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Determining plant species diversity of Scots pine stands in the Bolu Aladağ region of Türkiye

Determinación de la diversidad de especies vegetales de los rodales de pino silvestre en la región de Bolu Aladağ, Turquía

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SUMMARY

This study aims to determine how plant diversity changes at the alpha and gamma levels depending on stand type. Also, it tries to understand how plant diversity changes temporally and with relation to aspects during a given vegetation period. Sample areas were selected from pure Scots Pine stands with full canopy cover (70 - 100 %) and in different development stages (a, b, c, d) spread out within the Bolu Aladağ region of Türkiye. Field studies were carried out in 2016 from June-September. Sample stands were selected to cover two main aspects, north and south. The study was carried out by analyzing two repetitive and 10 quadrate samples in each stand. A total of 640 quadrate samples were analyzed, and the different plants were counted. In the study area, a total of 160 taxa were identified at the DUOF Herbarium. It was determined that while the stand type did not have a significant effect on taxon diversity, the effect of aspect and observation period was statistically significant (*P* < 0.05). Shannon index value was between 3.13 and 3.72 among the stands' different development stages, with the highest values found in the young stands. Diversity was higher on Northern aspects than Southern and rose and fell throughout the observation period with the highest values in June and August. Interestingly, while there was no significant effect of stand development stages on taxon diversity, a significant but low correlation has been found between stand diameter and evenness.

Keywords: Bolu-Türkiye, diversity, forest stand, Scots pine, sustainability.

RESUMEN

Este estudio intenta determinar cómo cambia la diversidad de plantas en los niveles alfa y gamma según los tipos de rodales. Además, trata de comprender cómo la diversidad vegetal cambia periódicamente y en relación a aspectos durante un período vegetativo. Las áreas de muestreo se tomaron de rodales de pino silvestre puro en el dosel completo (70 - 100 %) y en diferentes etapas de desarrollo (a, b, c, d) esparcidos en la región de Bolu Aladağ de Turquía. El estudio de campo se llevó a cabo entre junio y septiembre de 2016. Se seleccionaron rodales de muestra para cubrir dos aspectos principales, norte y sur. El estudio se llevó a cabo tomando dos muestras repetitivas y de 10 cuadrantes en cada rodal. Se tomaron un total de 640 muestras cuadradas y las diferentes plantas se determinaron como números. Se determinó que, si bien el tipo de rodal no tuvo un efecto significativo sobre la diversidad de taxones, el aspecto y el período de observación tuvieron un efecto estadísticamente significativo (*P* < 0,05). El índice de Shannon se modificó entre 3,13 y 3,72 entre las etapas de desarrollo de los rodales y el más alto en los rodales jóvenes. La diversidad es mayor en los aspectos del norte que en el sur y en zigzag a lo largo del período de observación con valores más altos en junio y agosto. Curiosamente, si bien no hubo un efecto significativo de las etapas de desarrollo del tipo de rodal sobre la diversidad de taxones, se ha encontrado una correlación significativa, por baja que sea, entre el diámetro del rodal y las tasas de uniformidad.

Palabras clave: Bolu-Turquia, diversidad, soporte forestal, pino silvestre, sostenibilidad.

INTRODUCTION

Forest ecosystems host various plant and animal species, and the protection of biodiversity in forests has become more important in recent years (FAO 2022). Forests consist of stands with different characteristics, which can affect ecological conditions such as microclimate and soil. These ecological conditions change the distribution patterns of understory flora, therefore the characteristics of different stands are essential in shaping plant diversity (Karaköse and Terzioğlu 2021).

Because stands, the basic units of the forest, have different crown closures, it is inevitable that the ground litter decomposition and soil conditions are affected by the differing amount of light that reaches the soil. Indeed, Svenning and Skov (2002) stated that the structure and types of stands are essential factors affecting the similarity of species in a region. Ister and Gökbulak (2009) have also stated that stand types have a significant effect on understory flora, and that while mixed stands provide better growing conditions for the understory, pure stands enable denser and more diverse flora formation. They claim that this is due to the shading effect of the tree canopy, the amount of ground litter added to the soil, and their effect on the conditions of competition in the understory. Pitkanen (1997) states that there is a high correlation between the variation of soil surface vegetation and site quality and stand age, and also states that basal area, proportions of different tree species, and canopy density are other important factors though less significant.

Efforts to manage forest ecosystems are based on utilization within the framework of ecosystem and biological diversity. In order to achieve ecosystem-based and sustainable utilization, the structure of vegetation, the most critical component of an ecosystem, must be understood in detail (Kavgacı 2007, Karaköse 2019). Although forests are said to be ecosystems rich in biodiversity, there is not enough information about biodiversity values in various forest ecosystems to allow for comparison or relative evaluation among them. Information about stand-level biodiversity is necessary for the successful development and planning of strategies for the utilization of these ecosystems.

Various floristic studies have been conducted in different regions of Turkey including those of Bolu and Aladağ, which were chosen as the study area (Akman *et al.* 1983, Sazak 1997, İkinci 2000, Aksoy 2001, Gülsoy and Özkan 2008, Kanoğlu 2011). Excluding the conservation areas, it is necessary to use data collected over large regions in forest planning and to produce numerical data by reducing them to the stand level. Measuring diversity is of great importance in ecological research and biodiversity conservation. Various indices have been developed to numerically express plant diversity based on the presence and abundance of plants in an area (Lu *et al.* 2007). The Simpson and Shannon indices, the total number of species, and species richness are the most common indices used to describe diversity (Hill 1973).

This study aims to describe the plant diversity of Scots pine forests in the Bolu Aladağ region at the stand level, and to produce numerical data that can be used in sustainable forest planning beyond the standard flora studies. In short, the study objective is to understand the effect of stand type or age class, aspect and time of observation on plant diversity of managed Scots pine forests.

METHODS

Study area. The study was carried out in the Aladağ region of the Köroğlu mountain range, extending in an east-west direction south of Bolu city center. Stands from which sample points were taken are located within the boundaries of Aladağ Forest Planning Unit (FPU), affiliated with Aladağ Forest Enterprise (figure 1). Aladağ FPU has a general area of 9,152 ha, 7,745 ha of which is forested land, and 1,406 ha is made up of plateaus with meadows and pasture lands. Of the forested area, 7,532 ha are productive forests and 213 ha are degraded.

The area is located between 31° 37’ 45’’ - 31° 42’ 59’’ east longitudes and 40° 34’ 40’’- 40° 37’ 51’’ north latitudes. The region is characterized by high mountainous terrain and generally consists of vast plains located between flat plateaus (Dündar 1989). The main tree species in the region are Scots pine (*Pinus sylvestris* L.) and Fir (*Abies nordmanniana* (Steven) Spach ssp. e*qui-trojani* (Asch.& Sint. *ex* Boiss.) Coode & Cullen). The study area varies between 1,360 m a.s.l. and 1,697 m a.s.l. The annual average precipitation is 545.3 mm, and the average annual temperature is 10.5 ºC.

The region is essentially an andesite massif (Duyar 2014). Generally, the soil type is uncultivated brown forest soil. While the clay content of the soils increases with elevation, the pH value of the soil tends to decrease, and the soil changes from mild acidity to medium acidity (Kantarcı 1979, Duyar 2014).

According to the P. H. Davis Flora of Turkey grid system, the study area is located in square A3 and the Sub-euxine zone of the Euro-Siberian phytogeographical region, and in the Middle Euxine (Sub-Euxine) and xerophytic (Xero-Euxine) sectors. Especially in the area behind Aladağ, there is a transition to Central Anatolian Steppe, and Iran-Turan (Irano-Turanian) influence is prominent. As for vegetation, the character of the Euro-Siberian vegetational region is present.

Transhumance activities are quite common in and around the region. Most people in the plateaus work in forestry and animal husbandry. The local people obtain their fuelwood and construction wood from the surrounding forests. In recent years, tourism, relaxation, and recreation in the region have also become more prominent, and an increase in population movement has been observed, especially in summer and on holidays (GDF 2005). The study area is certified by The Forest Stewardship Council (FSC).

