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Woody species diversity and stand structure along protection gradient in Hyrcanian lowland forests, North of Iran

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Key words: Biodiversity, Hyrcanian forest, restored forest, richness, Shannon-Wiener index.

Abstract

In this research woody species diversity and stand structure were studied in three different protection levels in Hyrcanian lowland forests: restored forest, where the protection level is very high, managed forest, which allows selective harvest of trees, and open access forest, where human population have unrestricted access to forest resources. The results showed that the number of woody species was highest in the restored forest (21 species) and was the lowest in the open access forest (13 species). The Box trees (Buxus hyrcana) that are rare in the Hyrcanian lowland forests had a highest species importance value (SIV) in the restored forest, that were not observed in the managed and open access forests. The Shannon-Wiener diversity index for woody species was the highest in the managed forest (1.05) and was the lowest in the open access forest (0.81). The tree and seedling density was the highest in the restored forest (191 and 447 stem/ha) and was the lowest in the open access forest (121 and 86 stem/ha). The managed forest had the highest basal area value (17.9 m2/ha) while the open access forest had the lowest (12.5 m2/ha)

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Introduction

Biodiversity refers to the natural variety and the physical organization or pattern of the variability among living organisms (Putz, 2000). However, researchers generally accept three levels of biodiversity: genetic, species, and ecosystem, but biodiversity studies typically focus on species. Species diversity is an important index in community ecology (Mayer and Harms, 2009). Species diversity at the property, compartment and stand level contributes to the habitat value and biodiversity of a forest. Forest ecosystems provide habitat for a disproportionate share of the world's biological diversity. Forests are among the most diverse and complex ecosystems in the world, providing a habitat for a multitude of flora and fauna. It is widely demonstrated that more species contribute to greater ecosystem stability. Structural characteristics of forest stands are widely recognized to be of fundamental importance for biodiversity (Noss, 1999; Ferris and Humphrey, 1999). Nowadays, forest management practices increasingly promote conservation and enhancement of biodiversity. 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 (Carey and Curtis, 1996; Hunter, 1999). It is now widely accepted that forests should be managed in an ecologically sustainable fashion (Kohm and Franklin, 1997; Lindenmayer et al., 2000). 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. During the last few decades Hyrcanian forests in the North of Iran were subjected to various human pressures like agriculture, road construction, monoculture afforestation and other activities (Poorzady and Bakhtiari, 2009). Degraded plant communities are generally quite difficult or sometimes impossible to restore (Van Diggelen and Marrs, 2003). The 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. 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 (Mossadegh, 1996). They are suitable habitats for a variety of hardwood species (approximately 80 woody species) and include various forest types (Marvi Mohadjer, 2005). On the base of altitude and vegetation structure, Hyrcanian forests could be divided into three subdivisions: lowland, submontane and montane forests (Akhani et al., 2010; Siadati et al., 2010; Naqinezhad et al., 2012). Today, the Hyrcanian lowland forests are degrading and deforesting rapidly due to population growth and associated socio-economic problems, industrial development, urbanism and more recently intensive irregular tourism (Poorzady and Bakhtiari, 2009; Akhani et al., 2010). Fully protected areas such as National Parks are often assumed to be the best way to conserve plant diversity and maintain intact forest composition and structure (Banda et al. 2006). Forest management typically has a marked affect on plant species diversity, which is an important ecological indicator (Lindenmayer et al., 2006). In this research effect of three levels of forest protection on woody species diversity and stand structure were studied in the Hyrcanian lowland forests. The forest protection levels that were studied includes, restored forest, managed forest and open access forest.

Material and methods

Study area

This study was carried out in the Hyrcanian lowland forest in Guilan province in the north of Iran that located between 37° 37' 0" to 37° 39' 0" N and 49° 0' 10" to 49° 0' 40" E and -20 to +20 m from sea level. The climate is temperate on based of Demarton classification and is very wet, with a mean annual temperature of 15.7 ˚C and mean annual precipitation of 1306 mm for along with the 1990 to 2008 years. Three forest areas with different protection levels were selected that includes: 1) Restored forest, that protection level is high and were not allowed cutting, hunting, domestic grassing and tourism in this forest. 2) Managed forest, that protection level is moderate

and management method is selectively logged and was not allowed cutting, hunting, domestic grassing and tourism in this forest. 3) Open access forest that protection level is low, where human population has unrestricted access to forest resources and domestic grassing.

