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Natural woody species biodiversity after Cypress (*Cupressus sempervirens* var. *horizontalis*) reforestation in Hyrcanian Forest, North of Iran

LEILA VATANI, SEYED MOSEH HOSSEINI♥, MOSLEM AKBARINIA, SAEED SHAMSI
Department of Forestry, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Mazandaran, Iran.
Tel.: +98-122-6253101-3, Fax.: +98-122-6253499, ♥email: hosseini@modares.ac.ir

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Abstract. *Vatani L, Hosseini SM, Akbarinia M, Shamsi S. 2017. Natural woody species biodiversity after Cypress (*Cupressus sempervirens *var.* horizontalis*) reforestation in Hyrcanian Forest, North Iran. Biodiversitas 18: 689-695.* The present study was conducted to investigate the impact of Cypress (*Cupressus sempervirens* var. *horizontalis*) reforestation (15 years old) on woody species diversity comparison natural Hyrcanian forests. 9 sample plots with 20 × 20m area were taken in each stand by a random systemic statistical method and also control area, then natural regeneration number of woody species were measured. Shannon-Wiener for diversity index, Mechanic for richness index and Simpson for evenness index were calculated to evaluate species biodiversity, using Ecological Methodology and SPSS software. The results showed that sixteen tree and shrub species were appeared in Cypress understory naturally, that some of the species were rare. There was no significant difference between the diversity and richness index obtained for Cypress reforestation and natural forest. Regarding the rate of evenness, only in one area was found a significant difference was observed between Cypress reforestation and natural forest that in reforestation was more than natural forest ($p<0.05$). Regarding the results obtained on the study, Cypress reforestation did not reduce the woody plant biodiversity until the age of fifteen years old and findings of this investigation suggested that the conditions under the Cypress canopy might be suitable for the presence of some woody species, 15 years after reforestation.

Keywords: Biodiversity, Cypress, Hyrcanian forest, reforestation, woody species

INTRODUCTION

Reforestations make up a considerable proportion of the total forest area and identification of high biodiversity value stands and of management practices to enhance biodiversity is essential if the goals of Sustainable Forest Management are to be achieved (Coote et al. 2013). Biodiversity is a multiple concept comprising of genetic, species and ecosystem attributes and it guarantees the survival and sustainability of forest ecosystems and is used as an index to compare ecological conditions of forest ecosystems (Parthasarathy and Karthikeyan 1997). Transformation is the greatest threats to biodiversity and reforestations can restore biodiversity (Jairo et al. 2015). These losses have had a substantial negative impact on biodiversity due to a large number of forest species which depend on oak and the environments oak-dominated forests provide (Felton et al. 2016).

Reforestations become an increasingly ubiquitous land use, intense debate surrounds the extent to which these anthropogenic forests protect or degrade biodiversity (Brockerhoff et al. 2008). Improved understanding of how reforestations affect biodiversity and other ecosystem services is critical to forming socially and ecologically sustainable land-use policies (Goldman et al. 2008).

Rouhi-Moghaddam et al. (2011) reported that the abundance and diversity of regenerated species in the understory of mixed reforestations of an oak-nettle tree were greater than those in a pure stand of oak and a mixed one with maple. The percentage of canopy cover and litter layer depth significantly showed a negative effect on their abundance and richness. Mixed afforestation resulted in significant effect in the development of succession in natural forests with the presence of primary species in the understories.

Moreover, changing the natural global forest whether by completely loss or conversion to afforestation has a considerable effect on biodiversity. Afforestation causes a fundamental impact on ecosystem functions and structure including negative variation micro-climate, production, nutrient cycling and water balance which may consequently affect biodiversity (Marquiss 2006).

Jéssica et al (2015) found that regardless of species richness and composition, secondary forests and reforested lands are functionally different from pastures, because of secondary forests establishment by natural regeneration. Reforestation in forest management may also produce negative ecological impacts that should be considered, for example, species associated with natural vegetation, at local scales, tended to be higher in native forests and shrublands than those in the regions planted with eucalypt.