Determination of sample stands and sampling of understory flora. The study was carried out in pure Scots pine stands. The age of sampled stands ranges between 10 and 120 years. We aimed to characterize the plant diversity in Scots pine stands in 4 different stand types and two aspects (north and south). For this purpose, pure Scots pine stands with normal canopy coverage (70 – 100 %) and in different development stages (a, b, c, d) were selected and grouped as follows:

Çsa3; Normal canopy, young and pure Scots pine stand with $d_{1,30}$ diameters less than 8 cm

Çsb3; Normal canopy, pure Scots pine stand with $d_{1,30}$ diameters between 8 - 19.9 cm

Çsc3; Normal canopy, pure Scots pine stand with $d_{1,30}$ diameters between 20 - 35.9 cm

Çsd3; Normal canopy, pure Scots pine stand with $d_{1,30}$ diameters of and greater than 36 cm

The study was conducted over the course of a vegetation period, and observations were made between June and September of 2016 on 2 aspects of pine stands in 4 different development stages with 2 repetitions. Information about the sampling pattern and the number of sample areas applied for this purpose is presented in table 1.

Consequently, 16 different stands were sampled. In order to represent the variation among stands, samplings were realized with two repetitions, and 10 quadrates spanning the whole extension of each stand were analyzed to represent the plants as well as possible. A total of 640 quadrates were sampled within the scope of the study, and the different taxa were counted.

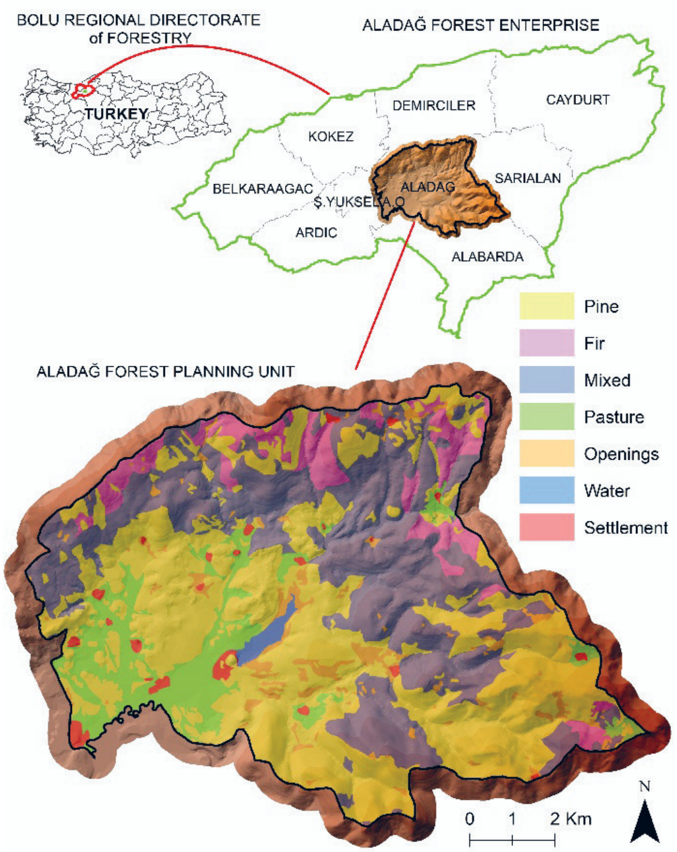

Figure 1. Location of the study area.

Localización de la zona de estudio.

Table 1. Sampling pattern applied in the study.

Patrón de muestreo aplicado en el estudio.

Tree Species	Stand Type (4)	Aspect (2)	Repetition (2)	Time of Observation (4)	Quadrate (10)	Total Quadrate (640)
Scots pine	Çsa Çsb Çsc Çsd	North South	2	June July August September	10	4 * 2 * 2 * 4 * 10 = 640

To characterize the plant diversity, sampling of the understory flora was carried out by monitoring the stands once a month during the vegetation period. By sampling the stands a total of four times in June, July, August and September of 2016, the flora's status was examined in terms of species and number during the vegetation period.

Sampling of the understory flora was carried out by applying the quadrate method along the transects. Before going into the field, the transect lines and the places where quadrate sampling would be performed were determined on the map. Transect lines were generally parallel to contour lines and covered the general area of stands (figure 2). The transect lines were not fixed and changed within the vegetation periods, therefore samples were taken at various points within the stand with the goal of representing the area in more detail.

10 quadrates were sampled per month in each stand. A total of 160 quadrates were sampled each month in 16 stands, using frames of 0.5 x 0.5m (0.25 m²) in size. The numbers of different plants included in the frame were recorded in the sample area reports. The names of the plants recognized in the field were written in the reports, and descriptive expressions were written for the unidentified plants. Plant samples were collected or photographed in order to identify them in the DUOF Herbarium.

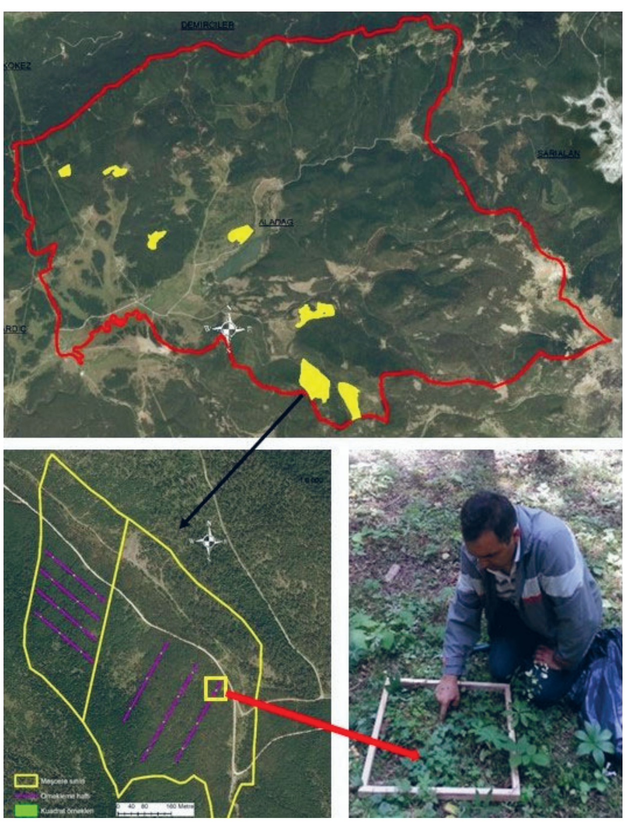

Figure 2. Sampled Scots pine stands and the sampling method

Rodales de pino silvestre muestreados y método de muestreo

Calculation of plant diversity indices. Many index values can be used when calculating diversity of ecosystems. For example, if a diversity calculation is made for each part of a community, the diversity in question is considered alpha diversity. However, if a large number of communities are brought together, and a diversity calculation is made on a larger scale, the diversity in question is considered gamma diversity. In order to determine the gamma diversity, large areas were included in the sampling area, and the species and numbers belonging to a large number of sampled areas were transformed into a single sample area and evaluated together. For example, the diversity indices belonging to the Çsc3 stand, 4 (time of observation) * 2 (aspect) * 10 (quadrate) * 2 (Repetition) = 160 quadrate samples were evaluated together. Also, different types of indices can be used to determine plant diversity in these alpha and gamma scales. When characterizing diversity, two factors are generally taken into consideration: richness and evenness. Species richness is a measure of the total number of species in a community or in a sample area. Evenness is a term that expresses how equally individuals in the community are distributed among different species. It shows the relative abundance of different species that make up the richness in the area. Species richness and evenness make up diversity. The higher the richness and evenness, the greater the diversity (Stirling and Wilsey 2001). In this study, Shannon-Wiener, Simpson dominance, Simpson diversity, and Pielou's evenness (homogeneity) indices were used to define plant diversity.

The mathematical expressions used to calculate the indices used in the study are shown below (Simpson 1949, Shannon and Weaver 1964, Pielou 1966).

Shannon-Wiener Diversity Index (SH):
$$SH = -\sum_{i=1}^{s} p_i \times ln p_i \quad [1]$$

Simpson Dominance Index (D)
$$D = \sum_{i=1}^{s} p_i^2 \quad [2]$$

Simpson Diversity Index (SI)
$$SI = 1 - D \quad [3]$$

Pielou's Evenness Index
$$PI = \sum_{i=1}^{s} \frac{SH}{lnS} \quad [4]$$

In these indices, p_i: refers to the ratio of the number of taxa to the total number of taxa, and s to the total number of taxa. The Shannon index can theoretically include infinite values above zero, but are usually distributed between 0 - 5. The larger the index value, the higher the variety. D in the Simpson dominance index represents values between 0 - 1. In this index, 0 (zero) indicates an infinite variety, and 1 (one) indicates no variety. Simpson's diversity index in the form of 1 - D was obtained by subtracting the D value from 1. This index also contains values between 0 - 1, and as the index value increases, the diversity increases. Pielou's Evenness Index contains values between 0 - 1. If each species is represented by an equal number of individuals, it is equal to 1.

