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CLASSIFICATION AND ORDINATION OF *PINUS NIGRA* DOMINATED FORESTS AT ALACAM MOUNTAINS (NW ANATOLIA-TURKEY)

Ali KAVGACI[1*], Orhan SEVGİ[2], Hüseyin Barış TECİMEN, Osman Yalçın YILMAZ[3], Serdar CARUS[4], Türker DÜNDAR[5]

[1]Southwest Anatolia Forest Research Institute, Antalya-Turkiye, alikavgaci1977@yahoo.com
[2]Forest Ecology and Soil Science Department of Forestry Faculty of Istanbul University, Istanbul-Türkiye.
[3]Surveying and Cadastre Department of Forestry Faculty of Istanbul University, Istanbul-Türkiye.
[4]Dendrometry and Yield Department of Forestry Faculty of Suleyman Demirel University, Isparta-Türkiye.
[5]Department of Wood Mechanics and Technology of Forestry Faculty of Istanbul University, Istanbul-Türkiye [1]

Abstract

Pinus nigra dominated forests at Alaçam Mountains at the northwest of Anatolia were sampled, elaborated and classified since those forests represents one of the most typical distiribution of *Pinus nigra* in Turkey and were not subjected to any phytosociological study. Additionally, pure *Fagus orientalis* stands at the upland of the mountains were added to the analysis. The ecological conditions were assessed by topographical and environmental (latitude and longitude) factors. Forest vegetation at Alaçam Mountains can be divided into four groups. Three of these communities represent the *P. nigra* forests whereas the last is formed by pure *F. orientalis* forest. It was established that the most important ecological factor is altitude, while the other factors do not correlate with the floristic differentiation of the communities. The names of the communities along the altitudinal gradient are as follow: *Cistus laurifolius-Pinus nigra* dominated forest, *Pteridium aquilinum-Pinus nigra* dominated forest, *Fagus orientalis-Pinus nigra* dominated forest, and *Galium odoratum-Fagus orientalis* dominated forest. These results indicate the rich diversity and differentiation at short distances at the study area, and altitude is the determining ecological factor on this richness. They also explore the need of a broad scale phytosociological study on *Pinus nigra* forests along whole Anatolia to define their floristic and ecological diversities.

Keywords: Alaçam mountains, classification, ordination, numeric analysis, phytoecology, phytosociology, *Pinus nigra* forests

Özet

Bu çalışmada, kuzeydoğu Anadolu'da yer alan Alaçam Dağları'ndaki *Pinus nigra* (Karaçam) ormanları, örneklenmiş, değerlendirilmiş ve sınıflandırılmıştır. *Pinus nigra*'nın Türkiye'deki en tipik yayılışlarından birini temsil eden bu ormanlarda bugüne kadar herhangi bir fitososyolojik araştırma gerçekleştirilmemiştir. Çalışmada ayrıca yüksek dağlık bölgedeki saf kayın (*Fagus orientalis*) ormanları da incelenmiştir. Ekolojik değerlendirmeler; topoğrafik ve çevresel (enlem ve boylam) faktörler ele alınarak yapılmıştır. Buna göre Alaçam Dağları'ndaki orman vejetasyonunun dört orman toplumundan meydana geldiği belirlenmiştir. Bitki toplumlarından üçü *P. nigra*'nın egemen olduğu toplumlar iken, sonuncusu saf *F. orientalis* ormanlarını temsil etmektedir. Yapılan ekolojik değerlendirmeler sonucunda, bitki toplumlarının yayılışı üzerinde en etkili faktörün yükseklik olduğu, diğer faktörlerin ise bitki toplumlarının farklılaşmasıyla bir ilişki göstermediği tespit edilmiştir. Yüksekliğe bağlı olarak değişim gösteren bitki toplumları sırasıyla şu şekildedir: *Cistus laurifolius-Pinus nigra* egemen ormanlar, *Pteridium aquilinum-Pinus nigra* egemen ormanlar, *Fagus orientalis-Pinus nigra* egemen ormanlar ve *Galium odoratum-Fagus orientalis* egemen ormanlar. Bu sonuçlar bölgedeki yüksek floristik çeşitlilik ile kısa mesafelerdeki floristik farklılaşmaların bir sonucudur. Bu çeşitlilik ve farklılığın oluşmasında belirleyici olan ekolojik faktör ise yüksekliktir. Çalışma sonuçları ayrıca bütün Anadoluda, *Pinus nigra* ormanlarının sahip olduğu floristik ve ekolojik çeşitliliğin ortaya konması bağlamında bir fitososyolojik araştırmanın gerekliliğini de ortaya koymaktadır.

Anahtar kelimeler: Alaçam Dağları, bitki ekolojisi, bitki sosyolojisi, ordinasyon, *Pinus nigra* ormanları, sayısal analiz, sınıflandırma.

INTRODUCTION

Species and subspecies of *Pinus nigra* have a significant distribution mainly at Mediterranean part such as *Pinus nigra* subsp. *lariocio* (Southern Italy, Corsica Sicily), *Pinus nigra* subsp. *salzmannii* (Mid and South Spain, Pyrenees mountains) *Pinus nigra* subsp. *dalmatica* (Islands and Northwestern shores of former Yugoslavia), *Pinus nigra* subsp. *nigra* (From Austria to mid-Italy, Greece and former Yugoslavia), *Pinus nigra* subsp. *pallasiana* (Balkans, South Carpathian mountains, Crimean, Turkey, Cyprus and Syria) (Bussotti 2002). *Pinus nigra* is a typical tree species at mountainous regions of Mediterranean basin (Mayer and Aksoy 1998).

Pinus nigra is the one of the five naturally distributed pine species in Turkey and besides its relict distribution at Northern Thrace, it mainly appears in Anatolia. It covers an area of about 4.2 million hectares (Akkemik et al. 2011) and it is one the characteristic species of the transitional climatic and vegetation zone between sea influenced areas (Mediterranean and Black Sea regions) and continental areas (Inner Anatolia) (Saatçioğlu 1976). In Turkey appear 4 varieties of *Pinus nigra* such as *Pinus nigra* subsp. *pallasiana* var. *pallasiana* (Louden), *Pinus nigra* subsp. *pallasiana* var. *pyramidata* (Acatay) Yalt., *Pinus nigra* subsp. *pallasiana* var. *şeneriana* (Saatçioğlu) Yalt., *Pinus nigra* subsp. *pallasiana* var. *yaltırıkiana* Alptekin (Saatçioğlu 1955, Acatay 1956, Alptekin 1986, 1987; Yaltırık 1993; Yücel 1999) and 16 variations (Alptekin 1986).

In addition to the pure forests, it also forms mixed forests with many different tree species depending on very large latitudinal and longitudinal geographical and ecological gradients (Mayer and Aksoy 1998). From the phytosociological point of view, as a result of these large gradients, *Pinus nigra* dominated or co-dominated forests were classified under different syntaxanomic units (Akman 1995).

One of the most intensive distributions of *Pinus nigra* appears at Alaçam Mountains at the northwest of Anatolia. These forests have been under the special attention of Turkish Forestry Organization due to the high wood quality. For these reasons, some studies with different aspects were realized in the past (Pamay 1960; Göker 1977; Sevgi et al. 2010; Yılmaz et al. 2012). Studies to determine yield performance for *Pinus nigra* at regional and national scale have been conducted (Gülen 1959, 1965; Kalıpsız 1963; Sun 1974; Erkan 1997). Regional study about soil and forest floor properties of *Pinus nigra* forests reveal that it was successively adaptive to survive on variety of parent rocks **(**Sevim 1954; Irmak and Çepel 1974; Eruz 1984; Sevgi 2003; Sevgi and Tecimen 2008). But, a comprehensive work does not exist on its vegetation characteristics although it is situated at the transition of three phytogeographic regions: Mediterranean, Irano-Turanian and Euro-Siberian.

