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THE VEGETATION ANALYSIS OF MIXED ULUDAG FIR (*Abies bornmülleriana* Mattf.) FORESTS IN BOLU AYIKAYA REGION/TURKEY

Süleyman ÇOBAN*, Gülen ÖZALP

Istanbul University Faculty of Forestry Deparment of Silviculture, TR-34473, Bahçeköy/İstanbul, Turkey.

*Corresponding author: scoban@istanbul.edu.tr

ABSTRACT

Uludag fir (*Abies bornmülleriana* Mattf.) forests which covers great part of the region, forms mixed stands mostly with Oriantal beech (*Fagus orientalis* Lipsky) and Scots pine (*Pinus sylvestris* L.) in addition to its pure stands. Defining natural tree composition of mixed fir forests are important in terms of selecting appropriate silvicultural methods.

Stand structure change considerably along different altitudinal zones in the study area. In addition, soil type and topographical features effect species distribution. Increasing precipitation and high atmospheric humidity in upper altitudinal zones create favourable conditions for *A.bornmülleriana.* However, it occurs in the shrub layer of most of the plant communities. The application of methods that create pure stands (shelterwood method, strip clear cutting method), may change forest tree composition of mixed stands. Tree mixture which is not close to natural mixture combinations result in more vulnerable forests. Current and changing climatic conditions are combining with such changes in stand structure increase vulnerability of forests to biotic and abiotic disturbances.

In order to decrease the risk of current and future disturbances impacting the functioning of the forest, close to nature silviculture considering potential plant communities must be adopted.

Keywords: *Abies bormülleriana*, Vegetation analysis, Mixed forests, Ayıkaya, Bolu.

BOLU AYIKAYA BÖLGESİNDEKİ KARIŞIK ULUDAĞ GÖKNARI (*Abies bornmülleriana* Mattf.) ORMANLARININ VEJETASYON ANALİZİ

ÖZET

Bölgede geniş alanlar kaplayan Uludağ göknarı (*Abies bornmülleriana* Mattf.) ormanları, saf ormanlarının yanısıra doğu kayını (*Fagus orientalis* Lipsky) ve sarıçamla (*Pinus sylvestris* L.) karışık ormanlar oluşturmaktadır. Karışık göknar ormanlarının doğal ağaç tür kompozisyonunun belirlenmesi uygun silvikültürel yöntemlerin seçilmesi açısından önemlidir.

Araştırma alanında farklı yükselti kuşaklarında meşcere kuruluşu önemli ölçüde değişim göstermektedir. Ek olarak, toprak tipi ve topoğrafik özellikler de tür yayılışı üzerinde etkili olmaktadır. Üst yükselti kuşaklarında

Yazışma yapılacak yazar: scoban@istanbul.edu.tr
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yağış miktarının artması ve yüksek atmosferik nem *A.bornmülleriana* için uygun koşullar oluşturmaktadır. Bununla birlikte, göknar tüm bitki toplumlarının çalı tabakasında görülmektedir. Saf meşcereler oluşturan yöntemlerin (siper durumu ve etek şeridi traşlama) uygulanması karışık meşcerelerin tür bileşimini değiştirebilir. Doğal karışım kombinasyonlarına uygun olmayan karışımlar hassas ormanların oluşmasına neden olmaktadır. Meşcere kuruluşunda meydana gelen bu şekildeki değişimlerle birlikte değişen iklim koşulları, ormanların biyotik ve abiyotik zararlılara hassasiyetini artırmaktadır.

Ormanların fonksiyonlarını etkileyen mevcut ve gelecekteki zararlardan oluşabilecek riskleri azaltmak için potansiyel bitki toplumlarını dikkate alan doğaya yakın silvikültür anlayışının benimsenmesi gerekmektedir.

Anahtar kelimeler: *Abies bormülleriana*, Vejetasyon analizi, Karışık ormanlar, Ayıkaya, Bolu.

1. INTRODUCTION

Turkey has a rich flora because of its location in the mediterranean at the intersection of phtogeographic regions of Euro-Siberian and Irano-Turanian. Its richness is of interest for both the total number of species and especially the number of endemics, of which there are *c.* 3,000 (Ekim, 1995; Ekim *et al*., 2000). Many endemic species are peculiar to the transitional belt in Turkey between Europe and Asia (Çolak and Rotherham, 2006). The exceptional diversity in Turkey's flora is the collective results of extent of a variety of climates, topographical diversity with marked changes in ecological factors over a short distance and altitude variations from sea level to 5000m (Celep and Doğan, 2007).

Mountains present different ecological units depending on altitude, exposure and extending direction. In other words, mountains provide different climatic zones in accordance with the altitude. North Anatolia mountains range running parallel to the Black Sea create a barrier for rain clouds moving inland. They cause abundant rainfall on the mountain slopes facing the coast. The coastal belt of the region from the colin to submontane zone includes broad-leaved mixed deciduous forests, which are composed of *Fagus orientalis*, *Alnus* sp., *Tilia* sp., *Castanea sativa* and it contains rich undergrowth herbaceous species. The foggy higher part of the Northern Anatolian mountains is covered with pine forests, which are associated with *Picea orientalis* (Eastern part of the North Anatolian mountains), *Pinus sylvestris, Abies* sp. and *Pinus nigra* (Atalay, 2002).

