Effect of plantations on plant species diversity in the Darabkola, Mazandaran Province, North of Iran

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ABSTRACT

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: 72-78. In this study, the effect of plantations on plant species diversity was investigated in Darabkola, Mazandaran province, north of Iran. To conduct the study, a natural mixed forest, a broad–leaved plantation (*Alnus subcordata-Acer velutinum*) and a coniferous plantation (*Cupressus sempervirens* var. *horizontalis-Pinus brutia*) were selected. 35 sampling plots were taken in systematic random method in each area. Data analysis was carried out using Simpson, Hill's N_2, Shannon-Wiener and Mc Arthur's N_1 diversity indices, Smith and Wilson evenness index and species richness. Results revealed that there were 32 plant species in natural forest and 30 plant species were found in each plantation. Rosaceae and Lamiaceae were the main families in the studied areas. Diversity and evenness indices of all vegetation layers had the most values in the natural forest. Richness of woody plants had the highest value in the natural forest, while herbaceous richness was the highest in coniferous plantation. Mc Arthur's N1 had the highest value among diversity indices and followed by Hill's N_2, Shannon-Wiener and Simpson indices, respectively. In addition, results showed that there were significant differences among diversity, evenness and richness indices in all vegetation layers in the three studied areas.

Key words: plantation, plant species diversity, Darabkola, Mazandaran.

INTRODUCTION

Afforestation and replanting programs have helped reverse the decline of forest cover. Currently 3% of the world's forests are plantations, comprised of 60 million hectares in developed nations and 55 million hectares in developing nations (Hartley 2002). Forest plantations that achieve yields corresponding to site potential are part of the economic growth of forest resources; such economic growth should not be hampered by a lack of ecological information. Conservation and enhancement of biological diversity is a key component of sustainable forest management in vegetation communities (Jobidon et al. 2004). Conservation of ecological services, prevent a lack of special species and aesthetics values, attention to principles of forest management, promote social and commercial of medical and industrial plants are the most important components of biodiversity conservation in forest plans (Pilehvar 2000). Biodiversity has been an important objective of forest management, because it provides a broader array of ecosystem services (Wang and Chen 2010).

There is a common belief that forest management negatively influences biodiversity (Wagner et al. 1998). Plantations are often viewed unfavorably compared to natural forests by the public and conservation biologists, because of the lack of biodiversity (Perley 1994; Potton 1994; Freedman et al. 1996). Plantations usually include exotic and non-native species, or native species in pure stands. Plantations contribute to biodiversity conservation variously. Most directly, plantations can contain substantial components of biotic diversity across many taxa (Ferns et al. 1992; Allen et al. 1995; Michelsen et al. 1996; Chey et al. 1997; Estades and Temple 1999), including rare species in some cases (Norton 1998; Tucker et al. 1998; Wilson and Watts 1999). Even exotic plantations can help to restore native biota to degraded sites by stabilizing soil and creating site conditions suitable for native animals and plants to recolonize (Lugo 1997). Plantations are most likely to contribute positively to biodiversity conservation when used to reforest degraded or deforested areas (Moss et al. 1979; Evans 1982; Moore and Allen 1999). In addition, plantations can benefit landscape composition (Estades and Temple 1999). It may seem that the best use of all plantations would be to maximize fiber production while minimizing costs (Moore and Allen 1999), but this assumes that plantations will increase the amount of natural forests that are taken out of production or harvested minimally. Replacement of native forest with exotic tree plantation could cause important changes in diversity and composition of community in local and regional scale (Brockerhoff et al. 2001).