Collection of data

Data were collected by systematic sampling design and in each forest stand 20 sample plots with an area 400 m2 (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 (Balvanera and Aguirre, 2006). 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 biodiversity indices, also species richness (S) was number of species per plot. 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 (Krebs, 1999; Sharma et al., 2009; Pourbabaei et al., 2012):

$$H' = - \Sigma ni / n \, Log2 \, ni / n \quad (1)$$

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

$$\text{Relative Density(RD)} = \frac{\text{Density of one species}}{\text{Total density}} \times 100 \quad (3)$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of one species}}{\text{Total frequency}} \times 100 \quad (4)$$

$$\text{Relative Dominance/Basal area (RDB)} = \frac{\text{Basal area of one species}}{\text{Total basal area}} \times 100 \quad (5)$$

$$SIV = RD + RF + RDB \quad (6)$$

Where, ni 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. 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 in the three stand types 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 21 woody species were recorded in sample plots that 17 (80.9%) were trees and 4 (19.1%) were shrubs (Table1). The number of woody species in restored, managed and open access forests was 21, 16 and 13 species (Table1). The Box tree (Buxus hyrcana) had a highest species importance value (SIV) in the restored forest, but Alder tree (Alnus glutinosa) has a highest SIV in the managed and open access forests. The trees of Buxus hyrcana, Acer cappadocicum, Zelkova caprinifolia, Diospyrus lotus, Ulmus minor, Populus nigra, Fraxinus excelsior and the shrub Ruscus hyrcanus were not observed in the open

access forest. The trees of Populus nigra were observed only in restored forest. The tree of Prunus avium has a lowest SIV in the three forest areas. The simplest and seemingly most straightforward measure of biodiversity is the number of species present in a specified area. The presence of 17 trees and 4 shrubs species in study area indicates considerable woody species diversity in the Hyrcanian lowland forest.

Table 1. . Species importance value (SIV) of woody plants in forest protection types.

Woody species	Tree/Shrub	Restored forest	Managed forest	Open access forest
Buxus hyrcana Pojark.	T	141.2	11.6	-
Parrotia persica (dc.)	T	43.2	55.9	53.8
Quercus castaniefolia Gled.	T	40.3	51.0	33.8
Alnus glutinosa (L.)	T	34.4	68.7	81.7
Pterocarya fraxinifolia (Lam.)	T	10.1	18.1	43.8
Carpinus betulus L.	T	8.2	48.5	56.4
Acer insigne Boiss.	T	3.6	22.4	18.4
Acer cappadocicum Gled.	T	3.5	11.2	-
Zelkova caprinifolia (Pall.)Diopp	T	3.5	8.4	-
Mespilus germanica l.	Sh	3.2	0.7	3.6
Diospyrus lotus l.	T	1.9	0.7	-
Ulmus minor Miller.	T	1.1	0.7	-
Gleditschia caspica Desf.	T	1.0	-	2.3
Albizzia julibrissin Durazz.	T	0.8	-	1.6
Ilex spinigera (Loes)loes	Sh	0.8	0.7	0.8
Prunus divaricata Ledeb.	Sh	0.7	-	1.1
Ruscus hyrcanus Woron.	Sh	0.7	0.5	-
Populus nigra L.	T	0.5	-	-
Fraxinus excelsior L.	T	0.5	0.5	-
Ficus carica L.	T	0.5	-	1.6
Prunus avium L.	T	0.3	0.4	1.1
Total	-	300	300	300

(-): Absence of species

It is widely demonstrated that forest trees and other woody plants help support many other organisms and have developed complex mechanisms to maintain high levels of biodiversity. Different tree species, also occupy different layers within the forest canopy. The number of woody species was reported 11 tree species and 3 shrub species in the Dr. Dorostkar's Forest Reservoir that located in Hyrcanian lowland forest (Nobakht et al., 2011). While, in this research 21 woody species (17 trees and 4 shrubs) were found in a restored forest in the Hyrcanian lowland area.

Ghazoul and Hellier (2000) suggested that species richness alone may not be a good indicator of the recovery of forest biodiversity. The results of this study showed that the Shannon-Wiener diversity index (H') was the highest in the managed forest (1.05) and was the lowest in the restored forest (0.83). The Shannon-Wiener diversity index in the restored and open access forests were not significant differences at $\alpha = 0.05$, but were significantly lower than managed forest (Table3). However, Shannon-Wiener diversity index in the restored forest was lower than managed forest, but has a higher value of species richness. The value of Shannon-Wiener diversity index for trees in selectively logged stand was reported 0.88 in the Hyrcanian Fagetum stand (Tavankar et al., 2011). The increased light levels in the forest under storey after selective logging usually result in the sudden occurrence of many herbaceous and woody pioneer species (Woods, 1989; Nykvist, 1996; Pinard et al., 1996; Cochrane and Schultze, 1999; Fredericksen and Mostacedo, 2000; Pinard et al., 2000).