Main study area, Ayıkaya region, is situated in the northern parth of Bolu province and appears to be in the euxine part of Euro-Siberian phytogeographic region between submontane-montane zones. Such transitional zones have interesting characteristics with their pure and mixed forests of broad-leaved and coniferous species.

Site conditions which change in short distances create different forest communities in the study area. In order to maintain sustainable management of such mixed forests; knowledges about mixture combinations, growth relations among tree species, site conditions, climatical factors, biological characteristics and competitive ability of species are required. In this context, plant sociology studies give useful informations for selecting appropriate silvicultural methods which will maintain natural species composition.

In this study, mixed stands of *A. bornmülleriana* were classified and variation in species composition in response to the measured environmental variables were examined from the vegetation data of Özpay (1998). In the conclusion, silvicultural methods were discussed.

2. MATERIALS AND METHODS

2.1. Study area

Ayıkaya region lies approximately at 31°34′42″- 31°41′54″ east longitudes and 40°51′40″- 40°57’45″ north latitudes (Figure 1). Altitude of the study area varies between 600 m (Kapıkaya hill) and 1781m (Karadere). There are not any settlements in or around the region except some upland meadows used by villages in Bolu.

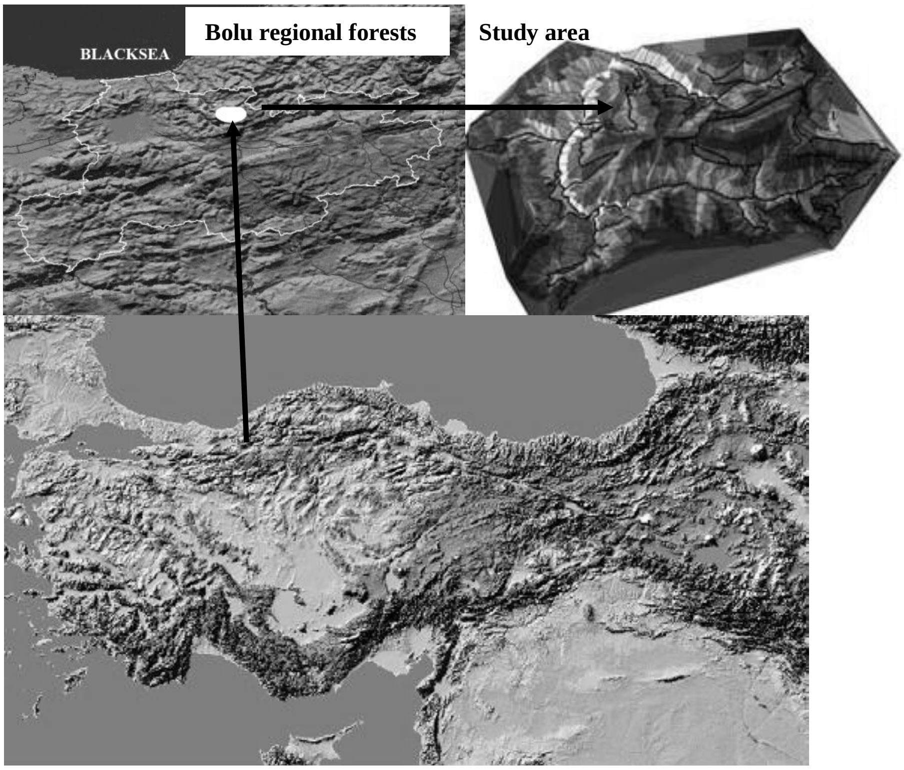

Figure 1. Location of the study area.

2.2. Climate

The meteorological data was collected from the observation stations of Bolu (742 m) and Şerif Yüksel Research Forest (1550 m) which are located in the south of the study area and from another station in the north, Yığılca (350 m), which measures only rainfall. Mean annual temperature values of Yığılca station were estimated by means of lapse-rate values (Table 1).

Table 1. Some climatical data of meteorology stations around Bolu.

	ANNUAL			Summer Months (VI+VII+VIII+IX)			January		
	BOLU	ŞERİF YÜKSEL	YIĞILCA	BOLU	ŞERİF YÜKSEL	YIĞILCA	BOLU	ŞERİF YÜKSEL	YIĞILCA
Mean Temperature ˚C	10.2	5.7	12.8	18	13.6	20.2	0.7	-3.8	4.0
Precipitation (mm)	533.6	882.6	1084.1	126.5	174.1	284.1	53.7	97.6	128

Bolu station exhibits a transitory character between mediterranean climate with a very cold less rainy winter and oceanic climate. However, influences of oceanic climate are seen in Yığılca. Climate type of Şerif Yüksel Research Forest according to Thornthwaite method indicated with B4C2'rb2' symbols which means a location "shows close characters to oceanic climate that is humid, micro thermal, no or less water deficiency"(Serin and Tosun, 1998).

