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Study on Structure and Plant Species Diversity in the Box Tree (*Buxus hyrcana* Pojark) Sites, East of Guilan, Iran

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ABSTRACT

The box tree is an evergreen species, valuable in view of biodiversity, conservation and also as a threatened species in the northern forests of Iran. Therefore, it is very crucial to characterize structure and plant species diversity to more effective conservation of this species. The study was carried out in the Anjilbon and Radarposhteh sites, eastern Guilan. The tree, tree regeneration and herbaceous species were sampled using random-systematic method. Litter depth was also measured in each site. To study structure, number of box trees per hectare and their height curves were plotted. The average diameter at breast height, the mean number and basal area per hectare of box tree were obtained. Plant species diversity in three layers was calculated using diversity indices and evenness was obtained using Smith and Wilson's index. Results revealed that the mean number of box tree per hectare and litter depth in the Anjilbon were higher than the Radarposhteh site, while the mean diameter, height and basal area per hectare in the Anjilbon were lower than the Radarposhteh site. Mean diversity and evenness of tree species in the Anjilbon were higher than the Radarposhteh site, whereas tree richness in the Radarposhteh was higher than the Anjilbon site. Also, the mean diversity, evenness and richness of tree regeneration in the Anjilbon were higher than the Radarposhteh site. The mean diversity and richness of herbaceous layer in the Anjilbon were lower than the Radarposhteh, whereas the average evenness in the Anjilbon was higher than the Radarposhteh.

Key Words: *Buxus hyrcana*, Structure, Diversity indices, Litter, Eastern Guilan.

INTRODUCTION

The box tree is an evergreen hardwood species of northern forests of Iran, and only this species appears in the form of tree while all the other evergreen species occure in the form of shrubs. Botanically, this species belongs to the family of Buxaceae, it has simple leaf with opposite arrangement. Males and females flowers are separate but in the same cluster, in the leaf axils in early spring, fruit is a small, woody, green capsule, to 8 mm long (Coombes 1994). Ecologically, box tree is a slow-growing species, shade tolerant.The longevity reachs 600 to 700 years. This species propagates readily by seed. Box tree grows on various soils preferably calcareous soil. Altitudinal distribution of this species ranges from –20 to 1200 m a.s.l., but optimal altitudinal class is from –20 to 400 m a.s.l., hence diameter increment is reduced in higher altitudes, the height increment shows no variation. This species tolerates –20 ^{o}C temperature. Box tree wood over 5 to 7 cm dbh (diameter at breast height) is considered merchantable (Roostami 1988).

Sites of box tree are mostly located in lowland sites, that is why the species is under anthropogenic interference. In the past, the Querco-Buxetum community has been real community in lowland sites, but nowadays these sites have mostly been converted to *Carpinus-Buxus* or *Parrotia-Buxus* types and distributed as irregular patches in the throughout northern forests. However, various box tree communities have been reported until now as follows: Querco-Buxetum, Scolopendrio-Buxetum, Smilaci-Buxetum, Fageto-Buxetum and Celtiseto-Buxetum (Zare et al. 1998).

Considering that this species is threatened due to degradation of their sites, therefore it is regarded protected species by Forests and Rangelands Organization in Iran. Study on plant species diversity is crucial to biological conservation and maintaining genetic

reserves. Several studies have been carried out on structure, floristic composition and species diversity in the forest ecosystems (Hale et al. 1999, Pabst and Spies 1999, Swamy et al. 2000, Chiarucci et al. 2001, Nebel et al. 2001a, Nebel et al. 2001b, Neumann and Starlinger 2001, Huang et al. 2003, Coroi et al. 2004, Jobidon et al. 2004). The assessment of structure and plant species diversity is now being used in many monitoring programs (Chiarucci et al. 2001). In the Guilan Province forests (north of Iran) only one study has been conducted on woody plants diversity in the box tree site (Pourbabaei 1999).

The aims of this study were to: (i) attending a checklist of plant species, (ii) to analyze structure and plant species diversity in these two sites of box tree and their comparisons, the latter objective is one of the basic features of plant communities which has been found to change in relation to disturbance and forest decline.

