CircumMed+Euro Pine Forest Database: an electronic archive for Mediterranean and European pine forests

Gianmaria Bonari*, Ilona Knollová, Pavla Vlčková, Fotios Xystrakis, Süleyman Çoban, Coşkun Sağlam, Yakiv P. Didukh, Stephan M. Hennekens, Alicia T.R. Acosta, Claudia Angiolini, Erwin Bergmeier, Andrea Bertacchi, José C. Costa, Emanuele Farfarillo, Daniela Gigante, Riccardo Guarino, Marco Landi, Carlos S. Neto, Simone Pesaresi, Leonardo Rosati, Federico Selvi, Alex Sotiriou, Adriano Stinca, Claudia Turcato, Rossen Tzonev, Daniele Viciani, & Milan Chytrý

Abstract

Large thematic databases of vegetation-plots are increasingly needed for vegetation studies and biodiversity research. In this paper, we present the CircumMed+Euro Pine Forest Database (GIVD ID: EU-00-026), which in September 2018 encompassed 5590 records from pine-dominated vegetation plots (relevés) and associated vegetation types from 23 countries of temperate Europe, Eastern Mediterranean and North Africa. These vegetation plots were collected through a detailed literature search for plots not included in the European Vegetation Archive (EVA). The database includes plots from 192 bibliographic references and unpublished vegetation plots by different authors. All vegetation plots are georeferenced, and coordinates are available with different accuracy as reported by the authors. The database is managed by the Vegetation Science Group, Department of Botany and Zoology of the Masaryk University in Brno (Czech Republic). It is registered in the Global Index of Vegetation-Plot Databases (GIVD) with the code EU-00-026 and is accessible through the European Vegetation Archive (EVA) or by asking the Custodian. The CircumMed+Euro Pine Forest Database is an important resource for conducting different types of broad-scale studies in the fields of vegetation classification, plant invasion ecology, macroecology and biological conservation.

Keywords: European Vegetation Archive **(**EVA); forest vegetation; Mediterranean Basin; phytosociology; pine forests; *Pinus*; relevé; Turboveg; vegetation plot.

Abbreviations: EVA = European Vegetation Archive; EU = European Union; EVS = European Vegetation Survey; GIVD = Global Index of Vegetation-Plot Databases.

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GIVD Fact Sheet

GIVD Database ID: EU-00-026			**Last update:** 2018-10-01
CircumMed+Euro Pine Forest database		**Web address:**	
Database manager(s): Gianmaria Bonari (gianmaria.bonari@gmail.com)			
Owner: Gianmaria Bonari			
Scope: The database stores pine-dominated vegetation plots and plots of related vegetation types from more than 20 countries across Europe and adjacent areas of the Mediterranean Basin.			
Availability: free upon request		**Online upload:** no	**Online search:** no
Database format(s): TURBOVEG		**Export format(s):** TURBOVEG	
Plot type(s): normal plots		**Plot-size range:** 4 to 2000 m^2	
Non-overlapping plots: 5590	**Estimate of existing plots:** 7000	**Completeness:** 80%	**Status:** completed and continuing
Total no. of plot observations: 5590	**Number of sources (bibliореferences, data collectors):** 192		**Valid taxa:** 0
Countries (%): AL: 0.2; BG: 1.7; CH: 0.01; CY: 4.7; CZ: 0.01; DZ: 6.4; ES: 2.3; FR: 2.9; GR: 17.1; HR: 1.6; IL: 7.9; IT: 18.9; LB: 1.1; MA: 1.4; PT: 0.7; RO: 0.3; RU: 0.5; SI: 0.03; SK: 0.05; SY: 0.9; TN: 0.1; TR: 36.0; UA: 1.5			
Formations: Forest: 90% = Terrestrial: 90% // Non Forest: 10% = Terrestrial: 10%			
Guilds: all vascular plants: 100%			
Environmental data (%): altitude: 84.9; soil pH: 1; other attributes: Codes of the habitat of Annex I of Habitats Directive: 4			
Performance measure(s): presence/absence only: 0%; cover: 100%			
Geographic localisation: GPS coordinates (precision 25 m or less): 9.2%; point coordinates less precise than GPS, up to 1 km: 29.4%; small grid (not coarser than 10 km): 47.6%; political units or only on a coarser scale (above 10 km): 13.7%			
Sampling periods: before 1930: 0%; 1930-1939: 0.7%; 1940-1949: 0.5%; 1950-1959: 0.2%; 1960-1969: 4.5%; 1970-1979: 16.8%; 1980-1989: 15.0%; 1990-1999: 15.0%; 2000-2009: 22.8%; 2010-2019: 16.4%; unknown: 0%			
Information as of 2018-10-01 further details and future updates available from http://www.givd.info/ID/EU-00-026			

