

Assessment of Structural Diversity of Beech Forest Stands in North of Iran

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Abstract

Stand structure is a key principle in stand biodiversity. High biodiversity was associated with the stands that have different trees species with different dimension. In this regard, for evaluation Structural diversity in different diameter and height classes and also their changing procedure of beech stands in north of Iran, 30 modified Whittaker plots by systematic random system were located. The heterogeneity indices of Shannon–Wiener, number of equally common species and evenness indices of Simpson and smith-Wilson were using for the quantitative data. In order to understand the diversity condition in horizontal and vertical composition of stand further, the diameter divided in 10-cm classes and method of Mohajer and the height divided in 10-m height classes and dominant height. Then diversity of each class was extract by ecological methodology software. Results showed the most diversity of trees and shrubs is in low height and diametrical classes. Thus, the study of biodiversity changes in different diameter and height category cause ecologically precise perspective in management of forest stands.

Keywords: Diameter and height classes, Beech stand, Shannon–Wiener index, Iran north

1. Introduction

Forests, trees in their biological group, were regarding as one of the vital ecosystems of human beings. Apart from their economic significance, forests provide the survival and stability of water, soil, and healthy air of any land and are considering as certain supporter for keeping and developing of agriculture systems and other food sources of human. Forest destroys result in intense environmental difficulties that are threatening total occupied globe and human life (Majnounian, 1986). North humid forests of Iran are part of the phytogeographic (European Siberian and northern America) (Majnounian, 1986). Evaluation of biodiversity improves our understanding of forests and environment changes (Majnounian, 1986). One main principle of biodiversity protection in multiple management of national forest is the protection of stands structure composition (Eyre et al, (2010). Stand structure is a key principle in stand biodiversity (MacArthur et al, (1961). High biodiversity was associated with the stands that have different trees with different dimension (Buongiorno et al, (1994), Lemay et al, (2005). Management of the forests in biodiversity completes with the management of structure diversity (Önal, 1997). The structural diversity of forests has researched in many studies. Ahani et al, (2006) do the research about tree species diversity based on the diameter classes in *Acer platanoids* sites Shafarud forests. Therefore, rhombus plots in half-hectare study in forest according to *Acer platanoids* (34 plots). For the first the features within each plot, are slope, aspect, height from sea level and then total diameter of trees up to more than 10-cm measured. Biodiversity accounted in four diameter classes (10-30, 35-50, 55-80, and 80-120 cm). The result showed that the Shannon and N_1 Mac Arthur indices in diameter class of 35-50-cm, have greatest amount, while the index of Simpson and N_2 hill shows the greatest amount in diameter class of 10-30-cm. Daneshvar et al, (2007) study the structural diversity in mixed beech forest of Shast Kalateh Gorgan. The results showed that a

combination of alder and hornbeam species with beech could indicate the succession initial processes. The size of biodiversity is different in initial processes of beech succession and the more we approach to the succession final processes in beech stand the diversity and richness of the wood species decreases. The aim of this study is the evaluation of trees and shrubs structural diversity in different diameter classes and height category and their changing procedure according to biodiversity indices.

2. Material and method

2.1 The region of study

The Gorgan research and academic Shast Kalateh forest is located in the northern slope of alborz mountain range and this mountain range is stretched to the south of caspian sea from east and west. This forest is located on the latitude of 36 degree and 47 minutes to 36 degree and 45 minutes to north and in longitude of 51 degree and 20 minutes to 54 degree and 21 minutes in east. Its expanse is 3116 hectares. Its annual rainfall measure is 649 millimeters.

2.2 Research method

This research is base on sampling by systematic random system and the center of plots in forest is determined. To study and investigation, 30 modified Whittaker plots (Stohlgren et al, 1995) in range of 850-950 altitude from the sea level in north aspect were located. In this 20*50 meter frame, the characteristic of trees and shrubs species (Species name, diameter, and height) recorded. The heterogeneity indices of shannon-wiener, number of equally common species and evenness indices of simpson, smith-wilson were used for the quantitative data. Toward better, understand diversity in composition of stand vertical and horizontal, trees diameter divided in 10-cm classes and method of Dr.mohajer (2005) and trees height divided in 10-m classes and dominant height. Then previously mentioned characteristics saved as information bank in Excel 2010. Then indices account by ecological methodology software. Analyze of data was done by analyze variance and multiple comparison of Duncan.