So, in this work, it was aimed to (a) determine the plant communities of *Pinus nigra* forest vegetation in the region (b) define their ecological and geographical gradients and (c) examine the species diversity. In addition to the both of pure and mixed *Pinus nigra* forests with some *Quercus* spp. (*Q. cerris* and *Q. frainetto*) and *Fagus orientalis*, pure *F. orientalis* forests which locally form the highest forest belt in the region were added to the analysis.

MATERIAL AND METHOD

Study area

The study was carried in Alacam Mountains situated at the border of Balıkesir and Kutahya cities in NW Anatolia-Turkey (Longitute of 29° 15' 30" - 28° 15' 00" and latitute of 39° 38' 00" - 39° 07' 30"). The mountains with an area of about 91 744 hectares are covered by pure stands of *Pinus nigra* forests at the middle and high altitudinal belts. In these areas, either *Fagus orientalis* locally accompany with it or forms pure stands, especially on the highest forest zone. In lowland and lower montane belts, *Pinus brutia*, *Juniper* species and Oak species appear by depending on ecological differences.

The average annual rainfall is about 629.3 mm and the average temperature is 13.2 ˚C in the region. The hottest month is July and the coldest month is February (Sevgi et al. 2010). According to the Thornthwaite (1948) climate system, the research area has a humid and mesothermal oceanic climate. The parent rock is mainly formed by Civana tuff, alluvion, metamorphic rocks, Dagardi melanj, granite and dasite (Sevgi et al. 2010).

Analysis of Vegetation Data

The field work was carried out in 2007 and 2008. We mainly sampled submediterranean *Pinus nigra* dominated forests in the region. Additionally *Fagus orientalis* pure forests in the high vegetation belt were sampled. We chose homogenous sampling plots with an area of 400 m^2. The protocol of each plot includes general, topographic and other data of individual plots, such as altitude, inclination, aspect, vegetation cover (total and of individual layers) and a list of all vascular

plants, in which a cover value was assigned to each species according to the nine degree Braun-Blanquet scale (Braun-Blanquet 1964; Westhoff and van der Maarel 1973). Totally 83 releves were sampled.

The samples (hereinafter relevés) were stored in the TURBOVEG database management program (Hennekens and Schaminée 2001). The hierarchical classification of the data set was carried out in the computer program PC-ORD (Mc Cune and Mefford 2006) by using Ward's method and Jaccard distance as a resemblance measure. Different levels of division were accepted in the dendrogram, resulting in four clusters interpretable in terms of ecology. Additionally, the diagnostic species of the accepted clusters were identified by a fidelity measure in the JUICE program (Tichý 2002). The threshold of the phi value was subjectively selected at 0.50 for a species to be considered as diagnostic (Chytrý et al. 2002). Determination of the higher syntax was performed according to the Akman (1995).

The results of the classification were visualized by ordination techniques in the CANOCO 4.5 package (ter Braak and Šmilauer 2002). Detrended Canonical Analysis (DCA) which is a direct ordination method assuming a unimodal response of species to the environment, was run due to the high heterogeneity in the matrix of species (Lepš and Šmilauer 2003). Topographic factors (aspect, altitude and inclination) and geographic factors (longitude and latitude) were used as explanatory variables and projected passively onto the ordination plane. Correlations between DCA relevé scores and explanatory variables were calculated using the non-parametric Kendall coefficient in STATISTICA (Anon. 2007).

Additionally, Canonical Correspondance Analysis (CCA), a unimodal and direct ordination technique used because of the wide gradient of relevés (Lepš and Šmilauer 2003), was chosen to show correlations between relevés and variables that were measured in the field (aspect, altitude, inclination, longtitude, latitude). The unrestricted Monte Carlo test with 9999 permutations was also used to test the statistical significance of the variables.

In addition to this analysis, species diversity of the communities was examined by the species number and Shannon-Wiener species diversity index for each relevé. Identification of the species was made according to the Flora of Turkey (Davis 1965-1985, Davis et al. 1988).

RESULTS

Classification

The classification of the database shows four clusters (Figure 1). Diagnostic species of these clusters and vegetation table of the relevés are shown in the Appendix. While three of these communities represent the *Pinus nigra* forests, the last is formed by pure *F. orientalis* forest.

Cluster 1 consists of *Cistus laurifolius-Pinus nigra* dominated forests. *C. laurifolius, Quercus cerris* var. *cerris* and *Cardamine hirsuta* are the diagnostic species of the community. *Q. frainetto* locally joins to the stand mixture of the community, which is usually formed by young stands and makes single – cohort stand structures.

Cluster 2 represents *Pteridium aquilinum-Pinus nigra* dominated forests. Diagnostic species of the community are *Fragaria vesca, Lathyrus laxiflorus subsp. laxiflorus, Luzula forsteri, Pteridium aquilinum* and *Viola sieheana*. This community constitutes single cohort stand structure so that it was only dominated by *Pinus nigra* in three layers and it is generally formed by mature stands in the region.

Cluster 3 represents *Fagus orientalis-Pinus nigra* dominated forests. *Quercus petraea subsp. petraea* locally joins to the stand mixture in this community. *F. orientalis* and *Galium rotundifolium* are the diagnostic species of this community. As a result of the occurrence of *F. orientalis*, this community, generally formed by mature stands, constitutes two or multi-cohort stand structures.

Cluster 4 includes *Galium odoratum-Fagus orientalis* dominated forest in the region. These two species are also the diagnostic species of the community. *P. nigra* does not join to the stand mixture of this community. It is generally formed by mature stands and has multi-cohort stand structure. The community, mainly appearing on the highest forest vegetation belt in the region, indicates the reduced effect of Black Sea climate towards the region. It also represents the extrazonal distribution of *F. orientalis* in southern Marmara and northern Aegean regions.