Introduction

Electronic vegetation databases represent a new generation of repositories for plant community data, containing hundreds of thousands of vegetation-plot records (relevés). They support different types of biodiversity-related studies (Schaminée et al. 2009; Dengler et al. 2011). The number of different vegetation databases is growing rapidly, especially in Europe, giving hope that data collected in the field by many researchers over more than a century will be stored and widely available (Ríos-Saldaña et al. 2018), creating unprecedented opportunities for various research and applications. A new database presented in this paper was created for the purposes of the project of the Vegetation Science Group (Department of Botany and Zoology, Masaryk University, Brno), named "Formalized classification of European Mediterranean and temperate pine forests", started in October 2017. Its ultimate goal is to provide a classification of Mediterranean and European temperate pine forests based on an extensive vegetation-plot dataset. In the final stage, this project will provide classification, formal definitions and expert system for pine forest types.

In addition to being iconic trees, pines are of paramount importance for the northern hemisphere vegetation (Richardson 1998). Pine forests predominantly occur in continental Europe and in most of the countries bordering the Mediterranean Sea, while their presence in oceanic Europe is limited to the boreal zone, Scottish Highlands, and Iberia. They are very diverse forests since they occur across long gradients, ranging from the sea level to high mountains, in most places in severe ecological

conditions. Pines can grow on both base-rich and acidic substrates, as well as on sandy soils close to the sea, where the organic soil is lacking. The combination of the broad ecological tolerance of pine trees and their open canopy structure creates a broad variety of light, semi-open habitats (Bonari et al. 2017a, 2018). The variation in species composition in pine forests is therefore higher than in any other forest type (e.g., Bonari et al. 2017b), making them an extremely interesting subject of ecological research.

We present here the CircumMed+Euro Pine Forest Database, its data structure and its possible further uses in vegetation research as well as in the management and conservation of pine forests in temperate and Mediterranean Europe and adjacent areas.

Data collection

European Vegetation Archive (EVA; Chytrý et al. 2016; http://euroveg.org/eva-database) was used to retrieve already existing electronic vegetation plots from pine forests. We got a selection of 42,235 vegetation plots (retrieved on May 2018 May) in which the cover of native European pines was greater than or equal than 15%. We excluded the high-mountain species *Pinus cembra* and *P. mugo* subsp. *mugo*, and the mire specialist *P. mugo* subsp. *rotundata*. Then we planned data digitization in order to fill the gaps in EVA. We searched published pine forest plot records in several scientific journals considered the most relevant for this purpose (Supplement S1). We systematically reviewed all the volumes of these journals available on the internet and in the libraries of the Department of Botany and Zoology at Masaryk University and the Scientific-Technologic Area at the University of Siena. Other data derived from unpublished vegetation plots of the database contributors (co-authors of this paper), theses and from articles of other journals retrieved on the internet. Although a large majority of the digitized vegetation plots were sampled in natural pine forests, plots from pine plantations were also included, because they are often difficult to recognize from natural pine forests.

Structure and content of the database

The database structure is based on the standard header data fields of Turboveg v. 2.135b (Hennekens & Schaminée 2001), but several fields were added. The current database fields are reported in Supplement S2. Relatively rapid development of the database was possible thanks to the use of ABBYY FineReader Express Program v. 6.0, which was already used for digitizing vegetation plots for other databases (e.g., Landucci et al. 2015; Marcenò & Jiménez-Alfaro 2017). In particular, it was used for converting vegetation-plot tables from published papers into a database format when high-resolution PDF of the paper was available. When vegetation plots were in low-resolution PDF format or not suitable for the Optical Character Recognition (OCR) conversion, they were retyped manually.