Data analysis. The program called PAST 2.17c (PAleontological STatistics) (Hammer and Ryan 2001) was used to calculate index values used to determine plant diversity. Multiple variance analysis was performed using SPSS 22.0 (IBM 2013) to determine the effect of stand type, aspect and time of observation on plant diversity and the averages were compared with the Tukey test.

RESULTS

Plants observed in Scots pine forests and calculated plant diversity indices are presented separately based on stand type, time of observation, and aspect. In the study area, a total of 160 taxa were identified. The families containing the most genera in the study area are presented in table 2. The most common family in the study area is Fabaceae, with 23 taxa.

Taxa determined by stand types. The stands containing the highest number of taxa were Çsd3 (107) stands, followed by Çsa3 (102), Çsb3 (85) and Çsc3 (74) stands. While these are the cumulative number of taxa per stand type, number of taxa found for the stand types Çsa3, Çsb3, Çsc3 and Çsd3 as a mean are 23 ± 5, 21 ± 4, 19 ± 4 and 23 ± 5, respectively. The highest number of individuals per unit area (m²) was found in Çsc3 (184) stands, followed by Çsd3 (153), Çsa3 (131) and Çsb3 (116) stands (table 3).

Table 2. Families with the most genera in the study area and their statistics.

Familias con más géneros en el área de estudio y sus índices.

Family	Number of Taxa	Ratio to Total Number of Taxa (%)
Fabaceae	23	14.38
Asteraceae	21	13.13
Poaceae	15	9.37
Rosaceae	12	7.5
Lamiaceae	11	6.87
Plantaginaceae	9	5.63
Ericaceae	5	3.12
Rubiaceae	5	3.12
Brassicaceae	4	2.5
Polygonaceae	4	2.5
Ranunculaceae	4	2.5
Others	47	29.38

Table 3. The number of taxa and individuals identified in stands.

Número de taxones e individuos identificados en los rodales.

Stand	Number of Taxa		Number of Individuals (Pcs m^{-2})
	Mean	Total	
Çsa3	23 ± 5	102	131 ± 6
Çsb3	21 ± 4	85	116 ± 4
Çsc3	19 ± 4	74	184 ± 8
Çsd3	23 ± 5	107	153 ± 7

Taxa determined by time of observation. Differing numbers of taxa were observed in different time periods. Some taxa were only observed during one period, while others were observed during more periods or all time periods during the study. The largest number of individuals were counted in July (172 pcs m^{-2}), followed by September (148), August (140) and June (123) (table 5).

Maximum number of taxa was observed in June and July with a value of 101. The lowest was 70 taxa, observed in September.

While some plant taxa are observed only in a certain period, such as *Leuzea repens, Alyssum murale, Anemone blanda* etc. (June)*; Alchemilla pseudocartalinica, Anthyllis vulneraria, Astragalus glycyphyllos* etc. (July); *Carlina corymbosa., Cichorium inthybus, Holcus lanatus* etc. (August); and *Briza minor, Crocus speciosus, Oxalis acetosella* (September) etc., some taxa such as *Brachypodium sylavticum, Calamintha grandiflora, Circium hypoleucum* were observed in all periods during the study (table 6).

Taxa determined by aspects. 84 plant taxa were detected in both the northern and southern aspects. 22 taxa were observed only in the northern aspect, and 54 taxa were observed only in the southern aspect. Taxa such as *Alchemilla pseudocartalinica, Asperula involucrata, Brachypodium pinnatum* were observed in both northern and southern aspects. However, taxa such as *Anthyllis vulneraria, Briza minor, Calamintha grandiflora* were observed only in northern aspects, whereas *Acroptilon repens, Agrimonia eupatoria, Alopecurus arundinaceus, Alyssum murale* were only observed in southern aspects (table 7).

More taxa and a higher number of individuals were identified in the southern aspect (table 8).

In the 640 quadrate samples that were measured, the highest number of taxa (49) was found in the Çsd3 stand in June and in the southern aspect, and the lowest number of taxa (23) were found in July in the Çsa3 stand and in the northern aspect (table 9).

Alpha diversity. Within the scope of the study, the diversity indices calculated at the alpha level were used in the statistical analysis performed to determine the differences in diversity based on stand type, aspect, and time of observation. In order to determine the effect of stand type,

Table 4. The taxa observed in Scots pine forests based on stand types.
Los taxones observados en los pinares de pino silvestre en función del tipo de rodal.

Çsa3	Çsb3	Çsc3	Çsd3	In all stands	
Agrimonia eupatoria	*Barbarea vulgaris*	*Anemone blanda*	*Acroptilon repens*	*Abies nordmanniana*	*Juniperus oxycedrus*
Cardamine bulbifera	*Dorycnium graecum*	*Astragalus glycyphyllos*	*Alyssum murale*	*Asperula involucrata*	*Lapsana communis*
Euphorbia amygdaloides	*Lapsana communis* subsp. *intermedia*	*Lathyrus laxiflorus* subsp. *laxiflorus*	*Anthyllis vulneraria*	*Brachypodium pinnatum*	*Lathyrus aureus*
Galium verum	*Pilosella piloselloides*	*Pyrola minor*	*Briza minor*	*Brachypodium sylvaticum*	*Lotus corniculatus*
Lathyrus aureus	*Pyrola minor*	*Trifolium repens*	*Campanula glomerata*	*Bromus sterilis*	*Luzula campestris*
Malva neglecta	*Salvia verticillata*		*Carlina corymbosa*	*Carex muricata*	*Melica uniflora*
Mycelis muralis	*Trogopogon longirostris*		*Centaurea triumfettii*	*Circium hypoleucum*	*Pilosella hoppeana*
Ononis spinosa	*Valeriana alliariifolia*		*Cota tinctoria* var. *discoida*	*Circium arvense*	*Pilosella piloselloides*
Orobanche arenaria	*Veronica gentianoides*		*Iris sintenisii*	*Clinopodium vulgare*	*Pinus sylvestris*
Oxalis acetosella	*Veronica orientalis*		*Knautia involucrata*	*Crepis foetida*	*Poa trivialis*
Polygala anatolica			*Lamium purpureum*	*Dactylis glomerata*	*Sanicula europea*
Potentilla argentea			*Medicago irigamella*	*Daphne pontica*	*Sedum pallidum*
Potentilla recta			*Moenchia mantica*	*Digitalis ferruginea*	*Trifolium medium*
Potentilla reptans			*Petrorhagia alpina*	*Dorycnium orientale*	*Trifolium pratense*
Pyrola chlorantha			*Pimpinella saxifraga*	*Epilobium angustifolium*	*Trifolium hybridum*
Asperula involucrata			*Poa bulbosa*	*Fragaria vesca*	*Veronica chamaedrys*
Rumex acotesella			*Polygonatum orientale*	*Galium rotundifolium*	*Veronica officinalis*
Rumex crispus			*Primula vulgaris*	*Galium verum*	*Veronica gentionoides*
Tragopogon longirostris			*Silene italica*	*Geranium robertianum*	*Viola odorata*
Trifolium resupirataum			*Thlaspi perfoliatum*	*Hieracium medianiforme*	*Viola suavis*

aspect, and time of observation on plant diversity, multiple variance analysis was performed, and the averages were compared with the Tukey test.

When the Scots pine stands were compared using the Simpson diversity index, it was determined that stand type had no significant effect on taxon diversity ($P > 0.05$), but that aspect and time of observation had a statistically significant effect on plant species diversity (figure 3).

When the Scots pine stands in the study area were evaluated in terms of Simpson's diversity index interactions, it was determined that the interaction between aspect and time of observation was significant ($P < 0.05$) while the other interactions were not. According to these results, the lowest variety in terms of the Simpson diversity index was measured as 0.67 in southern aspect stands in September, and the highest variation was measured as 0.90 in northern aspect stands in June and August (table 10).

When the Scots pine stands were compared using the Shannon diversity index, it was determined that stand type was not important in terms of taxon diversity ($P > 0.05$), but aspect and period had a statistically significant effect on diversity (figure 4).

When the Shannon diversity index was evaluated in terms of interactions, it was found that the aspect-period interaction was significant ($P < 0.05$), while the other interactions were not. According to these results, the lowest variety in terms of the Shannon diversity index was measured in southern aspect stands with 1.76 in September, and the highest diversity in southern aspect stands with 2.62 in June (table 11).

According to the Evenness values, which is an important indicator of the regularity of plant species distribution in the area, it was determined that stand type did not have a significant effect on the homogeneous distribution of the species in the area ($P > 0.05$), while the aspect and time of observation had a significant effect ($P < 0.05$). The species distribution was more homogeneous in the northern aspects compared to the southern aspects, and when conside-

Table 5. Species observed in Scots pine forests based on time of observation.