The values of species richness in the restored, managed and open access forests were 7.3, 4.1 and 3.2 species and have significantly differences at α = 0.05. The managed forest has a highest of evenness value. The evenness values in the restored, managed and open access forests were 0.33, 0.51 and 0.41 (Table2).

Table 2. Mean ± standard error of biodiversity indices in forest protection types.

Biodiversity indices*	Restored forest	Managed forest	Open access forest
Diversity (H')	0.83 ± 0.11b	1.05 ± 0.13a	0.81 ± 0.10b
Evenness (J)	0.33 ± 0.07c	0.51 ± 0.09a	0.41 ± 0.07b
Richness (S)	7.3 ± 1.01a	4.1 ± 1.06b	3.2 ± 0.83c

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

Table 5. Analysis of variance (ANOVA) for effect of forest protection types on biodiversity indices and characteristics of stand structure

	SS	DF	MS	F	P-Value
Shannon-Wiener diversity index (H')	0.709	2	0.355	28.72	0.000**
Pielou's evenness index (J)	0.325	2	0.163	26.16	0.000**
species richness (S)	185.73	2	92.87	98.32	0.000**
Canopy cover (%)	5954.4	2	2977.24	49.32	0.000**
Stand Basal area (m2/ha)	342.6	2	171.32	14.21	0.000**
Tree density (stem/ha)	49691	2	24845	92.15	0.000**
Seedling density (stem/ha)	1341144	2	670572	693.11	0.000**

**: Significance at α=0.01.

The tree and seedling density in the restored forest was significantly more than managed and open access forests (Table3). The seedling density was the lowest in the open access forest. This is partly due to the human disturbance such as livestock grazing. Also, tree and seedling density in the managed forest was significantly more than open access forest (α = 0.05). The managed forest had a highest basal area (17.9 m2/ha) and the open access forest had a lowest basal area (10.62 m2/ha). As shown in table 3, the canopy cover in restored forest was significantly higher (α = 0.05) than managed and open access forests.

Table 3. Mean ± standard error of characteristics of stand structure in forest protection types

Stand structure	Restored forest	Managed forest	Open access forest
Stand Basal area (m2/ha)	13.3 ± 4.2b	17.9 ± 2.9a	12.5 ± 3.2b
Tree density (stem/ha)	191.3 ± 22.2a	169.4 ± 8.7b	121.1 ± 16.2c
Seedling density (stem/ha)	447.1 ± 32.7a	322.3 ± 38.1b	86.5 ± 19.5c
Canopy cover (%)	83.1 ± 8.4a	78.0 ± 7.9a	59.9 ± 6.9b

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

The results of analysis of variance (ANOVA) showed that basal area, tree density, seedling density, canopy cover and values of Biodiversity indices (H', J and S) of woody species have significant statistically differences in three stand types (P < 0.05).

The forest biodiversity guidelines focus on how best to conserve and enhance biodiversity in forests, through appropriate planning, conservation and management. Considering to the results the species richness, seedling and tree density was higher in the fully protected forest (restored forest) and was lower in the low level of forest protection (open access forest). But, the Shannon-Wiener diversity index for woody species was highest in the managed forest (1.05) and was the lowest in the open access forest (0.81). Also, the stand basal area was highest in the managed forest. Forest protection should aim at ensuring that forests continue to perform all their productive, socio-economic and environmental functions in the future. Understanding the effects of forest management practices on plant species diversity is important for achieving ecologically sustainable forest management (Banda et al., 2006; Nagaike et al., 2006; Tavankar et al., 2011).

Conclusion

The results of this study indicated that special stands (e. g. Buxetum) needs to fully protection strategies for conservation of woody species and stand structure in the Hyrcanian lowland forests. The seedling density is very low in the open access forest and this condition can be a threat factor to sustainability of these forests.

References

Akhani H, Djamali M, Ghorbanalizadeh A, Ramezani E. 2010. Plant biodiversity of Hyrcanian relict forest, N Iran: An overview of the flora, vegetation, palaeoecology and conservation. Pakistan Journal of Botany 42, 231-258.

Banda T, Schwartz MW, Caro T. 2006. Woody vegetation structure and composition along a protection gradient in a Miombo ecosystem of western Tanzania. Forest Ecology and Management 230, 179-185.

Balvanera P, Aguirre E. 2006. Tree diversity, environmental heterogeneity, and productivity in a Mexican Tropical Dry Forest. Biotropica 38(4), 479-491.

