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Maquis vegetation in Mediterranean-climate region of Türkiye and recommendations for conservation and forestry practices

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Abstract: Maquis ecosystems are among the most uncertain and controversial vegetation types within Turkish forestry. Our review aims to describe and classify these ecosystems in Mediterranean-climate regions of Türkiye, shedding light on the evolution of their legal status in Turkish forestry since the last century. We emphasize their conservation importance and the neglect when compared to pine forests. The description and classification of maquis vary according to many studies, and even the distribution of maquis vegetation in Türkiye has not been fully clarified. Additionally, the legal status of maquis has changed many times over the years. While maquis were considered forests in the early years of the Republic of Türkiye, recent constitutional amendments allow maquis areas to be converted into agricultural land if it is deemed beneficial. Furthermore, clear-cutting is even encouraged for firefighting purposes. Given the rich ecological and biological diversity of these ecosystems and their role as carbon sink, a novel management and conservation approach for the management of maquis including conversion to Turkish pine forests, post-fire restoration, resilience and resistance to climate change should be developed.
Keywords: Habitat conservation, Maquis, Mediterranean vegetation, Mediterranean sclerophyllous forests, Vegetation classification

Türkiye'nin Akdeniz iklim bölgesindeki maki vejetasyonu ve koruma ve ormancılık uygulamaları için öneriler

Özet: Maki ekosistemleri, Türkiye ormancılığındaki en belirsiz ve tartışmalı vejetasyon tipidir. Araştırma makalemiz Türkiye'nin Akdeniz iklimi altındaki bölgelerde yer alan ekosistemlerin tanımlanması ve sınıflandırması ile son yüzyılda Türkiye ormancılığındaki makiliklerin yasal statülerin değişimini ortaya koymayı amaçlamıştır. Makiliklerin tanımı ve sınıflandırılması birçok çalışmaya göre değişiklik göstermektedir, hatta Türkiye'deki maki vejetasyonu dağılımı bile tam olarak net değildir. Bunun yanı sıra, seneler içinde makiliklerin yasal statüsünde de birçok defa değişiklik yaşanmıştır. Türkiye Cumhuriyeti'nin erken dönemlerinde makilikler ormandan sayılırken, son anayasa değişiklikleri ile makilik alanların, uygun görülmesi halinde, tarım arazisinde dönüştürülmesine izin verilmektedir. Ayrıca, yangınla mücadele kapsamında tıraşlama kesim bile teşvik edilmektedir. Bu ekosistemlerin ekolojik ve biyolojik çeşitliliği ile karbon yutağı görevi göz önüne alındığında, kızılçam ormanlarına dönüştürülmeleri, yangın sonrası onarımı, iklim değişikliğine karşı direnç ve direngenlik durumları dahil makiliklerin yönetimi için yeni bir planlama ve koruma yaklaşımı geliştirilmelidir.
Anahtar kelimeler: Habitat koruma, Maki, Akdeniz sert yapraklı ormanlar, Akdeniz vejetasyonu, Vejetasyon sınıflandırması

1. Introduction

Shrublands and sclerophyllous forests are among characteristic vegetation types of Mediterranean type ecosystems. These ecosystems are located in five regions of the world sharing the same climatic regime with a long drought period and mild rainy winters: the Mediterranean Basin, California, western and southern Australia, Chile, and the Cape Region of South Africa (between the 30th and 40th north and south latitudes) (Walter, 1968; Castri and Mooney, 1973; Tavşanoğlu and Gürkan, 2004). Shrublands of Mediterranean type ecosystems are called "maquis" in the Mediterranean Basin, "chaparral" in California, "kwongan" or "heather" in southwestern Australia, "matorral" in Chile, and "fynbos" in South Africa (Rundel et al., 1998). The Mediterranean Basin hosts 73% of this ecosystem type globally. California and southwestern Australia follow with 10% each, and the rest is in Chile (4%) and South Africa (3%) (Cowling et al., 1996).

The definition of maquis vegetation varies among vegetation ecologists. The most widely used definition of maquis is a type of Mediterranean vegetation dominated by shrubs, small trees and trees that are characteristically evergreen, hard and small-leaved, xeric, and 2-5 m tall

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(Mayer and Aksoy, 1998; Özalp, 2000; Papanastasis, 2000; Aksoy, 2006; Bergmeier et al., 2018). Earliest definitions of maquis vegetation included "uncultivated lands" which was a term used for all shrubland and scrublands (Rübel, 1914) or emphasized its cramped dense structure (Semple, 1919). Another common idea suggests that maquis vegetation can form the dominant vegetation in karstic areas even if they are destroyed by fire or due to anthropogenic reasons as their roots progress along the cracks of limestone in such areas (Atalay et al., 2014). A recent definition of maquis refers not only to the structural characteristics such as evergreenness, height, and density, but also to their vigorous resprouting ability following fire (Keeley et al., 2012). There are also two other related types of vegetation, consisting of shrubs and subshrubs throughout the eastern Mediterranean Basin: the garrigue and the phrygana. These vegetation types differ from maquis in some characteristics; the garrigue is dominated by a single oak species (*Quercus coccifera* L.), while the phrygana consists of smaller and often spiny and aromatic shrubs and subshrubs (Keeley et al., 2012). However, these two formations are included in the same vegetation type in some sources (Yaltırık, 1975; Aksoy, 2006), or garrigue and phrygana terms are sometimes used interchangeably which can lead to confusion (Keeley et al., 2012). An alternative, more modern approach is to consider them as separate vegetation types based on differences in vegetation structure and species composition (Keeley et al., 2012; Kavgacı et al., 2021; Tüfekcioğlu and Tavşanoğlu, 2022).

