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Investigating and Comparison of Regeneration Diversity of Plant Species in Maritime Pine (*Pinus Pinaster* Aiton.) Stands in Western Black Sea Forests of Bartin Region in Turkey

Halil Barış ÖZEL[1],Tuğrul VAROL[2*], Tuna EMİR[3], Emrah Şahin[4]

[1]*Bartin University, Faculty of Forest Engineering, 74100, Bartin-Turkey*
[2]*Bartin University, Faculty of Forest Engineering, 74100, Bartin-Turkey*
[3]*Bartin University, Faculty of Forest Engineering, 74100, Bartin-Turkey*
[4]*Erzurum Forest Regional Directorate 25000, Erzurum-Turkey*

Abstract: This paper, evaluates the regeneration diversity of woody species in two stands; *Pinus pinaster* Aiton. plantation and semi-natural stands. Two divisons in Karaçaydere series of Bartın were selected. The forest stand division numbers 19 (*Pinus pinaster* Aiton semi-natural stand) and 20 (*Pinus pinaster* Aiton plantation stand) with an area of 1.0 ha and 1.5 ha, respectively. The Random-Systematic method was carried out sampling plots of $25m^2$. In each plot number of plants, diameter at breast height (DBH) and plant species was measured. In each plot number of trees, DBH and density of woody species was determined. Data were analysed and the mean of each index was calculated and compared by t-test. Results showed that, diversity and richness indices in the plantation stand was more than in the semi-natural stand according to all plant indexes. Furthermore the highest values obtained from MacArthur's N_1 index among all plan indices in both plantation and semi-natural stands of maritime pine as 1.998 and 0.744 respectively. Light condition factor has been affected on the diversity of the woody plant species found in the research area.

Keywords: Plantation Stand, Semi-natural Stand.

1. Introduction

It is becoming increasingly difficult to meet the demand for rapidly increasing industrialization and the products and services of the community from the natural resources in the face of the population. As a matter of fact, forests, which are the best sources of carbon sequestration in the prevention of global warming, have been significantly degraded due to overuse, fires, run-offs and other biotic and abiotic factors, and natural structures have been degraded. According to FAO, about 4 million hectares of forest area have been lost in the world forest by 2015 [1]. On the other hand, fast-growing species and industrial plantations are being established in large areas in order to be able to meet some of the raw material demands of the whole humanity from the forests[2]. The industrial plantation area in the whole world was 187 million hectares in 2000 and this rate reached 255 million hectares in 2005 [3,4,5]. The establishment of industrial plantations with rapidly developing species in Turkey started in 1950 [6]. However, planned industrial plantation studies have been started in coastal areas since 1980[7,8]. Fast growing forest tree species such as *Pinus pinaster* Aiton., *Pinus radiata* D. Don, *Pinus taeda* L., *Pinus elliotti* Engelm, *Pinus halepensis* Mill., *Pseudotsuga menziesii* Mirb. Franco, *Pinus brutia* Ten. and *Pinus contorta* Dougl. were used in the industrial plantations established in Turkey [9]. *Pinus pinaster* Aiton is one of the species that has the highest volume and increment values in industrial plantations established in Turkey [10]. Some important discussions on these plantations, which have been established to meet the raw material needs of the forest industry, continue today. At the beginning of these discussions, exotic species used in the planting of industrial plantations have destroyed many natural and natural habitats, leaving the species with their disappearance [11,12,13,14]. New research work needs to be done in this regard. For this purpose, in this research carried out in the maritime pine plantation forests of Bartın-Karaçaydere series coastal watersheds, the diversity of natural plant species diversity in semi-naturalized and completely planted stands were compared. In addition, some suggestions have been made about the future and management of plantation forests in the direction of the data obtained from this research.

2. Material and Method

Study Area

The research was carried out in divisions number 19 (*Pinus pinaster* Aiton. semi-natural stand) and 20 (*Pinus pinaster* Aiton. plantation stand) forest.
The information about research area is given Table 1.

Division No	Area (ha)	Altitude (m)	Aspect	Slope (%)	Coordinate
19	1.0	290	NW	20	441487-4617029
20	1.5	287	NW	23	441487-4617026

Table 1: Description Information About Research Area.

