Journal of the Faculty of Forestry Istanbul University 2016, 66(1): 278-287

JOURNAL OF THE FACULTY OF FORESTRY ISTANBUL UNIVERSITY
İSTANBUL ÜNİVERSİTESİ ORMAN FAKÜLTESİ DERGİSİ
ISSN: 0535-8418 e-ISSN: 1309-6257

Online available at / Çevrimiçi erişim
http://dergipark.ulakbim.gov.tr/jffiu - http://dx.doi.org/10.17099/jffiu.60821

Research Article / Araştırma Makalesi

Ecological indicator values of forest communities in Çitdere Region (Yenice-Karabük)

Süleyman Çoban [1*]

[1*] Istanbul University, Faculty of Forestry, Department of Silviculture, 34473, Sariyer, Istanbul, Turkey

Corresponding author e-mail (İletişim yazarı e-posta): scoban@istanbul.edu.tr

Received (Geliş tarihi): 05.02.2015 - **Revised (Düzeltme tarihi):** 01.07.2015 - **Accepted (Kabul tarihi):** 02.07.2015

Abstract: Indicator species system, which has been used widely in Europe, has many advantages in vegetation analysis. It allows quick interpretation of ecological conditions using floristic data without doing any measurements about site conditions. Considering the amount of phytosociological studies carried out in Turkey, this system may provide important information about plants or plant communities if required modifications are done. In this study, Pignatti-Ellenberg indicator values (EIVs) modified for the check list of Flora Europea were used to analyse and compare forest communities of Çitdere region in terms of light (radiation), temperature, moisture, continentality, soil reaction and soil nutrient in order to test how effectively mean EIVs indicate ecological conditions. Main differences were found between communities which occur on sunny and shady exposures in terms of moisture, soil nutrient, light and temperature indicator values. When normal and original permutation tests were used, all of six indicator values were significant. With the modified permutation test, only mean temperature and light indicator values showed significant differences among 8 forest communities of the region. *Pinus sylvestris* and *Quercus petraea* forest communities which have relatively narrow distribution area showed higher correlation with temperature and continentality indicator values when weighted average by species cover was used.

Keywords: Ellenberg indicator values, ecology, plant sociology, vegetation analysis, site condition

Çitdere bölgesi (Yenice-Karabük) orman toplumlarının ekolojik gösterge değerleri

Özet: Vejetasyon analizi çalışmalarında, Avrupa'da yaygın olarak kullanılan gösterge tür sisteminin pek çok avantajı bulunmaktadır. Bu sistem, floristik veriler kullanılarak ekolojik koşullar hakkında herhangi bir ölçüm yapmadan kolayca yorum yapma imkanı sunmaktadır. Türkiye'de yapılmış olan çok sayıdaki bitki sosyolojisi çalışmaları dikkate alındığında, gösterge türlerle ilgili bazı değişiklerin yapılması durumunda bitki toplumlarının ya da türlerin gösterge değerleri hakkında önemli bilgiler elde edilebilir. Bu çalışmada, Avrupa florası için düzenlenmiş olan Pignatti-Ellenberg gösterge değerleri (EIVs) yardımıyla Çitdere bölgesindeki orman toplumlarını; ışık, sıcaklık, nem, karasallık, toprak reaksiyonu ve toprak besin maddesi kriterleri bakımından karşılaştırarak, ortalama gösterge değerlerin ekolojik koşulları ne oranda yansıttığı test edilmiştir. Güneşli ve gölgeli bakılarda yayılış gösteren toplumlar; nem, toprak besin maddesi, ışık ve sıcaklık gösterge değerleri bakımında farklılıklar göstermiştir. Normal parametrik ve permütasyon testleri kullanıldığında 6 gösterge değerinin tamamı, modifiye edilmiş permütasyon testi kullanıldığında ise sadece sıcaklık ve ışık ortalama gösterge değerleri bölgedeki 8 orman toplumu için istatistiksel olarak farklılık göstermiştir. Nispeten daha dar alanlarda yayılış gösteren *Pinus sylvestris* ve *Quercus petraea* orman toplumları, örtme derecelerine göre ağırlıklandırılmış verinin kullanılmasıyla sıcaklık ve karasallık gösterge değerleriyle daha fazla korelasyon göstermiştir.