The most disputed of plantation management is extensive use of exotic species in plantations (Potton 1994; Tucker et al. 1998). Most studies suggested that poly-culture plantations have abundant and diverse flora and fauna more than monocultures (Baguette et al. 1994; Donald et al. 1997; Khanna 1997; Twedt et al. 1999;

Humphrey et al. 2002; Carnus et al. 2006), especially where native species are planted. Poly-culture plantations are generally host of many animal species because of the strong relationship between native plant diversity and animal diversity within a divers forest stand (Braganc et al. 1998; Donald et al. 1998). Using native fast growing species such as *Alnus subcordata* and *Acer velutinum* increase the yield potential in short rotations caused by decreasing timber harvesting in natural forest in the north of Iran; on the other hand, these forests could play their environmental roles. Also, using native species in planta-tions could decrease the concern of adaptation and being infected the pests and diseases. The study on plantation in Iran and the other part of the world was extended in recent decades (Abdy and Mayhead 1992; Allen et al. 1995; Menalled et al. 1998; Ferris et al. 2000; Coroi et al. 2004; Lindenmayer and Hobbs 2004; Yamashita et al. 2004; Lee et al. 2005; Lemenih and Teketay 2005; Pourbabaei et al. 2005; Corney et al. 2006; Ginsberg 2006; Mosayeb Neghad et al. 2007; Pourbabaei and Roostami Shahraji 2007; Poorbabaei and Poorrahmati 2009).

The study on herbaceous species diversity in Lajim, Mazandaran province in Iran showed that herbaceous species diversity in natural broad–leaved forest was significantly more than coniferous plantation (Ghelichnia 2003). In addition, comparison of plant biodiversity in *Alnus subcordata* and *Acer velutinum-Fraxinus excelsior* plantations in Guilan province of Iran indicated that diversity indices (Shannon-Wiener and Mc Arthur's N_1), evenness index and species richness in *Acer velutinum-Fraxinus excelsior* was more than *Alnus subcordata* plantation and there was no significant difference between plantations in diversity and evenness indices, but there was a significant difference in richness (Pourbabaei et al. 2005). The investigation of biodiversity indices (Simpson, Menhinick richness and Peet's evenness) of woody species in mixed coniferous stand of *Pinus nigra-Picea abies* and natural broad-leaved coppice stand revealed that the most number of native species was recorded in natural broad-leaved coppice stand, but richness and evenness indices had lower value in natural forest (Memarian et al. 2007). Comparison of vegetation diversity in forest floor and fauna diversity in coniferous and broad–leaved plantations showed that flora and fauna diversity was lower in coniferous plantation. Therefore, the forest floor diversity could be a criterion to realize the effect of plantation on wildlife diversity (Magurran 1996).

Considering the necessity of plantation and importance of biodiversity conservation in all life forms (tree, shrub, herb and regeneration) in the north forests of Iran, the objec-tive of this study was the investigation and comparison of the effects of plantation on plant species diversity in Darabkola's region, Mazandaran province, north of Iran.