Especies determinadas en los pinares de pino silvestre en función del periodo de observación.

Time of Observation	Number of Taxa		Number of Individuals (Pcs m^{-2})
	Mean	Total	
June	23 ± 5	101	123 ± 3
July	21 ± 4	101	172 ± 9
August	23 ± 4	91	140 ± 5
September	19 ± 4	70	148 ± 7

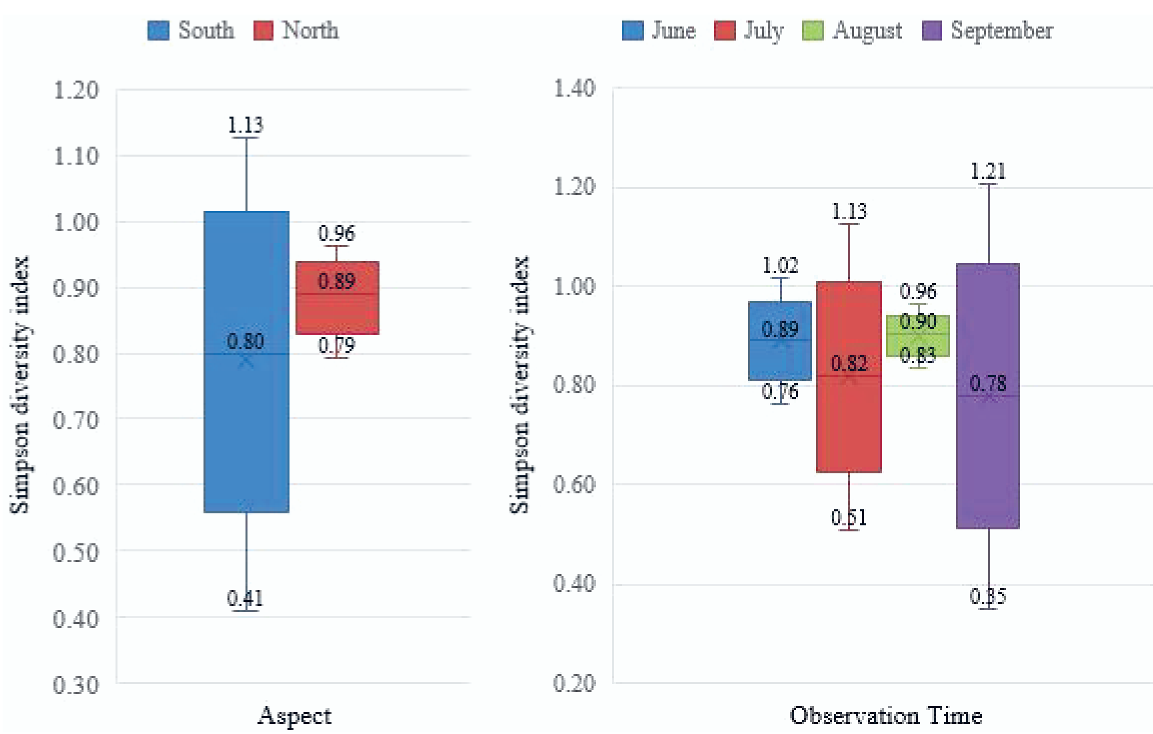

Figure 3. Variation of Simpson diversity index in Scots pine stands in terms of aspects and periods.

Variación del índice de diversidad de Simpson en masas de pino silvestre en función de aspectos y periodos.

Table 6. Determined species in Scots pine forests based on observation period

Especies determinadas en los pinares de pino silvestre en función del periodo de observación.

June	July	August	September	Determined every period	
Acroptilon repens	*Alchemilla pseudocartalinica*	*Carlina corymbosa*	*Briza minor*	*Abies nordmanniana*	*Poa nemoralis*
Alyssum murale	*Anthyllis vulneraria*	*Cichorium inthybus*	*Crocus speciosus*	*Brachypodium sylvaticum*	*Potentilla rupestris*
Anemone blanda	*Astragalus glycyphyllos*	*Holcus lanatus*	*Oxalis acetosella*	*Calamintha grandiflora*	*Primula vulgaris*
Barbarea vulgaris	*Campanula persicifolia*	*Malva neglecta*	*Pyrola chlorantha*	*Circium hypoleucum*	*Rubus sanctus*
Campanula glomerata	*Centaurea triumfettii*	*Potentilla argentea*	*Pyrola minor*	*Crepis foetida*	*Sanicula europea*
Cardamine bulbifera	*Cota tinctoria* var. *discoida*	*Potentilla recta*	*Pyrola secunda*	*Dactylis glomerata*	*Thymus longicaulis*
Centaurea triumfettii	*Dorycnium graecum*	*Salvia tomentasa*	*Pyrola chlorantha*	*Daphne pontica*	*Trifolium medium*
Euphorbia amygdaloides	*Euphrasia pectinata*	*Trifolium repens*	*Rumex acotesella*	*Digitalis ferruginea*	*Trifolium pratense*
Galium verum	*Knautia involucrata*	*Tragopogon longirostris*		*Dorycnium orientale*	*Trifolium hybridum*
Genista albida	*Leontodon taraxacoides*	*Veronica orientalis*		*Epilobium angustifolium*	*Verbascum blattaria*
Iris sintenisii	*Mycelis muralis*			*Euphorbia myrsinites*	*Veronica officinalis*
Lapsana communis	*Orobanche arenaria*			*Festuca ovina*	*Veronica multifida*
Lathyrus aureus	*Petrorhagia alpina*			*Fragaria vesca*	*Vicia narbonensis*
Lathyrus laxiflorus	*Pilosella piloselloides*			*Galium rotundifolium*	*Viola odorata*
Medicago irigamella	*Pimpinella saxifraga*			*Galium verum*	*Viola occulta*
Moenchia mantica	*Polygala anatolica*			*Helleborus orientalis*	
Platanthera bifolia	*Polygonatum orientale*			*Hieracium pannosum*	
Poa bulbosa	*Galium odoratum*			*Juniperus oxicedrus*	
Potentilla reptans	*Tragopogon longirostris*			*Lathyrus digitatus*	
Ranunculus brutius	*Trifolium resupirataum*			*Lotus corniculatus*	
Rhiranthus angustifolia				*Luzula campestris*	
Scorzona cana				*Ononis spinosa*	
Silene italica				*Pilosella hoppeana*	
Thlaspi perfoliatum				*Pilosella piloselloides*	
Trifolium pratense				*Pinus sylvestris*	
Valeriana alliariifolia					
Veronica gentianoides					

Table 7. The taxa observed in Scots pine forests based on aspects.
Taxones observados en los pinares de pino silvestre en función del aspecto.

