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Spatial area distribution of Oaks according to different selected parameters in Türkiye

Türkiye'de yayılış gösteren Meşelerin seçilen farklı parametrelere göre alansal dağılımı

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Abstract

Considering the recently prepared forest management plans, Oaks, which were previously represented by a single nickname (*Quercus* spp), are now separated based on their species. Although there are still forest management plans that are using old pseudonyms, the plans that have expired are being renewed while taking into account the distinction between Oak species. There is no study that provides up-to-date information on the spatial distribution, mixture status, and stands' distribution according to age, site and canopy classes. However, such studies provide valuable information at various levels, ranging from sectorial planning to revealing honey production efficiencies.This study examines the spatial distribution of Oaks across different parameters mentioned above by using the spatial database obtained from the General Directorate of Forestry. ArcGIS 10.8™ software was used to query the attribute data and present it in tables and figures. According to the results obtained, there are a total of 9.05 million ha of Oak stands, of which, 6,116,992.7 ha (67.6%) are pure or mixed within Oak species, and 2,928,775.9 ha (32.4%) are mixed. Pure and mixed stands within Oak species have 2,075,508.4 ha of productive (33.9%) and 4,041,484.3 ha degraded (66.1%). Moreover, 4,986,288.1 ha (81.5%) are managed as high forest and 1,130,704.6 ha (18.5%) are managed as coppice. Considering their developmental stage and crown closure (excluding degraded stands), 94.5% of those were less than 20 cm in dbh (diameter at breast height), with 44.1% of them having more than 70% of the cover. In conclusion, it is recommended that the parameters mentioned above be considered when publishing forestry statistics for Oaks.

Keywords: Oak, forest management plan, age class distribution, site, canopy, *Quercus*.

Öz

Son dönemde hazırlanan orman amenajman planları dikkate alındığında, önceden tek rumuz ile temsil edilen Meşelerin, günümüzde tür bazında ayrıldığı görülmektedir. Halen uygulamada olan eski rumuzların kullanıldığı planlar bulunmakla birlikte, süresi biten ve yenilenen planlarda tür bazında ayrımı yapılmış olan halihazırda 13 farklı Meşe türüne ilişkin; alansal dağılım, karışım durumu, ilgili meşcerelerin yaş, bonitet ve kapalılık sınıflarına dağılımı konularında güncel bilgiler sunan bir çalışma bulunmamaktadır. Ancak bu tür çalışmalar; sektörel planlamadan, bal veriminin ortaya konmasına kadar farklı seviyelerde kullanılabilecek yararlı bilgiler sunmaktadır. Gerçekleştirilen çalışmada, Orman Genel Müdürlüğünden temin edilen konumsal veri tabanı kullanılarak, Meşelerin yukarıda bahsedilen farklı parametrelere göre alansal dağılımı irdelenmiştir. Öznitelik verilerinin sorgulanması; tablo ve şekil olarak sunulmasında ArcGIS 10.8™ Coğrafi Bilgi Sistemleri yazılımı kullanılmıştır. Elde edilen sonuçlara göre; toplam 9,05 milyon hektar Meşe meşceresi olduğu, bunun 6.116.992,7 ha'ının (%67,6) saf ya da Meşelerin kendi içinde karışık, 2.928.775,9 ha'ının (%34,4) ise diğer türlerle karışık olarak yayılış gösterdiği belirlenmiştir. Meşelerin saf ya da kendi içinde karışım yaptığı meşçerelerin 2.075.508,4 ha'ı verimli (%33,9) ve 4.041.484,3 ha ise boşluklu kapalıdır (%66,1). Meşçerelerin 4.986.288,1 ha'ının koru (%81,5) ve 1.130.704,6 ha'ının (%18,5) baltalık olarak işletildiği, gelişme çağları düşünüldüğünde ise boşluklu kapalılar hariç %94,5'ünün çapının 20 cm'den az olduğu ve %44,1'sinin kapalılığının ise %70'in üzerinde olduğu tespit edilmiştir. Sonuçta, ormancılık istatistikleri yayınlanırken bahsedilen parametrelerin sunulmasının yararlı olacağı önerilmektedir.

Anahtar Kelimeler: Meşe, orman amenajman planı, yaş sınıfları, bonitet, kapalılık, *Quercus*.

1. Introduction

Quercus species, commonly known as Oaks, are the largest genus of the *Fagaceae* family and one of the largest genera of all tree families (Valencia-Ávalos, 2004). It is estimated that there are 430 Oak species globally, with several new species being described every year. The majority of Oaks are large trees growing to 20-30 meters, but there is an extraordinary morphological and ecological diversity across the various regions of the world and ecosystems where they grow (Menitsky, 2005). From small shrubs growing on dry, sandy soils in the western United States and mountain regions in Mexico, to towering trees in the canopy of the tropical forests of Southeast Asia (Menitsky, 2005; Nixon, 2006), the current global diversity of Oaks is the result of geographic and ecological diversification within wide-ranging lineages over 56 million years of evolution (Hipp et al., 2020).

