



Food and Agriculture  
Organization of the  
United Nations



# TECHNICAL REPORT

Maximize the production  
of goods and services by  
Mediterranean forest  
ecosystems in a context  
of global changes

January 2015



**Geographic distribution  
of 24 major tree species  
in the Mediterranean and  
their genetic resources**

*This report is the result of work conducted by the Secretariat of the FAO Silva Mediterranea Committee and Plan Bleu as part of the project "Maximize the production of goods and services of Mediterranean forest ecosystems in the context of global changes", funded by the French Global Environment Facility (FFEM) for the period 2012-2016.*



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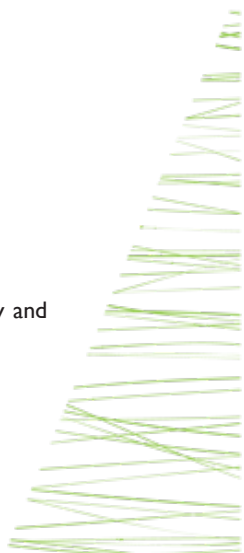
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## Acronyms

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**FFEM** French Global Environment Facility. [2](#)

**MENA** Middle East and North Africa. [5](#)

# Context

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This final report is a contribution to the regional project “Maximize the production of goods and services of Mediterranean forest ecosystems in the context of global changes” funded by the [French Global Environment Facility \(FFEM\)](#) and coordinated by FAO- Silva Mediterranea and Plan Bleu. The report is part of the activities of component I “Production of data and development of tools to support decision and management of vulnerable Mediterranean forest ecosystems affected by climate change and the ability of these forest ecosystems to adapt to global change” and, more in detail, is a result of the task I on “State of knowledge on the impacts of climate change on Mediterranean forest species”.

More information on the project available at <http://www.fao.org/forestry/silva-mediterranea/89603/en/>



# Contents

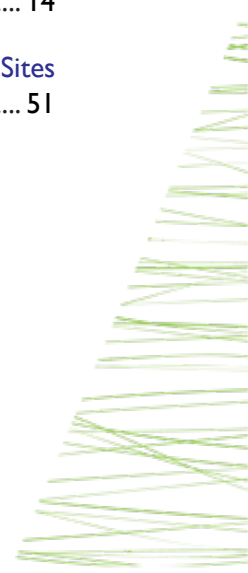
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Introduction .....	6
Project highlights.....	8
Materials and methods.....	9
Materials.....	9
Compiling the list of 24 key forest tree species .....	9
Methods.....	13
GIS tools used.....	13
Approach for native areas/countries .....	13
Results .....	25
Discussion, challenges and perspectives.....	52

## Figures and tables

---

Figure 4.1 : Distribution map of <i>Acer hyrcanum</i> sub. <i>tauricum</i> .....	26
Figure 4.2 : Distribution map of <i>Arbutus unedo</i> .....	27
Figure 4.3 : Distribution map of <i>Cedrus atlantica</i> .....	28
Figure 4.4 : Distribution map of <i>Cedrus libani</i> .....	29
Figure 4.5 : Distribution map of <i>Chamaerops humilis</i> .....	30
Figure 4.6 : Distribution map of <i>Ilex aquifolium</i> .....	31
Figure 4.7 : Distribution map of <i>Juniperus phoenicia</i> .....	32
Figure 4.8 : Distribution map of <i>Juniperus drupacea</i> .....	33
Figure 4.9 : Distribution map of <i>Juniperus excelsa</i> .....	34
Figure 4.10 : Distribution map of <i>Juniperus oxycedrus</i> .....	35
Figure 4.11 : Distribution map of <i>Laurus nobilis</i> .....	36
Figure 4.12 : Distribution map of <i>Pinus brutia</i> .....	37
Figure 4.13 : Distribution map of <i>Pinus halepensis</i> .....	38
Figure 4.14 : Distribution map of <i>Pinus nigra</i> .....	39
Figure 4.15 : Distribution map of <i>Pinus pinea</i> .....	40
Figure 4.16 : Distribution map of <i>Pistacia lentiscus</i> .....	41
Figure 4.17 : Distribution map of <i>Platanus orientalis</i> .....	42
Figure 4.18 : Distribution map of <i>Quercus canariensis</i> .....	43
Figure 4.19 : Distribution map of <i>Quercus cerris</i> .....	44
Figure 4.20 : Distribution map of <i>Quercus coccifera</i> .....	45
Figure 4.21 : Distribution map of <i>Quercus ilex</i> .....	46
Figure 4.22 : Distribution map of <i>Quercus suber</i> .....	47
Figure 4.23 : Distribution map of <i>Taxus baccata</i> .....	48
Figure 4.24 : Distribution map of <i>Tetraclinis articulata</i> .....	49
Tableau 3.1 : List of woody plant species selected for creating distribution maps .....	10
Tableau 3.2 : List of species, showing the accepted scientific name according to Catalogue of Life, the countries / regions of distribution according to Catalogue of Life, Med-Checklist, Kew World Checklist and EURO+MED .....	14
Tableau 4.1 : Geographical situation of pilot sites and their genetic resources for each species. Sites can be either central, marginal or disjunct for the genetic resources and species considered .....	51



## Introduction

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The Mediterranean Basin is one of the world's richest places in terms of animal and plant diversity. It is a highly diverse region and its mountains, rivers, forests and thousands of islands form a mosaic of natural and cultural landscapes of incomparable value. With around 25,000 species of native plants, of which more than half are endemic, and because many habitats and species are threatened, the Mediterranean is recognized as one of the Global Biodiversity Hotspots [18]. For millennia, Mediterranean forests have been subject to strong human pressure such as overgrazing, wood collection for fuel, wildfire, expansion of agricultural and urban zones, etc, with durable effects on species and population diversity and production. Being the home today of approx. 455 million people, from a wide variety of countries and cultures, and because a high number of tourists visit the region every year, the Mediterranean is under heavy human pressure from both visitors and residents, causing severe environmental degradation. Current human activities such as urban expansion, coastal development and pollution as well as unsustainable exploitation of natural resources, are contributing to the constantly increasing number of Mediterranean species with a high risk of extinction. Economic conditions have a major influence on the situation of forests in terms of exploitation, conservation possibilities and regulations: with poor communities depending heavily on natural resources, and economic development increasing the pressure on the environment, the loss of biodiversity is damaging the potential for economic growth, as well as affecting the safety of those populations in terms of food and health (medicinal plants) and limiting their options of survival. With human pressures increasing as well as the effects of climate change on forests, deforestation and forest degradation are expected to be important in [Middle East and North Africa \(MENA\)](#) countries, especially where populations are strongly dependent on forest ecosystems for their livelihood.

Hence sustainable management of forests is necessary for the long term survival and prosperity of communities as well as unhindered economic growth of the region. In this context an FAO / FFEM / Plan Bleu project was developed aiming to “maximize the production of goods and services of Mediterranean forest ecosystems in the context of climate change” in five countries in North Africa (Algeria, Morocco, Tunisia) and the Near East (Lebanon and Turkey). For this, pilot sites were chosen in all countries except Syria where the political situation did not make it possible to insure safety for experimental work.

The project is divided into 5 major components, with the first one targeting the “production of data and development of tools to support decision and management of vulnerable Mediterranean forest ecosystems affected by climate change and the ability of these forest ecosystems to adapt to global change”. One of the tasks of component 1 aims at collecting basic information on the geographic distribution of core and marginal populations of a number of key forest tree species in the Mediterranean, along with their ecological and genetic attributes.

In order to determine which populations are marginal populations for a given forest tree species (and devise appropriate silvicultural and genetic resource management), the general natural distribution of the species need to be characterized and the geographical position of the populations of interest need to be assessed in relation to the general distribution of the species. Besides determining geographical marginal populations, maps of species distributions are important for several



purposes such as biodiversity assessment, habitat management and restoration, species and habitat conservation plans, population viability analysis, environmental risk assessment, invasive species management, community and ecosystem modelling, as well as predicting the effects of global environmental change on species and ecosystems. However, species distribution maps are often lacking or are not made readily available for scientific investigation and strategic management planning at international level.

This report presents the work that was done in order to create distribution maps for 24 key Mediterranean forest tree species using the best possible information available from different sources.



## Project highlights

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A total of 24 key tree species were selected by the project partners for their importance for the biodiversity of the Mediterranean basin and for delivering ecosystem services to the Mediterranean forestry community. Twenty three of the 24 species are present in at least one of the 7 pilot sites selected for the project (Chrea, Djelfa/Senalba, Jabal Moussa, Maâmora, Barbara, Siliana, Düzlerçamı). We then collected information on their geographic distribution in order to produce 24 native distribution maps of each species. Since the target was to create natural distribution maps, we started searching online databases for published maps or geographic occurrence data for the 24 target species. Because of the paucity of data available, we also used data from published plant floras as well. We also included information sent to us by project partners and experts who worked on those species.

As a result, we report the production of 24 new maps of forest tree species distribution in the Mediterranean basin. The position of the pilot site species in terms of geographic marginality is also indicated on the maps. Although component I of the project focuses on only 5 out the 7 sites of the project (Djelfa, Düzlerçamı, Jabal Moussa, Maâmora and Siliana), we used the presence of species within the 7 sites as a rule to select which species would be the target of mapping. However, the marginality of populations will only be assessed for 5 pilot sites.

# Materials and methods

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## MATERIALS

### Compiling the list of 24 key forest tree species

Based on the reports presented to FAO by participants on each of the pilot sites, as well as the presentations made in different workshops, we compiled a list of over 60 woody plant species present in at least one of the 7 pilot sites. We then looked online in Catalogue of Life <http://www.catalogueoflife.org/> [20] for species accepted names and synonyms in order to group together taxonomic entities that might have been described under different species or subspecies names in different pilot sites. The list of synonyms and accepted names was also important later on to help us find data on the geographic distribution of the species in different references under different names.

As a next step, we assigned to each of the 60 species a priority index from 1 to 3, 1 being the highest priority and 3 the lowest. The number assigned was based on an estimation of the importance of the species to the Mediterranean region, its endemism as well as the possibility of finding available information on the species distribution. Ranking was discussed by project partners. Based on that index, we selected 23 species of trees and shrubs. All of the 23 exist in at least 1 of the 7 pilot sites. We added to that list *Pinus nigra* because of its ecological and forestry importance in the Mediterranean basin, its presence in several of the pilot countries, although not present in any of the pilot sites.

We decided to exclude *Olea europaea* from the final list of species despite its economic importance and the fact it was present in 3 pilot sites, because it would be hard to separate areas where *O. europaea* was native and where it was planted. Below (Table 3.1) is a table of the 23 species showing their Latin name as described in the pilot site, their accepted Latin name according to Catalogue of Life<sup>1</sup>, their common name in English and French. Count refers to the number of pilot sites where the species are present (pointed by the X under the pilot site's name).

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<sup>1</sup>The Catalogue of Life is the most comprehensive and authoritative global index of species currently available. It consists of a single integrated species checklist and taxonomic hierarchy. The Catalogue holds essential information on the names, relationships and distributions of over 1.5 million species. This figure continues to rise as information is compiled from diverse sources around the world

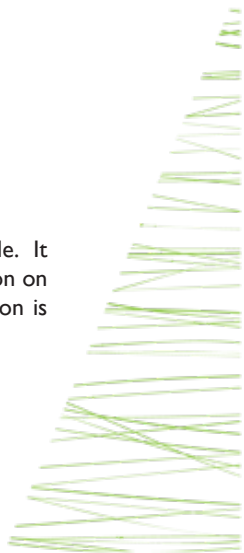
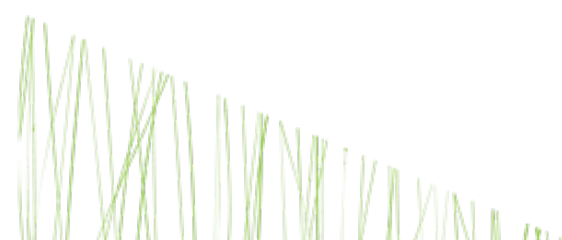


Tableau 3.1: List of woody plant species selected for creating distribution maps

Species name (in pilot site)	Accepted name (in Catalogue of Life)	Common name/Nom commun	Count	Düzlerçamı (Turkey)	Djelfa (Algeria)	Chrea (Algeria)	Jabal Moussa (Lebanon)	Maâmora (Morocco)	Barbara (Tunisia)	Siliana (Tunisia)
<i>Acer tauricum</i>	<i>Acer hyrcanum</i> subsp. <i>tauricum</i> (Boiss. and Balansa) Yalt.	Taurus Maple/Érable du Taurus	1				X			
<i>Arbutus unedo</i>	<i>Arbutus unedo</i> L.	Strawberry tree/Arbousier	2			X				X
<i>Cedrus atlantica</i>	<i>Cedrus atlantica</i> (Endl.) Manetti ex Carriere	Atlas Cedar/Cèdre de l'Atlas	1			X				
<i>Cedrus libani</i>	<i>Cedrus libani</i> A. Rich.	Cedar of Lebanon/Cèdre du Liban	1	X						
<i>Chamaerops humilis</i>	<i>Chamaerops humilis</i> L.	Mediterranean dwarf palm/Palmier nain	2			X		X		
<i>Ilex aquifolium</i>	<i>Ilex aquifolium</i> L.	Holly/Houx	1			X				
<i>Juniperus drupacea</i>	<i>Juniperus drupacea</i> Labill.	Syrian juniper/Genévrier de Syrie	1				X			
<i>Juniperus excelsa</i>	<i>Juniperus excelsa</i> M.-Bieb.	Greek juniper/Genévrier grec	1	X						
<i>Juniperus oxycedrus</i>	<i>Juniperus oxycedrus</i> L.	Prickly juniper/Genévrier oxycèdre	2		X	X				
<i>Juniperus phoenicea</i>	<i>Juniperus phoenicea</i> L.	Phoenician juniper/Genévrier rouge, de Phénicie	1		X					
<i>Laurus nobilis</i>	<i>Laurus nobilis</i> L.	Bay laurel/ Laurier noble	1			X				
<i>Pinus brutia</i>	<i>Pinus brutia</i> Ten.	Turkish pine/ Pin de Calabre, pin brutia	2	X			X			
<i>Pinus halepensis</i>	<i>Pinus halepensis</i> Mill.	Aleppo pine/ Pin d'Alep	5	X	X	X			X	X

=

<i>Pinus nigra</i>	<i>Pinus nigra</i> J.F. Arnold	European black pine/Pin noir	0							
<i>Pinus pinea</i>	<i>Pinus pinea</i> L.	Stone pine/ Pin pignon, pin parasol	2	X					X	
<i>Pistacia lentiscus</i>	<i>Pistacia lentiscus</i>	Mastic tree/Lentisque	5		X	X		X	X	X
<i>Platanus orientalis</i>	<i>Platanus orientalis</i> L.	Oriental plane/Platane d'Orient	2	X			X			
<i>Quercus calliprinos</i>	<i>Quercus coccifera</i> L.	Kermes oak/Chêne kermes	1				X			
<i>Quercus cerris</i>	<i>Quercus cerris</i> L.	Turkey oak/Chêne de Turquie	1				X			
<i>Quercus ilex</i>	<i>Quercus ilex</i> L.	Holm oak/Chêne vert	3		X	X				X
<i>Quercus mirbeckii</i>	<i>Quercus canariensis</i> Willd.	Algerian oak/Chêne Zéen, chêne zen	2			X			X	
<i>Quercus suber</i>	<i>Quercus suber</i> L.	Cork oak/Chêne liège	4		X	X				X
<i>Taxus baccata</i>	<i>Taxus baccata</i> L.	European yew/lf	1			X				
<i>Tetraclinis articulata</i>	<i>Tetraclinis articulata</i> (Vahl) Mast.	Barbary thuja/Thuya de Berbérie	1			X				



## Distribution data

Following the final selection of species, we looked for resources on geographic distribution data for those 24 species. The first source we checked was EUFORGEN (<http://www.euforgen.org/>). EUFORGEN is a collaborative programme among European countries to promote conservation and sustainable use of forest genetic resources. It serves as a platform for pan-European collaboration in this area, bringing together scientists, managers, policy-makers and other stakeholders. There, we found maps of species distribution available for download in shapefile format as well as jpeg. However, only 5 species on our list are available on EUFORGEN: *Pinus brutia*, *Pinus halepensis*, *Pinus nigra*, *Pinus pinea* and *Quercus suber*. We used the shapefiles for those species but had to find other resources for the remaining species.

Next, we looked for distribution data in GBIF (<http://www.gbif.org>). The Global Biodiversity Information Facility (GBIF) is an international open data infrastructure, funded by governments. It allows anyone, anywhere, to access data about all types of life on Earth, shared across national boundaries via the Internet. By encouraging and helping institutions to publish data according to common standards, GBIF enables research not possible before, and informs better decisions to conserve and sustainably use the biological resources of the planet. It was possible to find geographic points of presence on each of the species and download them, however while going through the information describing each point, we noticed that it was not possible to confirm whether the point of occurrence was from a native and natural habitat or resulted from an introduction (botanic garden, reforestation, afforestation, etc.).

Although GBIF offers the potential for data contributors to indicate whether a species occurrence point listed in the data base is native / naturalized / etc.) via a specific Darwin Core<sup>2</sup> field "establishmentMeans" (<http://rs.tdwg.org/dwc/terms/#Occurrence>), in practice, this field is almost always empty. One solution to this problem would have been to filter the points by overlapping them with geographic land use data and exclude all points in fields and cities, but that would shift the focus of our work from compiling distribution data to GBIF data analysis. Another problem we noticed in the GBIF archive was the lack of balanced contributions among countries and institutions. Most of occurrence points for those of our species of interest that were largely distributed were found in the UK and Western Europe. Thus, although GBIF occurrence points could potentially be of great value for refining species envelope models, they are not reliable for drawing maps without filtering for native distribution.

