Scholars Academic Journal of Biosciences (SAJB) **ISSN 2321-6883 (Online)**
Sch. Acad. J. Biosci., 2014; 2(2): 151-156 **ISSN 2347-9515 (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublishers.com **DOI:** 10.36347/sajb.2014.v02i02.015

Research Article

Effects of slope aspect on woody species diversity and stand structure in mountain Hyrcanian forests

Farzam Tavankar[1*], Mehrzad Naseri Khalkhali[2]
[1]Department of Forestry, Khalkhal Branch, Islamic Azad University, Khalkhal, Iran.
[2]Natural Resources Office, Resvanshahr, Guilan, Iran.

***Corresponding author**
Farzam Tavankar
Email: farzam_tavankar@yahoo.com

Abstract: In this research the effect of slope aspects on woody species diversity and stand structure (basal area, tree and seedling density and canopy cover) were studied in Hyrcanian mountain forests in the north of Iran. A total of 17 woody species (12 trees and 5 shrubs) from 12 families were recorded in the study area. The results showed the values of woody species evenness was more on the southern slopes, while the values of species diversity and species richness was more on the northern slopes. The slope aspect had not significantly effect on woody species richness, evenness and diversity ($P > 0.05$). The *Fagus orientalis* had the highest species importance value (SIV) in the study area, especially on the northern aspects. After *Fagus orientalis* the *Carpinus betulus* had the most SIV on the northern aspects, while on the southern aspects the *Quercus castaniefolia* had the most SIV. The stand basal area and canopy cover was more on the southern aspects, while tree and seedling density was more on the northern slopes. The slope aspect had significantly effect on the stand basal area, tree and seedling density and canopy cover ($P < 0.01$).
Keywords: Slope aspect, stand structure, species diversity, species importance value, Hurcanian forest.

INTRODUCTION

Conservation of forests biodiversity is one of important objective in sustainable forest management [1, 2]. Forests are among the most diverse and complex ecosystems in the world, providing a habitat for a multitude of flora and fauna. Forest ecosystems provide habitat for a disproportionate share of the world's biological diversity. Biodiversity refers to the natural variety and the physical organization or pattern of the variability among living organisms [3]. Three conceptual levels of biodiversity are recognized, ecosystem, species and genetic. Biodiversity studies typically focus on species. Species diversity is an important index in community ecology [4]. Species diversity at the property, compartment and stand level contributes to the habitat value and biodiversity of a forest. Forests are the most species rich of all terrestrial ecosystems and provide essential benefits to society. It is widely demonstrated that more species contribute to greater ecosystem stability. It is now widely accepted that forests should be managed in an ecologically sustainable fashion [5, 6]. The conservation of biodiversity has become a major concern for resource managers and conservationists worldwide, and it is one of the foundation principles of ecologically sustainable forestry [7, 8]. Nowadays, forest management practices increasingly promote conservation and enhancement of biodiversity. Pressures and stresses on forest biodiversity are sensitively increasing by the human activities such as clearance of forest areas for other land use and industrialization. It has been well documented that species composition and diversity can be used as indicators of past management practices in forested areas [6, 7]. Hyrcanian forests are located in the north of Iran and south coast of Caspian Sea, also called Caspian forests. These forests extended from costal of Caspian Sea to altitude of 2800 m of Alborz mountain belt [10]. The area of these forests is about 1.8 million hectares that 60 % of these forests are used for commercial purposes and the rest of them are degraded [11]. They are suitable habitats for a variety of hardwood species (approximately 80 woody species) and include a lot of forest types [11]. These are the most valuable forests in Iran. These forests are known as one of the most basic resources for wood production and have a big share in supplying wood to the related industries. On the base of altitude and vegetation structure, Hyrcanian forests could be divided into three subdivisions: lowland, sub-mountain and mountain forests [12- 14]. The knowledge of the floristic composition of an area is a perquisite for any ecological and phyto-geographical studies and conservation management activities [15]. Burton et al, (1992) referred to the importance of biodiversity in maintaining ecosystem productivity and stability in addition to retaining non timber and alternative forest

resources [1]. In this research the effects of slope aspect on woody species diversity and stand structure (basal area, tree and seedling density and canopy cover) were studied in the Hyrcanian forest of Iran.