Anahtar Kelimeler: Ellenberg gösterge değerleri, ekoloji, bitki sosyolojisi, vejetasyon analizi, yetişme ortamı

To cite this article (Atıf): Çoban, S., 2016. Ecological indicator values of forest communities in Çitdere Region (Yenice-Karabük). *Journal of the Faculty of Forestry Istanbul University* 66(1): 278-287. DOI: 10.17099/jffiu.60821

1.INTRODUCTION

A plant community can be defined as a collection of plant species growing together in a particular location that show a definite association with each other. Plant species of a community have similar requirements of environmental factors such as light, temperature, water, drainage and soil nutrients (Kent and Coker, 1992). For this reason, occurrence and abundance of different plant species enables ecologists to make statements about the prevailing environmental conditions. This method, which has been used for many years in Europe, is the main approach used to predict an environmental variable by means of the flora without measuring them (Jean-Claude and Eva, 2003; Wamelink et al., 2005). One of the most widely used indicator species system was proposed by Ellenberg et al. (1992), which describes the response of a species to edaphic and climatical parameters in Central Europe. Ellenberg (Ellenberg, 1979; Ellenberg et al., 1992) assigned 2726 Central European vascular plant species, with respect to moisture, soil nitrogen status, soil reaction, light regime, temperature and continentality. The values were developed mainly on the basis of field experience and quantification generally follows a nine-point scale (Schaffers and Sýkora, 2000).

Although Ellenberg indicator values (EIVs) were developed for Germany and surrounding areas, datasets have become available for several Central and Western European countries which have large number of species in common and similar latitudinal distribution (Schwabe et al., 2007). On the other hand, application of EIVs in other geographical regions was debated because of few shared species and differing ecological requirements of species across their range (Godefroid and Dana, 2007; Hill et al., 2000). However, using mean EIVs for vegetation analysis and comparing plant communities in different ecological conditions is widely accepted (Hill et al., 2000; Zelený and Schaffers, 2012). Recently, using indicator species in vegetation analysis have been increased in Turkey (e.g., Kavgacı et al., 2011; Kavgacı et al., 2010; Kavgacı and Carni 2008; Kavgacı, 2007) and also some studies were carried out for determining plant indicator values (Sürmen et al., 2014).

The goals of this study are to compare ecological characteristics of forest communities in Çitdere region using available Ellenberg Indicator Values (EIVs) prepared for the flora of Europe and to examine how effectively they can be used in vegetation analysis in Çitdere region which is in Euro-Siberian phytogeographic region.

2. MATERIAL AND METHODS

2.1 Study Area

Çitdere is located in Yenice district of Karabük province which is in the western part of Blacksea Region. It lies between 41º00" 14' and 41º05".06' northern latitudes and 32º 21" 06' and 32º 27" 45' eastern longitudes. The area is 50-60 km far away from seashore. The area extends along Şimşir Dere and Çitdere valley from nortwest to southeast and surrounded by high mountains on northest, east, south and west. Çitdere forests are managed by Yenice Forest Enterprise of Zonguldak Forest Regional Directorate. The area is a total of 6.091 ha and 5.964 ha of the area is covered by forests. The altitude of the region ranges from 640 m to 1810 m (Figure / Şekil 1).

There is not a meteorological station in the Çitdere region. The closest stations are in the Baklabostan (860 m) and Büyükdüz Research Forest (1560 m) in Karabük. Mean annual precipitation and temperature are measured as 1371.2 mm and 6.2°C at Büyükdüz station and as 1040.2 mm and 9.2°C at Baklabostan station. In general, the climate of the region is semi-humid/humid with no water deficiency during vegetation period (Özalp, 1989; Özalp, 1992).