Another debate on the maquis concerns its historical origins. The low-altitude Mediterranean belt consists of forests dominated by pines (e.g., *Pinus brutia* Ten., *P. halepensis* Mill.) or oaks (e.g., *Quercus ilex* L., *Q. suber* L.) or shrubland vegetation dominated by sclerophyllous small trees or large shrubs as *Arbutus unedo* L., *Pistacia lentiscus* L., *Quercus coccifera*, *Olea europea* L., and *Ceratonia siliqua* L. (Zohary, 1973; Akman, 1995; Mayer and Aksoy, 1998; Keeley et al., 2012). It has been suggested that maquis vegetation emerges due to the degradation of these pine and oak forests over time following heavy grazing, fires or timber extraction (Tansley, 1913; Semple, 1919; Polunin and Huxley, 1990; Öztürk, 1995). Similarly, a widespread view about the origin of the garrigue and phrygana claims that these vegetation types were formed as a result of the destruction of maquis over time (Knapp, 1965; Schmidt, 1969; Yaltırık, 1975). The reason maquis areas did not completely disappear might have been especially due to their use as coppice (Özalp, 2000). However, if the degradation causes the destruction of trees and shrubs within the forest, we may expect that the forests would not have turned into maquis but directly into garrigue vegetation (Tomaselli, 1977). Historically garrigue and maquis had been seen as a part of progressive evolution if there is no disturbance for the long term (Harshberger, 1926; Rikli, 1943; Tomaselli, 1977). An alternative theory suggests that the reason for the transition from forest to shrubland in the Mediterranean Basin is fire disturbance (Pausas and Bond, 2020). Therefore, considering maquis vegetation as a degraded habitat is an outdated idea that lacks strong evidence. This discussion can be extended to primary and secondary maquis vegetation, which refer to undisturbed and disturbed ecosystems, respectively. Due to the dominant species' ability to grow into trees, primary maquis formations may occur in areas that have resulted from the retreat of oak or pine forests, especially after frequent disturbances. Although maquis vegetation grows very well under favorable growing conditions, it is also important to note that primary maquis formations can occur in areas with low productivity, shallow soils, weak karstic structure, and low soil depth.

In Türkiye, the definition of maquis has expanded legally over time. The first official definition was made in law No. 5653 in 1950 as "all kind of small trees" and species. In accordance with the "Official Instruction Regarding the Determination of Forest Boundaries at the Confluence of Maquis and Forest Fields", also published in 1950, shrub species as *Cistus* spp. and *Erica* spp., large shrub species as *Laurus nobilis* L., *Myrtus communis* L., *Nerium oleander* L., *Paliurus spina-christi* Mill, *Phillyrea latifolia* L., *Quercus coccifera*, *Rhus* spp., *Styrax officinalis* L. and *Tamarix* ssp. were given as examples. In the following years, according to the Forest Law numbered 6831 in 1956, this definition was expanded to state that maquis consists of xerophytic, evergreen, sclerophyllous small trees up to 3 m in height. Later, in the 2/B Implementation Regulation of the Forest Law No. 6831 Forest Cadastre in 1986, liana species as *Asparagus acutifolius* L., subshrub species as *Ruscus acuelatus* L., shrub species as *Calicotome spinosum* L., large shrub species as *Anagyris foetida* L., *Arbutus* spp., *Cotinus coggygria* Scop., *Juniperus oxycedrus* L., *Ligustrum vulgare* L., *Pistacia lentiscus*, *Pistacia terebinthus* L., *Pyrus amygdaliformis* Vill. and *Spartium junceum*, tree species as *Ceratonia siliqua, Cercis siliquastrum* L., *Olea europea* var. *oleaster* and *Quercus ilex* were also added to the species list in the maquis definition. According to the instruction published by the General Directorate of Forestry in 2012 and communique "Procedures and Principles for the Regulation of Forest Management Plans", which was put into effect in 2017, maquis vegetation is considered to be composed of trees, small trees and shrubs that can reach at least 2 m in height. However, the species list in this communique defined only large shrubs and trees such as *Arbutus andrachne* L., *Celtis australis* L., *Ceratonia siliqua, Juniperus oxycedrus, Laurus nobilis, Myrtus communis, Olea europaea* var. *oleaster, Phillyrea latifolia, Pistacia lentiscus, Pistacia terebinthus, Quercus coccifera, Quercus infectoria* Olivier subsp. *boissieri* (Reuter), and *Styrax officinalis* as maquis species but left out smaller shrubs or sub-shrubs.

Finally, the instruction published in 2022 by the General Directorate of Forestry on the implementations in maquis areas defines maquis as a vegetation type that includes mostly evergreen shrub species, but also small trees and shrubs with hard and small leaves and thorns. This article mentions liana species as *Rubus* spp., shrub species as *Cistus* spp. and *Erica* spp., and large shrub species as mentioned above. Almost all these definitions include only small trees in the concept of maquis, and almost never involve shrub or subshrub species less than 2 m tall. In addition, garrigue and phrygana vegetation types are neither considered in the legal classification nor have any legal definitions. Akkemik (2021) also stressed that maquis should be called "Mediterranean sclerophyllous forest" so as not to be removed them from the forest legal status, especially for those that have lost their structural properties and tree elements due to fire and anthropogenic pressures like overgrazing and fuel wood.

2. The distribution of maquis vegetation in Türkiye

The size of the area covered by maquis vegetation in Türkiye historically varies according to different sources: 216,660 ha (Yiğitoğlu, 1941), 2.5-3 million ha (İnal, 1969), and 3 million ha including garrigue (Tomaselli, 1977). Moreover, Öztürk (1995) stated that about 2 million ha of maquis are found as understory in Turkish pine (*Pinus brutia*) forests. Unfortunately, no information is given for the distribution area of maquis vegetation in Türkiye in "Türkiye's Forest Presence" booklet published by the General Directorate of Forestry of Türkiye in 2021.