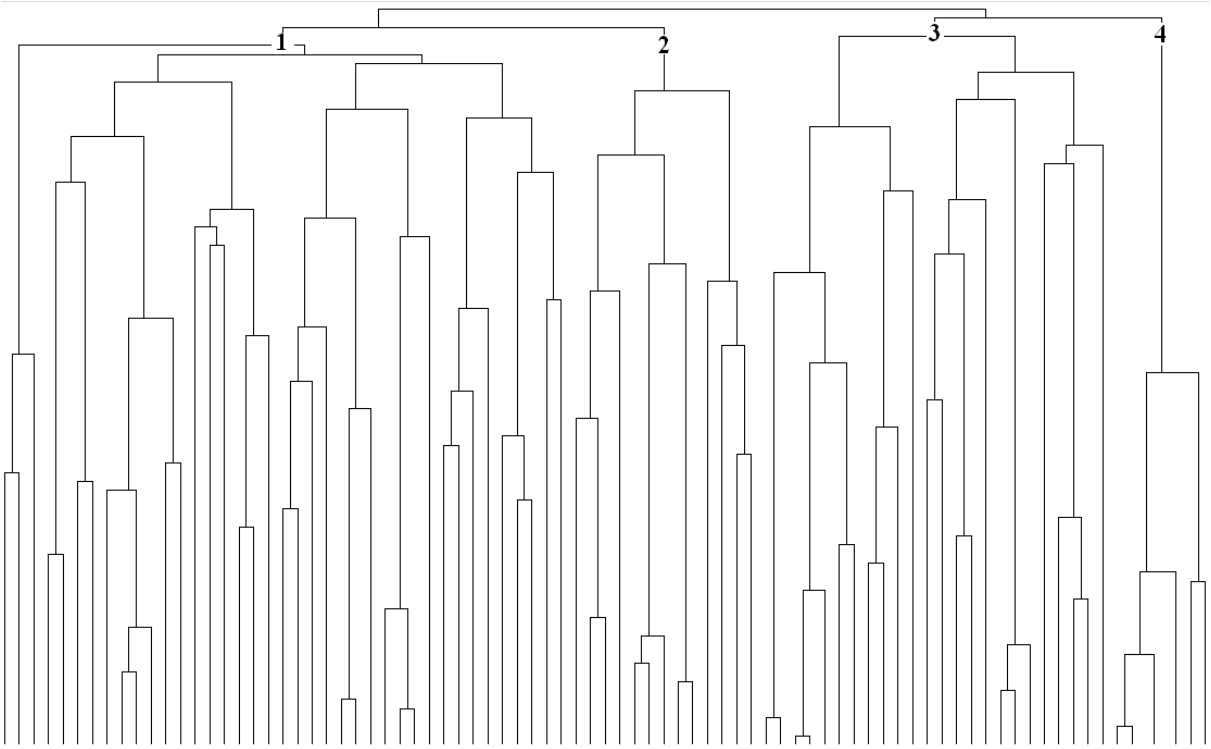

Figure 1. Hierarchical classification diagram of relevés of forests at Alacam Mountains. Numbers correspond to the communities: 1. *Cistus laurifolius-Pinus nigra* dominated forest, 2. *Pteridium aquilinum-Pinus nigra* dominated forest, 3. *Fagus orientalis-Pinus nigra* dominated forest, 4. *Galium odoratum-Fagus orientalis* dominated forest.

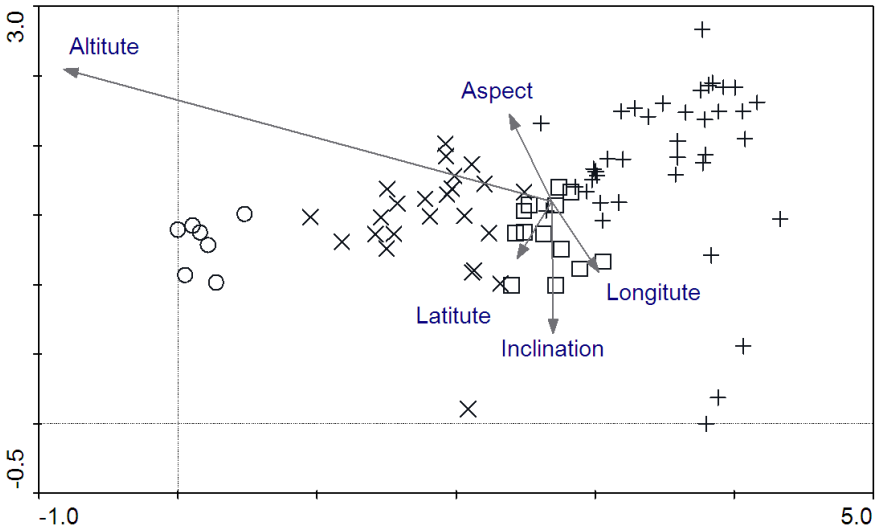

Figure 2. DCA ordination of all relevés. Legend: O. *Galium odoratum-Fagus orientalis* dominated forest, X. *Fagus orientalis-Pinus nigra* dominated forest, □. *Pteridium aquilinum-Pinus nigra* dominated forest, +. *Cistus laurifolius-Pinus nigra* dominated forest.

Table 1. Kendal correlation coefficients (weighted correlation) between first two DCA axes and environmental variables. Legend: *** means p<0.001, ** means p<0.01, * means p<0.05.

	Aspect	Altitute (m)	Inclination (%)	Latitute	Longitute
Axes 1	-0.018549	-0.668729***	-0.007417	-0.003538	0.179432*
Axes 2	0.139904	-0.205831**	-0.153374*	-0.051305	-0.301611***

Table 2: Results of forward selection: Environmental variables and the percentage of total variance of species data explained by CCA analysis.

Variable	Var.N	LambdaA	P	F
Altitude	2	0.39	0.001	5.55
Longitude	4	0.15	0.001	2.20
Inclination	3	0.12	0.002	1.85
Aspect	1	0.10	0.006	1.43
Latitude	5	0.06	0.446	0.92

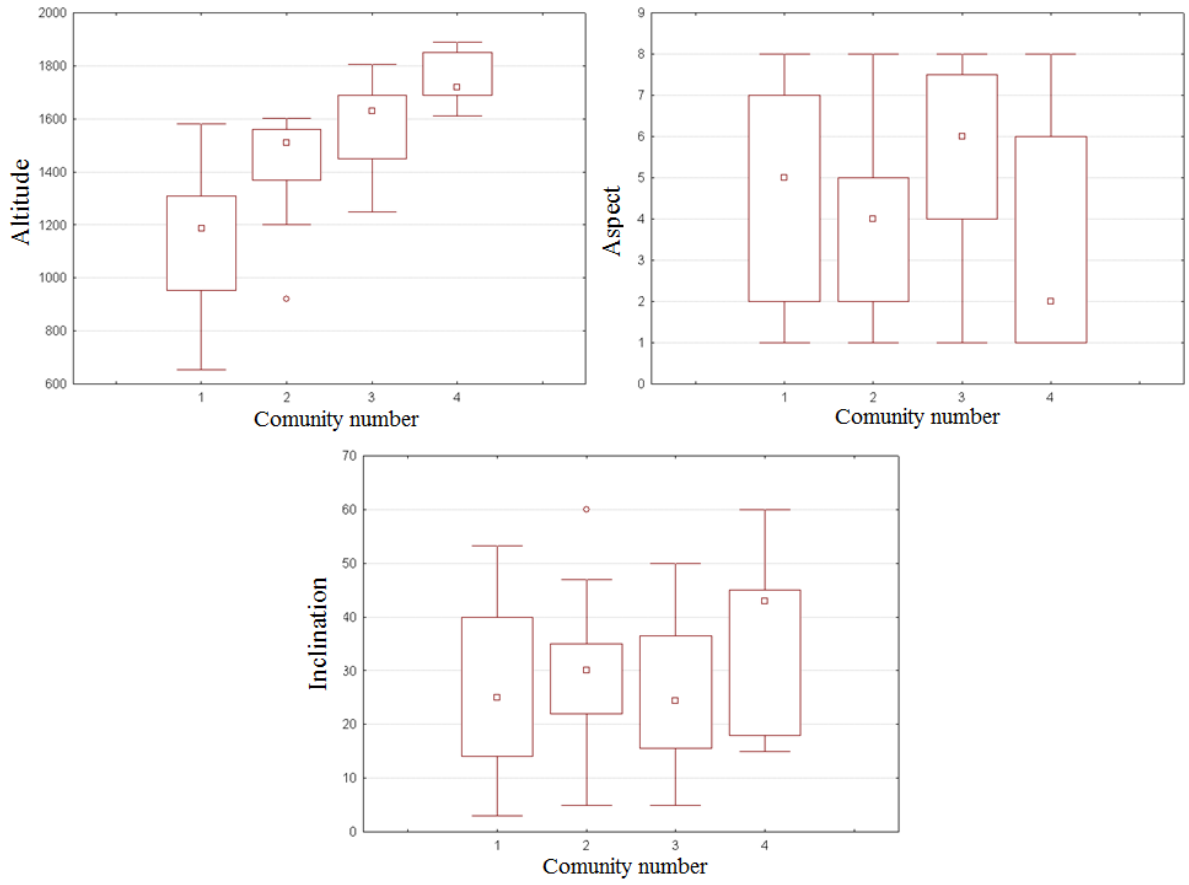

Figure 3. Box-Whisker diagrams of topographical factors for each community. See Figure 1 for the community numbers.