Out of the 430 Oak species that are distributed worldwide, 217 (41%) are facing conservation issues. This includes 112 species that are endangered, critically endangered or vulnerable (i.e., "threatened" according to the IUCN definition), as well as 105 species which are data deficient "or nearly threatened". Thirty-one per cent of Oak species are estimated to be threatened by extinction, following IUCN's method for calculating threat proportions incorporating Data Deficient species (IUCN, 2020). Furthermore, Oak species are native to 90 countries, predominantly in the northern hemisphere, with the highest species richness in Mexico (164 species), China (117), the United States (91), Vietnam (49) and Türkiye (18). These countries also have the highest number of threatened species estimated at 32, 36, 16, 20, and 1 respectively in these countries (Carrero et al., 2020).

Türkiye is a very rich country in terms of shrub, dwarf and tall Oak species, and subspecies, especially natural hybrids species. However, Oak forests in Türkiye have been severely damaged since ancient times, primarily due to their use as firewood and pasture, apart from a wide variety of uses such as ship, building wood material, veneer, clapboard etc. The wood, fruit, and leaves of the Oak tree are utilized in numerous fields, and some Oak species are grown primarily for their aesthetic value, rather than their economic value (Jansson et al., 2017). Furthermore, the galls and fruits of certain Oak species are utilized in pharmacopeia in Türkiye for production of tannin containing traditional medicine (Paaver et al., 2010).

Oaks are known for their ability to shoot and regenerate, and their high vitality makes them a valuable resource. For this reason, most of the Oak forests have been managed as coppice. Major threats to Oak species globally include land use change, climate change, native and non-native pests and diseases. Landscape-level changes are often due to habitat conversion for agriculture or urbanization, logging, or alterations in fire regimes. For many years, Oak species in Türkiye come second after pine species in terms of forest area cover (OGM, 2018). This has changed in 2015 (Mert et al., 2016) and continues to change with the effect of natural and artificial processes. In addition, species distinction is not taken into account in Türkiye's forestry statistics. Having knowledge about Oak forests is important for rational planning in order to sustainably produce goods and services from those forests.

Therefore, the aim of this study is to display:

- The oak taxa's current spatial distribution,
- The areal size of pure and mixture,
- Aerial distribution of high forest and coppice,
- Their distribution related to developmental stages (saplings, pole age, middle-aged and mature),
- Their age class distribution,
- Site class distribution,
- Crown closure distribution,
- The area of different Oak taxa and
- Comparison of the results with previously conducted studies to see the trend.

Finally, evaluating the status of Oak species in Türkiye.

2. Material and Method

The whole country was selected as the study area. Data was obtained from the "Forest Management Plans" prepared for the 2141 different forest planning units located throughout Türkiye.

In this study, the digital geographic database of 2020 produced by the « the General Directorate of Forestry (GDF, in Turkish O.G.M.) » was used to produce Oak spatial distribution under specific parameters. ArcGIS 10.8™ software was used to query the attribute data and present it in tables and figures.

Some of the different queries used to produce data and figures are presented in Figure 1.

It can be mentioned that queries were used to analyze 764,212 stands. The different figures generated are presented in the chapter of Results.