Maquis vegetation in Türkiye penetrates from coastal areas into the interior parts of Anatolia where the effect of the Mediterranean climate can be observed. In a general evaluation, maquis plants spread between the sea level and 1500 m elevations (Akman, 1995). As a matter of fact, *Quercus coccifera* dominated maquis vegetation can be seen together with species such as *Arbutus andrachne*, *Arbutus unedo*, *Ceratonia siliqua*, *Cistus creticus* L., *Olea europea*, *Phillyrea latifolia*, *Pistacia terebinthus*, *Quercus aucheri* Jaub. & Spach. and *Quercus ilex* between 300-1400 m altitude (Aksoy, 2006). Davis (1965) reported that *Ceratonia siliqua*, *Cistus* spp., *Laurus nobilis*, *Olea europea*, *Pistacia* spp. and *Quercus* spp. can spread up to 1000-1200 meters. In addition, maquis and Mediterranean sclerophyllous forests in the Mediterranean and Aegean regions contain a diverse plant communities (Kavgacı et al., 2021), reflecting the high plant biodiversity of these ecosystems. Since maquis species have different soil requirements (Özalp, 2000) and are adapted to different environmental conditions at different elevations, maquis vegetation have a high ecological diversity and vary in species richness and composition (Güngör, 2007).

3. Legal status of maquis vegetation and forestry practices in Türkiye

The first known public statements about maquis in Türkiye belong to years 1772 and 1796, when it was suggested that branches of oaks and other shrubs could be used in the construction of ships (Öztürk, 1995). In 1858, a law passed allowing for the clearance of shrubs (without specifically mentioning the term "maquis") and degraded forests for agricultural purposes (Öztürk, 1995). However, in the first years of the Republic of Türkiye, in a reference to Forest Law No. 3116 in 1937, maquis vegetation was considered within the forest status, whereas heathlands were excluded from this definition. In accordance with Law No. 5653 enacted in 1950 and the "Official Instruction Regarding the Determination of Forest Boundaries at the Confluence of Maquis and Forest Areas", maquis that do not produce regularly any kind of wood yield were excluded from the definition of forest. Following this law, 490,000 ha of 780,000 ha total area of maquis vegetation was excluded from the forest status (Kul, 1996).

According to Forest Law No. 6831, which entered into force in 1956, maquis areas are considered as forests only if they protect the soil and reduce the risk of erosion; those that do not meet these criteria are considered as non-forested areas (Ayanoğlu, 1996). However, until the "Regulation on the Determination of Heathland and Shrubland" was published in 1959, implementations continued in line with the older instruction in 1956, and during this time period, approximately 94,000 ha of maquis area were excluded from the forest status (Kul, 1996). Fortunately, as the contraction of legally forest land was prohibited in accordance with the 1961 Constitution, consequently the distinction of maquis areas from forested lands was suspended until the next regulation (Ayanoğlu, 1996). Accordingly, until the constitutional amendment in 1970, only 5,188 ha maquis area was excluded from the forest status (Kul, 1996). Overall, about 590,000 ha of maquis area had lost legal forest status between 1950 and 1970 in Türkiye.

Amendments made in Forest Law No. 6831 in 1973 excluded the maquis areas that had lost their "forest qualification" from forest status. This statement has a conceptual problem regarding what is the loss of the forest qualification (Aslan, 2015), and therefore, is quite subjective term opening several forest and shrubland areas to be converted to agricultural land or urban development areas. Following this, within the scope of the constitutional amendment made in 1982, it was decided that the heathland and maquis areas were open to conversion into agricultural areas by losing their forest status if they are considered "beneficial" for agriculture. As a result of these changes in the laws, a total of 410,000 ha of land area lost its forest status between 1974 and 1996, and it is thought that most of these areas were maquis (Kul, 1996). In 2000, a new article was added to the Forest Management Regulation as a precaution against disqualifying maquis as non-forested areas; therefore, maquis started to be classified as "other broadleaved" ("*diğer yapraklı*" in Turkish) stand type (Özalp, 2000; Taşdemir et al., 2018). In 2008, as a result of the amendment made in the technical prospectus, these areas were given the status of "productive forest" (Güzenge, 2011). In the forest management regulation published by the General Directorate of Forestry in 2008 (Resmi Gazete, 2008), various forest types are defined in terms of their structure and main tree species, regardless of their origin (either from seed or resprout), according to the implementation types. Among definitions for those forest types, any features characteristic for maquis vegetation were ignored.

However, an instruction published by the General Directorate of Forestry in 2012, reclassified the maquis areas identified by Regulation of 1959 as non-forest areas in forest management plans, while other maquis areas determined as such by the Forest Cadastre began to be classified as forested in the plans. The most striking effects of this change was that activities such as clear-cutting of maquis vegetation or converting maquis areas to Turkish pine forests could be carried out (personal communications with Emin Güzenge and Can Vatandaşlar, 2022). In the instruction, it was also highlighted that maquis areas should be converted into Turkish pine forest through afforestation or rehabilitation, since it was thought that a large portion of the maquis was originally Turkish pine forests. As a matter of fact, in accordance with the communique on the "Procedures and Principles of the Implementation of Forest Management Plans" published in 2019, regardless of the percentage of cover, all maquis areas are open to so-called "rehabilitation" in order to "protect the integrity of the ecosystem and to maintain canopy closure".

In the 2022 instruction prepared by the General Directorate of Forestry for implementations in maquis areas, detailed information is given regarding the rehabilitation plans for firefighting and benefiting from non-wood forest products. Accordingly, in Turkish pine forests (not exceeding 10 ha) with dense maquis as the understory, the maquis layer

can be clear-cut to facilitate firefighting. However, since any logging activity on most maquis species will end with the resprouting of individuals, these practices will open the way for the usage of maquis vegetation as coppice stands rather than its main purpose of decreasing fire danger (Turkey's Association of Forestry, 2022).