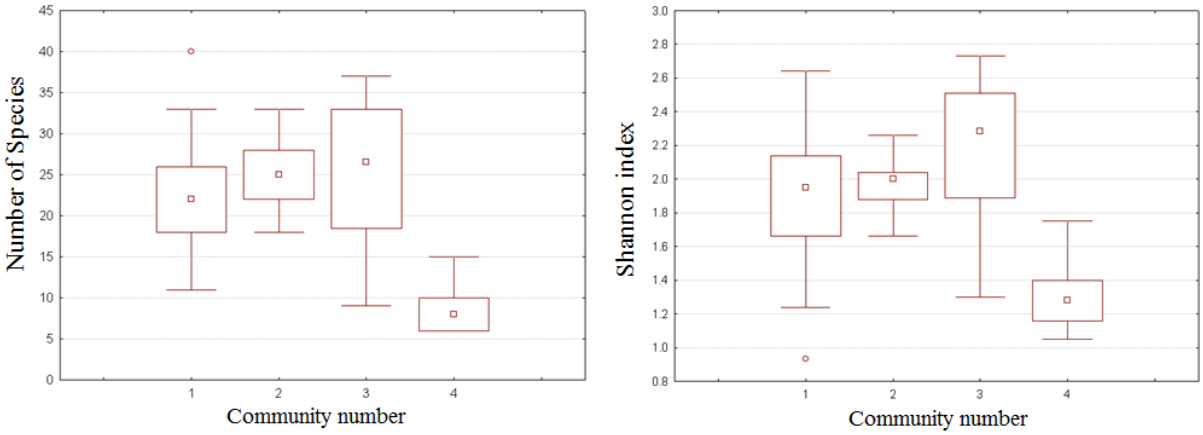

Figure 4. Box-Whisker diagrams of species numbers and Shanon-Wiever diversity index for each community. See the Figure 1 for the community numbers.

Ordination and comparison of topographic and geographic structure

In the DCA ordination diagram of the relevés, there is a clear gradient of the communities along the axes 1 (Figure 2). *Cistus laurifolius-Pinus nigra* dominated forests appears at the right part of the axes and *Pteridium aquilinum-Pinus nigra* dominated forest, *Fagus orientalis-Pinus nigra* dominated forest and *Galium odoratum-Fagus orientalis* dominated forests take place through the left part of the axes respectively.

As the correlation of environmental variables with the gradient of ordination is observed, it is also seen that the gradient along the axes 1 is clearly related to the altitude whereas the other variables are related to axes 2, which does not have a meaningful explanation on the vegetation differentiation. Kendal's correlation coefficient also revealed that altitude has a significant effect on forest vegetation along the axes 1 while longitude is correlated by axes 2 (Table 1).

An attempt was also made to evaluate the importance of topographic and geographic factors measured in the field, in order to understand the distribution of samples in the ordination diagram (Table 2). As a result of this analysis, it was seen that altitude is the main factor effecting the vegetation differentiation in the region. On the other hand, the box-whisker diagram of the topographical variables of the communities were observed (Figure 3), it was also seen that there is clear differentiation between communities along the altitudinal variation.

Forest communities in the study area reflect different species richness (Figure 4). Species richness is the lowest in the *Galium odoratum-Fagus orientalis* dominated forest and highest in the *Fagus orientalis-Pinus nigra* dominated forest. It is clear that species richness is higher at the middle elevation zone of the study area.

DISCUSSION AND CONCLUSION

In accordance with the classification analysis, it is seen that the forest vegetation in Alacam Mountains includes four different plant communities. Three of them are dominated by *Pinus nigra*, one of which is co-dominated by *Fagus orientalis*. The last community is purely dominated by *F. orientalis* and *P. nigra* does not take place in its floristic composition.

The main factor affecting the floristic differences between communities in Alacam Mountains is altitude. The highest part of the region is formed by *Galium odoratum-Fagus orientalis* dominated forest and through the lower elevation zones, this community is followed by *Fagus orientalis-Pinus nigra* dominated forest, *Pteridium aquilinum-Pinus nigra* dominated forest and *Cistus laurifolius-Pinus nigra* dominated forest respectively. It is known that, topographic factors have significant effect on community differentiation in Mediterranean Region (Fontaine et al. 2007, Kavgacı et al. 2010a,b,c) and our findings conform this knowledge.

Longitude, altitude and inclination also have correlation with the ordination axes 2, but since there is not a clear differentiation of communities along this axes, any meaningful explanation on vegetation differentiation could not be revealed.

P. nigra with an area of 4.2 million hectares, is one of the tree species having the largest distribution in Turkey. And its forests are intensively subjected to the phytosociological studies (Akman 1972, 1973, 1974; Quezel and Pamukçuoğlu 1973, Akman and Ketenoğlu 1976, Erik 1976, Görk 1982, Özel 1999, Türe et al. 2005, Kargıoğlu and Tatlı 2005, Karaer et al. 1999). All *Pinus nigra* dominated forests in Anatolia were classified under the class of *Quercetelia pubescentis* and the orders of *Querco-Carpinetalia* and *Querco-Cedretalia* (Akman et al. 1978). Additionally it was mentioned that the *Pinus nigra* forests in NW Anatolia should be grouped under *Quercetea pubescentis*, *Querco-Carpinetalia* and the alliance *Cisto-Pinion laurifolii* (Akman et al. 1978). However, *P. nigra* forests in the Egrigöz Mountain, one of the parts of Alacam Mountain Chain were classified under *Cisto-Pinion laurifolii (*Görk 1982). In this context, *Cistus laurifolius-Pinus nigra* dominated forest, *Pteridium aquilinum-Pinus nigra* dominated forest and *Fagus orientalis-Pinus nigra* dominated forests are also classified under the alliance *Cisto-Pinion laurifolii* in our study.

F. orientalis forest at the upland of Southern Marmara and Northern Aegean regions were classified under different syntaxanomic units: *Carpino – Acerion* (Akman 1979), *Quercion frainetto*, (Özel 1999), *Ostrya-Carpinion* (Tatlı et al. 2005). On the other hand, according to the intensive assessment of *F. orientalis* forests in Turkey and Bulgaria*, F. orientalis* forests at the upland of Southern Marmara and Northern Aegean (Western Anatolia) were grouped under the alliance *Cisto-Pinion* with the consideration that those forests represents the humid part of this thermophilous and submediterranean alliance (Kavgacı et al. 2012).

