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COMPARISON OF SPECIES RICHNESS AND DIVERSITY AT NATURAL STANDS AND PLANTATIONS OF STONE PINE (*PINUS PINEA* L.)

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Abstract

In recent years, plantation areas are criticized for the reduction of species diversity and deterioration of habitat quality. The effects of stone pine (*Pinus pinea* L.) plantations on species diversity were investigated in this study to enlighten the situation. A total of 73 sample areas were investigated from north western Turkey (Biga-Çanakkale) region, including 25 native and 48 plantation areas. Taxa of the sample areas were identified and species diversity and similarity analysis was performed. We found significantly lower number of plant species at plantation areas than natural areas at Pekmezli (4 yr old stand) and Kargı Çiftliği (25 yr old stand) blocks with p values 0.016 and 0.005 respectively. Shannon-Wiener index values of plantation areas were found to be 3.04 and 3.23 with p values 0.027 and 0.007 in Pekmezli and Kargı Çiftliği respectively. The Sorensen similarity analysis showed that, there was a higher similarity pattern in natural areas than in plantation areas. It was concluded that the plantation activities only in the areas of Pekmezli and Kargı Çiftliği negatively affected the number of species and diversity index values.

Key words: Anthropogenic effects, Mediterranean ecosystems, Plantation, Species diversity.

Introduction

Conversion of natural areas to agricultural and reforestation areas is very common and longstanding practice in the Mediterranean region (Carnus *et al.*, 2006; Berthrong *et al.*, 2009). During last several decades, pine forest plantations have shown a dramatical increase by re-forestation (Sheffer, 2012), afforestation and rehabilitation (Ozturk, 1995; Ozturk *et al.,*2002, 2008, 2010, 2011) in south Europe and Turkey. Existing plant community structure in maquis areas and degraded pasturelands are altered by reforestation, afforestation as well as plantation (Buscardo *et al.*, 2008; Andrés & Ojeda, 2002), which lead to a reduction or deterioration of biodiversity. Plantations potentially promote biodiversity when it has been implemented for rehabilitation of degraded lands, instead of replacing a natural vegetation type such as shrubland, maquis or forest land (Bremer & Farley, 2010). However, the effects of plantation activities on species diversity in the Mediterranean ecosystems (Maestre & Cortina, 2004) have been questioned, claiming the accomplishment of missing points. The effects of socio-economically pivoted plantations of plant communities have been a subject of interest in various geographies (Hofstede *et al.*, 2002; Brockerhoff *et al.*, 2003). The relations between the features of plantation areas and the species richness and density has been investigated by Chiarucci (1996) but the comparison of plantation areas and natural areas has been undertaken in only few studies (Andrés & Ojeda, 2002).

Stone pine (*Pinus pinea* L.) is one of the most important natural pine species of the Mediterranean region (Mayer & Aksoy, 1998). Its distribution in Turkey has been classified as; (i) dune stone pine forests (showing coastal distribution in the southern Mediterranean forest belt); (ii) kermes oak (*Quercus coccifera* L.) – stone pine communities (in south Aegean stone pine forests); (iii) high altitude Aleppo oak (*Quercusinfectoria* Oliv.) – stone pine communities (at 900-1200 m on the Marmara coast) (Mayer & Aksoy, 1998). Stone pine species is preferred in plantation for its cone production rather than its wood (Kılcı *et al.*, 2014).

Several shrub species accompanying stone pine in forests or in plantation areas under natural conditions have been identified by some authors (Topçuoğlu, 1966; Eliçin, 1981). However, there are many gaps on; (i) the effects of plantation activities in natural ecosystems (ii) the richness and diversity of species in natural areas in the neighborhood of plantation areas.

The main objective of this investigation was to determine the seeding effects of natural areas on the plant species richness and diversity among stone pine plantations. The ecological consequences generated from this study are anticipated to make a satisfying contribution to forest ecosystem managers.