MATERIALS AND METHODS

Study area

Three areas were selected including broad–leaved plantation consist of *Acer velutinum* and *Alnus subcordata* (parcel No. 30), coniferous plantation of *Cupressus sempervirens* var. *horizontalis* and *Pinus brutia* (parcel No. 40) and natural broad-leaved mixed forest (parcel No. 29), which located in district No. 1 of Drarabkola region in Mazandaran province, north of Iran and had 11, 14 and 15 ha area, respectively. These areas located in 36º 28 00 N latitude and 52º 31 00 E longitude in watershed No.74. Average altitude is 300 m asl. in broad-leaved plantation, 270 m asl. in coniferous plantation and 450 m asl. in natural forest. Average slope in the most parts of all regions was 30 and general aspect was northern (Figure 1).
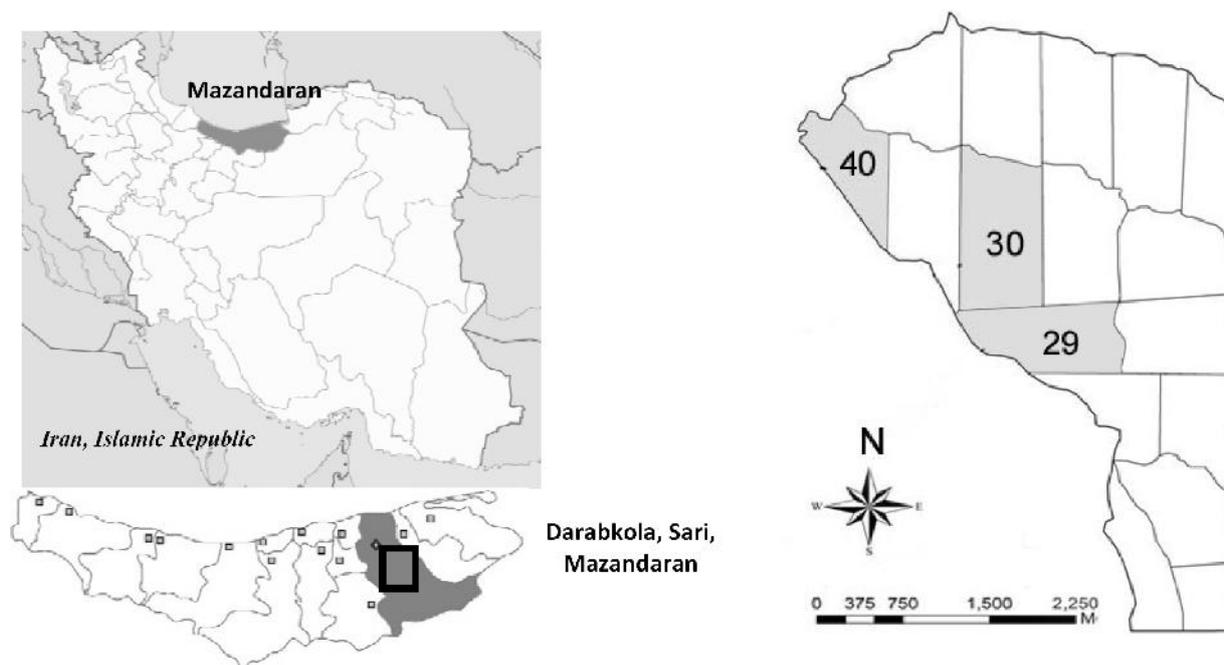
Figure 1. Location of the study area, Darabkola, Sari district, Mazandaran Province in northern Iran. Parcel no. 29. Natural stand, parcel no. 30. Broad leaved plantation, parcel no. 40. Coniferous plantation.

Procedures

The sampling method was systematic random. 35 sampling plots were surveyed in each area. All tree species (diameter at breast height, DBH   10 cm) were identified and measured, and shrub species and seedlings (DBH < 10 cm) were identified and counted in 400 m^2 (20 m × 20 m) sampling plots. Cover percentage of herbaceous species were estimated according to Braun-Blanquet criterion in 64 m^2 (8 m × 8 m) circular plots obtained minimal area method (Poorbabaei and Poorrahmati 2009; Eshaghi Rad et al. 2009).

Simpson (1-D) and Hill's N$_2$ diversity indices were used due to more sensitivity to the most frequent plant species. Shannon-Wiener (H) and Mc Arthur's N$_1$ diversity indices were used due to more sensitivity to frequency of rare species. Smith and Wilson evenness index (E$_{var}$) was used to study the distribution of individual among species. Diversity and evenness indices of each plot were calculated using Ecological Methodology software. Species richness (S) was number of species per plot (Krebs 1999). Finally, Jaccard's similarity index was used to find similarity among regions (Pourbabaei 2004):

$$JI = \frac{a}{a+b+c}$$

JI: Jaccard's index, a: number of common species in samples or communities, b: number of species that exist just in first sample or community, c: number of species that exist just in second sample or community.

Three studied areas were compared using one-way ANOVA and Tukey's test.

