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The impact of single selection method logging on the tree and shrub diversity in the Hyrcanian forests

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ABSTRACT

Selective cutting (single and group selection method) is most usual forest harvesting method in the Hyrcanian forests. In order to investigate impact of single selection method on the Hyrcanian forest two logged and unlogged sites in the Kheyrud forest research station of Tehran University, Mazandaran province, were selected. In each site 30 circle sample plots (1000 m^2) by randomized-systematic method in a net of 100 m × 100 m were collected. In every sample plot the data including the species, number of trees, diameter at breast height (cm) and height (m) were recorded. Afterward, in each sample plots the micro plots of 10 m × 10 m (100 m^2) were designed to record of shrub information. Species diversity index including Shannon Wiener (H'), Simpson (1-D) and Margaleff (R1) was used to diversity analysis. To data analyzing, used was made of the Ecological Methodology software (V.7) and SPSS18 software. The results showed the numbers of 9 and 11 in the logged forest and 5 and 7 in the unlogged forest for the species richness of trees and shrubs, respectively. Fagus orientalis Lipsky and Carpinus betulus L were the most dominant tree plants and Ilex spinigera (Loes). Loes. and Rubus persicus Boiss has dominant shrub plants in this area. Tree and shrub diversity in the unlogged area has higher means diversity index and differences between tree and shrub diversity indexes in the two areas were statistically significant. Results showed that shrub layer had the higher diversity indices (richness, diversity and evenness). In total Single selection method Logging has negative effect in the tree and shrub diversity.

Key words: Hyrcanian forest, Iran, Shrub diversity, Single selection method, Tree diversity.

INTRODUCTION

Iran, a country with relatively poor forest resources, is considered among the low forest cover countries (LFCC), with the forest cover of 7.4% of the country area [Jourgholami, 2008]. Hyrcanian (Caspian) forest in northern Iran

has a richness of biological diversity, with endemic and endangered species, and a diverse range of economic and social conditions. About 45% of the Hyrcanian forests are located in mountainous areas, where forest lands are not readily accessible with ground-based logging equipment's, but cable yarding technologies are still undeveloped in this forest area [7]. These forests cover 1.8 million hectares of land area and are none commercial forests of Iran. Approximately 60 percent of these forests are used for commercial purposes and the rest of them have been degraded. The Hyrcanian forests are extended at a maximum altitude of 2800 meters from sea level and have an uneven topography and very steep slopes. They are suitable habitats for a variety of hardwood species such as beech, hornbeam, oak, maple and alder that encompass various forest types including 80 woody species. These forests are known as one of the most basic resources for wood production contributing an important role in supplying wood to the related industries. Commercial logging in the Hyrcanian forests of Iran are accomplished within the legal framework of forestry management plan and annual remove in managed areas (1.2 million hectares) producing one million m^3 per year. The current forest harvesting method in these forests is mainly selective cutting. Chainsaw and cable skidder are two main logging machines for tree felling and timber extraction in these forests. The activities of tree felling and timber extraction are potentially damage to the natural regeneration. Globally there is a long history of research regarding damage to the residual stand which shows the importance of the issue [23]. The amounts of ground based logging damage to residual stand in selection cutting are affected by several factors, such as quantities and qualities parameters and tree and shrub diversity [21]. From the early 21^{th} century, the increasing use of mechanized wood harvesting brought with the problem of damage to the remaining trees in forest stands [25]. Not all tree species are equally susceptible to mechanical injury. Damage to the residual stand in forest operations is most often caused during transport of timber [24, 12 and 14]. Trees are wounded by machines and logs under extraction [21]. Single selection method which is one of the close to nature silviculture methods, aims to achieve an uneven-aged and mixed forest. Tree marking in this method needs to precise statistical data about tree distribution in diameter classes [17]. The studied changes in tree species diversity after successive clearcuts in the southern Appalachians and concluded that *Liriodendron tulipifera* increased substantially from 1977 to 1991. Diversity trends were due to changes in evenness rather than changes in species richness [13]. The study reported the damage level of 15% to seedlings in a single tree selection cutting operation in the northern Belize. There are several studies that focused on the ground based logging damages on the residual stand following selection cutting in the Hyrcanian forests [27]. The researchers compared damages to natural regeneration by two logging system, skidding operation and cable operation, in the Hyrcanian forests of Iran. Their results showed that approximately 11% of regeneration was damaged by the skidding operation, of which8.7% and 2.3% were wounded/bark removed, and broken/ uprooted, respectively, while approximately 5% of regeneration was damaged by the cable operation, of which (4% and 1% were wounded wounded/bark removed, and broken/ uprooted, respectively [4]. Study the effect of shelterwood silviculture method on the plant species diversity of beech (*Fagus orientalis* Lipsky.) forests in the Hyrcanian region. Their results showed that species richness of trees, shrub and herbaceous obtained the numbers of 7, 8, and 28 in the logged forest, and 6, 4, and 18 in the unlogged forest, respectively. Compared to logged forest diversity value in the tree layer was higher in the unlogged forest. Moreover, the evenness values in all vegetation layers were higher in the logged forest than the unlogged forest [22]. The researchers reported that 3.2% of the natural regeneration was damaged by felling operation and 4.8% was damaged by skidding operation in a selective logged parcel in the northern forests of Iran [15]. The researchers reported that 23% of stand regeneration were damaged by tree felling operation that the amount of damage to seedling was less than the small sapling and the thicket as well [16]. The investigated shrub and tree species diversity and its application in the forest planning of the Hyrcanian forest. Their results showed that the number of species and Margaleff indices were significantly greater in the unlogged area than the logged one. The eveness indices (Simpson and Smith & Wilson) were significantly greater in the unlogged area as well. Moreover, all of the heterogeneity indices were significantly higher in the unlogged area [19]. Logging has significant impacts on the forest structure and functions with consequences for many species besides those targeted for extraction [10]. Once an area has been logged, natural regeneration is allowed to take place, often with the intention of re-harvesting the area at 20–40-year intervals [9]. The aim of this study is to survey impact of single selection method logging on the tree and shrub diversity in the Kheyrud forest research station of Tehran University (Hyrcanian forest), Mazandaran province, northern Iran.

