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Plant species diversity in the ecological species groups in the Kandelat Forest Park, Guilan, North of Iran

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ABSTRACT

Pourbabaei H, Haghgooy T. 2012. Plant species diversity in the ecological species groups in the Kandelat Forest Park, Guilan, North of Iran. Biodiversitas 13: 7-12. Forest vegetation indicates conditions and productivity potential of forest habitat, because it reflects the interaction of climate, soil and topography. The aim of this research was to study relationship between vegetation and topography factors. In order to do this research, type, number and percentage cover of trees, shrubs (sample plot with 1000 m^2 area) and type and percentage cover of herbaceous species (sample plot with 64 m^2 area) investigated and recorded. The coverage percent of species were estimated on the basis of Domin scale. Vegetation classified using Two-Way Indicator Species Analysis (TWINSPAN). The results revealed that there were 6 ecosystem units (ecological groups) in the region. The comparison of diversity indices and topographic factors between groups were performed with ANOVA test. Results also indicated that there were significant differences between groups in terms of biodiversity indices and topographic factors. The formation of a particular group is affected by a combination of environment variables. The aspect was the most important variable of topographic factors in this study.

Key words: ecological species groups, Guilan, Iran, Kandelat, plant species diversity, topography.

INTRODUCTION

World conservation strategy includes the following objectives, Protection of ecological processes and vital systems, Protection of genetic diversity, sustainable use of species and ecosystems (Sharifi and Ghafori 2008). Protection of biodiversity of forests ecosystem is a strategic for sustainable forestry and understanding the dynamics and heterogeneity of natural forest (Spies and Barnes, 1985), because, more species diversity in the region meaning is more structural complexity, therefore these ecosystems have more ability in response to changes and are more stable (Jenkins and Parker 1998). More structural complexities of ecosystems also mean creating more opportunities for specialization of different parts of biological community. Thus, more functional relations are created in community (Sharifi and Ghafori 2008). Biodiversity is composed of two components, quantitative component (i.e. abundance of species) and qualitative component (i.e. number of species). The interaction of plants with environmental factors is determining the distribution and species abundance (Hix and Pearcy 1997). In other words, the investigation of species-environment relationships is necessary to understand vegetation patterns on forest landscapes (Host and Pregitzer 1991). Bioindicators can be defined as species whose presence or abundance readily reflect some measure of the character of the habitat within which they are found (Mc Geoch and Chown 1998). Besides its prime importance as a research tool in autoecology, the quantification of species-environment relationships recently gained importance as a tool to control the distribution of species and communities, to test biogeographical hypotheses, or to set up conservation priorities (Guisan and Zimmermann 2000). The primary aim of most studies is to acquire more insights into the distribution of species along a gradient, to determine which variable affects the presence or absence of species could be improved (Austin 1990). Hence, applying the ecological species group (comprised of co-occurring species exhibiting similar environmental affinities) and indicator species in each group, through measures such as presence and absence or partial coverage of each group will help to discern species-environment relationships (Barnes et al. 1982). Also In phytosocioloical studies, the concept of ecological species groups play an important role in biological societies classification, determining changes in vegetation, vegetation distribution and environmental factors, estimating species niches, calibrating indicator value for species, modeling potential distribution of species and plant communities and to assessment habitat quality (Pourbabaei et al. 2006). Physiographic factors, landscape position, soil and vegetation considered important in separating ecological species groups of central Vermont (Smith 1995). Four communities identified in coniferous forest of Mediterranean in Greece. Elevation and land form were important in separating these communities (Bergmeier 2002). The study of plant communities of Qilianshan Mountains in China in the gradient of different heights and on the northern slope, 8 ecosystem units were identified. Diversity and species richness at middle elevations (1500-2800 m asl.) was higher. Less rainfall in the lower altitudes and low temperatures at higher altitudes were the factors that lead to decrease species diversity (Wang et al. 2002). Comparing distribution of plant ecological groups with topographical factors (i.e., slope, aspect and elevation) in the beech forest of Siyahkle revealed that there were significant relationship between aspect and plant ecological groups distribution and in some ecological groups with slope, while elevation had no remarkable influence on plant ecological groups distribution (Pourbabaei et al. 2006). Ecological groups were classified in the Afratakhteh in Iran and were investigated the relationship between species groups and plant diversity indices. The results showed that ecological groups were completely different in terms of vegetation, biodiversity indices and physiographic variables such as elevation, slope and aspect. The diversity and richness decreased with increasing elevation and slope and difficult life conditions (Esmailzadeh and Hosseini 2007). Ecological species groups in the forests of eastern Noshahr in Iran were determined and the slope percent was the most important variable among physiographic factors (Taleshi 2004). Four ecosystem units were divided in Javanrud Deh-Sorkhe of forest ecosystem, that effective separation factors expressed slope percent and soil texture (Sohrabi 2005). The objectives of this study were: (i) To determine ecological species groups and their interrelations with topographical factors. (ii) To investigate species diversity indices between species groups. Accordingly, hypothesis that: $\mathbf{H_0}$: There is no significant difference between species groups in terms of topographical factors and species diversity indices.