North	South		North and South		
Anthyllis vulneraria	*Acroptilon repens*	*Medicago irigamella*	*Abies nordmanniana*	*Platanthera bifolia*	*Fragaria vesca*
Briza minor	*Agrimonia eupatoria*	*Medicago lupulina*	*Alchemilla pseudocartalinica*	*Poa pratensis*	*Galium rotundifolium*
Calamintha grandiflora	*Alopecurus arundinaceus*	*Mycelis muralis*	*Asperula involucrata*	*Poa nemoralis*	*Galium aparine*
Carlina corymbosa	*Alyssum murale*	*Ononis spinosa*	*Brachypodium pinnatum*	*Polygala supina*	*Genista albida*
Centaurea triumfettii	*Anemone blanda*	*Oxalis acetosella*	*Brachypodium sylvaticum*	*Primula vulgaris*	*Geranium pyrenaicum*
Clinopodium vulgare	*Argyrolobium biebersteinii*	*Pilosella piloselloides*	*Bromus tectorum*	*Prunella vulgaris*	*Helleborus orientalis*
Euphorbia amygdaloides	*Astragalus glycyphyllos*	*Pimpinella saxifraga*	*Campanula persicifolia*	*Ranunculus brutius*	*Hieracium medianiforme*
Moenchia mantica	*Barbarea vulgaris*	*Polygala anatolica*	*Campanula rapunculoides*	*Ranunculus gracilis*	*Holcus lanatus*
Orobanche alba	*Campanula glomerata*	*Polygonatum orientale*	*Carex muricata*	*Rosa canina*	*Juniperus oxicedrus*
Petrorhagia alpina	*Cardamine bulbifera*	*Polystichum setiferum*	*Circium hypoleucum*	*Rubus sanctus*	*Lapsana communis*
Poa bulbosa	*Centaurea triumfettii*	*Potentilla argentea*	*Circium arvense*	*Salvia forskahlei*	*Lathyrus laxiflorus*
Primula vulgaris	*Cichorium intybus*	*Potentilla recta*	*Clinopodium vulgare*	*Sanguisorba minor*	*Lathyrus aureus*
Prunella vulgaris	*Cota tinctoria*	*Potentilla reptans*	*Crepis foetida*	*Sanicula europea*	*Leontodon taraxacoides*
Pyrola chlorantha	*Cyclamen coum*	*Potentilla calabra*	*Crocus speciosus*	*Sedum pallidum*	*Lotus corniculatus*
Pyrola minor	*Dorycnium graecum*	*Pteridium aquilinum*	*Dactylis glomerata*	*Sedum album*	*Luzula campestris*
Pyrola secunda	*Euphrasia pectinata*	*Rhiranthus angustifolia*	*Daphne pontica*	*Taraxacum macrolepium*	*Melica uniflora*
Pyrola media	*Galium verum*	*Rubia sanctus*	*Daucus carota*	*Thymus longicaulis*	*Myosotis sylvatica*
Rumex acotesella	*Hypericum montbretii*	*Rumex crispus*	*Digitalis ferruginea*	*Trifolium aureum*	*Orthilia secunda*
Valeriana alliariifolia	*Iris sintenisii*	*Salvia verticellata*	*Digitalis lanata*	*Trifolium medium*	*Pilosella hoppeana*
Veronica gentianoides	*Knautia involucrata*	*Scorzona cana*	*Doronicum orientale*	*Trifolium pratense*	*Pilosella piloselloides*
Veronica orientalis	*Lamium* sp.	*Silene italica*	*Dorycnium graecum*	*Trifolium repens*	*Pinus sylvestris*
	Lapsana communis	*Thlaspi perfoliatum*	*Epilobium angustifolium*	*Tripleurospermum tenuifolium*	*Plantago lanceolata*
	Lathyrus aureus	*Tragopogon longirostris*	*Epilobium lanceolatum*	*Verbascum flavidum*	*Plantago major*
	Lathyrus laxiflorus	*Trifolium pratense*	*Epilobium hirsutum*	*Veronica chamaedrys*	*Viola odorata*
	Leontodon asperrimus	*Trifolium repens*	*Erodium cicutarium*	*Veronica officinalis*	*Viola sieheana*
	Malva neglecta	*Trifolium resupirataum*	*Euphorbia citricta*	*Veronica gentionoides*	*Filipendula ulmaria*
			Festuca ovina	*Vicia sativa*	*Filipendula vulgaris*

red periodically, it was found that the species distribution in the June period was more homogeneous compared to the other periods (figure 5). It was determined that interactions did not affect the distribution of species ($P > 0.05$).

Gamma diversity. The indices used in determining alpha diversity are also valid in determining gamma diversity. Indices representing larger communities (*e.g.* southern aspect Scots pine stands) refer to gamma diversity.

160 taxa were identified in Scots pine stands. When stand types were evaluated, the Simpson diversity index value was found to be 0.96 in all stands except Çsc3 according to gamma diversity. This value is 0.93 in the Çsc3 stand. While the stand with the highest Shannon diversity index value was Çsa3 (3.74), the lowest diversity value belongs to Çsc3 (3.13). In terms of evenness, the Çsa3 and Çsb3 stands have the highest value at 0.41, and the lowest index value in Çsc3 stands with 0.31 (table 12).

The evaluation of time of observation showed a decrease in the number of taxa from 101 in June and July to 70 in September. Within one vegetation period, the highest diversity for Scots pine stands according to the Shannon index was in June (3.72), and the lowest in September

Table 10. Aspect-time of observation interaction in Scots pine stands according to Simpson index.

Interacción aspecto-tiempo de observación en masas de pino silvestre en función del índice de Simpson.

Time of Observation	South	North
June	$0.88^{bc} \pm 0.05$	$0.90^{c} \pm 0.02$
July	$0.77^{ab} \pm 0.12$	$0.85^{bc} \pm 0.05$
August	$0.89^{bc} \pm 0.02$	$0.90^{c} \pm 0.01$
September	$0.67^{a} \pm 0.16$	$0.88^{bc} \pm 0.01$

Table 11. Interaction of Shannon diversity index in Scots pine stands in terms of aspect-time of observation.

Interacción del índice de diversidad de Shannon en masas de pino silvestre en función de los aspectos y del tiempo de observación.

Time of Observation	South	North
June	$2.62^{b} \pm 0.35$	$2.61^{b} \pm 0.18$
July	$2.15^{ab} \pm 0.47$	$2.36^{b} \pm 0.27$
August	$2.58^{b} \pm 0.20$	$2.60^{b} \pm 0.15$
September	$1.76^{a} \pm 0.44$	$2.46^{b} \pm 0.16$

Table 8. Number of taxa and individuals based on aspects.

Número de taxones e individuos en función de la orientación.

Aspect	Number of taxa		Number of individuals (Pcs m^{-2})
	Mean	Total	
South	22 ± 6	138	158 ± 8
North	21 ± 3	106	134 ± 5

Table 9. Number of taxa in Scots pine stands based on aspect and time of observation.

Número de taxones en el pino silvestre Número de taxones en masas de pino silvestre en función de la orientación y el periodo de observación.

	June		July		August		September	
	Mean	Total	Mean	Total	Mean	Total	Mean	Total
Çsa3		**55**		**54**		**61**		**46**
South	27 ± 1	43	28 ± 0	44	30 ± 5	47	20 ± 4	29
North	17 ± 0	25	19 ± 2	23	22 ± 3	31	21 ± 8	30
Çsb3		**50**		**46**		**47**		**37**
South	25 ± 6	35	22 ± 4	32	23 ± 0	34	16 ± 1	24
North	23 ± 0	34	19 ± 4	26	22 ± 3	32	18 ± 4	27
Çsc3		**39**		**37**		**45**		**31**
South	19 ± 5	27	17 ± 2	24	24 ± 2	34	17 ± 4	24
North	20 ± 1	29	16 ± 1	25	19 ± 0	28	24 ± 0	24
Çsd3		**63**		**61**		**51**		**39**
South	32 ± 7	49	22 ± 1	38	23 ± 1	39	17 ± 5	26
North	24 ± 1	36	25 ± 1	36	23 ± 6	33	21 ± 0	27

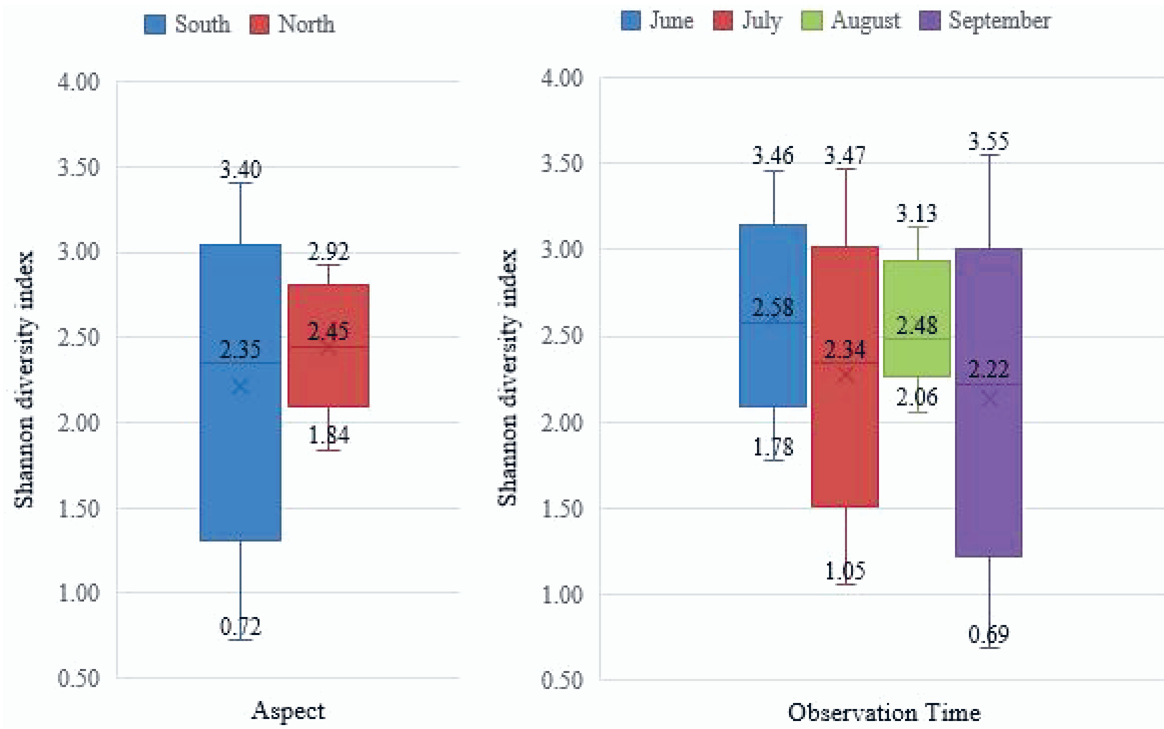

Figure 4. Variation of Shannon diversity index in Scots pine stands in terms of aspects and time of observation.