Carey AB, Curtis RO. 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. Wildlife Society Bulletin 24(4), 610-620.

Cochrane MA, Schultze MD. 1999. Fire as a recurrent event in tropical forests of the eastern Amazon: effects on forest structure, biomass, and species composition. Biotropica 31(1), 2–16.

Ferris R, Humphrey JW. 1999. A review of potential biodiversity indicators for application in British forests. Forestry 72(4), 313-328.

Fredericksen TS, Mostacedo B. 2000. Regeneration of timber species following selection logging in a Bolivian tropical dry forest. Forest Ecology and Management 131, 47–55.

Ghazoul J, Hellier A. 2000. Setting critical limits to ecological indicators of sustainable tropical forestry. International Forestry Review 2, 243-253.

Hunter ML. 1999. Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, UK. pp. 698.

Kohm K, Franklin JF. 1997. Forestry in 21st century, Island press, Covelo California. p. 475.

Krebs CJ. 1999. Ecological methodology. Harper and Row, New York. p. 547.

Lindenmayer DB, Margules CR, Botkin DB. 2000. Indicator of biodiversity for ecologically sustainable forest management. Conservation Biology 14(4), 941-950.

Lindenmayer DB, Franklin JF, Fischer J. 2006. General management principles and a checklist of strategies to guide forest biodiversity conservation. Biological Conservation 131(3), 433–445.

Marvi Mohadjer M.2005. Silviculture. Tehran University Press, Tehran. p. 387.

Mossadegh A. 1996. Silviculture. Tehran University Press, Tehran. p. 481.

Myers JA, Harms KE. 2009. Seed arrival, ecological filters, and plant species richness: a meta-analysis. Ecology Letters 12(11), 1250–1260.

Nagaike TA, Hayashi A, Kubo M, Abe MN, Arai N. 2006. Plant species diversity in a managed forest landscape composed of Larix kaempferi plantations and abandoned coppice forests in Central Japan. Forest Science 52(3), 324–332.

Naqinezhad A, Bahari SH, Gholizadeh H, Esmaeili R, Hamzehee B, Djamali M, Moradi H. 2012. A phytosociological survey of two lowland Caspian (Hyrcanian) remnant forests, Northern Iran, for validation of some forest syntax. Phytologia Balcanica 18(2), 173-186.

Nobakht M, Pourbabaei H, Beygom faghir M, Abedi R. 2011. Variations of diversity indices and Species Importance Value (SIV) of Plant species in the Dr. Dorostkar's Forest Reservoir Area, Gisum, Talesh. Journal of Natural Environment 63(4), 389-398.

Noss RF. 1999. Assessing and monitoring forest biodiversity: a suggested framework and indicators. Forest Ecology and Management 115, 135-146.

Nykvist N. 1996. Regrowth of secondary vegetation after the 'Borneo fire' of 1982–1983. Journal of Tropical Ecology 12, 307–312.

Poorzady M, Bakhtiari F. 2009. Biogeosciences and Forestry. iForest 2, 198-206.

Pinard M, Howlett B, Davidson D. 1996. Site conditions limit pioneer tree recruitment after logging of dipterocarp forests in Sabah, Malaysia. Biotropica 28(1), 2–12.

Pinard MA, Barker MG. Tay J. 2000. Soil disturbance and post-logging forest recovery on bulldozer paths in Sabah, Malaysia. Forest Ecology and Management 130, 213–225.

Pourbabaei H, Asgari F, Reif A, Abedi R. 2012. Effect of plantations on plant species diversity in the Darabkola, Mazandaran Province, North of Iran. Biodiversitas 13(2), 72-78.

Putz FE. 2000. Some roles of North American ecologists in land-use planning in the tropics. Ecological Applications 10, 676-679.

Sharma CM, Suyal S, Gairola S, Ghildiyal SK. 2009. Species richness and diversity along and altitudinal gradient in moist temperate forest of Garhwal Himalaya. Journal of American Science 5(5), 119-128.

Siadati S, Moradi H, Attar F, Etemad V, Hamzeh'ee B, Naqinezhad A. 2010. Botanical diversity of Hyrcanian forests; a case study of a transect in the Kheyrud protected lowland mountain forests in northern Iran. Phytotaxa 7, 1-18.

Tvankar F, Mahmoudi J, Iranparast Bodaghi A. 2011. 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 6(1), 27-40.

Van Diggelen R, Marrs RH. 2003. Restoring plant communities: introduction. Applied Vegetation Sciences 6(2), 106–110.

Woods P. 1989. Effects of logging, drought and fire on structure and composition of tropical forests in Sabah, Malaysia. Biotropica 21(4), 290-298.