In many countries, needle-leaf species is planted for forest development and reforestation, which it has a potential threat to the natural ecosystem and native species; and the canopy opening for reforestation can alleviate this risk (Paritsis and Aizen 2008); and richness index in reforestation with needle-leaf was less than of that in natural needle-leaf stands (Amezaga and Onaindia (1997). One of the methods to enhance the understory biodiversity was planting a combination of softwood and hardwood species (Deal 1997).

Enhanced biodiversity outcomes are expected with reforestations that utilize indigenous tree species (Pejchar et al. 2005; Carnus et al. 2006; Stephens and Wagner 2007; Brockerhoff et al. 2008). In Iran, at least 20% of reforestation in Northern forests has been planted by needle-leave mostly dominated Cypress. But, as far as, there is no research about the effect of Cypress reforestation on the biodiversity compared to that of in natural forests. Hence, the main purpose of this study was to determine the effect of Cypress reforestation on woody species biodiversity and we were interested to know that does Cypress reforestation provide a good condition for native species re-presence?

MATERIALS AND METHODS

Study area

Present work was conducted in 9 sites of 15 years-old Italian Cypress reforestation in central's part of Hyrcanian forests, Northern Iran (Figure 1). It is worth to mention that there are many hectares of lowland forests with an elevation of 100 to 700 m, that dominated by *Quercus castaneifolia* mixed together with *Carpinus betulus*, *Acer velutinum*, *Acer cappadocicum*, *Alnus glutinosa*, and *Parrotia persica*. Geographic information of studied areas is shown in Table 1.

Average annual precipitation during last 20 years was varied from 750 mm in Afratakht to 844 mm in Talukola and the average annual temperature was varied from 14.7°C in Talukola to 16.4°C in Afratakht. According to Dumartin's dryness coefficient, all studied areas are considered as humid regions (Table 2). Nine plots (20 x 20 m2) were specified in each reforestation area and in natural forests. Then all naturally grown woody species of each plot were counted.

Table 1. Geographic information of studied areas

Studied areas	Latitude	Longitude	Altitude (m)
Talukola	36˚ 27´ 31″	53˚ 06´ 02″	350
Afratakht	36˚ 28´ 30″	52˚ 58´ 36″	410
Nodeh	36˚ 22´ 44″	53˚ 10´ 00″	515

Table 2. Meteorological information of the three studied areas

Studied areas	Average annual precipitation (mm)	Average annual temperature (℃)	Dumartin´s dryness coefficient
Talukola	848	14.7	34.4
Afratakht	750	16.4	28.4
Nudeh	874	15	31.3