2.3 Biodiversity indices

2.3.1 Heterogeneity indices

2.3.1.1 Shannon-wiener index

The most popular measures of species diversity are based on information theory. This indeed assumes that individuals are randomly sample from an independently large population. This uncertainty can be measured by the Shannon-Wiener function:

where:

$$H' = \sum_{i=1}^s (p_i)(\log_2 p_i) \quad \left\{ \begin{array}{l} H' = \text{Information content of sample (bits/individual)} \\ \quad = \text{Index of species diversity} \\ s = \text{Number of species} \\ p_i = \text{Proportion of total sample belonging to } i \text{ th species} \end{array} \right.$$

2.3.1.2 Number of equally common species index

The Shannon-Wiener index may be expressed in another form (MacArthur, 1965) in units of numbers of species as:

where:

$$N_1 = e^{H'} \quad \left\{ \begin{array}{l} e = 2.71828 \text{ (base of natural logs)} \\ H' = \text{Shannon-Wiener function (calculated with base } e \text{ logs)} \\ N_1 = \text{Number of equally common species which would produce} \\ \quad \text{the same diversity as } H' \end{array} \right.$$

2.3.2 Evenness indices

2.3.2.1 Simpson index

For Simpson's measure of heterogeneity, maximum diversity is obtained when all abundances are equal ($p = 1/S$). It follows from this that the maximum possible value of the reciprocal of simpsons index ($1/D$) is always equal to the number of species observed in the sample. This leads to a simple definition of simpsons index of evenness:

where:

$$E_{1/D} = \frac{1/\hat{D}}{S} \quad \left\{ \begin{array}{l} E_{1/D} = \text{Simpson's measure of evenness} \\ \hat{D} = \text{Simpson's index (eq. 12.27)} \\ S = \text{number of species in the sample} \end{array} \right.$$

2.3.2.2 Smith and Wilson Index

Smith and Wilson (1996) invented a new index of evenness, which is based on the variance in abundance of the species.

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

where the arctangent is measured as an angle in radians and:

E_{var} = Smith and Wilson's index of evenness

n_i = Number of individuals in species i in sample ($i = 1, 2, 3, 4, \dots, S$)

n_j = Number of individuals in species j in sample ($j = 1, 2, 3, 4, \dots, S$)

S = 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 it is sensitive to both rare and common species in the community.

3. Results

3.1 Diversity indices in 10-cm diameter classes

The under study diversity indices in this paper indicate that the diameter classes decrease 10-cm by the increase of classes (Table1). The most diversity number is in diameter class of 0-10 cm and the least diversity number is in diameter class of 90-100- cm. The significance difference is between diameter classes in 1% level.

3.2 Diversity indices in diameter classes by method of Dr.mohajer

Diversity indices show decrease process with the increase of diameter classes (Table2), but it increase again in class 60-80-cm. The most diversity number is in the class of 0-10-cm. Evenness indices shows increase process with the increase of diameter classes that decrease in the class of 60-80-cm and increase again. The least evenness number is in the class of 0-10-cm and the most diversity number is in the class of dbh>80. The significance difference is between diameter classes in 1% level.

3.3 Diversity indices in 10-m height classes

Diversity indices have decrease process (Table3). The most diversity number is in height class of 0-10-m and the least diversity number is in height class of 40-50-m (Table4). The significance difference is between height classes in 1% level.

3.4 Diversity indices in dominant height of height classes

The most diversity number in all indices is for $h > 2/3 h_m$ class. Evenness indices in this division have increasing process and number evenness increase with increase height classes. The significance difference is between height classes in 1% level (Table4).