Very little accurate specific data of species occurrence was available online or with free access. Ideally the best accurate data source on species distribution would most likely be national forest inventories. In practice, this solution was not possible given that data are stored in national websites with restricted access and rather long approval request confirmation procedures. The duration of the project would not have made it possible to download all country resources one by one, considering that some species have geographic coverage spanning more than 50 countries. A common archive, compiled at international level, would be highly desirable. The European Union JRC Forest database project is a right step in this direction. However, we know of no similar project at the level of the Mediterranean basin.

It is also worth noting that scientific publications in the field of ecology, forestry, etc., potentially contain valuable information on the natural occurrence of species and populations. An initial search on the Web of Science®, an online scientific bibliographic resource, using *Pinus halepensis* as model, yielded over 1 500 journal references potentially containing occurrence data. This type of information, although potentially valuable for creating distribution maps and identifying marginal populations, was clearly beyond the scope of our allocated time for the project. Again, an international initiative aimed at using such data would be welcome and useful for scientific and management investigations, as well as for refining distribution maps and species envelop models.

Project partners contributed their own data. Algeria contributed its "National Forest Inventory" data through the "Direction Générale des Forêts". Lebanon contributed through the Ministry Of Agriculture (MOA) by granting access to the shapefile of the 1965 Forest Map of Lebanon. The Center for Applied Research in Agroforestry Development - Spain (IDAF) also contributed to the data on Lebanon by sharing their shapefiles on several species. These resources provided accurate occurrence points for parts of the geographical distribution of some project species.

While searching through the online databases for forest species distribution information, we noticed there was a distinct lack of online information regarding North African and East Mediterranean countries such as Morocco, Algeria, Tunisia and Lebanon where the pilot sites are located. However, a major part of the information regarding forest tree species in these countries is available either as hardcopies (paper maps) or books describing the flora of certain regions, where maps are sometimes combined with a written description of where the species occur.

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<sup>2</sup>The Darwin Core is body of standards. It includes a glossary of terms (in other contexts these might be called properties, elements, fields, columns, attributes, or concepts) intended to facilitate the sharing of information about biological diversity by providing reference definitions, examples, and commentaries. The Darwin Core is primarily based on taxa, their occurrence in nature as documented by observations, specimens, samples, and related information

We decided to gather data from Floras and digitize existing paper maps of distribution as they contributed significantly to our objectives. Following is the list of 16 references we used to collect geographic data on the 24 species of interest:

1. Atlas Flora Europaea, 1999 software;
2. Atlas of Turkish Forests (Türkiye Orman Atlası);
3. F. Aytar et. al, 2011. Biology and Control of *Calomicrus apicalis* Demaison, 1891 (Col.: Chrysomelidae), a New Pest of *Cedrus libani* A. Rich. in Turkey. *Silva Lusitana*, n° especial: 33 – 40;
4. A. Bigot, C. Floret, J.L. Guillerme, J.C. Jacquinet, A. Soler, 1965. Carte phyto-écologique de la Tunisie Septentrionale Feuille II Bizerte - Tunis, CNRS/CEPE;
5. H Bohbot, J Aronson & C. Fontaine, 2005. Approximate cork oak (*Quercus suber*) distribution. CEFE/CNRS, Montpellier;
6. de Bolòs & J. Vigo, 1984-2001. Flora dels Països Catalans, Vol I-IV, Editoriol Barcino;
7. L. Boulos, 1999. Flora of Egypt, Volume 1: Azollaceae-Oxalidaceae, Al Hadara Publishing;
8. K. Browitz, 1982. Chorology of trees and shrubs in South-West Asia and adjacent Regions;
9. P.H. Davis, 1978. Flora of turkey and the East Aeagean islands, Edinburgh at the University Press;
10. L. Emberger, 1936. Carte phytogéographique du Maroc;
11. M. Fennane, 1987. Etude phytoécologique des tetraclinaies marocaines. Thèse de doctorat en sciences, Université Aix-Marseille;
12. M. Fennane, 1999. Flore pratique du Maroc, manuel de détermination des plantes vasculaires vol 1: Pteridophyta, Gymnospermae, Angiospermae (Lauraceae- Neuradaceae), Institut Scientifique - Université Mohammed V - Agdal, Rabat;
13. M. Gounot, J.L. Guillerme, A. Schoenenberger, 1965. Carte phyto-écologique de la Tunisie Septentrionale Feuille I CAP BON – La Goulette – Sousse, CNRS/CEPE;
14. P. Quézel & S. Santa, 1962. Nouvelle Flore de l'Algérie et des régions désertiques méridionales, Centre national de la Recherche scientifique;
15. P. Quézel & F. Médail, 2003. Ecologie et biogéographie des forêts du bassin méditerranéen. Elsevier, Paris, France;
16. F. Yaltirak, 1984. Türkiye'nin Meseleri Teshis Kilavuzu, TOKB, Istanbul.

## METHODS

### GIS tools used

The software used to create the distribution maps as well as digitize paper maps and organize all the collected data into shapefiles was Qgis Desktop 2.0.1-Dufour, a free and open-source desktop geographic information system.

### Approach for native areas/countries

Finding and delineating an area or zone of native occurrence is a real challenge. In order to determine the areas or countries of native distribution of the species, we started by checking the Mediterranean eco-region [20] but noticed that several species exist natively outside of this area (e.g. *Arbutus unedo*, *Ilex aquifolium*, *Pinus nigra*). As a first step, we chose to compile data on the areas/countries of native distribution by listing the countries where each of the 24 species is considered native. We compiled the information on native distribution according to Catalogue of Life and noticed, based on expert knowledge found in publications and after consulting Prof. Frédéric Médail and Ing. Daniel Pavon at the Mediterranean Institute of Biodiversity and Ecology (Aix-Marseille University, France) that for some species the information was erroneous (ex: *Laurus nobilis* and *Ilex aquifolium*, indicated as native to North America).

Eventually we relied on 3 online databases for information on the native distribution of the 24 species:

1. EURO+MED Plantbase (<http://ww2.bgbm.org/EuroPlusMed/query.asp>);
2. Kew World Checklist (<http://apps.kew.org/wcsp/home.do>);
3. Med-Checklist (<http://ww2.bgbm.org/mcl/query.asp>).

These widely used and recognized online references allowed us to characterize countries of native distribution for each species as thoroughly as possible. Below (Table 3.2) is a table that shows the compilation of information found in these 3 only resources, as well as the native distribution of the species according to Catalogue of Life.

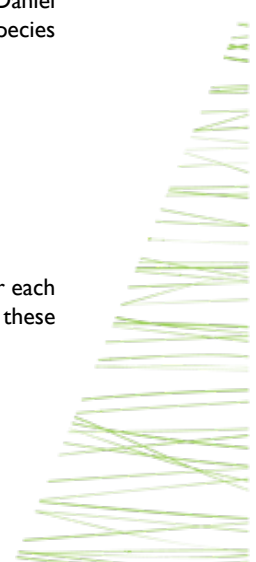


Tableau 3.2: List of species, showing the accepted scientific name according to Catalogue of Life, the countries / regions of distribution according to Catalogue of Life, Med-Checklist, Kew World Checklist and EURO+MED

Accepted Name (CoL)	Distribution according to Catalogue of Life (CoL)	Distribution according to Med-Checklist	Distribution according to Kew World Checklist	Distribution according to Euro+Med <sup>3</sup>
<i>Acer hyrcanum</i> subsp. <i>tauricum</i> (Boiss. and Balansa) Yalt.	Turkey (S-Anatolia: Aleppo etc., SSW-Anatolia), Lebanon (C-Lebanon), Syria (W-Syrian Mountains)	Asiatic Turkey (An) present as native; Lebanon and Syria (LS) present as native	N.A	N.A.
<i>Arbutus unedo</i> L.	Africa; Africa; Europe and Northern Asia (excluding China)	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) absent but reported in error; Italy (It) present as native; Jugoslavia (Ju) present as native Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey-in-Europe (Tu) present as native	N.A.	AE(G) Ag Al Bl Bu Co Cr Ct Cy Ga Gr Hb(E) Hs(S) -Ij It LS Lu Ma Sa Si(S) Sl Tn Tu(A E) Uk [Ca(C T)]
<i>Cedrus atlantica</i> (Endl.) Manetti ex Carriere	NW Africa: Algeria, Morocco (Atlas Mts.) Algeria (Ag) present as native; Morocco (Ma) present as native	N.	NC. Morocco to N. Algeria (12) fra por (13) grc ita 20 ALG MOR	N.A.
<i>Cedrus libani</i> A. Rich.	Lebanon, Syria, Turkey	Lebanon and Syria (LS) present as native; Asiatic Turkey (An) present as native	Turkey to Lebanon; Cyprus-34 CYP LBS TUR	N.A.
<i>Chamaerops humilis</i> L.	W. and C. Medit.	N.A	W. and C. Medit. 12 BAL COR FRA POR SAR SPA 13 ITA SIC 20 ALG LBY MOR TUN (81) dom	Ag Bl Ga Hs It Li Lu Ma Sa Si Tn

<sup>3</sup>Abbreviations available at <http://ww2.bgbm.org/mcl/legend.asp>



<i>Ilex aquifolium</i> L.	North America; Oceania	Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Bulgaria (Bu) present as native; Corsica (Co) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native	N.A.	Ag Al Au(A) Be(L) BH Bl(M) Br Bu Cg Co Ct Da Ga Ge Gr Hb(E) He Ho Hs(A S) It LS Lu Ma Mk No dRm Sa Si(S) Sl Sr Su Tn Tu(A) [cHu]
<i>Juniperus drupacea</i> Labill.	Greece, Turkey (mountains along Mediterranean coast), Syria, Lebanon, Israel. The most extensive range is in the Cilician Taurus Mts. of S Turkey extending into N Syria; disjunct populations occur in Lebanon and one locality in Israel, with the farth	Asiatic Turkey (An) present as native; Greece (Gr) present as native; Lebanon and Syria (LS) present as native	S. Greece; S. Turkey to Israel- 13 GRC 34 LBS PAL TUR	N.A.
<i>Juniperus excelsa</i> M.-Bieb.	SE Europe: Albania, Bulgaria, Greece, Macedonia; E Europe: Ukraine: Krym [Crimea]; Caucasus: Armenia, Azerbaijan, Gruzija, Severo-Osetiya, Russia(?); Central Asia: Kazakhstan, Kirgizstan, Tadzhikistan, Turkmenistan, Uzbekistan; W Asia: Afghanistan, C	East Aegean Islands (AE) absent but reported in error (107); Albania (Al) present as native (197); Asiatic Turkey (An) present as native Bulgaria (Bu) present as native; Crete and Karpathos (Cr) absent but reported in error (143); Cyprus (Cy) present as native; Greece (Gr) present as native; Israel and Jordan (Ij) absent but reported in error (64); Italy (It) naturalized (350); Jugoslavia (Ju) present as native; Lebanon and Syria (LS) present as native; Crimea (RK) present as native	N. Balkan Pen. to NW. Iran-13 ALB BUL GRC YUG 14 KRY 33 NCS TCS 34 CYP IRN LBS TUR	N.A.



<i>Juniperus oxycedrus</i> L.	Mediterranean Region, around the Black Sea and Middle East: Albania, Algeria, Bosnia-Herzegovina, Bulgaria, Caucasus, Croatia, Cyprus, France, Greece, Iran (Azerbaijan), Iraq, Israel, Italy, Jordan, Lebanon, Libya, Macedonia, Malta, Morocco, Portugal East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Bulgaria (Bu) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; Egypt (Eg) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Crimea (RK) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey-in-Europe (Tu) present as native	W.	WC. Medit.-12 BAL COR FRA POR SAR SPA 13 ITA 20 ALG MOR TUN	N.A.
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<i>Juniperus phoenicea</i> L.	Macaronesia: Canary Is., Madeira Is.; Mediterranean Region: Albania, Algeria, Andorra, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Egypt (Sinai), France, Greece, Italy, Jordan, Lebanon, Libya, Morocco, Portugal, Romania, Spain, Tunisia, Turkey; Sa	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (BI) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; Egypt (Eg) absent but reported in error (107); France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Crimea (RK) absent but reported in error (107); Sardinia (Sa) present as native; Sicily (Si) present as native; Sinai (Sn) present as native; Tunisia (Tn) present as native	SW. and S. Portugal to S. and E. Spain and S. France-12 FRA POR SPA	N.A.
<i>Laurus nobilis</i> L.	North America	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (BI) naturalized (115); Corsica (Co) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) naturalized (148); Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) doubtfully native; Morocco (Ma) present as native; Malta (Me) doubtfully native; Crimea (RK) naturalized; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey-in-Europe (Tu) present as native	N.A.	N.A.
<i>Pinus brutia</i> Ten.	E Mediterranean Region; around the Black Sea; Caucasus; Turkey; NW Iran; N Iraq	East Aegean Islands (AE) present as native; Asiatic Turkey (An) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; Greece (Gr) present as native; Italy (It) (presumably) extinct; Lebanon and Syria (LS) present as native; Turkey-in-Europe (Tu) present as native	S. Balkan Pen. to NW. Iran and Lebanon-13 BUL GRC KRI TUE 14 KRY (20) alg mor 33 NCS TCS 34 CYP EAI IRN IRQ LBS TUR (50) wau	N.A.

<i>Pinus halepensis</i> Mill.	Mediterranean, from Morocco and Portugal to Greece and the coast of Libya at Jabal al Akhdar, and in Israel, Jordan, Lebanon, SW Syria	Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Corsica (Co) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) casual alien; Morocco (Ma) present as native; Malta (Me) naturalized; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey- in-Europe (Tu) absent but reported in error (60)	Medit.-12 BAL COR FRA por SAR SPA 13 ALB GRC ITA SIC YUG 20 ALG LBY MOR TUN (21) cny 34 EAI LBS PAL TUR (50) soa vic (51) nzs	N.A.
<i>Pinus nigra</i> J.F. Arnold	SW, S and SE Europe; N Algeria; N Morocco; Cyprus; Turkey; from the Krym [Crimea] in Ukraine along the Black Sea coast eastwards to Krasnodar in the Caucasus	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Bulgaria (Bu) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) absent but reported in error (143); Cyprus (Cy) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Morocco (Ma) present as native; Crimea (RK) present as native; Sicily (Si) present as native; Turkey-in-Europe (Tu) present as native	Medit., E. Austria to N. Caucasus-(10) den grb ire swe 11 AUT bgm cze ger net swi 12 COR FRA SPA 13 ALB BUL GRC ITA ROM TUE YUG 14 KRY 20 ALG MOR 33 NCS 34 CYP EAI TUR (50) nsw soa vic	N.A.
<i>Pinus pinea</i> L.	Mediterranean Europe and Near East (doubtfully native in many areas of E Mediterranean)	East Aegean Islands (AE) doubtfully native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) doubtfully native; France (Ga) present as native; Greece (Gr) doubtfully native; Spain (Hs) present as native; Italy (It) present as native; Jugoslavia (Ju) doubtfully native; Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Turkey-in-Europe (Tu) doubtfully native	S. Europe to Lebanon-12 BAL COR FRA POR SPA 13 ALB GRC ITA KRI SIC tue yug (20) alg lby mor tun (21) cny 34 CYP EAI LBS TUR (50) nsw	N.A.