Study area: The study area lies in the Northwestern region of Turkey (Biga-Çanakkale) (Fig. 1), with a landform rising from north to south. The data from Biga meteorological station has revealed that the average annual temperature is 14.0°C, average temperature 5.6°C in January and 23.1°C in July; annual precipitation is 666 mm, average precipitation is 12 mm in July and 113 mm in December (Anon., 2007). The soils of the area are chiefly decomposed from terrestrial deposited Pliocene rocks and volcanic depositions formed in Pliocene (Yıkılmaz *et al.*, 2002; Akkaya, 2008). Dominant plant species in Biga province are Calabrian pine and other shrubs. In the places where

Calabrian pine forests are damaged, shrub species under the forest form a secondary maquis vegetation (Akkaya, 2008). Stone pine natural forests are accompanied by characteristic plant species of the Mediterranean climate such as; *Pinusbrutia* Ten., *Arbutus andrachne* L., *Phillyrealatifolia* L., *Pistacia* spp., *Cistus* spp., *Laurusnobilis* L., *Paliurusspina-christi* Mill., *Rhus* spp., *Rhamnus* spp., *Quercuscoccifera* L., *Oleaeuropaea* L., *Tamarix* spp., *Quercusithaburensis* subsp. *macrolepis* (Kotschy) Hedge &Yalt.) and *Quercuscerris* L. (Topçuoğlu, 1966).

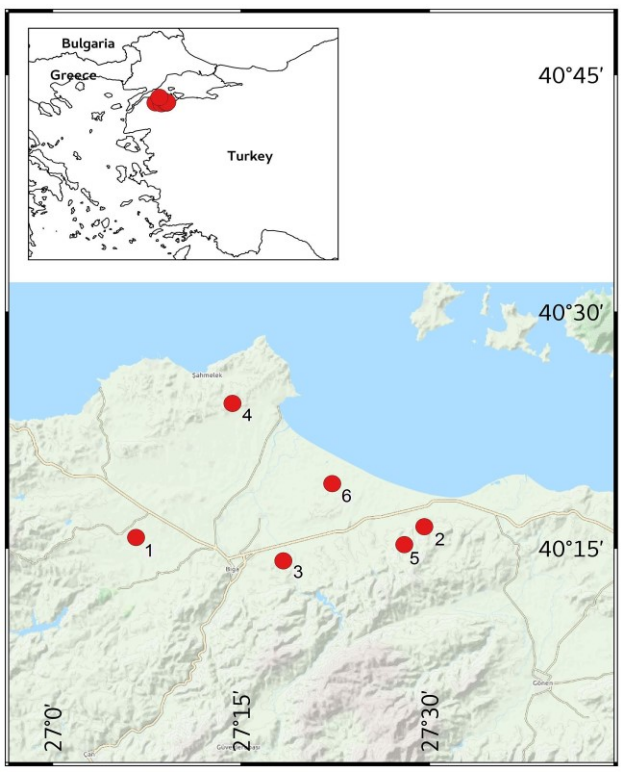

Fig. 1. Map showing the general location and the sampling sites. The numbers 1, 2, 3, 4, 5, and 6 on the figure refer to Pekmezli, Kepekli, Bahçeli, Örtülüce, İlyasalan, and Kargı Çiftliği sites respectively.

Material and Methods

The location names of the sampled areas are Pekmezli, Kepekli, Bahçeli, Örtülüce, İlyasalan and Kargı Çiftiği (Fig. 1; 1 to 6). Natural and plantation sample areas were selected to be contiguous and reveal similar site features such as parent rock, topography and microclimate. However, forest roads or formation of other clearances at a width of 8-12 m between natural and plantation areas have been accepted as a buffer zone for separation of two contrasting sampling plots (Fig. 2). In addition, care was taken to keep the natural areas exposed to windward direction prior to plantation areas. As the wind direction has the most important contribution to seed distribution, this factor has been ruled out for all areas. Natural vegetation cover is tall oak-pasture at Pekmezli (43 m above sea level (asl) – 6 × 6 m plantation distance (PD)), maquis at Kepekli (90 m asl – 6 × 6 m PD), Örtülüce (150 m asl - 5 × 5 m PD) and İlyasalan (200 m asl - 6 × 3 m PD), shrubs at Bahçeli (105 m asl - 5 × 5 m PD) and a pasture at Kargı Çiftliği (34 m asl - 6 × 6 m PD).

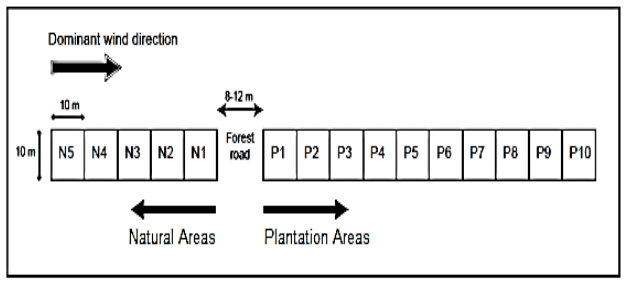

Fig. 2. The sampling venue layout and numbering of sub-sample areas in the blocks.