STUDY SITES

The study sites are located in the Anjilbon (watershed No.22, 36° 57' 15" to 37° 1' 40" N latitude, 49° 37' 30" to 49° 39' 00" E longitude) and Radarposhteh (watershed No.24, 37° 5' 50" to 37° 7' 30" N latitude, 49° 42' 15" to 49° 45' 30" E longitude) areas, eastern Guilan Province-Iran (Figure 1). The first site belongs to parcel No.36, with 11.81 ha area of box tree forest, elevation ranges from 100 to 350 m a.s.l (on average of 200 m a.s.l) and slope varies from 59 to 120 %. The second site belongs to parcel No.11, with 23.43 ha area of box tree forest, elevation ranges from 80 to 170 m a.s.l (on average of 120 m a.s.l) and slope varies from 0 to 60 %. The main aspect is northwestern in both sites. Climatically, mean annual precipitation and temperature are 940 mm and 17.5°C respectively in both sites. Edaphically, soil texture is loamy, soil type is leaching brown forest with acidic brown forest in some parts.The humus type is mul in both sites (Forests and Ranglands Organization 1991, 1997).

Figure 1. Study area in the east of Guilan, north of Iran.

MATERIALS AND METHODS

Field Sampling

Field sampling was carried out using systematic-random procedure. The number of sampling plots was obtained using following formula (Avery and Burkhart 1994):

$$n = \frac{t^2.(Sx\%)^2}{(E\%)^2}$$

where n is the number of plots, t is t-student which is assumed 1.96 if p-value is 5 %, S_x is standard deviation which its value replaced using data of similar forest (here 24) and E is percentage of error (considered 8 this study). Regarding this information, the number of sampling plots was obtained 36. Therefore, 36 plots were sampled in each site. Tree species were sampled in 10 m x 10 m plots.The tree layer including all tree species stems 2 cm dbh 1.3 m dbh and height 1.3 m in a plot were identified and diameters and height of all box trees were recorded. To study tree regeneration (dbh < 2 cm and height < 1.3 m), a 1m 1 m subplot was placed within the larger plot and individual of regeneration were counted. To quantify ground flora, nested plot sampling was performed within larger plot and plot area of 2 m x 4 m was obtained using species / area curve (Mueller and Ellenberg 1989). Due to less cover of herbaceous species, species individuals were counted and identified in the field where possible and unknown species were collected and identified in the herbarium. In the large plot, 3 to 5 points were randomly determined and depths of litters were recorded in the basis of mm.

Data Analysis

Stand structure

In order to study stand structure, curves of number per hectare and height of trees were plotted and the mean number, diameter and basal area of trees were calculated at each site. Further, Species Importance Value (SIV) was calculated according to the formula of Curtis and McIntosh (1950, 1951) at each site:

SIV= Relative frequency + Relative density + Relative dominance

where, Relative frequency is percent proportion of samples containing a species in all samples; Relative density is the percent proportion of number of individuals of a species in the total of all individuals in the sample; and Relative dominance is the percent proportion of total basal area of a species in the total basal area of all species in the sample.

Also, Jaccard's Index (Sj) was used to quantify similarity between two sites as follows (Ludwig and Reynolds 1988):

Sj = a / (a+b+c)

where, a is the number of common species; b is the number of species at one site, and c the number of species at the other site

Plant Species Diversity

Diversity was analysed separately for three layers (i.e., tree, tree regeneration and herbaceous). Tree species diversity was calculated by converting their dbh values to basal area (m^2) and substituting it for number of individuals in the calculations, and basal area of each tree species was summed in each plot. In addition, the number of individuals for tree regeneration and herbaceous layers were considered as abundance in calculations.

The Simpson's and Shannon- Wiener's diversity indices, Hill's N_2 and McArthur's N_1 were separately calculated for tree, tree regeneration and herbaceous layers. These formulae are as follows:

$$1 - D = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$$

where 1-*D* is Simpson's diversity index, S is the total number of species, n_i is the number of individuals in the *i*th species and N is the total number of individuals.

$$N_2 = \frac{1}{D} = \frac{1}{\sum_{i=1}^{s} P_i^2}$$

where Hill's N_2 shows a number of very abundant species and p_i is the proportion of individuals in the *i*th species (i.e., n_i/N).

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

where H' is Shannon-Wiener's diversity index.

$$N_1 = 2^{H'}$$

McArthur's N_1 indicates the effective number of abundant species and is recommended using N_1 rather than H' because the units (number of species) are more clearly understandable to ecologist (Ludwig and Reynolds 1988).