MATERIAL AND METHODS

Study area

This study was conducted in parcels of 142 and 258 in Nav forest in the north of Iran. The Nav forests are located between 37° 38' 34" to 37° 42' 21" N, 48° 48' 44" to 48° 52' 30" E. The area of parcel 142 is 41 ha and the area of parcel 258 is 52 ha. The general slope aspect of parcel 142 is northern and general slope aspect of parcel 258 is southern. Elevation of the study area is ranged from 1,350 m to 1500 m a.s.l. The mean annual precipitation is approximately 950 mm and the mean annual temperature is 9.1^{o} C. The original vegetation of this area is uneven-aged mixed forest dominated by *Fagus orientalis* Lipsky and *Carpinus betulus* L. The soil type is forest brown and soil texture varies between sandy clay loams to clay loam. For these forests, the silvicultural method is selection cutting and harvesting system is ground-based logging.

Collection of data

Data were collected by systematic sampling design and in each slope aspect (NE, NW, SE and SW) 15 sample plots with an area 400 m^2 (20 × 20 m) were taken in regular distances (50m) from each other. In each plot, all woody species were identified, diameter at breast height (DBH) of all trees (DBH ≥ 5 cm) were measured by diameter tape. Individuals of trees with DBH < 5 cm were counted by species as seedling [16]. Canopy cover was also measured in all plots.

Analysis of data

The species diversity includes species richness (the number of species) and species evenness (the relative abundances of the different species). The species diversity, richness and evenness were calculated in each plot. The Shannon-Wiener diversity index (H') and Pielou's evenness index (J) was used to calculated values of species diversity and evenness indices, also species richness (S) was number of species per plot. Jacard's similarity index (JI) was used to measure the similarity in species composition among slope aspects. The species importance value for each species was calculated in each stand type. The indices of H', J, JI and species importance value (SIV) were calculated by following formulas [9, 17- 19]:

$$H' = -\Sigma n_i / n \, Log_2 \, n_i / n \quad (1)$$

$$J = H' / \ln S \quad (2)$$

$$JI = \frac{a}{a+b+c} \quad (3)$$

$$\text{Relative Density}(RD) = \frac{\text{Density of one species}}{\text{Total density}} \times 100 \quad (4)$$

$$\text{Relative Frequency}\ (RF) = \frac{\text{Frequency of one species}}{\text{Total frequency}} \times 100 \quad (5)$$

$$\text{Relative Dominance/Basal area}\ (RDB) = \frac{\text{Basal area of one species}}{\text{Total basal area}} \times 100 \quad (6)$$

$$SIV = RD + RF + RDB \quad (7)$$

Where, n_i is the SIV of a species, n is the sum of total SIV values of all species in forest type, ln is Natural logarithm, S is the total species number in each forest type, a, is number of common species in communities, b, is number of species that exist just in first community and c, is number species that exist just in second community. Kolomogrov-Smirnov test showed that data of woody species diversity and evenness were followed of normal distribution. The averages of species diversity, evenness, richness and density of natural trees and regeneration and canopy covers in the four slope aspects were compared using a one-way ANOVA. Multiple comparisons were made by Tukey test (significance at $\alpha < 0.05$). SPSS 19.0 software was used for statistical analysis; also the results of the analysis were presented using descriptive statistics.