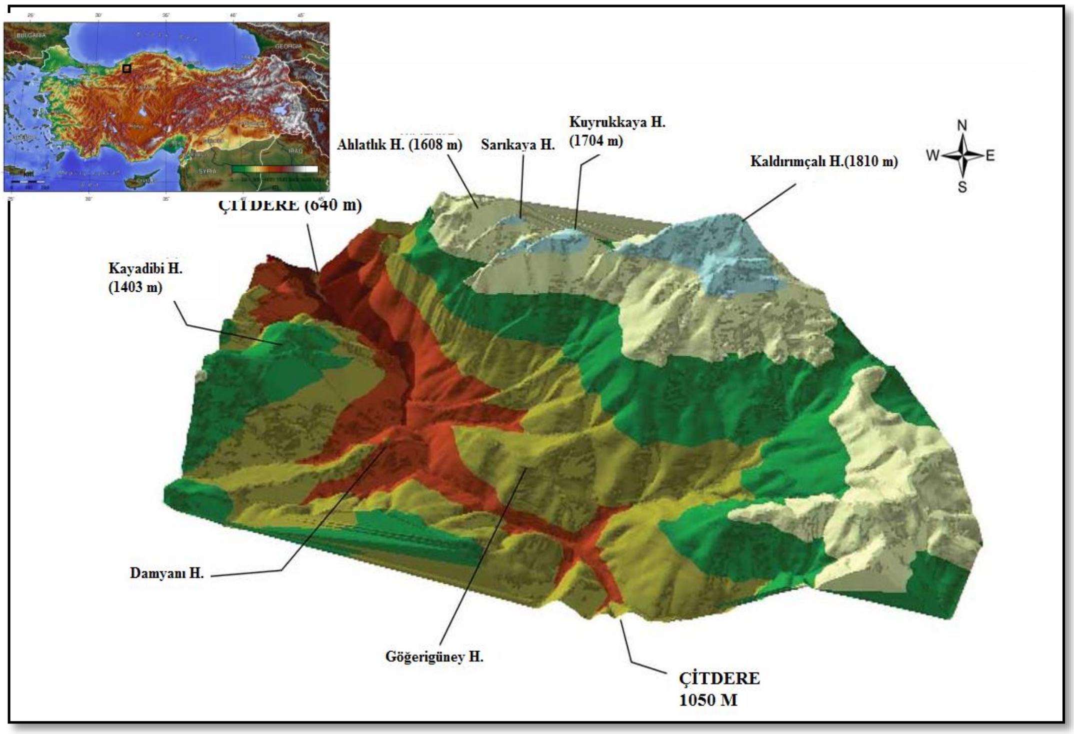

Figure 1. Location and digital terrain model of the study area (Günay and Küçük, 2007).
Şekil 1. Araştırma alanının konumu ve sayısal arazi modeli (Günay ve Küçük, 2007).

2.2 Forest Communities

Forests of the region mainly consists of pure and mixed stands of *Fagus orientalis* Lipsky, *Abies bornmülleriana* Mattf., *Pinus sylvestris* L., *Pinus nigra* Arnold, *Quercus hartwissiana* Stev., *Quercus petraea* ssp. *iberica* (Steven ex M.Bieb.) Krassiln, *Carpinus betulus* L. and other deciduous tree species. 14 forest communities and subcommunities have been determined by Özalp (1989). Main forest communities which were used in this study are given below (Özalp, 1989, Özalp, 1992):

1. *Abies bornmülleriana-Fagus orientalis* with *Pinus sylvestris (*Altitude: 1000 m- 1600m; Bedrock: flysch, clay, sandstone, limestone)
2. *Ilex-colchica-Abies bornmülleriana-Fagus orientalis (*Altitude: 1000 m- 1400 m*;* Bedrock: clay)
3. *Taxus baccata-Fagus orientalis (*Altitude: 900 m- 1350 m; Bedrock: Limestone)
4. *Ostrya carpinifolia-Tilia rubra (*Altitude: 900 m- 1150 m*;* Bedrock: limestone)
5. *Melamphyrum arvense-Quercus petraea (*Altitude: 800 m- 1300 m*;* Bedrock: marmorean, clay, sandstone)
6. *Pinus sylvestris-Pinus nigra (*Altitude: 1350 m- 1450 m*;* Bedrock: limestone)
7. *Fagus orientalis (*Altitude: 900 m- 1200 m*;* Bedrock: limestone, flysch)
8. *Quercus hartwissiana-Fagus orientalis (*Altitude: 1000 m- 1200 m*;* Bedrock: limestone, flysch, sandstone).

2.3 Method

Vegetation data was taken from Özalp (1989) and a total of 133 sample plots stored in TURBOVEG database (Hennekens and Schaminée, 2001). Then vegetation data was exported to JUICE software (Tichý, 2002; Tichy and Jason, 2006). Forest communities defined by Özalp (1989) were accepted for the analysis. Two lists of indicator values prepared for JUICE software were used in the analysis. One is original Ellenberg Indicator Values (EIVs) prepared for Central Europe (Ellenberg et al., 1992) and second is Ellenberg-Pignatti indicator values modified for the Flora Europea (Ellenberg et al., 1992; Pignatti, 2005).