<i>Pistacia lentiscus</i>	Portugal, Spain, Baleares, France, Corsica, Sardinia, Malta, Sicily, Italy, former Yugoslavia, Albania, Greece, Crete, Libya, Tunisia, Algeria, Morocco, Turkey (Inner Anatolia, S-Anatolia: Aleppo etc., SSW- Anatolia, SW-Anatolia, W-Anatolia, WN-Anatolia), Cyprus (C-Mountains, E-Cyprus, N-Cyprus, S-Cyprus), E-Aegean Isl., European Turkey, Israel (coastal W-Israel, N-Israel), Lebanon (C-Lebanon, coastal W-Lebanon), Syria (coastal W-Syria), Canary Isl. (introduced) (Lanzarote (introduced), Fuerteventura (introduced), Gran Canaria (introduced), Teneriffa (introduced), La Gomera (introduced))	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr); present as native; Cyprus (Cy) present as native; Egypt (Eg) present as native (335); France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Malta (Me) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native	N.A.	N.A.
<i>Platanus orientalis</i> L.	Baleares (introduced), Sicily, Italy, former Yugoslavia, Albania, Bulgaria, Greece, Crete, Russia, Caucasus / Transcaucasus, C-Asia, Taiwan (introduced), China (introduced), Turkey (N-Anatolia, S- Anatolia: Aleppo etc., WN-Anatolia), Cyprus (C-Mountains, S-Cyprus), Iran (EC-Iran, NE-Iran: Mts., N-Iran: Mts., NW-Iran: Iranian Aserbaijan, S-Iran, W-Iran: Mts.), Iraq (NE-Iraq, NW-Iraq), Israel (E-Israel: Rift Valley, N-Israel), Jordania (W-Jordania), Lebanon (C-Lebanon, coastal W-Lebanon), Syria (coastal W-Syria, C-Syrian Desert), Pakistan (introduced), Pakistani Kashmir (introduced), Jammu and Kashmir (introduced), N-India (introduced), Morocco (introduced), Algeria (introduced), Tunisia (introduced)	East Aegean Islands (AE) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) casual alien; Bulgaria (Bu) present as native; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; Greece (Gr) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Lebanon and Syria (LS) present as native; Sicily (Si) present as native; Turkey-in-Europe (Tu) present as native	N.A.	AE(G) Al Bu Cr Ct Cy Gr Ij It LS Mk Si(S) Tu(A) [Bl(M) He It cPo Sk SI]

<i>Quercus coccifera</i> L.	Medit.	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Bulgaria (Bu) present as native; Corsica (Co) absent but reported in error; Crete and Karpathos (Cr) present as native; Cyprus (Cy) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (Ij) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) present as native; Lebanon and Syria (LS) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey-in-Europe (Tu) present as native	Medit.-12 BAL FRA POR SAR SPA 13 ALB BUL GRC ITA KRI ROM SIC TUE YUG 20 ALG LBY MOR TUN 34 CYP EAI LBS PAL TUR	AE(G) Ag Al Bl Bu Cr Cy Ga Gr Hs Ij It Ju Li LS Lu Ma Rm Sa Si Tn Tu(A E)
<i>Quercus cerris</i> L.	S. and SC. Europe to Afghanistan	East Aegean Islands (AE) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Bulgaria (Bu) present as native; Crete and Karpathos (Cr) doubtfully present; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) naturalized; Italy (It) present as native; Jugoslavia (Ju) present as native; Lebanon and Syria (LS) present as native; Sicily (Si) present as native; Turkey-in-Europe (Tu) present as native	S. and SC. Europe to Afghanistan-11 AUT bgm CZE ger HUN SWI 12 FRA 13 ALB BUL GRC ITA KRI ROM SIC TUE YUG 34 AFG EAI IRN LBS TUR (51) nzs	Al Au Bu Cr Cz Ga Gr He Hu It Ju LS Rm Si Tu(A E) [Ge]

<i>Quercus ilex</i> L.	Medit. to SC. Europe	East Aegean Islands (AE) present as native; Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (BI) present as native; Corsica (Co) present as native; Crete and Karpathos (Cr) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Israel and Jordan (IJ) absent but reported in error; Italy (It) present as native; Jugoslavia (Ju) present as native; Libya (Li) doubtfully present; Lebanon and Syria (LS) absent but reported in error; Portugal (Lu) present as native; Morocco (Ma) present as native; Malta (Me) present as native; Crimea (RK) naturalized; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native; Turkey-in-Europe (Tu) doubtfully present	SC. and S. Europe to Israel-11 CZE SWI 12 BAL COR FRA POR SAR SPA 13 ALB GRC ITA KRI SIC YUG (34) cyp EAI LBS PAL TUR (51) nzn nzs	Ag Al BI Co Cr Cz Ga Gr He Hs IJ It Ju Li LS Lu Ma Sa Si Tn Tu(A) [Ca Cy]
<i>Quercus canariensis</i> Willd.	S. Portugal, Spain, NW. Africa	Algeria (Ag) present as native; Spain (Hs) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Tunisia (Tn) present as native	S. Portugal to Spain, NW. Africa-12 POR SPA 20 ALG MOR TUN	Ag Hs Lu Ma Tn
<i>Quercus suber</i> L.	W. and C. Medit.	Algeria (Ag) present as native; Balearic Islands (BI) naturalized; Corsica (Co) present as native; France (Ga) present as native; Spain (Hs) present as native; Italy (It) present as native; Jugoslavia (Ju) absent but reported in error; Portugal (Lu) present as native; Morocco (Ma) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Tunisia (Tn) present as native	W. and C. Medit.-12 COR FRA POR SAR SPA 13 ITA SIC YUG 20 ALG MOR TUN (21) cny	Ag Co Ga Hs It Ju Lu Ma Sa Si Tn [Ca]



<i>Taxus baccata</i> L.	Europe; North Africa (Atlas Mts.); Macaronesia (Azores, Madeira); Caucasus; Western Asia: from Turkey to N Iran	Algeria (Ag) present as native; Albania (Al) present as native; Asiatic Turkey (An) present as native; Balearic Islands (Bl) present as native; Bulgaria (Bu) present as native; Corsica (Co) present as native; France (Ga) present as native; Greece (Gr) present as native; Spain (Hs) present as native; Italy (It) present as native; Jugoslavia (Ju) present as native; Portugal (Lu) present as native; Morocco (Ma) present as native; Crimea (RK) present as native; Sardinia (Sa) present as native; Sicily (Si) present as native; Turkey-in-Europe (Tu) present as native	Europe to N. Iran, NW and Africa-10 DEN FIN GRB IRE NOR SWE 11 AUT BGM CZE GER HUN NET POL SWI 12 BAL COR FRA POR SAR SPA 13 ALB BUL GRC ITA KRI ROM SIC TUE YUG 14 BLR BLT KRY RUC RUE RUN RUS RUW UKR 20 ALG MOR (21) mdr 33 NCS TCS 34 IRN TUR	Ab(A) Ag Al Ar Au(A) Az(C L P) Be Bl(M) Br Bu Co Ct Da Es Fe Ga Ge Gg(D) Gr Hb He dHo Hs(A S) Hu It La Lt Lu Ma Mk No Po Rf(CS) Rm Sa Si(S) Sk Sl Sr Su Tu(A E) Uk(K) [nBe(L)]
<i>Tetraclinis articulata</i> (Vahl) Mast.	N Algeria, Malta, Morocco, S Spain, N Tunisia, NE Libya (?); in Malta and Spain only tiny relict populations remain. Such relict trees are also reported from 'Cyrenaika' = Jabal al Akhdar in NE Libya but I have seen no other accounts of this nor herb	Algeria (Ag) present as native; Cyprus (Cy) doubtfully naturalized; Spain (Hs) present as native; Libya (Li) present as native; Morocco (Ma) present as native; Malta (Me) present as native; Tunisia (Tn) present as native	S. Spain, Malta, Morocco to NE. Libya-12 SPA 13 SIC 20 ALG LBY MOR TUN	N.A.



Relying on these references has a few unavoidable drawbacks. First we noticed that some countries are mentioned repetitively in the same reference and each time the country is mentioned a different “status” for the species may be described (e.g. native and naturalized). The main problem however was that these countries or areas differed from the actual and current political borders of the countries. For example, some islands such as Corsica, Sicily and the Balearic Islands were considered separately from France, Italy and Spain respectively; Yugoslavia was mentioned without specifying if the status corresponded to all countries of former Yugoslavia or some of them only; some countries were grouped together, such as Lebanon and Syria (grouped as LS) without any possibility of knowing if the species was native for one or both countries. A solution to this problem would be to check the Flora or national inventory of each country, and/or get the feedback of an expert on flora in the specific region. A worthwhile but time consuming endeavor much beyond the scope of this project! Therefore we decided to include all countries that were mentioned as part of groups or former countries at the risk of including some countries where the species were not native, trying to avoid the exclusion of countries where the species were indeed native.

Following the compilation of countries of native distribution for each of the species, we re-created the areas or borders using the QGIS software, in order to create shapefiles of countries of native distribution that stored the same information presented above for each species but with the geographic boundaries included. We used the FAO-GAUL 2012-2103 shapefile to generate country boundaries. After overlaying the information on countries of native distribution with the geographic distribution data for each of the species (practically overlaying the shapefiles of the countries of native distribution and the shapefiles of the polygons and points of distribution), we noticed that some data (points and / or polygons) extracted from floras showed the species present in areas not included in the countries of native distribution identified by online databases (Table 3.2). Therefore, assuming that floras mention only native species, we decided to include all countries where the species appear as present according to floras in the countries of native distribution.

### Approach for data on species presence/absence

In the following we will describe how we compiled all the data we could acquire, from already made shapefiles, jpeg maps, paper maps, national floras, etc.. The main target was to transform all non-georeferenced and digitized data into shapefiles to integrate them into QGIS and then overlay and extract the necessary information to create the distribution maps for each species. Starting with the shapefiles that we acquired, we used for species (when available) shapefiles from:

- EUFORGEN;
- Algerian National Inventory [11];
- Lebanon Forest Map [14];
- Occurrence points of certain species in Lebanon [21].

The following will detail the steps used to transform paper maps into shapefiles, i.e. digitizing. Note that these steps were also applied for digital maps in raster format except for the first step of redrawing. After acquiring the paper maps, we redrew them as high resolution electronic images (modifying the contours when needed, according to expert knowledge available) and georeferenced<sup>4</sup> each map using well identified geographical reference points. We used the QGIS Georeferencer plugin to georeference the raster images.

Following the georeferencing, we digitized<sup>5</sup> each map in order to integrate the data into a shapefile. When digitizing and adding features (whether polygons or points) we used a specific shapefile structure, with attributes targeting specific information on the created features, such as the country of occurrence, the name of the species in Latin, its common name, the source of the data, etc. This structure was designed mainly to help later extract and select data by target information. We reproduced each map by creating features (points or polygons) and filling the different attribute fields with the corresponding information. Eventually we had all our digitized maps' data in one shapefile for polygons and one shapefile for points.

The next step was to select the data for each of the 24 species, and create 24 new shapefiles. Once the shapefile containing the compiled digitized distribution data for each species was created, we overlaid (1) the created polygon

<sup>4</sup>Georeferencing is aligning geographic data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data.

<sup>5</sup>Digitizing is the process of converting the geographic features on an analogue map into digital format using a digitizing tablet, or digitizer, which is connected to a computer. Features on a paper map are traced with a digitizer puck, a device similar to a mouse, and the x,y coordinates of these features are automatically recorded and stored as spatial data.



shapefile, (2) the created points shapefile (when available for the species), (3) the aforementioned acquired shapefiles (EUFORGEN, Lebanon, Algeria) (when available for the species), (4) the shapefile of the countries of native distribution and (5) the map of the world (GAUL) for every species to create the 24 distribution maps. In total over 100 maps were digitized and over 18 000 entries (points/polygons) were created.

### Pilot site classification

After compiling the data and creating the distribution maps, we placed the pilot sites (where the species are present) on the distribution map of the corresponding species, in order to determine which sites contain marginal populations of the species. We classified the populations as either “marginal” (in the 5% outer rim of the distribution envelope) or “disjunct” (separated from the core by at least 50 km). All other situation were classified as “central”. The status of each site (central, marginal or disjunct) was decided by measuring the distance of the pilot site from the center and the margins of the distribution envelope, using the maps produced in the project.

# Results

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We produced distribution maps for 24 Mediterranean tree species, key for the project. All maps are available as figures (jpeg format) and electronic georeferenced files (shape files in a QGIS project).

In these maps, we show in dark gray the countries of native distribution according to the three sources mentioned above. The countries in dark gray with an orange border are those that were not considered native originally (using information from MedCheckList, etc.) but were added because the data we collected from floras indicated they were native there. In general, unless otherwise mentioned in the legend, all areas and points in blue are those showing a general distribution of the species. In bright green however (points and areas) we highlight more specific information, either coming from a national inventory or from a detailed published map. The stars in different colors show the pilot site placement on the map, when the site includes the species displayed on the map. When the species is not present in any of the 5 pilot sites, no stars are present on the map. The 24 maps are presented below. Please note that they are meant to be accurate only at the level of the entire distribution range of the species, and not at country level. The diversity of data resolutions used for drawing the maps does not make it possible to downscale the information.



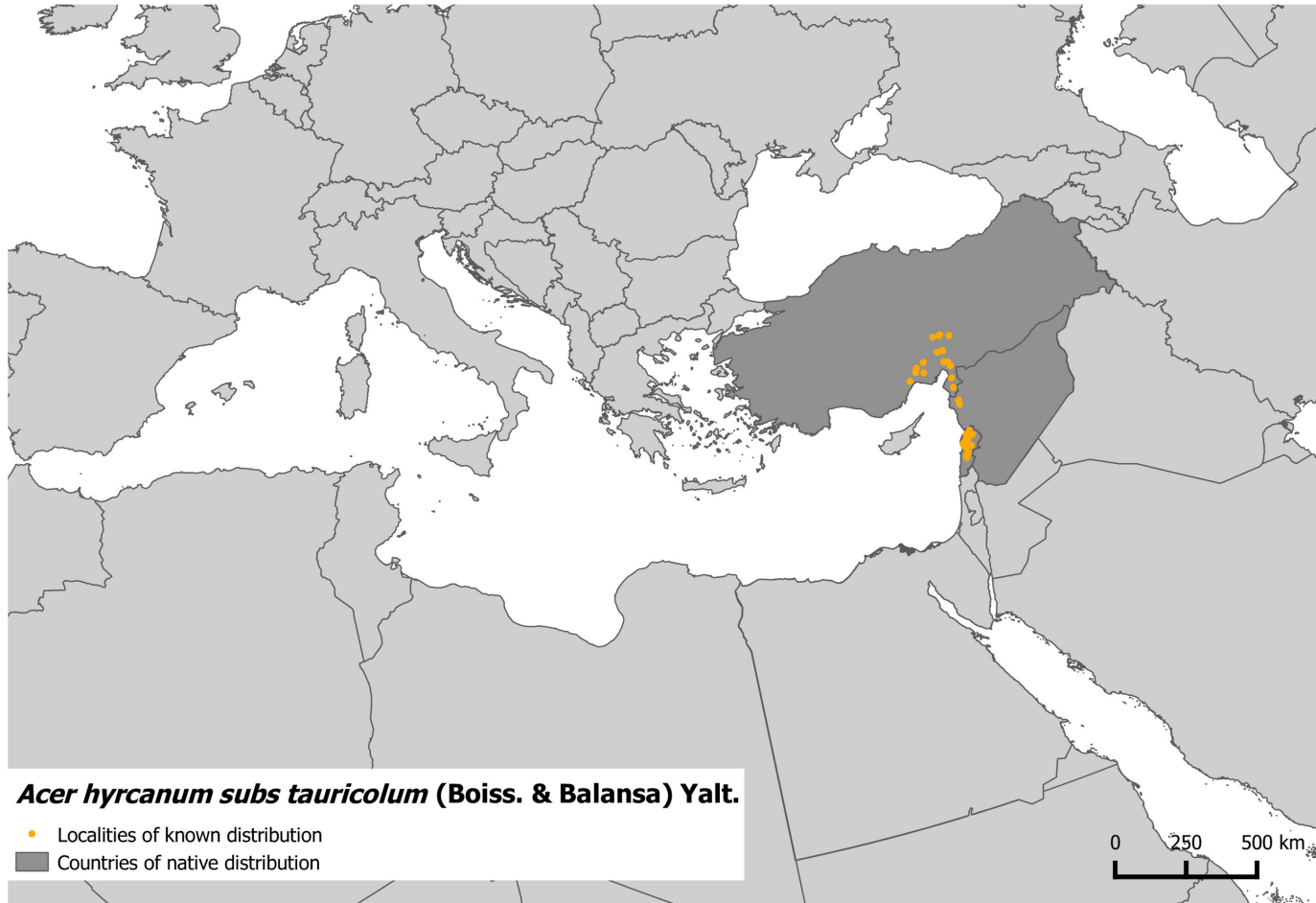
Figure 4.1: Distribution map of *Acer hyrcanum* sub. *tauricum*

