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An investigation on plant species composition and diversity in the coniferous and broadleaved plantations: Case study of Bibi Yanlu Forest Park, Astara, Iran

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[♥]email: tohidsalahi@yahoo.com, [♥♥] h_pourbabaei@guilan.ac.ir, hpourbabaei@gmail.com
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Abstract. *Salahi T, Pourbabaei H, Salahi M, Karamzadeh S. 2017. An investigation on plant species composition and diversity in the coniferous and broadleaved plantations: Case study of Bibi Yanlu Forest Park, Astara, Iran. Biodiversitas 18: 958-963.* The aim of this study was to investigate vegetation composition in hardwood and coniferous plantations in 220 ha of Loblolly pine (*Pinus taeda* L.), Caucasian alder (*Alnus subcordata* C.A.Mey) and poplar (*Populus deltoids*) and its comparison with natural forests in Bibi Yanlu protected forest park in Astara, north of Guilan Province, Iran. Totally, 60 sampling plots of 1000 m^2 by systematic-random method using 150 × 150 m grid in plantation and 200 × 200 m in the natural forest were established. To study the biodiversity, Shannon-Wiener, Simpson's diversity indices, Hill evenness and richness indices were utilized. The results of this research showed that there is a significant difference for diversity and richness indices between natural forest and plantations. Diversity and richness indices in the natural forest were higher than Loblolly pine, poplar and alder plantations. The Hill evenness index between natural forest and plantations did not indicate significant differences. In terms of herbaceous and woody species similarity, alder plantation was closer to natural forest, and pine plantation had the least similarity with the natural forest.

Keywords: Vegetation composition, plant diversity, coniferous and broad-leaved plantations, Astara

INTRODUCTIONS

As one of the renewable resources, forests are the base for sustainable development and the dynamic, evolution and changes of the sources led to the further effort of a human for the understanding environment and its structure (Basiri 2003). As a result of the destruction of forests and reduction of its area, the extinction of plant and animal species, and finally the reduction of biodiversity in the world would be arising. In an ecosystem, the more the diversity of a species the longer the food chains, and consequently the environment become more stable and its self-regulation properties get greater (Vatani 2004). The degradation and reduction of forests indicate the necessity of a forestation for restoring and developing renewable natural resources. Plantation forests due to their specific characteristics, can affect the diversity of the understory plant species, and cause the elimination or the presence of some species (Ahmadi Malakut et al. 2011). The area of coniferous plantation forests in the north of Iran has been estimated at 40,000 ha by 2000 (Asadollahi 2000).

Forests in the north of the country are one of the most important world's genetic resources. Given the destruction of forests in the north and reduction in their area, it is required to afforest for restoring the degraded forests, as well as providing the wood need of the country. Having these objectives achieved, therefore, it is necessary to precisely select the kind of species (Pourrahmati 2005). Potentially, a forestation with native and non-native species to promote the under storey regeneration and enhance biodiversity has been recommended (Mojarrabi et al. 2011). On the other hand, according to the Rio Earth Conference (1992), to maintain and even improve biodiversity is the main indicator for determining the stability of forests (UN 2010). Thus selection of the native tree species with desirable growth rate and lowest inconsistency with plant and soil conditions should be considered (Ahmadi Malakut et al. 2011). Increased demand for natural resources such as wood products, creating green space and expanding forest coverage underline the necessity of a forestation more than before. Therefore, today afforestation is an integral part of forestry science (Rostami and Pourbabaei 2007).

The importance of afforestation for modifying climate, increasing precipitation, preventing soil erosion, creating an industrial wood product and decreasing air pollution is a widely known fact. (Mosaddegh 2009). The aim of this study was to examine and compare the composition and diversity of plant species of the forest floor in three plantation sites of Loblolly pine (*Pinus taeda*), Caucasian Alder (*Alnus subcordata*) and Poplar (*P. deltoids*), and their comparison with a natural forest. The results can be utilized in planning plantation projects in the north of Iran, as well as the selection of suitable species for plantation projects.