MATERIALS AND METHODS

Study site description

Iranian habitats support about 8000 species of flowering plants (belonging to 167 families and 1200 genera), of which almost 1700 are endemic [2]. This plant species growing on four ecological zones (Figure 1).The study was

carried out in the Kheyrud forest research station of Tehran University, located approximately 7 km east of Nowshahr, Mazandaran province, northern Iran (Figure 2).

Figure 1. Distribution of Hyrcanian zone in the four ecological zones of Iran

The research was carried out in parcel 104 (unlogged area) and parcel 110 (logged area with single selection method) in the Patom forest management unit of the Forest research station of Tehran university. Elevation ranges between 250 and 350 meters above the sea level and lies on a northern aspect. Rainfall ranges from 1420 to 1530 mm/year, with the heaviest precipitation in the summer and fall. Temperatures are moderate, ranging from a few below 0°C in December, January, and February to +25°C during the summer [6].

Field measurements

In this study in each site 30 circle sample plot (1000 m^2) by randomized-systematic method in a net of 100 m × 100 m were collected. In every sample plot the kind of species, number of trees, diameter at breast height (cm) and height (m) were recorded. In the sample plots the micro plots of 10 m×10 m (i.e. area of 100 m^2) were designed and shrub information was recorded then. Species diversity indexes including Shannon Wiener (H′), Simpson (1-D), and Margaleff (R_1) were used to evaluate plant diversity in each sampling plot. The means of different between diversity indexes of the two areas were calculated by t-test. To analysis data, used was made of the Past, Ecological Methodology software (V.7) and SPSS18 software.