In some cases, associated vegetation types were also digitized because vegetation plots were in the same table as the pine-forest plots. Before data storing in Turboveg v. 2.135b, all vegetation plots were double-checked by both the compiler (either G. Bonari or P. Vlčková) and the EVA data manager I. Knollová. The vegetation plots were georeferenced with Google Earth Pro v. 7.3.2.5491 using the locality reported by the original authors. Species nomenclature of the database follows the Turboveg checklist of European vascular plants adapted from Flora Europaea (Tutin et al. 1968–1980, 1993), although many additions were necessary, especially for Turkish and North African taxa. The database also includes bryophyte and lichen taxa when reported by original authors. Moreover, wherever information about vegetation-plot classification (i.e., class, order, alliance, association) was reported by original authors, including nomenclature types, it was stored.

In September 2018, CircumMed+Euro Pine Forest Database contained 5590 vegetation plots from 23 countries (Fig. 1). The proportion of vegetation plots dominated by different pine species within the CircumMed+Euro Pine Forest Database is reported in Table 1. Only 8% of plots were from unpublished sources, while the rest was digitized from 192 documents, including 159 papers from 73 journals, 18 theses, 6 books, 5 conference proceedings volumes and 4 other types (Supplement S3 for their full list). Most papers were from the journals *Ecologia Mediterranea* (15), *Turkish Journal of Botany* and *Fitosociologia* (7 each), *Phytocoenologia* and *Acta Botanica Croatica* (6 each), *Colloques Phytosociologiques*, *Documents Phytosociologiques* and *Parlatorea* (5 each). The countries with most newly digitized vegetation plots are Turkey (36%), Italy (19%) and Greece (17%; Fig. 2). The datasets with the largest vegetation-plot numbers for particular countries in the database are reported in Table 2. The sampled area is unknown for 13% of the vegetation plots due to lacking information in the original publications. However, the most frequently sampled areas range from 101 to 1000 m^2 (57%) and 11−100 m^2 (28%; Fig. 3A), in agreement with the established tradition forest vegetation sampling. Most of the vegetation plots are relatively species-poor, containing between 11−20 species (39%) and 21−30 species (21%; Fig. 3B), although there is a high variation in species richness (some vegetation plots have more than 80 species). Most of the vegetation plots were recorded in altitudinal ranges of 1001−1500 m a.s.l. (27%), 501−1000 (21%) and 101−500 (19%), although this information is missing for 15% of the vegetation plots (Fig. 3C). Most plots were sampled in the decades 1991−2000 and 2001−2010 (Fig. 3D), showing an increasing interest in this vegetation type starting from the 1980s. However, lacking dates of vegetation plots were replaced in the statistics by the year of publication minus one. All vegetation plots were georeferenced, 61% of them with a precision higher than 1 km. Other data available with a lower degree of completeness are total cover (45%), geology (34%), codes of the habitat of Annex I of Habitats Directive (4%) and pH (1%). A majority

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of plots are in the semi-restricted data availability regime (94%), while 6% are in the restricted access regime (see EVA website for definitions of the data access regimes).

After merging orthographic or other variants of the syntaxon names, the CircumMed+Euro Pine Forest Database contains 12 class names (13% of the vegetation plots contain this information); 28 order names (35%); 72 alliance names (44%); and 243 association names (59%). However, syntaxa need to be carefully revised in the future in order to identify synonyms and names that were not effectively or validly published. The high diversity of association names can be explained by the fact that most of the digitized vegetation plots come from geographically restricted studies where the authors described local communities. There are also 90 vegetation plots that have been designated as nomenclature types (most of them of associations).