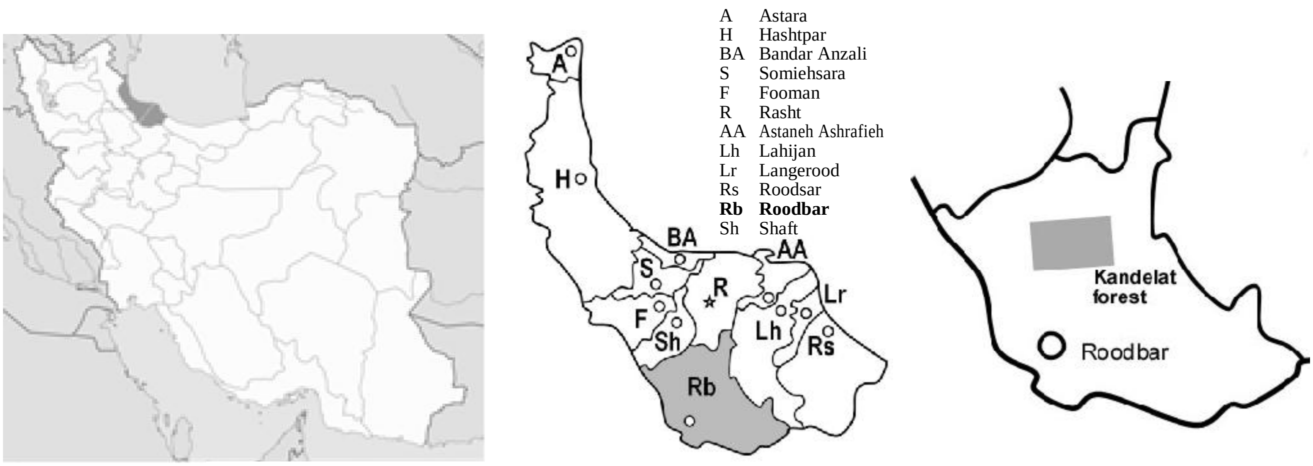
MATERIALS AND METHODS

Study area

The study area is located in the Guilan province of northern Iran (Western Hyrcanian). The entire Guilan forest covers 550133.74 ha (36^o 36' to 38^o 27' N Latitude, 48^o 31' to 50^o 30' E Longitude). This research was conducted in an area of 614.85 ha at the elevation of 100-550 meters above sea level (36^o 58' 50" to 37^o 1' 24" N Latitude, 49^o 34' 15" to 49^o 37' 30" E Longitude) in Kandelat Forest Park. Average annual precipitation is 950.2 mm and average annual temperature is 16^o C. The climate is very humid. The parent materials are mainly calcareous. Also, the forest types were known as the mixed deciduous broad-leaved forests, it contains almost forest types: *Parrotia persica-Carpinus betulus*, pure type of *Parrotia persica*, *Parrotia persica-Carpinus betulus-Buxus hyrcana*, *Parrotia persica-Quercus castaneifolia-Carpinus betulus* and *Parrotia persica-Fagus orientalis-Carpinus betulus* (Forest and Rangelands Organization of Iran 2000).