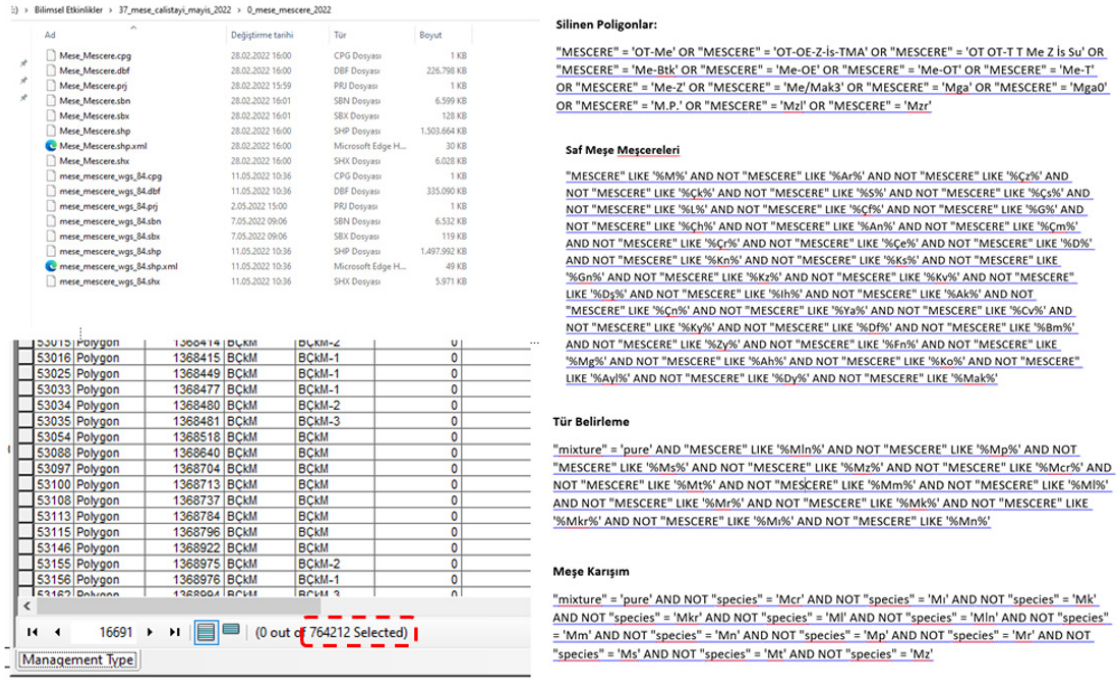


Figure 1. Arrangement of the database and some queries used to produce data and figures
Şekil 1. Şekil ve verilerin elde edilmesi için veri tabanının düzenlenmesi ve gerçekleştirilen bazı sorgulamalar

3. Results

The maps were created within this research using database arrangement and queries presented in Figure 1. It was found that the total Oak stands have 9,045,768.6 ha area in Türkiye (Figure 2).

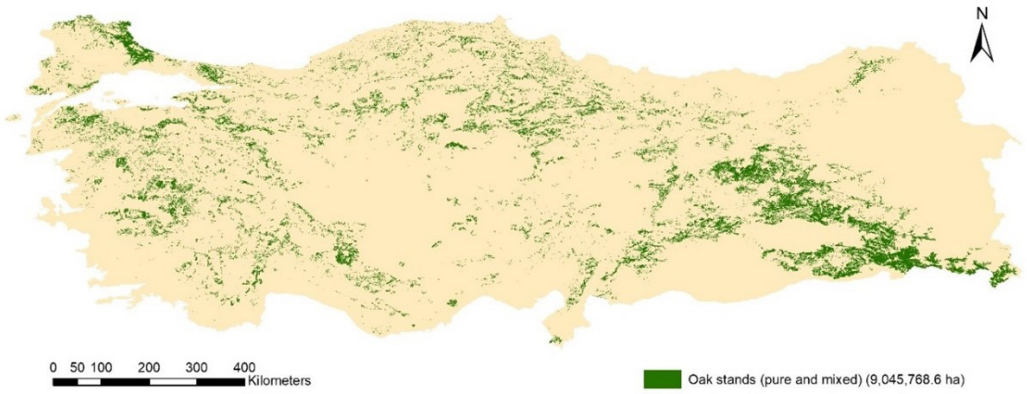


Figure 2. Spatial distribution of Oak stands in Türkiye
Şekil 2. Türkiye'deki Meşe meşcerelerinin konumsal dağılımı

While 6,116,992.7 hectares (ha) of that area is pure (including mixtures within Oak species), the remaining 2,928,775.9 ha is mixed with other species (Figure 3). Pure stands consist of; *Quercus cerris, Q. petraea, Q. coccifera, Q. pubescens, Q. infectoria, Q. trojana, Q. frainetto, Q. ithaburensis, Q. vulcanica, Q. robur, Q. libani, Q. ilex* and *Quercus hartwissiana.*

Oaks are mixed with; *Juniperus* spp., *Fraxinus carpinifolia*, *Ostrya carpinifolia*, *Olea eurepea, Pistacia terebinthus, Ailanthus altissima* and Maquis taxa, *Pinus brutia, Pinus nigra* subsp. *pallasiana, Cedrus libani, Pinus sylvestris, Picea orientalis, Pinus pinea, Abies* spp., *Pinus halepensis, Arceuthos drupacea, Pinus pinaster, Pinus radiata, Pinus elderica, Pseudotsuga menziesii, Fagus orientalis, Fagus sylvatica, Castanea sativa, Carpinus* spp., *Alnus* spp., *Populus* spp., *Fraximus* spp., *Tilia* spp, *Acer* spp., *Platanus orientalis, Robinia pseudoacacia, Juglans regia, Ostrya carpinifolia, Laurus nobilis, Prunus dulcis, Olea eurepea, Cor-*

ylus spp., *Pistacia terebihthus, Pyrus elaeagrifolia, Arbutus unedo, Ailanthus altissima and Maquis* taxa in Türkiye. It is seen that Oaks make mixture with many species.