According to these assessments, the syntaxonomical scheme of the study area can be suggested as follow:

Quercetea pubescentis Doing Kraft 1955

Querco-Carpinetalia orientalis Quézel, Barbero et Akman, 1980

Cisto-Pinion Akman, Barbero & Quézel 1978

Cistus laurifolius-Pinus nigra dominated forest

Pteridium aquilinum-Pinus nigra dominated forest

Fagus orientalis-Pinus nigra dominated forest

Galium odoratum-Fagus orientalis dominated forest

These results indicate the rich diversity and differentiation at short distances at the study area, and altitude is the determining ecological factor on this richness. They also explore the need of a broad scale phytosociological study on *Pinus nigra* forests along whole Anatolia to define their floristic and ecological diversities. And these findings may take essential tasks during a large scale classification, especially for the distribution at western Anatolia.

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REFERENCES

Acatay, A. (1956). Ehrami Karaçam (*Pinus nigra* var. *pyramidata*). *İstanbul Üniversitesi Orman Fakültesi Dergisi* A Seri A, 6(2): 92-99

Akkemik, Ü., Yılmaz, H., Oral, D., Kaya, A. (2011). Pinus. In: Yaltırık F, Akkemik U (eds) Türkiye'nin Doğal Gymnospermleri (Açık Tohumlular). OGM Press, Ankara, 214s.

Akman, Y. (1972). The vegetation of Beynam Forest. *Communications, De la Faculté des Sciences de l'Université d'Ankara*, Serie C, Tome 16C: 29-53.

Akman, Y. (1973). Aperçu preliminaire sur les conditions phytocologiuques de la chaine de L'Amanus dans la region du Hatay. *(I, II, III). Communications, De la Faculté des Sciences de l'Université d'Ankara*, Serie C Tome 17C: 75-164.

Akman, Y. (1974). Etude phyto-ecologique de la region de Beypazarı-Karaşar et Nallıhan. *Communications, De la Faculté des Sciences de l'Université d'Ankara*, Serie C Tome 18C: 51-113

Akman, Y. (1995). Türkiye Orman Vejetasyonu. Ankara Üniversitesi Fen Fakültesi, Ankara, 450 s.

Akman, Y. Ketenoğlu, O. (1976). The phytosociological and phytoecological investigation on the Ayaş Mountain. *Communications, De la Faculté des Sciences de l'Université d'Ankara*, Serie C Tome 20, Suppl 1: 1-43

Akman, Y., Barbéro, M., Quézel, P. (1978). Contribution à l'étude de la végétation forestière d'Anatolie méditerranéenne. *Phytocoenologia* 5: 1-79.

Akman, Y., Barbéro, M., Quézel, P. (1979). Contribution à l'étude de la végétation forestière d'Anatolie méditerranéenne. *Phytocoenologia* 5: 189-276.

Alptekin, Ü. (1986). Anadolu Karaçamı (Pinus nigra Arn. ssp. pallasiana (Lamb.) Holmboe)'nın coğrafik varyasyonları. *İstanbul Üniversitesi Orman Fakültesi Dergisi* Seri A, 36(2):132-154.

Alptekin, Ü. (1987). Pinus nigra Arn. ssp. pallasiana (Lamb.) Holmboe var. Şeneriana Saatçi'nin yeni bir yayılış alanı. *İstanbul Üniversitesi Orman Fakültesi Dergisi* Seri A, 37(1): 100-106.

Anonimous (2007). STATISTICA (data analysis software system). Version 8.0. StatSoft, Inc., www.statsoft.com

Braun-Blanquet, J. (1964). Pflanzensoziologie. Grundzüge der Vegetationskunde. 3rd ed. Springer Verlag, Wien-New York, 865 pp.

Bussotti, F. (2002). Pinus nigra Arnold. Pine of Silvicultural Importance CABI Publishing pp: 266 – 286.

Chytrý, M., Tichý, L., Holt, J., Botta-Dukát, Z. (2002). Determination of diagnostic species with statistical fidelity measures. *Journal of Vegetation Science*, 13: 79-90.

Davis, P.H. (1965-1985). Flora of Turkey and the East Aegean Islands. Vol. 1-9, Edinburgh Univ. Press, Edinburgh.

Davis, P.H., Mill, R.R., Tan, K. (1988). Flora of Turkey and the East Aegean Islands. Vol. 10, Edinburgh Univ. Press, Edinburgh.

Erik, S. (1976). Step-Orman geçiş bölgesinde yer alan Karagöl çevresinin vejetasyonu üzerine sosyolojik ve ekolojik bir araştırma. Ormancılık Araştırma Enstitüsü Dergisi, 22(2): 54-57.

Erkan, N. (1997). Elazığ ve çevresindeki Karaçam (P. nigra Arnold.) ağaçlandırmaları için hacim tablosu. *Güneydoğu Anadolu Ormancılık Araştırma Enstitüsü Dergisi,* Cilt:1, Sayı: 1, Sf: 35-44 ISSN: 1301 – 6253.

Eruz, E. (1984). Balıkesir Orman Başmüdürlüğü Bölgesindeki Saf Karaçam Ormanlarının Gelişimi ile Bazı Edafik ve Fizyografik Özellikler Arasındaki İlişkiler. İ.Ü. Yayın Nu: 3244, Or. Fak. Yayın Nu: 368, İstanbul.

Fontaine, M., Aerts, R., Özkan, K., Mert, A., Gülsoy, S., Suel, H., Waelkens, M., Muys, B. (2007). Elevation and exposition rather than soil types determine communities and site suitably in Mediterranean mountain forests of southern Anatolia. Turkey. *Forest Ecology and Management* 247: 18-25.

Göker, Y. (1977). Dursunbey ve Elekdağ Karaçamlarının (Pinus nigra var. pallasiana) Fiziksel, Mekanik Özellikleri ve Kullanış Yerleri Hakkında Araştırmalar. Orman Bak. O.G.M. Yay. Nu: 613/22.

Görk, G. (1982). Egrigöz Dagı (Emet) Flora ve Vejetasyonu. Doktora Tezi, E.Ü. Fen Bilimleri.Enstitüsü, İzmir.

Gülen, İ. (1959). Karaçam (P. nigra Arnold) gövde hacım tablosu. *İstanbul Üniversitesi Orman Fakültesi Dergisi* Seri A, 1: 97-112.

Gülen, İ. (1965). Karaçam (Pinus nigra Arnold) çap artımı ile hacim artımı arasındaki münasebetler üzerinde araştırmalar. T.C: Tarım Bak. O.G.M. Yay. Nu:419/9 Dizerkonca Matbaası, İstanbul.

Irmak, A., Çepel, N. (1974). Bazı Karaçam, Kayın, ve Meşe Meşcerelerinde Ölü Örtünün Ayrışma ve Humuslaşma Hızı Üzerine Araştırmalar. İ.Ü. Yayın Nu: 1973 Or. Fak. Yayın Nu: 204 Taş Matbaası İstanbul.

Hennekens, S. M., Schaminée, J. H. J. (2001). TURBOVEG a comprehensive data base management system for vegetation data. *Journal of Vegetation Science*, 12: 589-591.

Kalıpsız, A. (1963). Türkiye'de karaçam (Pinus nigra Arnold) meşcerelerinin tabii bünyesi ve verim kudreti üzerine araştırmalar. T.C: Tarım Bak. O.G.M. Yay. Nu: 349/8, Yenilik Basımevi, İstanbul.