Conclusions and future perspectives

Since 1 June 2018 the CircumMed+Euro Pine Forest Database is registered in the Global Index of Vegetation-Plot Databases (GIVD, http://www.givd.info) with the code EU-00-026 (CircumMed+Euro Pine Forest Database, https://www.givd.info/ID/EU-00-026). Moreover, it is a member database of the European Vegetation Archive (Chytrý et al. 2016). Future scientific and applied non-commercial projects dealing with vegetation classification, plant invasion patterns, macroecology, management and conservation can use data from this database. The CircumMed+Euro Pine Forest Database is still uploading data from missing vegetation types or geographic regions, although the level of data coverage for the Mediterranean Basin is already satisfying. Data can be obtained through EVA (http://euroveg.org/eva-database-obtaining-data) or by contacting the database custodian directly. Gianmaria Bonari and Milan Chytrý are respectively the Custodian and the Deputy Custodian of the CircumMed+Euro Pine Forest Database.

Author contributions

G.B. and M.C. conceived the idea of the database. G.B. and P.V. carried out the largest part of the data digitization. I.K. and S.M.H. helped with the database management. C.S. and S.C. provided most of the Turkish literature and refined the georeferencing for Turkish vegetation plots. F.X. provided a large part of the Greek literature and refined the georeferencing for Greek vegetation plots. Y.P.D. provided the Crimean data and refined the georeferencing for Crimean vegetation plots. E.B. provided Greek vegetation plots. J.C.C. and C.S.N. provided the Portuguese vegetation plots. R.T. provided the Bulgarian vegetation plots. A.S. provided the Cyprian vegetation plots. A.T.R.A., C.A., A.B., G.B., E.F., D.G., R.G., M.L., S.P., L.R., F.S., A.S., C.T. and D.V. provided the Italian vegetation

plots. G.B. wrote the paper, with contributions of M.C. All the authors commented on the manuscript before submission.

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Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., & Webb, D. A. (1968–1980). *Flora Europaea* (Vol. 2–5). Cambridge: Cambridge University Press.

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Figures & Tables

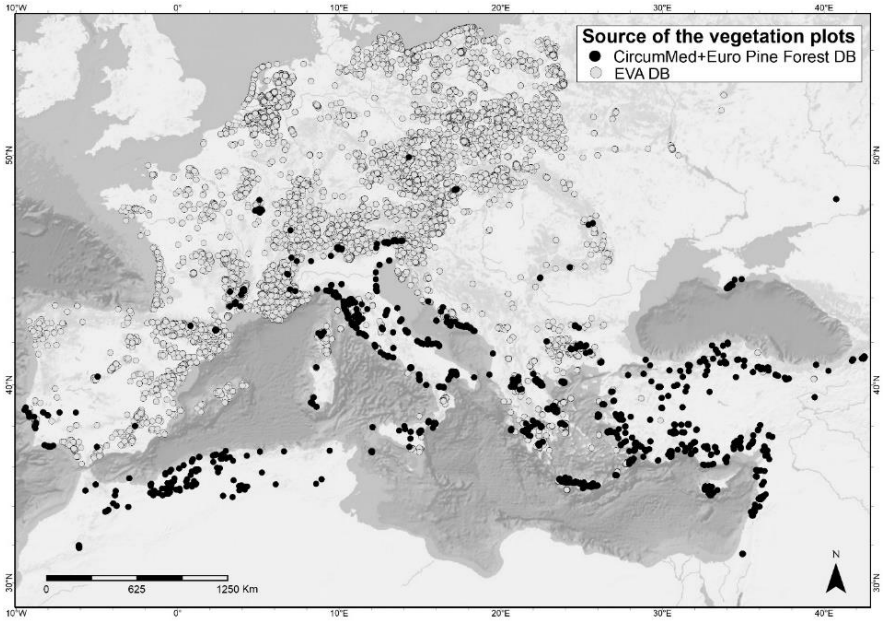

Fig. 1. Map of the georeferenced vegetation plots stored in the CircumMed+Euro Pine Forest Database in September 2018 (black circles) and pine dominated vegetation-plot selection from EVA (white circles).

Fig. 2. Numbers of vegetation plots per country in the CircumMed+Euro Pine Forest Database in September 2018.