Figure 4.2: Distribution map of *Arbutus unedo*

Figure 4.3: Distribution map of *Cedrus atlantica*

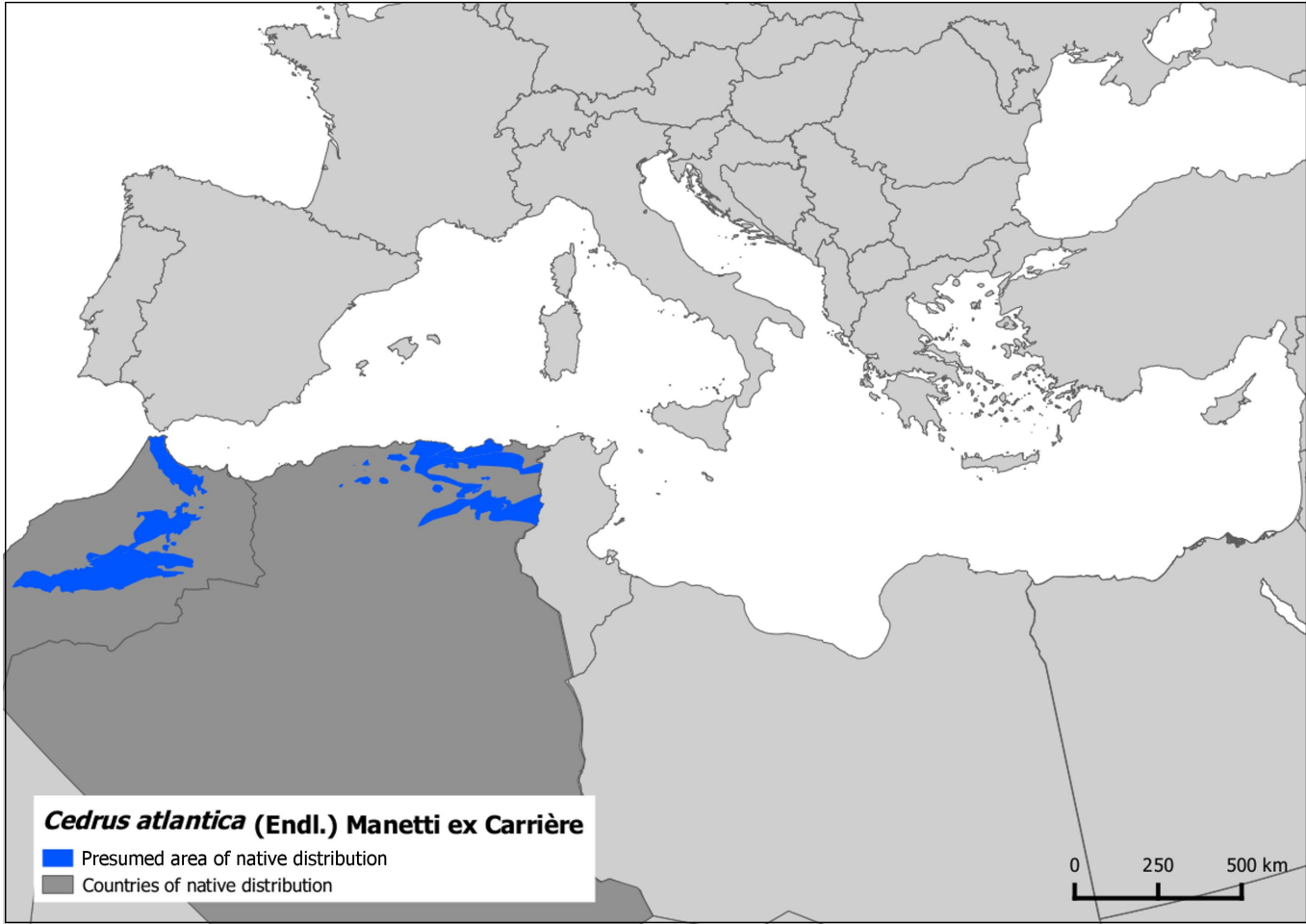


Figure 4.4: Distribution map of *Cedrus libani*

Figure 4.5: Distribution map of *Chamaerops humilis*

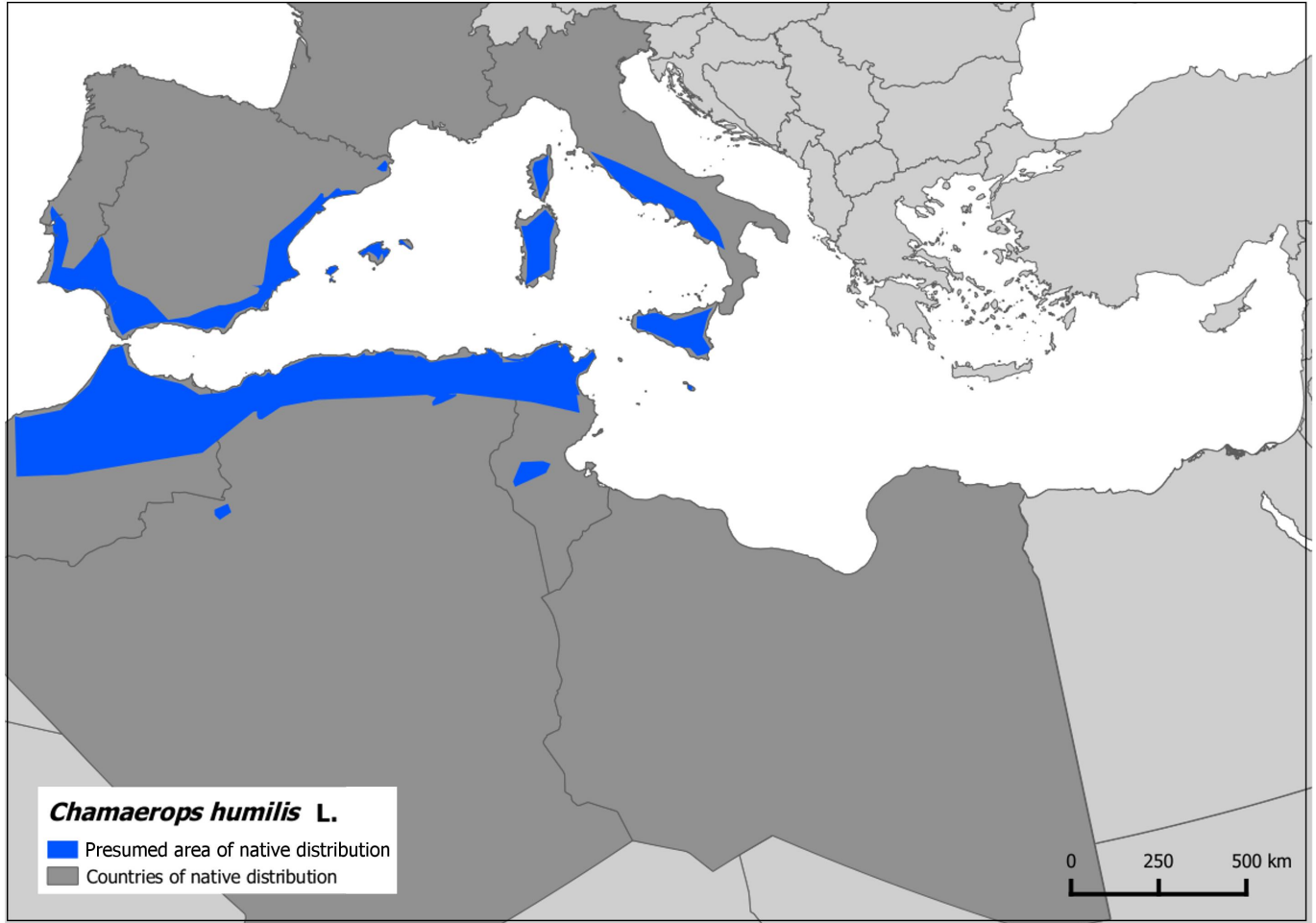




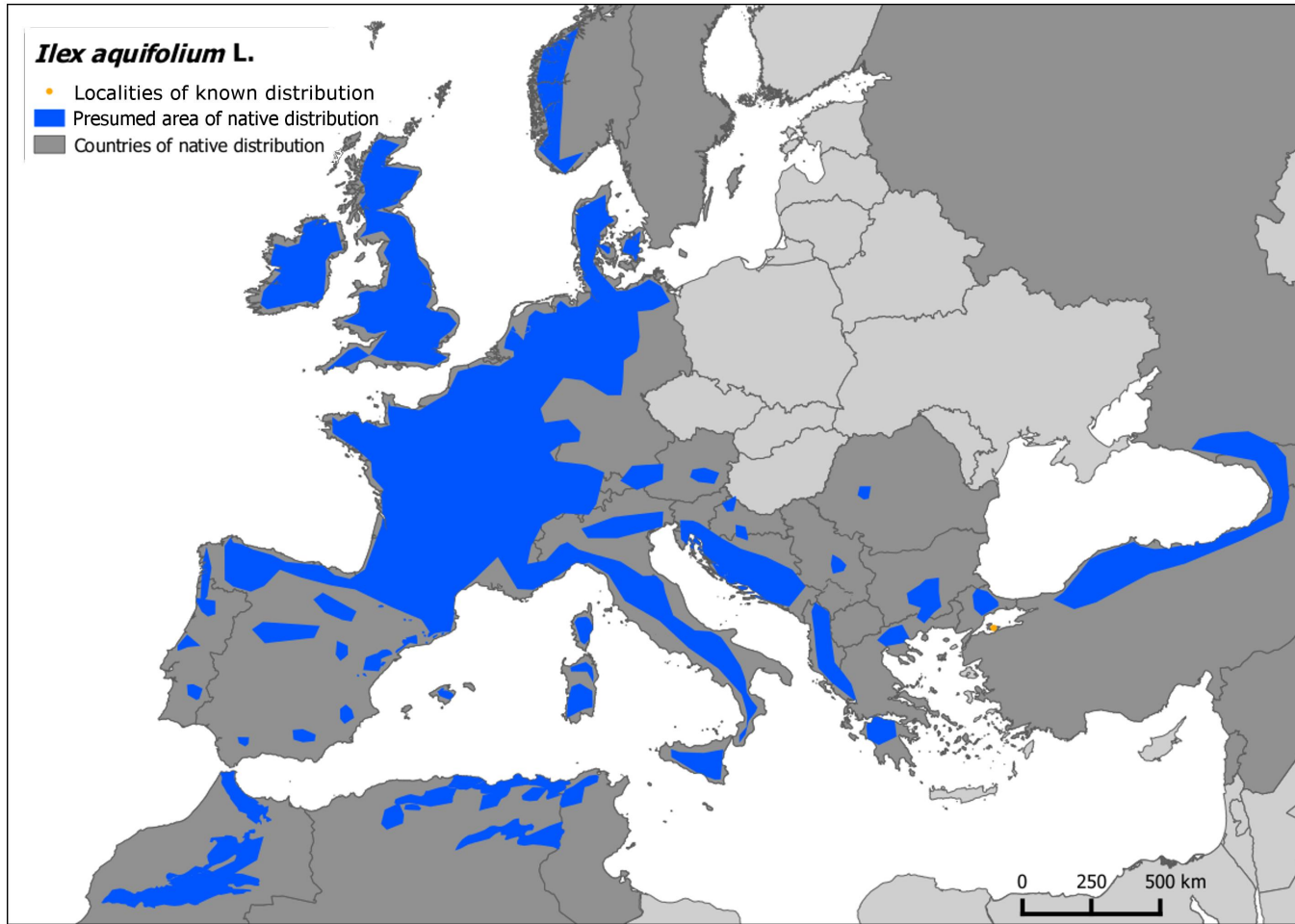
Figure 4.6: Distribution map of *Ilex aquifolium*

Figure 4.7: Distribution map of *Juniperus phoenicea*

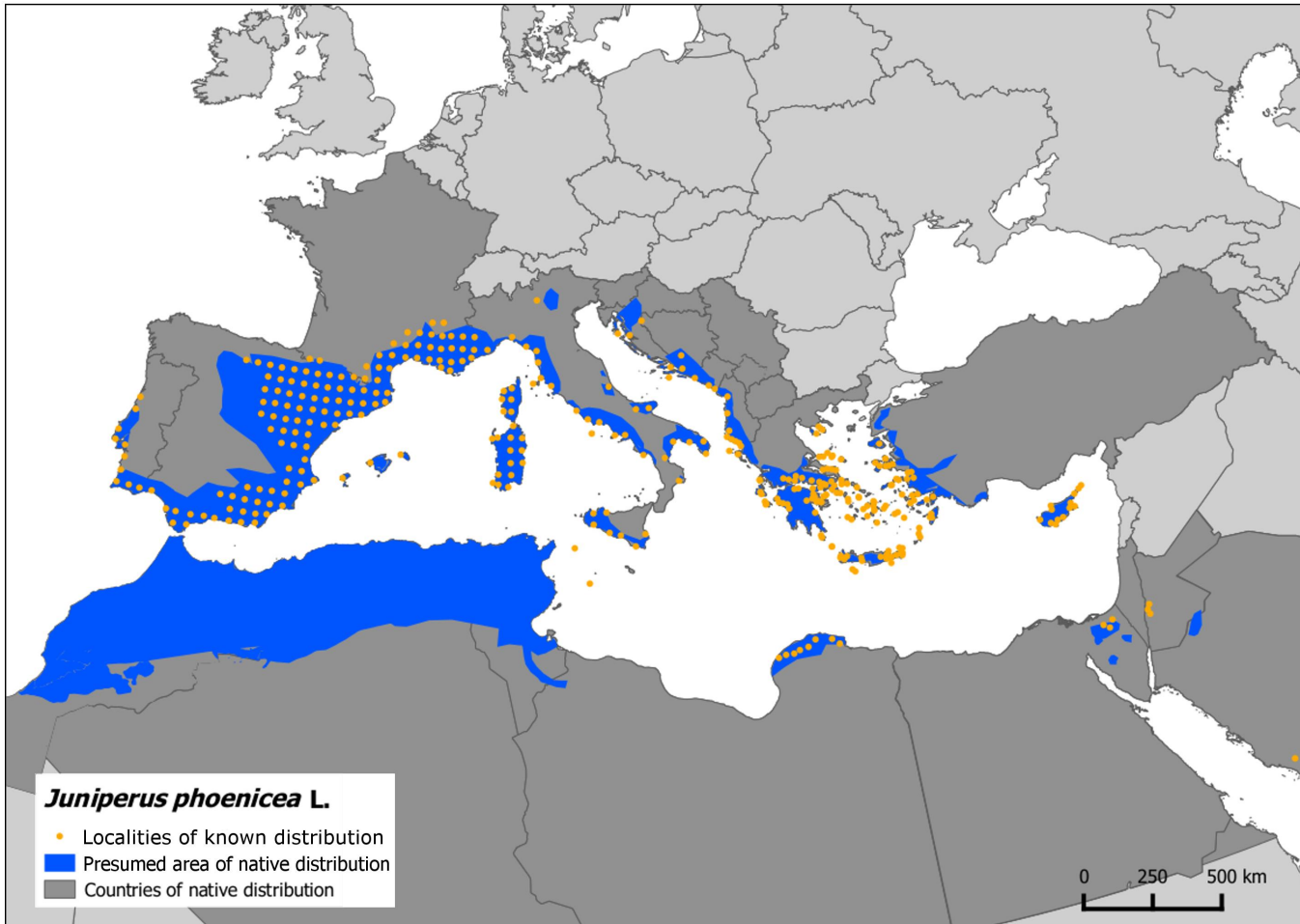


Figure 4.8: Distribution map of *Juniperus drupacea*

Figure 4.9: Distribution map of *Juniperus excelsa*

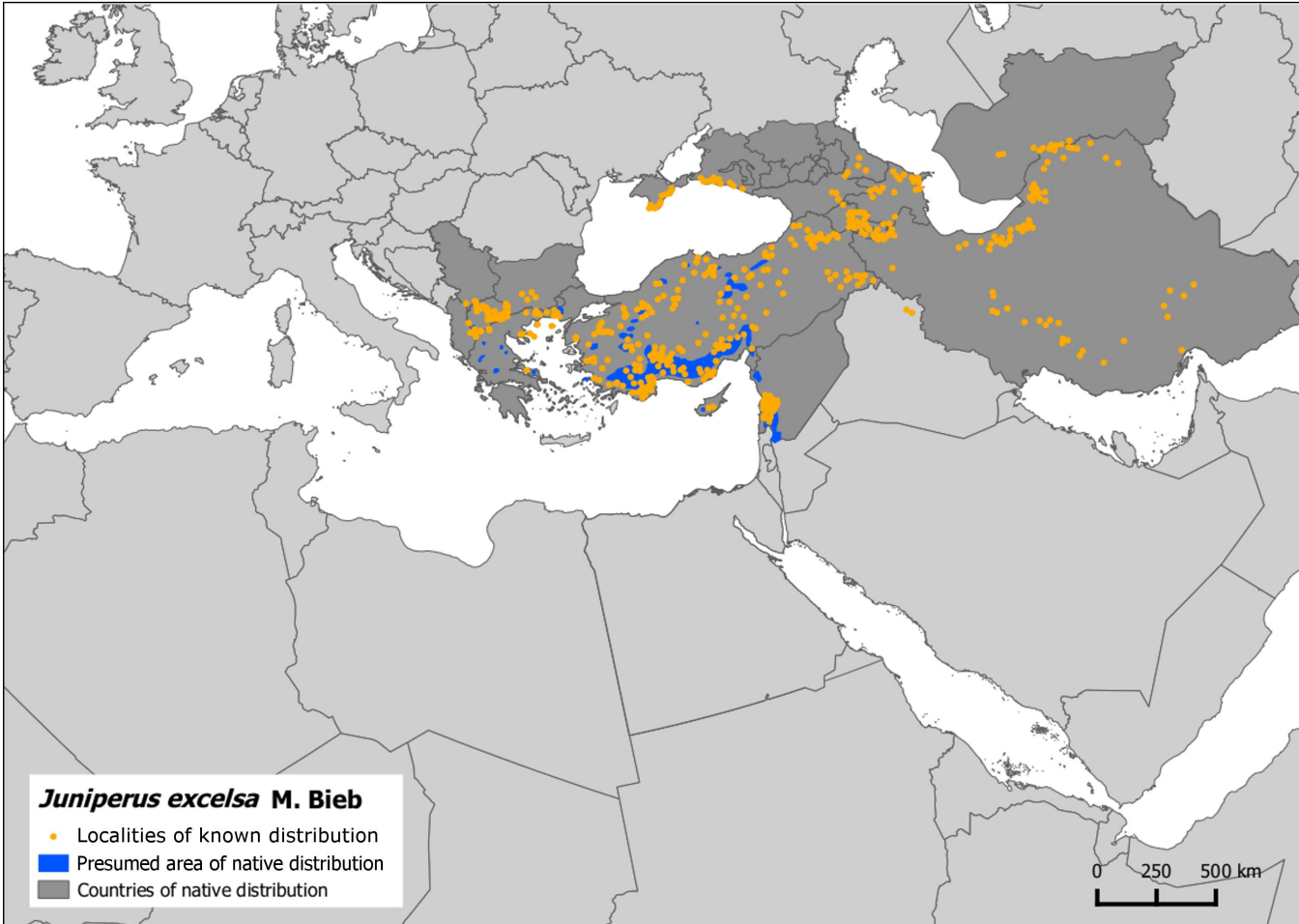


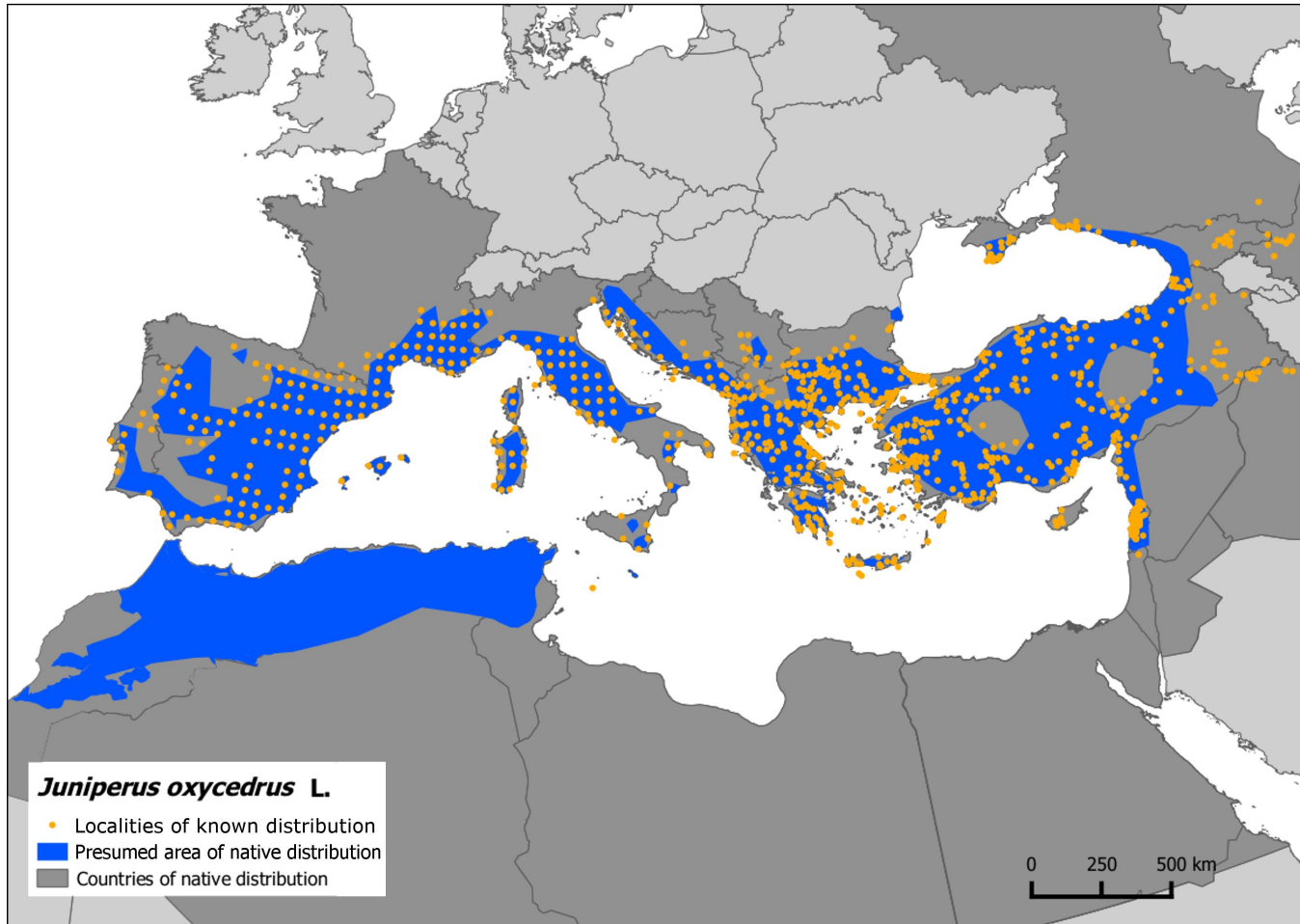
Figure 4.10: Distribution map of *Juniperus oxycedrus*