EIVs were assigned to the species data and average EIVs of sample plots as unweighted and weighted by species cover were calculated in JUICE (Tichy and Holt, 2006). Mean EIVs of forest communities were compared using Modified Permutation Test (MoPeT) script using JUICE-R function (Zelený and Schaffers, 2012). Number of indicator species was counted and percentage of every indicator value parameter was calculated for each community. Differences in mean EIVs among forest communities were calculated using analysis of variance (ANOVA) and significance of the results were tested with parametric, original and modified permutation tests (499 permutations). Sorensen dissimilarity measures were calculated in order to show floristical differentiation between forest communities within JUICE.

Unconstrained ordination was run under CANOCO 4.5 (ter Braak & Šmilauer 2002) and environmental variables passively projected on diagram. The gradient length was found as 3.5 SD which implies both linear and unimodal methods work well. For this reason, Detrended Correspondence Analysis (DCA), which is an unimodal method, was used for the ordination of vegetation samples with mean EIVs and Principal Components Analysis (PCA), which is a linear method, was used for species and mean EIVs.

3. RESULTS

3.1 Assignment of Ellenberg indicator values to the species data

Original EIVs and Pignatti's EIVs for all of Europe were separately assigned to the species data. The highest number of species having indicator values were found in Pignatti's EIVs for all of Europe. For instance, the percentage of species having light, temperature, continentality, moisture, soil reaction and nutrient indicator values taken from Pignatti's EIVs averaged 60 %, 54%, 60%, 56%, 46%, 52 % respectively. On the other hand, these values were found as 37%, 28%, 36%, 31%, 26% and 32% from original EIVs.

The percentage of species having indicator values (non-zero values) for each EIVs in each community was the highest for light, continentality and temperature respectively. Conversely, the number of species having indicator values related to soil reaction was the lowest in all communities (Figure / Şekil 2).

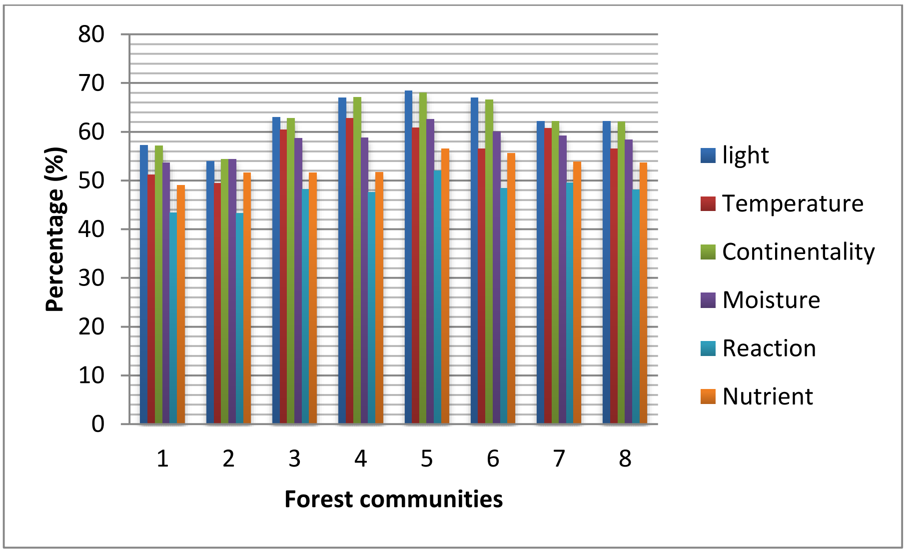

Figure 2. Percentage of non-zero EIVs of species within forest communities (1: *Abies bornmülleriana-Fagus orientalis* with *Pinus sylvestris*; 2: *Ilex-colchica-Abies bornmülleriana-Fagus orientalis*; 3: *Taxus baccata-Fagus orientalis*; 4: *Ostrya carpinifolia-Tilia rubra*; 5: *Melamphyrum arvense-Quercus petraea*; 6: *Pinus sylvestris-Pinus nigra*; 7: *Fagus orientalis*; 8: *Quercus hartwissiana-Fagus orientalis*).

