

The interaction between diversity of herbaceous species and history of planting, Masal's plantations, Guilan Province, Iran

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Abstract. Pourbabaei H, Eskandari M, Daryaei MG, Heydari M. 2015. The interaction between diversity of herbaceous species and history of planting, Masal's forests, Guilan Province, Iran. *Biodiversitas* 16: 84-88. The purpose of this study was to determine the relationship between the plantation age and diversity of herbaceous species. The study area is located in the Masal's plantations of Guilan in north of Iran. For this purpose, 60 plots were sampled by a randomized-systematic method throughout the study area in order to record the herbaceous species, the Whitaker's nested plot was applied and the minimal area was obtained 64 m² (8 × 8 m). In order to evaluate the plant diversity, some indices including Shannon-Wiener's diversity (H), species richness (S) and Smith-Wilson's evenness (E_{var}) were utilized. Results indicated that 31 herbaceous species were found in two plantations. There were significant differences between two sites regarding H and E_{var}. Whereas, there was no significant difference in view of species richness between two sites. In addition, results revealed that older plantation has not caused to increase richness and evenness of species.

Keywords: Age, diversity, herbaceous species, plantation, Masal's plantations.

INTRODUCTION

There is a very close relation between plants and other living organisms in an ecosystem. Observing appearance of land's plants shows that these species choose their habitat according to their intrinsic ecological needs (Heydari and Mahdavi 2009). Plants with more complicated structure than climate and soil become stable in lands and waters and have a major role on life of living things, preserving nature and balance of ecosystem as a resources of local system. Therefore, vegetation is always as an integral part of ecosystem. Although forests have covered only 30% of the land, but current process of destruction and subversion of forest is worried (Mosaddegh 1994). On the other hand, regarding increased population and daily increasing requirements of wood products and other services of forest, developing forests through afforestation is inevitable in present and future (Shabaniyan et al. 2009). In other words, destruction and declining natural forests have made it necessary to afforest in order to reconstruct and develop forests. Plantation forests, or planted forests, are cultivated forest ecosystems established by planting or seeding in the process of afforestation and reforestation, primarily not only for wood biomass production but also for soil and water conservation or wind protection (Carnus et al. 2006).

Presently, the objectives of plantations not only for the production of lumber and wood products but also include the provision a habitat for wildlife and non-commercial plants and the conservation of biological diversity (Nagaike et al. 2003). Plant species diversity in plantations has a prominent role in order to preserve genetic resources, assessing ecological succession and identifying species

which are at risk (Brockerhoff et al. 2003). Plantations can promote regeneration of understorey by shading out grasses, increasing soil nutrients, improving micro-climate, and generally increasing the chance for seed germination and establishment, which is difficult in highly degraded sites (Senbeta and Teketay 2001).

Plantations can make an important contribution to the conservation of native biodiversity, but not if their establishment involves the replacement of native natural or semi-natural ecosystems. While a plantation stand will usually support fewer native species than a native forest at the same site, plantations are increasingly replacing other human-modified ecosystems (e.g., degraded pasture) and will almost always support a greater diversity of native species. In addition, plantations can play an important role in sustaining native biodiversity in production landscapes and indeed be an opportunity for biodiversity (Brockerhoff et al. 2008). Stand age is one of the most important factors that affects on plant species diversity (Nagaike et al. 2010, 2003; Li et al. 2014). In areas where primary or old-growth forests have already disappeared or diminished considerably, long rotation plantations are thought to mitigate the detrimental effects on biological diversity (Ratcliffe and Peterken 1995). With increasing rotation age in plantations allows to restore old-growth habitats, which can be cause structural and biological diversity (Ferris et al. 2000; Humphrey et al. 2000; Peterson and McCune 2001). The plantations also have an important role in ecological reconstruction and create various environmental services. Therefore, a comprehensive study about plantation effect on all part of ecosystems (living and non-living) is necessary. Today, survey in biodiversity is crucial in

terrestrial ecosystems due to extinction of plant species and reduction of their population (Pourbabaei et al. 2004).

The purpose of the study was to determine floristic list and to compare herbaceous species diversity in two different age plantations with the same species.