Variación del índice de diversidad de Shannon en masas de pino silvestre en función de los aspectos y del tiempo de observación.

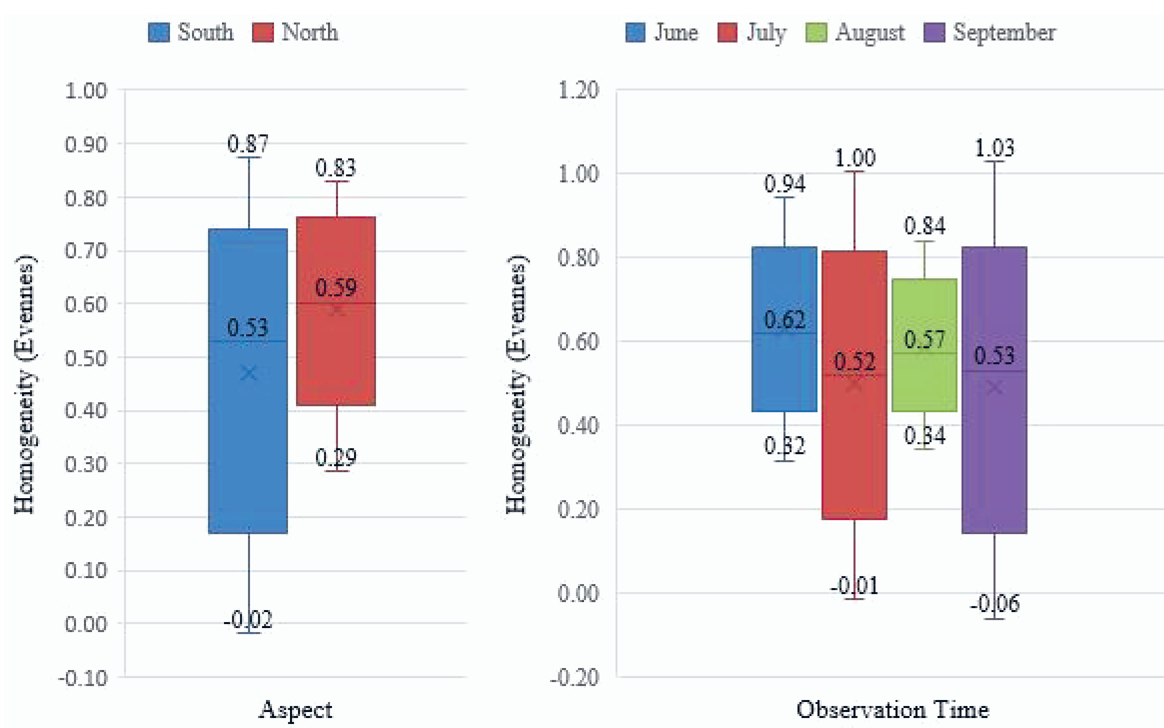

Figure 5. Variation of homogeneity (Evenness) values in terms of aspect and periods.

Variación de los valores de homogeneidad (Evenness) en función del aspecto y de los periodos.

with 3.03. Simpson diversity index was highest in August (0.97). Evenness value was highest in August with 0.43, and lowest in July with 0.28 (table 13).

For the interaction between stand type and time of observation, the highest Shannon value was observed in stand Çsa3 in August with 3.57, while the lowest value was observed in stand Çsc3 with 2.38 in July (table 14. According to the Simpson diversity index, the highest value was observed in stand Çsa3 with 0.96 and the lowest value in September in this stand with 0.81. Evenness values range from 0.29 to 0.58. The lowest value was found for September in stand Çsa3 and for July in stand Çsc3. The highest value was observed in stands Çsa3 and Çsb3 in August (table 14).

Species richness and number of individuals are higher in southern aspects. Shannon value is also higher in the southern aspect than the northern aspect. The Shannon value is 3.67 in the southern aspect and 3.57 in the northern. Although the number of taxa and individuals in the southern aspect is higher, the Simpson value was determined to be lower (0.94). The Evenness value is at its highest in the northern aspect of the Scots pine stands with 0.33, and lower in the southern aspect with 0.28 (table 15).

When the stand type-aspect interaction was evaluated, the highest value was observed in stand Çsd3 in the southern aspect with 3.46, while the lowest value was observed in Çsc3 in the northern aspect with 2.94. The Shannon diversity index in the southern aspect is higher in all Scots pine stands. According to the Simpson diversity index, the highest Simpson value was 0.95 and it is seen only in Çsd3 stands on the northern aspect. The lowest value for Scots pine was in Çsc3 stands in the southern aspect with 0.91. While the highest evenness value was observed in stand Çsa3 in the northern aspect with 0.46, the lowest was in stand Çsc3 in the southern aspect with 0.34 (table 16).

When the interaction between aspect and time of observation was evaluated in Scots pine stands, the highest Shannon index value was observed in the southern aspect in August with 3.64, while the lowest value was observed in the southern aspect in September with 2.40. The Simpson index value reached its highest values in both aspects in June and August. Evenness value was observed at its lowest in the southern aspect in September with 0.22, while its highest value was reached in the southern aspect in August with 0.47 (table 17).

The relationship between stand type and plant diversity. Stand parameters were calculated using the inventory made independently from the sampling for above-ground flora. The correlations between the DBH, basal area and stand volume per ha of the stands and the Simpson, Shannon and Evenness indices were tested by correlation

Table 12. Variation of diversity indices based on stand types.

Variación de los índices de diversidad en función del tipo de rodal.

Stand Type	Number of Quadrate	Number of Taxa		Number of Individuals*		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
Çsa3	160	23 ± 5	102	131 ± 6	5,238	0.15 ± 0.1	0.04	0.85 ± 0.1	0.96	2.47 ± 0.4	3.72	0.57 ± 0.2	0.41
Çsb3	160	21 ± 4	85	116 ± 4	4,631	0.13 ± 0.1	0.04	0.86 ± 0.1	0.96	2.46 ± 0.4	3.55	0.59 ± 0.1	0.41
Çsc3	160	19 ± 3	74	184 ± 8	7,349	0.17 ± 0.1	0.07	0.83 ± 0.1	0.93	2.22 ± 0.3	3.13	0.49 ± 0.1	0.31
Çsd3	160	23 ± 5	107	153 ± 7	6,113	0.15 ± 0.1	0.04	0.84 ± 0.1	0.96	2.43 ± 0.4	3.64	0.52 ± 0.1	0.36

* This is the total number of individuals in 160 quadrate samples.

Table 13. Variation of diversity indices based on observation period.

Variación de los índices de diversidad en función del periodo de observación.

Time of Observation	Number of Quadrate	Number of Taxa		Number of Individuals*		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
June	160	23 ± 5	101	123 ± 3	4,938	0.11 ± 0.0	0.04	0.89 ± 0.0	0.96	2.62 ± 0.3	3.72	0.62 ± 0.1	0.40
July	160	21 ± 4	101	172 ± 9	6,885	0.18± 0.1	0.07	0.82 ± 0.1	0.93	2.26 ± 0.4	3.35	0.50 ± 0.2	0.28
August	160	23 ± 4	90	140 ± 5	5,593	0.10 ± 0.0	0.03	0.90 ± 0.0	0.97	2.60 ± 0.2	3.67	0.60 ± 0.1	0.43
September	160	19 ± 4	70	148 ± 7	5,915	0.22 ± 0.2	0.10	0.78 ± 0.2	0.90	2.12 ± 0.5	3.03	0.48 ± 0.2	0.29

* This is the total number of individuals in 160 quadrate samples.

Table 14. Diversity indices based on stand type and time of observation.

Índices de diversidad según el tipo de rodal y el tiempo de observación.