Sampling methods

For this purpose, first, status of the study area were identified and prepared topographic map (scale 1:25000). Considering the large area of the region (614.85 ha), to investigate vegetation zone, was used stratified sampling to increase the accuracy of sampling. If the studied characteristics, is much variation between individuals, community can be divided into groups that feature elements of each group is less heterogeneity and is more heterogeneity between groups, then to select samples in each group randomly. Classification of community and sampled in each class will lead to the easier implementation (Bihamta and Zare 2008). In this study, classification criteria were slope, aspect, elevation, and forest dominant types. Initially the maps were prepared by slope (in classes of 0-30%, 30%-60% and more than 60%), aspect (4 main aspects), elevation (in classes of 100-250, 250-400 and 400-550 m asl.) with the dominant types (*Parrotia persica-Carpinus betulus*, pure type of *Parrotia persica*, *Parrotia persica-Carpinus betulus-Buxus hyrcana*) in GIS. These maps intergraded by overlying method and the outcome was a composed map along with 18 homogenous units. The fact that the units were homogeneous in terms of slope, aspect, elevation and vegetation type, Regardless of units area, were taken five sampling plots (as 5 replicates) in each homogeneity unit (Momeni et al. 2006). Totally, 73 sampling plots were



Islamic Republic of Iran *Guilan Province* *Kandelat forest park*

Figure 1. Location of the study area

randomly taken (except plots which were on the road, facilities). Area of sampling plots in the tree and shrub layers were considered 1000 m^2. Size of sampling plots in the herbal layers was determined using nested plot sampling and species/area curve. In this study, regarding that the minimal area was different in different homogeneous units, hence, the largest minimal area for the entire field (64 m^2) was considered. Primarily, characteristics of each sampling plot (i.e. elevation, aspect and slope) were recorded. Then, types and numbers of trees and shrubs species and type of herbal species were identified. Also, coverage percent of species were estimated on the basis of Domin scale.

Data analysis

At first, TWINSPAN analysis was carried out in order to classify vegetation by using PC-ORD software (Me Cune 1999). The main idea of TWINSPAN analysis is based on primary phytosociology hypothesis that believes each group of samples is distinguished by a group of different species. These species are placed in bilateral table. In this method, plots are compared based on presence or absence of species and factor that called pseudo species and plots which have more similarity, are grouped into one group. Stopping point for the formation of groups was considered the third level based on experience and the highest similarity with the conditions of the study area (Mc Nab et al. 1999). Group names were considered based on indicator species in each group. The Shannon-Wiener's diversity index (Pitkanen 1998), Pielou's evenness index (Peet 1974) and Margalef's richness index was used in order to study the plant species diversity in ecological species groups (Ludwig and Reynolds 1988).

$$H' = -\sum_{i=1}^{s} P_i \log_2 P_i$$

$$J' = \frac{H'}{LogS}$$

$$R_1 = \frac{S-1}{Ln(N)}$$

H'= Shannon-Wiener's diversity index, Pi = relative frequency of in species, R1 = Margalef's richness, S = number of species, J' = Pielou's evenness, N= Total individual of species.

Considering the data were normal, to study the diversity indices and topographic factors between groups, ANOVA test was used to evaluate overall differences in the different classes. Considering the homogeneity of variance Duncan test was used for comparing means. It should be mentioned that the aspect quantities by using Cos (45-A)+1. It's value varies between zero to 2. Zero represents the driest aspect and 2 represent the wettest aspect (Beers et al. 1966).

RESULTS AND DISCUSSION

Results

The results of the TWINSPAN analysis are summarized in Fig 1. In the first level, 73 sampling plots were divided into two groups (Eigenvalue = 0.3863). Groups which are seen on the left side include: *Parrotia persica* and *Rubus hyrcanus*. The indicator woody species on the right side is *Carpinus betulus*. There isn't any indicator herbal species on the right side. In the second level, 31 sampling plots were divided into two groups (Eigenvalue = 0.3154) which indicator herbal species are *Primula heterochroma* and *Athyrium filix-femina* on the left side. There isn't any indicator woody species on the left side. Also, on the right side there isn't any indicator species. In this level, 42 sampling plots were divided into two groups (Eigenvalue = 0.3784) which indicator woody species is *Parrotia persica* on the left side and indicators woody species which are seen on the right side include: *Fagus orientalis* and *Ruscus hyrcanus*. In the third level, 21 sampling plots were divided into two groups (Eigenvalue =0.3607) which indicators species on the left side are *Inula vulgaris* and *Crataegus microphylla* and on the right side include: *Pteris cretica*. Also, there isn't any indicator woody species on the right side. In this level, 29 sampling plots were divided into two groups (Eigenvalue = 0.3156). Indicators woody species on the left side are *Quercus castaneifolia* and *Ruscus hyrcanus* and on the right side include: *Diospyros lotus*. Also, there isn't any indicator herbal species on the right side. The classification was stopped at third level of division, leaving only groups with a sufficient number of samples to characterize the vegetation communities. Thus, 73 sampling plots were classified into six groups.