MATERIALS AND METHODS

Study area

Bibi Yanlu Forest Park is a part of Astara Chay Forestry plan, District No.1 forests (Figure 1). The total area of Bibi Yanlu Forest Park is 1512 ha of which 320 ha has been planted. The afforestation areas that were considered for the study were Loblolly pine (*Pinus taeda*), Alder (*Alnus subcordata*), Poplar (Populus deltoids) plantations, and a natural forest. The area is located in the west of the Guilan Province and the south of the border city of the Astara Port, and 200 km from the center of the province. The park is situated within geographical coordinates between longitude 48˚ 42' 28" and 48˚ 49' 30" E and latitude 38˚ 24' 00" to 38˚ 02' 30" N. The climate is very humid based on Emberger climogram, and hot and humid summers with moderate winters, as well as Emberger coefficient equal to 171.4. From the characteristics of this type of climate is the fluctuation of minimum temperature between 0 to 5ºC and sometimes in the winter, it is seen frost and snows. Furthermore, based on the Embrothermic curve there is no dry period and it is humid at the whole seasons. The average annual temperature of the station is 15ºC, the minimum temperature is 1.9 °C in January, and the maximum temperature rarely exceeds 30 °C, which coincides with the month of July. The average frost days are 11 days, occurring most of them in months of January and February. The average monthly precipitation is 137.6 mm, the highest precipitation in September and October, and the lowest in August occurs. The average relative humidity of the investigated station is 82% (FRWO 2008).

The type of soil texture in the most of the areas is loam to sandy clay loam. Drainage of the land's surface is favorable due to a large number of small and large valleys and general slope of the field, except one point where leaching clay from the upstream and its accumulation in the field of the poplar species plantation, not only drainage is possible but also it has created problems for plant growth. Brown dominant soil type, only on the part of the plantation area, is acidic washed brown soil with the Argillic horizon. Soil structure of the whole of the field is generally fine and coarse grained till multi-faceted. Soil pH is generally acidic and its range at the whole of the field is between 4 and 6.5. The depth of the soil is shallow to relatively deep. Geologically, it belongs to the Miocene period (FRWO 2008).