Since diversity is composed of two components: richness and evenness, in this investigation we used the number of species (S) as richness. Evenness which indicates how individuals are distributed between species. In this study, Smith and Wilson's evenness index was used as follows (Krebs 1999):

$$E_{var} = 1 - \left[\frac{2}{\pi \arctan\left\{ \sum_{i=1}^{s} (\log_e(n_i) - \sum_{j=1}^{s} \log_e(n_j)/S)^2 / S \right\}} \right]$$

where the arctangent is measured as an angle in radians, and E_{Var} is Smith and Wilson's index of evenness, n_i is number of individuals in species in sample, n_j is number of individuals in species j in sample and s is number of species in entire sample. This is the best available index of evenness, according to Smith and Wilson (1996) because it is independent of species richness and is sensitive to both rare and common species in the community. All diversity calculations were conducted using Ecological Methodology Software (Krebs 1999).

RESULTS

A) Anjilbon site

Stand Structure

The distribution of tree number per hectare and height of box tree by diameter at breast height are shown in Figures 2 and 3, respectively. The SIV of all tree, shrub and herbaceous species are indicated in the Figures 4 and 5, respectively. The mean number of box trees (dbh >2 cm) per hectare was 3366.7± 172.7 (Standard error), mean number of box tree regenerations (dbh <2 cm) per hectare was 210833.33± 22265.98, and mean number of other tree species per hectare was 51.24± 16.54. The mean basal area of box trees (m^2 ha^{-1}) was 0.329± 0.001 and mean basal area of other tree species was 0.081± 0.020. The mean diameter of box trees was 5.43± 0.216 cm and mean height of box trees was 3.645± 0.246 m. In this site, the mean litter depth was 1.883± 0.159.

Floristic Characteristics

The two sampling plots maintained only box tree species. Total number of tree species and other species (herb, shrub, liana and semi-parasite) were 10 and 17, respectively. Type of tree species as follows: *Albizia julibrissin* (Willd.) Benth., *Alnus subcordata* C.A.Mey., *Buxus hyrcana* Pojark., *Carpinus betulus* L., *Diospyros lotus* L., *Ficus carica* L. var. *genuine* Boiss., *Gleditsia caspica* Desf., *Parrotia persica* (DC.) C.A.Mey., *Pterocarya fraxinifolia* (Lam.) Spach., *Ulmus glabra* Huds. Other species included herbaceous such as *Dryopteris filix-mas* (L.) Schott., *Euphorbia helioscopia* L., *Fragaria vesca* L., *Mentha sylvestris* L., *Oplismenus undolatifolius* Beauv., *Phyllitis scolopendrium* L., *Polygonum persicaria* L., *Pteridium aquilinum* (L.) Kuhn., *Pteris cretica* L., *Rubus fruticosus* L., *Sambucus nigra* L., *Urtica dioica* L., *Viola odorata* L. and shrub species such as *Ilex aquifolium* L., *Ruscus hyrcanus* Juz., *Hedera pastuchowii* L. (liana) and *Viscum album* L. (semi-parasite). In tree regeneration layer, 12 subplots maintained only box tree species and in this layer 10 woody species were similar to species of tree layer with difference that *Acer insigne* L. appeared in this layer, but *Ulnus glabra* did dot appear.

The mean richness of tree, tree regeneration and other species per sampling unit were 3.029± 0.149, 2.917± 0.158 and 3.656± 0.177, respectively.

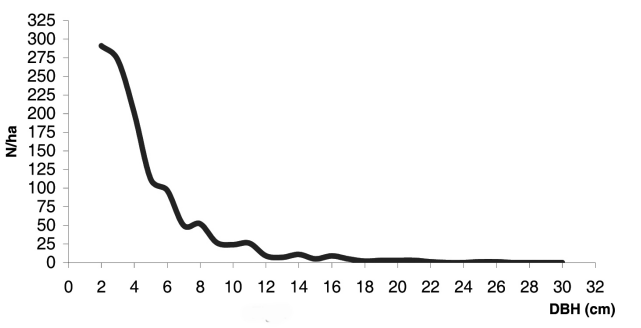

Figure 2. Distribution of number of box trees per hectare by diameter in the Anjilbon site.