2.3. Geology and Soil Characteristics

Bolu massive, which is composed of plutonic magmatic rocks, is known as Bolu granitoid. This is widespread over the northwest, north and northeast of Bolu.

Over the large part of the area, the bedrock is sedimentary sandstone and the major soil groups are noncalcerous brown forest soils. Özpay (1998) identified that soil type are clayey loam at 1200 m and 1300 m, sandy loam at other altitudes in the study area.

2.4. Vegetation and Forest Communities

Ayıkaya region shows a transitional characteristic between sub-montane and montane zones. Sub-montane zone is distinguished mainly by *F. orientalis* dominated forests and above these forests, distinctive montane zone is seen with *F. orientalis-A. bornmülleriana-P.sylvestris* mixed forests. Generally, pure *F. orientalis* forests occur on northern aspects at lower altitudes (800-1200m). Vegetation units of Ayıkaya mixed forests, that consist of *A. bornmülleriana*, *F. orientalis, P. sylvestris, P. nigra* species, can be summarized in terms of plant sociology as below (Mayer and Aksoy, 1998):

2.4.1. Sub-Montane *Rhododendron ponticum-Ilex colchica–Fagus orientalis* and (*Abies bornmülleriana*-)*Fagus orientalis* forest.

In general, *A. bornmülleriana-F.orientalis* mixed stands are found on shady exposures which are humid and rich with fine soil between 800-1200 m altitudes. Differential species are *Lathyrus laxiflorus*, *Pteridium aquilinum* and *Galium paschale*.

2.4.2. Sub-montane semihumid *Rhododendron ponticum-Abies bornmülleriana-Fagus orientalis* forest.

a) *Fagus orientalis* Development Type:

In this community, *F. orientalis* is dominant in forest tree composition. *Cardamine bulbifera* group *(Pyrola media*, *Luzula forsteri*, *Epilobium montanum*) and *Ilex colchica* group (*Epipactis latifolia*, *Athyrium flix-foemina*, *Lamium galeobdolon*, *Hordelymus europaeus*) are characteristic for this community. *Rhododendron* is only found on local areas. This community is close to sub-euxine zone. On upper slopes, stable *Vaccinum arctostophyllos-F. orientalis-A. bornmülleriana* mixed forest occurs. *P. nigra* sub-unit is seen on south exposures in submontane zone and *P. sylvestris* variant is seen in high montane zone.

b) *Abies bornmülleriana* Development Type:

Stable mixed forests are rarely present on mountains which have euxine character. In this community, proportion of *A. bornmülleriana* has increased compared to *F. orientalis*. Above 1000 m elevation, there is a distinctive sub-unit which can be distinguished with *Cardamine bulbifera* and *Galium odoratum.* Distribution of *P. sylvestris* is limited to steep, middle and upper slopes and its differential species are *Cyclamen coum*, *Melica uniflora*, *Euphorbia amygdaloides*. *P. nigra* sub-community are found on south faced ridges in upper and middle slopes (1000-1500 m).

2.4.3. Montane *Pinus sylvestris-Abies bornmülleriana-Fagus orientalis* forest

This community is a transitional type to sub-euxine zone of *A. bornmülleriana* forests. South and east exposures with an altitude of 900-1300 m are covered by mixed stands of *A. bornmülleriana- F. orientalis-P. sylvestris.*

2.5. Data Analysis

Vegetation analysis of this study is based on sample plots (Özpay, 1998) which investigates the accompanying flora to Oriantal Beech (*Fagus orientalis* Lipsky.) at varied site conditions in different altitudes in Güzören catchment area in the study area.

Environmental variables that are used in the analysis are altitude (m), land slope (degree), exposure (shady and sunny exposures), soil type and stand density (1=under stocked: 11-40 %, 2= moderate dense stands: 41-70%, 3= fully-stocked stands: 71-100 %). Exposure were classified as sunny (south, southeast, west, southwest) and shady (north, northeast, northwest and east) exposures (Çepel, 1995).

All sample plots (55 plots) were stored in TURBOVEG database (Hennekens and Schaminée, 2001) and then, transferred to JUICE software (Tichý, 2002). The data was classified using indicator species analysis TWINSPAN (pseudospecies cut levels 0, 5 and 25) classification (Hill, 1979).

Detrended correspondence analysis (DCA) was used to find major gradients in species composition. In DCA, the length of the longest axis provides an estimate of the beta diversity in the data (the value 3.2 for this data suggest that linear ordination methods is appropriate in direct gradient analysis) (Leps and Smilauer, 2011). Subsequently, Redundancy Analysis (RDA) were calculated to extract the variation that is explainable by the measured environmental variables with CANOCO 4.5 (ter Braak And Šmilauer, 2002).

The plant cover values (**r**: 1-5 individuals, **+**: rare, 1: many individuals with low dominance, **2**: covering 1/20, **3**: covering 1/4 – 1/2, **4**: covering 1/2 - 3/4, **5**: covering more than 3/4) were transformed to an ordinal scale (1, 2, 3, 4, 5, 6, 7) which implies a log-like transformation in ordination analysis.