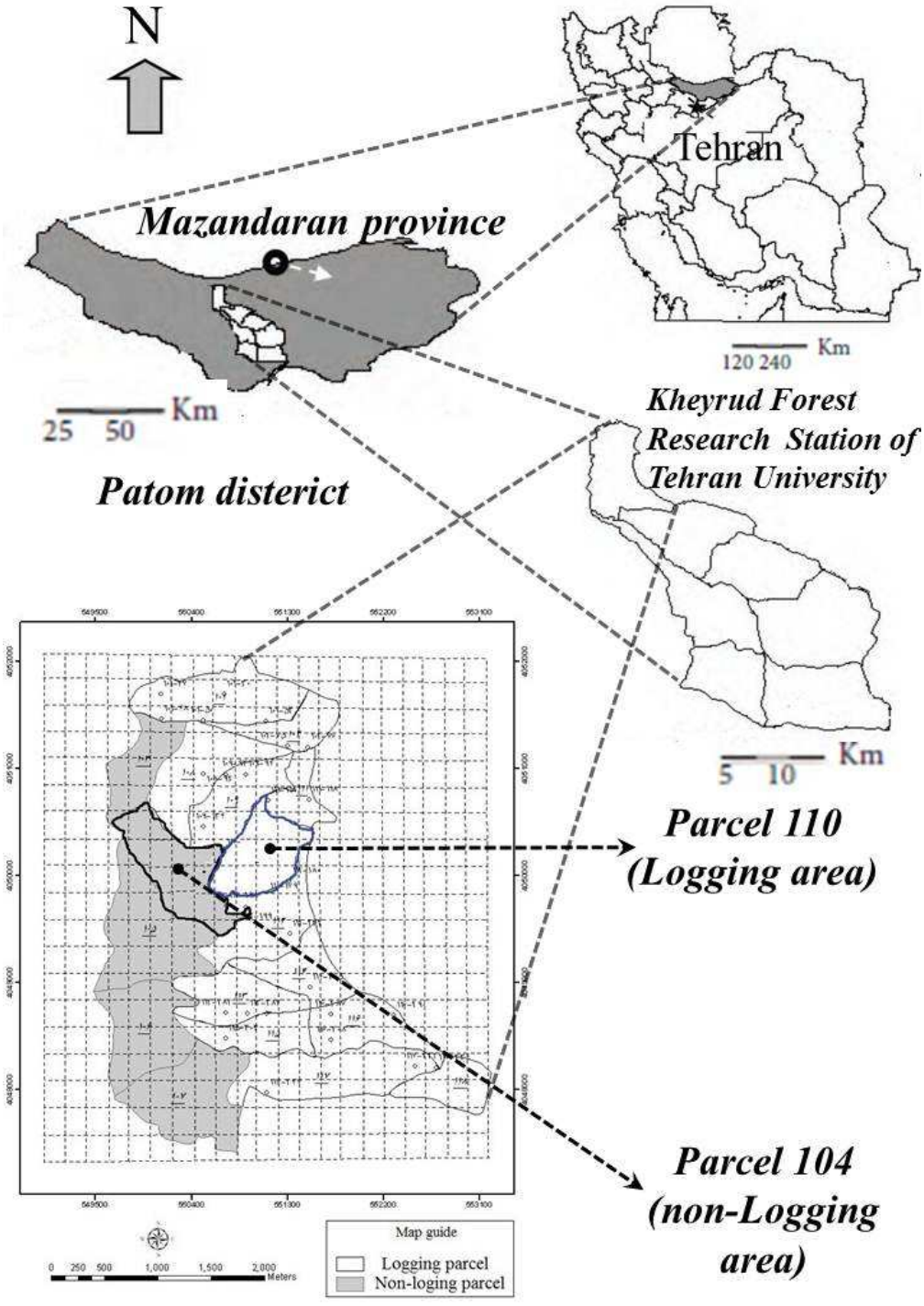


Figure 2. Study site location with in the forest research station of Tehran University

Table 1: Biodiversity indices used in this study.