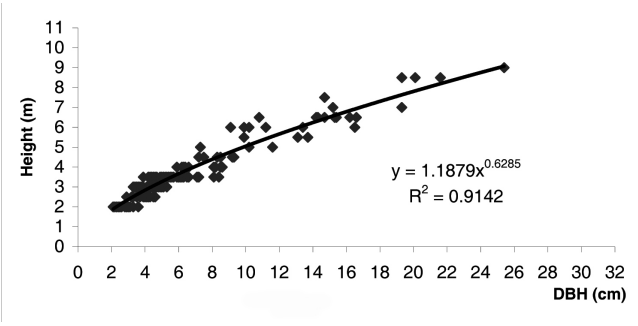

Figure 3. Height curve of box tree by diameter at the Anjilbon site.

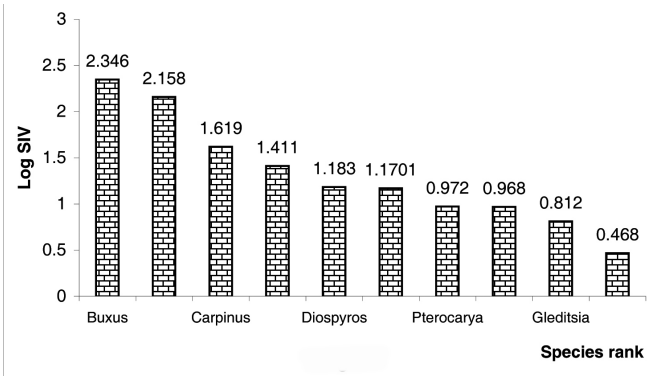

Figure 4. SIV of tree layer in the Anjilbon site.

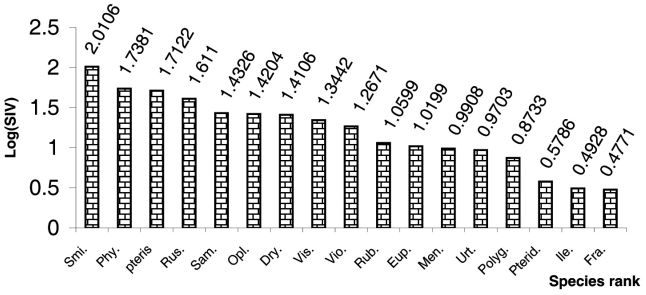

Figure 5. SIV of herbaceous layer in the Anjilbon site.

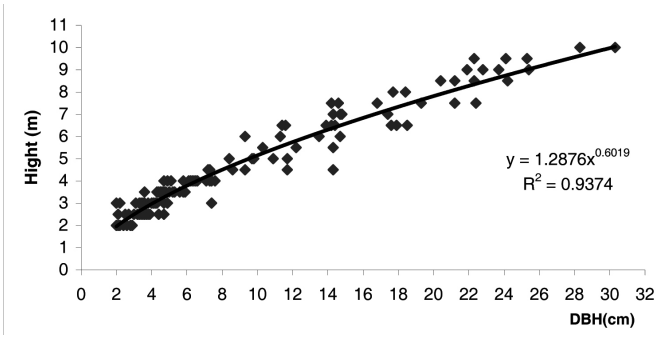

Figure 6. Distribution of number of box trees per hectare by diameter at the Radarposhteh site.

B) Radarposhteh Site

Stand Structure

The curves of tree number per hectare and height of box tree by diameter at breast height are shown in Figures 6 and 7, respectively. The SIV of all tree, shrub and herbaceous species are indicated in Figures 8 and 9, respectively. The mean number of box trees (dbh >2 cm) was 2186.1± 91.99 per hectare and mean number of box tree regenerations (dbh <2 cm) was 360555.6± 54318.2 per ha and mean number of other tree species per hectare was 43.75± 10.0. The mean basal area of box trees was 0.9 ± 0.003 m^2 ha^{-1} and mean basal area of other tree species was 0.085± 0.02 m^2 ha^{-1}. The mean diameter of box trees was 8.2± 0.53 cm and mean height of box trees was 8.75± 0.35 m. In this site, mean litter depth was 1.72± 0.10 cm.