3. RESULTS

3.1. Multivariate analysis of vegetation data

3.1.1. Indirect Gradient Analysis

Indirect gradient analysis is used to show variation within vegetation data. Indirect ordination using detrended correspondence analysis (DCA), show the total variability by the length of the axes, which gives a measure of the total heterogeneity in vegetation data.

First gradient is the longest one and explains about 7.5% of the total species variability, whereas other axes explain less. Also the first axis is very well correlated with environmental data (r=0.920) and correlation for other axes is considerably lower (Table 2). This suggest that the data is governed by a single dominant gradient.

Table 2. Summary table of DCA analysis.

Axes		**1**	**2**	**3**	**4**	**Total inertia**
Eigenvalues	:	0.434	0.310	0.191	0.173	5.768
Lengths of gradient	:	3.218	3.189	2.822	2.114	
Species-environment correlations	:	0.920	0.380	0.533	0.485	
Cumulative percentage variance						
of species data	:	7.5	12.9	16.2	19.2	
of species-environment relation	:	31.6	35.2	0.0	0.0	
Sum of all eigenvalues						5.768
Sum of all canonical eigenvalues						1.078

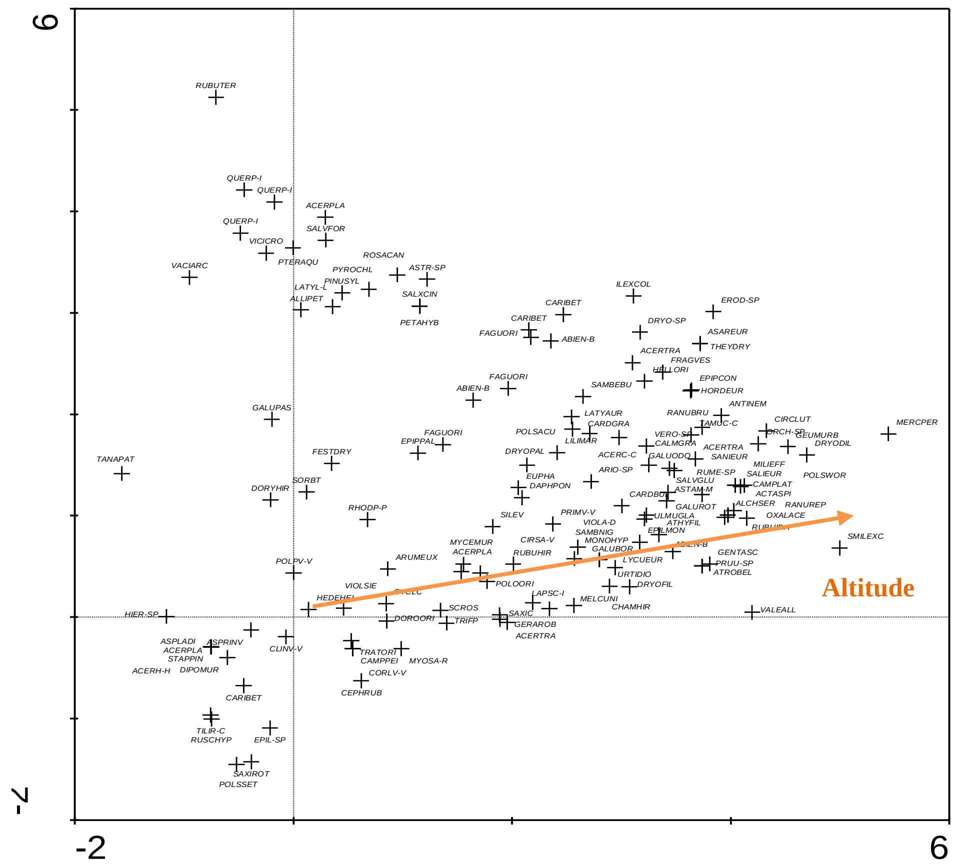

Figure 2. Species ordination (DCA) diagram of vegetation data (altitude passively projected on diagram).

3.1.2. Direct Gradient Analysis

Direct gradient analysis is used to display the variation of vegetation in relation to environmental factors by using environmental data. As the name suggests, the environmental data are used directly to organise the information on vegetation.

RDA analysis also gave smilar result with DCA that the first axis explains 12.4 % and second axis 5.2 % of the total variability in the species data (Table 3).

Among these variables altitude is found as the most important one which accounts for 42 % (F=6.53, P=0.002) of total variability explained by all the environmental variables from Monte Carlo permutation tests (499 permutations).

Table 3. Summary table of RDA analysis.