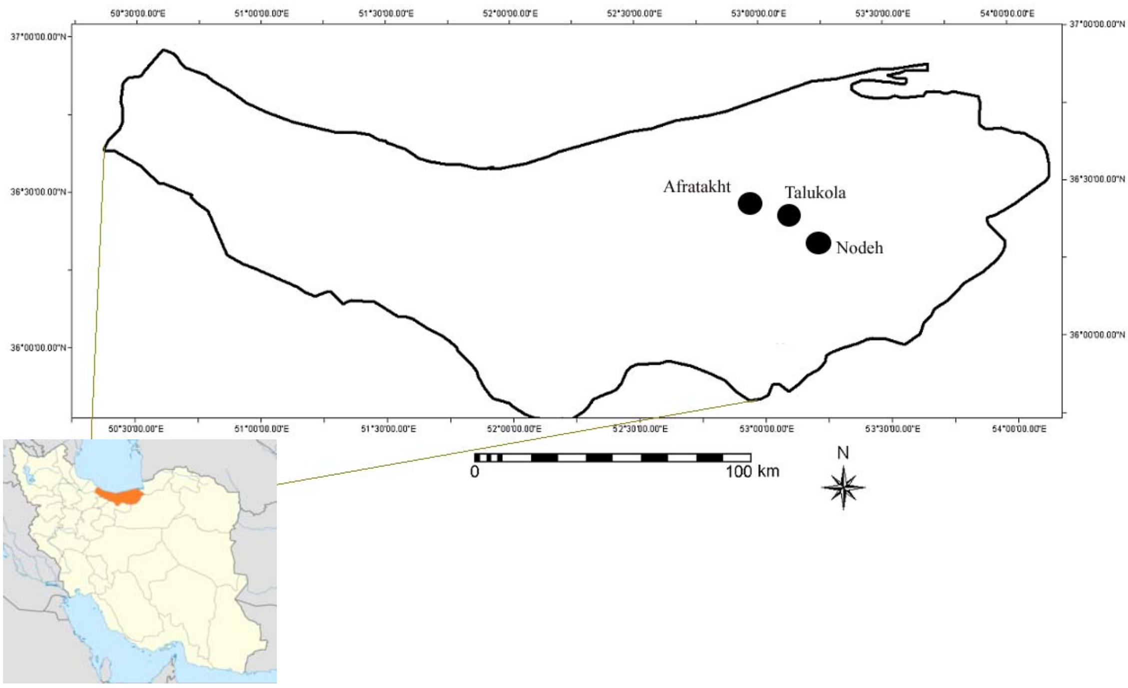

Figure 1. Map of Mazandaran Province, located in north of Iran, showing geographical origins of the three locations, Talukola, Afratakht and Nodeh

Data analysis

Shannon-Wiener diversity index (H') is most sensitive to the rare species in the community (Dougall and Dodd 1997). It is mathematically calculated by following formula and was used to determine diversity:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad (1)$$

Where, H is the Shannon-Wiener function (bits/individual) and S and ρ_i are the numbers of species and relative proportion of the species, respectively.

The amount of evenness (evenness index), V', was computed by Simpson index, D and Simpson maximum's diversity, D_{max} which is equal to 1/s (S is the number of species) as following formula:

$$V' = D/D_{max} \quad (2)$$

Richness index was mathematically calculated by below formula:

$$R^2 = S/\sqrt{N} \quad (3)$$

Where, R^2, S and N are Menhenic richness index, the number of species and abundance of all species, respectively.

After grouping and rearranging the data, index of diversity, richness, and evenness were calculated using Ecological Methodology Software version 7.2 (Krebs 1998). Based on biodiversity, richness and evenness indexes, differences between Italian Cypress reforestation and natural hardwood stands were analyzed by using Sample T Test at SPSS version 19.

RESULTS AND DISCUSSION

Results

The results indicate that The number of understorey plant species in the sample plots in the planted forests was 16 species (ten tree species and six shrub ones) (Table 3-4). Instance, fourteen woody species, including nine tree species and five shrub ones grew in the adjacent natural hardwood stand. Understory species in the stand dominated by Cypress involve Caucasian zelkova (*Zelkova carpinifolia*), Caucasian oak (*Quercus castaneifolia*), elm (*Ulmus minor*), Italian Cypress , Persian parrotia (*Parrotia persica*), maple (*Acer velutinum* Bois), Caucasian hornbeam (*Carpinus betulus*), common pear (*Pyrus communis* L.), Persian silk tree (*Albizia julibrissin*), willow (*Salix* spp.), Caucasian wingnut (*Pterocarya fraxinifolia*), Cherry (*Prunus caspica*), date plum (*Diospyros lotus*), pomegranate (*Punica granatum*), common medlar (*Mespilus germanica*) and Hawthorn (*Crataegus aronia*). The species grown in adjacent natural hardwood site were Caucasian zelkova, Caucasian oak, Persian parrotia, maple, Cappadocian maple *(Acer cappadocicum*), Caucasian hornbeam, Persian silk tree, cherry, date plum, pomegranate, common medlar, hawthorn, black alder (*Alnus glutinosa*) and Caspian locust (*Gleditsia caspica*).

Five species including willow, elm, Italian Cypress, common pear and Caucasian wingnut were established in Cypress reforestations, but not in the adjacent natural hardwood one. Elm, common pear and cherry are rare species in Iranian forests. For instance, black alder, Caspian locust and Cappadocian maple did not appear in the site reforested by Italian Cypress. Caspian locust was a rare species as well.