Karaer, F. Kılınç, M., Kutbay, H.G. (1999). The woody vegetation of Kelkit valley. *Turkish Journal of Botany,* 23: 319-344.

Kargıoğlu, M., Tatlı, A. (2005). A phtosociologic research on the forest vegetation of Yandag (Isparta-Turkey). *Pakistan Journal of Biological Sciences*, 8: 929-939.

Kavgacı, A. Čarni A., Tecimen, B., Özalp, G. (2010a). Diversity and ecological differantiation of oak forests in NW Thrace (Turkey). *Archieves of Biological Sciences,* 62(3): 705-718.

Kavgacı A., Čarni A., Başaran S., Başaran M. A., Košir P., Marinšek A., Šilc U. (2010b). Vegetation of temporary ponds in cold holes in the Taurus mountain chain (Turkey), *Biologia*, 65(4): 621-629.

Kavgacı, A., Başaran, S., Başaran, M.A. (2010c). Cedar forest communities in Western Antalya (Taurus Mountains-Turkey). *Plant Biosystems,* 144(2): 271-287.

Kavgacı, A., Arslan, M., Bingöl, Ü., Erdoğan, N. Čarni, A. (2012). Classification and phytogeographical differentiation of oriental beech forests in Turkey and Bulgaria. *Biologia*, 67(3): 461-473.

Lepš, J., Šmilauer, P. (2003). Multivariate analysis of ecological data using CANOCO. Cambridge University Press, Cambridge.

Mayer H, Aksoy H. (1998). Türkiye Ormanları. Orman Bak. Ormancılık Araştırma Ens. Müd. Bolu Muhtelif Yayın Nu: 1 ISBN: 975 – 7829 – 56 – 0

Mc Cune, B., Mefford. M.J. (2006). PC-ORD 5, Multivariate analysis of ecological data. MjM Sofware Design, Gleneden Beach, Oregon.

Özel, N., (1999). Kazdağları Orman Vejetasyonu Üzerine Fitososyolojik ve Fitoekolojik Arastırmalar. Ege Ormancılık Araştırma Müdürlüğü Teknik Bülteni, No 11, 81s. İzmir.

Quézel, P., Pamukçuoglu, A. (1973). Contribution a l'étude phytosociologique de quelques groupements forestiers du Taurus. Feddes Reportorium 84: 185-229.

Pamay, B. (1960). Dursunbey Alaçam Orman Mıntıkasındaki Yangın Sahalarının Ağaçlandırılması İmkanları ve Buna Ait Denemeler, Ziraat Vekaleti Orman Umum Müd.

Yayınlarından Neşriyat Sıra No: 321, Seri No: 29, Marifet Matbaası, S: 217.

Saatçioğlu, F. (1955). *Pinus nigra* Arnold'un yeni bir varyetesi. *İstanbul Üniversitesi Orman Fakültesi Dergisi* Seri A, 5(2): 266-267.

Saatçioğlu F. (1976). Silvikültür I. Silvikültürün biyolojik esasları ve prensipleri. İstanbul Üni. Orman Fakültesi Yayın Nu: 2187/222.

Sevgi, O. (2003). Bayramiç İşletmesi'nde (Kaz Dağları) Karaçam'ın (Pinus nigra Arnold.) Yükseltiye Göre Beslenme Büyüme İlişkileri. (Doktora Tezi). 221 sayfa.

Sevgi,O., Tecimen, H. B. (2008). Changes in Austrian Pine forest floor properties in relation with altitude in mountainous areas. *Journal of Forest Science*, 54(7): 306–313.

Sevgi O., Yılmaz O.Y., Carus S, Dündar T, Kavgacı A, Tecimen H.B. (2010). Alaçam Dağları'nda Karaçam Ormanlarının Yükseltiye Göre Beslenme - Büyüme Modelleri ve Odununun Teknolojik Özellikleri. TÜBİTAK - 104 O 551 proje kesin raporu.

Sevim, M. (1954). Alaçam (Dursunbey) Ormanlarında Ekolojik ve Pedolojik Araştırmalar. Orman Umum Müd. Yayımlarından Sıra Nu:131, Seri Nu:2, Çelikcilt Matbaası, S: 64.

Sun, O. (1974). Karaçam-Tek Ağaç Hacim Bağıntıları Üzerine Bir İnceleme. Ormancılık Araştırma Enstitüsü Dergisi, 2: 74-102.

Tatlı A., Varol Ö. & Tel A.Z. (2005). Gümüş Dağı (Kütahya-Türkiye) orman vejetasyonu üzerine fitososyolojik bir araştırma. *Ekoloji Çevre Dergisi* 14: 6-17.

Ter Braak, J. F. C., Šmilauer, P. (2002). CANOCO Reference Manual and CanoDraw for Windows User's Guide, Software for Canonical Community Ordination (version 4.5). Wageningen.

Thornthwaite, C.W. (1948): An approach toward a rational classification of climate. *Geographical Review* 38: 55-94.

Tichy, L. (2002). JUICE, software for vegetation classification. *Journal of Vegetation Science* 13: 451 - 453.

Türe, C., Tokur, S., Ketenoğlu, O. (2005). Contribution to the syntaxonomy and ecology of the forest and shrub vegetation in Bithynia, Northwestern Antolia - Turkey. Phyton (Austria), 45(1): 81-115.

Westhoff, V. & van der Maarel, E. (1973). The Braun-Blanquet approach. In: R.H. Whittaker (ed.), Handbook of Vegetation Science 5, Ordination and classification of communities. W. Junk, Hague, p. 617-726.

Yaltırık, F. (1993). Dendroloji I. sf: X + 458, İ.Ü. Yayın Nu: 3443, Or. Fak. Yayın Nu: 419 İstanbul Matbaa Teknisyen Basımevi.

Yılmaz, Y. Sevgi, O., Tecimen, H.B., Carus, S., Kavgaci, A. (2012). Land use pattern at Alacam mountainous range land (Submediterranean-Turkey) due to edaphic and physiographical factors. *Journal of Environmental Biology* 33: 355-361.

Yücel, E. (1999). Ehrami Karaçam (*Pinus nigra* ssp. *pallasiana* var. *pyramidata*)'ın coğrafik varyasyonları (I). 1th. Int. Sym. Protection of Natural Environment and Ehrami Karaçam, sf: 730 - 739, 23 – 25 September Kütahya.