Şekil 2. Orman toplumlarında bulunan gösterge değeri alan türlerin yüzdesi (1: *Abies bornmülleriana-Fagus orientalis* with *Pinus sylvestris*; 2: *Ilex-colchica-Abies bornmülleriana-Fagus orientalis*; 3: *Taxus baccata-Fagus orientalis*; 4: *Ostrya carpinifolia-Tilia rubra*; 5: *Melamphyrum arvense-Quercus petraea*; 6: *Pinus sylvestris-Pinus nigra*; 7: *Fagus orientalis*; 8: *Quercus hartwissiana-Fagus orientalis*).

3.2 Unconstrained Ordination Analysis of Forest Communities

Melamphyrum arvense-Quercus petraea and *Pinus sylvestris-Pinus nigra* forest communities which occur on southern exposures (S, SW, SE) are closely correlated with temperature and light indicator values. On the other hand, *Melamphyrum arvense-Quercus petraea* community which distributes on lower altitudinal zone (800 m-1300 m) shows high temperature, whereas *Pinus sylvestris-Pinus nigra* community on higher altitudes (1350 m-1450 m) shows higher light indicator value. Humid *Abies bornmülleriana* and *Fagus orientalis* forest communities are associated with moisture and soil nutrient indicator values. *Taxus baccata-Fagus orientalis* and *Ostrya carpinifolia-Tilia rubra* communities, which typically occur on limestone bedrock, are also correlated with soil reaction (Figure / Şekil 3).

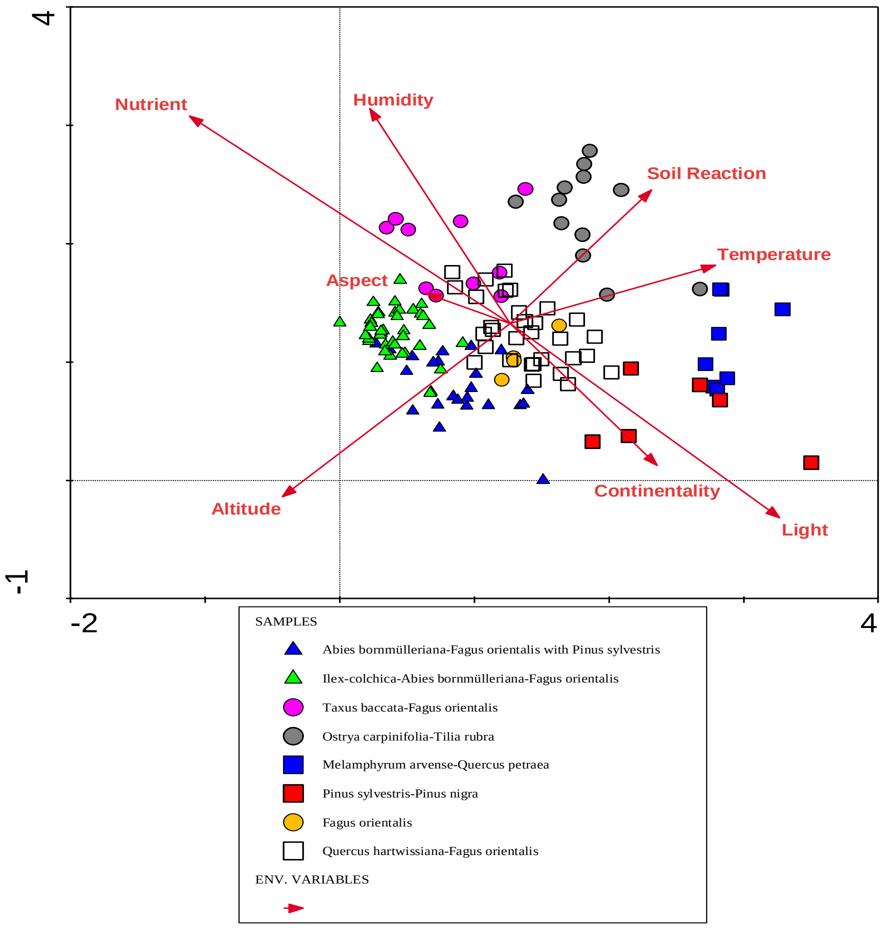

Figure 3. Detrended Correspondence Analysis (DCA) of forest communities.
Şekil 4. Orman toplumlarının Detrended Correspondence Analizi (DCA).

