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THE HISTORY OF EUROPEAN VEGETATION DATABASES: FROM RELEVÉ NOTEBOOKS TO A CONTINENTAL RESEARCH INFRASTRUCTURE

Chytrý Milan

Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic
chytry@sci.muni.cz

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Abstract – Europe holds the world's richest legacy of vegetation-plot data thanks to more than a century of phytosociological sampling. The past three decades transformed scattered, paper-based records from vegetation plots into interoperable, queryable databases, culminating in the European Vegetation Archive (EVA), a governed infrastructure that integrates national, regional, and thematic databases and enables continental syntheses. This historical overview traces the development from early relevé traditions to the present. The main periods include the first experimentations with information technologies in the 1960s–1980s, the digitization wave supported by the IAVS Working Group European Vegetation Survey in the 1990s, the applications of vegetation-plot databases beyond vegetation classification in the 2000s, the consolidation achieved by the establishment of EVA in the 2010s, and the emergence of new databases, FloraVeg.EU and ReSurveyEurope, alongside the gradual transition towards open science in the 2020s.

Keywords: Biodiversity informatics, database, ecoinformatics, Europe, European Vegetation Archive, phytosociology, plant community, relevé, vegetation change, vegetation classification, vegetation plot

Introduction

Vegetation-plot data, also called relevés in the phytosociological research tradition (Braun-Blanquet, 1928), are site-specific lists of plant species co-occurrences with cover-abundance estimates, supplemented with information about the location, environmental conditions, and sampling methods. These data have traditionally been sampled mainly for vegetation classification, but more recently they have been increasingly used for habitat monitoring and assessing vegetation change. Europe's early and sustained adoption of phytosociological standards created an unparalleled stock of such observations, which by the late 20th century existed primarily as paper records in published literature, unpublished research reports and field notebooks dispersed across individual researchers and institutions (Rodwell, 1995; Ewald, 2001; Schaminée et al., 2009). The digitization era converted this latent archive into a computational asset, first via national or thematic databases and later through continent-level integration in the European Vegetation Archive (EVA).

In this article, I briefly review the development of European vegetation databases from early attempts to the present. As I have been part of this process since the 1990s, this is partly a personal account of events. To some extent, it is based on my memory and perspective, and should be read as such rather than as a strictly objective history.

Historical roots: the phytosociological tradition

The Zürich–Montpellier school, founded by Josias Braun-Blanquet (1884–1980) in the 1910s–1920s, formalized the relevé: a standardized procedure to capture community

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composition within a plot using species lists, cover scales, and site descriptors (Braun-Blanquet, 1928). Since then, European botanists and ecologists have sampled millions of vegetation plots. The main aim of this effort was to create a hierarchical system of formally defined vegetation types, in the 1930s also coordinated by Braun-Blanquet under the title Prodrome groupements végétaux (Prodromus of Plant Communities; Braun-Blanquet, 1933 et seq.). Consequently, European vegetation-plot data provide a comprehensive empirical record across environmental gradients and land-use regimes, which is much denser than records on other continents (Bruelheide et al., 2019).

In this early period, when statistical data analysis had not yet been established in vegetation science, vegetation-plot data were just used to document the species composition of subjectively delineated vegetation types. Only much later did some innovative vegetation scientists consider them as primary data for analysis (e.g., Goodall, 1954).

Two features of these pioneer times were important for the digital future: (i) standardization – despite some regional differences (Guarino et al., 2018), researchers used comparable field protocols that made later integration feasible; and (ii) decentralization – data collections were dispersed in published literature and unpublished materials in institutions and archives of individual researchers, which required considerable efforts to integrate these data on single platforms.

Phytosociology meets information technologies (1960s–1980s)

In the 1960s, vegetation scientists began to consider computer-assisted analysis of vegetation-plot data. Ellenberg & Cristofolini (1964) introduced the use of punched cards for coding vegetation-plot data, and Benninghoff & Southworth (1964) presented the first computer-ordered phytosociological table. In 1968, Sandro Pignatti (Fig. 1), with Giovanni Cristofolini and Duilio Lausi, founded the Working Group for Data-Processing within the International Association for Vegetation Science (IAVS).

The main aims of this group were to develop a system for coding and storing vegetation-plot data and methods for their analysis, mainly multivariate classification and ordination (van der Maarel, 1974). The group organized regular meetings, and its members worked to support the research program of the Prodromus der europäischen Pflanzengesellschaften (Prodromus of European Plant Communities), initiated by Reinhold Tüxen to revive Braun-Blanquet's initiative from the 1930s (Tüxen, 1971). The University of Trieste team (Cristofolini, Lausi, and Pignatti) developed the data input system, and by 1974, the group stored 5500 vegetation-plot records, mainly of coastal salt marshes, on punched cards and tapes, which were used for experiments in numerical analysis of these data (van der Maarel, 1974). The first example of computer-assisted vegetation classification at the European scale was developed by Kortekaas et al. (1976), focusing on *Spartina*-dominated salt marsh communities. The group also published collections of methodological articles (e.g., van der Maarel et al., 1976; Mucina & van der Maarel, 1989) that significantly contributed to the adoption of numerical methods in vegetation science. However, Tüxen's Prodromus program did not continue, and most classical phytosociologists were reluctant to adopt new approaches, partly because computers were scarce at the time, and so were the skills to operate them. Consequently, little progress had been made in creating large databases of vegetation plots by the end of the 1980s, and van der Maarel (1989) concluded that European phytosociology had been stagnating.