MATERIALS AND METHODS

Study area

The study area is located in west of Guilan Province and in Talesh mountain range, Iran (Figure 1). The mean annual precipitation and temperature are 989.7 mm and 16°C, respectively. The climate is very humid with cool winters based on Emberger method. Soil of the region is brown calcic along with brown calcimorphic soil (FRWO 2008). General altitude of the region is 150-200 m asl. and the average slope is from 20 to 25 percent.

Two plantations areas (i.e., Ahaklan and Tabarsa) with an area 100 ha and located in Masal City, 55 kilometers from the center of Guilan Province were selected. The two sites have the same conditions in terms of physiographic factors and dominated species were as follows: *Alnus subcordata* C.A. Mey, *Acer insigne* Boiss, *Fraxinus excelsior* L., *Quercus castaneifolia* C.A. Mey, *Populus deltoids* Marsh., *Robinia pseudoacacia* L. The Ahaklan and Tabarsa sites had 9 and 22 years old, respectively.

Data collection

The study design was a random-systematic method with grid dimension of 150 m × 200 m and 60 sample plots were taken from the two sites. The size of the sample plot was obtained 68 m² using Whitaker's nested plots and species/area curve. The factors such as percentage of canopy cover, herbaceous species and light, litter depth were recorded in each sample plot. The herbaceous species were identified in herbarium of Faculty of Natural Resources, Guilan University, Iran.

Data analysis

To measure diversity, Shannon-Wiener index (Shannon and Weaver 1949) was used, which is computed as following equation:

$$H = -\sum_{i=1}^s P_i \ln P_i$$

P_i is relative frequency of i^{th} species.

To measure richness Margalef's index (Clifford and Stephenson 1975) was used, which is computed as following equation:

$$R_1 = \frac{S-1}{\ln N}$$

S is total number of species and N is total population in sample plot.