Analysis of variance's results showed that there was not any significant difference between the reforestation and natural forest about diversity and richness indexes. Shannon-Viner's diversity index in Cypress reforestation in Talukola and Nodeh areas was less than its adjacent natural forest. In contrast, Shannon-Viner's diversity index in reforestation was more than the adjacent natural forest in Afratakht (Figure 2). Considering evenness index, the differences between Cypress reforestation and its adjacent natural forest was not significant in three sites ($p < 0.05$). The evenness index in Italian Cypress stand was more similar to the adjacent natural forest in all three regions (Figure 3). Regarding the richness index, differences between the stand of Cypress and the adjacent natural forest were significant in any two studied areas. Richness index of Cypress reforestation site was similar to the adjacent natural forest in Talukola region. In Afratakht area, it was more in the reforestation by Cypress comparing to its adjacent natural forest. It was found the opposite situation for Nodeh region (Figure 4).

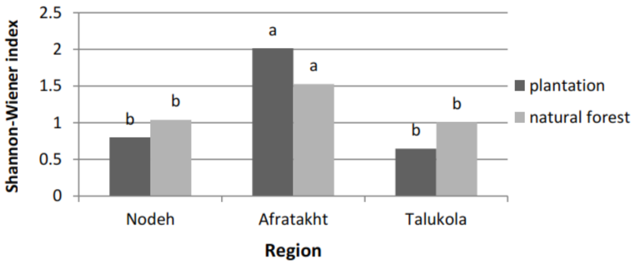

Figure 2. Shannon-Wiener diversity index of wooden species of Cypress reforestation and adjacent natural hardwood stand in Talukola, Afratakht and Nodeh of Mazandaran Province, north of Iran

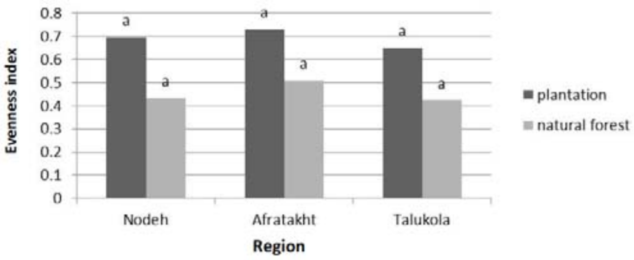

Figure 3. Evenness index of Cypress reforestation and adjacent natural hardwood stand in Talukola, Afratakht and Nodeh of Mazandaran Province, north of Iran

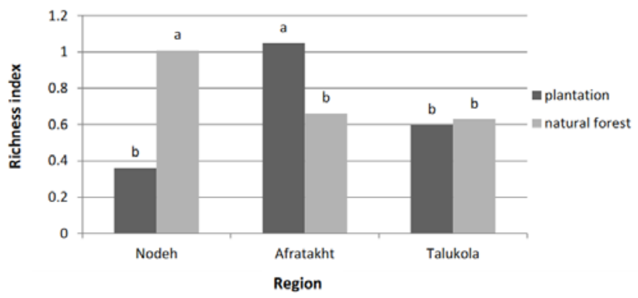

Figure 4. Richness index of wooden species of Cypress reforestation and adjacent natural hardwood stand in Talukola, Afratakht and Nodeh of Mazandaran Province, north of Iran

Table 5. The rate of Biodiversity, evenness, richness indexes in Cypress reforestation and adjacent natural deciduous hardwood forest in three sites in Mazandaran Province, north of Iran

Site	Type of index	ICA	NDHS
Talukola	Biodiversity	0.674	1.410
	Evenness	0.651	0.424
	Richness	0.600	0.630
Afratakht	Biodiversity	2.017	1.529
	Evenness	0.732	0.508
	Richness	1.049	0.662
Nodeh	Biodiversity	0.801	2.039
	Evenness	0.696	0.432
	Richness	0.361	1.007

Note: * = statistically significant at p< 0.05, ** = statistically significant at p<0.01, ns = non-significant. ICA = Italian Cypress reforestation, NDHS = Natural Deciduous Hardwood Stand

Table 3. Tree species germinated in the natural deciduous hardwood forest and Italian Cypress reforestation in three regions in Mazandaran Province, north of Iran (1= presence 0= absence)