Indices	References	Equation*
Shannon's (H')	Peet, 1974 [20]	$H' = \sum_{i=1}^{S} pi \ln(pi)$
Simpson (1-D)	Peet, 1974 [20]	$1 - D = (\sum (pi)^2$
Margaleff (R_1)	Ejtehadi, 2009 [1]	$M = \frac{S-1}{Ln\ (N)}$

**S and pi refer to total number of species in the sample and proportion of individuals in the species, respectively.*

RESULTS AND DISCUSSION

Species biodiversity is used greatly in vegetation studies, and environmental evaluation is one of the main criteria to determine ecosystems condition [18]. Forest diversity is the important feature in management of forest ecosystems [29]. The study of forest stand profile especially in virgin forests is very important and gives us comprehensive information about structure of these forests [17]. Selective logging is a major economic activity in much of the moist tropics and increasing areas of forest are being allocated to timber concessions [28].The plant species that identified in the studied region belonged to 23 trees and shrub species and 16 families (Table 1). Rosacae family had high number of species. *Fagus orientalis* Lipsky and *Carpinus betulus* L. were the most dominant woody plants for the class of tree. *Ilex spinigera* (Loes). Moreover, Loes and *Rubus persicus* Boiss.were dominant shrub species.

Table 2. List of plant species (Tree and Shrub) in the studied areas

Ser. no	Scientific name	Family name	Tree/Shrub	logging	Non-logging
1	*Fagus orientalis* Lipsky	Fagacea	Tree	×	×
2	*Carpinus betulus* L.	Corylaceae	Tree	×	×
3	*Alnus glutinosa* L	Betulaceae	Tree	×	×
4	*Acer velutinum* Boiss.	Aceraceae	Tree		×
5	*Castanea sativa* Hill.	Fagacea	Tree		×
6	*Parrotia persica* (DC.) C. A. may.	Hamamelidaceae	Tree	×	×
7	*Fraxinus excelsior* L.	Oleaceae	Tree		×
8	*Acer cappadocicum Gled.*	Betulaceae	Tree		×
9	*Diospyros lotus* L.	Ebenaceae	Tree	×	×
10	*Buxus hyrcana* Pojark.	Buxaceae	Shrub	×	×
11	*Ficus carica* L. (var. genuine)	Moraceae	Shrub	×	×
12	*Hypericum anderocemum*	Hypericaceae	Shrub		×
13	*Ruscus hyrcanus* Juz.	Asparaginaceae	Shrub	×	×
14	*Cerasus avium* (L.) Moench	Rosaceae	Shrub		×
15	*Crataegus ambigua* Becker	Rosaceae	Shrub	×	
16	*Crataegus microphylla* (Willd) Jacq.	Rosaceae	Shrub		×
17	*Mespilus germanica* L.	Rosaceae	Shrub	×	×
18	*Ilex spinigera* (Loes). Loes.	Aquifoliaceae	Shrub	×	
19	*Pyrus communis* L.	Rosaceae	Shrub		×
20	*Prunus divaricate* Ledeb.	Rosaceae	Shrub		×
21	*Rubus persicus* Boiss.	Rosaceae	Shrub	×	×
22	*Rubus caesius* L.	Rosaceae	Shrub	×	
23	*Smilax exelsa* L.	Liliaceae	Shrub		×

Results showed that richness of the species and were obtained numbers of 9 and 11 for trees, and 5 and7 for shrubs in the logged and unlogged forest, respectively.