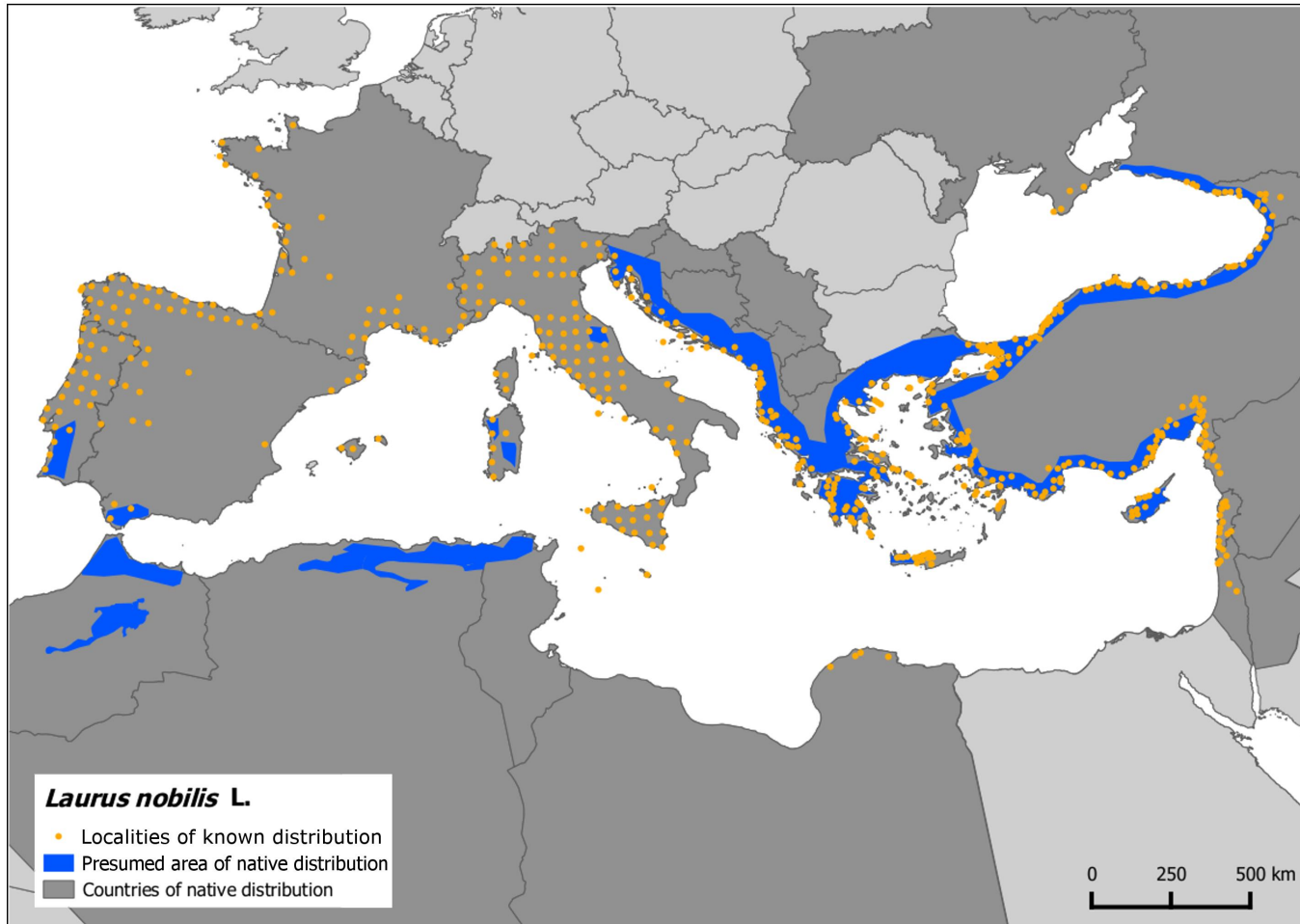
Figure 4.1 I: Distribution map of *Laurus nobilis*

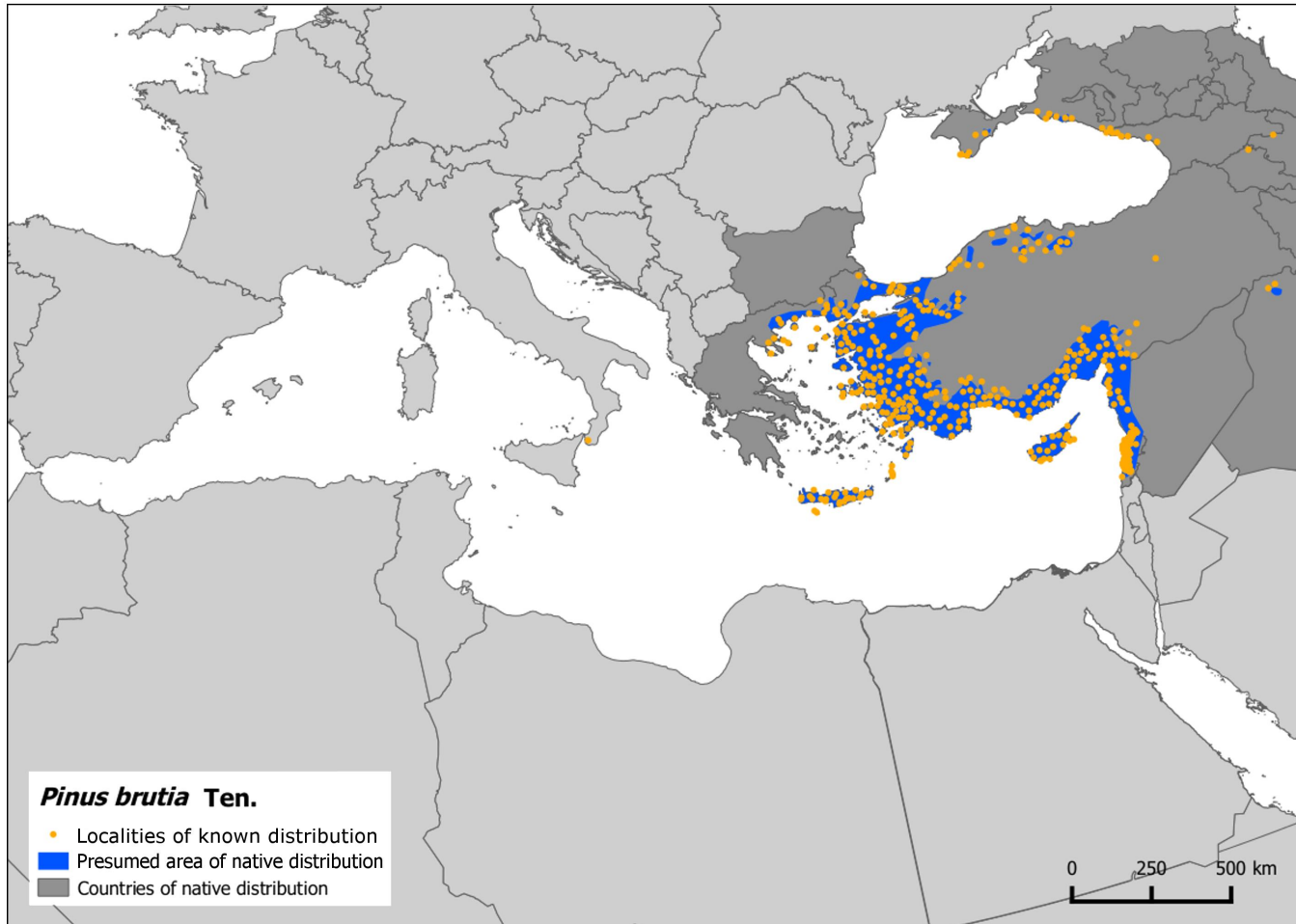
Figure 4.12: Distribution map of *Pinus brutia*

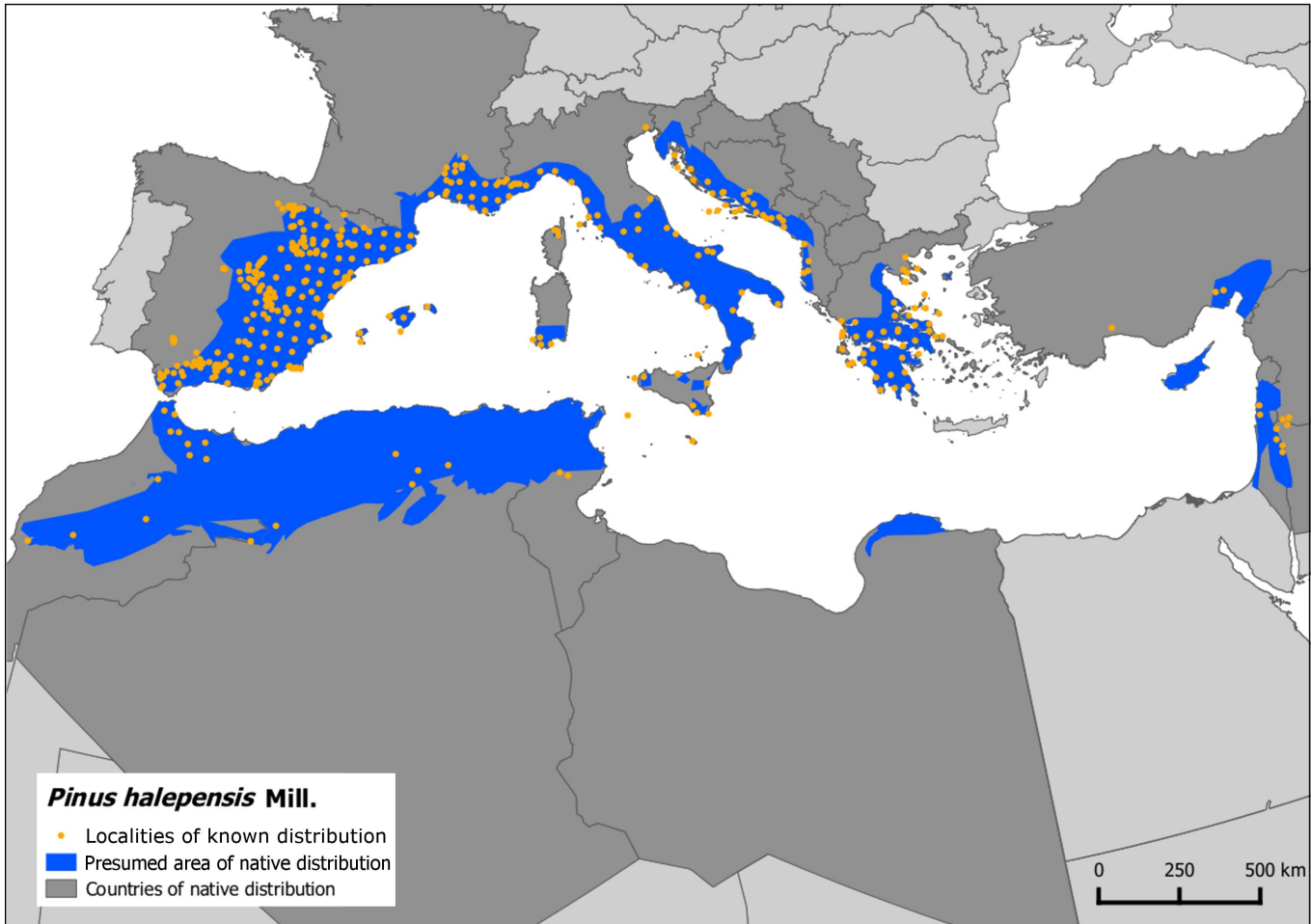
Figure 4.13: Distribution map of *Pinus halepensis*



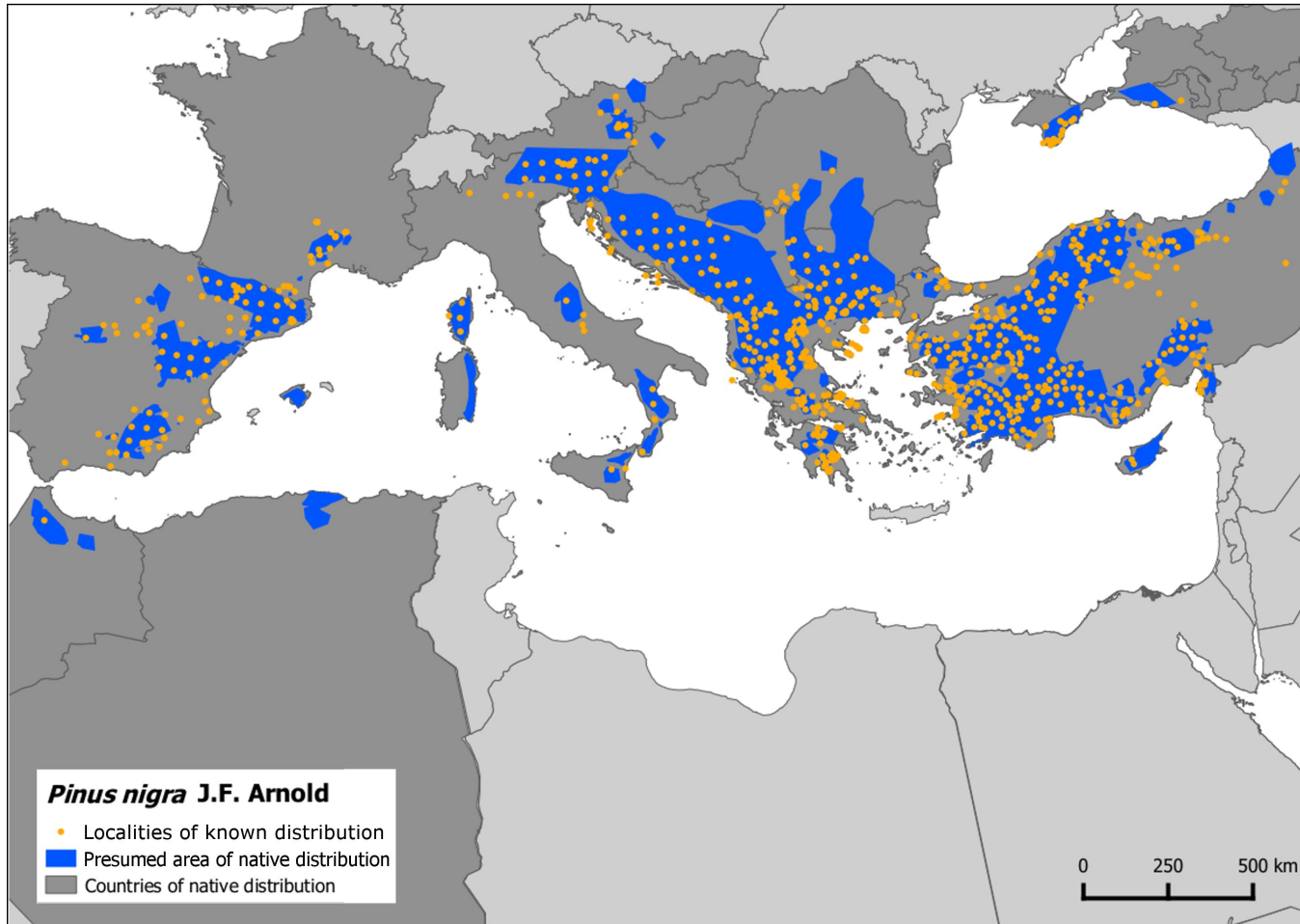
Figure 4.14: Distribution map of *Pinus nigra*