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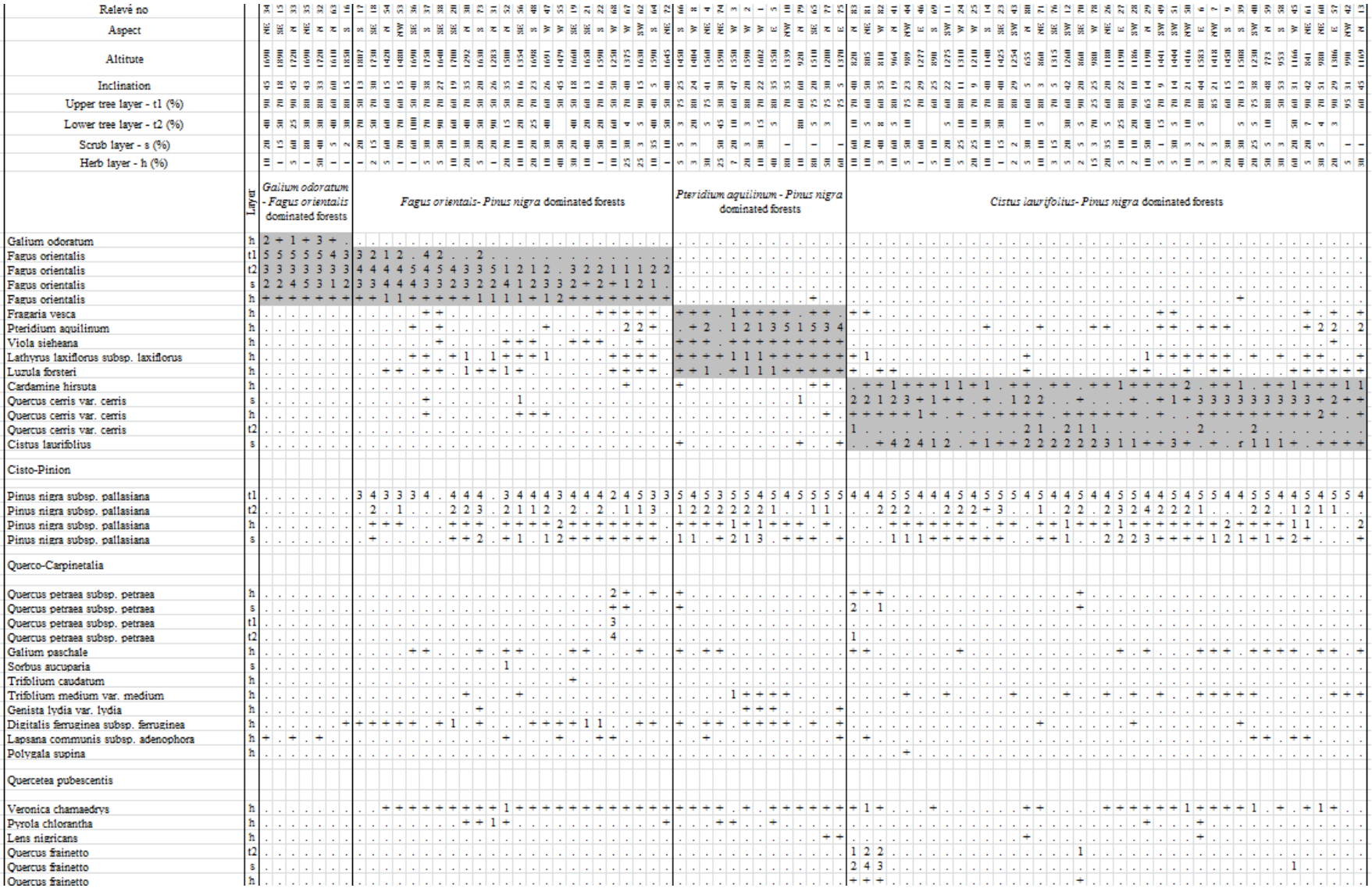
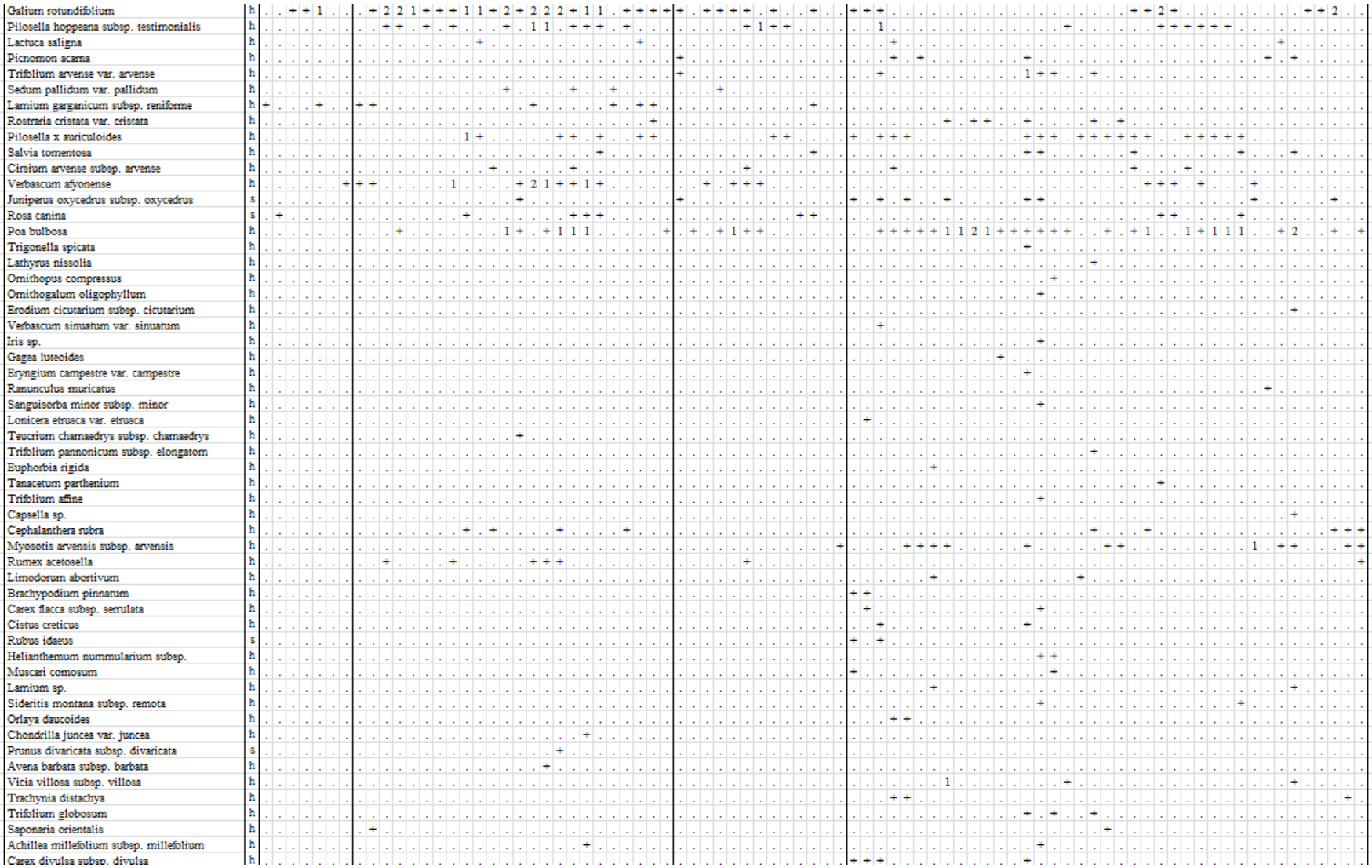
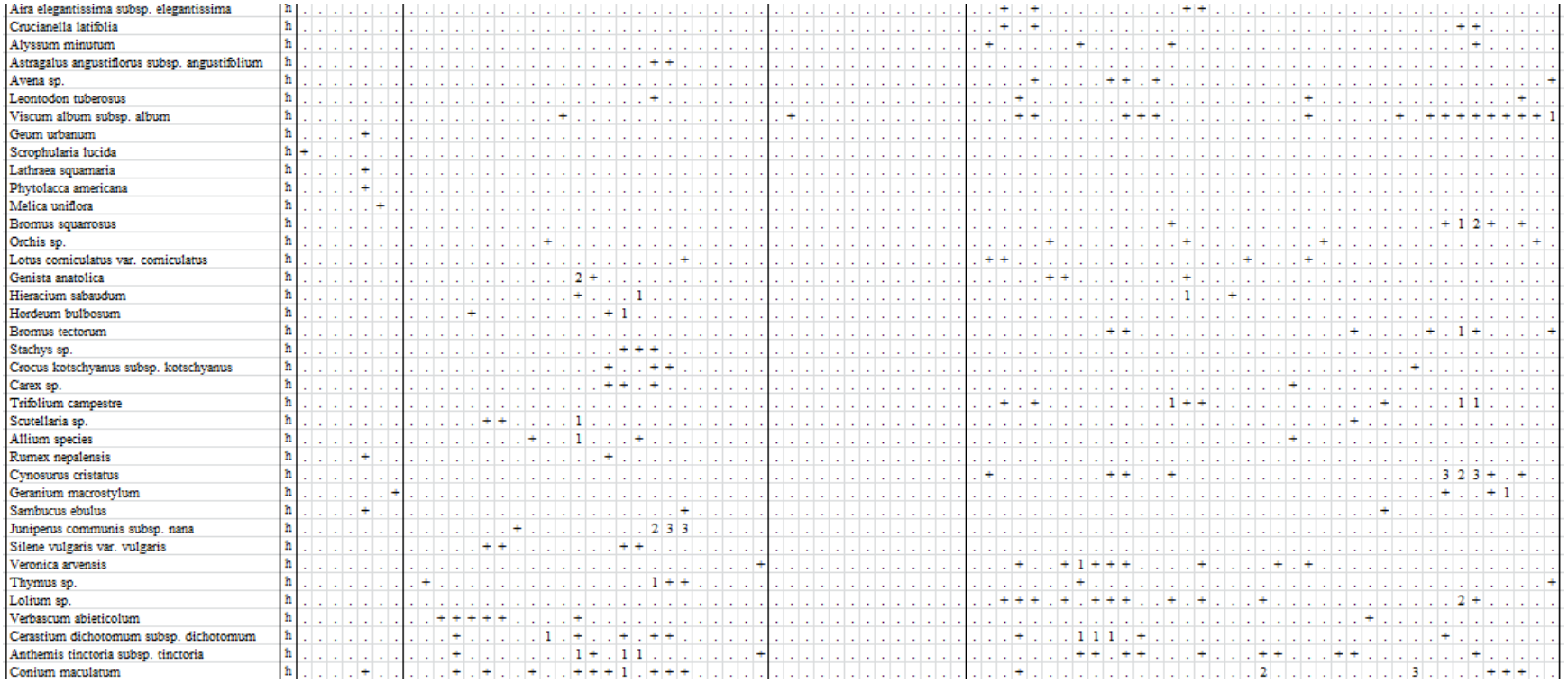
Appendix: Vegetation Table of the Forests at Alaçam Mountains.