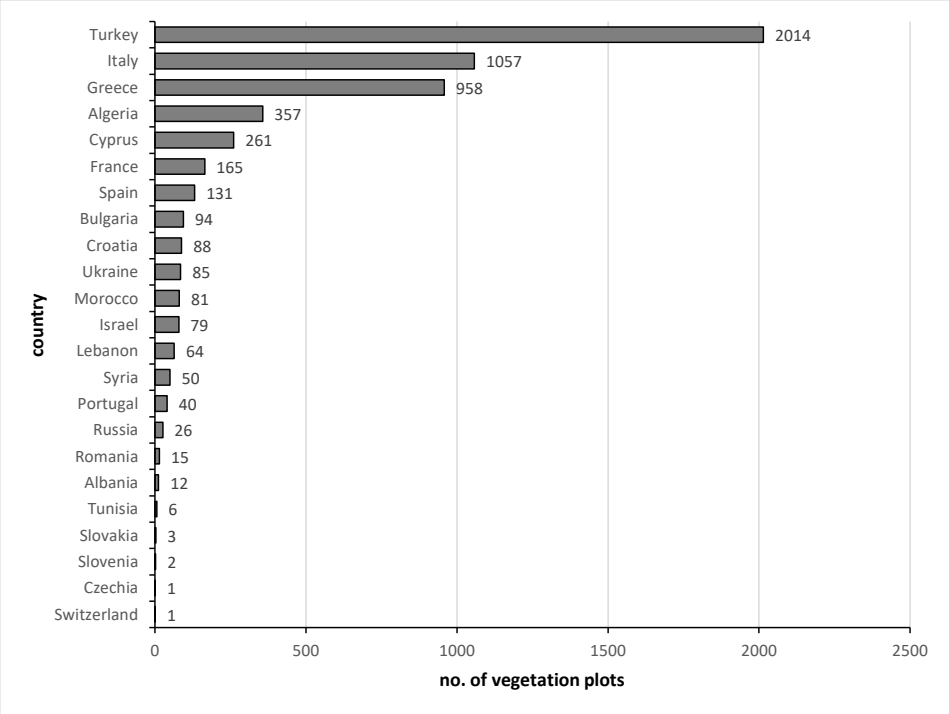

Fig. 3. Numbers of vegetation plots currently stored in the CircumMed+Euro Pine Forest Database in September 2018 for A) plot size; B) number of all species, including bryophytes and lichens; C) altitude; D) year.

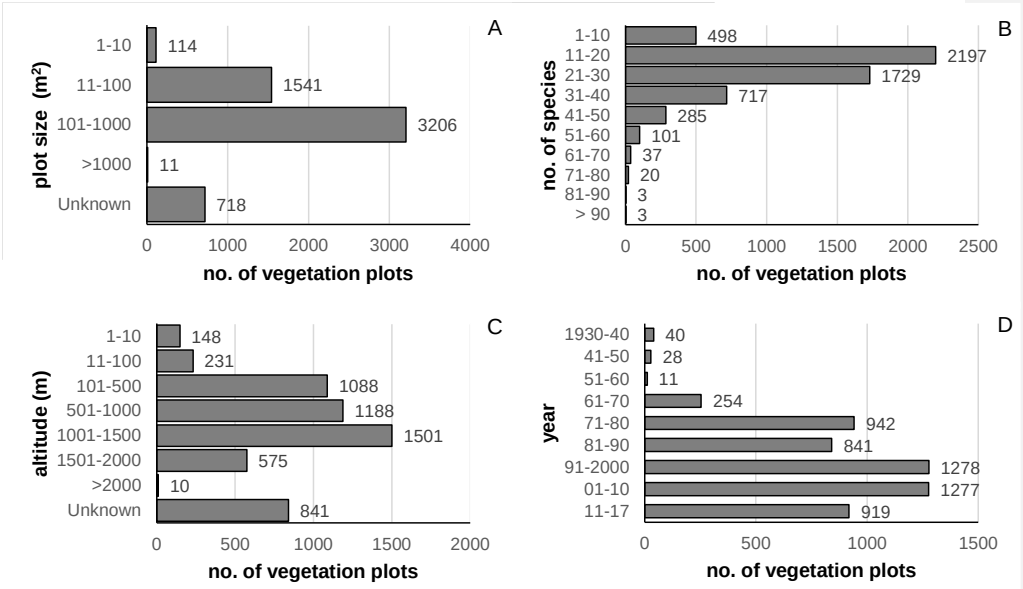

Table. 1. Proportion of vegetation plots dominated by different pine species in the CircumMed+Euro Pine Forest Database in September 2018.