The ages of stone pine plantations were recorded to be 4, 7, 12,18, 25 and 26, years respectively in each sampling block from number 1 to 6. Plant samplings were made at both natural (5, 3, 4, 5, 3, 5 plots) and plantation (10, 5, 6, 9, 8 and 10 plots) areas. The intersected structure of sampling block is shown in Figure 2. In each block, natural areas are represented by N1, N2 while plantation areas are shown by codes P1, P2. Hereafter "NT" represents the taxa available in the entire natural areas for each block, whereas, "PT" represents the taxa available in all the plantation areas. In total, 73 sample areas were analyzed from 6 aforementioned sites (Fig. 1), 25 of them are from plantations, 48 are from natural areas.

The borderline of natural and plantation areas was accepted as zero point and numeration of sub-sample plots started from this zone (Fig. 2).

Sample area size and taking samples: The size of sub-sampling plots for collecting the plant samples was 10 x 10 m= 100 m^2 which were flagged at corners prior to sampling. For the species diversity, samplings were made 5 times during 2012 and 2013. Plant collection for identification was continued for 18 months during the same period. Individuals belonging to the species were counted in 2 x 2 m quadrates with 5 replications and coverage degrees of species assigned according to the Braun-Blanquet method (Kılınç & Kurtbay, 2004; Kavgacı, 2007). Collected plant samples were pressed and dried, their identification was done with the help of "Flora of Turkey and the East Eagean Islands" (Davis *et al.*, 1965-1985, 1988; Güner *et al.*, 2000). The identified plant samples were compared with the identified plants present at the Istanbul University, Faculty of Forestry Herbarium (ISTO) to check the species determination.

Statistical analysis methods: Data set was created from the plant species collected at separate times. The species diversity was determined by Shannon-Wiener diversity index (Magurran, 1988, 2005). Sorensen similarity analysis was conducted to determine the internal similarities of sample areas at natural and plantation sampling plots (Legendre & Legendre, 1998). Both species diversity index and similarity analysis were made via Species Diversity and Richness (SDR) IV software. The Braun- Blanquet coverage degrees were transferred into SDR software after alteration by Van der Maarel (1979) method. The species richness and diversity index values of sampled plots were compared as follows: 1) natural areas in themselves, 2) plantation areas in themselves, and 3) minimum, maximum and average similarity values of the natural and plantation areas (natural-plantation).

Prior to comparison of the groups, normality and homogeneity of variances were tested. The normally distributed and having equal variance data was analyzed by independent T test, and the groups not showing normal distribution were analyzed by Mann-Whitney U test (Özdamar, 2002; Orhunbilge, 2002). SPSS 18 software package was used for these analyzes.

Results

Comparison of Species Richness: The number of taxa identified in all areas was 253. The highest number of taxa in natural areas was detected in Kargı Çiftliği (102) and the lowest number of taxa was detected in İlyasalan (27). In plantation areas; Kargı Çiftliği had the highest species richness (85) whereas Kepekli and Bahçeli had the lowest (48).

While the number of taxa of natural sample areas of the blocks varied between 13 and 50, it varies between 14 and 42 in plantation areas (Table 1).

Comparison of the number of taxa results for each of the sampled areas is given in Table 1. We detected significant difference at sites Pekmezli ($p<0.05$; sig. 0.016) and Kargı Çiftliği ($p<0.05$; sig. 0.005) between the numbers of taxa in natural and plantation sampling plots (Table 1).

Number of taxa variation at 6 research plots too can be seen in Table 1. The number of taxa in plantation areas for the plots Kargı Çiftliği, Örtülüce and Pekmezli decreased with the distance from natural areas. This decrease becomes more evident further than block number P4 (Fig. 2).

Comparison of the species diversity: Shannon-Wiener index values of natural areas were found between 3.89 and 2.39 whereas in plantation areas they were between 3.68 and 2.43 (Table 2). In natural and plantation areas, the highest average Shannon-Wiener values were determined in Kargı Çiftliği with 3.76 and 3.23, respectively. The lowest average species diversity index values were found in İlyasalan with 2.65 for natural areas, 2.74 in Bahçeli for plantations (Table 2).