Figure 4.15: Distribution map of *Pinus pinea*

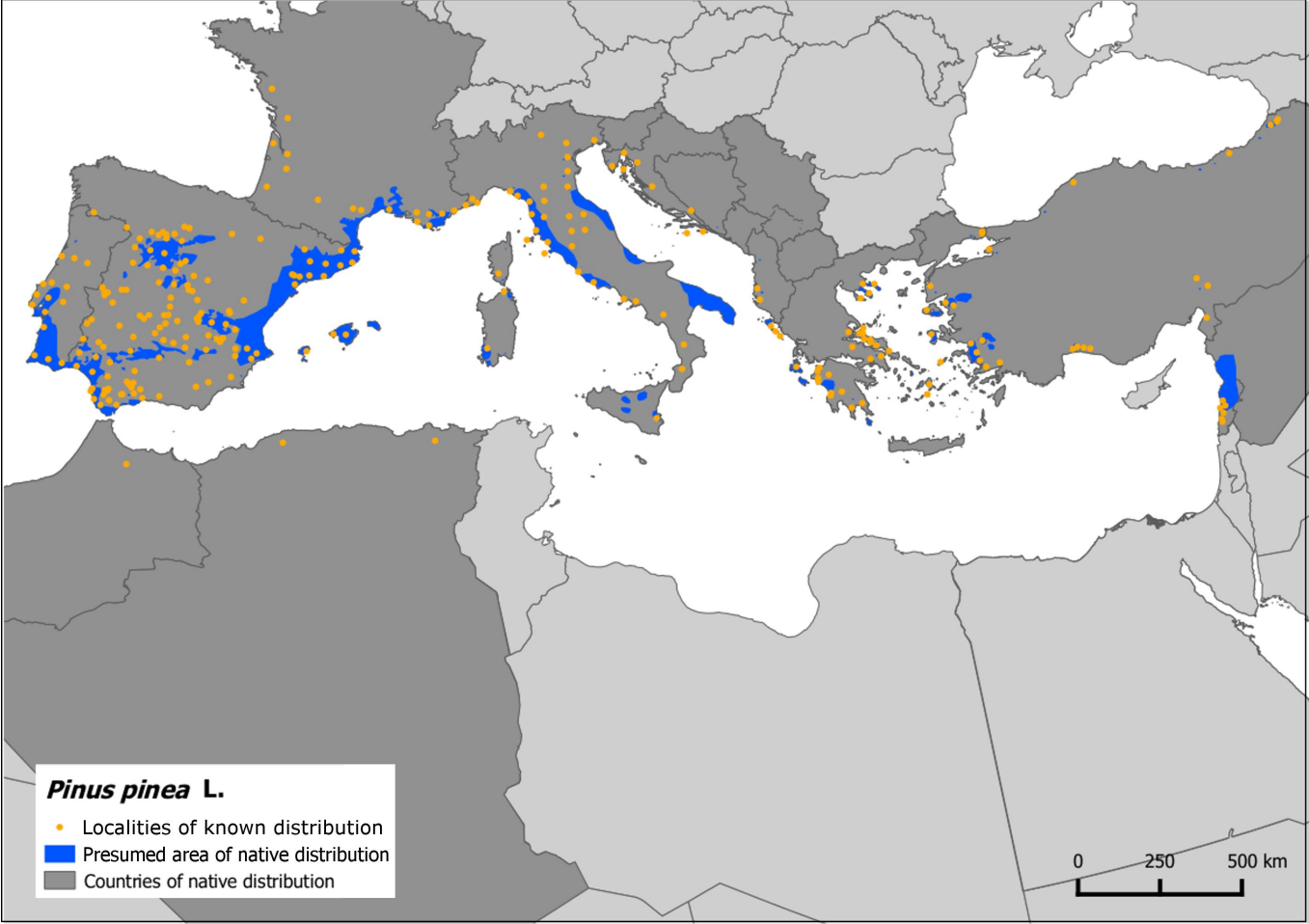


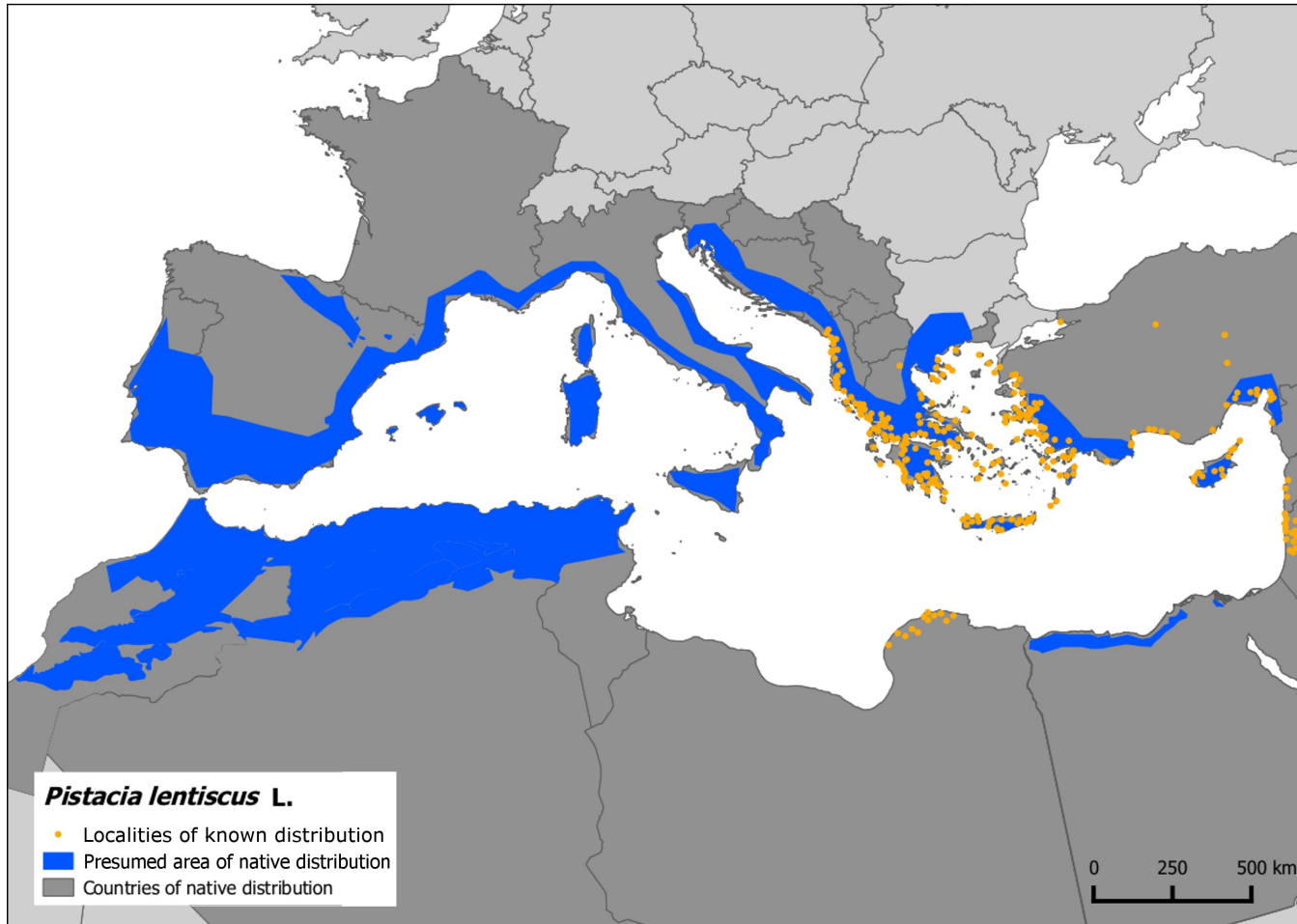
Figure 4.16: Distribution map of *Pistacia lentiscus*

Figure 4.17: Distribution map of *Platanus orientalis*

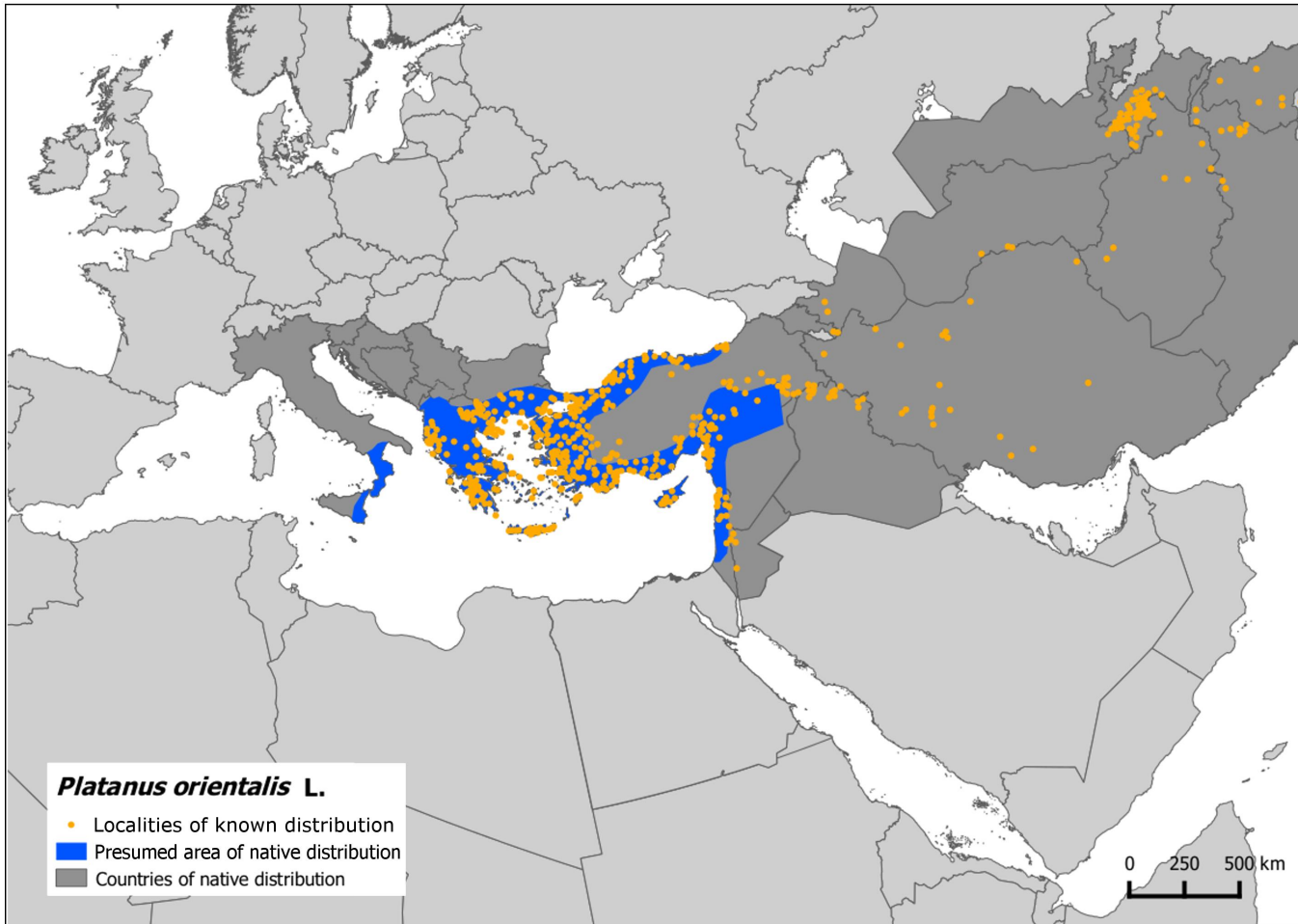


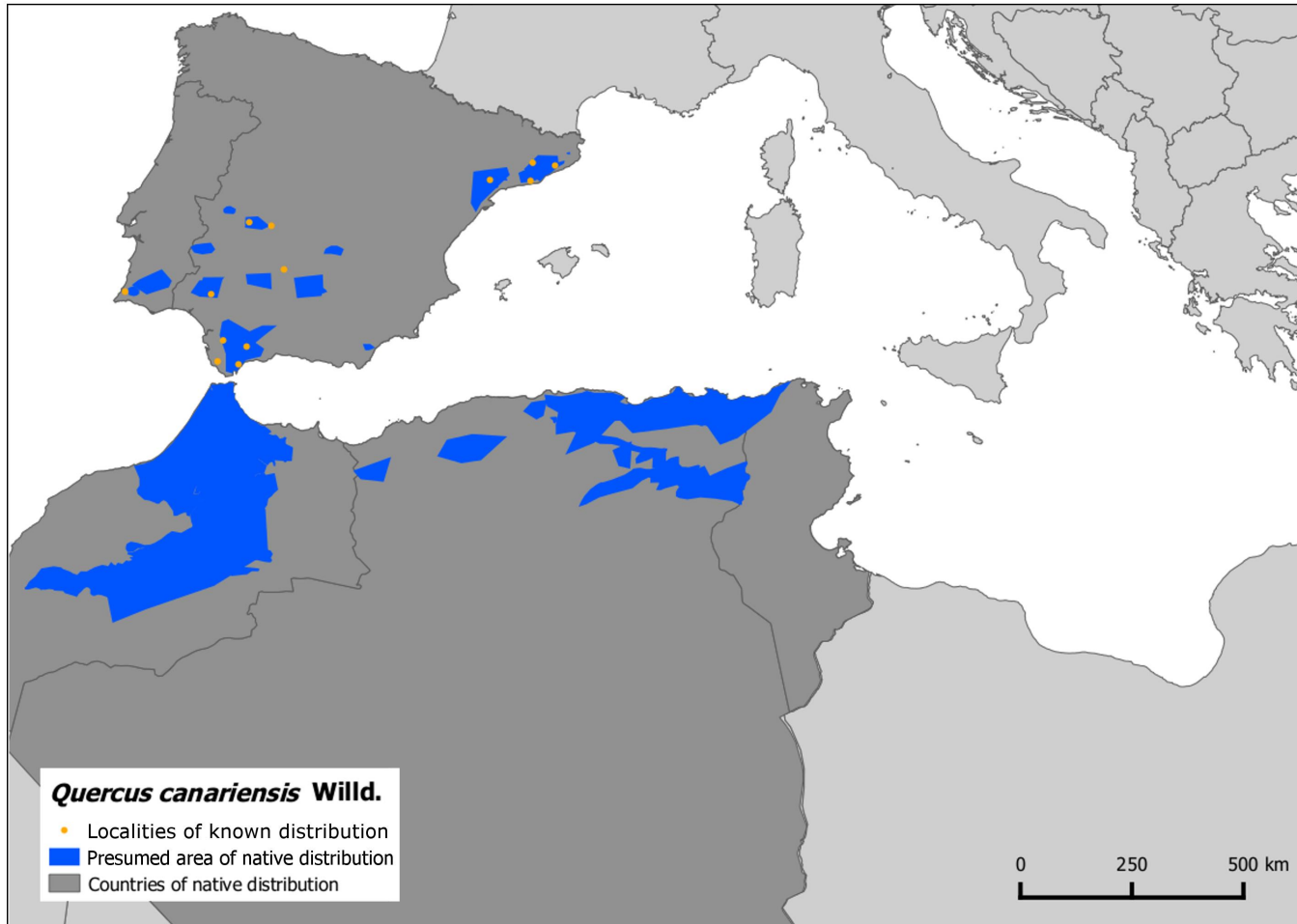
Figure 4.18: Distribution map of *Quercus canariensis*