Species diversity between groups

ANOVA and Duncan's tests showed that there were significant differences between groups in terms of biodiversity indices ($P<0.05$). Figure 2 shows the changes of Shannon-Wiener's diversity index between ecological groups. Maximum of Shannon-Wiener's diversity index is in group 1. While there was not any significant differences between groups of 1, 2, 4 and 6, there were statistically significant differences between other groups. The lowest value of Shannon-Wiener's diversity index is in group 3. Figure 3 shows the changes of Pielou's evenness index between ecological groups. Group 4 had the highest value of Pielou's evenness index. While there was not any significant difference between 4 and 5 groups, however there was significant difference between other groups. The lowest value of Pielou's evenness index was in group 3. Figure 4 shows the changes of Margalef's richness index between groups. The highest value of Margalef's richness was in 2 groups. Group 5 had the lowest value of Margalef's richness index. While there was not any significant differences between groups of 5, 3 and 6 and also, between groups of 1 and 4, there were statistically significant differences between other groups. ANOVA results of diversity indices between groups and mean and standard error of diversity indices were listed in Table 1.

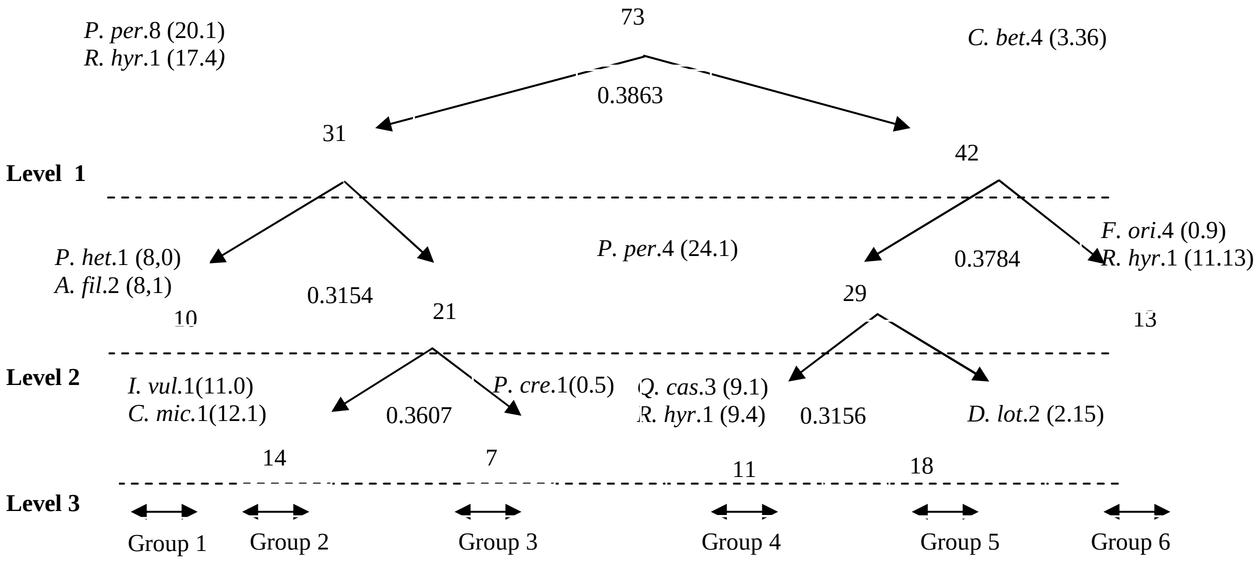


Figure 1. Classification of ecological species groups by using TWINSPAN analysis

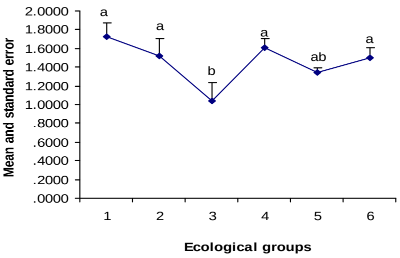


Figure 2. Changes in Shannon-Wiener's diversity index between ecological groups

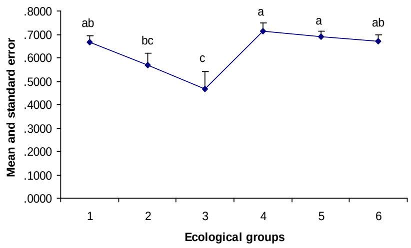


Figure 3. Changes in Pielou's evenness index between ecological groups

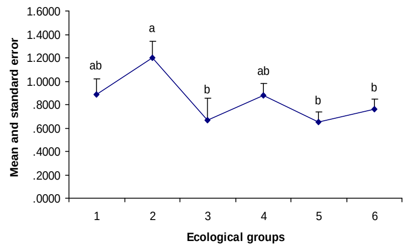


Figure 4. Changes in Margalef's richness index between ecological groups

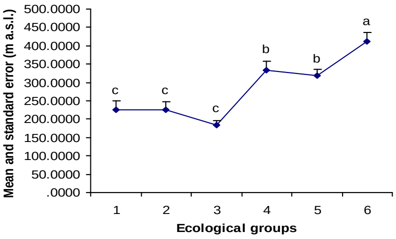


Figure 5. Changes of elevation between ecological groups

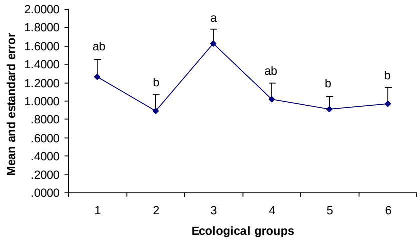


Figure 6. Changes of quantities aspect between ecological groups

Topographic factors between groups

ANOVA and Duncan's tests showed that there are significant differences between groups in terms of topographic factors. The results showed that elevation in the group 6 is significantly higher than other groups.

While there was not any significant difference between 4 and 5 groups, and also 1, 2 and 3 groups, there were statistically significant differences between other groups (Figure 5). There were not any significant differences between groups in terms of slope. Group 3 had the highest amount of quantities aspect. In other words, group 3 is located in the more humid aspects, and also had statistically significant difference with the other groups (Figure 6). ANOVA results of topographic variables between groups and mean and standard error of topographic factors were listed in Table 1.

