Ground Vegetation Change According to the Elevation Level in Pure Fir Forests (*Abies nordmanniana* subsp. *bornmülleriana* Mattf.) in Ardiç-Bartin, Turkey

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Abstract
The aim of this research that is examining the changes in the flora in Uludag Fir (*Abies nordmanniana* subsp. *bornmülleriana*) stands with respect to the altitude was carried out between 2009 and 2010. The Ardıç Watershed Area, which was chosen as study area, included in Ardıç Forest Range District belongs to Ulus Forest Enterprise Directorate. 18 sample plots were established between 900 and 1,500 m altitudes in the Uludag fir stands. The average size of sample plots was chosen as 20 x 20 m. Totally 1,500 plant specimens have been collected from all sample plots. The Braun-Blanquet method was used for the determination of present plant density in this research. At the end of the identification of these specimens, 60 taxa belonging to 35 families have been determined. These taxa include 75 genera, 108 species, 13 subspecies and 3 varieties. The forest community in the study area is described as the *Abies nordmanniana* subsp. *bornmülleriana* plant association of the Euxin region.
Keywords: Plant association, flora, Uludag fir, altitude, ground vegetation

Introduction

Biodiversity represents an important renewable natural resource with scientific, educational, cultural and ecological values. The development activities which may affect biodiversity include pollution, habitat destruction and degradation by physical, chemical and human activities. They may cause significant and often irreversible loss of biodiversity (Hegazy, 1999). The landscape vegetation of the world has been subjected to change for thousands of years on a scale not yet seen on any other continent. Degradation of forest lands due to grazing, agriculture, fire, urban and industrial development, tourism and population growth and movements has dramatically altered the face of the world (Heywood, 1998).

Barnes *et al*. (1998) has defined the biodiversity as "*the kinds and numbers of organism and their patterns of distribution*". Also, biodiversity has become an increasingly popular topic within the discussion of sustainability in the last decade, though the maintenance of diversity of forest ecosystems is required since many years. Biodiversity measurement focusing on the species level and species diversity is one of the most important indices which are used for the evaluation of ecosystems at different scales. Differentiation of plant communities has been at the heart of vegetation science for centuries, with a traditional focus on the distribution, composition and classification of plant communities (Kashian *et al*. 2003). Magurran (1988) has defined the plant communities as „an assemblage of functionally similar species populations that occur together in time and space". Plant communities are separated from each other based on indicator species in combination with a distinctive floristic composition (Dansereau, 1960) and therefore Mishra *et al.* (2004) and Rad *et al.* (2009) had informed that any depletion of biodiversity is bound to alter the community attributes.

Silvicultural practices in different plant communities are characteristic to plant specific and diversity. So, silvicultural practices include forest management that combines timber harvesting and biodiversity preservation. According to the scientists the aim of a research strategy is to study biodiversity pattern of undisturbed forests and semi-natural woodlands and transfer the knowledge to managed forests (Mitchell *et al.*, 2002; Rad *et al.*, 2009).

Turkey has rich areas for plant diversity in the middle latitudes. Avcı (2005) considers that the main reasons for this fact are climates varieties, geomorphologic and soil diversities and the location of the area at

the junction of three flora region (*Euro-Siberian*, *Mediterranean* and *Irano-Turanian*). When all these factors are combined, it provides many opportunities for the plants to grow and distribute. The flora of Turkey includes about 12,000 species and still a great number of new species have to be described. The rate of endemism in Turkey is relatively high (30%) compared with other European countries as Greece (14.9%), France (2.9%) (France), Spain (18.6%) or Poland (0.1%). The number of endemic species in Turkey is greater than 3,000 (Avcı, 2005).

This research work that is examining the changes in the flora of Uludag fir (*Abies nordmanniana* subsp. *bornmülleriana*) stands with respect to the altitude was carried out between 2009 and 2010. Ardıç Watershed Area, which was chosen as study area, is included into Ardıç Forest Range District belonging to Ulus Forest Enterprise Directorate. 18 sample plots were established between 900 and 1,500 m altitudes in the Uludag fir stands.