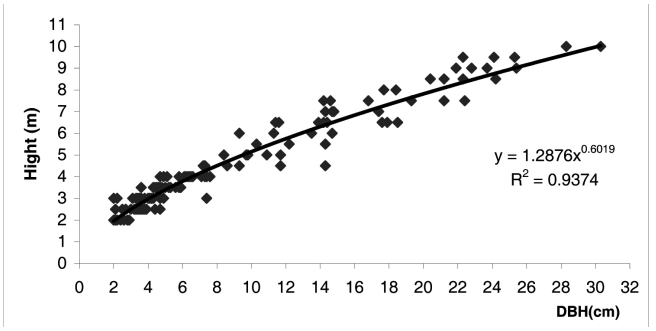

Figure 7. Height curve of box tree by diameter in the Radarposhteh site.

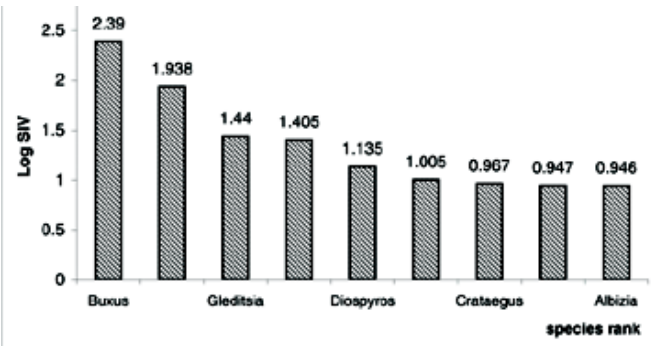

Figure 8. SIV of tree layer in the Radarposhteh site.

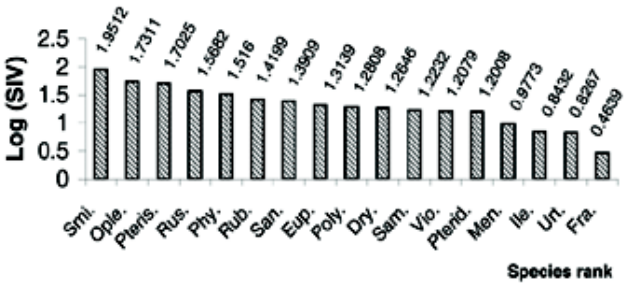

Figure 9. SIV of herbaceous layer in the Radarposhteh site.

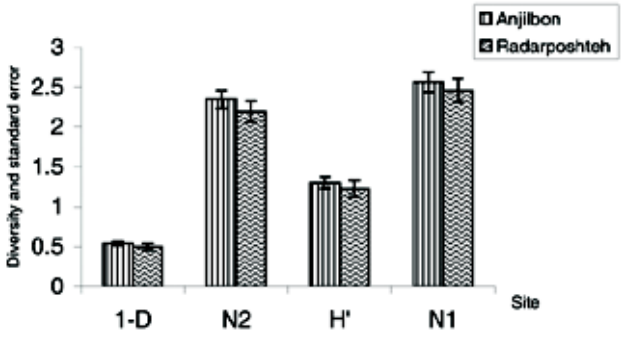

Figure 10. Diversity indices and their standard errors in tree layer in the studied sites.

Floristic Characteristics

The 14 sampling plots maintained only box tree species. Total number of tree species and other species (herbaceous, shrub, liana and semi-parasite) were 9 and 17, respectively. Tree species were similar to Anjilbon site with exception that *Ulmus glabra* and *Ficus carica* var.*genuine* were not observe, but *Crataegus microphylla* C.Koch was present in this site. In addition, other species were similar to Anjilbon site with exception that *Viscum album* was not observed, but *Sanicula europaea* was present in this site.

The mean richness of tree species, tree regeneration and other species per sampling unit were 3.227± 0.173, 2.552± 0.127 and 3.788± 0.167, respectively.

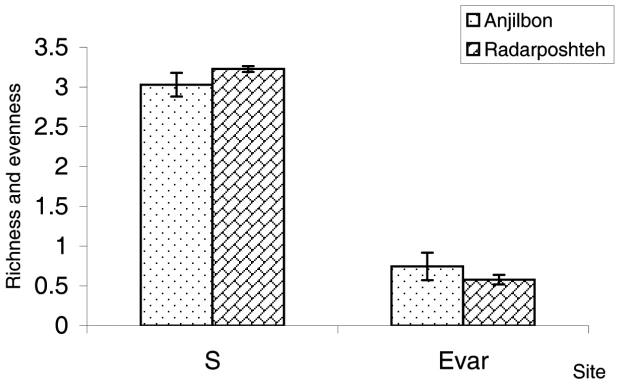

Figure 11. Richness and evenness and their standard errors in tree layer in the studied sites.