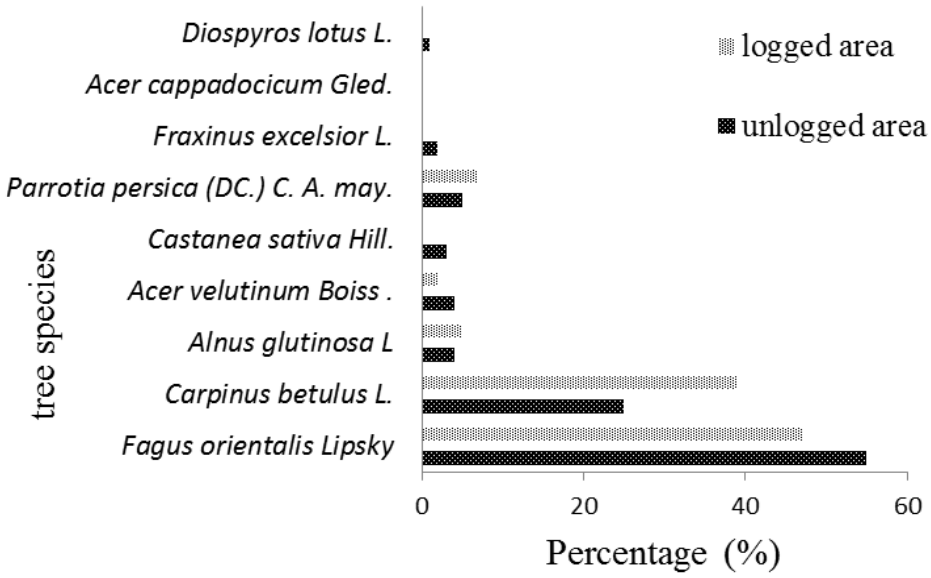


Figure 3. Comparison of tree species percentage in the logged and unlogged area.

Results of figure 3 showed 9 and 5 tree species in the non-logging and logging area, respectively. *Fagus orientalis Lipsky* and *Carpinus betulus* L were the most dominant tree plants in this area as well. Diameter dispersion is the important parameter in the logged and unlogged area.

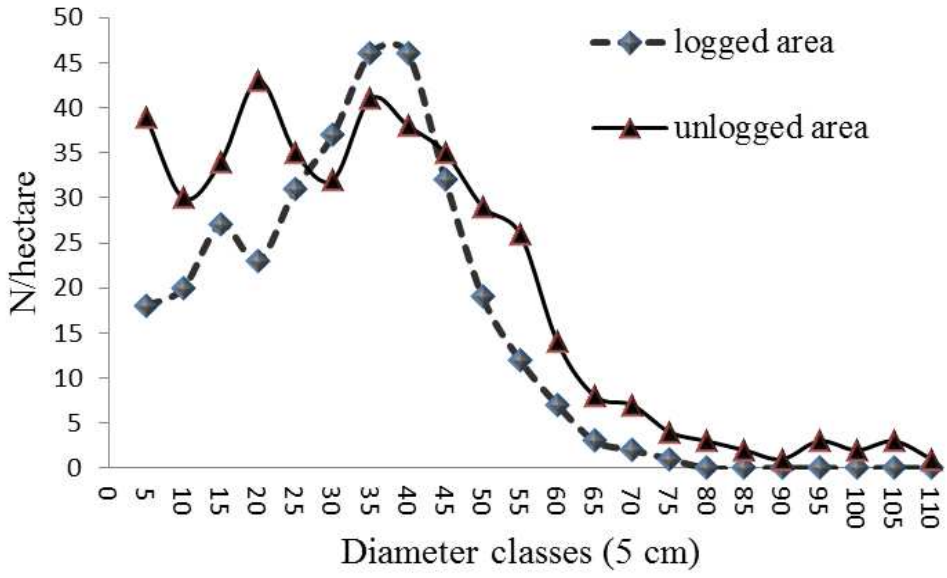


Figure 4. Diameter distribution of trees on the diameter classes in the logged and unlogged area.

Diameters of trees of the two areas were measured at breast height and recorded in 5 cm classes. We measured trees ranging from 5 to 75 cm in the logging area and 5 to 110 cm DBH (Diameter Breath Height) in the non-logging area.