The spatial distribution of pure Oak stands and mixed Oak stands is presented in Figure 3.

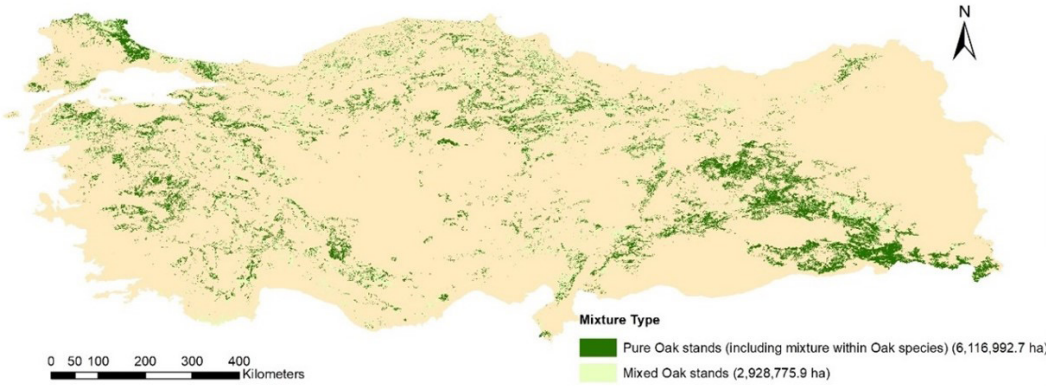


Figure 3. Pure and mixed Oak stands distribution in Türkiye
Şekil 3. Türkiye'de saf ve karışık Meşe meşcerelerinin dağılımı

Within the 6,116,992.7 ha of pure Oak stands, 2,075,508.4 ha (33.93%) is productive, while 4,041,484.3 ha (66.07%) is degraded (Figure 4).

Figure 4. Productive and degraded Oak stands distribution in Türkiye
Şekil 4. Türkiye'de verimli ve boşluklu kapalı Meşe meşcerelerinin dağılımı

Within the 6,116,992.7 ha of pure Oak stands, 4,986,288.1 ha is high forest, while 1,130,704.6 ha is coppice (Figure 5).

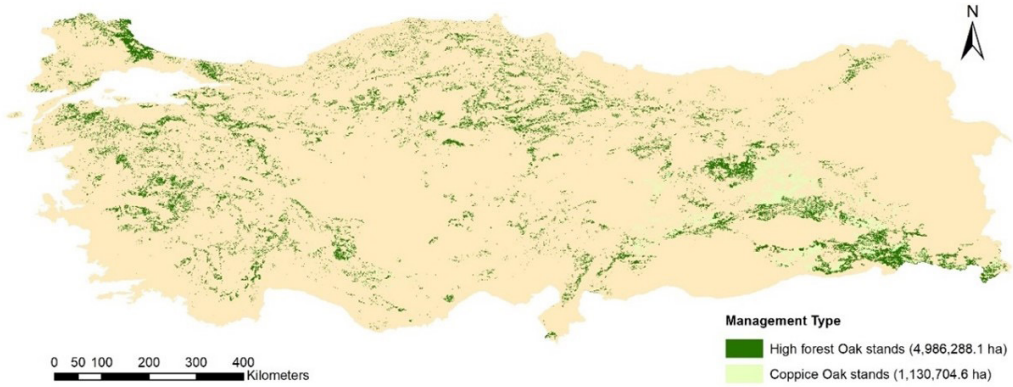
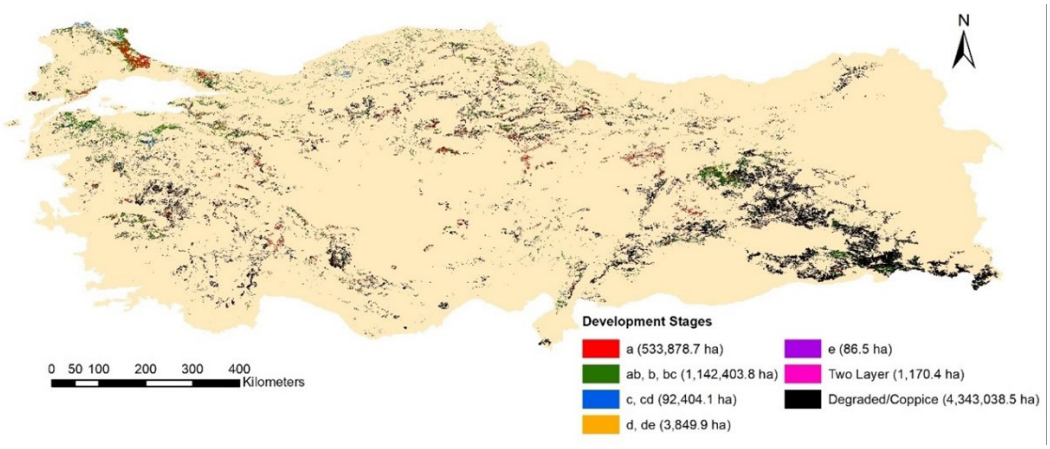