Material and Method

Material

Forests of the Ardıç district are situated in the *Northwest Euxinic* forest subzone of the *Euxinic* forest zone (Mayer and Aksoy 1998). According to the inventory data of 2010, the total forest area in the region is 12,456 ha, of which 28.6% is degraded forest. General soil type is stony, alkaline, sandy clay and sandy clayish mud of mediocre depth. Ardıç district is under the effect of Western Black Sea sub-climate (IIc). All seasons are rainy, the month with highest mean rainfall is December (198.4 mm), the one with the lowest is June (53.0 mm). Annual average temperature is 8.3 °C, the coldest month is January, and the warmest month is July. The vegetation period in the research area is six months (May–October) (OGM 2011).

Method

In this study carried out in Uludağ fir forests in Bartın-Ardıç district, the change of ground vegetation depending on altitude levels was investigated. For this reason, sample plots were established in six different altitude levels (900-1,000 m, 1,000-1,100 m, 1,100-1,200 m, 1,200-1,300 m, 1,300-1,400 m, and 1,400-1,500 m) and changes of ground vegetation were recorded. Sample plots 20 x 20 m-sized were established according to the random block method to determine detailed ground vegetation species. 3 sample plots were established in each altitude level. When sample plots were established in the forests, no silvicultural treatments have been performed in homogenous forest stands.

The plots were established from 900 m to 1500 m elevation, with the altitude range of 100 m and 3 replicates for each altitude level. According to the method of Braun-Blanquet (1964), the plots were chosen in homogenous forest stands. In each plot, all tree, shrub, and herb species were recorded.

Species richness index was estimated as the number of species inventoried in the plot. To quantify the diversity of the plant species, the Shannon index (*H'*) as a measure of species abundance and richness was applied. This index which takes into account both species abundance and species richness is sensitive to changes in the importance of the rarest classes and is the most commonly used index (Heuserr, 1998; Kent and Coker, 1992; Rad *et al*., 2009).

For any sample it is calculated as (Kent and Coker, 1992; Kavgacı and Özalp, 2006; Rad *et al*., 2009):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where *s* equals the number of species and *i p* is the relative cover of *i*th species.

SPSS (Statistical Package for Social Science) 9.0 pack program was used for the statistical analysis of all data obtained from measurements in the sample plots. Furthermore, models were determined using the regression analyses between stand dynamics and altitude levels.

Results and Discussion

Totally 1,500 plant samples were collected and 108 species including 12 trees, 10 shrubs and 86 herbs were recorded in the

study area in different layers. In a similar research carried out in natural oriental beech (*Fagus orientalis* Lipsky.) forests in Tehran, 152 samples were established and 104 species including 12 trees, 9 shrubs and 83 herbs were recorded in the study area according to the altitude levels (Rad *et al*., 2009).

The number of species in the area decreases as the altitude increases (Figure 1).

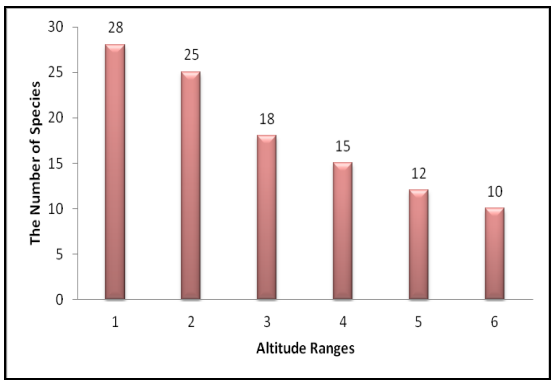

Figure 1. Distribution of the number of species according to the altitude levels

As shown in Figure 1, the highest number of species is found in the first and second altitude levels. It means that the number of species is higher at low altitudes than at high altitude. The cause of this situation can be the more difficult ecological conditions of high altitudes. However Wang et al. (2006) found similar results in terms of relations between species richness and altitude levels in the northeast region of China. On the other hand, in a research carried out by Özpay (1999) in Bolu-Ayıkaya Watershed, it was found that there is a close correlation between the altitude and the number of ground vegetation species in the natural oriental beech forests.

