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Comparison of Frequencies in Order to Estimate of Tree Species Diversity in Caspian Forests of Iran

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Abstract

Species diversity is one of the most important indices that used to evaluate the sustainability of forest communities. In the present study, three variables including number of individuals (frequency of species), basal area and volume of tree species were compared to estimate tree species diversity in broadleaves forests of Iran. Based on systematic random design, 30 plots (circle plot, 1000 m^2) was selected. Type of species, number of species, DBH and height of trees were measured. Simpson (1-D), Hill (N_2), Shannon-Wiener (H'), Mc Arthur (N_1), Smith-Wilson (E_{var}) and Margalef (R_1) indices used to estimate tree species diversity. Species diversity was calculated in each plot. ANOVA test showed that there was a significant difference between of three variables used for estimation of species diversity. Number of trees variable has more precision than basal area and volume variables to estimate of species diversity. But Duncan test revealed that there were significant difference between of basal area and volume variables with number of trees. Therefore, basal area and volume variables were selected as more suitable variables in order to estimate of biodiversity indices in northern forests of Iran.

Key Words: biodiversity, Caspian forest, tree species indices, type of data

Introduction

Species diversity and biodiversity are widely used terms in ecology and natural resource management. In the modern scientific and political terminology, the biodiversity is a concept entailed in daily life with various social and economic dimensions. Biodiversity is important for biological conservation, monitoring, forest dynamic, ecological recreational and forest management. Biodiversity measurement is recognized as guidance for conservation plans in local scale. Estimation of tree diversity and forest structure are a key pre-requisite for planning and managing of forest ecosystems (Motz et al. 2010). In recently years, to describe biodiversity changes used different indices. In forest ecosystems, the biodiversity evaluation has become an important issue in order to study of ecosystems and their conservation (Aubert et al. 2004). In vegetation studies, species biodiversity is used greatly, and one of the main criteria to study of ecosystems status is environmental assessment. In each work concerning the study of the diversity of communities, the use of diversity indices is a necessary tool to calculate and quantify the diversity status (Van Strien et al. 2012; Bandeira et al. 2013). In addition, these indices estimate biological and ecological quality of an ecosystem through the structure of the community (Danilov and Ekelund 1999); they are also possible indicators to monitor

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the level of pollution in environment (Washington 1984). In forest ecosystems for understanding the interactions between of patterns and processes is needed to estimate of tree species diversity and these indices are good quantitative descriptors of forest structures (Pommerening 2002; Aguirre et al. 2003; Lexerod and Eid 2006; Sterba and Zingg 2006). Reconstruction of forest structures are needed to biodiversity indices as important input variables in growth models and computer visualizations (Hasenauer 2006; Pommerening 2006; Pommerening and Stoyan 2008). To estimate of diversity indices can used number individuals, basal area and stem number (Motz et al. 2010). Species diversity of woody plants in northern forests of Iran was evaluated and used basal area and number of individuals for estimation of tree and shrub species diversity, respectively (Pourbabaei and Dado 2005). In order to study of woody species diversity in conifer mixed and broadleaves mixed stands was used number of individuals for estimation of biodiversity indices (Memarian et al. 2007). In the north forests of Iran were used basal area and number of individuals of species to estimate woody species diversity and herbaceous species respectively (Pourbabaei and Abedi 2008; Pourbabaei et al. 2010). Ebrahimi et al. (2014) used the number of individuals to estimate of tree and herbaceous species diversity in north forests of Iran. The purpose of present study was comparison types of data including number of individuals, basal area and volume of tree species to estimate tree species diversity using Simpson (1-D), Hill (N_2), Shannon-Wiener (H'), Mc Arthur (N_1) Smith-Wilson (E_{var}) and Margalef (R_1) indices in broadleaves forests of Iran.

Materials and Methods

Study area

This study was carried out in a 32.4 ha forest area of Guilan province in northern Iran. The study area is located in longitude between 49° 05' 10" to 49° 15' 10" N and in latitude between 37° 28' 10" to 37° 15' 10" E. Elevation ranges between 250 to 500 m, a.s.l. and mean annual precipitations and temperature are 1400 mm and 15.4 °C, respectively. Common forest soils are acidic with pH 5.5 to 6.5. This area has a humid climate based on Emberger's climate classification.

Methods

After estimation of standard deviation, number of plots was calculated by using Eq. (1).

$$n = \frac{t^2 \times S_x\%^2}{E\%^2} \qquad \text{Eq. (1).}$$

Where, n is number of plots, t is t-student table that is depended to probability level and number of plot, $S_x\%$ is percent of standard deviation and E% is percent of inventory error.