Axes		**1**	**2**	**3**	**4**	**Total variance**
Eigenvalues	:	0.124	0.052	0.028	0.022	1.000
Species-environment correlations	:	0.932	0.908	0.803	0.828	
Cumulative percentage variance						
of species data	:	12.4	17.6	20.4	22.6	
of species-environment relation	:	51.4	73.1	84.8	93.8	
Sum of all eigenvalues						1.000
Sum of all canonical eigenvalues						0.240

RDA diagram reveals the strongest gradient which is related with altitude as it was found in previous analyses. As it is seen on the diagram, while *A.bornmülleriana, F. orientalis* accompanied by herb species like *Galium odoratum*, *Calamintha grandiflora*, *Dryopteris filix-max*, *Rubus idaeus*, *Rubus hirtus*, *Oxalis acetosella*, *Ranunculus brutius*, *Galium rotundifolium*, etc. are found on higher elevations, *Quercus petraea* and *Pinus* *sylvestris* accompanied by *Festuca drymeja, Vicia crocea, Pteridium aquilinum, Galium paschale, Polystichum setiferum, Myosotis arvensis*, etc. have a strong correlation with slope degree, sandy soils and sunny exposures (southeast and west). *Acer trautvetteri, Ulmus glabra, Sambucus nigra, Cardamine bulbifera, Actaea spicata, Geum urbanum, Cardamine graeca, Lathyrus aureus, Salvia glutinosa, Helleborus orientalis, Tamus communis, Lilium martagon, Geranium robertianum, Cardamine graeca, Cirsium arvense* are possitively correlated with clayey soils on shady exposures.

Differential species of Sub-Montane *Rhododendron ponticum-Ilex colchica–Fagus orientalis* forest, i.e. *Lathyrus laxiflorus*, *Pteridium aquilinum* and *Galium paschale*, are possitively correlated with stand density which show dependence on fully stocked stands.

Characteristic species of Sub-montane semihumid *Rhododendron ponticum-Abies bornmülleriana-Fagus orientalis* forest, i.e. *Cardamine bulbifera,Hordelymus europaeus*, *Galium odoratum*, are found on soils which have high clay content on shady exposures.

Rhododendron ponticum is mostly seen under dense stands. On the other hand, competitive species like *Urtica dioica* and *Rubus hirtus* are found under relatively open canopies (moderate dense stands).

The effect of sunny exposure couldn't clearly be seen in ordination analysis, since only 3 of the sample plots were sunny exposured (southeast and west). All others had shady exposures. Because of this, there are not enough relevant data with a clear difference to make a conclusion. However, exposure was also included in the analysis in order to show the effect on species distribution (Figure 3).

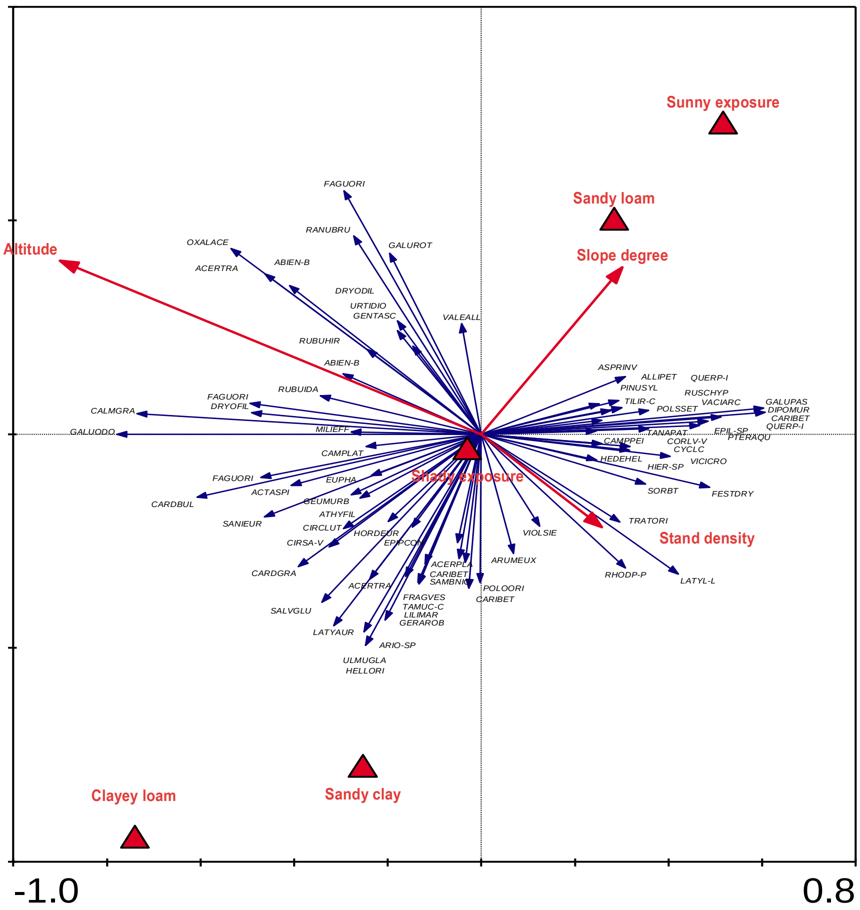

Figure 3. Species-environment biplot from RDA (down-weighting of rare species was applied and minimum weight was set to 6 %).

