

## PAPER DETAILS

TITLE: Current Status and the Last Locations of Turkey's Native Buxus species (*Buxus sempervirens* L. and *Buxus balearica* Lam.) Under Threats

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PAGES: 179-196

ORIGINAL PDF URL: <https://dergipark.org.tr/tr/download/article-file/2251436>



## Current Status and the Last Locations of Turkey's Native Buxus species (*Buxus sempervirens* L. and *Buxus balearica* Lam.) Under Threats

Türkiye'nin Tehdit Altındaki Doğal Şimşirlerinin (*Buxus sempervirens* L. ve *Buxus balearica* Lam.) Mevcut Durumu ve Kalan Son Lokasyonlar

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Geliş Tarihi (Received): 14.02.2022

Kabul Tarihi (Accepted): 03.06.2022

Yayın Tarihi (Published): 22.08.2022

**Abstract:** We investigated the current status and the last locations of Turkey's native Buxus species under threats especially with boxwood moth (*Cydalima perspectalis*) in detail throughout the country for the first time. Within the scope of the studies, detailed field and survey studies were carried out to determine the latest status of existing boxwood existence in regions and provinces. The study was carried out in 26 (the existence of boxwood is definitely 23 provinces, 3 provinces are thought to be boxwood) provinces. According to the results obtained from field studies conducted in 23 provinces, 59 districts and 195 locations for which boxwood presence information was obtained, it was determined that boxwood remained in 29 locations in 15 provinces and 23 districts. With these results, it was determined that Turkey's boxwood presence has decreased by 85%, and only 15% of the presence of boxwood remains. Due to the continuing effect of the boxwood moth, it is under serious threat in the remaining locations. The last remaining locations of Turkey's native Buxus species under threats were determined and described in this first pioneering research study on this matter. We suggest urgent studies for the protection of boxwood genetic resources in Turkey.

**Keywords:** *B. sempervirens*, *B. balearica*, extinction, native locations, threats, Turkey's flora

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**Özet:** Türkiye'nin doğal şimşir türlerinin özellikle şimşir güvesi (*Cydalima perspectalis*) tehdidi altındaki mevcut durumu ve son lokasyonları ilk kez ülke genelinde detaylı olarak araştırılmıştır. Çalışmalar kapsamında bölge ve illerdeki mevcut şimşir mevcudiyetinin son durumunun tespiti için detaylı arazi ve etüt çalışmaları yapılmıştır. Çalışma 26 (şimşir mevcudiyetinin kesin olarak bulunduğu 23 il ve var olduğu düşünülen 3 ilde) ilde gerçekleştirilmiştir. Şimşir mevcudiyeti bilgisi alınan 23 il, 59 ilçe ve 195 lokasyonda yapılan saha çalışmalarından elde edilen sonuçlara göre, şimşirin 15 il ve 23 ilçede 29 lokasyonda kaldığı belirlenmiştir. Bu sonuçlarla Türkiye'nin şimşir mevcudiyetinin %85 oranında azaldığı ve sadece %15'inin kaldığı tespit edilmiştir. Şimşir güvesinin etkisinin devam etmesi nedeniyle kalan yerlerde ciddi tehdit altındadır. Şimşirler konusundaki bu ilk öncü araştırma çalışmasında, Türkiye'nin tehdit altındaki doğal şimşir türlerinin kalan son lokasyonları ve mevcut durumu tespit edilmiş ve açıklanmıştır. Türkiye'de şimşir genetik kaynaklarının korunması için acil çalışmalar yapılmasını öneriyoruz.

**Anahtar Kelimeler:** *B. sempervirens*, *B. balearica*, yok olma, doğal lokasyonlar, tehditler, Türkiye florası

**Atıf/Cite as:** Sarı, Ö., Çelikel, F. G. & Yaşar, H. (2022). Current Status and the Last Locations of Turkey's Native Buxus species (*Buxus sempervirens* L. and *Buxus balearica* Lam.) Under Threats. Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi, 8 (2), 179-196. DOI: 10.24180/ijaws.1073061

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## INTRODUCTION

Boxwood plants are used as ornamental plants and for different purposes. In the past, boxwood had a wide range of uses in industry, such as making household items, ornaments, parts of agricultural tools, machine parts, optical and surgical instruments, and making various containers. Today, although the trade of boxwood wood has decreased compared to the past, its use continues in some areas, especially for sculpture and musical instrument making (Richter, 1988; Baytop, 1999; Türkyılmaz, 2004). In addition, its durable and showy green leaves are used in various ceremonies and festivals (Record and Garrat, 1925; Gottwald, 1958; Brondegard, 1992). The boxwood trade in Europe reached its peak between 1860 and 1910. In this period, it reached a processing amount of over 10.000 tons. However, the rapid depletion of large and high-quality boxwood populations in the Caucasus, Turkey and Iran, the most important supply region, has caused a sharp decline in the trade volume of boxwood (Gottwald, 1958). Due to the presence of volatile alkaloids in different parts of boxwood, it has also been used in the treatment of some diseases in alternative medicine (Akkemik and Kaya, 1998; Baytop, 1999). In many regions of Turkey where boxwood is widespread, making spoons and ornaments from boxwood wood has continued as an economic activity from past to present. Apart from these uses, the most important use of boxwood today is their use as ornamental plants due to their ostentatious structures. Boxwoods are used as hedges, potted plants and for various decorative purposes. Its shoots are used as green filling in floriculture. Boxwood is heavily preferred in parks and gardens because it does not shed leaves in winter, has the ability to shoot, has a beautiful appearance and can adapt to different environments (Larson, 1996; Sarı and Çelikel, 2019; Sarı and Çelikel, 2021).

According to the records of The Plant List (2013), 104 accepted species of boxwood are distributed worldwide. The *Buxus* genus can grow in a wide ecological area and even above 3000 m altitude. *Buxus* species are distributed among five major geographical regions. It includes Europe, the Mediterranean basin and the Middle East, China, Japan, Korea, Malaysia and the Philippines, Africa, the Caribbean Islands, Mexico and South America, India, the northwestern Himalayas and the former Soviet Union regions. The only area where *Buxus* is not native is North America and Australia (Larson, 1996).

*Buxus* species are distributed in both open and forest areas (rocky areas, broad-leaved, deciduous and evergreen forests) along river beds, slopes and moist valleys or basins in Turkey. According to Davis (1982) two species of *Buxus* spp. naturally occur in Turkey. These are Anatolian boxwood (*B. sempervirens*) and Spanish boxwood (*B. balearica*). *Buxus* spp. distributed in the flora of Turkey. In order to determine the species and their locations, new locations were determined in addition to the locations determined by previous researchers (Aytuğ, 1984; Davis, 1982; Korkmaz and Engin, 2001; Avcı and Özhatay, 2005). According to the results of the study, in the provinces of Artvin, Rize, Trabzon, Giresun, Ordu, Sinop, Kastamonu, Zonguldak, Bartın, Karabük, Düzce and Bolu in the Black Sea Region, in the provinces of Sakarya, Kocaeli, Istanbul, Bursa and Bilecik in the Marmara Region and in the provinces of Kahramanmaraş, Adana, Osmaniye, Hatay and Antalya in the Mediterranean Region studies were carried out. In these studies new boxwood locations were determined in addition to the existing boxwood locations. Of these locations, only *B. balearica* species is distributed in Adana and Antalya locations, while both species are distributed in Hatay (Sarı, 2021; Sarı and Çelikel, 2021).