Table 1. ANOVA results of diversity indices and topographic variables between groups and mean and standard error of diversity indices and physiographic variables in the study area

Mean and standard error	df	Mean square	P	F	Indices and variables
1.468±0.058	5	0.110	0.002*	4.261	H'
0.642±0.017	5	0.082	0.001*	4.759	J'
0.844±0.053	5	0.556	0.015*	3.079	R_1
294.2±12.36	5	81065.14	0.000*	13.624	Elevation
38.57±2.21	5	580.633	0.145^{ns}	1.708	Slope
1.07±0.083	5	1.188	0.031*	2.635	Aspect

Note: * Significant at 5 percent level; ns; no significant

Discussion

The aim of this research was to investigate diversity indices and topographic factors between ecological groups. The results of ANOVA and Duncan's tests showed that there were significant differences between groups in terms of biodiversity indices and topographic factors. Thus, null hypothesis was rejected and alternative hypothesis was accepted. The analyses done in relation to topographic factors and their relationships with ecological groups can be concluded that the aspect was the important variable among topographic factors in this study. Tsuyuzaki and Takhashi (2007) stated that topography and it's relationship with environmental factors such as light and soil moisture is the most important factor in determining the structure of plant communities and also, is a necessary condition for maintaining high diversity of rare species in degraded areas of Hokkaido in Japan. Also, the topographic factors were introduced as an important factor in distribution of alpine vegetation in the mountains of New Zealand (Mark et al. 2000).

Group 1, with indicator herbal species of *Primula heterochroma* and *Athyrium filix-femina* had the highest species diversity. In this group no indicator woody species existed. Probably, the low frequency of tree species in the lower elevations, due to proximity with the village and uncontrolled cutting of trees and thus opening the canopy, has led to increase diversity in the flora of the forest floor. Also, Kashian et al. (2003) identified species groups in forests of the Northwestern Michigan and expressed the absence of trees as indicator species in the groups located in the northern aspects (where most of the groups were present) due to the low number of tree species.

Group 2, with the indicator woody species of *Crataegus microphylla* and indicator herbal species of *Inula vulgaris* had the highest species richness between the groups. This group had the highest species richness in the least humid aspects (probably, southern or western aspects). Perhaps the reason is the higher temperature and lower cover percentage of tree species and thus increases the light in forest floor. Perring (1959) stated the aspect is the important variable among physiographic factors to determine species status in Chalk grassland. He expressed that the moisture in the southern slopes was 10 to 20 percent less than northern slopes in the region and thus species diversity was higher in less moisture.