Other vegetation types, in which maquis species are potentially present, are open Turkish pine stands with 11-40% cover ("*1 kapalı Çz*" in Turkish) and 1-10% cover ("*BÇz" in Turkish*) (Tüfekcioğlu and Tavşanoğlu, 2022) as well as the vegetation types without any trees, the so-called "forest soil" (*"OT" in Turkish*) (Tüfekcioğlu and Tavşanoğlu, 2022) (Table 1). According to Communiques No. 298 "Technical Principles of Silvicultural Practices" and No. 295 "Procedures and Principles for the Implementation of Forest Management Plans", published in 2014 and 2019, respectively, these types of stands are subject to rehabilitation implementations that the usage of local plant species for increasing overall biological diversity are recommended.

4. Maquis vegetation types in the mediterranean area of Türkiye

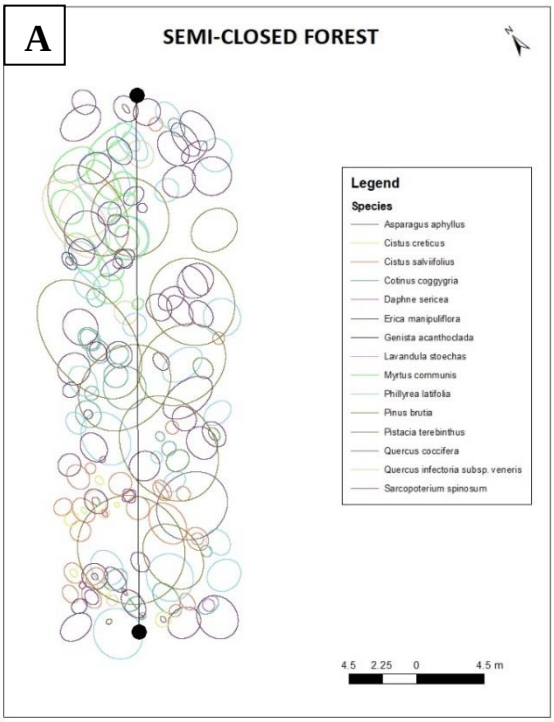
As maquis vegetation has a spatially dynamic structure (Aktepe and Tüfekcioğlu, 2021), maquis species are often entwined each other and therefore do not have clear boundaries. Mayer and Aksoy (1998), Polunin and Huxley (1990) and Aksoy (2006) classified maquis vegetation based on the dominant species such as *Quercus coccifera* maquis, *Olea europea* maquis, *Arbutus andrachne* maquis, or based on the average height of individuals such as tall maquis, low maquis and garrigue. In the classical study by Harshberger (1926), the main classification criteria is the presence of trees, and thus four vegetation units for Mediterranean shrublands were defined: garrigue without any trees, garrigue with some tree species such as oak or pine, maquis without any trees, and maquis with some tree species. On the other hand, Keeley et al. (2012) and Kavgacı et al. (2017) directly divide the eastern Mediterranean vegetation into three main classes as forests, shrubs and phrygana. However, Kavgacı et al. (2021) reclassified Turkish Mediterranean forests and shrublands into seven vegetation types, in other words into vegetation alliances, where shrublands and sclerophyllous forests are grouped and used together as "macchia and Mediterranean sclerophyllous forests". Given that some other studies (Castillo et al., 2020; Soto and Valencia, 2022) covering Mediterranean ecosystems grouped and named maquis and Mediterranean sclerophyllous forests in the same way, Akkemik (2021) suggested that maquis and Mediterranean sclerophyllous forests fall into the same definition and should be used as "Mediterranean sclerophyllous forests".

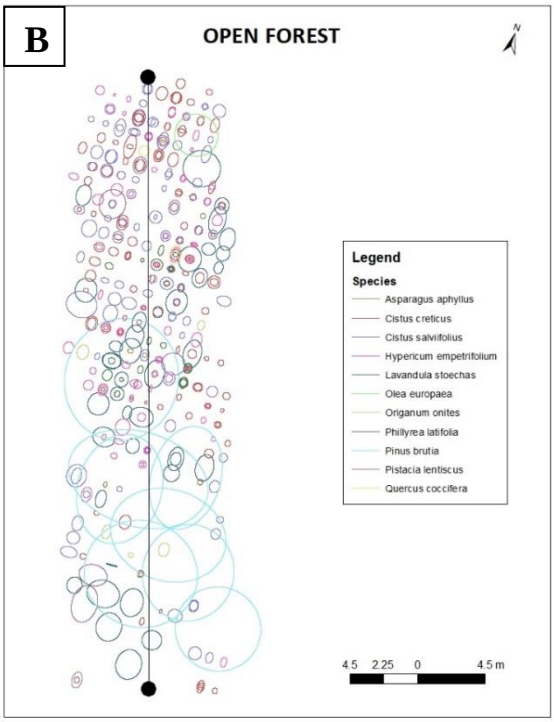
On the other hand, the alternative biome state approach, prominent in recent years, classifies Mediterranean ecosystems as either open or closed vegetation types and asserts that open states are as continuous and permanent as closed vegetation states (Pausas and Bond, 2020). Incorporating this open/close vegetation state approach to the classical forest-shrubland-scrubland system, Tüfekcioğlu and Tavşanoğlu (2022) classified low elevation forest and maquis vegetation of Mediterranean Türkiye into five main vegetation types (Figure 1). Their study suggests that semi-closed and open forests are similar to each other, but closed shrublands, open shrublands and scrublands have completely different vegetation structure from each other (Tüfekcioğlu and Tavşanoğlu, 2022). This classification can be extended to include closed pine forests to cover all possible physiognomic vegetation types of the low elevation Mediterranean vegetation (Table 1). The results of Tüfekcioğlu and Tavşanoğlu (2022) suggest that maquis vegetation in Türkiye can also be efficiently classified in an open/closed framework.