*B. sempervirens* L. is mostly a 1-2 m tall shrub, sometimes a 15 m tall tree. The leaves are short-stalked, long-ovoid, full-edged, leathery and poisonous. The upper surface is bright green, the lower surface is hairy and yellowish light green along the veins. The length of the leaves can be 1.5-3.5 cm, and the width can be 0.5-1.5 cm. Young shoots are 4-cornered. They usually bloom from March to April. Male and female parts are on the same flower. Each flower has 4 yellow colored stamens and the longer female stamens. The female organ ovary has 3 eyes. There are 6 seeds in a capsule. Its seeds are 5-6 mm long, 3-angled, dark brown in color and shiny (Davis, 1982; Köhler, 2007). *Buxus balearica* is an evergreen, mostly shrub form, which is endemic to the Mediterranean Basin, generally spreading on rocks (La'zaro, 2005). *B. balearica* differs from *B. sempervirens* L. in that it has adapted to the long summer drought, which is the main characteristic of the Mediterranean climate. It does not exceed 4-5 m in length. Its leaves are long, egg-shaped and usually lanceolate, 2.5-5 cm long, 1-1.5 cm wide. The ends of the leaves, which are light green on both sides, are

rounded or slightly notched. Its shoots are hairless. It blooms from late February to May (La'zaro and Traveset, 2005) and grows naturally up to 900 m high (Davis, 1982; Blanca et al., 1999; Köhler, 2007).

Boxwood plants have faced to the threat of extinction in recent years both in the world and in Turkey due to the destruction mostly caused by some pests and diseases. Boxwood moth (*Cydalis perspectalis*), a pest native to East Asia (Inoue, 1982), has caused significant damage to natural and landscape boxwood locations in Europe, the Caucasus and Turkey since 2006. Its spread has been by the transportation of the eggs of the pest between regions and countries during commercial activities. The pest that was seen in Europe in 2006 (Krüger, 2008) entered the North Caucasus basin with the imported boxwoods for the 2012 Sochi Winter Olympics. It spread throughout the Caucasus, Georgia and spread to Artvin. Later, all Black Sea Region and Marmara Region boxwood locations were affected (Sarı ve Çelikel, 2021). In addition, Ak et al. (2021) reported that moth is also seen in the Mediterranean Region.

With this study, some field studies were carried out to reveal the current situation of boxwoods in Turkey as well as to take plant samples under protection and propagation. *Buxus* spp. it was aimed to collect the species and populations by determining their distribution areas and to preserve the collected material by converting it into a gene pool. In addition, the extent of the damage caused by diseases and pests on the locations has been tried to be revealed.

## MATERIAL AND METHOD

### Data Collection and Study Area

Two species of boxwood (*B. sempervirens* and *B. balearica*) distributed in Turkey were used as plant material (Figure 1).



**Figure 1.** *B. sempervirens* (a) and *B. balearica* (b) shoots  
Şekil 1. *B. sempervirens* (a) ve *B. balearica* (b) sürgünü

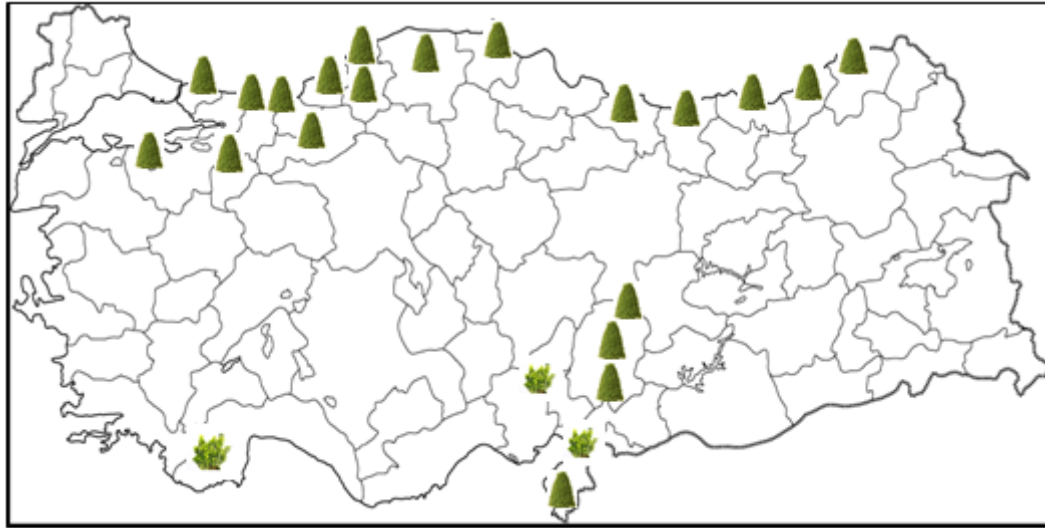
In the study the first activity to determine the locations of the boxwood species of the Turkish flora was the examination of previous studies on this subject. Within the scope of these studies; Basic sources such as Flora of Turkey (Davis, 1982), Red Book of Plants of Turkey (Ekim et al., 2000), 122 Important Plant Areas of Turkey (Özhatay et al., 2005), as well as researches and theses on boxwood, newspaper articles were examined, information was compiled from local people and spoon and wood craftsmen. Davis (1982) reported that *B. sempervirens* L. is distributed in Kocaeli, Bolu, Zonguldak, Kastamonu, Trabzon, Rize, Artvin, Denizli and Kahramanmaraş and *B. balearica* Lam. is distributed in Antalya, Adana and Hatay provinces. In addition, the locations reported by Aytuğ (1984) are the same as the locations reported by Davis (1982), except for Denizli province. Also, Korkmaz and Engin (2001) reported that there is a boxwood location at 300 m in the western part of the Kepez valley, in the Durağan district of Sinop province. In addition to these locations previously determined by the researchers, information was collected by creating an information collection form for the determination of new locations and sending it to sub-units and National Park Directorates through the Regional Directorates of Forestry in the Black Sea, Marmara, Aegean and Mediterranean Regions. 21 responses were received from the institutions. Of these forms, the

answer was that there were no plants in 8 forms. With the information obtained from these forms, the information about the distribution of boxwood in Turkey was obtained in 15 provinces, 42 districts and 177 locations. When the information obtained from the forms is combined with other research studies, it was that there are boxwoods in 23 provinces, 59 districts and 195 locations throughout the country (Figure 2). The provinces in which the presence of boxwood is detected are given in Table 1 the field program was created by evaluating the information obtained.

**Table 1.** Regions and provinces with boxwood presence.

Çizelge 1. Şimşir varlığı tespit edilen bölge ve iller.