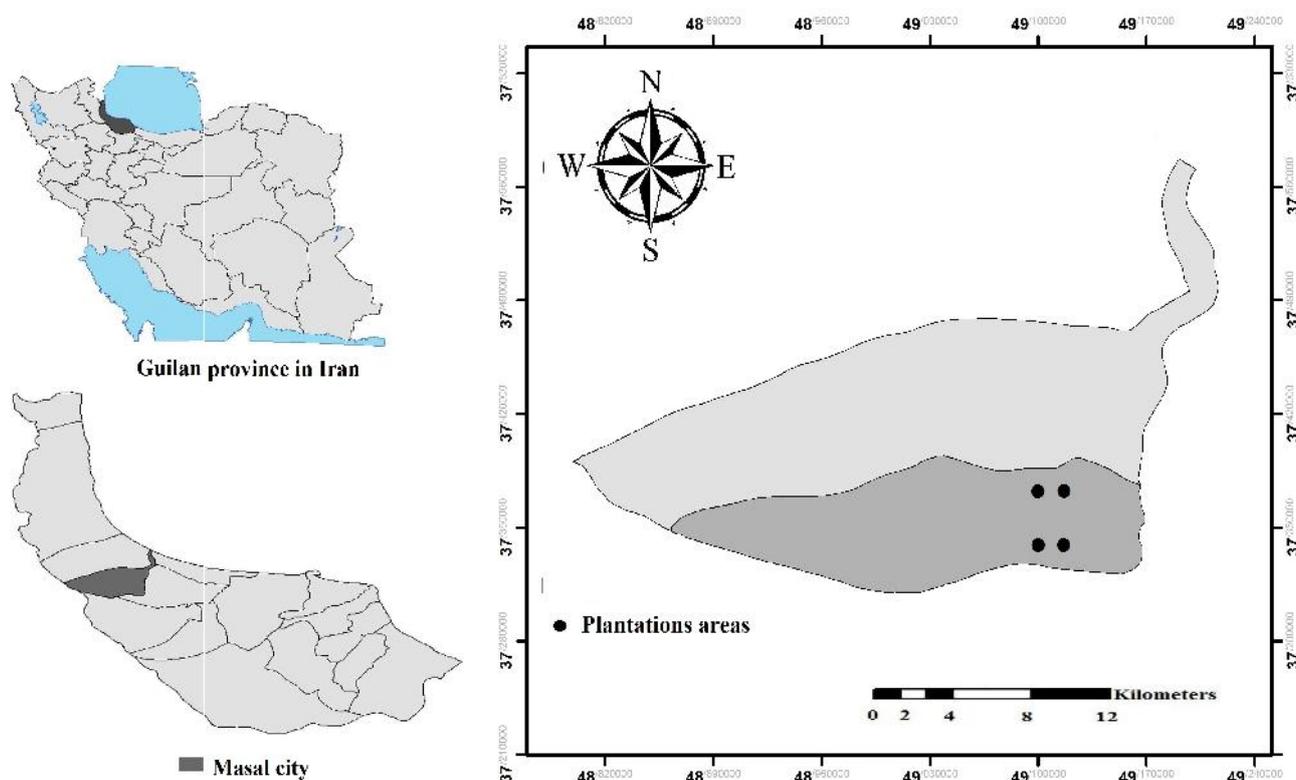


Figure 1. Study areas location in Masal City, Guilan Province, Iran.

To measure evenness, Smith-Wilson's index (Smith and Wilson 1996) was used, which is computed as following equation:

$$E_{\text{var}} = \frac{2}{f \arctan \left\{ \frac{\sum_{i=1}^s (\log_e(ni) - \sum_{j=1}^s \log_e(nj) / s)^2}{S} \right\}}$$

Where, ni is population of species i in sample plot, nj is population of species j in sample and S is numbers of species in all samples. Mentioned indices computed by Ecological Methodology software for Windows version 6.0 (Krebs 1989).

To compare structural characteristics and averages of diversity and evenness in the two sites, student t-test was used. Before doing the test, Kolmogorov-Smirnov test was used to be certain about the normality of data. These statistical analyses were done using SPSS 16.0.

RESULTS AND DISCUSSION

Our findings revealed that there are significant differences in percentage of canopy cover and herbaceous species ($P < 0.05$), so that percentage of canopy cover, and light were higher in 22 years than in 9 years old plantation. However, percentage of herbaceous species was more in 9 years old than in 22 years old plantation.

In 9 years old plantation, species which had percentage of cover more than 10% are as follow: *Rubus hyrcanus* 20.38, *Asplenium adiantum-nigrum* (14.72), *Carex sylvatica* (13.83), *Microstegium vimineum* (11.75), *Potentilla reptans* (11.54), *Sambucus ebulus* (11) and *Calystegia sepium* (10). In addition, in 22 years old plantation species which had percentage of cover more than 10% are as follow: *Oplismenus undulatifolius* (16.58), *Carex sylvatica* (15), *Viola alba* (13.09), *Sambucus ebulus* (12.5), *Microstegium vimineum* (11.67). Totally, there were 31 species belonging to 26 families in the two plantations. The 21 species were common in the both sites, 4 species were only in Ahaklan (9 years old) and 6 species were found only in Tabarsa (12 years old) as well as 4 species had 1% or less coverage the in both sites (Table 1).

Table 1. List of species [(-) herbaceous absence; (+): presence]