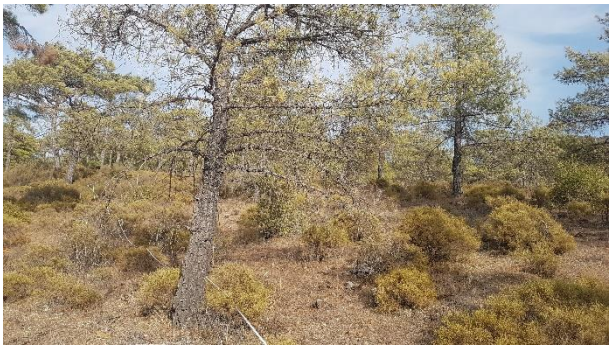
Table 1. Main vegetation types observed at the low-elevation belt of the Mediterranean Türkiye. The classification is based on that used in Tüfekcioğlu and Tavşanoğlu (2022) with some changes, their corresponding classes in forest management plans (Turkish abbreviations in parentheses) and relevant scientific articles (Keeley et al., 2012; Kavgacı et al., 2017)

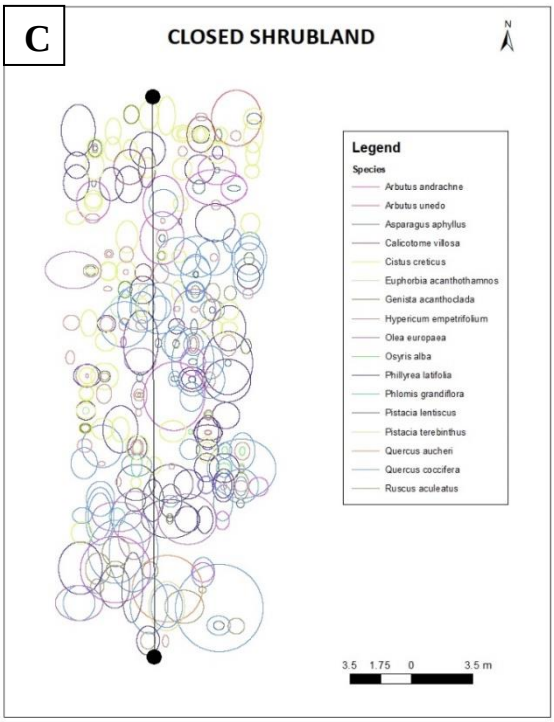
Low-elevation belt of the mediterranean Türkiye		
Vegetation types	In forest management plans in Türkiye	In most scientific articles
Closed forest	Turkish pine forest or other forests with total cover more than 41% ("*2 kapalı Çz*" or "*3 kapalı Çz*" in Turkish or such as oak forests "*M*" in Turkish)	Mediterranean woodlands and forests
Semi-closed forest	Turkish pine forest with total cover between 11% and 40% ("*1 kapalı Çz*" in Turkish)	Mediterranean woodlands and forests
Open forest	Turkish pine forest or other forests with total cover < 10% ("*BÇz" in Turkish* or such as oak forests "*BM*" in Turkish)	Mediterranean woodlands and forests
Closed shrubland	Maquis with total coverage between 11% and 100% ("*Mak3" in Turkish*)	Maquis or Mediterranean sclerophyllous forests
Open shrubland	Maquis with total cover < 10% ("*BMak" in Turkish*)	Phrygana or Garrigue
Scrubland	Forest soil without any trees (*"OT" in Turkish*)	Phrygana or Garrigue

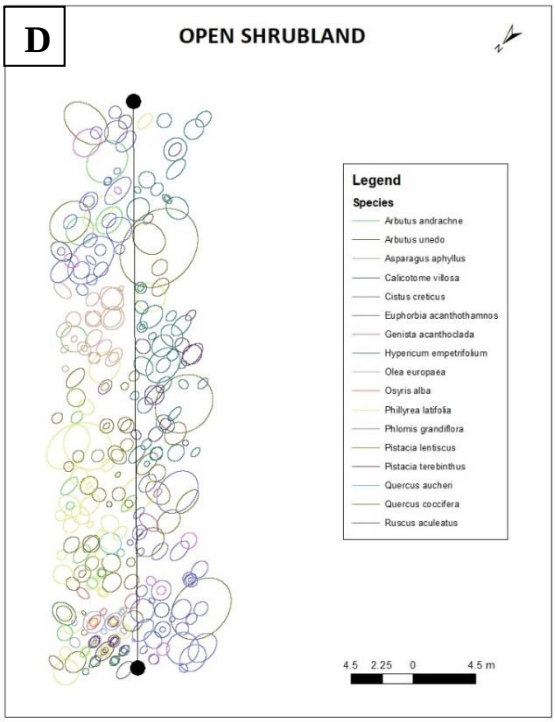
1 kapalı Çz: 1 kapalı kızılçam meşceresi, 2 kapalı Çz: 2 kapalı kızılçam meşceresi, 3 kapalı Çz: 3 kapalı kızılçam meşceresi, BÇz: Boşluklu kapalı kızılçam meşceresi, Mak3: Kapalılığı yüksek maki, BMak: Boşluklu kapalı maki, M: Meşe meşceresi, BM: Boşluklu kapalı meşe meşceresi, OT: Ağaçsız orman toprağı


A
SEMI-CLOSED FOREST
Legend
Species
Asparagus aphyllus
Cistus creticus
Cistus salvifolius
Cotinus coggygria
Daphne sericea
Erica manipuliflora
Genista acanthoclada
Lavandula stoechas
Myrtus communis
Phillyrea latifolia
Pinus brutia
Pistacia terebinthus
Quercus coccifera
Quercus infectoria subsp. veneris
Sarcopoterium spinosum
4.5 2.25 0 4.5 m