RESULTS AND DISCUSSION

Results

Results showed that natural forest has 32 plant species, which consist of 10 trees, 4 shrubs and 18 herbaceous species. 30 plant species were recorded in *Alnus subcordata-Acer velutinum* broad–leaved plantation including 7 trees, 5 shrubs and 18 herbaceous species, and 30 plant species including 8 trees, 4 shrubs and 18 herbaceous species were presented in *Cupressus*

sempervirens var. *horizontalis-Pinus brutia* coniferous plantation (Table 1). Values of biodiversity indices in tree, shrub, herbaceous and regeneration layers had higher values in the natural forest (Table 2).

Natural forest had the highest value of evenness in all vegetation layers and coniferous plantation had the lowest value (Table 3). Natural forest had the highest value of species richness in all vegetation layers other than herbaceous layer (this layer had the most value in broad–leaved plantation) (Table 4). ANOVA test indicated that there were significant differences among diversity, evenness indices and richness in all vegetation layers in the three studied areas ($P < 0.05$) (Table 5).

In tree layer, the results of Tukey test ($P < 0.05$) revealed that there was no significant difference between natural forest and broad–leaved plantation in Simpson, Shannon–Wiener and evenness indices. While, natural forest and coniferous plantation had significant difference in all diversity indices. Also, broad–leaved and coniferous plantations had significant differences in all diversity indices in this layer.

In shrub layer, Tukey test revealed that there was no significant difference between natural forest and broad–leaved plantation in all diversity indices. In addition, broad–leaved and coniferous plantations had significant difference in species richness. There was significant difference between natural forest and coniferous plantation in all indices in this layer.

In herbaceous layer, Tukey test indicated that there was no significant difference between natural forest and broad–leaved plantation, but there was significant difference between natural forest and coniferous plantation in all indices. In addition, broad–leaved and coniferous plantations had significant differences in all indices except evenness index.

In regeneration layer, Tukey test showed that there was no significant difference between natural forest and broad–leaved plantation, but natural forest and coniferous plantation and also two plantations had significant differences in all indices.

Jaccard's similarity index revealed that natural forest and broad–leaved plantation had the most similarity in woody and herbaceous layers, and the lowest value was between natural forest and coniferous plantation (Table 6).

Table 2. Mean and standard errors values of diversity indices in different vegetation layers in the studied areas

Vegetation layers		1-D	N2	H'	N1
Natural forest	Tree	0.32 ± 0.03	1.47 ± 0.10	0.76 ± 0.07	1.68 ± 0.11
	Shrub	0.21 ± 0.03	0.91 ± 0.13	0.46 ± 0.07	1.03 ± 0.15
	Herb	0.56 ± 0.04	2.94 ± 0.25	1.96 ± 0.12	3.53 ± 0.27
	Regeneration	0.40 ± 0.03	1.75 ± 0.08	0.92 ± 0.06	1.94 ± 0.08
Broad–leaved plantation	Tree	0.24 ± 0.04	1.01 ± 0.16	0.52 ± 0.08	1.07 ± 0.17
	Shrub	0.15 ± 0.03	0.66 ± 0.13	0.33 ± 0.07	0.73 ± 0.15
	Herb	0.55 ± 0.03	2.73 ± 0.19	1.61 ± 0.09	3.34 ± 0.22
	Regeneration	0.34 ± 0.03	1.50 ± 0.13	0.81 ± 0.08	1.68 ± 0.14
Coniferous plantation	Tree	0.05 ± 0.01	0.31 ± 0.08	0.12 ± 0.03	0.34 ± 0.09
	Shrub	0.09 ± 0.02	0.35 ± 0.09	0.17 ± 0.04	0.37 ± 0.10
	Herb	0.18 ± 0.04	0.81 ± 0.18	0.47 ± 0.10	0.94 ± 0.21
	Regeneration	0.19 ± 0.04	0.80 ± 0.17	0.41 ± 0.09	0.87 ± 0.18

Note: 1-D = Simpson diversity index, N$_2$ = Hill's diversity index, H = Shannon-Wiener diversity index, N$_1$ = Mc Arthur's diversity index

Table 3. Mean values of evenness in different vegetation layers in the studied areas