Family name	Scientific name	F.*	F.	P.C.**	P.C.	Plantation age (year)	
		22	9	22	9	22	9
Aspleniaceae	<i>Asplenium adiantum-nigrum</i> L.	22	18	9.83	14.72	+	+
Euphorbiaceae	<i>Acalypha australis</i> L.	17	4	9.5	7.5	+	+
Convolvulaceae	<i>Calystegia sepium</i> L.	4	1	2.75	10	+	+
Cyperaceae	<i>Carex divulsa</i> L.	26	30	4.7	4.6	+	+
Cyperaceae	<i>Carex sylvatica</i> L.	26	30	15	13.83	+	+
Asteraceae	<i>Conyza bonariensis</i> L.	7	8	1.86	2.84	+	+
Umbelliferae	<i>Eryngium caucasicum</i> Trautv.	-	10	-	5.5	-	+
Geraniaceae	<i>Geranium robertianum</i> L.	-	8	-	6.87	-	+
Asteraceae	<i>Helianthus tuberosus</i> L.	-	2	-	1	-	+
Hypericaceae	<i>Hypericum androsaemum</i> L.	13	21	4.31	4.69	+	+
Hypericaceae	<i>Hypericum perforatum</i> L.	3	-	1	-	+	-
Asteraceae	<i>Inula caspica</i> Bium.	2	1	0.25	5	+	+
Lamiaceae	<i>Lamium album</i> L.	3	-	3.5	-	+	-
Lamiaceae	<i>Mentha aquatica</i> L.	21	17	11.67	5.29	+	+
Poaceae	<i>Microstegium vimineum</i> Trin.	21	20	11.67	11.75	+	+
Poaceae	<i>Oplismenus undulatifolius</i> (Ard.) P.Beauv.	19	17	16.58	9.7	+	+
Oxalidaceae	<i>Oxalis acetosella</i> Boiss.	12	8	3.89	4	+	+
Plantaginaceae	<i>Plantago major</i> L.	2	-	0.75	-	+	-
Aspleniaceae	<i>Phyllitis scolopendrium</i> (L.) Scop.	3	-	5	-	+	-
Polygonaceae	<i>Polygonum hydropiper</i> L.	6	6	9.25	6.67	+	+
Rosaceae	<i>Potentilla reptans</i> L.	9	13	6.11	11.54	+	+
Asclepiadaceae	<i>Periploca graeca</i> L.	-	2	-	1	-	+
Pteridiaceae	<i>Pteris cretica</i> L.	19	18	9.76	7.51	+	+
Rosaceae	<i>Rubus hyrcanus</i> Juz.	5	13	0.5	20.38	+	+
Caprifoliaceae	<i>Sambucus ebulus</i> L.	6	10	12.5	11	+	+
Lamiaceae	<i>Satureja hortensis</i> L.	2	2	7.62	3	+	+
Asparaginaceae	<i>Smilax excelsa</i> L.	17	24	6.94	5.83	+	+
Solanaceae	<i>Solanum nigrum</i> L.	-	1	-	1	-	+
Caryophyllaceae	<i>Stellaria media</i> (L.) Cyr.	3	-	6.67	-	+	-
Asteraceae	<i>Taraxacum syriacum</i> Boiss.	-	2	-	3	-	+
Violaceae	<i>Viola alba</i> L.	21	23	13	7.83	+	+

Note: *F.: Frequency, **P.C.: Percent Coverage.

Table 2. Diversity indices in herbaceous layer

Indices	Plantation age		Sig.
	9	22	
H'	3.01	2.63	0.03
E _{var}	0.66	0.51	0.04
R ₁	2.09	1.88	0.20

Table 3. Relationships between the herbaceous diversity indices and environmental factors in 9 and 22 years old stands

Age	Index	Pearson	Litter	Light	Canopy
9	R ₁	r	0.10	-0.10	0.01
		P	0.57	0.58	0.95
	H'	r	0.18	0.01	-0.12
		P	0.33	0.93	0.52
	E _{var}	r	0.17	0.10	-0.17
		P	0.35	0.59	0.34
22	R ₁	r	-0.10	0.37	-0.4
		P	0.56	0.04	0.03
	H'	r	-0.15	0.42	-0.39
		P	0.41	0.03	0.02
	E _{var}	r	-0.15	-0.17	-0.07
		P	0.40	0.36	0.68

Plant diversity

Regarding to diversity and evenness, there were significant differences between the two sites ($P < 0.05$), but there was not any significant difference in view of richness ($P > 0.05$). Average cover herbaceous was higher in species such as *Plantago major* and *Microstegium vimineum* in 9 years of plantation, but *Oplismenus undulatifolius* had the most average cover in 22 years of plantation (Table 2).

Relationships between the herbaceous diversity indices and canopy cover, light and litter depth

The result showed that there were significant positive correlations between Shannon-Wiener and richness indices with light in 22 years stand. In other hand, Shannon-Wiener and richness indices had negative correlation with canopy cover. There were not any correlations between diversity indices with canopy cover, light and litter depth in 9 years stand. Also, there was not any significant correlation between the herbaceous diversity indices and litter in the both stands (Table 3).