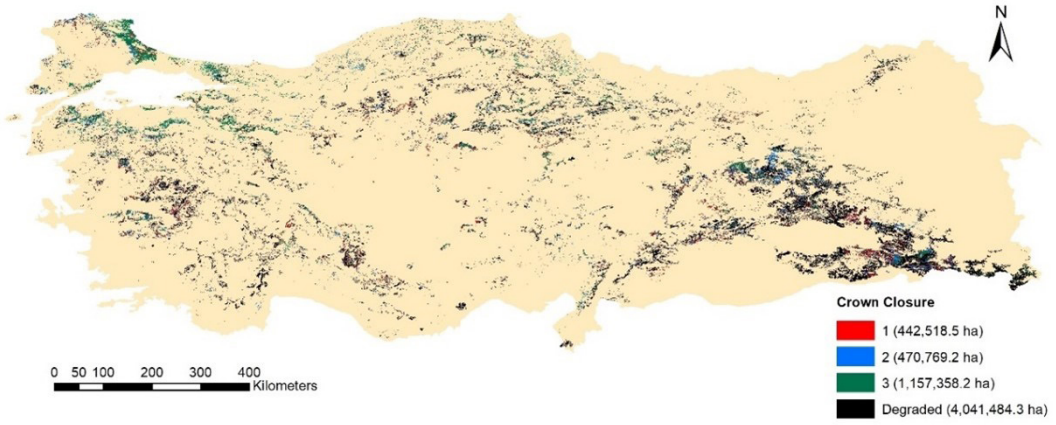
Figure 5. High and coppice Oak stands distribution in Türkiye
Şekil 5. Türkiye'de koru ve baltalık Meşe meşcerelerinin dağılımı

The developmental stages for oak are defined as follows: a = 0-8 cm, b = 8-20 cm, c = 20-36 cm, d = 36-52 cm, e = >52 cm in dbh; where dbh is diameter at breast height of the tree). The distribution of pure stands across these developmental stages is depicted in Figure 6, with the following statistics:a=533.878,7 ha; ab, b and bc=1.142.403,8 ha; c and cd=92.404,1 ha; d and de=3.849,9 ha; e=86,5 ha; Two layer=1.170,4ha; Degraded/ Coppice=4.343.038,5ha. It is understood that the majority of the Oak stands managed for high forest have less than 20 cm dbh (94,5%) when excluding degraded and coppice stands.



a = 0-8 cm, b = 8-20 cm, c = 20-36 cm, d = 36-52 cm, e = >52 cm in dbh
Figure 6. Developmental stage distribution of Oak stands in Türkiye
Şekil 6. Türkiye'de Meşe meşcerelerinin gelişim çağları dağılımı

The crown closures of Oaks forests are categorized into the following classes: Degraded = 0-10%, 1 = 10-40%; 2 = 40-70%; 3 = 70-100%. Figure 7 shows the distribution of pure stands across these crown closure classes, with the following statistics; 1=442.518,5 ha; 2=470.769,2 ha; 3=1.157.358,2 ha; Degraded= 4.041.484,3 ha. Although most of the pure Oak stands are degraded (67,7%), majority of the productive forests (55,8%) have over 70% crown closure when excluding degraded stands.



1 = 10-40%; 2 = 40-70%; 3 = 70-100%; Degraded = 0-10% of crown closure
Figure 7. Crown closure class distribution of Oak stands in Türkiye
Şekil 7. Türkiye'de Meşe meşcerelerinin kapalılık sınıfları dağılımı

Figure 8 illustrates the distribution of pure stands across age classes, with the following statistics: I= 665.976,1 ha; II = 682.491,6 ha; III= 254.919,6 ha; IV= 81.691,9 ha; V= 42.860,9 ha; VI= 20.321,6 ha; VII= 3.886,4 ha; VIII= 812,3 ha; IX= 187,3 ha; X= 78,5 ha; XI= 0,0 ha; XII=19,5 ha Degraded/Coppice= 4.343.038,5 ha. Age class has a 20-year interval. Meaning that I = 0-20 age; II = 20-40 age; III = 40-60 ages and so on.