Regions	Provinces
Black Sea Region	Artvin, Rize, Trabzon, Giresun, Ordu, Samsun, Sinop, Kastamonu Zonguldak, Bartın, Karabük, Düzce, Bolu
Marmara Region	Sakarya, Kocaeli, İstanbul, Bursa, Bilecik
Mediterranean Region	Kahramanmaraş, Adana, Osmaniye, Hatay, Antalya



*B. sempervirens*



*B. balearica*

**Figure 2.** Distribution areas of boxwood in Turkey.

Şekil 2. Türkiye’de şimşir yayılış alanları.

Among these locations, only *B. balearica* species is distributed in Adana and Antalya locations, while both species are distributed in Hatay province. In addition to these locations, the study was conducted in Gümüşhane, Denizli and Muğla. Within the scope of the whole study, field studies were carried out in 25 provinces. Within the scope of the studies of scanning the flora of Turkey, taking plant material (cuttings) and determining the status of the population and photographing the plants.

Plant sampling from the field was carried out throughout the year mainly in autumn. During the study, observations were made about the condition of the population studied. Determining the coordinates and altitude of the sample point with a GPS device. It was recorded with information about the place and time of collection. One of the examinations made during the field studies carried out is to determine the damage caused by the boxwood moth (*Cydalima perspectalis*). In this context, the extent of the damage suffered by the populations during field studies was tried to be revealed in all locations.



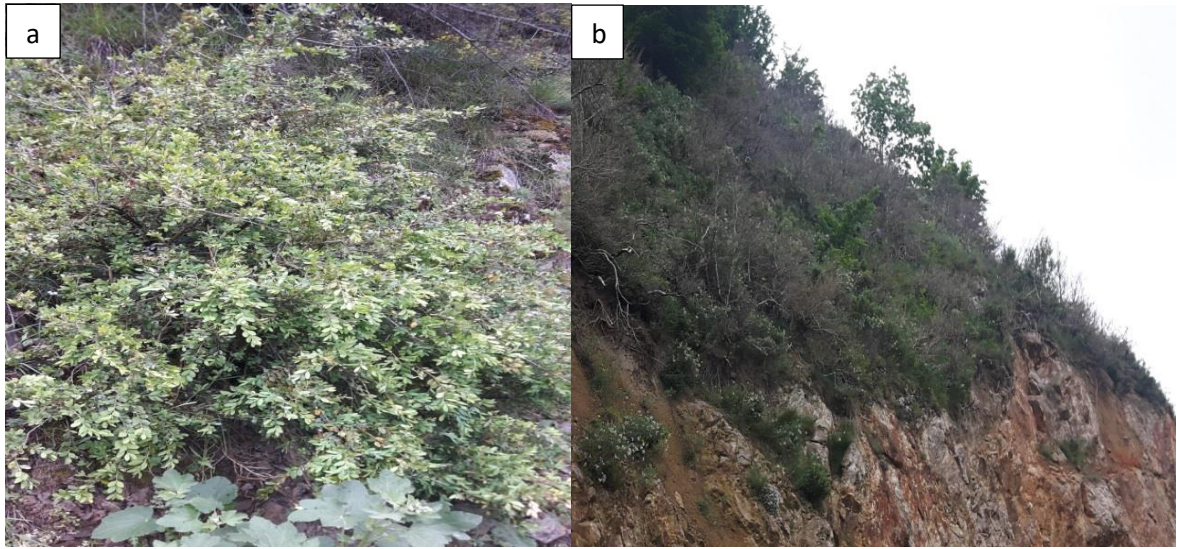
Within the scope of this project, approximately 190 types of *B. sempervirens* species and 15 types of *B. balearica* collected during field studies were collected. During the whole study, a total of 20000 km has been travelled.

## RESULTS AND DISCUSSION

### *Last remaining locations of boxwood in the Black Sea Region*

#### *Artvin*

*B. sempervirens* species is widespread in Artvin. In the location studies, the districts of Artvin were surveyed. It was determined that quite a few boxwoods (1-3 m tall) remained in the National Park at 550 altitude and 41°11'20.43" N, 41°44'33.36" E coordinates in the Hatila Valley National Park. Samples of these remaining boxwoods were taken and reproduced. In studies carried out in other districts of Artvin, it was determined that the boxwood locations are completely dry (due to the effect of *C. perspectalis*) and there is no greening again. It was determined that the last boxwoods, which have been severely damaged by the pests, are in danger of extinction in the national park (Figure 3; Table 1).



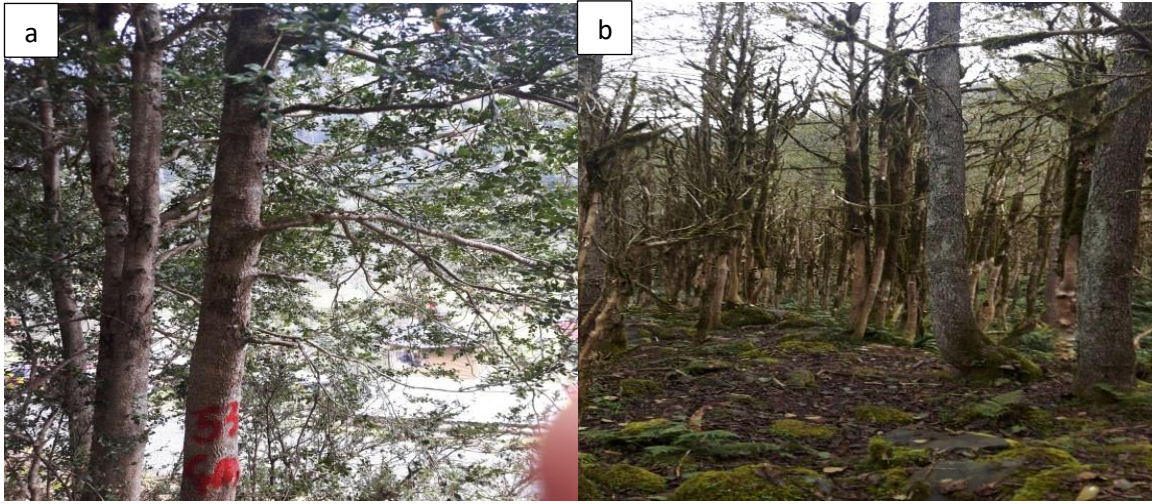
**Figure 3.** Views of boxwood locations in Artvin province (a: boxwood remaining green, b: drying boxwood area).

Şekil 3. Artvin ilinde şimşir lokasyonlarının görünümü (a: yeşil kalan şimşirler, b: kuruyan şimşirlik alan).

#### *Rize*

*B. sempervirens* species is widespread in Rize. In the location studies, the districts of Rize were surveyed. In the village of Zilkale Meyadan in Çamlıhemşin district, at an altitude of 1050, it was determined that quite a few boxwood trees remained along the road at 40°53'50.23" N 40°56'33.04" E coordinates. There is a very large boxwood forest in the location. This forest between the road and the stream is covered with old boxwood trees. However, the forest dried up due to the effects of pests (*C. perspectalis*). Information has been obtained from various sources that some studies have been carried out on this forest. However, studies were insufficient to save this forest. It was determined that there are very few boxwood trees left along the road at the edge of the forest. It was reproduced by taking samples from these boxwood trees. It was determined that the last boxwoods remaining in this location are in danger of extinction. Live boxwoods were not encountered in studies conducted in other locations (Figure 4; Table 1).