RESULTS AND DISCUSSION

A total of 17 woody species (12 trees and 5 shrubs) from 12 families were recorded in sample plots (Table 1). The family of Rosaceae with 7 woody species had the most number of woody species in the study area. The number of woody species in the north eastern slope (NE) was more than other aspects. The species of *Ceracus avium* was observed only in NE slope. The *Ulmus glabra* that is a rare and valuable tree species in the Hyrcanian forests was observed only in the northern slope aspects (NE and NW). The Woody species importance value (SIV) in different slope aspects is shown in table 1. The *Fagus orientalis* had the highest SIV in the slope aspects, especially in the northern aspects. The most SIV of *Fagus orientalis* was in the NW aspect. After Fagus *orientalis* the *Carpinus*

betulus had the most SIV in the northern aspects, while in the southern slopes the *Quercus castaniefolia* had the most SIV. The SIV of *Quercus castaniefolia* in the aspects of NE and NW was 2.2 and 4.3, while in the SE and SW was 87.9 and 85.5. The Beech stands are the most economically valuable in the Hyrcanian forests and produce the most of timber in the Iran. The mixed and pure Beech stands occupy about 20% of these forests and produce more than 35% of the total wood stock volume of the Hyrcanian forests [20]. High species diversity in ecosystems led to high food chain and more complex network environment [21].

Table 1- Woody species importance value (SIV) in slope aspects

Woody species	Family	Tree/shrub	Slope aspects			
			N.E	N.W	S.E	S.W
Fagus orientalis Lipsky	Fagaceae	Tree	192.8	211.7	121.9	127.6
Carpinus betulus L.	Corylaceae	Tree	25.6	20.3	45.7	46.2
Acer insigne Boiss.	Aceraceae	Tree	17.5	10.3	4.5	5.2
Acer cappadocicum Gled.	Aceraceae	Tree	16.1	12.1	8.9	8.0
Alnus subcordata C.A.M.	Betulaceae	Tree	15.3	12.1	7.4	5.0
Quercus castaniefolia Gled.	Fagaceae	Tree	2.2	4.3	87.9	85.5
Tilia begonifolia Stev.	Tiliaceae	Tree	6.5	6.7	2.3	2.3
Ulmus glabra Huds.	Ulmaceae	Tree	5.2	6.0	-	-
Zelkova caprinifolia (Pall.) Diopp	Ulmacea	Tree	4.9	4.2	5.1	4.6
Acer platanoides L.	Aceraceae	Tree	4.1	4.1	2.0	1.8
Fraxinus coriarifolia Scheel	Oleaceae	Tree	2.3	2.4	1.2	1.0
Parrotia persica (dc.)	Hamamelidacea	Tree	1.5	1.5	5.3	5.0
Mespilus germanica l.	Rosaceae	Tree	1.4	1.5	5.2	4.2
Ceracus avium (L.) Mohench	Rosaceae	Tree	1.0	-	-	-
Pyrus communis L.	Rosaceae	Tree	1.0	-	1.2	1.1
Prunus divaricata Ledeb.	Rosaceae	Tree	0.9	1.1	-	1.0
Sorbus torminalis (L.) Crantz.	Rosaceae	Tree	0.6	0.7	0.7	0.9
Vaccinium microphylla (Willd)	Vacciniaceae	Shrub	0.6	0.7	0.4	0.3
Laurocerasus officinalis (L.)	Rosaceae	Shrub	0.2	0.2	-	0.1
Crateagus microphylla (Willd)	Rosaceae	Shrub	0.1	0.1	0.1	0.1
Ilex spinigera Loes.	Aquifoliaceae	Shrub	0.1	-	0.1	0.1
Ruscus hyrcanus Juz.	Asparaginaceae	Shrub	0.1	-	0.1	-
Total			300	300	300	300

(-): Absence of species

The values of biodiversity indices in different slope aspects are shown in table 3. The results of this study showed that the Shannon-Wiener diversity index (H') was highest in the NW aspect (0.90) and was the lowest in the SE aspect (0.76). While, Pielou's evenness index (J) was highest in the SW (0.85) aspect and was the lowest in the NE aspect (0.75). Overall, diversity value was more in the northern slopes and evenness value was more in the southern slopes. Also the richness value in the northern slopes was more than the southern slopes. Hashemi (2010) reported the species diversity is more in the northern aspect and also species diversity in slops less than 30% has the most amounts in the hyrcanian forests [22]. Pourbabaei and Haghgooy (2013) reported that aspect had significant effect on diversity and evenness of the tree species, so species diversity and evenness on south aspect were significantly more than the other aspects in the Kandelat Forest Park in north of Iran [23].