Vegetation layers	Natural forest	Broad–leaved plantation	Coniferous plantation
Tree	0.56 ± 0.05	0.43 ± 0.07	0.11 ± 0.03
Shrub	0.35 ± 0.05	0.28 ± 0.06	0.15 ± 0.04
Herbaceous	0.55 ± 0.04	0.42 ± 0.04	0.25 ± 0.05
Regeneration	0.62 ± 0.03	0.51 ± 0.05	0.28 ± 0.06

Table 4. Mean values of species richness in different vegetation layers in the studied areas

Vegetation layers	Natural forest	Broad–leaved plantation	Coniferous plantation
Tree	2.26 ± 0.13	1.71 ± 0.13	1.71 ± 0.07
Shrub	1.83 ± 0.16	1.37 ± 0.14	0.88 ± 0.14
Regeneration	2.51 ± 0.12	2.43 ± 0.21	1.46 ± 0.23
Herbaceous	5.43 ± 0.44	6.17 ± 0.49	1.57 ± 0.34

Table 5. Results of ANOVA analysis of diversity, evenness indices and richness in different vegetation layers

Vegetation layers	Biodiversity indices	Mean square	df	F	*P*-Value
Tree	1-D	0.665	2	17.021	0.000
	N_2	12.061	2	18.419	0.000
	H	3.609	2	17.918	0.000
	N_1	15.890	2	21.286	0.000
	E_{var}	1.906	2	15.474	0.000
	S	10.314	2	23.483	0.000
Shrub	1-D	0.130	2	2.914	0.059
	N_2	2.814	2	4.179	0.018
	H	0.783	2	4.146	0.019
	N_1	3.782	2	4.739	0.011
	E_{var}	0.381	2	3.164	0.046
	S	8.267	2	10.890	0.000
Herb	1-D	1.666	2	26.453	0.000
	N_2	48.317	2	19.534	0.000
	H	16.312	2	27.282	0.000
	N_1	73.398	2	23.602	0.000
	E_{var}	0.823	2	8.307	0.000
	S	213.438	2	33.905	0.000
Regeneration	1-D	0.426	2	7.432	0.000
	N_2	8.453	2	8.663	0.000
	H	2.486	2	7.957	0.000
	N_1	10.946	2	9.751	0.000
	E_{var}	1.072	2	9.391	0.000
	S	12.067	2	9.185	0.000

Note: 1-D = Simpson diversity index, N_2 = Hill's diversity index, H = Shannon-Wiener diversity index, N_1 = Mc Arthur's diversity index, E_{var} = Smith and Wilson evenness index, S = species richness.

Table 6. Percentage of Jaccard's similarity index of woody and herbaceous species in the studied areas

Study area	Woody species	Herbaceous species
Natural forest-Broad–leaved plantation	0.63	0.50
Natural forest-Coniferous plantation	0.37	0.40
Broad–leaved plantation-Coniferous plantation	0.50	0.38

Discussion

There is no single or simple answer to the question of whether planted forests are good or bad for biodiversity. Plantations can have either positive or negative impacts on biodiversity of the tree, stand or landscape level (Hartley 2002; Zerbe 2002; Lindenmayer and Hobbs 2004; Ginsberg 2006; Paritsis and Aizen 2007). It has been argued that plantation may protect natural biodiversity indirectly by enabling greater wood production from smaller, intensively managed areas, thus sparing remaining natural forests harvesting pressure (Carnus et al. 2006).

In our study, the number of tree species recorded in the natural forest, broad–leaved and coniferous plantations were 10, 8 and 7, respectively. Grazing, collection of litter and dry branches may be most likely reduced in woody species number in plantations (Yirdaw and Luukkanen 2003), and forest managers should pay attention to the natural composition of forest communities (Eshaghi Rad et al. 2009). In this study, species of shrubs was higher in broad–leaved plantation. Plantation management studies have shown that shrub species are more resistant and recover more easily than tall tree species (Nagaike 2002)

We found that number of plant species in natural forest were significantly higher than plantations. Single species plantations have often been criticized for being associated with a low level of biodiversity in the ecosystems (Montagnini et al. 1995; Lindenmayer and Hobbs 2004). High biological diversity at the landscape level could bring about many benefits from forests including wood production, water and environmental conservation, carbon stocking, education and science recreation. To achieve this objective, it is essential to retain some natural forests in the reforestation area, avoiding large scale clear-cutting (Kamo et al. 2002).