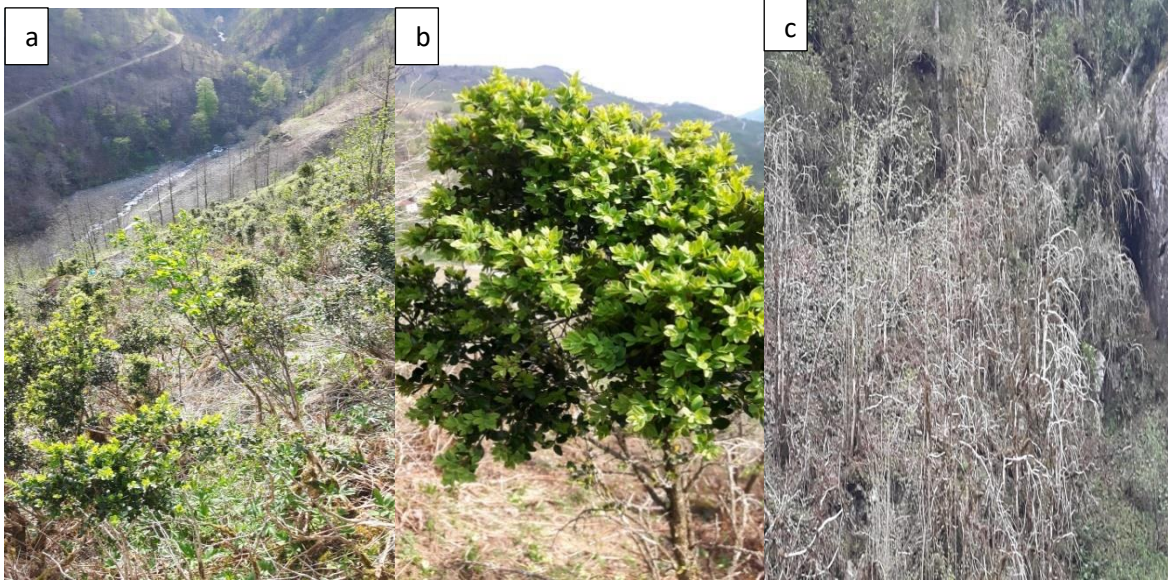




**Figure 4.** Views of boxwood locations in Rize province (a: boxwood remaining green, b: drying boxwood plants).  
 Şekil 4. Rize ilinde şimşir lokasyonlarının görünümü (a: yeşil kalan şimşir, b: kuruyan şimşirlik alan).

### Trabzon

*B. sempervirens* species is widespread in Trabzon province. In the location studies, the districts of Trabzon were surveyed. Maçka district Şimşirli village at 1000-1080 altitude at 40°47'15.59" N, 39°43'49.97" E coordinates, Arsin district Çamlıkyurt village at 1200 m altitude 40°42'34.07" N, 39°49'31.71" E, Araklı district Çamlıktepe village 1100-1200 m at 40°43'28.39" N, 40°00'56.06" E coordinates, Sürmene district, Yeniköy 620 m altitude, 40°46'33.37" N, 40°031'0.39" E coordinates, Hayrat district Yeniköy at 840 m altitude, 40°47'26.33" N, Boxwood forests were identified at 40°22'35.56" E coordinates and at an altitude of 1074 m in Köprübaşı district, Büyükdöğanlı village, at coordinates 40°43'33.92" N, 40°07'16.00" E. However, almost all of these forests are dried up (*C. perspectalis*). Only a very small number of boxwoods remaining at the altitudes above were found and cutting was taken from these boxwoods to reproduce. Among the Eastern Black Sea provinces, the province of Trabzon has come to the fore in terms of both the number of locations and the maintenance of the boxwood tree that survives (Figure 5; Table 1).



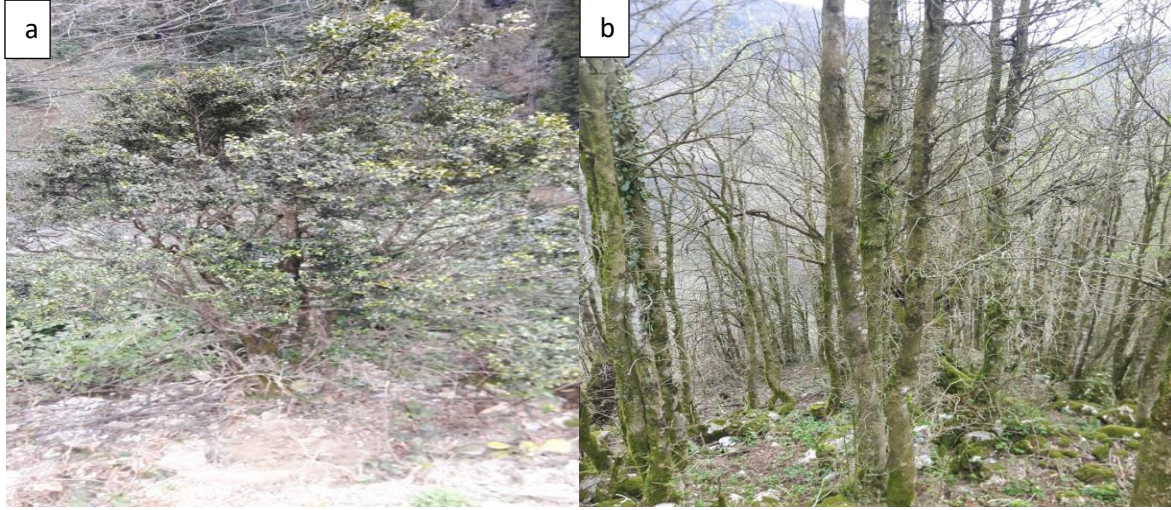
**Figure 5.** Views of boxwood locations in Trabzon province (a, b: boxwood remaining green, c: drying boxwood plants).

Şekil 5. Trabzon ilinde şimşir lokasyonlarının görünümü (a,b: yeşil kalan şimşirler, c: kuruyan şimşirlik alan).



### Giresun

In the province of Giresun, *B. sempervirens* species are widespread. In the location studies, the districts of Giresun were surveyed. It was determined that there is boxwood forest at altitudes of 980-1000 m and coordinates 40°37'47.64" N, 38°23'46.26" E in Dereli district Kuzalan Nature Park. Intense damage caused by pests (the effect of *C. perspectalis*) has been detected in this forest. This boxwood forest in the national park extends along the stream and goes down to Dereli district and lower altitudes. However, all boxwood plants except the national park have dried up. This situation is seen in the location as one goes up the stream. Yet another location was determined in Deregözü village of Doğankent district at an altitude of 40°45'25.76" N, 38°53'47.39" E at 1230 m. Again, other boxwood locations on this route were found to be completely dry. Other districts were examined, and it was observed that there were quite large boxwood forests including several villages in the region, but these forests were completely dry (Figure 6; Table 1).



**Figure 6.** Views of boxwood locations in Giresun province (a: boxwood remaining green, b: drying boxwood plants).  
Şekil 6. Giresun ilinde şimşir lokasyonlarının görünümü (a: yeşil kalan şimşirler, b: kuruyan şimşirlik alan).