Discussion

Our findings in the studied sites showed that percentage of herbaceous species in 9 years old plantation was significantly more than 22 years old. This is probably due to opening canopy of 9 years old site. On the other hand, opening canopy cover creates situation to enter more light in the environment so that it is a suitable environment for herbaceous species. Rees and Juday (2002) stated that richness of plant species in forests is affected by open or closed canopy of overstorey. Also, there was significant difference in diversity and evenness between two sites and these values were more in 9 years old plantation. However, there is not significant difference between two plantations

in view of richness. In spite of, richness mean was a few more in Tabarsa site. Nagaike et al. (2003) in three different ages of a plantation concluded that plantation with higher age had less diversity and richness than younger plantation and opening canopy, obtaining much light and pruning weeds are reasons for high diversity in younger plantation. The results of Nagaike's studies indicated that the relationship between stand age and plant species diversity and richness of forest floor plants have been varied in plantations. Several studies have shown a positive correlation between plant species diversity and plantation age (Kirby 1988; Kiyono 1990), whereas Hill and Jones (1978) and Sykes et al. (1989) demonstrated that the richness of herbaceous species in *Picea sitchensis*, *P. abies*, and *Tsuga heterophylla* plantations decreased with increasing stand age. Peterken and Game (1984) found that the richness of herbaceous species was not correlated with plantations age that were planted between 1600 and 1947 in England (Nagaike et al. 2003).

The result showed that there was significant positive correlation between Shannon-Wiener and richness indices with light in 22 years stand. On other hand, Shannon-Wiener and richness indices had negative correlation with canopy cover. There were not any correlations between diversity indices with canopy, light and litter depth in 9 years old stand. Canopy cover values are closely related to understorey light levels (Machado and Reich 1999) and they are effective on net primary productivity and nitrogen cycling rates (Reich et al. 2001). Higher light availability in younger plantation is favorable for the growth of heliophytes; lower light availability in older plantation is more favorable for neutrophilous or shade-tolerant plants (Christian et al. 1994).

It seems light availability in 22-year-old stand was more favorable for plant species diversity. This result can be justified because the light in young plantation is intense and direct. Light is commonly considered to be the major limiting factor of forest vegetation cover and (or) richness (Barbier et al. 2008).

Higher opening canopy cover provides condition for a higher abundance of *Rubus hyrcanus* in 9 years old site where had significant difference with 22 years old site in view of percentage of canopy cover of *Rubus hyrcanus*. If the salvage cutting does not apply until canopy is closed, tree regeneration is disturbed and shadows destroyed it. Also, *Asplenium adiantum* is found wherever light is very much so it creates a competitive condition for other species and it is more successful in this competition. In addition, *Calystegia sepium* and *Potentilla reptans* were more in 9 years old site which is due to high light requirement these species. There were six species (*Eryngium caucasicum*, *Geranium robertianum*, *Helianthus tuberosus*, *Periploca graeca*, *Solanum nigrum* and *Taraxacum syriacum*) which they only found in nine years old plantation. On the other hand, *Oplismenus undulatifolius* had a high percentage in 22 years old plantation and this species is indicating high compacted soil. This is due to presence of wild and domestic animals of adjacent regions come to this area of plantation and cause a compacted soil. In addition, the other reason for less percentage of vegetation in 22 years

old plantation than 9 years old site is closed canopy cover and shortage of light and higher regeneration of *Buxus hyrcana* species in this site. Since *Buxus hyrcana* is a shade tolerant species, consequently it prevents to establish shade intolerant herbaceous species and it is decreased percentage of vegetation. Also, Pourbabaei et al. (2004), stated the same reason for low percentage cover of some species in the Tanian region in Somesara city. Veinotte et al. (1998) and Humphrey et al. (2000), found that plant diversity in plantation increases rapidly in early ages of plantation due to intensity of light and sometimes invasive species become dominant species. When the age of plantation is increased and the light intensity decreased, as a result it causes to decrease herbaceous diversity. Kuksina and Ulanova (2000) stated that when canopy cover is closed in plantations, plant species diversity declines.

Kryshen (2000) found about 90% vascular species in a Aspen plantation during 1 to 2 first years, but 3 to 4 years after planting when canopy cover was closed, presence of vascular plant declined to 58% and annual plants declined to 40%. In general, plantations in a long-term help to maintaining ecological processes in ecosystems. Also, different managements have major effects on diversity of plant species in forest ecosystems (Nagaike et al. 2003).

Regarding to the aim of plantation whether is for restoration or economic exploitation; we should achieve our purposes using different managements in different plantations. Regarding that this research has conducted in two sites with different plantation ages, it is recommended that such studies which conducted in consecutive years with pure and mixed species being compared and surveyed.

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