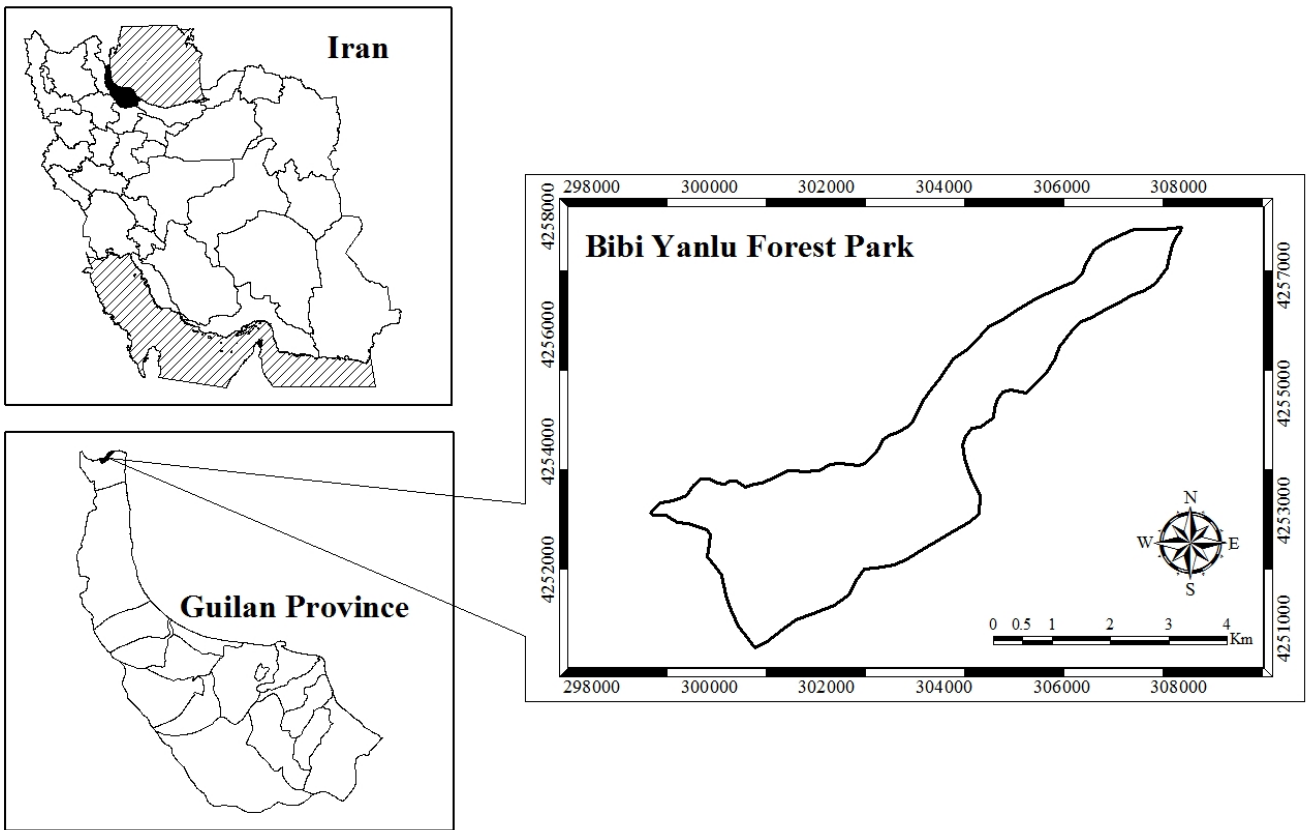

Figure 1. Bibi Yanlu Forest Park location in Guilan Province, Iran

Field sampling

Due to the homogeneity of forest communities, systematic-random was used for sampling. Furthermore, based on the studies for determining the best grid of data collection, 15 plots of 1000 m^2 were determined for each afforestation and natural forest (Pourbabaei, 1998). Data collection in plots was conducted based on a grid of 150 × 150 m in plantations and 200 × 200 m in natural forest. After recording the field characteristics, aspect and slope in each plot, the minimal area method was used to determine the size of the plot in the herbaceous layer. The plot size was obtained 64 m^2. The kind of plant species in each plot was identified and their abundance-dominance estimated according to Braun-Blanquet criterion (Pourbabaei et al. 2004). In total, 60 plots were taken in plantation sites and natural forest.

After drying the samples, to identify the plant species, the flora of Iran (Asadi et al. 2002) and color flora of Iran (Ghahreman, 1990-1999) were used. The distribution of plant species based on the classification method of Zohary's growth regions was determined (Zohary et al. 1993-1980). In order to study the structure of area vegetation, first, the growth form of each plant species identified by Runkiaer's method, then based on that, the life spectrum of area plants was determined (Runkiaer, 1934). The amount of variety in each sample using the Shannon-Wiener index and Simpson (Ejtehadi 2009) and the species richness index on the basis of species number (Humphries et al. 1996), as well as the value of evenness with the modified index of Hill for each of afforestation site was calculated (Krebs, 1999). In addition, the amount of similarity between afforestation sites obtained by Jaccard's similarity index (Mesdaghi 2001). The formulas are as following:

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

$$D = \sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$$

H: Shannon-Wiener diversity index, p_i: the relative abundance of *i*th species, and *s*: the total number of species

D-1: Simpson's diversity index, *s*: the number of species, *n*: the frequency of species, *N*: the total number of species

E_5: as the ratio of modified Hill

S: the total number of species on the plot

$$IS_J = \frac{a}{a+b+c}\times 100$$

IS_J: Jaccard's similarity index, a: the number of common species to both afforests, b: the number of species only in the first afforest, c: the number of species only in the second afforest.

First, the normality of data was evaluated by Kolmogorov-Smirnov test and the homogeneity of variances by Leven's test. Species diversity indices calculated by Past software, for comparing the index between afforests and forest ANOVA test was used and after significant in indices difference, the multiple comparisons of means were performed by Duncan test (Pitkanen, 1998). The analysis was performed using SPSS version 16.0 (Kinnear and Gray 2000).