Figure 4.19: Distribution map of *Quercus cerris*

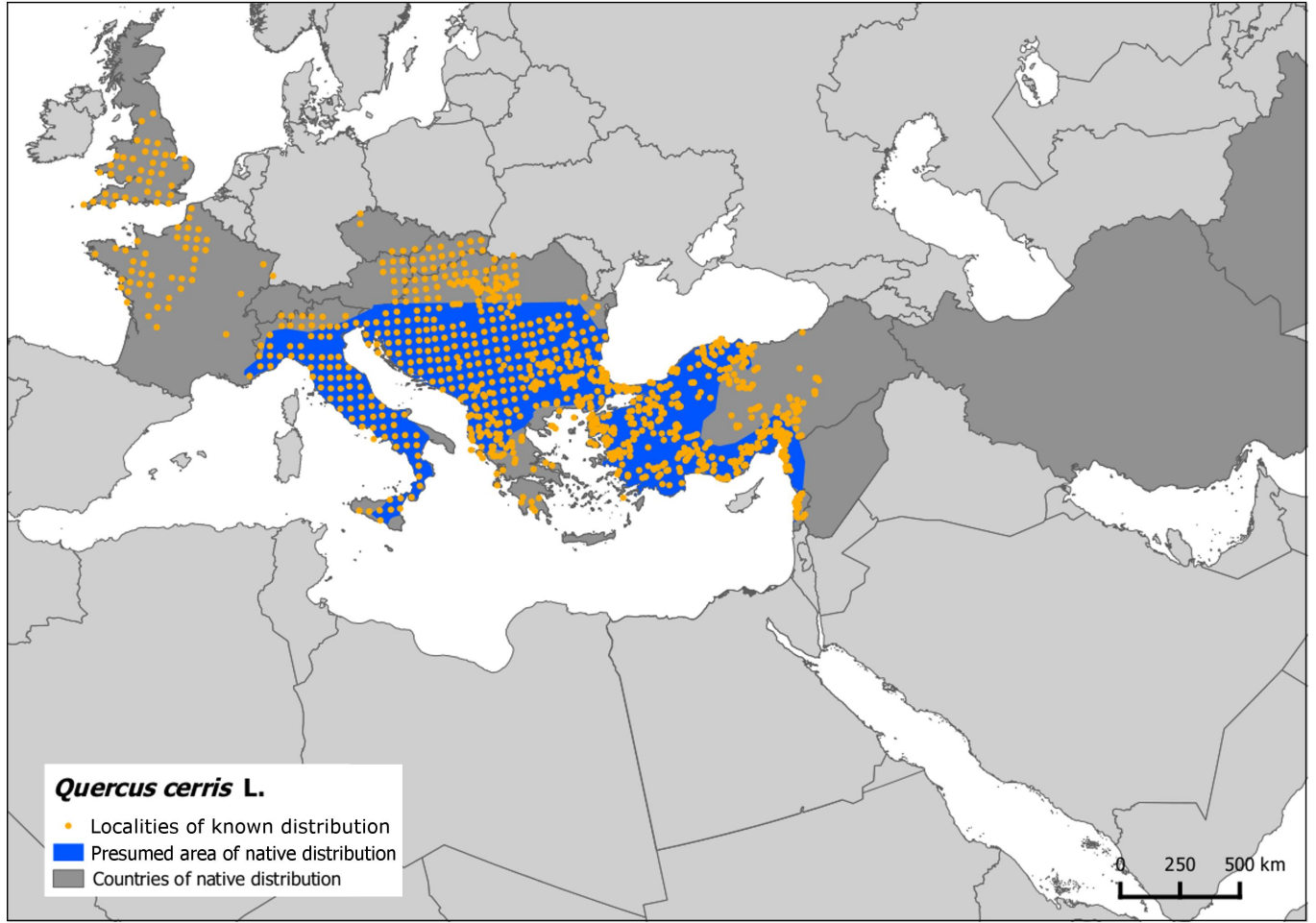


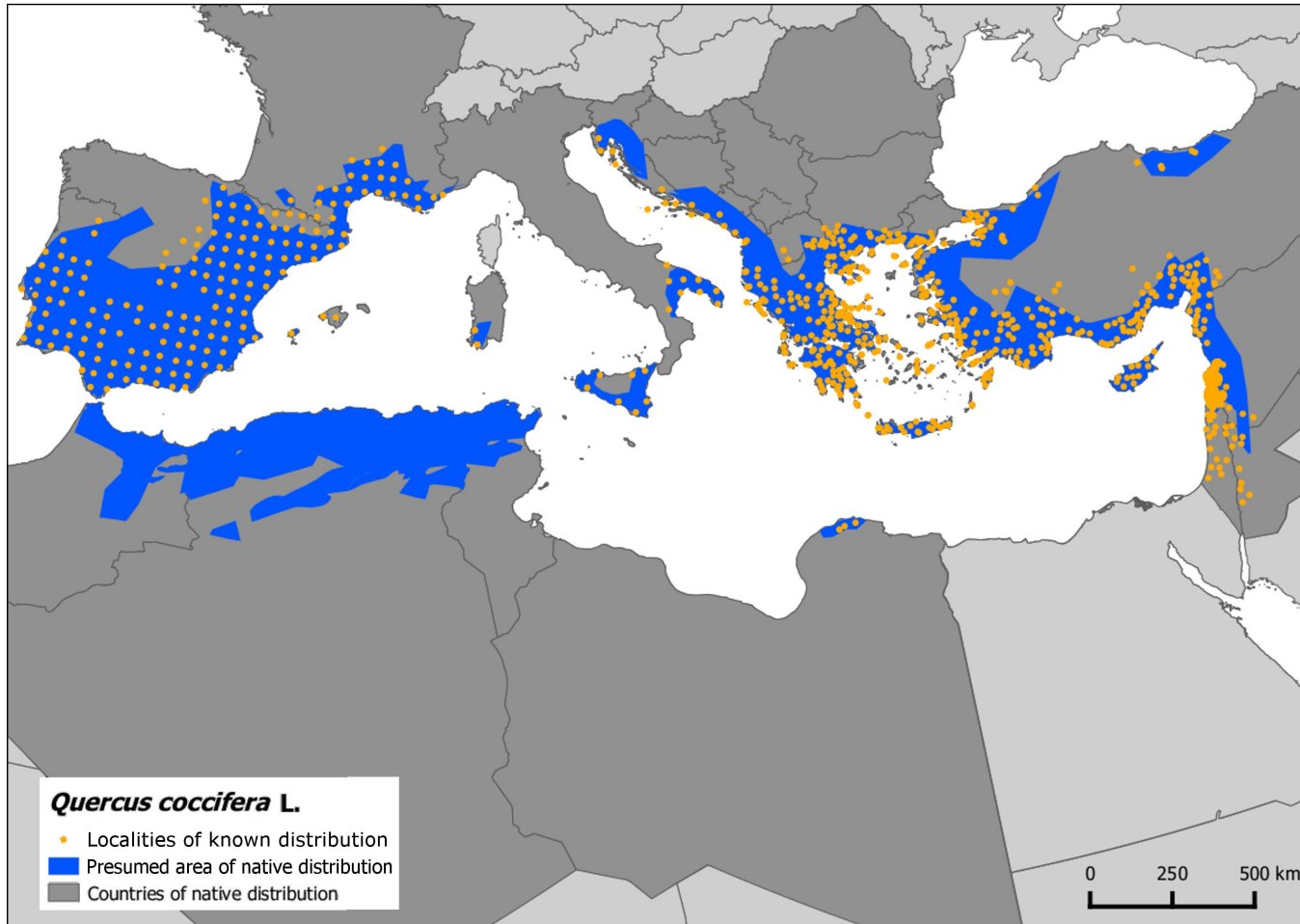
Figure 4.20: Distribution map of *Quercus coccifera*

Figure 4.21: Distribution map of *Quercus ilex*

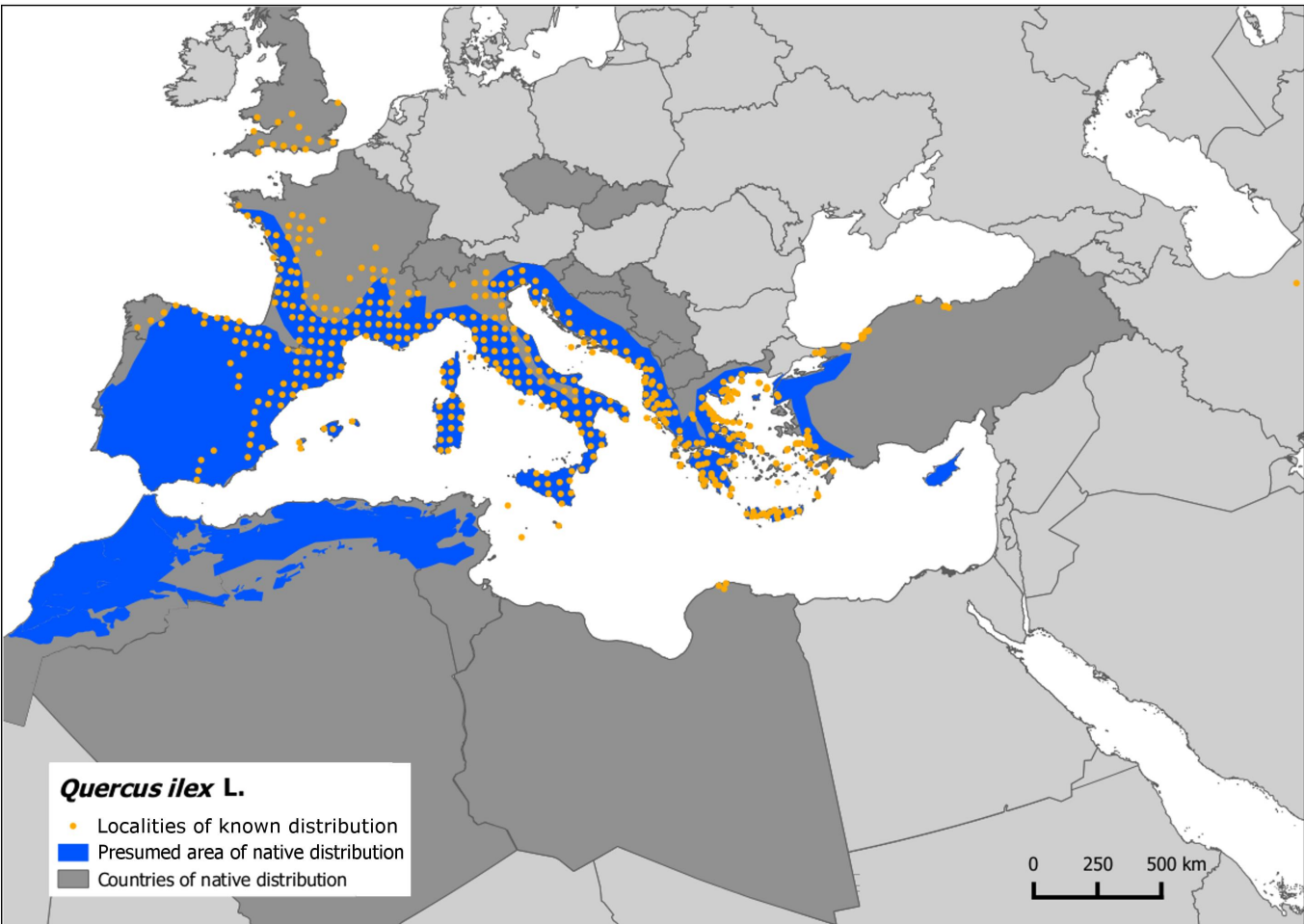




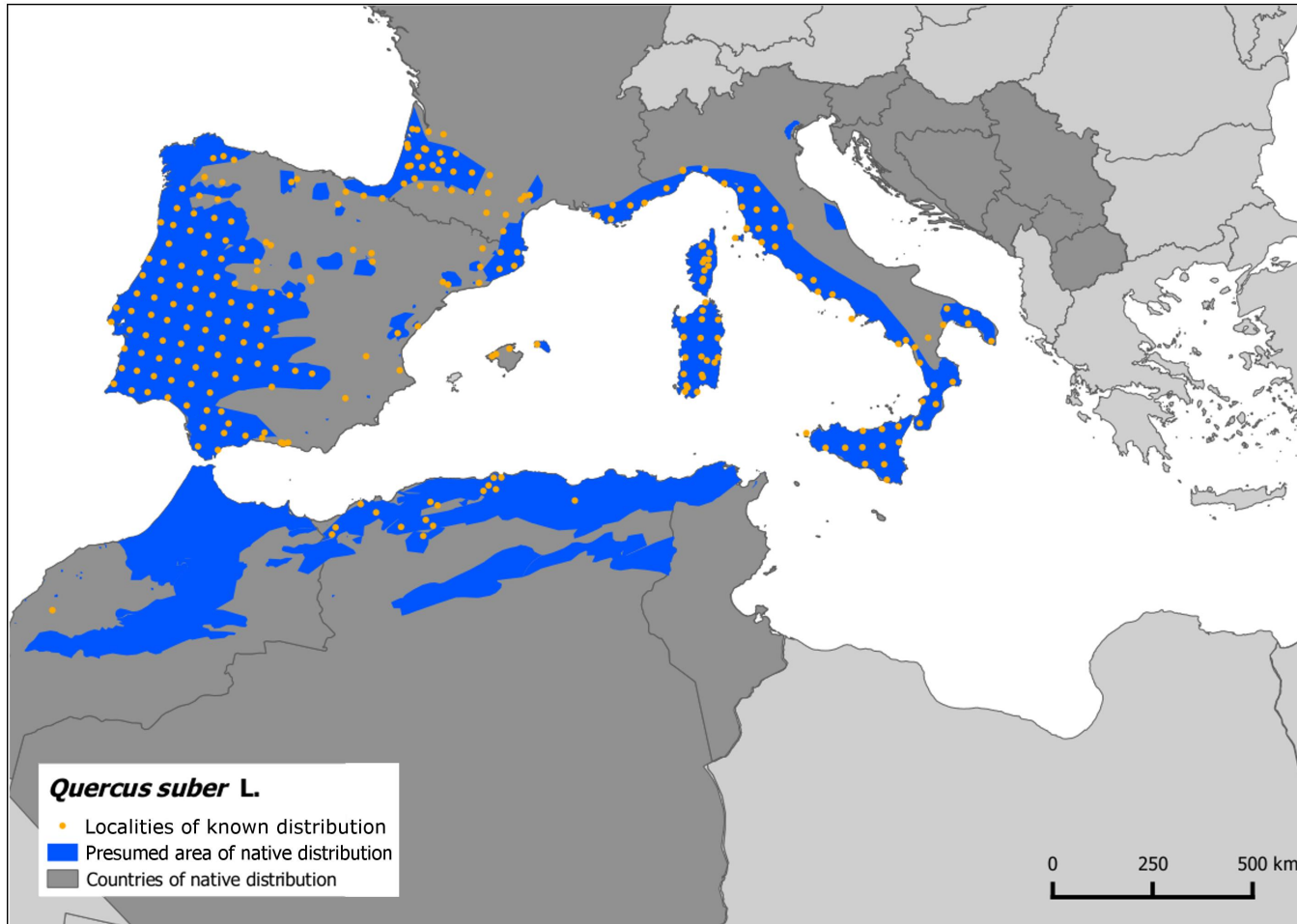
Figure 4.22: Distribution map of *Quercus suber*

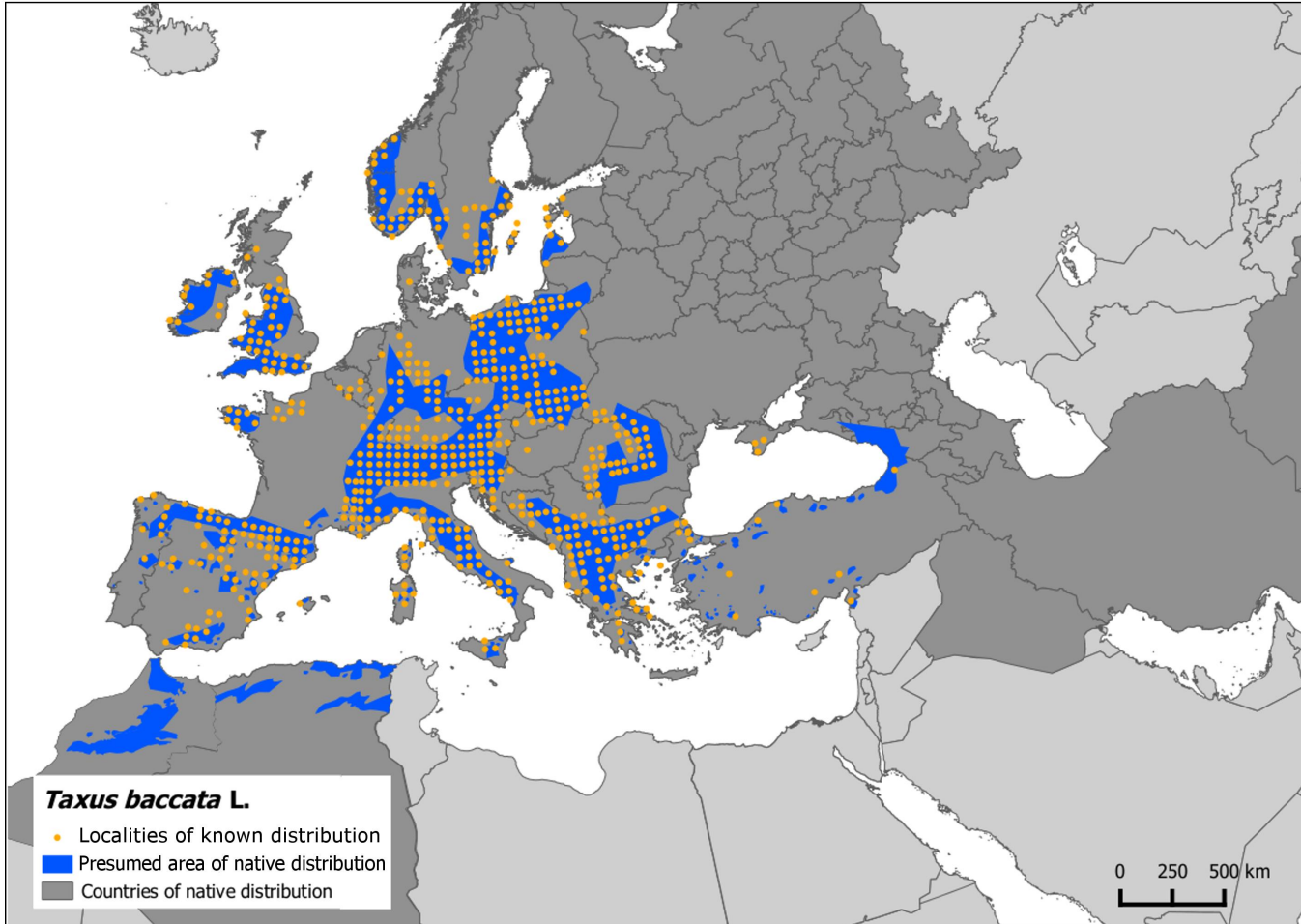
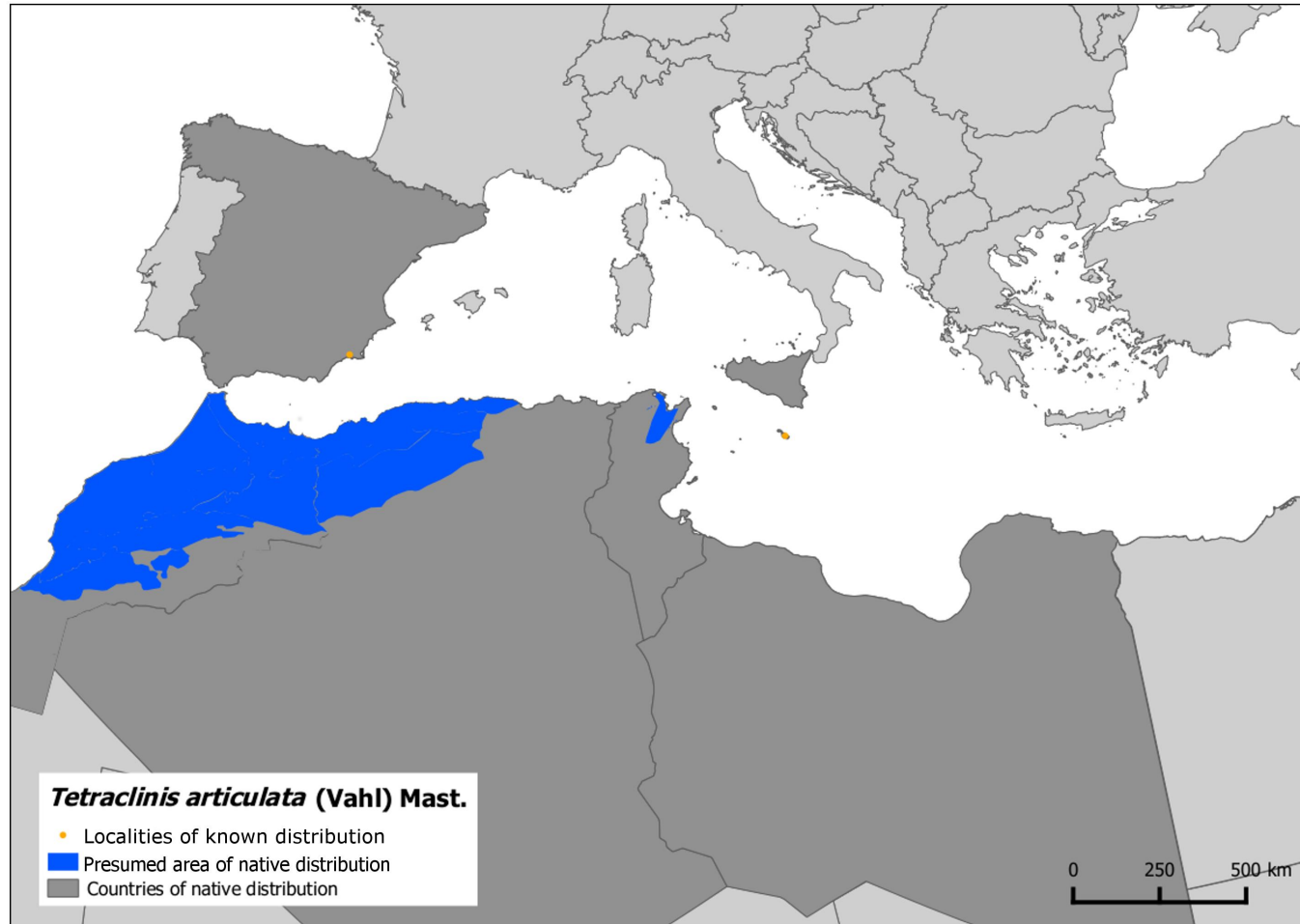
Figure 4.23: Distribution map of *Taxus baccata*