In six blocks, Shannon-Wiener index values of plantation areas in Kargı Çiftliği, Örtülüce and Pekmezli decrease with the increasing spatial axis from natural areas. This decrease becomes more evident after P4 blocks and, shows a similar trend with the number of taxa.

Table 1. Comparison of the number of taxa between natural and plantation areas in the blocks.

Blocks	Natural areas				Plantation areas				Significance
	N	Lowest	Highest	Average	N	Lowest	Highest	Average	
Pekmezli*	5	25	50	35	10	15	30	23	**0.016**
Kepekli**	3	18	24	22	5	16	25	22	0.923
Bahçeli**	4	19	25	22	6	14	23	19	0.214
Örtülüce**	5	19	45	29	9	21	41	26	0.550
İlyasalan**	3	13	22	17	8	16	26	20	0.669
Kargı Çiftliği*	5	40	53	47	10	23	42	29	**0.005**

* Mann-Whitney U Test

**Independent T test was used

Table 2. Comparison of Shannon-Wiener Index values of natural and plantation areas.

Blocks	Natural areas				Plantation areas				Significance
	N	Lowest	Highest	Average	N	Lowest	Highest	Average	
Pekmezli*	5	3.11	3.83	3.43	10	2.67	3.36	3.04	**0.027**
Kepekli**	3	2.76	3.06	2.96	5	2.68	3.14	2.99	0.877
Bahçeli**	4	2.76	3.05	2.91	6	2.43	2.97	2.74	0.118
Örtülüce**	5	2.81	3.71	3.19	9	2.92	3.62	3.12	0.490
İlyasalan**	3	2.39	2.91	2.65	8	2.62	3.12	2.81	0.482
Kargı Çiftliği*	5	3.59	3.89	3.76	10	2.99	3.68	3.23	**0.007**

* Mann-Whitney Test

**Independent T test was used

Table 3. Similarity values of natural, plantation and natural-plantation areas.

Blocks	Natural			Plantation			Natural – Plantation		
	Lowest	Highest	Average	Lowest	Highest	Average	Lowest	Highest	Average
Pekmezli	0.39	0.51	0.44	0.39	0.71	0.51	0.27	0.63	0.40
Kepekli	0.43	0.67	0.53	0.36	0.63	0.51	0.15	0.43	0.30
Bahçeli	0.35	0.68	0.51	0.33	0.63	0.48	0.22	0.59	0.37
Örtülüce	0.48	0.68	0.56	0.22	0.58	0.39	0.18	0.47	0.30
İlyasalan	0.57	0.87	0.68	0.33	0.67	0.48	0.30	0.58	0.45
Kargı Çiftliği	0.40	0.62	0.49	0.27	0.63	0.42	0.16	0.45	0.29

Comparison of similarities: Sorensen similarity values of natural sampling plots varied between 0.44 and 0.68 while it was between 0.39 and 0.51 in plantation plots (Table 3).

Similarities of the blocks are presented in Table 3. The highest similarity values were detected in natural areas. Similarity features of the investigated samples ranked in natural>plantation>natural-plantation order (Table 3).

Discussion and conclusions: Removal of plant cover before plantation, eliminates the species that would accompany the trees in the environment, and affect the soil properties. Elimination of vegetation prior to plantationactivities, permits light to reach the understory vegetation (Härdtle *et al.*, 2003). Therefore, although it is not one of the forestry purposes, removal of overstory and soil preparation provides a good habitat for many herbaceous species. In the study by Gulsoy *et al*. (2014), the impact of soil on tree growth has been assigned as one of the most important variant in semi-arid regions of Turkey.As such, the impact of plantationactivities on the number, coexistence and diversity of plant taxa available in the habitat needs to be investigated.

In this study, the number of taxa identified in the whole area is 253. The number of taxa recorded for the Biga Flora (Sevgi *et al*. project continuing) is reported to lie around 600 taxa. The floral studies in the proximity of the region show that the number in Lapseki-Ezine district (120 km SW) is 267 taxa, in Troy National Park (102 km W) 515 taxa, in Yenice - Eybek Mountain (45 km S) 325 taxa, in Gökçeada (Imbros) (150 km W) 711 plant species and in Bozcaada (Tenedos) (144 km SW) 437 plant species (Seçmen, 1977; Tokcan, 2002; Uysal *et al.*, 2003; Mutlu, 2011). The total number of taxa determined in our study area is close to the average number value verified by studies cited here.