Tree species richness and evenness were the lowest values in coniferous plantation. It seems that due to lack of attention to the mix structure and presence of many individuals of two species include *Cupressus sempervirens* var. *horizontalis* and *Pinus brutia* reduced evenness in this site. It was stated that species richness and evenness were the most in natural forest and the least in *Acer velutinum* and *Pinus taeda* plantations in the north of Iran (Baktash 2003).

Also, we found that diversity of herbaceous species in natural forest is more than plantations. Ghelichnia (2003) showed the same results in the comparison of diversity in natural hardwood stand and softwood plantation in Mazandaran province, north of Iran.

Investigation on the relation of plant diversity, planting distance and soil types in native and exotic pine plantations showed that more planting distance caused more richness, less woody species abundant and more coverage of herbaceous species. Also, light absorption of pine's needles and their fallings had negative impact on plant diversity (Newmaster et al. 2006). Broad–leaved deciduous species increase the organic matter of soil and caused soil productivity (Jalali et al. 2007).

Results of this study revealed that seedling had been established in broad–leaved plantation. The growth of under storey is influenced by various factors, including

competition for light and nutrients, pattern tree regeneration, soil and microclimatic effects and past stand conditions (disturbance) (Kamo et al. 2002). It remains to be determined which factors were most important in our study stands. Many studies considered that plantations should be managed to produce natural regeneration instead of clear cut (Kamo et al. 2002; Nagaike 2002; Nagaike et al. 2006; Koonkhunthod et al. 2007). Increasing structural complexity could attract seed dispersing wildlife and thus increase seed inputs from neighboring native forest (Koonkhunthod et al. 2007). Natural forests as a seed source, the forest plantations should be established contiguous to natural forest stands or, if that is not possible, plantation corridors may be established (Yirdaw and Luukkanen 2003). Different plant and animal species that guaranty the environmental health, adapted to native trees thus native tree species should accompany exotic tree species in plantations (Hartley 2002). Investigation of stand structure and species diversity of *Notofagus dombeyi* and pine plantations showed that plantation of exotic pine species had significant effect on reduction of biodiversity and species richness and changed vegetation structure (Paritsis and Aizen 2007).

Natural forest had the most value of richness in regeneration layer in our study, and minimum regeneration was considered in coniferous plantation because of closed canopy cover and litter in forest floor. Also, silvicultural treatments (especially releasing in broad–leaved plantation) caused the growth of invasive species such as *Rubus hyrcanus* that prevented regeneration growth in broad–leaved plantation, but this problem was less in natural forest due to the canopy coverage of seed trees that are the best shelter of lighting conditions to survival of natural regeneration. Nevertheless, total number of regeneration was low in natural forest because of the forest degradation and the less abundance of regeneration of *Fagus orientalis* and *Quercus castaneifolia*, in contrast regeneration of *Parrotia persica* was high. It seems that thinning could help increase structural diversity. Then, structural diversity maintains plant diversity