Quercus infectoria subsp. infectoria h
Sorbus torminalis var. torminalis s
Sorbus torminalis var. torminalis h
Origanum vulgare subsp. vulgare h
Populus tremula h
Populus tremula s
Populus tremula t1
Populus tremula t2
Doronicum orientale h
Lathyrus digitatus h
Euphorbia amygdaloides var. amygdaloides h
Brachypodium sylvaticum h
Clinopodium vulgare subsp. vulgare h
Others
Dactylis glomerata subsp. glomerata h
Minuartia juressi subsp. juressi h
Epilobium lanceolatun h
Festuca heteropphylla h
Verbascum adenocarpum h
Rubus canescens var. canescens s
Festuca gigantea h
Poa sp. h
Crataegus monogyna subsp. monogyna s
Silene italica h
Muscari neglectum h
Dorycnium graecum h
Primula vulgaris subsp. vulgaris h
Cirsium hypoleucum h
Coronilla varia subsp. varia h
Poa nemoralis h
Astragalus acmonotrichus h
Thymus zygioides var. zygioides h
Senecio vernalis h
Rumex tuberosus subsp. tuberosus h
Theligonum cynocrambe h
Hypericum adenotrichum h
Osyris alba s
Aetheorhiza bulbosa subsp. microcephala h
Ajuga chamaepitys subsp. chia var. chia h
Galium album susbp pycnotrichum h
Aristolochia sp. h
Alliaria petiolata h
Mercurialis annua h
Hypericum perforatum h
Vicia cuspidata h
Tuntitis laxa h
Salvia forskahlei h
Scilla autumnalis h
Potentilla recta h
Galium aparine h
Campanula sp. h
Campanula lyrata subsp. lyrata h
Trifolium alpestre h
Genista albida h


Galium rotundifolium h
Pilosella hoppeana subsp. testimonialis h
Lactuca saligna h
Picnomon acarna h
Trifolium arvense var. arvense h
Sedum pallidum var. pallidum h
Lamium garganicum subsp. reniforme h
Rostraria cristata var. cristata h
Pilosella x auriculoides h
Salvia tomentosa h
Cirsium arvense subsp. arvense h
Verbascum afyonense h
Juniperus oxycedrus subsp. oxycedrus s
Rosa canina s
Poa bulbosa h
Trigonella spicata h
Lathyrus nissolia h
Ornithopus compressus h
Ornithogalum oligophyllum h
Erodium cicutarium subsp. cicutarium h
Verbascum sinuatum var. sinuatum h
Iris sp. h
Gagea luteoides h
Eryngium campestre var. campestre h
Ranunculus muricatus h
Sanguisorba minor subsp. minor h
Lonicera etrusca var. etrusca h
Teucrium chamaedrys subsp. chamaedrys h
Trifolium pannonicum subsp. elongatom h
Euphorbia rigida h
Tanacetum parthenium h
Trifolium affine h
Capsella sp. h
Cephalanthera rubra h
Myosotis arvensis subsp. arvensis h
Rumex acetosella h
Limodorum abortivum h
Brachypodium pinnatum h
Carex flacca subsp. serrulata h
Cistus creticus h
Rubus idaeus s
Helianthemum nummularium subsp. h
Muscari comosum h
Lamium sp. h
Sideritis montana subsp. remota h
Orlaya daucoides h
Chondrilla juncea var. juncea h
Prunus divaricata subsp. divaricata s
Avena barbata subsp. barbata h
Vicia villosa subsp. villosa h
Trachynia distachya h
Trifolium globosum h
Saponaria orientalis h
Achillea millefolium subsp. millefolium h
Carex divulsa subsp. divulsa h


Aira elegantissima subsp. elegantissima h
Crucianella latifolia h
Alyssum minutum h
Astragalus angustiflorus subsp. angustifolium h
Avena sp. h
Leontodon tuberosus h
Viscum album subsp. album h
Geum urbanum h
Scrophularia lucida h
Lathraea squamaria h
Phytolacca americana h
Melica uniflora h
Bromus squarrosus h
Orchis sp. h
Lotus corniculatus var. corniculatus h
Genista anatolica h
Hieracium sabaudum h
Hordeum bulbosum h
Bromus tectorum h
Stachys sp. h
Crocus kotschyanus subsp. kotschyanus h
Carex sp. h
Trifolium campestre h
Scutellaria sp. h
Allium species h
Rumex nepalensis h
Cynosurus cristatus h
Geranium macrostylum h
Sambucus ebulus h
Juniperus communis subsp. nana h
Silene vulgaris var. vulgaris h
Veronica arvensis h
Thymus sp. h
Lolium sp. h
Verbascum abieticolum h
Cerastium dichotomum subsp. dichotomum h
Anthemis tinctoria subsp. tinctoria h
Conium maculatum h