Data Collection

The research area is located in the Western Black Sea sub-climate type of Black Sea macro climate type. Accordingly, the mean temperature is 12.64°C and the mean precipitation is 1035 mm. In general, the climate is of the moist climate type in all seasons. In the research area, the soil texture is sandy-clay-slime textures. Structure is multi-piece structure. In terms of depth, it falls into deep soil class [15].

In the study, a total of 15 sample plots were collected in a number of 5x5 m according to the random sampling method in the number and distribution to best represent the research area and the diversity of plant species in both sections were determined. The species and numbers of the plants in the sample plots were determined. In addition, the height breast diameter (DBH) and height of the plants in the form of trees were measured in the sample plots. The following equations and explanations have been used to determine plant diversity and richness in plantations and semi-natural stands of maritime pine.

Data Analysis

Plant species diversity and species richness have been identified using the indices described in the following subheadings.

Diversity index measures

Simpson's diversity index
Formula of this index:

$$D = \sum_{i=1}^{N} \left(\frac{n_i (n_i - 1)}{N(N-1)} \right) \qquad \text{(Eq.1)}$$

Where; s is number of species; n_i is frequency of the i species and N is total frequency of species.
The value of this index also ranges between 0 and $1 - s^{-1}$. In 1973, N_2 formula was obtained by Hill based on D^{-1} index:

$$N_2 = \frac{1}{D} \qquad \text{(Eq.2)}$$

Where; N_2 is very frequent species; p_i is relative frequency of these species.
The value of this index also ranges between 1 and s (number of specie). Simpson's diversity index is a measure of diversity. In ecology, it is often used to quantify the diversity of a habitat. It takes into account the number of species present, as well as the abundance of each species. It is more sensitive to very frequent species.

Shannon wiener index
It is more sensitive to rare species in the plant community. Formula of this index:

$$H' = -\sum_{i=1}^{s} p_i Log_2 p_i \qquad \text{(Eq.3)}$$

Where; H is Shannon wiener index; s is number of species; p_i is relative frequency of the i species. The value of this index also ranges between $Log_2[N/(N/S)]$ and Log_2S. The number of frequent species is calculated from another formula which is $N_1 = 2^H$ where; N_1 is number of frequent species. Recent formula was developed by Magurran (1996) based on Shannon wiener index where; N_1 is number of frequent species.

Brillouin diversity index

Formula of this index:

$$H = \frac{1}{N} Log_2^{\left[\frac{Ni}{n^i_1 n^i_2 n^i_3}\right]} \qquad \text{(Eq.4)}$$

Where; N is total species frequency and $n^i_1\ n^i_2\ n^i_3$refers to frequency of different species.

Richness index measures

Margalef's richness index

$$R_1 = \left[\frac{S-1}{Ln(N)}\right] \qquad \text{(Eq.5)}$$

Where; $R_1$is Margalef's richness index; *s* is total number of species and *N* is total frequency of species.

Menhinick's richness index

$$R_2 = \left[\frac{S}{\sqrt{N}}\right] \qquad \text{(Eq.6)}$$

Where; R_2 is Menhinick's richness index; s is total number of species and N is total frequency of species.

Statistical Analysis

The t-test was used to compare the mean values of plant diversity and the index of richness in the study. Furthermore, all statistical analyzes were performed in the SPSS packet statistical program.

Results and Discussion

The mean height, mean diameter (DBH) andnumber ofplant species in square meter in the plantation and semi-natural stands of Pinus pinaster Aiton that make up the research area are shown in Table 2.

Species	Plantation Stand			Semi-Natural Stand		
	Height (m)	DBH (cm)	Number of Plant Species (n/m^2)	Height (m)	DBH (cm)	Number of Plant Species (n/m^2)
Fagus orientalis Lipsky.	2.1	1.3	4.3	1.5	0.86	1.2
Carpinus betulus L.	1.7	1.1	2.2	-	-	-
Quercus petraea (Matt.) Liebl.	1.5	0.92	1.3	-	-	-
Quercus robur L.	1.4	1.2	1.5	-	-	-
Rhododendron ponticum L.	1.2	0.87	3.6	1.4	0.72	1.6
Buxus sempervirens L.	-	-	-	0.76	0.54	1.0
Ulmus minor Miller.	0.98	0.76	1.0	-	-	-
Rosa canina L.	1.5	0.53	3.8	1.2	0.84	2.7
Rubus fruticosus L.	1.2	0.94	5.4	1.3	0.56	1.3
Laurus nobilis L.	1.8	1.3	2.2	-	-	-

Table 2: Mean Height, DBH and Number of Plant Species Per Square Meter in Plantation and Semi-Natural Stand of Maritime Pine.