B
OPEN FOREST
Legend
Species
Asparagus aphyllus
Cistus creticus
Cistus salvifolius
Hypericum empetrifolium
Lavandula stoechas
Olea europaea
Origanum onites
Phillyrea latifolia
Pinus brutia
Pistacia lentiscus
Quercus coccifera
4.5 2.25 0 4.5 m




C
CLOSED SHRUBLAND
N
Legend
Species
Arbutus andrachne
Arbutus unedo
Asparagus aphyllus
Calicotome villosa
Cistus creticus
Euphorbia acanthothamnos
Genista acanthoclada
Hypericum empetrifolium
Olea europaea
Osyris alba
Phillyrea latifolia
Phlomis grandiflora
Pistacia lentiscus
Pistacia terebinthus
Quercus aucheri
Quercus coccifera
Ruscus aculeatus
3.5 1.75 0 3.5 m


D
OPEN SHRUBLAND
Legend
Species
Arbutus andrachne
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Phlomis grandiflora
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Pistacia terebinthus
Quercus aucheri
Quercus coccifera
Ruscus aculeatus
4.5 2.25 0 4.5 m

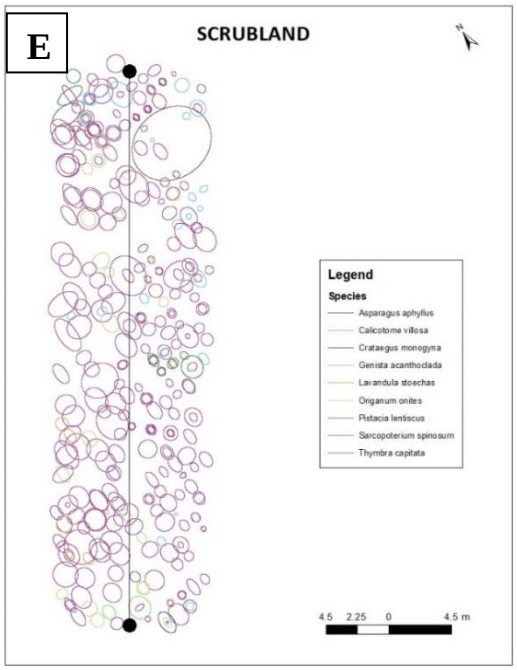

Figure 1. Top views of transects representing the horizontal structure of different maquis vegetation types in the Mediterranean Türkiye drawn based on data in Tüfekcioğlu (2022): (A) Semi-closed forest ("*1 kapalı Çz*" in Turkish), (B) Open forest ("*BÇz" in Turkish*), (C) Closed shrubland ("*Mak3" in Turkish*), (D) Open shrubland ("*BMak" in Turkish*), (E) Scrubland (*"OT" in Turkish*). Each circle represents a woody plant individual given in different colors (based on the species to which the individual belongs) and sizes (based on diameter measurements; Tüfekcioğlu, 2022)

5. Ecological properties of the maquis vegetation and sclerophyllous mediterranean forest

The Mediterranean region of Türkiye, comprising of both forests and shrublands, includes ca. 5000 plant species, of which 30% are endemic (Thompson, 2005). Mediterranean shrublands including maquis vegetation have a significant share of this diversity, both in structural and floristic aspects (Naveh and Whittaker, 1980; Coşgun, 2022; Tüfekcioğlu and Tavşanoğlu, 2022). Maquis vegetation can be found in several vegetation states from open and closed shrublands to Mediterranean sclerophyllous forests, depending on the disturbance frequency and climatic potential of the environment. The dense structure of closed maquis vegetation provides a safe environment for many mammal species to hide, shelter, breed and roam (Ambarlı et al., 2019; Kankılıç and Bilgin, 2019). Moreover, the fruits of different maquis species ripening in different seasons constitute an important food source for many animals throughout the year. In particular, the mixture of maquis species with Turkish pine creates a vegetation type rich in terms of tree species composition (Zeydanlı et al., 2019) and is considered a valuable biodiversity element (Lise et al., 2019). Besides the biodiversity-supporting function of closed maquis vegetation and Mediterranean sclerophyllous forests, open maquis habitats have also high level of biodiversity. For example, among all Mediterranean-type shrublands of the world, one of the highest plant diversity levels are observed in the heavily grazed open shrublands and woodlands of the eastern Mediterranean Basin (Cowling et al., 1996). Finally, maquis have other functions such as soil protection and erosion control due to their strong and deep root systems (İnal, 1969; Uslu, 1982; Taşdemir et al., 2018) and the contribution to ecosystem functioning (Aktepe and Tüfekcioğlu, 2021).

Of major ecological importance is the fact that maquis vegetation is highly adapted to climatic conditions of the Mediterranean Basin, particularly the summer drought, and disturbances such as fire and herbivory. Plant species living in this region must resist water deficits created by the long dry summer conditions via specific adaptations. In that sense, maquis species bear several plant traits to prevent the loss of water such as small and sclerophyllous leaves and to acquire water from the soil through their deep roots (Tavşanoğlu and Gürkan, 2004). Summer drought often leads to wildfires throughout the Mediterranean Basin. Maquis species are resilient to fires thanks to their high resprouting ability from belowground buds and lignotubers, or due to their ability for post-fire seedling germination and establishment (Keeley et al., 2012; Tüfekcioğlu, 2022). These two regeneration mechanisms shape the long-term vegetation dynamics in Mediterranean ecosystems, and maquis species can locally persist as part of the vegetation even under high fire frequencies (Bahar, 2018). Indeed, fire is the main driver of vegetation transitions from forest to shrubland in the Mediterranean Basin (Pausas and Bond, 2020). Herbivory is another important factor shaping vegetation structure and plant diversity in maquis vegetation (Tavşanoğlu and Coşgun, 2009; Papanikolaou et al., 2011). Since there is a long history of interaction between Mediterranean vegetation and wild and domestic herbivores, many maquis species have traits such as spines, thorns, and chemicals giving bad taste that provide protection from browsing (Focardi and Tinelli, 2005). In addition to their high resprouting ability after disturbances, these traits make maquis vegetation resistant and resilient to browsing and grazing. Studies investigating

herbivory-vegetation relationships in the Mediterranean Basin suggest that moderate-level grazing and browsing activities create more open habitats that promote plant diversity (Naveh and Whittaker, 1980; Papanikolaou et al., 2011).