C) Comparison of two sites in view of diversity, richness and evenness

Tree Layer

The mean values of Simpson, N_2, Shannon-Wiener and N_1 diversity in the Anjilbon were found higher than the Radarposhteh site (Figure 10), with no significant difference. Similarly, mean value of evenness was higher in the Anjilbon than the Radarposhteh site and with significant difference ($P<0.05$). On the other hand, mean value of richness was higher in the Radarposhteh than the Anjilbon site (Figure 11), but no significant difference was observed.

Tree Regeneration Layer

The mean values of Simpson, N_2, Shannon-Wiener and N_1 diversity were higher in the Anjilbon than the Radarposhteh site same as tree layer (Figure 12), with no significant difference. In addition, the mean value of richness and evenness were higher in the Anjilbon than the Radarposhteh site (Figure 13), but no significant difference.

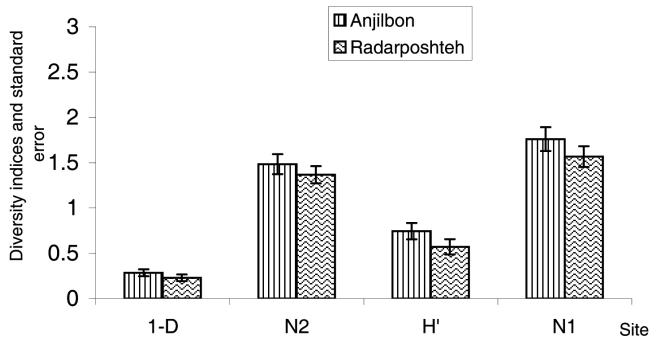

Figure 12. Diversity indices and their standard errors in regeneration layer in the studied sites.

Herbaceous Layer

The mean values of diversity of Simpson, N_2, Shannon-Wiener, N_1 and richness were higher in the Radarposhteh than the Anjilbon site (Figures 14 and 15), with no significant difference, while mean value of evenness was higher in the Anjilbon than the Radarposhteh site (Figure15), with no significant difference.

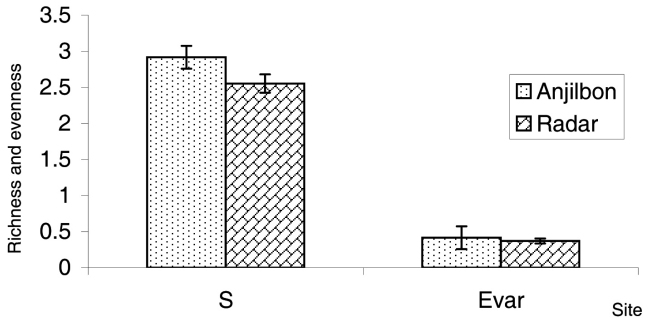

Figure 13. Richness and evenness and their standard errors in regeneration layer in the studied sites.

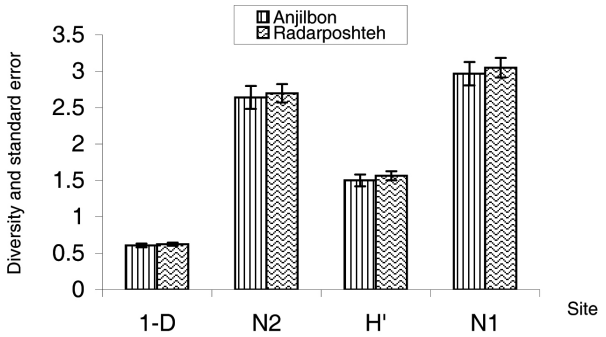

Figure 14. Diversity indices and their standard errors in the herbaceous layer in the studied sites.

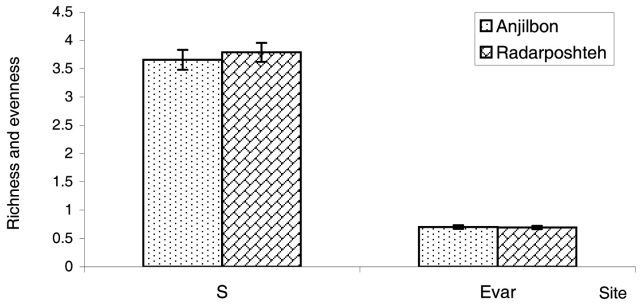

Figure 15. Richness and evenness and their standard errors in herbaceous layer in the studied sites.