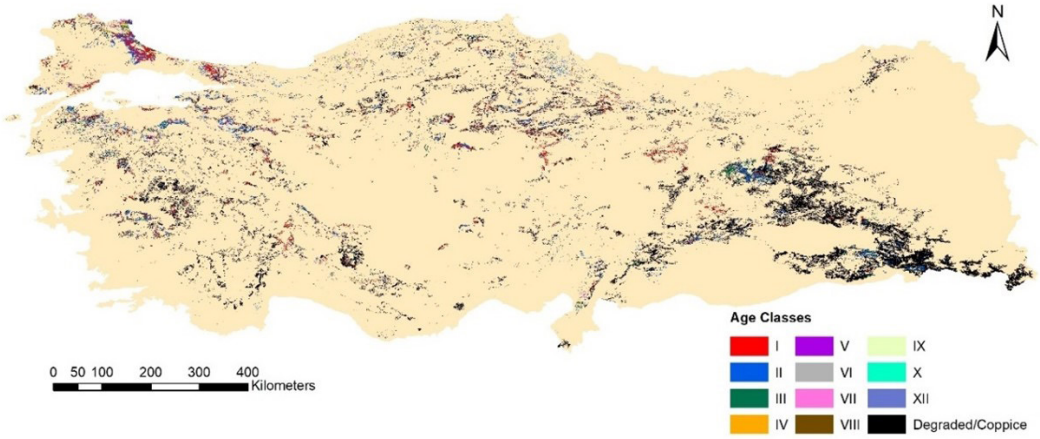


Figure 8. Age class distribution map of Oak stands in Türkiye
Şekil 8. Türkiye'de Meşe meşcerelerinin yaş sınıfları dağılımı

It can be mentioned that pure stands age class II and I are the most represented in the pure Oak population (Figure 9).

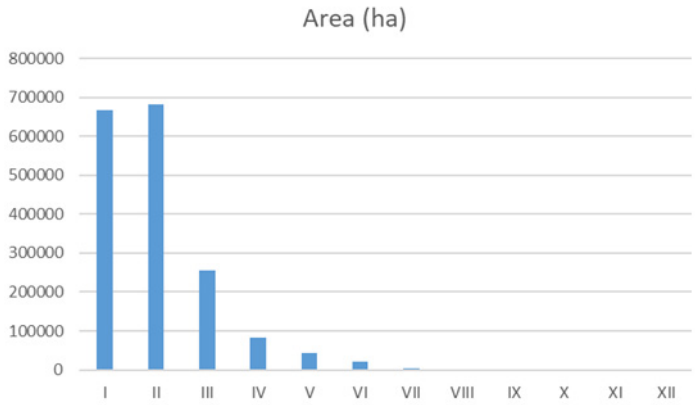


Figure 9. Age class distribution of Oak stands in Türkiye
Şekil 9. Türkiye'de Meşe Meşcerelerinin yaş sınıflarına alansal dağılımı

Figure 10 shows the distribution of pure stands across site classes; I= 11.272,5 ha; II = 138.122,7 ha; III= 724.804,9 ha; IV= 387.890,3 ha; V= 491.210,2 ha; Undefined Oaks/Degraded = 4.363.691,9 ha

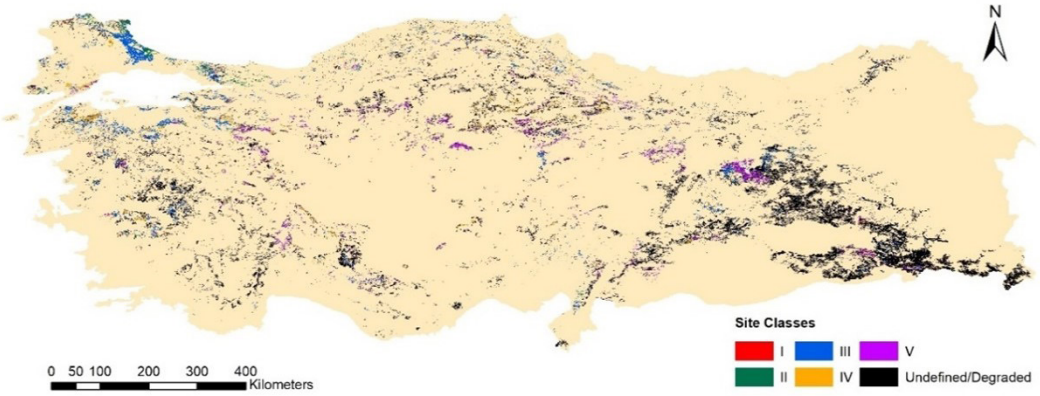


Figure 10. Site class distribution map of Oak stands in Türkiye
Şekil 10. Türkiye'de Meşe Meşcerelerinin bonitet sınıflarına dağılımı

It can be mentioned that most of the pure stands place on site classes of III, IV and V (Figure 11).