RESULTS AND DISCUSSION

In the study area, 92 plant species (14 tree species, 6 shrub species, and 72 herbaceous species) belonging to 79 genera and 48 families were identified, out of which 39, 37, and 45 herbaceous species found in plantations of Loblolly Pine, Popular, and Alder respectively, as well as 48 herbaceous species found in natural forest. In addition, 11, 14, and 10 wood species in Loblolly Pine, Popular, and Alder plantations, respectively, as well as 11 wood species in the natural forest were found. The herbaceous species of Meadow foxtail (*Alopecurus pratensis* L.), Black spleenwort (*Asplenium adiantum-nigrum*), Cathedral bell (*Cobaea scandens*), Witch weed (*Striga asiatica*), Basil (*Ocimum basilicum*), Brittle bladder-fern (*Cystopteris fragilis*), Male fern (*Dryopteris filix-mas*), Common avens (*Geum urbanum*), Burnet saxifrage (*Pimpinella affinis*), Common prickly fern (*Polystichum aculeatum*), and Clustered dock (*Rumex conglomeratus*) were exclusively in natural forest. Furthermore, the species of common Walnut (*Juglans regia*) and Date-plum persimmon (*Diospyros lotus*) only were observed in natural forest and in plantations were absent.

The mean and error of different biodiversity indices for herbaceous species in afforestation and natural forest in the study area are indicated in Table 1.

The results of analysis of variance showed that there is a significant difference at the 95% level between plantations and natural forest in terms of Shannon-Wiener index. The most amount of the Shannon-Wiener diversity index was in natural forest and the lowest of that in Loblolly Pine plantation (Figure 2).

Analysis of variance test of Simpson index between plantations and natural forest showed a significant difference at 95% level. The highest amount of Simpson index belongs to natural forest, and between Poplar and Alder plantations was not a significant difference, as well as the Loblolly Pine stand contained the lowest amount of index (Figure 3).

The results of ANOVA test of the amount of richness showed that there is a significant difference between plantations and natural forest. Natural forest and Loblolly Pine plantation had the highest and the lowest of species richness, respectively (Figure 4).

Statistical tests in terms of Hill's evenness index did not show a significant difference between plantations and natural forest. Jaccard's similarity coefficient between plantations and the natural forest is shown in Table 2.

Table 1. Analysis of variance (ANOVA) of indices of diversity, richness, and evenness in the herbaceous layer between plantations and natural forest

Index	Loblolly Pine	Poplar	Alder	Natural forest	Significant level
Shannon-Wiener diversity	1/06 ± 0/1	1/51 ± 0/16	1/44 ± 0/12	1/86 ± 0/13	0.001*
Simpson diversity	0.48 ± 0.05	0.65 ± 0.04	0.64 ± 0.03	0.77 ± 0.01	0.000*
Richness	7.3 ± 1.06	8.1 ± 1.37	8.06 ± 1.3	12 ± 1.61	0.01*
Evenness	0.59 ± 0.03	0.58 ± 0.05	0.61 ± 0.03	0.55 ± 0.04	0.7ns

Note: *It is significant at the 0.05 level, ns: no significant

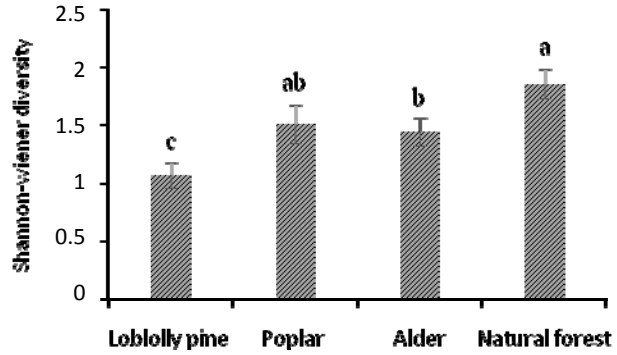

Figure 2. The mean of the Shannon-Wiener diversity index between plantations and natural forest