4. Discussion

One main principle of biodiversity protection in multiple management of national forest is the protection of stands structure composition (Marvie mohadjer, (2005). Stand structure is a key principle in stand biodiversity (Pourbabaie & Dado, (2004). High biodiversity associated with the stands that have different trees with different dimension (Majnounian, 1986., Önal, 1997). As we see in 2-4 tables, the most diversity is in low height and diametrical classes. Purbabaie et al (2005) and Sohrabi Muri (2011) came into conclusion in their investigation that diversity of regeneration layers is more than tree layer. This is due to the decrease of canopy of small saplings and it need low light than higher age process in this classes. By the increase of diametrical and height classes, the diversity decreased. It is obvious that the structure diversity naturally in the virgin forest decrease depend on site condition and with increase of stand age and its move toward climax, because gradually increase of trees age dominant species dominant against the under species. Evenness has increasing process with increase of trees age. It seems that the distribution of species well organized in higher height and diametrical classes. The study of trees spatial variance can be use in control of existing spatial structure, describing and understanding of regeneration and dynamic patterns of forest. Trees are the main elements in forest ecosystems that other living thing life of this ecosystem depends on the life of them. Therefore removing of the tree threatened the life of the existent in this ecosystem. Principally low biodiversity indices amount is not due to the undesirable condition or inappropriate damage and management. However, inappropriate management and principally any human

interference in nature can accelerate or slow down this procedure. Thus, the study of biodiversity changes in different diameter and height category cause ecologically precise perspective in management of forest stands (Daneshvar et al, (2007). Therefore, it suggested that:

- 1- Marking for trees selection should not be only for harvesting of the wood, but also it should consider the uneven aged structure, keeping the seed trees and their regeneration and the diversity of wood species.
- 2- Since management and directing of biodiversity to the ideal diversity have direct relation with protection of regeneration of wood species, so sufficient care should be give to the protection and diversity increase and mixing in this class.
- 3- Since biodiversity is very effective in the protection and increase of the stability of one ecosystem, thus protection and diversity increase of wood species in all spatial and time scales should be consider in the designing, programming, and management of under study forest and similar forests.

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Table 1. The comparison of diversity and evenness indices in 10-cm diameter classes

Diameter classes	diversity	indices	evenness	indices
	Shannon-wiener	Number.o.e.c.species	Simpson	Smith and Wilson
0-10	1/17 a	2/35 a	0/34 cd	0/18 d
10-20	0/75 b	1/59 b	0/54 ab	0/5 ab
20-30	0/62 bc	1/33 bc	0/59 a	0/58 a
30-40	0/44 cde	1/01 cde	0/43 abcd	0/42 abc
40-50	0/53 cd	1/08 cd	0/48 abc	0/49 ab
50-60	0/34 de	0/7 de	0/34 cd	0/34 bcd
60-70	0/38 de	0/77 de	0/37 bcd	0/38 bc
70-80	0/28 de	0/59 de	0/27 d	0/28 cd
80-90	0/33 de	0/66 de	0/33 cd	0/33 bcd
90-100	0/31 de	0/63 de	0/31 cd	0/31 bcd
dbh>100	0/37 de	0/74 de	0/3 cd	0/31 bcd

Table 2. The comparison of diversity and evenness indices by method of Dr.Mohajer

Diameter classes	diversity	indices	evenness	indices
	Shannon-wiener	Number.o.e.c.species	Simpson	Smith and Wilson
0-10	1/17 a	2/34 a	0/34 c	0/34 c
10-30	0/83 b	1/76 b	0/58 ab	0/59 ab
30-60	0/86 b	1/77 b	0/64 ab	0/63 ab
60-80	0/39 c	0/81 c	0/38 b	0/39 b
dbh>80	0/72 bc	1/51 bc	0/66 a	0/68 a

Table 3. The comparison of diversity and evenness indices in 10-m height classes

Height classes	diversity	indices	evenness	indices
	Shannon-wiener	Number.o.e.c.species	Simpson	Smith and Wilson
0-10	0/99 a	2/08 a	0/32 b	0/15 b
10-20	0/82 ab	1/75 ab	0/58 a	0/5 a
20-30	0/66 b	1/5 b	0/61 a	0/55 a
30-40	0/82 ab	1/74 ab	0/64 a	0/59 a
40-50	0/35 c	0/97 c	0/43 b	0/32 b

Table 4. The comparison of diversity and evenness indices in height classes by dominant height

Height classes	diversity	indices	evenness	indices
	Shannon-wiener	Number.o.e.c.species	Simpson	Smith and Wilson
$h < 1/3 < h_m$	0/99 ab	2/09 a	0/31 b	0/13 c
$1/3h_m < h < 2/3h_m$	0/75 b	1/68 b	0/6 a	0/49 b
$h > 2/3h_m$	1/05 a	2/15 a	0/69 a	0/62 a