Table 3- Mean ± standard deviation of biodiversity indices in the slope aspects

Biodiversity indices	Slope aspects*			
	N.E	N.W	S.E	S.W
Diversity (H')	0.88 ± 0.25^{b}	0.90 ± 0.26^{a}	0.76 ± 0.30^{a}	0.79 ± 0.28^{a}
Evenness (J)	0.75 ± 0.22^{a}	0.80 ± 0.30^{a}	0.82 ± 0.28^{a}	0.85 ± 0.31^{a}
Richness (S)	4.2 ± 1.85^{a}	4.3 ± 0.84^{a}	3.5 ± 2.00^{a}	3.7 ± 1.46^{a}

*Different letter in rows indicates statistically significant differences at α=0.05.

The stand basal area in the southern slopes was more than northern slopes, while the tree density in the northern slopes was more than southern slopes (Table2). The maximum basal area (21.6 $m^2.ha^{-1}$) was measured in the south western (SW) aspect and the minimum basal area (17.6 $m^2.ha^{-1}$) was measured in NE aspects. The most tree density (184.8 $stem.ha^{-1}$) was measured in the north western (NW) aspects and the

least tree density (118.4 stem.ha^{-1}) was measured in the SW aspects. Also the most seedling density (412.2 stem.ha^{-1}) was measured in the NW aspects and the least tree density (259.4 stem.ha^{-1}) was measured in the SW aspects. The canopy covers in the northern slopes (NE and NW) was significantly higher than southern slopes (SE and SW).

The most similarity of woody species (75.7%) was found between NE and SW aspects according to Jaccard's similarity index (Table 4).

The results of ANOVA tests are shown in table 5. According ANOVA tests, the slope aspect had significantly effect on stand basal area, tree and seedling density and canopy cover ($\alpha < 0.01$), but had not significantly effect on diversity indices ($\alpha > 0.05$). Kabrickt & Shifley (2004) reported that the plant species diversity on the southern slope aspects is more than other slope aspects in the Missouri [24]. Parma and Shataee Jouybari (2010) studied the Impact of physiographic and human factors on crown cover and diversity of woody species in the Zagros forests of Iran and reported that the crown cover and species diversity were higher in the northern slopes [25]. Tavankar (2013) reported biodiversity indices in plantation sites are lower than adjacent natural forests in Hyrcanian lowland forests [26].

Table 2- Mean ± standard deviation of stand structure in stand types

Stand structure	Slope aspects*			
	N.E	N.W	S.E	S.W
Stand Basal area (m^2.ha^{-1})	17.6 ± 1.9^{c}	18.2 ± 1.8^{bc}	20.6 ± 1.8^{ab}	21.6 ± 1.7^{a}
Tree density (stem.ha^{-1})	176.3 ± 17.8^{a}	184.8 ± 18.1^{a}	123.3 ± 11.7^{b}	118.4 ± 14.7^{b}
Seedling density (stem.ha^{-1})	384.9 ± 19.8^{b}	412.2 ± 32.6^{a}	286.5 ± 23.6^{c}	259.4 ± 34.1^{c}
Canopy cover (%)	87.6 ± 11.9^{a}	87.2 ± 12.0^{a}	63.9 ± 17.9^{b}	67.6 ± 17.8^{b}

*Different letter in rows indicates statistically significant differences at α=0.05.