Stand Type	Observation Time	Number of Taxa		Number of Individuals*		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
Çsa3	June	22 ± 6	55	112 ± 3	1,118	0.13 ± 0.1	0.06	0.87 ± 0.1	0.94	2.51 ± 0.2	3.30	0.61 ± 0.2	0.50
	July	23 ± 6	54	143 ± 6	1,427	0.13 ± 0.1	0.07	0.87 ± 0.1	0.93	2.53 ± 0.2	3.21	0.57 ± 0.2	0.46
	August	26 ± 5	61	130 ± 4	1,302	0.08 ± 0.0	0.04	0.91 ± 0.0	0.96	2.78 ± 0.1	3.57	0.64 ± 0.1	0.58
	September	20 ± 5	46	139 ± 9	1,391	0.26 ± 0.2	0.19	0.74 ± 0.2	0.81	2.08 ± 0.6	2.58	0.47 ± 0.3	0.29
Çsb3	June	24 ± 4	50	92 ± 2	920	0.08 ± 0.0	0.05	0.92 ± 0.0	0.95	2.79 ± 0.14	3.33	0.70 ± 0.0	0.56
	July	20 ± 4	46	134 ± 5	1,343	0.13 ± 0.1	0.06	0.87 ± 0.1	0.94	2.41 ± 0.2	3.11	0.57 ± 0.1	0.49
	August	23 ± 2	47	118 ± 4	1,185	0.11 ± 0.0	0.05	0.89 ± 0.0	0.95	2.56 ± 0.15	3.32	0.58 ± 0.1	0.58
	September	17 ± 3	37	118 ± 6	1,183	0.23 ± 0.2	0.08	0.77 ± 0.2	0.92	2.08 ± 0.6	2.89	0.52 ± 0.2	0.49
Çsc3	June	19 ± 3	39	136 ± 4	1,366	0.13 ± 0.0	0.07	0.87 ± 0.0	0.93	2.39 ± 0.2	2.98	0.58 ± 0.1	0.51
	July	16 ± 2	37	238 ± 13	2,384	0.28 ± 0.1	0.16	0.72 ± 0.1	0.84	1.80 ± 0.2	2.38	0.38 ± 0.1	0.29
	August	21 ± 3	45	181 ± 6	1,813	0.11 ± 0.0	0.06	0.89 ± 0.0	0.94	2.48 ± 0.1	3.13	0.58 ± 0.1	0.51
	September	20 ± 5	31	179 ± 6	1,786	0.16 ± 0.1	0.13	0.83 ± 0.1	0.87	2.21 ± 0.2	2.46	0.47 ± 0.0	0.38
Çsd3	June	28 ± 6	63	153 ± 3	1,534	0.10 ± 0.0	0.05	0.90 ± 0.0	0.95	2.78 ± 0.3	3.43	0.60 ± 0.1	0.49
	July	23 ± 2	61	173 ± 9	1,731	0.19 ± 0.1	0.08	0.81 ± 0.1	0.92	2.30 ± 0.4	3.06	0.46 ± 0.2	0.35
	August	23 ± 3	51	129 ± 5	1,293	0.11 ± 0.0	0.05	0.89 ± 0.0	0.95	2.56 ± 0.2	3.23	0.57 ± 0.0	0.49
	September	19 ± 4	39	156 ± 8	1,555	0.24 ± 0.2	0.09	0.76 ± 0.2	0.91	2.08 ± 0.5	2.90	0.49 ± 0.2	0.47

* This is the total number of individuals in 40 quadrate samples.

Table 15. Variation of diversity indices based on aspects.

Variación de los índices de diversidad en función de los aspectos.

Aspect	Number of Quadrate	Number of Taxa		Number of Individuals		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
South	320	22 ± 6	138	157 ± 8	12,623	0.20 ± 0.1	0.06	0.80 ± 0.1	0.94	2.28 ± 0.5	3.67	0.48 ± 0.1	0.28
North	320	21 ± 3	106	134 ± 5	10,708	0.11 ± 0.0	0.04	0.89 ± 0.0	0.96	2.51 ± 0.2	3.57	0.61 ± 0.1	0.33

Table 16. Indices of diversity based on stand type and aspects.

Índices de diversidad en función del tipo de rodal y de los aspectos.

Stand Type	Aspect	Number of Taxa		Number of Individuals*		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
Çsa3	South	26 ±5	86	155 ± 7	3,102	0.19 ± 0.1	0.06	0.80 ± 0.1	0.94	2.37 ± 0.5	3.45	0.45 ± 0.2	0.37
	North	20 ± 4	53	107 ± 3	2,136	0.09 ± 0.0	0.06	0.90 ± 0.0	0.94	2.50 ± 0.1	3.19	0.69 ± 0.1	0.46
Çsb3	South	21 ± 5	63	113 ± 6	2,261	0.18 ± 0.1	0.06	0.82 ± 0.1	0.94	2.33 ± 0.5	3.27	0.53 ± 0.2	0.42
	North	20 ± 3	59	135 ± 3	2,700	0.09 ± 0.0	0.06	0.90 ± 0.0	0.94	2.58 ± 0.2	3.22	0.66 ± 0.1	0.42
Çsc3	South	19 ± 4	59	195 ± 9	3,901	0.20 ± 0.1	0.09	0.80 ± 0.1	0.91	2.14 ± 0.4	2.99	0.48 ± 0.1	0.34
	North	20 ± 3	51	172 ± 7	3,448	0.14 ± 0.0	0.07	0.85 ± 0.0	0.93	2.30 ± 0.2	2.94	0.52 ± 0.1	0.37
Çsd3	South	23 ± 7	86	167 ± 8	3,359	0.21 ± 0.1	0.06	0.78 ± 0.1	0.94	2.27 ± 0.5	3.46	0.47 ± 0.1	0.37
	North	23 ± 3	70	137 ± 5	2,754	0.10 ± 0.0	0.05	0.89 ± 0.0	0.95	2.58 ± 0.2	3.35	0.58 ± 0.1	0.41

* This is the total number of individuals in 80 quadrate samples.

Table 17. Indices of diversity based on aspect and time of observation.

Índices de diversidad según el aspecto y el tiempo de observación.

Aspect	Observation Time	Number of Taxa		Number of Individuals*		Dominance		Simpson		Shannon		Evenness	
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
South	June	25 ± 6	85	137 ± 4	2,736	0.11 ± 0.1	0.04	0.88 ± 0.1	0.96	2.62 ± 0.4	3.61	0.57 ± 0.1	0.44
	July	22 ± 5	84	193 ± 11	3,868	0.23 ± 0.1	0.14	0.78 ± 0.1	0.86	2.15 ± 0.5	2.99	0.42 ± 0.2	0.24
	August	25 ± 4	80	151 ± 5	3,025	0.11 ± 0.0	0.04	0.90 ± 0.0	0.96	2.60 ± 0.2	3.64	0.55 ± 0.1	0.47
	September	17 ± 3	50	150 ± 10	2,994	0.33 ± 0.2	0.25	0.67 ± 0.2	0.75	1.77 ± 0.4	2.40	0.39 ± 0.2	0.22
North	June	21 ± 3	62	110 ± 3	2,202	0.09 ± 0.0	0.05	0.91 ± 0.0	0.95	2.61 ± 0.2	3.36	0.67 ± 0.1	0.46
	July	19 ± 4	63	151 ± 6	3,017	0.14 ± 0.0	0.06	0.86 ± 0.1	0.94	2.40 ± 0.3	3.16	0.57 ± 0.1	0.37
	August	22 ± 3	59	128 ± 4	2,568	0.10 ± 0.0	0.04	0.91 ± 0.0	0.96	2.60 ± 0.2	3.42	0.64 ± 0.1	0.52
	September	21 ± 4	54	146 ± 5	2,921	0.11 ± 0.0	0.06	0.89 ± 0.2	0.94	2.50 ± 0.2	3.12	0.58 ± 0.1	0.42

* This is the total number of individuals in 80 quadrate samples.