3.3 Statistical Differences in Mean Eivs Among Forest Communities

When differences among forest communities were tested, all of six mean EIVs were significant (P<0.05) with parametric and original permutation tests. However, with the modified permutation test only mean temperature and light indicator values are significant at P<0.05 (Table / Tablo 1).

Table 1: One-way ANOVA for mean EIVs among forest communities.
Tablo 1. Orman toplumlarının ortalama gösterge değerleri için tek yönlü ANOVA.

	F-value	P (Par. test)	P (Perm. test)	P (Modified)
Light	46.208	<0.001	< 0.01	**<0.05**
Temperature	48.224	<0.001	< 0.01	**<0.05**
Continentality	19.621	<0.001	< 0.01	0.168
Humidity	28.857	<0.001	< 0.01	0126
Soil reaction	16.093	<0.001	< 0.01	0.234
Nutrient	34.199	<0.001	< 0.01	0.076

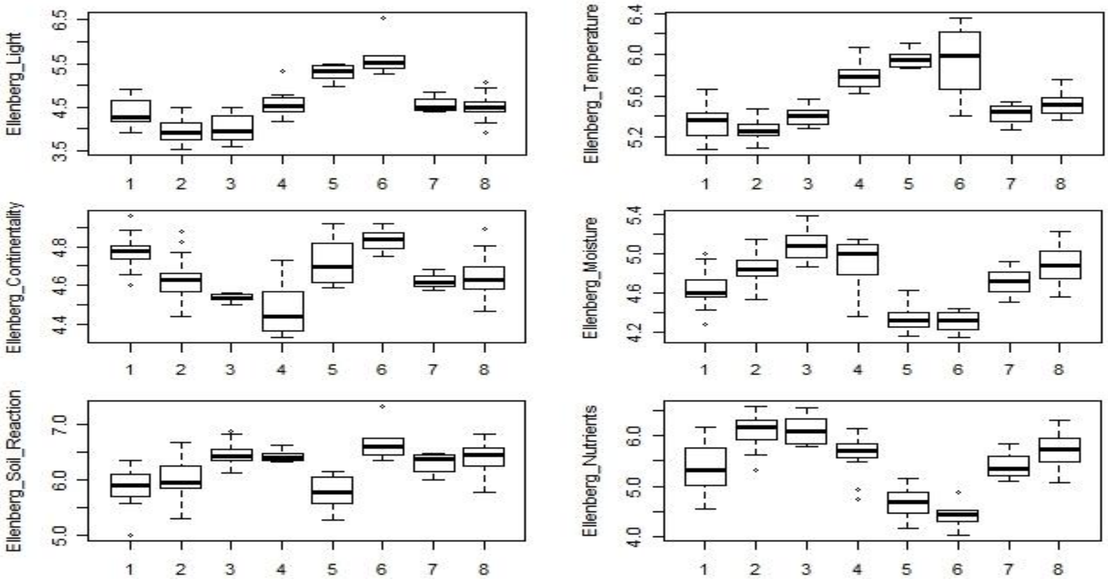

Figure 4. Differences in mean EIVs for the forest communities; whiskers present the lowest and the highest values, thick line inside the box presents median (1: *Abies bornmülleriana-Fagus orientalis* with *Pinus sylvestris*; 2: *Ilex-colchica-Abies bornmülleriana-Fagus orientalis*; 3: *Taxus baccata-Fagus orientalis*; 4: *Ostrya carpinifolia-Tilia rubra*; 5: *Melamphyrum arvense-Quercus petraea*; 6: *Pinus sylvestris-Pinus nigra*; 7: *Fagus orientalis*; 8: *Quercus hartwissiana-Fagus orientalis*).

Şekil 4. Orman toplumlarının ortalama gösterge değerleri arasındaki farklılıklar; bıyıklar en düşük ve en yüksek değerleri, kutu içindeki kalın çizgi medyan değerini göstermektedir. (1: *Abies bornmülleriana-Fagus orientalis* with *Pinus sylvestris*; 2: *Ilex-colchica-Abies bornmülleriana-Fagus orientalis*; 3: *Taxus baccata-Fagus orientalis*; 4: *Ostrya carpinifolia-Tilia rubra*; 5: *Melamphyrum arvense-Quercus petraea*; 6: *Pinus sylvestris-Pinus nigra*; 7: *Fagus orientalis*; 8: *Quercus hartwissiana-Fagus orientalis*).