6. Conclusions

Definition and classification of vegetation types related to maquis species

Definitions for maquis mostly include tree and large shrub species. However, the fact that subshrub and shrub species are dominant enough to direct the features of plant communities should also be taken into consideration. As stated by Tüfekcioğlu (2022), since subshrubs and shrubs are resistant to drought because of their leaf traits, vegetation types where these species are most common (semi-closed, and open forests and closed and open shrublands) are also drought resistant. Therefore, maquis vegetation should be defined as a Mediterranean vegetation type consisting mainly of tall and dense shrubs, but also subshrub and tree forms in a multi-layered structure. Even the same species can be found in several different growth forms; for example, *Quercus coccifera* individuals can be observed in shrub, large shrub or tree forms depending on the disturbance level. Therefore, it can be pointed out that maquis vegetation is an important biodiversity element both in terms of diversity of plant species and growth forms.

Although the most obvious difference in Mediterranean vegetation types is between forest-shrubland-scrubland, it is also necessary to consider open and closed states of forests and shrublands as separate vegetation types (Tüfekcioğlu and Tavşanoğlu, 2022). Five maquis vegetation types in the Mediterranean Türkiye (Figure 1) should be considered separately in the decisions being made for the protection and management practices to be followed in the Mediterranean vegetation. Especially, as scrublands (*"OT" in Turkish*) contain maquis species with high density and only a few large individual shrubs as *Quercus* spp., these vegetation types should be classified as maquis vegetation types in forest management plans instead of "forest soil without any trees".

Recommendations for forestry Implementations

The main forestry policy today in the Mediterranean region of Türkiye is to convert open forests and shrublands into closed Turkish pine forests. On this matter, there are two different historical views on the relationship between Turkish pine and maquis. On the one hand, Turkish pine forests had historically been thought to be facilitated by human activities and grow rapidly on garrigue vegetation and replace the maquis as the climax. As this continues to be supported by human interventions, Turkish pine forests became to represent a stable state (i.e. so-called 'paraclimax'); when not supported, they would revert to a Mediterranean sclerophyllous forest – that is, the climax state (Tomaselli, 1977). On the other hand, Öztürk (1995) stated that the maquis species fill the open spaces in Turkish pine forests; therefore, Turkish pine seeds cannot reach the soil and regenerate naturally. As a result, such areas were expected to evolve from Turkish pine forests into maquis vegetation. For this reason, it is recommended that any maquis dominant areas should be "restored" back into Turkish pine forests through afforestation (Saatçioğlu, 1952). The alternative vegetation state theory (Pausas and Bond, 2020) contradicts with such historical ideas, as it suggests that the frequency of fire disturbance is the main factor determining maquis - pine forest transitions, independent of the origin of fire (natural or human-caused). For ecologists, consequently, maquis vegetation is not seen as a degraded habitat, but a primary component of a long-term transition dynamics driven by fire. In many cases, maquis vegetation is found in a mosaic structure with pines and phryganic subshrubs, making this classification more complex. A solution can be to introduce open and closed vegetation concepts into Mediterranean vegetation typology (Tüfekcioğlu and Tavşanoğlu, 2022). In that sense, the mosaic structure of open forests *("BÇz" in Turkish)* should also be evaluated in planning stages before such forestry activities in the Turkish pine axis are carried out, since they have a wide variety and richness of shrub and subshrub species and only a few Turkish pine individuals.

As a matter of fact, the instruction published by the General Directorate of Forestry in 2012, the communiques "Technical Principles of Silvicultural Practices" in 2014 and "Procedures and Principles for the Implementation of Forest Management Plans" in 2019 sided with the second theory and gave directives for the rehabilitation of maquis and their conversion into Turkish pine forests. However, the destruction of present vegetation for any reason, such as the "rehabilitation" of open shrublands into Turkish pine forests, cutting or converting maquis into coppice forests (Işık et al., 1997; Özalp, 2000) or clearing all the understory (Güzenge, 2011) will damage diversity and functioning of the maquis (Özkan and Özdemir, 2016). Moreover, in areas with a slope higher than 15%, the removal of maquis will adversely affect the area's ability to protect the soil against erosion (Saatçioğlu, 1952).

For any implementation to be planned for maquis areas, the vegetation type must first be properly determined. As a matter of fact, it is known that forests and shrublands are more resistant to drought and fire (Tüfekcioğlu, 2022) compared to scrublands. For forestry implementations to be planned for these vegetation types, their advantageous resistance capacities should be taken into account. In the future, when the effects of climate change will become more prevalent, plant communities with those structures must be protected. On the other hand, even if rehabilitation work is to be carried out, it should be done using drought-resistant species such as subshrubs and shrubs. This situation is also valid for post-fire restoration implementations; instead of afforestation with Turkish pine, shrub species with resprouting abilities should be allowed to return in areas previously covered with maquis before the fire (Tüfekcioğlu et al., 2022).