Species (scientific name)	Studied area							
	Talukola		Afratakht		Nodeh		Total	
	ICA	NDHS	ICA	NDHS	ICA	NDHS	ICA	ICA
Quercus castaneifolia	1	1	1	1	1	0	1	1
Ulmus minor Miller	0	0	1	0	0	0	1	0
Acer velutinum	1	0	0	1	0	0	1	1
Parrotia persica	1	1	1	1	1	1	1	1
Zelkova carpinifolia	1	0	1	1	1	1	1	1
Cupressus sempervirens var *horizontalis*	1	0	0	0	1	0	1	0
Carpinus betulus	0	0	0	0	0	1	0	1
Acer cappadocicum	0	0	0	0	1	1	1	1
Pyrus communis	1	0	0	0	0	0	1	0
Pterocarya fraxinifolia	1	0	0	0	0	0	1	0
Gleditsia caspica	0	0	0	1	0	1	0	1
Alnus glutinosa	0	1	0	0	0	1	0	1
Diospyros lotus	1	1	0	0	0	1	1	1
Number of species	8	4	4	5	4	7	10	9

Note: ICA = Italian Cypress reforestation, NDHS = Natural Deciduous Hardwood Stand

Table 4. Shrub species are grown in the natural deciduous hardwood forest and Italian Cypress reforestation in three regions in Mazandaran Province, north of Iran (1= presence 0= absence)

Species (scientific name)	Studied area							
	Talukola		Afratakht		Nodeh		Total	
	ICA	NDHS	ICA	NDHS	ICA	NDHS	ICA	ICA
Salix spp	1	0	0	0	0	0	1	0
Albizia julibrissin	1	1	0	1	0	0	1	1
Punica granatum	0	0	1	1	1	0	1	1
Crataegus aronia	1	1	1	0	1	1	1	1
Mespilus germanica	1	1	1	0	1	1	1	1
Prunus caspica	1	0	1	0	1	1	1	1
Total number of species	4	4	4	2	4	3	6	5

Note: ICA = Italian Cypress reforestation, NDHS = Natural Deciduous Hardwood Stand

Discussion

Traditionally, foresters tend to consider tree reforestations as a renewable resource for producing timber and cellulose. Using a reforestation to catalyze the natural regeneration of tree species is a very different concept from the traditional approach (Kamo 2002). Reforestation of single tree species are usually set up for reforestation. However, single species reforestations have often been criticized for being associated with a low level of diversity in the ecosystems. The value of increasing forest cover depends in large part on the characteristics, or ecological quality, of the resulting forests (Farley 2007; Perz 2007; Lambin and Meyfroidt 2010; Putz and Redford 2010). A number of factors, such as reforestation species, influences whether biodiversity increases or becomes more impoverished following reforestation establishment. One of the most important factors of biodiversity loss is deforestation and forest degradation (Sodhi et al. 2004; Harris et al. 2012). Although forest degradation has a broad definition, it is often associated with a reduction in forest biomass (Sasaki and Putz 2009; Sasaki et al. 2011; Thompson et al. 2013). The extensive deforestation and degradation of forests are a significant reason for the biodiversity loss and global warming (Thompson et al. 2014).

The results of this study indicate that many woody species, including tree and shrub, became established in the planted forests with single tree species in the neighborhood of a natural forest. It is noteworthy that the reforestation with Cypress was carried out to enhance wood production in 600 hectares of lowland forests of northern Iran. Because of clear cutting and afforestation with fast-growing needle-leaved and broad-leaved species, all of the trees, some shrubs and those species covering understory level were completely demolished in some parts of these forests. Demolishing the habitat is considered the most serious biodiversity threat (MacDonald 2003). Therefore, the managing of this type of forest usually consisted as a weak method leading to biodiversity reduction (Wagner et al. 1998). However, the appearance of many trees and shrubs species of the region on the understory of 15-year-old Cypress stand including some rare species such as elm and common pear can be one of the most important results of reforestation with Cypress. These rare species has never grown in the adjacent stands involving deciduous natural hardwood forests. The appearance of ten trees and six shrubs in the understory of the 15-year-old site reforested with Italian Cypress can possibly be a good sign for rehabilitation of converted ecosystem of the forest.