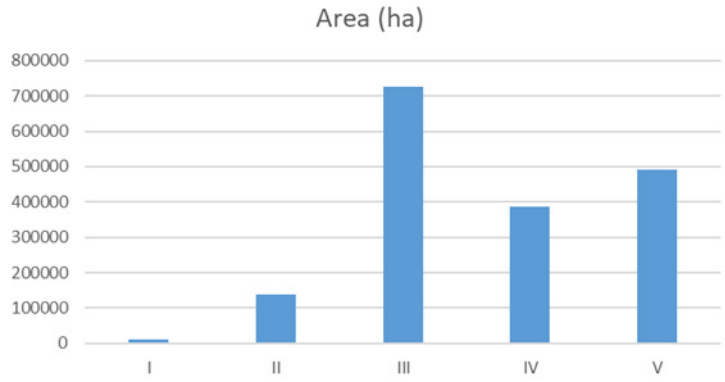


Figure 11. Site class distribution of Oak stands in Türkiye
Şekil 11. Türkiye'de Meşe Meşcerelerinin bonitet sınıflarına alansal dağılımı

When analyzing the distribution of Oak species:

Undefined Oak=4.381.661,8 ha; Mixed Oak =405.764,8 ha; Ml (*Quercus cerris*) =501.045,2 ha; Mz (*Q. petraea)* =242.381,8 ha; Mkr *(Q. coccifera)* =197.576,6 ha; Mt (*Q. pubescens)* =180.618,7 ha; Mm *(Q. infectoria)* =118.080,9 ha; Mn (*Q. trojana)* =38.617,7 ha; Mcr (*Q. frainetto)* = 24.952,7 ha; Mp (*Q. ithaburensis*) =11.244,9 ha; Mk *(Q. vulcanica)* =10.308,4 ha; Ms (*Q. robur)* = 3.176,8 ha; Mln (*Q. libani)* = 752,8 ha; Mr (*Q. ilex*) = 359,1 ha; Mı (*Q. hartwissiana)* = 449,8 ha.

According to this analysis, 13 oak species were found to have a defined distribution, while the distribution of the other 5 species was either undefined or a mixture of oak species. It is worth noting that the most widely distributed oak species in Türkiye are *Quercus cerris, Q. petraea*, and *Q. coccifera* (see Figure 12).

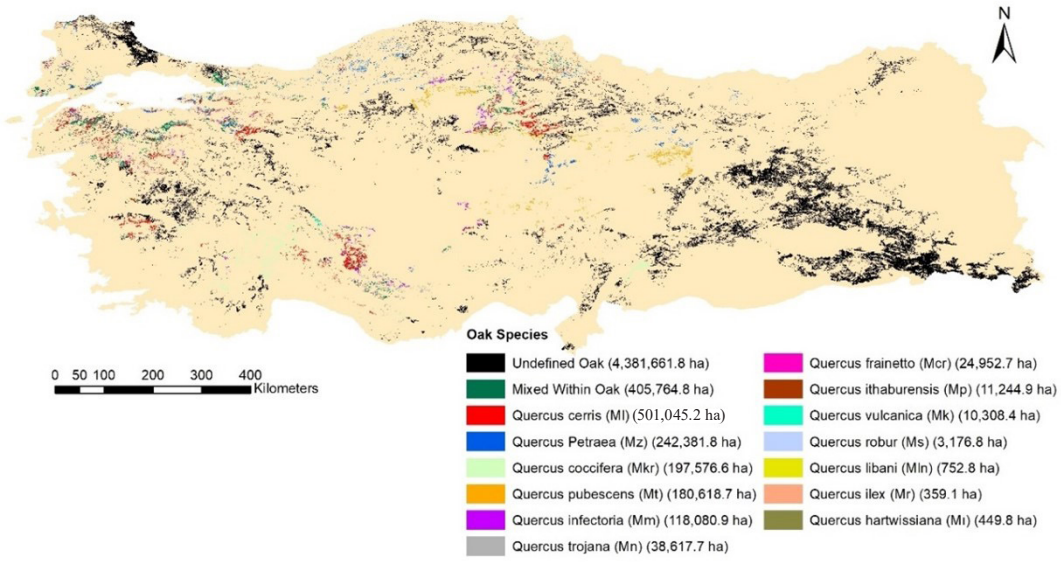


Figure 12. Different Oak taxa distribution in Türkiye
Şekil 12. Türkiye'de farklı Meşe türlerinin konumsal dağılımı

The temporal changes in Oak species stands area in Türkiye are presented in Table 1.