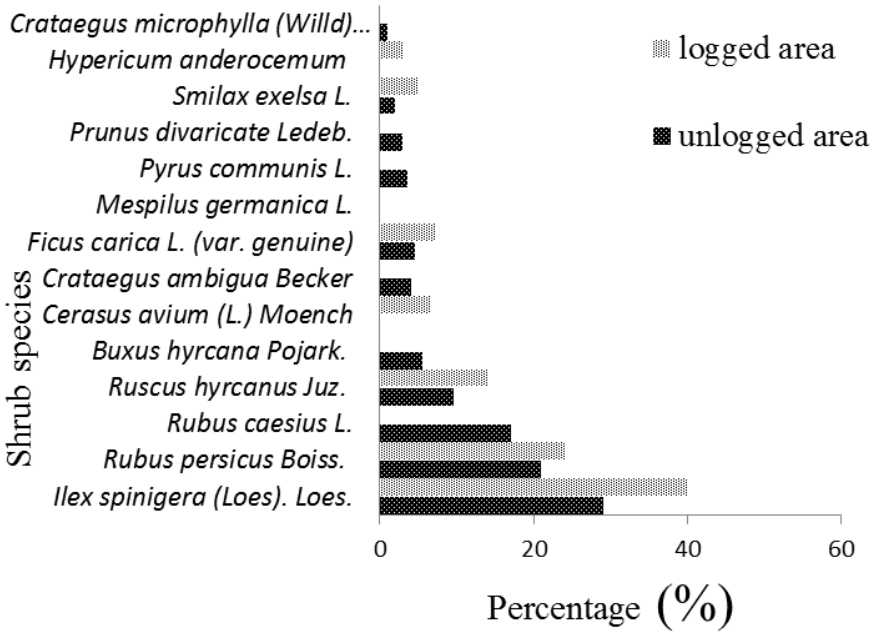
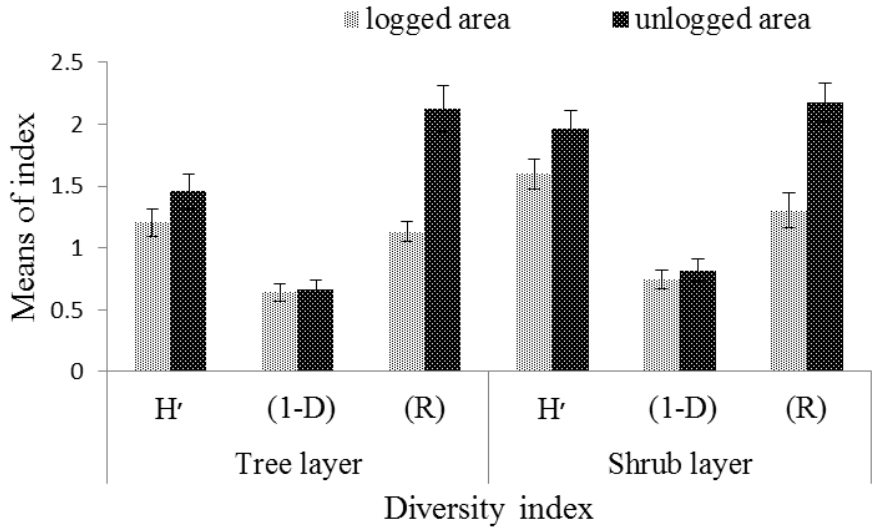


Figure 5. Comparison of shrub species percentage in the logged and unlogged area.

Results of figure 4 showed 11 and 7 in the non-logging area and logging area, respectively. *Ilex spinigera* (Loes). Loes. And *Rubus persicus* Boiss. Were the most dominant shrub plants in this area as well.



H′ (Shannon), 1-D (Simpson) and R (Margaleff)

Figure 6. The comparison of diversity indices in tree and shrub layers.

The results of Figure 6 showed that the computed tree species diversity index is as follows: mean Shannon index: 1.45 and 1.2, Simpson index: 0.66 and 0.64, and Margaleff index: 2.12 and 1.13. Shrub species diversity index is as follows: mean Shannon index: 1.96 and 1.6, Simpson index: 0.82 and 0.74, Margaleff index: 1.17 and 1.64 in unlogged and logged area.