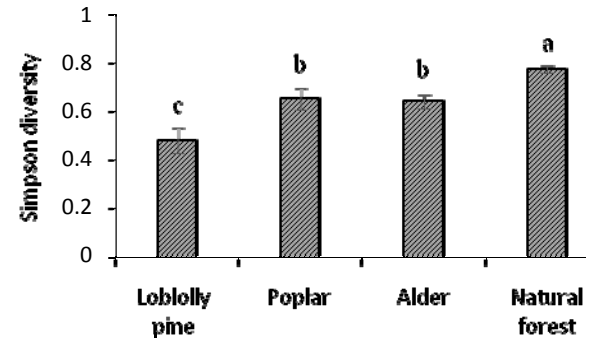

Figure 3. The mean of the Simpson diversity index between plantations and natural forest

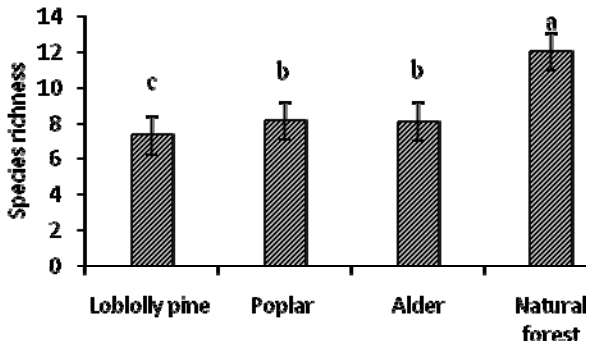

Figure 4. The mean of the species richness index between plantations and natural forest

Table 2. Jaccard's similarity coefficient between plantations and natural forest for herbaceous and woody species

Type of forest	No. of common species	No. of non-common species	Jaccard's similarity coefficient
Loblolly Pine-Natural forest	33	41	44
Poplar-Natural forest	32	39	45
Alder-Natural forest	39	38	50

Discussion

As seen in Figure 2, the value of Shannon-Wiener's biodiversity index among plantations is less than natural forest. In other words, plant diversity in the natural forest was more than plantations and the difference between them was significant. In addition, the value of Simpson's biodiversity index as can be seen in Figure 3, in natural forest is more than plantations. Study on plant species diversity in Loblolly Pine, Maple tree plantations and natural forest in the forests of Siahkal (Guilan) showed that biodiversity in the natural forest was more than plantations, but there was no significant difference. While in the mixed plantations of Ash-Maple tree, the number of herbaceous species was more than Loblolly Pine and Maple tree of Siahkal plantations, and the richness of trees and shrubs species were equal and which was greater than Maple pure plantation of Siahkal, as it is obvious the diversity is more in mixed ash-maple than pure maple plantation (Baktash 2003).

In another study, the diversity of floor plant species of Norway spruce plantation (*Picea abies*) has been compared with broad leaf natural forest in the region of Lahjim, Mazandaran and results showed that plant species diversity in natural forest is more than Norway spruce plantation, and there is significant difference between them (Ghelichnia 2003). Memarian et al. (2007), in examining the comparative study of biodiversity in the mixed coniferous stand with broadly mixed leaf stand in the region of Kelardasht concluded that Simpson's diversity index showed the highest value in the type of mixed broadleaf. In this study, the stand of coniferous compared to the stand of the nearby mixed broadleaf has less diversity.

Different factors affect the less diversity and richness of Loblolly Pine coniferous stand. One of the reasons could be due to litters of Loblolly Pine, which causes soil acidification and reduction of soil fertility such that thick

litters of this stand were highly covered (Figures 2, 3, and 4). In Figure 4, the species richness is more in natural forest. More humidity and optimum light on the natural forest floor has caused more species richness than plantations. Ahmadi Malakut et al. (2011) studied the vegetation condition of the forest floor both plantation forests and natural forest. Measurements showed that species diversity in natural forest is more than plantation forests.

Baktash (2003) studied the vegetation condition in two different stands of a Maple tree, Loblolly Pine plantations and a natural forest. The results showed that species diversity in natural forest and Maple plantation had the highest and lowest of amount respectively. Roberts et al. (2002) in Canada and on species composition and the species diversity of vascular plants in the floor story of *Picea abies* plantation in three age categories (5 to 7, 10 to 12, and 14 to 16 years) and natural forest was found that mean of species richness in natural forest and *Picea abies* plantation forest is 37 species and 33-36 species respectively. According to this study, natural forests due to multi-story vegetation cause diversity in the environmental conditions. Consequently, this can be known as a factor for the diversity of grass species in the studied natural forest.