It can be mentioned from Table 1 that the extension of Oak species all over Türkiye has progressively evolved over the years and merely 4,5 times over 100 years and the dynamics are always evolving.

4. Discussion and Conclusions

According to this study, a total of 9,045,768.6 ha of Oak stands were identified (Figure 1), of which 7,581,317.5 ha is pure or Oak dominant mixed stands, compared to the 6.7 million ha (Table 1) of Oak stands that are recorded in the national sta-

Table 1. Temporal changes in Oak area in Türkiye
Tablo 1. Türkiye'de Meşe alanlarının zamansal değişimi

Year	Area (million ha)	Reference
1926	2,1	HGM (1926)
1969	6,6	Soykan (1969)
1980	4,6	OGM (1980)
1996	5,7	Ertaş (1996)
2010	6,4	Şahin et al. (2013)
2012	5,1	OGM (2012)
2015	5,6	OGM (2015)
2020	6,7	OGM (2020)
2022	7,6	This Study (Pure Oak and Oak dominated)

OGM means D.G. Forestry, Türkiye

tistics on forests in Türkiye. The majority of Oak stands belong to the developmental stage class "bc" and nearly ¾ of the stands were degraded according to their crown closure. 33.9% of the stands were managed as productive and 66.1% were degraded, 67.6% were pure and 32.4% were mixed with other species. Moreover, 8.5% were managed as high forest while 18.5% were managed as coppice. 94.5% of them were less than 20 cm in diameter at breast height, and 44.1% of them were having less than 70% of the cover.

The general spatial distribution of Oak species in Türkiye is continuously increasing, and Oak species spatial distribution is continuously progressing. Species differentiation in Oak started in 2014, and only 30% of species have been identified in the last 8 years. This may explain why not all the 18 Oak species in Türkiye are distinguished in forest management plans.

Considering the length of current forest management plans, (10 or 20-year plans are in use), it is expected that the species identification will not be completed until mid-2030s. It has been observed in the field that there are problems in some regions in the distinction based on species, but the distinction of Oak species should be continued at the planning stage. Training should continue to be given to forest management teams (including the private sector) in order to help them to distinguish different Oak taxa in Türkiye. As well, understanding the ecological and physiological characteristics of each Oak species can also help prevent incorrect implementation of silvicultural plans. While some Oak species may be well-suited for implementation within silvicultural operations, others are at risk of extinction due to future climate change conditions according to Fosso and Karahalil (2021) and Fosso et al. (2022). This means that knowing the spatial distribution of different Oak taxa in Türkiye can be critical for successful regeneration and conservation.

Data sharing, including stand type maps or plan text, should be made readily available to universities and other research institutions. This is because studies within this scope contribute to a wide range of research areas, from estimating honey yield produced in honey forests to modeling studies. As noted in the introduction section, Oak species are crucial in the dispersal of insects and bird species, and their spatial distribution analysis can be used to analyze biodiversity distribution and other forest ecosystem services related to each Oak species. According to Mirzaei et al. (2016), the spatial distribution pattern of woody plants, especially trees, has gained much interest from plant ecologists, leading to the introduction of many different methods for quantifying spatial patterns. It is very important to characterize the distribution of each Oak species in order to identify specific physiographic factors that can help in their sustainable management.

Several factors can explain the increasing progression of Oak species (Table 1) across the national territory of Türkiye. These factors include the immigration of local people to big cities, legislative and cadastral applications, and the different usages and utilities of Oak species, which have contributed to their increased area of occupation. Besides, the cutting of trees for different uses, the collection of seeds by local people and the non-regeneration of Oak trees can change their spatial distribution leading to a decreasing pattern. It can also be mentioned that Oak species are native to Türkiye, so this may be favorable for their natural expansion over the years with local climatic conditions. Furthermore, Oak species are well adapted to future climatic conditions in Türkiye (Fosso and Karaha-

lil, 2021; Fosso, 2021; Fosso and Karahalil, 2020). Another factor may be the silvicultural activities over the forest that are more oriented to degraded forest area restoration and rehabilitation, and Oak species are well-suited for such silvicultural operations (Fausset, 2021). For instance, in 2006, a national decision was made to replace coppice forests with high forests. Since then, coppice forest areas have sharply dropped in Türkiye (Sauti and Karahalil, 2022).

In conclusion, Oak species are unequally distributed across Türkiye, and their spatial structure is crucial for describing forest stand structure and dynamics over the management period. It is very important to characterize their distribution in each stand and all over the Turkish territory in order to take into account the variability of Oak species in silvicultural planning and forest management operations.

Oaks should be categorized according to species, age, site, and canopy parameters. The fragmentation status of Oak stands, such as the smallest, largest, and average patch size, should also be taken into consideration when publishing forestry statistics.

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