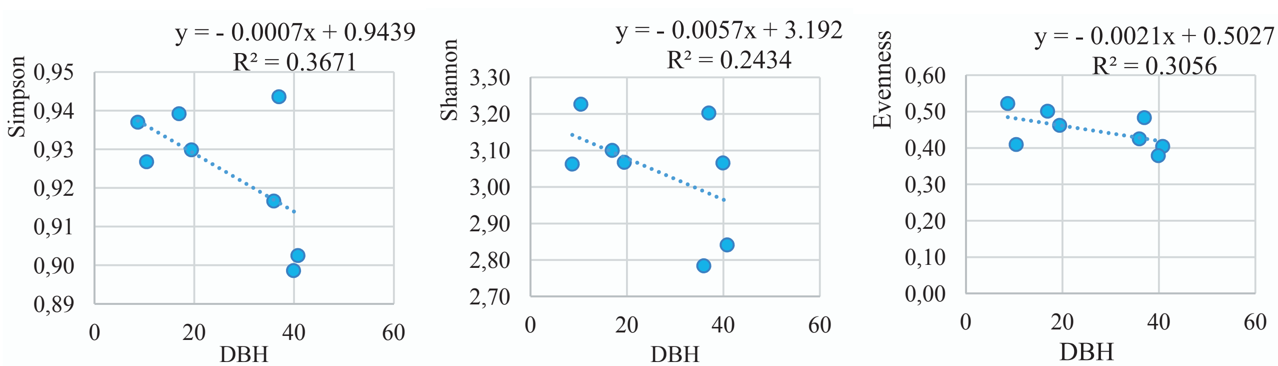

Figure 6. Index values for Scots pine stands based on the stand diameter.

Valores de los índices de los rodales de pino silvestre en función del diámetro del rodal.

Table 18. Correlations between stand parameters and indices.

Correlaciones entre los parámetros del rodal y los índices.

	DBH	G	V
Simpson	- 0.688	- 0.647	- 0.673
Shannon	- 0.492	- 0.421	- 0.434
Evenness	- 0.573	- 0.546	- 0.563

analysis and a significant correlation was found at 95 % confidence level (table 18).

The DBH had a stronger correlation than other stand parameters and can alone explain 36.7 % of the variation in Simpson index. The correlations are all negative and indices decreased by increasing DBH. This can also be understood as plant diversity being higher in young stands than older stands (figure 6).

DISCUSSION

A total of 160 taxa were identified, belonging to 46 families and 110 genera. A total of 23,331 individuals were counted in 640 quadrates within the study area. The most common family in the study area was Fabaceae with 23 genera, followed by Asteraceae with 21 genera. Stefańska-Krzaczek *et al.* (2019) observed 116 taxa in Scots pine stands in Poland (Europe) and Sukhbaatar *et al.* (2018) observed 80 plant species in Mongolia (Asia). More taxa were observed in this study, possibly due to the diversified habitat structure of the study area, influenced by three phytogeographical regions. The understory flora of this region present characteristics of the Middle Euxine (Sub-Euxine) flora of the Euro-Siberian phytogeographical region, especially in the stands on the northern aspects of the study area. In the southern aspects, there are xerophytic (Xero-Euxine) plant taxa with Euro-Siberian character. Because the study area is close to the border of transition to Central Anatolian Steppe in regards to general plant geography, plant taxa with the vegetation character of the Irano-Turanian phytogeographical region are also sometimes found.

The most prominent taxa in the 640 quadrates were Poaceae with 3,089 individuals, Fabaceae with 1,710 individuals, and Rosaceae with 1,265 individuals. The family Poaceae are of great importance for human and animal nutrition. Due to the importance of this species for human nutrition, genetic resources should be protected to eliminate any negative effects that may be encountered in the future. *Fragaria vesca* is also very valuable as a non-wood forest product, and can be used to generate income for local people.

Statistical analyses were performed using the diversity indices calculated at the Alpha diversity level. No significant difference was found among stand types according to the Shannon diversity index calculated at the alpha level. The Shannon index is highest for the Çsa3, which represent the young stands that were regenerated after forest removal. This finding is compatible with the studies of Stefańska-Krzaczek (2012) and Stefańska-Krzaczek *et al.* (2019). It is thought that more sunlight reaching the soil and the colonization of plants after the regeneration of old stands affects this. Also, Tecimen *et al.* (2017) found for stone pine stands that the Shannon value decreases with increasing canopy closure as the stands get older.

It has been determined that aspect and time of observation have a statistically significant effect on plant species diversity. More taxa on southern aspects were identified (138) than on northern aspects (106) and Shannon value is higher on southern aspects for gamma diversity. Northern aspects of Scots pine stands have higher diversity than southern aspects for both Simpson and Shannon index values and even for Evenness values as an average at the alpha diversity level. Pausas (1994) found more species richness on the northern aspects in the understory of Pyrenean Scots pine forest and concluded that environmental parameters like soil moisture and nutrients are more effective for estimating species richness. Similarly, Grae and Heskjaer (1997), Meier *et al.* (2005) and Petersson *et al.* (2021) mentioned that nutrients and humidity in the soil are determinants of plant diversity. In this study, Shannon value was found to be higher in June on southern aspects, but in the following months diversity values were higher on northern aspects. This is likely due to the presence of snow cover in the region lasting until the end of May, whose melting brings suitable habitat conditions in terms of light and humidity on southern aspects. Following this period, these habitats lose moisture due to summer drought, and northern aspects become more suitable.

Considering time of observation, Simpson and Shannon indices showed a similar trend, reaching the highest values in June and the lowest in September. It is thought that the study area's location adjacent to the steppe transition zone and the partial drought in summer affect the distribution of plants in terms of species and number. The higher diversity values of the northern aspects may be due to their more favorable soil moisture conditions during the summer months.

It has been determined that, in terms of Evenness, stand type does not have a significant effect on the homogeneous distribution of taxa in Scots pine stands. Species distribution is more homogeneous on northern aspects than southern aspects, and when considered periodically, it has been determined that species distribution is more homogeneous in June compared to other periods.

When effects of time of observation were evaluated for the Scots pine stands, similar changes were observed in the Simpson and Shannon indices at the gamma diversity level. The diversity values calculated according to both Shannon and Simpson were higher in June and August compared to July and September. Diversity indices were high in June because at the beginning of the vegetation period, all plant species in the environment can be determined. The higher diversity in August compared to July can be explained by the taxa's more homogeneous distribution, although the number of taxa decreases periodically. This can be explained by the increasing evenness values of the suppressed species such as *Medicago irigamella, Melica uniflora, Dactylis glomerata, Poa bulbosa, Galium rotundifolium* coming to the area following the removal of the plants that were dominant in the previous months due to drought and grazing pressure.

When Scots pine stands were evaluated in terms of gamma diversity level, the diversity value calculated according to Simpson was higher in the northern aspects. The diversity value calculated according to Shannon, on the other hand, was lower on the northern aspects. It is thought that more plants grow on northern aspects because the soil is more humid. Again, the evenness value, which expresses the representation ratio of the species at the gamma diversity level, has been calculated at a higher level in the northern aspects compared to the southern aspects of the Scots pine stands.

Graae and Heskjaer (1997) did not observe the effect of stand structure on species diversity in their study to determine the differences between managed and non-managed forests. However, they stated that there is less species richness in old stands. Pitkanen (1997) also reported that species diversity is higher in young stands in fertile areas, and although less significant, the basal area, crown closure, and species mix ratio in trees have a similar effect. Behera and Misra (2006), in their analysis of herbaceous vegetation in four different stands consisting of broadleaf species, could not find a significant difference between stands in terms of the Shannon diversity index. In this study, the diversity was high in young stands of Scots pine and generally decreased as age of the stand increased. It is thought that canopy cover of the stand has an effect here as well. Although the canopy cover varies between 70 - 100 % in all stands, the lower percentage of cover in older stands and higher percentage in younger stands may lead to higher diversity in older stands. On the other hand, when the relationship between diversity indices and the stands' structural parameters such as volume, basal area and stand diameter was evaluated, a significant correlation was found at a 95 % confidence level. For Scots pine stands, a relationship between stand diameter and Simpson value was found to be 0.37, the highest R^2 value.

CONCLUSION

While forests are being managed, only stand types are subject to change under normal conditions. Therefore, knowing the diversity of vegetation according to stand type will help to predict future patterns of diversity that depend on changes in stand type over time. The present study has revealed the plant diversity values of Scots pine tree stands, showing that diversity can be calculated for different working groups and the entire forest. Plant diversity, determined numerically, is a tool for forest planning in the context of integration and management. It is thought that the data obtained in this context will be useful for observations at the later stages of the certification process for the area.

Since stands with normal closure (71 - 100 %) are generally formed under successful management conditions, this study is limited to stands with only normal closure. Therefore, it is necessary to numerically evaluate the diversity of vegetation for different canopy conditions, as well as different site quality, altitudes and tree species. These numerical values can help make comparisons of the influence of different tree species and stand types on plant diversity indices.

AUTHORS' CONTRIBUTIONS

MG, HZ and MÖ designed the study and the experimental design, HZ, MÖ, ASD and MG conducted the field data collection and analyzed the results, and NA contributed to the identification of the taxa together with the discussion and interpretation of the results. All authors prepared the manuscript.

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