We sampled a systematic random sampling grid of 100×100 m to collect data in 30 circular plots of 1000 m^2 area. In each plot, type of species, number of species, DBH and height of trees were measured. To estimate of tree species diversity used types of data including number of individuals (frequency of species), basal area and volume of trees. Simpson (1-D), Hill (N_2), Shannon-Wiener (H'), Mc Arthur (N_1), Smith-Wilson's evenness (E_{var}) and Margalef's richness (R_1) indices are five frequently biodiversity indices and selected for estimating of species diversity. Their equations are given in Table 1 (Krebs 1999; Scott and Anderson 2003; Magurran 2004; Ebrahimi et al. 2014).

In order to compare types of data including number of individuals (frequency of species), basal area and volume of trees were used ANOVA test.

Table 1. Biodiversity indices and its equations

Index	Equation
Simpson (1-D)	$1-D = 1-\sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$
Shannon-Wiener (H')	$H' = \sum_{i=1}^{s}(P_i)(\log_2 P_i)$
Hill (N_2)	$\frac{1}{D} = \frac{1}{\sum p_i^2}$
Mc Arthur (N_1)	$N_1 = e^{H'}$
Smith-Willson (E_{var})	$E_{var} = 1-\left(\frac{2}{\Pi}\right)\left[arctan\left\{\frac{\sum(log_e(n_i)-\sum^{(n_j)}/s)^2}{s}\right\}\right]$
Margalef (R_1)	$R_1 = \frac{S-1}{Ln(N)}$

Results

Results showed that there are 16 species in study area (Table 2). Also the results showed that number of trees, basal area and volume variables are 21.327 tree·ha^{-1}, 1.561 m^2·ha^{-1} and 20.49 m^3·ha^{-1} (Table 2).

Calculation of biodiversity indices based on number of individuals showed that mean of Simpson, Hill, Shannon-Wiener, Mc Arthur, Smith-Wilson and Margalef indices are 0.732, 3.531, 2.007, 4.126, 0.732 and 1.358 respectively. Other statistical parameters and further details of tree species diversity are shown in Table 3.

Statistical parameters in calculation of biodiversity indices based on basal area characteristic are provided in Table 4. Results showed that mean of Simpson, Hill, Shannon-Wiener, Mc Arthur, Smith-Wilson and Margalef indices are 0.595, 2.824, 1.695, 3.397, 0.489, 0.489 and 16.529 respectively.

Mean of Simpson, Hill, Shannon-Wiener, Mc Arthur, Smith-Wilson and Margalef indices based on volume of species are 0.581, 2.694, 1.647, 3.285, 0.444, 0.444 and 1.824 respectively (Table 5).

The results of ANOVA test showed that there is a significant difference between type of data including number of individuals, basal area and volume of trees in estimation of biodiversity indices. Further details of ANOVA test are provided in Table 6.

Duncan test indicated that there are significant difference between of basal area and volume variables with number of trees in estimate of biodiversity indices (exception of Margalef index). The results are shown in Table 7.

Table 2. Results of measured variables

Species	No. of tree (tree/ha)	Basal area (m^2/ha)	Volume (m^3/ha)
Castanea sativa	6.574	0.615	6.008
Albizia julibrissin	0.340	0.006	0.071
Carpinus betulus	5.586	0.395	6.055
Gleditsia caspica	2.191	0.077	0.782
Quercus castaneifolia	0.710	0.186	3.895
Acer velutinum	1.173	0.050	0.717
Parrotia persica	0.154	0.004	0.051
Diospyros lotus	3.395	0.167	2.144
Fraxinus excelsior	0.463	0.036	0.496
Acer cappadocicum	0.370	0.009	0.096
Tilia begonifolia	0.062	0.002	0.019
Alnus sabcordata	0.185	0.007	0.101
Ulmus glabra	0.031	0.003	0.045
Juglans regia	0.031	0.001	0.008
Pterocarya fraxinifolia	0.031	0.000	0.004
Ficus carica	0.031	0.000	0.002
Total	21.327	1.561	20.493

Table 3. Results of biodiversity indices based on number of individual variable

Index	Mean	SD	$S_{\bar{x}}$	E%
Simpson	0.732	0.081	0.014	3.232
Hill	3.531	0.920	0.168	8.040
Shannon-Wiener	2.007	0.334	0.060	5.052
Mc Arthur	4.126	0.983	0.179	7.342
Smith-Willson	0.732	0.235	0.043	11.74
Margalef	1.358	0.382	0.069	10.16