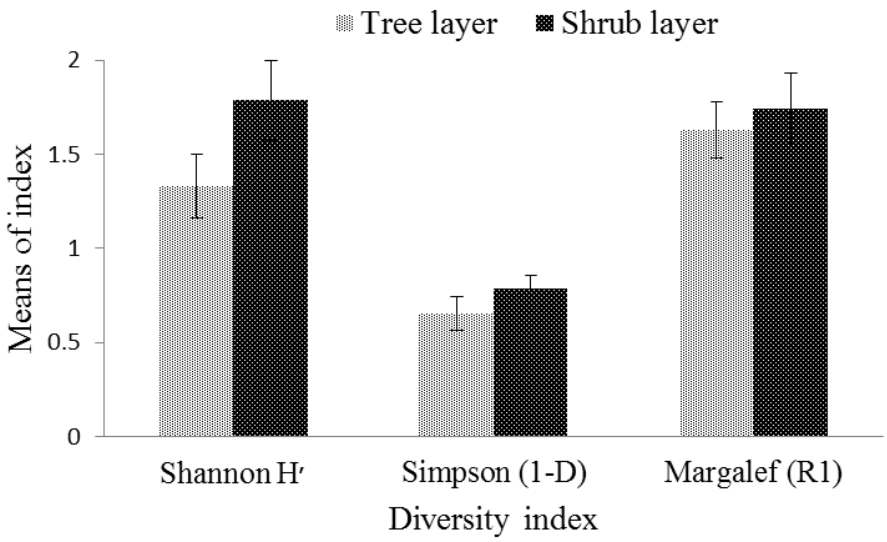


Figure 7. The comparison of diversity indices in tree and shrub layer.

Results of figure 7 showed that the Shannon index has maximum quantity

Table 3. The results of t-test to analysis to compered the means biodiversity index in two areas.

Vegetation layers	Diversity index	df	F	Sig.
Tree layer	Shannon's (H′)	59	6606.56	0.000
	Simpson (1-D)	59	426.43	0.039
	Margaleff (R_1)	59	6324.12	0.000
Shrub Layer	Shannon's (H′)	59	2671.54	0.000
	Simpson (1-D)	59	301.54	0.012
	Margaleff (R_1)	59	6423.22	0.000

There was significant difference between tree and shrub diversity indexes of the two areas.

The plant species that identified in the studied region belonged to 23 trees and shrub species and 16 families. The presence of 23 tree and shrub species in 60 ha area indicates considerable plant diversity in the study area (table 2). Rosacae family had high number of species. Rosacae family had high number of species (table 2). *Fagus orientalis* Lipsky and *Carpinus betulus* L. were the most dominant woody plants for the class of tree. Moreover, *Ilex spinigera* (Loes). Loes and *Rubus persicus* Boiss were dominant shrub species (table 2, figure 3 and figure 5)DBH of the trees ranked from 5 to 75 cm in the logging area and 5 to 110 cm in the non-logging area, because logging operation has negative effect on the bigger trees by harvesting of these trees. Results showed a negative impact of logging on the numbers (N/hectare) but in the unlogged area have higher number of tree (N/hectare) and in lowest diameter class (5 - 25 cm) have more number of trees in the diameter classes (Figure 3). Results showed that richness of the species and were obtained numbers of 9 and 11 for trees, and 5 and7 for shrubs in the logged and unlogged forest, respectively. (Table 1). The results of Figure 6 showed that the computed tree species diversity index is as follows: mean Shannon index: 1.45 and 1.2, Simpson index: 0.66 and 0.64, and Margaleff index: 2.12 and 1.13. Shrub species diversity index is as follows: mean Shannon index: 1.96 and 1.6, Simpson index: 0.82 and 0.74, Margaleff index: 1.17 and 1.64 and herbaceous species diversity index is as follows: mean species Shannon index: 2.26and 1.35 in unlogged and logged area. The comparison of tree and shrub diversity in the unlogged area has higher diversity index and logging have negative effect in the tree and shrub diversity (figure 6). There was significant difference between tree and shrub diversity indexes of the two areas. Our results showed that shrub layer has the higher diversity indices (i.e. richness, diversity, and evenness) (figure 7). Because single selection method in Hyrcanian forest has negative effect on the tree diversity but this method compared with other logging method (i.e. clear cut, shelterwood, and group selection method) has a lower negative effect on the tree diversity. In several studies negative effect of logging and forest harvesting on the regeneration and plant diversity have been shown (Whitman *et al*, 1997 [27], Hosseini *et al*, 2000 [4], Lotfalian *et al*, 2008 [14], Majnounian *et al*, 2009 [15], and Nouri *et al*, 2010 [19]). In our study logging have negative effect on the tree and shrub diversity.

CONCLUSION

Selective logging occurs at different intensities (number of trees removed per hectare) and with different felling regimes, according to the objectives of the forest managers [5]. The single selection method logging has forest destruction in the minute scale and suggested the suitable method for harvesting and biodiversity conservation [8]. In this study single selection method has negative effect on the tree and shrub species diversity but compared with other logging method has a minimum of diversity destruction.

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