A 20-year-old reforestation of Black pine (*Pinus nigra)* in Northern Iran has caused an appearance of some worth industrial species such as Caucasian oak whereas its reforestation has not been previously successful (Rahmani et al. 1990). Fourteen trees and four shrubs grew in the understory of 15-year-old stand reforested with maple as well as seven trees and one shrub established in a 15-year-old site of alder reforestation (Vatani et al. 2008, 2009). Regarding biodiversity indexes, there was no significant difference between the sites afforested with alder and adjacent natural deciduous hardwood forest (Vatani et al. 2009). Stephens and Wagner (2007) reported biodiversity reduction observed in reforested stands when is compared with natural forests that this result advertises with our results. Also, Amezaga and Onaindia (2008) found negative effects of reforesting with 29-year-old *Pinus radiata* and *Larix kaempferi* on the richness of species, plant coverage and soil seed bank in comparison to a natural softwood forest in Basc, north of Spain, result adversely with our results.

Furthermore, a research conducted by Dougall and Dodd (1977) exposed the biodiversity reduction in a 69-year-old reforestation of softwood and hardwood compared to that in natural forest. Ghelichnia (1990) concluded that the biodiversity indexes in a 38-year-old reforestation of an exotic conifer (*Picea abies*) are less than those in the adjacent natural forest, these results agreement with our results.

According to our results, appearing the species in the understory of reforested stand might be due to different reasons such as transportation of seeds by birds, insects, wind and soil seed bank. Regarding Dougall and Dodd (1997), about 52 species whose seeds existed in soil samples taken from the 64-year-old mixed stand of softwood and hardwood reforestation and the adjacent natural forest were established. In contrast, the outcomes of our study not only resulted in reduced biodiversity but also in appearing of some rare species. This is previously confirmed in even alder and maple reforestation (Vatani et al. 2008 and 2009). One of the reasons can be the age of reforestation. Basically, in the initial stage after clear cutting and reforestation and because of intensive light, some of the light-demanding species including non-woody ones and weeds increase rapidly instead of establishing non-aggressive species (Veinotte et al. 1998; Humphrey et al. 2000). This reason is possibly because of this fact that as planted species grow gradually, their canopy is closed start. Consequently, it affects understory vegetation by changing the soil and reducing the light (Kuksina and Ulanova 2000). For example, about 90% of vascular species appeared during initial two years in a *Populus* reforestation. But the rate of vascular species and one-year-old species reduced down to 58% and 40% respectively at the age of four when the canopy grew (Kryshen 2000). Accordingly, it is predictable in our case that by increasing the age of the reforested stand and the natural ones, soil conditions will change and the light reduces due to the canopy growth leading to the biodiversity decline or even demolishing some rare species such as elm, Persian silk, Persian locust, common pear and some industrial light-demanding ones like alder, maple and oak.

Some of the management methods like thinning are in coordination with the protection of biodiversity. The research of Battles et al. (2001) revealed that the richness of understory species in a reforested site and the one managed by shelterwood method was significantly greater than an 80-year-old site with no active management (reverse forest). In addition, stands managed by single-tree selection had species richness values close to those of the reserve forest. One of the methods to enhance the understory biodiversity of *Picea* and Suga's pure reforestation was planting a combination of softwood and hardwood species (Deal 1997) this result Compared with our results and showed the equal conditions.

Some investigations showed low levels of biodiversity in reforestations (Matthews et al. 2002; Barlow et al. 2007; Makino et al. 2007), other studies showed that reforestations could play an important role in biodiversity, conservation and restoration of forest species, particularly when management aims to balance environmental and economical goals (Hartley 2002; Carnus et al. 2006; Brockerhoff et al. 2008).

Our findings in this article had important implications about impacts of reforestation on plant biodiversity. In evaluating reforestation, it is important to consider how this type of forest development will affect a range of environmental goods and services including forestry products, biodiversity, etc. Reforestation can have either positive or negative impact on biodiversity at the tree, stand, or landscape level depending on the ecological context in which they are found. In our research, the appearance of many trees and shrubs species need to pay more attention to perform silvicultural operations in Cypress reforestation especially gradual thinning in order to improve the stand structure. The biodiversity of Cypress reforestation is protected by providing the conditions for seed germination and seedling establishment of native deciduous species which can mostly dominate the stand in climax stage. Thus we suggest that more effort is needed to measure this ratio in the field for several years later, because it is uncertain that increasing the age of reforestation changes the present biodiversity at future.

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