Figure 4.24: Distribution map of *Tetraclinis articulata*

The status of species in each pilot site regarding geographical marginality is described in Table 4.1 below. For each site where one of the 24 species occurs, we were able to indicate whether the species, and hence its genetic resources, are central, marginal or disjunct in reference to the whole distribution area. In total, 5 species / sites appear as either marginal or disjunct out of a total of 25 species / site pairs (20% of the total).

Here, we focused on geographical marginality and not ecological. A study of the ecological marginality of these populations, potentially more significant and comprehensive, would require biotic and abiotic ecological information as well as a digital elevation model of the study area, which is not available for all regions. Geographic marginality can be assessed from distribution data and can indicate reduced genetic diversity (reduced and unbalanced gene flow from central areas) and some level of ecological marginality when ecological and geographical marginalities coincide. When assessing the marginality of populations, we compared the position of a pilot site to the whole distribution, and based on the following criteria, we labelled it as either “central”, “marginal” or “disjunct”. The assessment was made by:

1. Measuring the length of extension of distribution line passing through the pilot site;
2. Measuring the length from the pilot site to the limit of the measured extension;
3. Calculating the 5% length that puts the pilot site in a “Marginal” position;
4. Assessing the position of the pilot site by comparing the value obtained in 2 to the value obtained in 3.

Tableau 4.1: Geographical situation of pilot sites and their genetic resources for each species. Sites can be either central, marginal or disjunct for the genetic resources and species considered

Species name (in pilot site)	Accepted name (in Catalogue of Life)	Pilot site	Extension length (km)	5% limit (km)	Site distance (km)	Marginality	Comments
<i>Acer tauricum</i>	<i>Acer hyrcanum</i> subsp. <i>tauricum</i> (Boiss. and Balansa) Yalt.	Düzlerçamı	515	25.75	50	Central	
<i>Arbutus unedo</i>	<i>Arbutus unedo</i> L.	Siliana	2 158	107.9	190	Central	
<i>Cedrus libani</i>	<i>Cedrus libani</i> A. Rich.	Düzlerçamı	250	12.5	80	Central	
<i>Chamaerops humilis</i>	<i>Chamaerops humilis</i> L.	Maâmora	717	35.85	216	Central	
<i>Juniperus drupacea</i>	<i>Juniperus drupacea</i> Labill.	Jabal Moussa	540	27	90	Central	
<i>Juniperus excelsa</i>	<i>Juniperus excelsa</i> M.-Bieb.	Düzlerçamı	170	8.5	3	Marginal	
<i>Juniperus oxycedrus</i>	<i>Juniperus oxycedrus</i> L.	Djelfa	320	16	100	Central	
<i>Juniperus phoenicea</i>	<i>Juniperus phoenicea</i> L.	Djelfa	345	17.25	100	Central	
<i>Pinus brutia</i>	<i>Pinus brutia</i> Ten.	Düzlerçamı	160	8	90	Central	
		Jabal Moussa	534	26.7	85	Central	
<i>Pinus halepensis</i>	<i>Pinus halepensis</i> Mill.	Djelfa	360	18	130	Central	
		Düzlerçamı				Disjunct	420 km away from closest patch
		Siliana	240	12	112	Central	
<i>Pinus pinea</i>	<i>Pinus pinea</i> L.	Düzlerçamı	4 081	204.05	605	Central	patchy distribution
<i>Pistacia lentiscus</i>	<i>Pistacia lentiscus</i>	Djelfa	310	15.5	85	Central	
		Maâmora	315	15.75	48	Central	
		Siliana	205	10.25	80	Central	
<i>Platanus orientalis</i>	<i>Platanus orientalis</i>	Düzlerçamı	600	30	88	Central	
		Jabal Moussa	915	45.75	321	Central	
<i>Quercus calliprinos</i>	<i>Quercus coccifera</i> L.	Jabal Moussa	1 211	60.55	420	Central	
<i>Quercus cerris</i>	<i>Quercus cerris</i> L.	Jabal Moussa	955	47.75	70	Central	
<i>Quercus ilex</i>	<i>Quercus ilex</i> L.	Djelfa	270	13.5	5	Marginal	
		Siliana	2 069	103.45	101	Marginal	
<i>Quercus suber</i>	<i>Quercus suber</i> L.	Maâmora	265	13.25	45	Central	
		Siliana	90	4.5		Marginal/Disjunct	35 km away from closest limit of distribution

## Discussion, challenges and perspectives

We have created 24 maps of key forest trees species for Mediterranean forestry. These maps (in different formats) are available for the scientific as well as forest management and policy communities. They will make it possible, among other things to situate biodiversity assessment, habitat management and restoration, and species and habitat conservation plans within their broader context. Here, the maps were used to locate geographically peripheral (marginal or disjunct) populations and genetic resources within the limits of the distribution area. Marginal or disjunct forest genetic resources make up 20% of the total of species / site pairs where the evaluation was possible. This is worth mentioning because marginal and disjunct resources can be considered as needing special management care, both in terms of conservation and for use, and thus extra efforts (and both capacity and budget) on the part of management. These forests may contain fragile resources (low genetic diversity) because of genetic drift and inbreeding driven by their often low population size, and these demand conservation planning. It could include maintaining a suitable habitat even under climate change, developing a silviculture that increases rotations to accelerate genetic adaptation, translocation of threatened resources to more suitable habitats (assisted migration). These peripheral populations may also contain original traits and genes because of local adaptation to particular constraints. These resources demand adequate management plans so that they can be used adequately in breeding programs and not be altered by unwanted gene flow that would result from plantations of exotic material.

Creating maps of native distribution provided several challenges, from determining the native areas, to finding reliable data and compiling them to form a homogenous coherent map. Following are a few of the most challenging problems we faced.

1. Compiling maps with data of different accuracy. When data came from different sources of information, they were usually of different levels of accuracy, which was then difficult to regroup as a single type of information in the maps we created. During the data mining phase, we found:
  - Data that showed points of occurrence based on grids (of different size);
  - Data that provided information on the specific area of presence of the species (ex: maps found in scientific publications);
  - Data that provided more of a general information, showing an area where it is highly likely to come across the species (ex: the Catalan flora). These maps show huge areas of distribution that could go from a country to another, sometimes even include a whole country or island;
  - Data that described, in a text, the species as present in a certain area, and the only map would be the map of the country divided into areas. (ex: Flore Nouvelle de l'Algérie, Flore pratique du Maroc, Flora of Egypt). In these cases the present/absence was visualized by highlighting the whole area. Meaning if a text would say that the species is present in the North in sections A and B, then the sections A and B would be shown as areas of presence.

In general, data for some countries were only available at a very coarse grain while for others a combination of accuracy and generality was possible. Thus, our distribution maps result from compromises made to accommodate these different types of data and displaying a distribution information as accurate as possible. This type of problem can be resolved by getting data of National Forests Inventories from countries. Also by getting feedback from experts who worked on the species, and who could narrow down the global area of distribution.

2. Compiling data from maps published at different times, sometimes during different decades. For example, our main source of information for species in Morocco was the "Carte phytogéographique du Maroc" by Emberger dating from 1936, while at the same time we were provided with more recent data, compiled in the past years, such as the data provided by IDAF that were collected in 2013.
3. Difficulty in georeferencing and digitizing maps that were hand-drawn initially, with countries having different proportions. This led to some problems in accurately overlaying the georeferenced raster with the shapefile of countries. After the georeferencing, some areas showing the species' presence were distorted and therefore the digitized polygons were not accurately reproducing the information as seen on the initially published maps.

4. Since we were interested in creating maps on the scale of whole Mediterranean basin, some accurate data in small areas or countries (e.g. islands, Lebanon) could not be fully valorized. At the same time, whenever we digitized a map on the Mediterranean scale, the points or polygons created for these small areas were only “accurate” at that scale, making it impossible to accurately use them on the country, or island’s scale.
5. Another challenge we sometimes faced was the lack of specific data in maps available from the literature, particularly forest distribution maps when the species found in the forests were only described at the genus level.
6. Synonymy was also an issue in this work. Considering that some of the information we could retrieve was over 50 years old, some species names had changed, were merged with others or separated into different subspecies, and new accepted names agreed upon. For example in some references *Tetraclinis articulata* was described as *Callitris articulata*, also *Quercus canariensis* was described as *Quercus faginea*, (zeen oak).

Below, we indicate which steps could be taken in the future to improve the maps produced and use them to their fullest potential:

1. It would improve the accuracy of the countries of native distribution as well as the accuracy of the actual distribution, if a network of experts could provide their feedback on the maps. This could be done by posting the maps (in their figure format) on a website for consultation.
2. It would be very important, as mentioned earlier, to check the national inventories (when made available) to narrow down and describe with further accuracy the areas of distribution. This will be made easier if and when an international portal of national forest inventories is created (as underway for Europe at the European Forest Data Centre (EFDAC), <http://forest.jrc.ec.europa.eu/efdac/>).
3. To improve visualization of small forest patches (particularly of marginal and disjunct forests) and make full use of zooming options for data gathered at finer spatial scales, our current accurate data (particularly that extracted from national inventories or scientific publications) could be clustered into larger polygons visible on large scale maps. This would require designing a clustering algorithm adjustable to scale.
4. To tackle climate change and land use change issues, it would also be interesting to try and create maps of potential species distribution based on the biotic/abiotic conditions that make a habitat suitable for each species. Our maps of current distribution could be compared to those, providing a further idea of where major risks for Mediterranean forests and their genetic resources are located.



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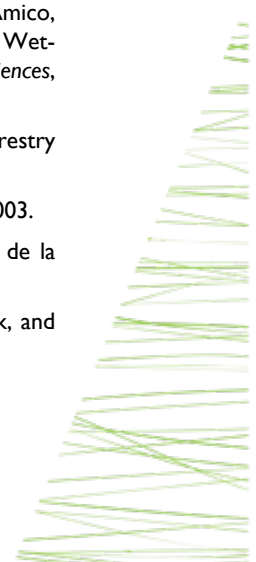
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# Bibliography

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- [1] Euro+med (2006-): Euro+Med PlantBase - the information resource for Euro-Mediterranean plant diversity, 2015.
- [2] F. Aytar, S. Dagdaş, and C. Duran. Biology and control of *Calomicrus apicalis* Demaison, 1891 (Col.: *Chrysomelidae*), a New Pest of *Cedrus libani* a. Rich. in Turkey. *Silva Lusitana*, pages 33–40, 2011.
- [3] A. Bigot, C. Floret, J.L. Guillerm, J.C. Jacquinet, and A. Soler. *Carte phyto-écologique de la Tunisie Septentrionale Feuille II Bizerte - Tunis*. CNRS/CEPE, 1965.
- [4] A. Bohnot, J. Aronson, and C. Fontaine. Répartition approximative des chêne-lièges (*Quercus suber*). 2005.
- [5] L. Boulos. *Flora of Egypt, Volume I: Azollaceae-Oxalidaceae*. I, 1999.
- [6] K. Browitz. *Chorology of trees and shrubs in South-West Asia and adjacent Regions*. 1982.
- [7] R.K. Brummit. *World geographical scheme for recording plant distributions, edition 2, plant taxonomic database standards no. 2, edition 2, international working group on taxonomic databases for plant sciences (TDWG)*. 2001.
- [8] A. Cuttelod, N. García, D. Abdul Malak, H. Temple, and V. Katariya. The Mediterranean: a biodiversity hotspot under threat. In J.-C. Vié, C. Hilton-Taylor, and S.N. Stuart, editors, *The 2008 Review of The IUCN Red List of Threatened Species*. IUCN Gland, Switzerland, 2008.
- [9] P.H. Davis. *Flora of turkey and the East Aegean islands*. Edinburgh at the University Press, 1978.
- [10] O. de Bolos and J. Vigo. *Flora dels països catalans*. I–IV, 1984–2001.
- [11] Direction Générale des Forêts. *Inventaire Forestier National, Algérie*. Direction Générale des Forêts, Alger, Algérie, 2003. 23
- [12] Louis Emberger. *Carte phytogéographique du Maroc*. Masson et Cie., Paris, France, 1971.
- [13] Atlas Florae Europaeae. *Atlas Florae Europaeae (AFE) — Distribution of Vascular Plants in Europe*. Societas Biologica Fennica Vanamo, Helsinki, Finland, 1999.
- [14] FAO. *National Forest and Tree Assessment and Inventory, TCP/LEB/2903. Final report*. FAO, Rome, 2005. 23
- [15] M. Fennane. *Flore pratique du Maroc, manuel de détermination des plantes vasculaires vol I: Pteridophyta, Gymnospermae, Angiospermae (Lauraceae- Neuradaceae)*. Institut Scientifique - Université Mohammed V - Agdal, Rabat, 1999.
- [16] J. Franklin. *Mapping species distributions: spatial inference and prediction*. Ecology Biodiversity and Conservation, Cambridge University Press, 2009.
- [17] M. Gounot, J.L. Guillerm, and A. Schoenenberger. *Carte phyto-écologique de la Tunisie Septentrionale Feuille I CAP BON – La Goulette – Sousse*. 1965.
- [18] N. Myers, R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca, and J. Kent. Biodiversity hotspots for conservation priorities. *Nature*, 403:853–858, 2000. 6
- [19] Orman Genel Müdürlüğü. *Atlas of Turkish Forests (Türkiye Orman Atlası)*. Orman Genel Müdürlüğü, Ankara, Turkey, 2013.
- [20] D.M. Olson, E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D’Amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoureux, W.W. Wetzel, P. Hedao, and K.R. Kassem. Terrestrial ecoregions of the world: a new map of life on earth. *Biosciences*, 51(114):933–938, 2001. 9, 13
- [21] M.A. Navarrete Poyatos. *Shapefiles of species occurrence in Lebanon*. Center for Applied Research in Agroforestry Development, IDAF, 2013. 23
- [22] P. Quézel and F. Médail. *Écologie et biogéographie des forêts du bassin méditerranéen*. Elsevier, Paris, France, 2003.
- [23] P. Quézel and S. Santa. *Nouvelle Flore de l’Algérie et des régions désertiques méridionales*. Centre national de la Recherche scientifique, Paris, France, 1962.
- [24] Y. Roskov, L. Abucay, T. Orrell, D.Nicolson, C.Flann, N.Bailly, P.Kirk, T.Bourgoin, R.E.DeWalt, W.Decock, and De A.Weaver. *Species 2000 and ITIS catalogue of life, 2016 annual checklist*. 2016.



- [25] S.J. Sinclair, M.D. White, and G.R. Newell. How useful are species distribution models for managing biodiversity under future climates? *Ecology and Society*, 15(1), 2010.
- [26] G. Long W. Greuter, H.M. Burdet and an international network of expert advisers. *Med-checklist: inventaire critique des plantes vasculaires des pays circumméditerranéens*. Genève: Berlin: Conservatoire et Jardin botaniques de la Ville de Genève; Secrétariat Med-checklist, Botanischer Garten and Botanisches Museum Berlin-Dahlem, 1984.
- [27] WCSP. *World Checklist of Selected Plant Families. Facilitated by the Royal Botanic Gardens, Kew*. Royal Botanic Gardens, Kew, UK, 2015.
- [28] John Wiecezorek, Markus Döring, Renato De Giovanni, Tim Robertson, and Dave Vieglais. *Darwin Core*. 2009.
- [29] F. Yaltirak. *Türkiyenin Meseleri Teshis Kılavuzu*. TOKB, İstanbul, 1984.