Groups 3, with indicator herbal species of *Pteris cretica* is located in areas with high humidity and showed the lowest diversity and evenness. The high percentage of ferns presence indicates the good condition and high moisture (Atashgahi et al. 2009; Razavi 2008). In the study area, this group is located in the most humid aspects. In addition, in this group also aspect was effective than other physiographical factors. While this group is located in lower slope and elevation, and had the lowest biodiversity.

Group 4, with indicator woody species of *Quercus castaneifolia*, is representing high species diversity and favorable edaphic conditions. *Quercus castaneifolia* as indicator species of this group is seen often on calcareous, deep and rich soils. Also, it is present on calcareous of parent materials. In the study area, this ecological group is observed in the middle elevations (333.36 m asl.) and aspects of less moisture content and moderate slope (38.2 percent). Gorjy-bahri (1989), while studying of the growth demands of *Quercus castaneifolia* in Noshahr forests, expressed that distribution of *Quercus castaneifolia* follows from the nature of light and generally is present in aspects with high light (South, Southwest and West). Also, this tree species was observed at middle elevations and low to moderate slopes. Because the growth conditions in low slopes and high light is better than the ridge. Baruch (2005) was considered important effect of elevation and physiographic changes in the ecological species groups of oak forests. In addition the presence of *Ruscus hyrcanus* as indicator shrub species is representing favorable of habitat conditions. *Ruscus hyrcanus* indicates habitat that the chemical characteristics of soil (C, N, P, ph and T.N.V) are higher than other habitats (Matajy and Zahedi 2006). According to studies, high biodiversity of this group is due to it's favorable conditions of habitat.

Group 5, with indicator woody species of *Diospyros lotus* is representing area of high slope and lower moisture. The lowest species richness was observed in this group, While the evenness of the group 5, was higher of 1, 2, 3 and 6 groups and had significant differences statistically. Therefore it is concluded that evenness had more influence in increasing the diversity of group 5. Zahedi and Mohammadi (2002), while studying of species groups of Neka forest of Iran, expressed that significant differences between ecological groups and geographical aspects had existed, and group of *Diospyros lotus* often was present on the edges and ridges. *Diospyros lotus* is due to its ecological demand and wide range of tolerance of habitat conditions, in small groups with time and place order as an immature system to play an important role in achieving to mature and stable community and the rehabilitation of degradation forest ecosystems, in north of Iran.

Group 6, with indicator woody species of *Fagus orientalis* and *Ruscus hyrcanus* is representing high species diversity and was located at high elevations (411.8 m asl.), moderate slope (38.5%) and slopes with less moisture. Matajy and Babai (2006) stated this community were often observed on moderate slopes (15%-30%), the drier slopes (south-west, west and south) and elevations from 800 to 1600 m asl. studied communities in the limestone plains of north-eastern France, were located at an elevation between 300 to 400 m and moderate slopes of 25% to 30%, on the calcareous soils and hot and dry habitats (Habibi 1992). In the Khyroud Kenar of Noshahr area of Iran, *Fagus orientalis* and *Ruscus hyrcanus* were observed in different physiographic and edaphic conditions, that is indicating the effect of a series of habitat factors in establishing the plant community and the community was able to tolerate a range of changes of edaphic conditions (Matajy et al. 2007). Abella and Shelburne (2004) stated that formation of a particular group is affected by a combination of environment variables that also have interaction in creating the environmental conditions are favorable for the establishment of the groups. Kashian et al. (2003) had stressed that species groups developed on a study area should not be extrapolated for geographically because of variations in species-site relationships within a region. Pregitzer and Barnes (1982) expressed that codified and focused study on species groups of remaining in the process of succession in older forests are the involved factor in maintaining the species composition and told that regardless has been given to how the environmental relationships and species composition in ancient forests in the presence and absence of species is effective. Picard and France (2003) expressed that use of ecological groups in modeling forest dynamics is more desirable than using of specie separately.

CONCLUSION

In the study area, is also essential to implement short-term planning with regarding to general changes of ecological conditions and social-economic which are resulted of excessive use of local farmers, lopping of trees and grazing. Also, it is recommended helping to natural regeneration, restoration and enrichment of the forest ecosystem through surface scratches and seeding.

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