Mean EIVs of forest communities are derived from their species composition. For this reason, sample plots which have similar species composition correspond to similar ecological conditions. In this respect, similarity or dissimilarity measures calculated from species composition of sample plots can show the magnitude of the difference in mean EIVs. For instance, dissimilarity between *Abies bormülleriana* and/or *Fagus orientalis* dominated forest communities are rather low (Sorensen dissimilarity: 35 %) compared to dissimilarity of these communities with *Pinus sylvestris* and *Quercus petraea* forests (Sorensen dissimilarity: 71% and 94%). Accordingly, significant differences in mean EIVs were found between the communities having high dissimilarity in species composition. For example, when semi-humid *Quercus petraea* and *Pinus sylvestris* dominated forests were compared with humid forests (*Fagus orientalis* and *Abies bornmülleriana* forests), significant differences (P.modif <0.005) were found for mean light, temperature, moisture and nutrient values.

Pinus sylvestris and *Quercus petraea* communities which occur on sunny exposures have higher temperature and light indicator values, *Abies bormülleriana* and/or *Fagus orientalis* dominated forest communities have higher moisture and nutrient indicator values. However, *Pinus sylvestris-Pinus nigra* community which occurs only on limestone bedrock shows higher median value for soil reaction compared to others (Figure / Şekil 4). In the calculation of mean EIVs of samples, presence/absence and cover-weighted indicator values were used. In the ordination diagram, cover-weighted indicator values for continentality was a better predictor for *Pinus nigra* and *Quercus petraea* forests but unweighted mean EIVs had no differences for other parameters. Species like *Tilia rubra*, *Fraxinus exelsior*, *Acer platanoides*, *Cardamine impatiens*, *Cardamine bulbifera*, *Galium odoratum*, *Circaea lutetiana*, *Dryopteris filix-max* etc. had positive correlation with soil nutrient and humidity, whereas *Dorycnium graecum*, *Melampyrum arvense*, *Genista tinctoria*, *Brachypodium pinnatum*, *Sorbus torminalis* were positively correlated with temperature and light indicator values. *Ostrya carpinifolia*, *Acer campestre*, *Carpinus betulus*, *Staphylea pinnata*, *Cornus mas*, *Asplenium adiantum-nigrum* were associated with mean soil reaction (alkaline soils) (Figure / Şekil 5).

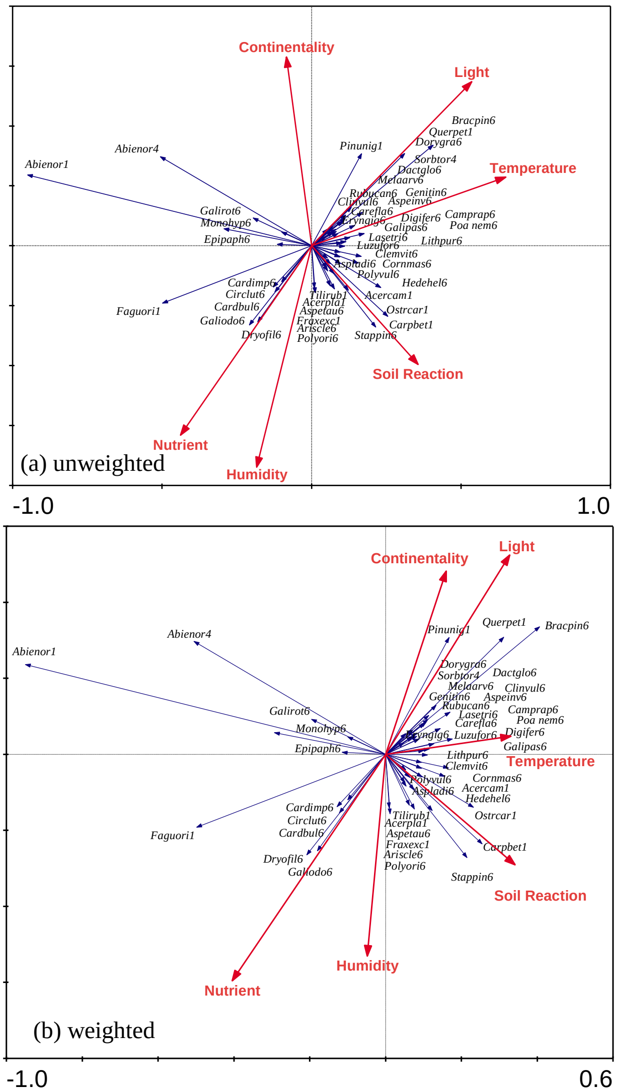

Figure 5. PCA of species with unweighted (a) and weighted (b) indicator values (with 25% inclusion 53 species included, numbers at the end of species names express vegetation layer; 1: tree layer, 4: shrub layer, 6: herb layer).