Table 1. List of plant species in the studied areas

Scientific name	Family name	Natural forest	Coniferous plantation	Broad–leaved plantation
Acer velutinum Boiss.	Aceraceae	+	+	-
Alnus subcordata C. A. Mey	Betulaceae	+	+	-
Artemisia annua L.	Asteraceae	-	-	+
Asplenium trichomanes L.	Aspleniaceae	+	+	+
Atropa belladonna L.	Solanaceae	+	-	+
Bromus benekenii (L.) Triman	Poaceae	-	+	-
Carex stenophylla Wahlenb.	Cyperaceae	+	+	+
Carpinus betulus L.	Betulaceae	+	+	+
Chenopodium album L.	Chenopodiaceae	-	-	+
Cornus australis C.A. Mey.	Cornaceae	-	+	-
Crataegus microphylla C.Koch	Rosaceae	+	+	+
Cupressus sempervirens var. *horizontalis* G.	Cupressaceae	-	-	+
Diospyros lotus L.	Ebenaceae	+	-	-
Equisetum sp.	Equisetaceae	-	+	-
Fagus orientalis Lipsky.	Fagaceae	+	-	-
Geum urbanum L.	Rosaceae	+	+	-
Gleditsia caspica Desf.	Caesalpinaceae	-	+	+
Hedera pastuchovii Woren.ex. Grossh.	Araliaceae	+	-	-
Hypericum perforatum L.	Hypericaceae	-	+	+
Lamium album L.	Lamiaceae	+	+	+
Lamium amplexicaule L.	Lamiaceae	-	-	+
Mentha pulegium L.	Lamiaceae	+	+	+
Mespilus germanica L.	Rosaceae	+	+	+
Morus nigra L.	Moraceae	+	-	-
Nepeta micrantha Bge.	Lamiaceae	-	-	+
Oplismenus undulatifolius (Ard) P.Beauv.	Gramineae	+	+	-
Oxalis corniculata L.	Oxalidaceae	+	+	+
Parrotia persica (DC.) C.A. Mey.	Hammamelidaceae	+	+	+
Phyllitis scolopendrium(L.) Newm.	Aspleniaceae	+	+	+
Picris pauciflora Willd.	Asteraceae	-	+	-
Pinus brutia Ten.*	Pinaceae	-	-	+
Plagiomnium cuspidatum L.	Mniaceae	+	+	-
Potentilla reptans L.	Rosaceae	-	-	+
Poterium sanguisorba M.	Rosaceae	+	-	-
Prunus divaricata Ledeb.	Rosaceae	+	+	+
Pteris cretica L.	Pteridaceae	+	+	+
Punica granatum L.	Punicaceae	-	-	+
Quercus castaneifolia C. A. Mey	Fagaceae	+	+	+
Robinia pseudoacacia L.*	Papilionaceae	-	-	+
Rubus hyrcanus Juz.	Rosaceae	+	+	+
Rumex acetosa L.	Polygonaceae	-	+	-
Ruscus hyrcanus Woron.	Liliaceaea	+	-	-
Salvia nemorosa L.	Lamiaceae	-	-	+
Scutellaria nepetifolia Benth.	Lamiaceae	+	-	-
Smilax excelsa L.	Liliaceaea	+	-	+
Sorghum sp.	Poaceae	-	+	-
Ulmus glabra Hudson.	Ulmaceae	+	-	-
Veronica persica Poir.	Scrophulariaceae	+	-	-
Viola alba L.	Violaceae	+	+	+
Zelkova carpinifolia (Pall.) Dipp.	Ulmaceae	+	+	+

Note: (+: presence,-: absence, *: Exotic species)

(Jobidon et al. 2004). Plantation management practices, such as weeding, salvage logging and thinning effectively set the plant community back to a previous stage of succession (Nagaike et al. 2003)

There were higher similarity between natural forest and broad–leaved plantation in woody and herbaceous species layers (63 and 50% respectively), while coniferous

plantation and natural forest have the lowest similarity in woody species layer (37%). Poorbabaei and Poorrahmati (2009) considered high similarity in species composition between plantation and adjacent natural forest due to the natural forest was the main source of seed in plantation. Neighboring of plantation and natural forest has been resulted in dispersion of hardwood trees seeds within the plantation.

CONCLUSION

In conclusion, we found that the natural mixed forest had the most plant diversity and plantations reduced species diversity in this area. Also, we found that coniferous species could diminish the biodiversity especially in herbaceous layer more than broad–leaved species in plantations.

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