The total number of taxa identified at natural and plantation area sampling plots reveal noteworthy differences. Total number of taxa of natural and plantation areas have the highest values in Kargı Çiftliği, while the lowest number of taxa was detected in İlyasalan and Bahçeli at natural and plantation areas respectively (Table 1). The existence of taxa should have sourced from the ancestors prior to carrying out of plantations.

The number of taxa in Pekmezli and Kargı Çiftliği natural areas were obviously found to be higher, in Örtülüce, Kepekli and Bahçeli moderately high and in İlyasalan the lowest (Table 1). Cultivation maintenance works carried out in Pekmezli area seems to be responsible for a reduction in the number of species entering plantation areas. However, increased number of new species in the first years of plantation has been reported by Arduini & Ercoli (2012). Our results from Pekmezli; with a high ground water level; coincide with the findings of Buscardo *et al.* (2008).Therefore, continuation of plant sampling work in Pekmezli in the years ahead will provide essential information. In 25-year-old Kargı Çiftliği plantation; with a higher canopy closure of stone pine stands; the number of taxa recorded by us from the plots was low. The branch pruning practices to improve the light access into the crowns has resulted in higher amount of litter production. This might have inhibited the growth of new species. The similarity of taxa numbers in Kepekli and Bahçeli might be due to their age similarities; being close to each other 7 and 12 respectively. Less canopy closure of pines or high plant seed transfer may have increased the number of taxa at plantation areas. At İlyasalan area (26 yr old), seed migration has been interrupted by tall scrubs. The negative relation between the number of taxa and canopy closure of tree and shrub layers detected by Kavgacı, (2007) and Adili *et al.* (2013) is in confirmity with our findings.

When the number of taxa of natural and plantation areas is compared, similar results with the total number of taxa is obtained. Mean number of taxa was 35 in natural areas in Pekmezli and 23 in plantation areas and was determined to be significantly different ($p<0.016$) (Table 1).Similarly, mean number of taxa in natural areas in Kargı Çiftliği was 47 but 29 in plantation areas, this was determined to be significantly different ($p<0.005$) (Table 1). In other areas, no significant differences were obtained. Consequently, the number of taxa in the plantation areas in Örtülüce and İlyasalan could not be found higher. The Sorensen similarity values of the plantation areas also support this situation.

Shannon-Wiener results of natural and plantation areas of the blocks are similar to the number of taxa. Likewise, the significance of Shannon-Wiener index values at Pekmezli and Kargı Çiftliği areas are 0.027 and 0.007 respectively, and were found to be significantly different from the plantation areas (Table 2).

With distancing from natural areas, in Kargı Çiftliği, Örtülüce and Pekmezli, the number of taxa and Shannon-Wiener index values decreased. The distance to the natural seed sources can affect the number of taxa and Shannon-Wiener index values. Since canopy closures increase as stands get older, the number of taxa and Shannon-Wiener index values decrease. When the similarities of natural and plantation areas in the blocks are examined between themselves and each other, they ranked in natural areas> plantation> natural and plantation order (Table 3). The lowest average similarity values among natural areas is detected in Pekmezli as 0.44 and the highest in İlyasalan (0.68). Therefore, the presence of differences among the sample area units may be the evidence that it could not be determined by a dominant factor. Accordingly, the lowest average value of similarity in plantation areas is 0.39 in Örtülüce and the highest value is 0.51 in Pekmezli and Kepekli (Table 3).

We can conclude that, species diversity of natural areas and plantation areas was found to be different in two blocks, and in four blocks there were no differences. Thus, this result stresses the fact that habitat characteristics have an important impact on the diversity and similarity. It is possible to generalize that stone pine plantations in some specific areas affect the number and diversity of taxa negatively. However, the plantation at a distance of 6 x 6 m might offer a great opportunity for other species to merge in to the plantation zone. The removal of shrubs casting a shadow is advantageous for new species in the area.The effects of plantations on understory diversity may change due to different ages of the stands (Nagaike, 2003) or the plantation of different mixed species (Ou *et al*., 2015). Therefore, the studies in aged stands, with varying plot sizes and habitats need to be followed.

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