Jaccard's Index Value

Nine woody species were common between two sites. Two woody species (i.e., *Acer insigne* and *Ulmus glabra*) were exclusively found in the Anjilbon site and one woody species (i.e., *Crataegus microphylla*) in the Radarposhteh site. Therefore, Jaccard's index value was obtained 75% in woody species layer. Sixteen herbaceous species were common between two sites. *Sanicula europaea* was exclusively found in the Radarposhteh site and *Viscum album* in the Anjilbon site. Therefore, Jaccard's index value was obtained 88.8% in the herbaceous layer.

DISCUSSION

The aim of this study was determination of stand structure and plant diversity in two box tree sites. Study of stand structure and plant diversity is very important to biological conservation, monitoring, forest dynamics, forest management and ecorestoration (Battles et al. 2001, Bebi et al. 2001, Wood, 2001, Huang et al. 2003, Jamir and Pandey 2003, Pamanujam and Cyril 2003, Kotwal and Banerjee 2004, Laguna et al. 2004, Ruiz-Jaén and Aide 2005). Considering that no article was found similar to this study on box tree sites, therefore two sites of this species were selected for comparison. In both sites, *Parrotia persica and Carpinus betulus* trees were observed in the overstory and box tree in the understory. Total number of trees and tree regeneration species (richness) in the Anjilbon was higher than the Radarposhteh site, while mean tree richness per plot in the Radarposhteh was higher than the Anjilbon site. This result is attributed to anthropogenic activities in the Anjilbon site, as the site is affected by human intervention and grazing. The mean richness of herbaceous species showed similar trend in both sites. The number of herbaceous species is restricted in box tree sites, as the species is ecologically shade-tolerant and its density per hectare is high. Number of box tree per hectare in the Anjilbon was higher than the Radarposhteh site, since the larger box trees were removed by human intervention, thus smaller box trees were established. Inversely, number of box tree regeneration was decreased in the Anjilbon site because of high density of box tree and higher percentage cover of species. On the other hand, the number of box tree regeneration in the Radarposhteh was higher than the Anjilbon site, since the number of large box trees in this site was higher than the Anjilbon site and percentage cover of species was lower in the Radarposhteh site. The number of other species per hectare in the Anjilbon was higher than the Radarposhteh site, which is related to lesser canopy in the Anjilbon site. Mean basal area per hectare of tree species in the Radaposhteh was higher than the Anjilbon site, because the diameter of tree was higher in the Radarposhteh site. Also, the mean diameter and height of box tree in the Radarposhteh

was higher than the Anjilbon site, as trees with higher diameter have been cut in the Anjilbon site. In both sites, *Buxus hyrcana* had the highest value of SIV.The lowest value of SIV in the Anjilbon site belonged to *Ulmus glabra* and in the Radarposhteh site belonged to *Albizia julibrissin*. *Smilax excelsa* (liana) and *Fragaria vesca* had the highest and lowest value of SIV, in both sites, respectively.

The mean litter depth in the Anjilbon was higher than the Radarposhteh site because of high density of trees in the Anjilbon site, and this result probably related to more biological activities in the Radarposhteh site, since ecological conditions (temperature and moisture) were almost suitable due to lower slope and elevation.

The mean diversity of trees and tree regeneration species in the Anjilbon were higher than the Radarposhteh site, since the mean value of evenness was higher in the Anjilbon site. Inversely, mean diversity of herbaceous species in the Radaposhteh was higher than the Anjilbon site, since mean richness was higher in the Radarposhteh site. In both study sites, mean diversity of tree layer was higher than other box tree sites due to higher value of evenness, while mean richness was lower than other sites (Pourbabaei 1999). According to IUCN category, *Buxus hyrcana* species is considered threatened species (IUCN 2001).

This research helps to complete the description of plant biodiversity and stand structure, and may be used to interpret aspects of forest and population dynamics. If remeasurements are carried out, data for modeling may also be provided. However, inventories of the abundant understorey individuals are time consuming, and for forest management purposes it may make more sense to focus sampling on the species to be managed, as specific knowledge on their ecology will probably be more desirable in a forest management context. Regarding that *Buxus hyrcana* has been considered as protected and threatened species, therefore its sites are recommended to be declared as genetic reserves.

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