### Ordu

*B. sempervirens* species is widespread in Ordu province. In the location studies, the districts of Ordu were surveyed. Kuşnefek castle location in Kumru district, at an altitude of 730 m, spreads around and above the Kuşnefek castle hill at the coordinates of 40°51'44.84" N, 37°16'38.87" E. Its spread area is limited to the castle location. Boxwoods in this area spread out of the stream bed. For this reason, it is thought that boxwoods were brought to this area and proliferated in this area. The effect of the pest (*C. perspectalis*) is seen in the location. It was determined that the last boxwoods remaining in this location are also in danger of extinction. No live boxwoods were found in the studies carried out in other district locations. Other locations have completely dried up (Figure 7; Table 1).

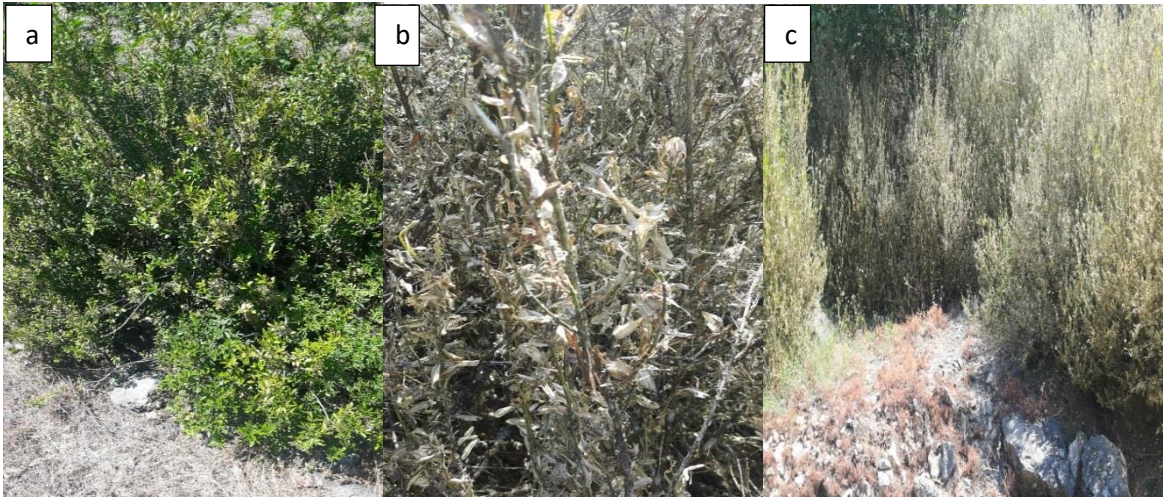




**Figure 7.** Views of boxwood locations in Ordu province (a: boxwood remaining green, b: drying boxwood plants).  
 Şekil 7. Ordu ilinde şimşir lokasyonlarının görünümü (a: yeşil kalan şimşirler, b: kuruyan şimşirlik alan).

### Sinop

*B. sempervirens* species is widespreaded in the province of Sinop. In the location studies, the districts of Sinop were surveyed. It was determined that Durağan district, Güngören village has 400 m altitude, 41°21'07.36" N, 34°59'31.97" E coordinates boxwood forest. This boxwood was recorded as the healthiest and most diverse boxwood forest identified in the region in the first location determination study. However, during the visit made 2 months after the first location visit, it was determined that this forest dries up quite quickly, except for a small number of boxwood, due to pest (*C. perspectalis*) factors. Again in the Durağan district, in Boyabükü village, it was determined from the literature records that it is a small boxwood location at 790 m altitude, 41°17'13.80" N, 35°13'52.81" E coordinates and the location was visited. The location is not a stream bed but a hilly place. Since the hill resembles a place with a historical identity, it is thought that the boxwoods in this area also moved here and spread here. In this location, the symptoms of pests have been found. There is a danger that these two locations will disappear completely in a short time due to the diseases and pests in the locations (Figure 8; Table 1).

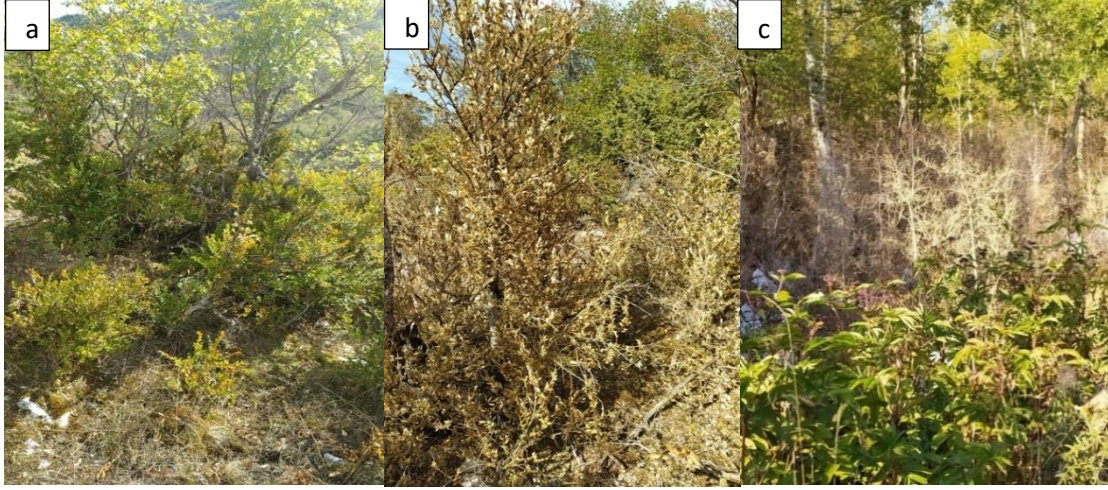


**Figure 8.** Views of boxwood locations in Sinop province (a: boxwood remaining green, b, c: drying boxwood plants).  
 Şekil 8. Sinop ilinde şimşir lokasyonlarının görünümü (a: yeşil kalan şimşirler, b, c: kuruyan şimşirlik alan).



**Kastamonu**

*B. sempervirens* species is widespread in Kastamonu province. In the location studies, the districts of Kastamonu were surveyed. Azdavay, 1035 m altitude, 41°35'59.17.14" N, 33°13' 55.52.34" E coordinates, the last green boxwoods in Kastamonu province were detected in this area. The Azdavay-Pınarbaşı road continues intermittently along the way to Pınarbaşı at the 5th km. However, its harmful effect (*C. perspectalis*) is also present in this forest and a large part of the forest has dried up. The impact of harmful continues. For this reason, it is very likely to disappear in this location. Living boxwoods were not found in other districts and within the Küre Mountains National Park, and it was determined that the boxwoods were completely dry (Figure 9; Table 1).



**Figure 9.** Views of boxwood locations in Kastamonu province (a: boxwood remaining green, b, c: drying boxwood plants).

Şekil 9. Kastamonu ilindeki şimşir lokasyonlarının görünümü (a: yeşil kalan şimşirler, b,c: kuruyan şimşirlik alan).