According to Table 2, it is determined that 9 plant species are found in the plantation stand of maritime pine, and 5 plant species are found in the semi-natural stand of maritime pine. In particular, it was determined

that the eastern beech individuals, which are generally found as shoots, have the highest height (2.1 m) and diameter (1.3 cm) in the tree species and this type follows the burrow. In terms of the frequency of locality, it was determined that *Rubus fruticosus*L, *Rosa canina* L. and *Rhododendron ponticum* L. species existed in both stands type.

The results of statistical analysis for comparing mean of different regeneration diversity indices of woody species in natural and plantation stands are shown in Tabel 3. It can be deduced that, there is significant difference between mean diversity indices (*P<0.01*).

Parameters	**Plantation stand**	**Semi-Natural stand**	***t***
Simpson's index	0.399	0.123	-4.086**
Shannon-Wiener index	0.685	0.216	-3.953**
Hill(N_2)	1.774	0.616	-3.965**
Brillouin's index	0.564	0.173	-4.132**
MacArthur(N_1)	1.998	0.744	-3.669**
Margalef index	0.791	0.259	-4.009**
McIntosh's index	0.296	0.082	-3.831**

**: *P<0.01*significant statistical differences.

Table 3: Mean Plant Diversity Indices of Plant Species in Plantation and Semi-Natural Stands By Means of T-Test.

The results of statistical analysis for comparing mean of different plant richness indices of plant species in plantation and semi-natural stands are shown in Table4. There is no significant difference between mean Margalef's richness index in two studied stands whereas, there is significant difference between mean Menhinick's richness index in two stands (P<0.05). Accordingly, the plant richness index value is higher in the plantation stand than in the natural stand.

Parameters	**Plantation stand**	**Semi-Natural stand**	***t***
Margalef's richness index	0.645	0.423	-1.782^{ns}
Menhinick's richness index	0.678	0.471	-2.482*

*: *P<0.05*significant statistical differences**ns:** non- significant)

Table 4. Mean Plant Richness Indices Values of Plantation and Semi- Natural Stands by Means of T-Test.

The establishment of artificial forests through plantation directly affects the diversity and richness of the undergrowth of the stands[16]. Therefore, the microecological conditions and the dynamics of the stands of the new forests using artificial methods vary considerably [17].At the beginning of these changing dynamics is light ecology. After the establishment of the forests, the maintenance work related to the age of development affects light ecology [18].In this context, firstly the shade-resistant species come to the lower part of the stand and then it is seen that the species with higher light intensities with increasing light intensities are coming to the area [19]. This is especially evident in the areas where clearcuttings are made [20]. Because of increasing light intensities depending on maintenance cuttings, it has been identified as pioneer species of *Rhododendron ponticum* L., *Ulmus minor* Miller., *Rosa canina* L., *Rubus fruticosus* L. and *Laurus nobilis* L. at the maritime pine plantation in Karaçaydere series, respectively (Table2). As a matter of fact, when the plant diversity indices are examined, it is determined that the number of species found in the plantation area related to the coastal area is more than all the indices are semi-natural stands. Also, there was a significant difference in p <0.01 level for both index types in both types of stands (Table3). In another survey conducted in this area, it has been determined that single and multi-annual pioneer species have been introduced to the lower layer as a result of the cuts especially to increase plant diversity. In the same study in Loblolly pine (*Pinus taeda* L.) is reported that the diversity of the plant is very high according to the MacArthur(N_1) index after the first maintenance sections in the plantation stands [21]. In the study, the plant variety of two stands type was examined in richness and the obtained results are given in Table 4. According to *Menhinick's richness index*, there was a difference in *P <0.05* confidence level between two types of stands. As for that the plant richness index value is higher than the