3.2. Classification of Vegetation Data

Four communities were identified from the classification of 55 sample plots. This classification summarizes general distribution of species and describe vegetation structure. As it was determined in ordination analysis, classification also shows that frequency of *A.bornmülleriana* increase at higher altitudes in tree layer. Besides, it occurs with high percentage frequency in shrub and herb layer of other communities. However, *P.sylvestris* is only found in tree layer of 2nd group (Frequency :40%, Cover values:2-3) and 3rd group (one plot with 2 cover value). *Q. petraea* co-occur with *P.sylvestris* in 2nd group which seem to be drier site condition (Table 4).

Table 4. Synoptic table with percentage frequency and cover range of 55 releves of *Fagus orientalis* dominated forest in Güzören catchment. Percentage values exceeding 50 are set in green. Taxa in shrub and herb lalyer with constancy values less than 25 % were ommitted. (1) *710-815m, E* (2) 920-1150m, *NE, E, SE* (3) *1010-1310m, NE, N,* (4) *1300-1700m, W, NW, NE.*

Group No.		**1**	**2**	**3**	**4**
No. of relevés		**9**	**10**	**14**	**22**
	Layer				
Fagus orientalis	*Tree*	100 $^{3-4}$	100 $^{3-5}$	100 ^{4}	100 $^{3-4}$
Fagus orientalis	*Shrub*	.	60 ^{2}	64 $^{1-3}$	68 ^{2}
Fagus orientalis	*Herb*	22 $^{1-2}$	90 ^{1}	100 $^{+-2}$	95 $^{+-2}$
Abies nordmanniana s. bornmuell	*Tree*	.	.	7 ^{2}	32 ^{2}
Abies nordmanniana s. bornmuelleria	*Shrub*	44 $^{+-2}$	60 $^{+-1}$	93 $^{+-2}$	68 $^{+-2}$
Abies nordmanniana s. bornmuelleria	*Herb*	.	50 $^{r-+}$	43 $^{+-3}$	82 $^{r-2}$
Pinus sylvestris	*Tree*	.	40 $^{2-3}$	7 ^{2}	.
Quercus petraea s. iberica	*Tree*	11 $^{+}$	60 $^{+-2}$	.	.
Quercus petraea s. iberica	*Shrub*	.	40 $^{+-2}$	.	.
Quercus petraea s. iberica	*Herb*	.	50 $^{r-+}$	.	.
Carpinus betulus	*Tree*	67 $^{2-2}$	.	.	.
Carpinus betulus	*Shrub*	.	20 $^{1-2}$	43 $^{1-2}$	.
Carpinus betulus	*Herb*	.	10 ^{1}	21 $^{r-2}$	.
Acer trautvetteri	*Herb*	.	.	29 $^{r-+}$	45 $^{r-1}$
Acer trautvetteri	*Shrub*	.	10 ^{2}	57 $^{1-2}$	9 $^{1-2}$
Tilia rubra s. caucasica	*Tree*	22 ^{2}	.	.	.
Acer platanoides	*Tree*	11 $^{+}$	.	.	.
Acer hyrcanum s. hyrcanum	*Tree*	11 $^{+}$	.	.	.
Acer platanoides	*Shrub*	.	10 $^{+}$	7 $^{+}$	.
Acer platanoides	*Herb*	.	.	14 $^{+}$	.
Acer campestre s. campestre	*Herb*	.	.	7 $^{+}$	.
Acer trautvetteri	*Tree*	11 $^{+}$	.	.	5 ^{2}
Sorbus torminalis v. torminalis	*Tree*	22 $^{+-2}$	20 $^{+}$	.	.
Prunus species	*Tree*	.	.	7 ^{2}	.
Rhododendron ponticum s. ponticum	*Shrub*	78 $^{r-4}$	60 $^{+-2}$	50 $^{+-3}$	23 $^{+-3}$
Rubus hirtus	*Shrub*	89 $^{+-2}$	50 $^{+}$	71 $^{+-3}$	95 $^{+-4}$
Festuca drymeja	*Herb*	89 $^{+-2}$	80 $^{+-1}$	21 $^{+}$	32 $^{+-1}$
Hedera helix	*Shrub*	33 $^{+-2}$	10 $^{+}$	.	9 $^{r-2}$
Cyclamen coum v. coum	*Herb*	44 $^{r-1}$	30 $^{+}$	29 $^{r-+}$	9 $^{r-+}$
Sambucus nigra	*Shrub*	11 ^{r}	.	29 $^{+}$	5 $^{+}$
Galium paschale	*Herb*	78 $^{+}$	30 $^{r-+}$	.	5 $^{+}$
Diplotaxis muralis	*Herb*	78 $^{+-1}$	10 $^{+}$	.	.
Trachystemon orientalis	*Herb*	56 $^{+-2}$	20 $^{r-1}$	29 $^{+}$	5 ^{r}
Myosotis arvensis s. arvensis	*Herb*	56 $^{+-1}$	.	21 $^{r-+}$	18 $^{+}$
Vicia crocea	*Herb*	22 $^{r-2}$	50 $^{+}$	7 $^{+}$	.
Pteridium aquilinum	*Herb*	11 $^{+}$	80 $^{r-+}$	7 ^{1}	.
Lathyrus laxiflorus s. laxiflorus	*Herb*	44 $^{+}$	80 $^{+-1}$	50 $^{r-1}$	5 ^{r}
Galium odoratum	*Herb*	.	.	71 $^{+-2}$	91 $^{1-2}$
Calamintha grandiflora	*Herb*	11 $^{+}$	.	71 $^{r-1}$	91 $^{+-1}$
Cardamine graeca	*Herb*	.	40 $^{+-1}$	79 $^{+-1}$	55 $^{+-1}$
Cardamine bulbifera	*Herb*	11 ^{r}	10 ^{r}	86 $^{r-1}$	77 $^{+-1}$
Euphorbia amygdaloides v. amygdaloi	*Herb*	44 $^{r-2}$	.	64 $^{+-1}$	59 $^{+-1}$
Melica uniflora	*Herb*	22 $^{r-+}$	10 $^{+}$	29 $^{+-1}$	32 $^{+-1}$
Daphne pontica	*Shrub*	33 $^{+}$	30 $^{+-1}$	64 $^{+-1}$	36 $^{+-1}$
Helleborus orientalis	*Herb*	.	.	50 $^{+}$	9 $^{+}$
Aristolochia species	*Herb*	11 $^{+}$	10 ^{r}	57 $^{r-2}$	9 $^{+-2}$
Sanicula europaea	*Herb*	.	.	64 $^{+-2}$	45 $^{r-1}$
Ulmus glabra	*Shrub*	.	.	50 $^{+-2}$	.
Polygonatum orientale	*Herb*	33 $^{r-+}$	10 ^{r}	50 $^{+}$	18 $^{r-+}$
Geranium robertianum	*Herb*	44 $^{+-1}$	.	50 $^{r-1}$	23 $^{r-1}$
Lathyrus aureus	*Herb*	.	40 $^{+}$	57 $^{+-1}$	27 $^{+-1}$