**Bolu**

*B. sempervirens* species is widespread in Bolu province. In the location studies, the districts of Bolu were surveyed. Boxwoods spread over a wide area at 900-1010 m altitude, 40°28'19.25" N, 30°47'04.20" E coordinates, which is the intersection point of Göynük district Hisarözü, Değirmenözü and Hacımahmut villages, and covers the upper parts of these three villages. Boxwood forest is spread over a wide area. No harmful factors were found in the south-facing parts of the boxwoods in the location. However, symptoms of the pests (*C. perspectalis*) were seen in the north-facing parts, although they were not common. Boxwood locations in this area are therefore endangered. In addition, this forest is the last large living area in the Western Black Sea Region. No live boxwoods were found in studies conducted in other districts. Location is a priority conservation areas that need (Figure 10; Table 2).



**Figure 10.** Views of boxwood (*B. sempervirens*) locations in Bolu province.

Şekil 10. Bolu ilindeki şimşir (*B. sempervirens*) lokasyonlarının görünümü.

#### Other locations

Studies were carried out in Düzce, Karabük, Zonguldak and Bartın locations in the region, but live boxwoods were not found. It was determined that boxwoods are drying (due to the influence of *C. perspectalis*).

**Table 2.** The last remaining locations of boxwoods in the Black Sea Region.

Tablo 2. Karadeniz Bölgesinde kalan son şimşir lokasyonları.

Province	District	Village/ location name	Altitude	Coordinate
Artvin	Center	Hatila Valley National Park	550	41°11'20.43" N 41°44'33.36" E
Rize	Çamlıhemşin	Zilkale Meydan village	1050	40°53'50.23" N 40°56'33.04" E
Tarbzon	Maçka	Şimşirliköy	1000-1080	40°47'15.5" N 39°43'49.97" E
	Arsin	Çalıkyurt	1200	40°42'34.07" N 39°49'31.71" E
	Araklı	Çamlıktepe	1100-1200	40°43'28.39" N 40°00'56.06" E
	Sürmene	Yeniköy	620	40°46'33.37" N 40°03'10.39" E
	Hayrat	Yeniköy	840	40°47'26.33" N 40°22'35.56" E
	Köprübaşı	Büyükdoğanlı	1074	40°43'33.92" N 40°07'16.00" E
Giresun	Dereli	Kuzalan Nature Park	980-1000	40°37'47.64" N 38°23'46.26" E
	Doğankent	Deregözü village	1230	40°45'25.76" N 38°53'47.39" E
Ordu	Kumru	Kuşnefek castle	730	40°51'44.84" N 37°16'38.87" E
Sinop	Durağan	Güngören	400	41°21'07.36" N 34°59'31.97" E
		Boyabükü	790	41°17'13.80" N 35°13'52.81" E
Bolu	Göynük	Hisarözü Değirmenözü Hacımahmut	900-1010	40°28'19.25" N 30°47'04.20" E
Kastamonu	Azdavay	Azdavay-Pınarbaşı road 5.km	1035	41°35'59.17.14"N 33°13'55.52.34"E



### The last locations of boxwood in the Marmara Region

#### Sakarya

*B. sempervirens* species are widespread in Sakarya. In the location studies, the districts of Sakarya were surveyed. Taraklı district Karagöl plateau, Kemaler, İçdedeler, Abdallar, Mahmudlar, at an altitude of 1130 m, at 40°30'26.50" N, 30°34'14.37" E coordinates, spreads over a wide area along the plateau entrance and the plateau and covers the upper parts of these three villages. No disease or harmful factors were found in the boxwoods in the location (Figure 11; Table 3).



Figure 11. Views of boxwood (*B. sempervirens*) locations in Sakarya province.

Şekil 11. Sakarya ilindeki şimşir (*B. sempervirens*) lokasyonlarının görünümü.

#### Bursa

*B. sempervirens* species is widespread in Bursa. In the location studies, the districts of Bursa were surveyed. Mustafa Kemal Pasha district, Çivilicam village, shows an altitude of 1066 m, at 39°54'09.34 "N, 28°42'59.53" E coordinates. No disease or harmful factors were found in the boxwoods in the location. Çivilicam village is considered to be an important transition location since it is the last remaining location in this region and includes different types. Therefore, its protection is very important (Figure 12; Table 3).



Figure 12. Views of boxwood (*B. sempervirens*) locations in Bursa province.

Şekil 12. Bursa ilindeki şimşir (*B. sempervirens*) lokasyonlarının görünümü.



### Other locations

Studies were carried out in Bilecik, Kocaeli and Istanbul locations in the region, but no live boxwoods were found. It was determined that boxwoods are drying (Due to the influence of *C. perspectalis*) (Figure 13).



**Figure 13.** Views of the dried boxwood (*B. sempervirens*) locations in Bilecik province.

Şekil 13. Bilecik ilindeki kuruyan şimşir (*B. sempervirens*) lokasyonlarının görünümü.

**Table 3.** The last remaining locations of boxwoods in the Marmara Region.

Tablo 3. Marmara Bölgesinde kalan son şimşir lokasyonları.

Province	District	Village/ location name	Altitude	Coordinate
Bursa	Mustafa Kemal Paşa	Çivilicam village	1066	39°54'09.34"N 28°42'59.53"E
Sakarya	Taraklı	Karagöl plateau, Kemmaler, İçdedeler, Abdallar, Mahmudlar	1130	40°30'26.50"N 30°34'14.37"E

### The last locations of boxwood in the Mediterranean Region

#### Adana

*B. balearica* species is distributed in Adana province. In the location studies of Adana were surveyed. It shows distribution in Feke district, on the Belenköy-Suphandere road, at an altitude of 900 m, at 37°52'32.65" N, 35°50'48.50" E coordinates. No disease or harmful factors were found in boxwoods in the location (Figure 14; Table 4).



**Figure 14.** Views of boxwood (*B. balearica*) location in Feke district of Adana province.

Şekil 14. Adana ili Feke ilçesindeki şimşir (*B. balearica*) lokasyonunun görünümü.

