediterranean mountain forests of southern Anatolia, Turkey. Forest. Ecol. Manag. **247**, 18, **2007**.
16. VELMOERE M., VAECKE L., WAELKENS M., SMETS E. Modern and ancient olive stands Sagalassos (Southwest Turkey) and reconstruction of the ancient agriculturel landscape in two valleys. Global. Ecol. Biogeogr. **12**, 217, **2003**.

17. BOYDAK M. Regeneration of Lebanon cedar (*Cedrus libani* A. Rich.) on karstic lands in Turkey. Forest. Ecol. Manag. **178**, 231, **2003**.
18. FAKIR H., GUNDOGDU E., SENTURK O. Mapping of Fauna and Flora in Functional Planning based on Geographical information systems: A case study from Yukarıgökdere, Isparta, Turkey. Fresenius Environmental Bulletin **18**, (11), 1992, **2009**.
19. OZKAN K., NEGIZ M.G. Woody vegetation classification and mapping by using hierarchical methods in Isparta-Yukarıgokdere district. Suleyman Demirel University, Faculty of Forestry Journal **12**, 27, **2011** [In Turkish].
20. GÜNER Ş.T., ÖZKAN K., ÇÖMEZ A., ÇELİK N. Woody Indicator Species of Probable Productive Potantial Areas of Anatolian Black Pine (*Pinus nigra* subsp. *pallasiana*) in the Inner Anatolia Region. Ecology, **20**, 51, **2011**.
21. HIJMANS R.J., CAMERON S.E., PARRA J.L., JONES P.G., JARVIS A. Very high resolution interpolated climate surfaces for global land areas. Int. J. Climatol. **25**, 1965, **2005**.
22. WEISS A. Topographic Position and Landforms Analysis. ESRI User Conference, San Diego, CA, **2001**.
23. McKENNEY D.W., PEDLAR J.H. Spatial models of site index based on climate and soil properties for two boreal tree species in Ontario, Canada. Forest. Ecol. Manag. **175**, 497, **2003**.
24. CHU C.M., TSAI B.W., CHANG K.T. Integrating Decision Tree and Spatial Cluster Analysis for Landslide Susceptibility Zonation. Proc. World Acad. Sci. Eng. Tech. **59**, 470, **2009**.
25. NAVARRATE E., ESPINOSA M. Using the Non-Parametric Classifies CART to Model Wood Density. J. Data. Sci. **9**, 261, **2011**.
26. MEYNARD C.N., QUINN J.F. Predicting species distributions: a critical comparison of the most common statistical models using artificial species. J. Biogeogr. **34**, 1455, **2007**.
27. DE'ATH G., FABRICIUS K.E. Classification and Regression Trees: A Powerful Yet Simple Technique for Ecological Data Analysis. Ecology **81**, (11), 3178, **2000**.
28. MOISEN G.G. Classification and Regression Tree. In: Jorgensen SE (Ed) In Encyclopedia of Ecology pp. 582-588, **2008**.
29. MATHSOFT S-PLUS 4 Guide to Statistics. MathSoft, Inc., Seattle, WA, **1997**.
30. ATALAY I. Vegetation Geography of Turkey. Ege University Bookshop, Bornova, Turkey, pp. 300, **1994** [In Turkish].
31. OZKAN K., KANTARCI M.D. Subregions and site section groups on Beysehir Watershed. Suleyman Demirel University, Faculty of Forestry Journal **2**, 123, **2008** [In Turkish].
32. OZKAN K. Environmental factors as influencing vegetation communities in Acipayam district of Turkey. J. Environ. Biol. **30**, (5), 741, **2009**.
33. OZKAN K., GULSOY S. Ecological land classification and mapping based on vegetation-environment hierarchical analysis – a case study of Buldan forest district (Turkey). Pol. J. Ecol. **58**, (1), 55, **2010**.
34. AVCI M. Diversity and Endemizm in Turkey's Vegetation. Istanbul University Faculty of Arts and Sciences, Geography Journal **13**, 27, **2005** [In Turkish].
35. KAYA, Y. Distribution of endemic plants in the World and Turkey. Erzincan Faculty of Education Journal **7**, (1), 85, **2005** [In Turkish].
36. OZKAN K., SUEL H. Endemic plant species in a karstic canyon (Mediterranean Region, Turkey): relation to relief and vegetation diversity. Pol. J. Ecol., **56**, (4), 709, **2008**.
37. GÜNER Ş.T., ÖZKAN K., ÇÖMEZ A. Key factors in the site selection of *Rosa canina* (L.) – aplying the generalized additive model. Pol. J. Ecol, **59**, 475, **2011**.
38. HERNANDEZ P.A., FRANKE I., HERZOG SK., PACHECO V., PANIAGUA L., QUINTANA H.L., SOTO A., SWENSON J.J., TOVAR C., VALQUI T.H.,VARGAS J., YOUNG B.E. Predicting species distributions in poorly-studied landscapes. Biodivers. Conserv. **17**, 1353, **2008**.
39. LI D., GAO S., WU Y., SUN L., GUO S., LI J. Model to assess the habitat suitability for endangered bird species: brown eared-pheasant crossoptilon mantchuricum swinhoe in xiaowutaishan reserve, China. Pol. J. Ecol., **56**, 723, **2008**.
40. ULBRICH U., MAY W., LI L., LIONELLO P., PINTO J.G., SOMOT S. The Mediterranean Climate Change Under Global Warming. In: Lionello P, Malanotte-Rizzoli P Boscolo R (eds) Mediterranean climate variability and predictability. Elsevier, Amsterdam, pp. 398-415, **2006**.
41. SMOTH S., SEVAULT F., DÉQUÉ M., CRÉPON M. 21st century climate change scenario for the Mediterranean using a coupled Atmosphere-Ocean Regional Climate Model. Global Planet Change **63**, 112, **2007**.