Dryopteris filix-max	*Herb*	11 $^{+}$	10 $^{+}$	43 $^{+-2}$	59 $^{+-3}$
Oxalis acetosella	*Herb*	.	.	.	64 $^{+-1}$
Epilobium species	*Herb*	33 $^{r-+}$	.	.	.
Asperula involucrata	*Herb*	33 $^{+-1}$	.	.	5 $^{+}$
Viola alba s. dehnhardtii	*Herb*	11 $^{+}$	.	29 $^{+-1}$	5 ^{r}
Epilobium montanum	*Herb*	.	.	29 $^{r-+}$	18 $^{+-1}$
(S) Cirsium arvense s. vestitum	*Herb*	22 $^{r-+}$	.	43 $^{r-1}$	41 $^{+}$
Anthriscus nemorosa	*Herb*	.	.	36 $^{+-1}$	18 $^{+-1}$
Actaea spicata	*Herb*	.	.	29 $^{+-1}$	27 $^{+-1}$
Salvia glutinosa	*Herb*	.	.	36 $^{+}$	18 $^{r-+}$
Mycelis muralis	*Herb*	11 ^{r}	.	43 $^{r-+}$	9 $^{r-+}$
Athyrium filix-foemina	*Herb*	.	.	29 $^{+-2}$	23 $^{+-2}$
Lilium martagon	*Herb*	.	.	29 ^{r}	5 ^{r}
Galium rotundifolium	*Herb*	.	.	14 $^{+}$	36 $^{+-1}$
Ranunculus brutius	*Herb*	.	.	.	27 $^{+-1}$
Urtica dioica	*Herb*	22 $^{+-1}$	.	14 $^{+}$	32 $^{+-1}$

4. DISCUSSION

Forest types of Ayıkaya region change considerably along different altitudinal zones. Increasing precipitation and high atmospheric humidity in upper altitudinal zones create favourable conditions for *A.bornmülleriana.* In addition; soil type and topography (slope degree and aspect) of the area have also an effect on species distribution. For instance, sandy soils retain far less water than soils with a high clay or organic matter content. Therefore, on sunny slopes with sandy soils (sandy loam) *P.sylvestris* and *Q.petraea* which are more tolerant to drier conditons than *A.bornmülleriana* become dominant.

The presence of individual species (i.e., the differences in the composition of individual species) can be used as an indicator of disturbance levels (Onaindia et. al., 2004). For instance, Endels *et al*. (2004) state that a combination of high nutrient levels and relatively open canopy may lead to vigorous growth and ultimately dominance of competitive species like *Urtica dioica* or *Rubus* spp. As it is seen in RDA diagram (Figure 3), these species are found under relatively open canopies. Therefore, high cover values of mentioned species can be used as an indicator of high light intensities. In addition, indicator value for nutrient level of the species must be subjected to further studies.

Both ordination analysis and classification of available vegetation data of the region reveal that *A.bornmülleriana* forms mixed stand with *F.orientalis* at higher elevations between 1300-1700m, on shady exposures. In addition *P.sylvestris* between 920-1310 m. and *Q. petraea* between 710-1150 m forms mixed stands with *F.orientalis* mostly on sunny exposures. However, seedlings and saplings of *A.bornmülleriana* are found at lower altitudes as well.