Şekil 5. Ağırlıklandırılmamış (a) ve ağırlıklandırılmış (b) gösterge değerleri ile türlerin PCA grafiği (% 25 sınır değeri ile 53 tür gösterilmiştir, tür isimlerinin sonundaki sayılar vejetasyon katlarını ifade etmektedir; 1: ağaç katı, 4: çalı katı, 6: ot katı).

4. CONCLUSION

Indicator species system has many advantages in vegetation analysis and has been used widely in applied plant ecology, forestry and agriculture, especially in Europe (Ter Braak and Gremmen, 1987; Hill and Carey, 1997; Hawkes et al., 1997; Dzwonko, 2001; Diekmann, 2003; Klaus et al., 2012). These values were derived from field experience of plant ecologists and reflect the realised optima of species. This approach can provide information on the environmental conditions of phytosociological units without field measurements, especially when old measurements are not available (Diekmann, 2003). Assessment of many species occur together allows a more reliable estimation of site conditions than assessment of a single species, as the overlap of ecological tolerances of many species is smaller than the ecological amplitude of a single species. For this reason, mean indicator values of species in a sample plot or community may provide more reliable information. In addition, since measured factors are not often available in old vegetation data, the informational potential offered by mean EIVs may be useful (Zelený and Schaffers, 2012). In order to use this system outside of Europe, calibration for local conditions is inevitable (Hill et al., 2000). For instance, indicator values of species like *Fagus orientalis, Abies bornmülleriana, Quercus macranthera, Quercus hartwissiana, Daphne pontica, Rhododendron ponticum* etc. have not been identified yet. According to Hill et al., (2000), missing, indifferent or uncertain values should be supplied by using average values for sociological-ecological groups.

In this study, it was shown that ecological characteristics of forest communities can be compared with the limited number of species which have indicator values. This is true when forest communities which occur on sunny and shady exposures were compared in terms of humidity, nutrient, temperature and light indicator values. With the increasing dissimilarity in species composition among communities, significant discrimination can be got for more parameters. In other words, differences among EIVs are correlated with compositional dissimilarity. Therefore, a better differentiation of communities with EIVs depends on the quality of the classification method used in the classification of forest communities. In this study, when all main forest communities were compared with their mean indicator values, significance of every parameter changed depending on statistical test used. However, Zelený and Schaffers (2012) state that mean EIVs may be simply used in descriptive analysis and differences in mean EIVs derived from species composition among communities should not be tested with any statistical inferences. They suggest to use a modified permutation test instead of other methods (ANOVA, t-test or non-parametric alternatives).

In case of smaller ranges of environmental conditions and less species having indicator values, using species abundance values (weighted for species cover) instead of presence/absence data will be more beneficial. This is because species presence/absence data may vary little in these cases, whereas species abundances may vary appreciably (Schaffers and Sýkora, 2000). In the study area, *Pinus sylvestris-Pinus nigra* community, which has a narrow distribution area, shows higher correlation with continentality and temperature values when cover data is used. Since these communities generally prevail on southern exposures and steep slopes, *Pinus sylvestris-Pinus nigra* and *Melamphyrum arvense-Quercus petraea* communities show the lowest soil nutrient indicator values.

Indicator plants and indicator values should not be used as ways of providing measured values. They only indicate type and magnitude of important environmental variables and have proved to be simple and easy to use values for comparison of sites and their conditions in space and time (Schulze *et al.*, 2002). Forest communities develop as a combination of all factors in environment (climate and soil). Therefore, classification of forest communities will gather this ecological information (Kavgacı and Özalp, 2006). In order to benefit from this potential of vegetation data in practice, particularly in forestry, modification of available EIVs and determination of uncommon species are indispensable. Therefore, a large database of vegetation sample plots and environmental variables from a variety of ecosystem in Turkey are required for calibration of EIVs.

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