While in the plantation forests due to single-storey vegetation or closed cover a broadly homogeneous growth environment is created that only certain species can be established. In addition, the factors can be involved in decreasing species richness in plantation forest compared to the natural forest. Out of which can be noted indiscriminately forests cutting, monoculture and the disruption of forest structure in plantation areas. Ahmadi Malakut et al. (2011) also came to similar results to this study. Less richness in the stand of Poplar plantation compared to the control stand may be due to the high density of the coppice shoots that prevents the entry of the shrub species. This can reveal the importance of forest management on the increase in richness. This is confirmed in Kirby, Busing, and Garna's studies (Nagaike et al. 2003), which the richness in the stand of *Larix* sp. after stand management has increased.

Poplar is one of the species that grows better in light texture soils. In general, Poplar likes soils with a light texture, good drainage, and high humidity. While in the study area, soil texture is heavy and loamy and it is no proper drainage, and less species diversity of the stand of Poplar than natural forest may be due to the same issue (FRWO 2008). Indices of richness and species diversity in Poplar plantation was more than Loblolly Pine plantation. But there was no significant difference with Poplar plantation. Perhaps this is due to the open canopy of Poplar plantation against Loblolly Pine plantation, which causes the light to reach the forest floor and to allow growth of wood and herbaceous species (Figures 2, 3, and 4). Some studies have shown that forest management can be caused the increase of richness (Nagaike et al. 2003).

Other studies on plantation generation have shown that the properties of the canopy of planted species may affect the understorey communities (Lugo, 1997; Parrotta, 1995). The stand of Poplar due to having more open canopy than other stands, causing light to reach the soil and herbaceous and allow growth of wood and herbaceous species, but in other stands as a result of the closed canopy (even up to 95%), this was impossible. In many cases, plantations will involve preserving ecosystem sequence and raising biodiversity in the long-time, for example, the development of vegetation in the coastal strip, creating plantations in the eroded areas, the proper use of tree species regarding habitat and ecological needs each region, the implementation of mixed plantations and the timely performance of cultured operations in the level of plantations (Mohammadnezhad-Kiasari et al. 2007). In relation to being a not significant comparison of Hill's evenness index means between the natural stand and plantation stands seems according to field observations and other soil properties, the soil of the area enjoys enough fertility to meet the nutritional needs of plants, and plants have not an inter-species competition to supply their nutrition elements. This can be the reason for the uniform distribution of the vegetation in the natural and plantation stands. Vatani et al. (2007) in examining of natural generation diversity at 15 years old plantation of Alder in down areas showed that for the evenness index between the areas of plantation stand and natural stand there is no significant difference. Mojarrebi et al. (2011), in comparison of generation density and plant diversity in the plantation of *Populus deltoides* and Maple tree stands of Mazandaran Province, showed that for Hill's evenness index between them there is not a significant difference. In terms of the similarity of wood and herbaceous species between natural forest and plantation forests, Poplar plantation forest was closer to natural forest and Loblolly Pine plantation forest had the least similarity to natural forest, as well as Poplar plantation forest compared to Alder had the least similarity to natural forest.

Ghorji Bahri and Hemati (2004) showed that Alder is also from fast-growing trees of forests in the north of the country, which forms various types in the pure and mixed stands. They caused the rapid establishment in the forest empty spots and also fixing the nitrogen of atmosphere in the soil and strengthening soil fertility. Nowadays, Loblolly Pine plantation forest in the province of Guilan has reached the age of exploitation and the forest growing in them is of great importance. The points that highlight the results of the study is that plantation with Alder species shows better results than other plantations in the study area. On the one hand, the Alder species cause fixing nitrogen in the soil, as well as soil fertility. While in the plantation with Loblolly Pine happened the opposite of this case.

In the plantation stand with Poplar species as a result of leaching clay from upstream and its accumulation in the area has created problems in the growth of the species (FRWO 2008). Therefore conservation of natural forests should be done regarding established species in this area because these ecosystems are the result of species adaptation to environmental conditions in long years.

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