Dominant pine species in the vegetation plot	Percentage (%)
Vegetation plots with the presence of one pine species > 15%	
Pinus brutia	14.4
Pinus halepensis	15.8
Pinus heldreichii	0.8
Pinus nigra aggr. (including subsp. *dalmatica, laricio, nigra, pallasiana* and *salzmannii*)	22.0
Pinus pinaster	5.7
Pinus pinea	5.6
Pinus sylvestris	7.8
Pinus uncinata	0.1
Vegetation plots with the presence of two or more pine species	
Co-dominated (*Pinus*) plots	7.5
Plots of other vegetation types	
Pine forest-related vegetation types with *Pinus* cover < 15% or no *Pinus* species	20.3

Table. 2. Publications with more than 50 vegetation plots for a given country in the CircumMed+Euro Pine Forest Database in September 2018. Full citations are available in Supplement S3.

N° of vegetation plots	Contribution	Country
255	Aksoy (1978)	Turkey
231	Bauer & Bergmeier (2011)	Greece
178	Sotiriou (2010)	Cyprus
175	Hadjadj-Aoul & Loisel (1999)	Algeria
161	Konstantinidis et al. (2012)	Greece
120	Akman et al. (1978)	Turkey
102	Baumgartner (1965)	Algeria
93	Tzonev et al. (2018)	Bulgaria
88	Akman et al. (1983)	Turkey
83	Quézel & Barbero (1988)	France
77	Özalp (1989)	Turkey
76	Barbero et al. (1976)	Syria
74	Ayaþlýgil (1987)	Turkey
73	Akman et al. (1979)	Turkey
71	Xystrakis (2009)	Greece
63	Barbero & Quézel (1979)	Cyprus
62	Aksoy et al. (2012)	Turkey
56	Habeck & Reif (1994)	Greece
55	Verroios & Georgiadis (2011)	Greece
53	Volk (1993)	Turkey
51	Brullo et al. (1998)	Greece
51	Bergmeier (2002)	Greece

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Electronic Supplements

Supplement S1: A literature survey was accomplished for the following scientific journals:

Acta Botanica Croatica, *Acta Botanica Gallica*, *Annali di Botanica*, *Archivio Geobotanico*, *Biologia*, *Braun-Blanquetia*, *Colloques Phytosociologiques*, *Delpinoa*, *Documents Phytosociologiques*, *Ecologia Mediterranea*, *Feddes Repertorium*, *Folia Geobotanica*, *Hacquetia*, *Informatore Botanico Italiano*, *Lazaroa*, *Phytocoenologia*, *Parlatorea*, *Studia Geobotanica*, *Tuexenia*.

Supplement S2: CircumMed+Euro Pine Forest Database fields. Asterisks indicate the fields in which information was present for all the vegetation plots stored by September 2018.

Database fields
Relevé number*
Cover abundance scale*
Country*
Nr. table in publication
Nr. relevé in table
Date
Relevé area (m^2)
Altitude (m)
Aspect (degrees)
Slope (degrees)
Cover total/tree/shrub/herb/moss/lichen layer (%)
Cover bare rock (%)
Height (highest/lowest) trees/shrubs (m)
Average height (high/lowest) herbs (cm)
Maximum height herbs (cm)
Mosses and lichens identified (y/n)
Latitude*
Longitude*
Precision* (m)
Locality
Author of the relevé
Association name
Alliance name
Order name
Class name
Geology
pH
EU Habitat (Annex I of Habitats Directive)
Holotypus
Privacy* (data availability regime)
Biblioreference*
Remarks
Data compiler*

Supplement S3: List of publications and other sources included in the CircumMed+Euro Pine Forest Database in September 2018.

Abdelkrim, H. (1988). Les formations steppiques à alfa (*Stipa tenacissima* L.): Autoécologie, syntaxonomie et importance pastorale. *Colloques Phytosociologiques*, *16*, 445–456.

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