Seedling and saplings of *P. sylvestris* and *A. bornmülleriana* have different growth and survival characteristics in mixed stands. In low light (understorey of closed stands), light demanding *P. sylvestris* have notably lower survival, whereas shade tolerant *A. bornmülleriana* is capable of establishing and surviving even under a closed canopy and sustain for a long time. Absence of *P. sylvestris* generations under mixed *P. sylvestris-A. bornmülleriana* forest is related to the high light demand of *P. sylvestris* seedlings, not an inhibition of germination in *P. sylvestris* seeds. *P. sylvestris* seedlings which do not get enough light die and disappear in a short time. According to Özalp (1989), regeneration of *P. sylvestris* under shade tolerant tree species like *Abies* sp. and *F. orientalis* is not possible without a silvicultural treatment. High shade tolerance of *A. bornmülleriana* enables regeneration of its seedlings where canopy closure is broken slightly which provides the survival of seedlings. Therefore, the proportion of shade intolerant tree species were decreased or totally eliminated due to their high economic value in mixed stands. When *P. sylvestris* were removed, *A.bornmülleriana* generations dominates understorey for long periods and grow after the canopy is removed. Even though *P. sylvestris* regenerated they can not live longer because of their high light demand. Çalışkan (1991) and Çalışkan *et al*. (2004) told that such changes in forest composition were observed even in a short time period from (Aksoy, 1978) to (Çalışkan, 1991; Çalışkan et al., 2004) in *P. nigra- Q. petraea-A.bornmülleriana* (*Pino nigrae-Quercetum dychorochensis abietosum bornmüllerianae*) mixed forest in Karabük-Büyükdüz Research Forest. These changes are the result of silvicultural treatments based on economically important trees and determination of annual yield for one species considering yield calculation based on increment in forest management plans (Ata *et al*., 1989; Çörtü, 2008).

5. CONCLUSION

In managing forest resources, one of the most desirable stand types in terms of sustaining biodiversity is uneven-aged mixed forests where many tree and shrub species can live together with harmony. The uneven-aged mixed forests are highly resistant to biotic and abiotic agents and they provide rich gene combinations and genetic variations. Besides, they improve the visual quality and aesthetic value of the forest (Çalışkan, 1991; Boydak and Bozkuş, 1996). In contrast, mixture of trees in a stand is important if they provide an aim in point of ecological, silvicultural and economical way. Tree mixture which is not close to natural mixture combinations may create more vulnerable forests.

Current and changing climatic conditions are combining with these human impacts on forest conditions to trigger widespread bark beetle-caused tree mortality. For instance, *Pityokteines curvidens* (Germ.), which is a secondary insect, becomes primary insect in suitable conditions where trees grow at the edge of their ecological range (Şimşek, 2005). Especially Fir bark beetle causes serious damages in the region. In addition, *Cryphalus piceae* and *Ips acuminatus* damages are also seen. The activity of these insects in fir stands can become critical when trees are subject to recurrent physiological stresses from a variety of biotic and abiotic factors. During the first phase of an infestation the most vulnerable trees are those which have been uprooted or broken, or which exhibit signs of stress due to adverse site conditions, or which have been weakened by low winter temperatures. (Cerchiarini and Tiberi, 1997). According to Forest Management Plan of Ayıkaya Forests (2008-2027); 51% (74.959m^3) of total utilization (145.639m^3) in previous planning period (1995-2006) was an extra-ordinary yield**.** It was recorded that most of the extra-ordinary yield was caused by insects and pathogen-related outbreaks.

Different forest types in the study area which are changing in short distances indicate that silvicultural treatments have to be appropriate for sustainable management of such mixed forests. Silvicultural methods applied in mixed stands require knowledge about mixture combinations, growth relations among species, site condition, climatical factors, biological characteristics and competitive ability of species. For this reason, with the application of methods that create pure stands (shelterwood method, strip clear cutting method), forest tree composition will change in response to silvicultural operation (Ata, 1987). Maguire *et al*. (2007) stated that characterizing both target and non-target attributes is essential for developing silvicultural systems that reach the desired balance between economically viable production of timber, regeneration of desired tree species and protection of other forest values. Forestry activities, such as silvicultural conversion, restoration and 'close-to nature' silvicultural operations, can be organized effectively if guided by 'naturalness zone maps'. With naturalness maps prepared according to hemeroby classes for five or ten-year periods, it is possible to predict human impacts on forest ecosystems and so influence the degree to which 'close-to-nature' silvicultural practices may meet targets set for forest management and conservation. In addition, application of 'close-to-nature' silviculture could significantly reduce the problems facing unique forest types in the region today (Çolak *et al*., 2003; Çolak and Rotherham, 2006).

Further studies on classification and development of plant communities will assist in preparation of naturalness maps and hemeroby classes in Ayıkaya region. However, although it will take time to change current practices for sustainable management of mixed forests, silvicultural practices considering naturalness of forest may meet targets set for forest management and conservation.

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