Table 4- Jacard's similarity index between slope aspects

Slope aspects	N.E	N.W	S.W
S.E	81.8 %	71.4 %	85.0 %
S.W	85.7 %	85.0 %	-
N.W	81.8 %	-	-

Table5- Analysis of variance (ANOVA) for effect of slope aspects on vegetation structure and biodiversity indices

	SS	DF	MS	F	P-Value
Stand Basal area (m^2.ha^{-1})	147.8	3	49.3	7.28	0.000**
Tree density (stem.ha^{-1})	54181.5	3	18060.5	72.42	0.000**
Seedling density (stem.ha^{-1})	247629.8	3	82543.2	104.1	0.000**
Canopy cover (%)	7165.4	3	2388.5	10.3	0.000**
Shannon-Wiener diversity index (H')	0.21	3	0.07	0.82	0.487$^{N.S}$
Pielou's evenness index (J)	0.23	3	0.08	0.84	0.461$^{N.S}$
species richness (S)	6.63	3	2.21	0.86	0.469$^{N.S}$

N.S: No significance, *: Significance at α=0.05, **: Significance at α=0.01.

Baduni & Sharma (2006) indicated that plant species diversity on the southern slope aspects is more than other slope aspects in Garhwal Himalaya forests [27]. In a study woody species diversity were compared in three different protection levels in Hyrcanian lowland forests and reported that the Shannon-Wiener diversity index was highest in the managed forest and was the lowest in the open access forest [28].

CONCLUSION

In this research woody species diversity and stand structure were studied in different slope aspects of Nav forest area in the mountain Hyrcanian forests of Iran. The Nav forest is one of the best forest stands in the northern Iran, which plays an important role in national wood production. Considering to the results of this study, the northern aspects have more productivity than southern slopes. The Beech (*Fagus orientalis* Lipsky) was the most industrial commercial tree species in these forests. Also Oak (*Quercus castaneifolia*) was important commercial trees on the southern aspects. 17 woody species were observed in these forest stands. These forests have ecologically importance for conservation of biodiversity. The decline of forest habitat and the related loss of biodiversity is a worldwide environmental issue. The results of this research indicated slope aspect have significantly effect on stand structure. The conservation of biodiversity has become a major concern for resource managers and conservationists worldwide and it is one of the foundation principles of ecologically sustainable forestry [7, 8]. Iran is one of the low forest cover countries. The silvicultural method is single selection cutting in the Nav mountain forests. Tavankar et al.

(2012) reported the single selection cutting method had not significantly effect on tree species diversity in 10 years period in the Hyrcanian forest [29]. Our suggestion for biodiversity conservation is to leave the tree species that are less dense in these stands, such as *Ulmus glabra*, *Zelkova caprinifolia*, *Fraxinus coriarifolia* and *Ceracus avium* and logging operation focus on the tree species that are high density.