The mean number of woody and herbal species calculated by using Shannon index/altitude levels (mean species richness) varies between 15 and 36 in the Ardıç region (Figure 2).

According to Figure 2, there is a negative correlation between mean species richness and altitude ranges at the 96% (R^2 = -0.96) significance level. In this context the mean species richness calculated by using Shannon index decreases depending on altitude levels. In a research carried out by Brunet et al. (1997) in the south Swedish mixed oak forests it was confirmed that there is an important negative correlation between mean species richness and altitude levels. The important reasons of this situation (low number of species at high altitudes) are the extreme ecological conditions as well as human and animal activities.

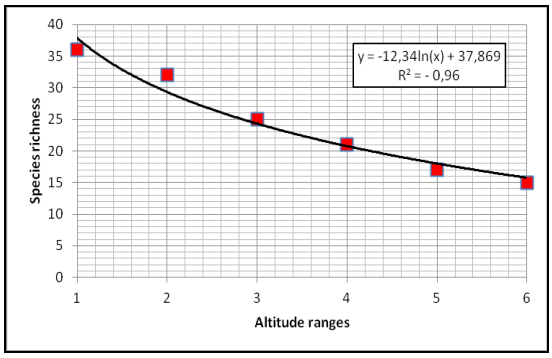

Figure 2. Mean species richness in the different altitude levels in Ardıç district

In this study area located in the Euxin region, *Fagus orientalis* Lipsky.-*Abies nordmanniana* subsp. *bornmülleriana* Mattf. association was described. Another research was carried out in the North Anatolia forests and *Fagus orientalis* Lipsky.-*Abies nordmanniana* subsp. *bornmülleriana* Mattf. association was described (Gemici and Seçmen, 1990). The distinctive species of the association are *Fagus orientalis* Lipsky., *Abies nordmanniana* subsp. *bornmülleriana* and *Rhododendron ponticum* subsp. *ponticum* L. The other species with high presence and dominance values within the association are *Phyllitis scolopendrium, Polystichum aculeatum, Dryopteris caucasica, Helleborus orientalis, Nigella arvensis var. anatolica, Actaea spicata, Caltha polypetala, Delphinium bithynicum, Ranunculus sericeus, Berberis vulgaris, Glaucium grandiflorum var. grandiflorum, Corydalis caucasica subsp. abantensis, Lepidium campestre, Thlaspi perfoliatum, Cerastium sylvaticum, Silene chlorifolia, Geranium lucidum, Oxalis acetosella, Rhamnus catharticus, Genista sessilifolia, Vicia crocea, Lathyrus laxiflorus subsp. laxiflorus, Trifolium retusum, Trigonella lunata, Amygdalus orientalis, Fragaria vesca, Cotoneaster integerrimus, Pyracantha*

coccinea, Hedera helix, Sambucus ebulus, Scabiosa argentea, Campanula latifolia, Vaccinium myrtillus, Primula vulgaris subsp. *vulgaris, Globularia orientalis, Galeopsis ladanum, Daphne pontica, Euphorbia cardiophylla, Buxus sempervirens, Galium odoratum, Arum euxinum, Ruscus hypoglossum, Colchicum triphyllum, Platanthera chlorantha.*

Conclusion

Based on this information the following suggestions for the sustainability of species richness of Uludag fir forests in the Ardıç region can be made:

- The rate of mixed forests should be protected.
- The changes of species richness depending on the ecological conditions and human activities should be monitored closely.
- The more detailed management and silvicultural plans should be prepared for the conservation of ground vegetation in the Uludag fir forests.
- Measures should be taken against fire and grazing.
- Silvicultural techniques for minimum damage to ground vegetation should be applied.
- Species of ground vegetation with indicator properties should be determined for different altitude levels.
- Transport direction and techniques for minimum damage to ground vegetation should be determined.
- Endangered species should be determined immediately and these species should be protected by using *in situ* and *ex situ* conservation techniques.

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