Discussion

Generally, biodiversity measurement typically focuses 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. In the past studies has been used various characteristics to estimate of species diversity. In the

Table 4. Results of biodiversity indices based on basal area variable

Index	Mean	SD	$S_{\bar{x}}$	E%
Simpson	0.595	0.159	0.029	8.236
Hill	2.824	0.942	0.172	10.303
Shannon-Wiener	1.695	0.470	0.085	8.774
Mc Arthur	3.397	1.001	0.182	9.054
Smith-Willson	0.489	0.206	0.037	15.13
Margalef	1.652	1.755	0.328	39.70

Table 5. Results of biodiversity indices based on volume variable

Index	Mean	SD	$S_{\bar{x}}$	E%
Simpson	0.581	0.159	0.029	8.435
Hill	2.694	0.916	0.167	10.476
Shannon-Wiener	1.647	0.471	0.086	8.824
Mc Arthur	3.285	0.968	0.176	9.054
Smith-Willson	0.444	0.213	0.038	17.11
Margalef	1.824	0.940	0.171	18.75

Table 6. Results of comparison type of data in estimation of biodiversity indices

Index	F	p-value
Simpson	10.903	0.000*
Hill	6.832	0.002*
Shannon-Wiener	6.172	0.003*
Mc Arthur	6.444	0.002*
Smith-Willson	15.082	0.000*
Margalef	21.679	0.000*

Statistically significant at the 0.05 probability level.

Table 7. Comparison mean of different variable based on Duncan test

Index	Mean		
	Number of tree	Basal area	Volume
Simpson	0.732a	0.595b	0.581b
Hill	3.531a	2.824b	2.694b
Shannon-Wiener	2.007a	1.695b	1.647b
Mc Arthur	4.126a	3.397b	3.285b
Smith-Willson	0.732a	0.489b	0.444b
Margalef	1.358a	1.652ab	1.824b

Different letters shows significant difference at the 0.05 probability level.

present study, three variables (number of trees, basal area and volume) were used for estimation of biodiversity indices in northern forests of Iran. The results of study showed that there is a significant difference between of three variables to estimate of biodiversity indices (Table 6). Comparison mean of biodiversity indices indicated that there is a significant difference between of number of trees with basal area and volume variables (Table 7). Also, mean of biodiversity indices estimated based on number of trees was more than mean of biodiversity indices derived from basal area and volume variables. Pourbabei and Abedi (2008) used basal area variable in order to estimate of Simpson (0.444), Hill (1.922), Shannon-Wiener (1.029) and Mc Arthur (2.104) indices in northern forests of Iran. While mean of these indices are 0.595, 2.824, 1.695 and 3.397 respectively (Table 4). Differences in type of forests, species and condition topographic are the reasons of difference in the results. Some researchers suggested that number of trees can be used to estimate of biodiversity indices (Ismaeil Ramaji et al. 2010; Ebrahimi et al. 2014). For example, Moradi Emamgheysi et al. (2016) used number of trees variable to estimate diversity of tree species in protected forests of Ardal's Chartagh that due to type of species and condition topographic are not consistent with results of present study. Comparison of statistical error (E %) showed that number of trees variable has less statistical error than to basal area and volume variables in estimation of biodiversity indices. Also basal area variable has less statistical error than to volume variable in estimation of biodiversity indices (Tables 3-5). So far, no studies have been conducted on a suitable variable for estimating tree species diversity and in many studies were used different variables to estimate of tree species diversity. As the results show, the mean of biodiversity indices estimated from basal area and volume variables was the same, while these values are different from the values obtained of the number of trees variables. Regarding to the study area is undisturbed, these forests have a more productive aspect. On the other hand, measurements of basal area and volume variables in these forests are more important than other characteristics (number of trees). Therefore, it seems that the basal area and volume variables are more appropriate than the number of trees in order to estimate biodiversity indices.

Conclusion

The knowledge of effect implement forest management systems on regeneration density and species diversity is very important and essential for conservation and forest sustainable development. Plant diversity plays key ecological roles in forest ecosystems, including influencing succession, resilience and nutrient cycling. Therefore this study was carried out in northern forests of Iran to obtain different species diversity indices which will be used as a document and data base for future management and long-term ecological studies. Results showed that number of trees variable has more precision than basal area and volume of species in estimation of biodiversity indices. But there is a significant difference between of basal area and volume variables with the number of trees variable. Therefore, basal area and volume variables were selected as more suitable frequency criteria for estimation of Simpson, Hill, Shannon-Wiener, Mc Arthur, Smith-Wilson and Margalef indices in northern

forests of Iran.

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