REFERENCES

1. Burton PJ, Balisky AC, Coward LP, Cumming SG, Kneeshaw DD; The value of managing for biodiversity. Forestr Chronicle, 1992; 68(2): 225-237.
2. Brockerhoff EG, Jactel H, Parrotta JA, Quine CP, Sayer J; Plantation forests and biodiversity: oxymoron or opportunity? Biodiversity Conservation, 2008; 17: 925–951.
3. Putz FE; Some roles of North American ecologists in land-use planning in the tropics. Ecological Applications, 2000; 10:676-679.
4. Myers JA, Harms KE; Seed arrival, ecological filters, and plant species richness: a meta-analysis. Ecology Letters, 2009; 12(11): 1250–1260.
5. Kohm K, Franklin JF; Forestry in 21st century, Island press, Covelo California. 1997; 475.
6. Lindenmayer DB, Margules CR, Botkin DB; Indicator of biodiversity for ecologically sustainable forest management. Conservation Biology, 2000; 14(4): 941-950.
7. Carey AB, Curtis RO; 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. Wildlife Society Bulletin, 1996; 24(4): 610-620.
8. Hunter ML; Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, UK. 1999; pp. 698.
9. Kneeshaw DD, Leduc A, Drapeau P, Gauthier S, Pare D, Carignan R, Doucet R, Bouthillier L, Messier C; Development of integrated ecological standards of sustainable forest management at an operational scale. Forest Chronicles, 2000; 76: 481-493.
10. Mossadegh A; Silviculture. Tehran University Press, Tehran. 1996; pp. 481.
11. Marvi Mohadjer M; Silviculture. Tehran University Press, Tehran. 2005; 387.
12. Akhani H, Djamali M, Ghorbanalizadeh A, Ramezani E; Plant Biodiversity of Hyrcanian relict forest, N Iran: An overview of the flora, vegetation, palaeoecology and conservation. Pakistan Journal of Botany, 2010; 42: 231-258.
13. Naqinezhad **A**, Bahari **SH**, Gholizadeh H, Esmaeili R, Hamzehee B, Djamali **M,** Moradi H**;** A phytosociological survey of two lowland Caspian (Hyrcanian) remnant forests, Northern Iran, for validation of some forest syntax. Phytologia Balcanica, 2012; 18(2): 173-186.
14. Siadati S, Moradi H, Attar F, Etemad V, Hamzeh'ee B, Naqinezhad A; Botanical diversity of Hyrcanian forests; a case study of a transect in the Kheyrud protected lowland mountain forests in northern Iran. Phytotaxa, 2010; 7: 1-18.
15. Jafari SM, Akhani H; Plants of jahan nama protected area, golestan province, N. Iran. Pakistan Journal of Botany, 2008; 40(4): 1533-1554.
16. Balvanera P, Aguirre E; Tree diversity, environmental heterogeneity, and productivity in a Mexican Tropical Dry Forest. Biotropica, 2006; 38(4): 479-491.
17. Krebs CJ; Ecological methodology. Harper and Row, New York. 1999; pp. 547.
18. Pourbabaei H, Asgari F, Reif A, Abedi R; Effect of plantations on plant species diversity in the Darabkola, Mazandaran Province, North of Iran. Biodiversitas, 2012; 13(2): 72-78.
19. Tavankar F; Plant species recovery and natural tree regeneration on skid trails in the Hyrcanian forests of Iran. Journal of Biodiversity and Environmental Sciences, 2012; 2(12): 16-23.
20. Soltani A; Improvement of Seed Germination of *Fagus orientalis* Lipsky. Ph.D. Thesis, Swedish University of Agricultural Sciences. 2003.
21. Ardakani MR; Ecology. Tehran University Press, Tehran. 2007.
22. Hashemi SA; Evaluating Plant Species Diversity and Physiographical Factors in Natural Broad Leaf Forest. American Journal of Environmental Sciences, 2010; 6(1): 20-25.
23. Pourbabaei H, Haghgooy T; Effect of physiographical factors on tree species diversity (case study: Kandelat Forest Park). Iranian Journal of Forest and Poplar Research, 2013; 21(2): 243-255.
24. Kabrickt MJ, Shifley RS; Oak forest composition, Site quality, and dynamics in relation to site factors in the southeastern Missouri Ozarks. USDA Forest Service, 2004; 311.
25. Parma R, Shataee Jouybari, Sh; Impact of physiographic and human factors on crown cover and diversity of woody species in the Zagros forests (Case study: Ghalajeh forests, Kermanshah province). Iranian Journal of Forest and Poplar Research, 2010; 18(4): 539-555.
26. Tavankar F; Effect of Conifer Plantations on Species Diversity of Natural Tree and Regeneration in Caspian Forests, Iran. International Journal of Agriculture: Research and Review, 2013; 3(4): 782-787.
27. Baduni NP, Sharma CM; Population structure and community analysis on different aspects of

Sal-savanna forest type in outer Garhwal Himalaya. Indian Forester, 2006; 127(9): 1001-1011.

28. Tavankar F; Woody species diversity and stand structure along protection gradient in Hyrcanian lowland forests, north of Iran. Journal of Biodiversity and Environmental Sciences, 2013; 3(8): 29-35.
29. Tvankar F, Mahmoudi J, Iranparast Bodaghi A; The effect of single selection method on tree species diversity in the Northern forests of Iran (Case study: Asalem-Nav, Guilan province). Journal of Science and Technology of Natural Resources, 2011; 6(1): 27-40.