semi-natural stand in the maritime pine plantation. This is due to the fact that other ecological conditions, especially light conditions, are suitable for pioneer species in plantation stands of maritime pine. As a matter of fact, in the middle of the semi-natural maritime pine stand, the trees have high crown projection areas and the light intensity entering the stands is very low. For this reason, only pioneer plant species with high tolerance to shadows could come to the area in semi-natural stands of maritime pine. Similar results were obtained in a survey conducted in Naran valley [22]. According to the findings obtained from this survey, it can be said that the maritime pine introduced by plantation and the Karaçaydere series began to become natural due to the time. In this context, it is determined that a one layer organization dominates the semi-natural maritime pine in the 19^{th} division, and that the juvenility of maritime pine as a result of fully naturalized in the ground layer have begun to occupy the area as a group. This signaled that occurred the area with the appropriate conditions could bring in future pure stands or oriental beech and some oak species and mixed forest stands with maritime pine. As a matter of fact, many studies on this subject have determined that exotic species are naturalized after long years due to adaptation to actual ecological conditions and behave like climax species [23,24,25,26].

Conclusion

The continuation of this research carried out in the Karaçaydere series and in the plantation and semi-natural stands of the maritime pine for a longer period is important in terms of definitively revealing the changes in the diversity and richness of both stands.In addition, the future rates of inclusion of the natural and native forest tree species that will be coming to the area in the future in both stands should be determined, and the volume production should be determined and the management strategies of the stands should be determined in accordance with this information. On the other hand, specimens of semi-natural stands of maritime pine habitats should be preserved and the continuity of nature or semi-natural industrial plantations should be ensured by exploiting the fast growth feature of large maritime pine habitats. This is especially important in terms of reducing social oppression on natural forest resources. However, all plants in the form of woody, herbaceous and shrub that come to the lower layer of the stand should be preserved in order to protect ecological balance and especially to improve soil conditions.

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Authors Profile

Halil Barış Özel was born at 27 June 1977. Halil Barış Özel was finished Bachelor Science at 1999, Master of Science at 2002 and Ph.D. degree at 2007 respectively. Furthermore Halil Barış ÖZEL has been Assoc Prof. Dr. Degree at 2013 in the İstanbul University. Halil Barış ÖZEL finished Bachelor Science, Master of Science and Ph.D. in the Zonguldak Karaelmas University in Bartın city in the Turkey. Halil Barış ÖZEL has special issues amount Silviculture, Afforestation, Forest Genetic, Plant Biodiversity, Plantation, Regeneration and Afforestation Mechanization. Özel is working still as a Assoc. Prof. Dr and Head Vice of Forest Engineering Divison in the Bartın Faculty of Forestry. He published very numbers paper and article in national and international journals about silviculture, forest genetics, plany biodiversity and afforestation. Furthermore ÖZEL was made as section author in the name of « Forest Introduction and Resources » book as a publishing Françis and Taylor.

Tugrul Varol wasborn 04 June 1972 in Trabzon. Tuğrul VarolfinishedBachelorSc. at 1992, Master of Science at 1996 andPh.D at 2004 inthe Karadeniz Technical University, Zonguldak Karaelmas University and Bartın city in Turkey. Tuğrul Varol has beenspecialissuesforestroad, forest fire, GIS andForestMechanization.Varol wasstartedworkingresearchassitantbetween 1994-2004 and heworkedAssist. Prof. Dr. at 2004 still in the Bartın Faculty of Forestry. Hepublished a lot of paperandmanuscriptvariousnationalandinternationaljournalsabout his specialissues.

Tuna Emir was born 18May 1987 in Trabzon. Tuna Emirfinished Bachelor Science. at 2009 in the Zonguldak Karaelmas Universityin Bartın city in the Turkey, Master of Science at 2013in the Bartın University.Tuna Emir has been special issues forestroad, forest fire, Ergonomics, occupational health and safety and forest mechanization. Emir was started working research assistantat 2011 and he is working still as research assistant in the Bartın Faculty of Forestry. He published a lot of paper and manuscript various national and international journals about his specialissues.

Emrah Sahin was born in Andırın in 1983. After graduating from Bartin University, Faculty of Forestry, Department of Forestry Engineering, in 2013.He started his master's degree at Bartin University, Institute of Science, Department of Forest Engineering. He is still continuing to graduate study at the same department.