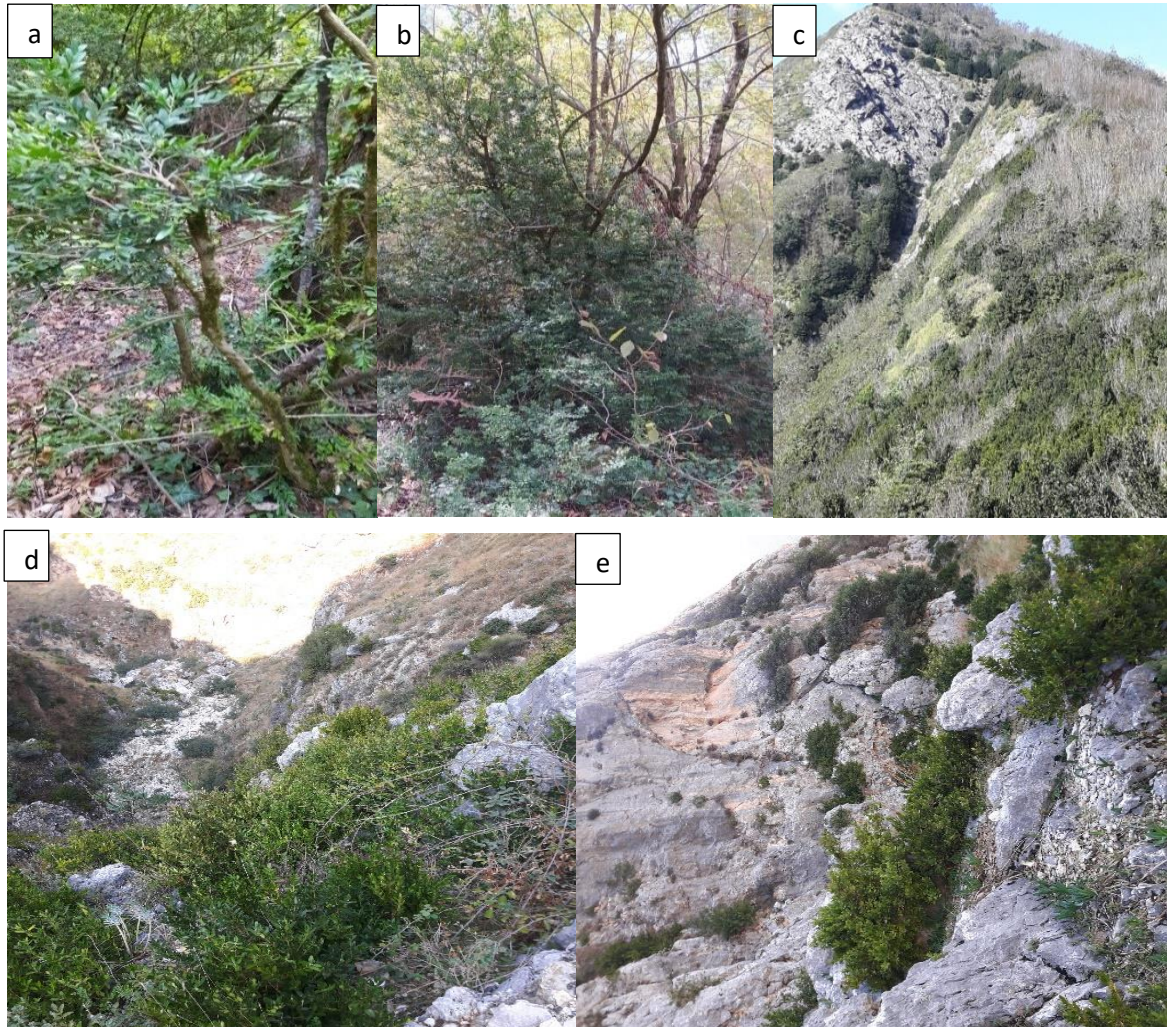


### Hatay

The province of Hatay is a location where both *B. sempervirens* and *B. balearica* species spread. In the location studies, the districts of Hatay were surveyed. Samandağı ileçsi Büyük oba village has a fairly large boxwood forest at altitudes of 750-1250 m, with its peak at 36°11'15.98" N, 35°55'55.18" E coordinates. This forest is very dense and healthy. No disease or harm was observed. However, at a later stage, it was determined that the boxwood moth reached this forest and caused damage.

The other area where *B. sempervirens* spread in the province of Hatay is Dörtöyl district. Between Dörtöyl and Erzin district, the Kozlu creek locality, 941 m altitude 36°14'13.73.94" N, 36°55'39.72.66" E coordinates were studied. This boxwood forest stretches from the stream bed to the mountain peak. However, the boxwood moth (*C. perspectalis*) was detected at this boxwood location. Approximately the boxwood moth was effective in 1/3 of the forest. This determination is the first one made in the Mediterranean Region during the studies. For this reason, boxwood moth seriously threatens the existence of boxwood in the Mediterranean Region after the Black Sea and Marmara Regions.

The other boxwood species *B. balearica*, which is distributed in the province of Hatay, is distributed in the area behind the Habib-i Neccar Mountain, Saint Pierre Church in the city center and are located in a very small location. Boxwoods found in this area are partially threatened by construction and tourism activities (Figure 15; Table 4).



**Figure 15.** Views of boxwood locations in Hatay province (a, b, c: *B. sempervirens*, d, e: *B. balearica*).

Şekil 15. Hatay ilinde şimşir lokasyonlarının görünümü (a,b,c: *B. sempervirens*, d,e: *B. balearica*).



**Kahramanmaraş**

*B. sempervirens* species spread in Kahramanmaraş province. In the location studies, the districts of Kahramanmaraş were surveyed. It spreads in the mountainous area 3-4 km away from the district center in Andırın, at an altitude of 1325 m, at 37°33'46.71" N, 36°22'56.83" E coordinates. There is no road to reach the area, it is accessible by footpath. No disease or harmful factors were found in the boxwoods in the location (Figure 16; Table 4).



**Figure 16.** Views of boxwood locations in Kahramanmaraş province (*B. sempervirens*).

Şekil 16. Kahramanmaraş ilinde şimşir lokasyonlarının görünümü (*B. sempervirens*).

**Osmaniye**

*B. sempervirens* species spread in the province of Osmaniye. In the location studies, the districts of Osmaniye were surveyed. Düziçi district, Düldül Mountain spreads at altitudes of 1200-2100 m, 37°21'24.08" N, 36°28'14.05" E. the location was determined as the highest location (2100 m) reached by boxwoods (*B. sempervirens*) in terms of spreading height. No disease or harmful factors were found in the boxwoods in the location (Figure 17; Table 4).



**Figure 17.** Views of Düldül Mountain boxwood locations in Düziçi district of Osmaniye province (*B. sempervirens*).

**Antalya**

*B. balearica* species is widespread in Antalya province. In the location studies, the districts of Antalya were surveyed. It was determined that it spreads from the Adrasan castle of Musa Mountain in Kumluca district to the summit of the mountain, at an altitude of 600-800 m, at 36°19'02.61" N, 30°28'01.11" E coordinates. No disease or pests were found in the boxwoods in the location, but it was observed that the boxwood population decreased considerably (Figure 18; Table 4).

**Table 4.** The last remaining locations of boxwoods in the Mediterranean Region.

Tablo 4. Akdeniz Bölgesinde kalan son şimşir lokasyonları.

Province	District	Village/ location name	Altitude	Coordinate
Adana	Feke	Between Belenköy and Suphandere	900	37°52'32.65" N 35°50'48.50" E
	Samandağ	Büyükoba village	725-1250	36°11'15.98" N 35°55'55.18" E
Hatay	Dörtyol	Kozludere location	930-1050	36°19'0.336" N 36°55'2.3556" E
	Merkez	Habib-i Neccar Mountain ( <i>B. balearica</i> )	180	36°12'34.00" N 36°10'58.14" E
Kahramanmaraş	Andırın	Mountainous area	1325	37°33'46.71" N 36°22'56.83" E
Osmaniye	Düziçi	Düldül mountain location	1300-2100	37°21'24.08" N 36°28'14.05" E
Antalya	Kumluca	Musa mountain (Adrasan castle) ( <i>B. balearica</i> )	600-800	36°19'02.61" N 30°28'01.11" E

Since the existence of boxwood is mentioned in various sources in the Mediterranean region, studies have also been carried out in Muğla, but the existence of boxwood has not been found. A maple tree of the plant known as boxwood has been identified in the region. Due to the fact that maple is used in wood carving and is mostly preferred for spoon making, it is named as boxwood among the people. Mixing of maple with boxwood is also common in Antalya and Kahramanmaraş.