As stated by Tüfekcioğlu (2022), scrublands are not resistant to fire and climate change. However, it is the most resilient vegetation type against both fire and climate change compared to other types. In other words, the recovery capacity of the plant composition in scrublands is higher than in other vegetation types in the event of damage due to an increase in temperature, drought or frequent and wild fires. Since scrubland is classified as forest soil without any trees (*"OT" in Turkish*) in forest management plans in Türkiye, those that are not subject to rehabilitation are generally allowed to be grazed. Nevertheless, the roles of scrublands in the ecosystem must be taken into account when making

management decisions regarding promoting ecosystem resilience to fire (Valdecantos et al., 2009).

The primary forestry policy in Türkiye's Mediterranean region focuses on converting open forests and shrublands into closed Turkish pine forests. Before such implementations, it is crucial to give careful consideration to maquis vegetation types and develop appropriate management. It should be emphasized that shrublands exhibit greater resistance to drought and fire, while scrublands are more resilient. However, even though most shrub species forming maquis vegetation can resist severe droughts, the expected increase in fire frequency in the Mediterranean Basin due to climate change (Sayedi et al., 2023) may result transformation of Mediterranean sclerophyllous forests and closed maquis into open shrublands (Schaffhauser et al., 2011), as alternative vegetation state theory implies (Pausas and Bond, 2020). There are also concerns about the post-fire restoration of maquis and Mediterranean sclerophyllous forests by focusing solely on the economic purposes (including the afforestation of burned areas using pine saplings) will be a waste effort due to changes in climate and fire regimes (Tavşanoğlu, 2021). Therefore, future forestry practices should also consider the possible effects of climate change on maquis vegetation, especially due to more frequent fires under a future novel climate.

Conservation strategies for maquis vegetation

Today, according to the Forestry Law of Türkiye, maquis areas that "do not have any forest characteristics or soil protection capabilities and with no potential benefits to be converted into agricultural areas" are not considered legally as "forest". This has led to the removal of more than one million hectares of maquis area from the forest status in the past. Therefore, land use of many maquis areas have been repurposed as touristic developmental, agricultural or rangeland areas. On the other hand, maquis considered as "forest" are being transformed into Turkish pine stands or being cut down for various purposes. The majority of the maquis areas which have not undergone any intervention are either located on steep cliffs and slopes or occur far from settlements. Due to such limitations, studies for the protection of important ecosystems such as maquis have been very incomplete.

For the protection of maquis, both legal steps and practical applications should come to the fore (Tomaselli, 1977). It is obvious that there is a need for new regulations in the Forestry Law, especially to prevent the conversion of maquis into agricultural areas, which affects not only their diversity but also their resilience and resistance capacities to fire and climate change. In addition to the fact that Mediterranean type ecosystems will be most severely exposed to the effects of climate change (Giorgi and Lionello, 2008; Enright et al., 2014), it is also a known fact that these effects will be experienced directly in the form of major droughts (Cubash et al., 1996) and frequent fires (Lavorel, 1999). Certain implementations such as afforestation with pines and clear-cuts for coppice management should be avoided when possible, as maquis are ecologically valuable ecosystems, especially considering their ability to resist drought (Tavşanoğlu and Gürkan, 2004), their role as carbon sinks in the ecosystem (Carrión-Prieto, 2017), and their contribution to the diversity of wildlife (Katsimanis et al., 2006). Moreover, recovery of a disturbed maquis vegetation can take place in a short time. To turn this ability into a management advantage, maquis vegetation should be left in their natural state as much as possible after a fire (Tüfekcioğlu et al., 2022) and if necessary, can further be supported with plant species found in its pre-disturbance state. In order to develop a conservation approach based on planning, it may be suggested to add a maquis protection class to the regulation, which aims to protect biological diversity, which can be included in the nature protection sub-function under the ecological function in forest management planning.

To properly differentiate between conservation areas for maquis vegetation and areas aimed to turn into Turkish pine forests, it is important to clearly highlight the distinct characteristics of maquis that set them apart from Turkish pine vegetation. This can be achieved by emphasizing the ecological functions that maquis provide and their unique functional and species diversity. Identifying open Turkish pine forest vegetation solely based on tree-level closure classes is inadequate, as this vegetation type often also comprises a significant maquis component. Therefore, future forest management plans should acknowledge these forest stands as complex ecosystems with a mosaic vegetation structure.

Final recommendations for planners and practitioners:

- The definition of maquis should be revised; besides tree and large shrub species, subshrub and shrub species should also be included in the definition. Moreover, the multi-layered structure of maquis should also be highlighted in the definition.
- The classification of Mediterranean vegetation types should be expanded to include both open and closed habitats, and also scrubland vegetation that has been classified as forest soil without any trees (*"OT" in Turkish*) in forest management plans. Based on this new definitions and classifications, the distribution of maquis areas in Türkiye should be reevaluated and the necessary updates should be made in "Türkiye's Forest Presence" booklet published by the General Directorate of Forestry.
- The policy of converting open forests and shrublands into closed Turkish pine forest should be abandoned. This afforestation and/or rehabilitation implementations should be re-evaluated in management plans, considering that these vegetation types are valuable for and have high level of resistance and resilience to drought and fire.
- Scrublands, which are generally used as afforestation, grazing or agricultural land, are the most resilient vegetation among the Mediterranean vegetation types to climate change and fire. A novel approach in managing scrubland ecosystems is required in forest management plans to benefit from their resilience capacity in the environments of a warmed future.
- In order to ensure an exact legal protection of maquis, this vegetation should be included in the definition of forest in the Forestry Law of Türkiye. By this way, the human use of maquis areas for tourism, agriculture or grazing purposes would be prevented or minimized. In addition, the rehabilitation recommendations for converting maquis into Turkish pine forests in regulation plans should also be removed and conservation and protection strategies should be prioritized in these plans.

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