Boxwood, which was an important plant for the people living in the states established in the Anatolian geography in the past, was also very important in the Ottoman period. It can be described as an industrial plant of the period, especially because of the features it had at that time. Today, with the advancement of technology and the change in preferences, it has lost its importance in Turkey. However, the importance of boxwood has not been lost in America and Europe and different areas of use have been developed (Mitchell et al., 2018). Especially as an ornamental plant, it was preserved its importance and value today. Due to the damage caused by diseases and pests in Turkey, boxwood has become the agenda again in recent years and its importance has begun to be understood. Boxwood locations in the provinces of Artvin, Rize, Trabzon, Giresun, Ordu, Sinop, Kastamonu, Bartın, Zonguldak, Karabük, Düzce and Bolu since 2011 in the Black Sea Region, and in the provinces of Sakarya, Bilecik, Izmit, Kocaeli and Istanbul in the Marmara Region, since 2011 very small areas remained. It was observed that the large boxwood forests, especially in the provinces of Rize and Giresun, have completely disappeared. Turkey national boxwood presence has decreased approximately by 90% especially in the Black Sea Region due to boxwood moth (Sarı and Çelikel, 2019). The fact that the boxwood moth was encountered during the project activities carried out in the boxwood forest in the Dörtyol district of Hatay province in the Mediterranean Region is an indication that the pest began to seriously threaten the Mediterranean Region after the Black Sea and Marmara Regions (Ak et al., 2021).





**Figure 18.** Views of boxwood locations in Antalya province (*B. balearica*).

Şekil 18. Antalya ilinde şimşir lokasyonunun görünümü (*B. balearica*).

Although researches on boxwoods have been carried out in different areas in the world, there are almost no studies on *B. sempervirens* and *B. balearica* in Turkey. There are no studies on the evaluation of naturally spreading boxwoods as ornamental plants. With this first and comprehensive study on boxwoods in Turkey, the current distribution areas of boxwoods and the latest status of their locations were revealed. Studies were carried out in all boxwood locations across the country.

According to the results obtained from field studies conducted in 23 provinces, 59 districts and 195 locations for which boxwood presence information was obtained, it was determined that boxwood remained in 29 locations in 15 provinces and 23 districts. When these results are evaluated regionally; It was determined that there are 17 boxwood (*B. sempervirens*) locations in 8 provinces and 14 districts in the Black Sea Region. The presence of boxwood (*B. sempervirens*) was determined in 5 locations in 2 provinces and 2 districts in the Marmara Region. In the Mediterranean Region, boxwood (3 locations *B. sempervirens*, 2 locations *B. balearica*) was detected in 7 locations in 5 provinces and 7 districts. The presence of boxwood was not found in the studies carried out in the Aegean Region. With these results, it was determined that Turkey's boxwood presence has decreased by 85%, and only 15% of the presence of boxwood remains. The effect of *C. perspectalis* continues. For this reason, this remaining boxwood existence is also under serious threat. In addition to the already known locations, new locations have been identified at the provincial level during this study.

In field studies, the plant materials were collected from the last remaining native boxwood locations throughout the country and they were propagated by vegetative cutting methods, therefore boxwood genetic resources were taken under protection.

Within the scope of the study, the national boxwood existence has been taken under protection to a great extent with the reproduction studies. The collection works of the project have been completed. Especially in the Black Sea Region, cuttings were taken and propagated from the last locations before the plants disappeared. Some locations that were propagated by cuttings were later invaded by the boxwood moth (*C. perspectalis*) and disappeared. For example, the location in the Durağan district of Sinop province was destroyed in a two-month period by the invasion of the boxwood moth. This extinction has shown that the boxwood moth is the main threat to boxwood forests. The boxwood moth spreads very rapidly and feeds on the leaves of the boxwood, causing the plant to dry out.

Many boxwood forests in the Black Sea Region have been in dry forest since 2011 and the spread of the boxwood moth continues rapidly. For this reason, forest losses continue rapidly. This situation was detected and recorded. In addition, it was determined that there are very old forests in the Western Black Sea, especially in Bartın, as in the Eastern Black Sea Region, where the presence of boxwood forests is quite



rich in Turkey. However, desiccation has reached the final stage in these forests, and some of them have completely dried up. There are three locations of *B. balearica* identified during the studies in Turkey and the boxwood presence in these locations has decreased considerably. No harmful effects have been reported in *B. balearica* locations. However, it was observed that the boxwood moth caused damage to *B. balearica* plants propagated by cutting. Similar to our findings, the Brua (2014) study reported that neither boxwood moth nor boxwood blight has yet reached the natural distribution areas of *B. balearica*, but the tests performed show that *B. balearica* is a suitable host for *C. perspectalis*.

These invasive species could indirectly cause ecological, social, cultural and religious changes due to the loss of Buxus. Buxus forests in Europe and the Caucasus are unique ecosystems that should be preserved. Interestingly, these ecosystems are rather poorly studied both ecologically and culturally (Mitchell et al., 2018). Also in Turkey although some local studies have been carried out for the protection of boxwood, these studies have been insufficient. There is no previous study on boxwoods naturally grown in the country. Although some local studies have been carried out for the protection of boxwood, these studies have been insufficient. There is no previous study on boxwoods naturally grown in the country. Therefore, this study is the first preliminary study in this context.

## CONCLUSION

As a result, boxwoods have their own unique distribution areas. It is very difficult to fight against diseases and pests by keeping these areas under control. Despite this hardship, it is very important that all kinds of struggles are made as soon as possible in order to protect our national boxwood existence. Considering the spread rate of the boxwood moth in the studies, it was seen that the most effective control against the boxwood moth is using some environmental friendly treatments. In addition, it is clear that biological control cannot keep up with the spreading rate of the boxwood moth with today's methods and will not show sufficient effect. The protection and reproduction of the last remaining boxwood locations, which are very valuable for Turkey, is another important issue. Within the scope of the project carried out for this purpose, studies are continuing to increase the materials obtained from nature in different types, to develop them for the ornamental plants sector as sustainable usage and lastly but certainly not the least to protect the national boxwood gene resources. In addition to these studies in progress, we suggest more research studies to contribute to the boxwood existence of Turkey for the future.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## DECLARATION OF AUTHOR CONTRIBUTION

Ömer SARI: Methodology, Investigation, Conceptualization, Validation, Writing original draft. Fisun Gürsel ÇELİKEL: Methodology, Investigation, Conceptualization, Validation, Review and editing. Halil YAŞAR: Investigation and plant collection in the Mediterranean Region.

## ACKNOWLEDGMENT

This study was supported by the Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Agricultural Research and Policies (Project No: TAGEM/BBAD/Ü/19/A1/P2/1071).

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