Although international efforts to create large vegetation databases were not realized, there were remarkable initiatives in some countries:

Figure 1. Sandro Pignatti (1930–2025), a pioneer of data processing and databanking in vegetation science and founder of the IAVS Working group European Vegetation Survey. Photo from a conference excursion of the European Vegetation Survey in March 2015.

- In Switzerland, data from more than 5000 forest vegetation plots were stored as punched cards already in the 1960s, as a resource for the preparation of Swiss forest vegetation classification (Ellenberg & Klötzli, 1972). The development of the electronic database began at the Swiss Federal Institute for Forestry Experimentation (now WSL) in 1981, and by 1986, it contained data from more than 3000 forest plots (Sommerhalder et al., 1986; Wohlgemuth, 1992).
- In Italy, Sandro Pignatti's group at the University of Trieste started to create a network of national databases of Italian flora and vegetation in the second half of the 1970s (Nimis et al., 1984). They computerized approximately 6000 taxa, each with several characteristics, which served as the basis for Flora d'Italia (Pignatti, 1982). Although at that time, Pignatti and his team shifted their focus to preparing this flora, they also created a prototype databank of Italian vegetation, containing data from 450 beech forest plots (Nimis et al., 1984).
- In France, a small group of vegetation ecologists, including Henry Brisse, Patrice De Ruffray, and Gilles Grandjouan, began developing the database SOPHY in the 1970s. This database included data from France and adjacent areas. By 1995, it contained 63,640 vegetation plots and was likely the largest vegetation-plot database worldwide at that time (Brisse et al., 1995). However, this research group remained largely isolated from the international scientific community, and the database was inaccessible to researchers abroad. Even within France, it was only used to a limited extent.
- In the United Kingdom, the National Vegetation Classification project started in 1975, coordinated by John Rodwell (Fig. 2) from the University of Lancaster. In 1981, a national vegetation-plot database was created at this university, containing plots surveyed during the project and additional data from collaborators, including more than 31,000 vegetation plots (Rodwell, 1991–2000; Marshall et al., 2025). The project collaborators also developed original methods of data analysis, such as Twinspan, an algorithm and computer program for divisive classification of vegetation-plot data (Hill, 1979), which has been used internationally for vegetation classification ever since.
- In the former Czechoslovakia, the preparatory work for the national vegetation database started at the Institute of Botany of the Czechoslovak Academy of Sciences in Průhonice at the turn of the 1980s. Neuhäuslová & Kolbek (1982) prepared a standardized species list for this database, and in the late 1980s, Eduard Brabec developed the computer program FYT for storing and handling small sets of vegetation plots, which was used by different researchers. However, a proper national vegetation database was not established in the 1980s.
- In the Netherlands, the national vegetation database started in 1987, jointly with the project of national vegetation classification led by Joop Schaminée (Fig. 2; Schaminée et al., 1995–1999). A considerable sampling effort was associated with this project: more than 100,000 plots were sampled in the field only during 1990–1995. Consequently, the database soon became the largest vegetation-plot database in the world, with approximately 600,000 plots included by 2012 (Schaminée et al., 2012). The computer program Turboveg for storing and managing vegetation databases was developed by Stephan Hennekens within the framework of this project (Hennekens, 1995; Hennekens & Schaminée, 2001).

Figure. 2. Two visionary leaders of the European Vegetation Survey and its ambitious research program through the 1990s to 2010s: Joop Schaminée (left) and John Rodwell (right). Photo from a visit to Kröller-Müller Museum after a planning workshop of SynBioSys Europe in Wageningen, October 2001.

European Vegetation Survey and the start of the digitization wave (1990s)

New spirit in phytosociology

The early 1990s were a period of renewed activity in European vegetation science, which Sandro Pignatti called, "A new spirit in phytosociology" (Pignatti, 1995). The main drivers of these dynamics were (1) the rapidly increasing availability of affordable computing and database software, (2) the fall of the Iron Curtain, which lifted the previous barriers to international scientific collaboration at the continental scale, and (3) the foundation of the IAVS Working Group European Vegetation Survey (EVS). This group was founded by Sandro Pignatti, in collaboration with John Rodwell, Ladislav Mucina, Victor Westhoff, and other vegetation scientists, at a workshop at the Botanical Garden of Rome in March 1992. The aims of this group included supporting national vegetation survey programs and coordinating international vegetation survey activities (Mucina et al., 1993; Rodwell et al., 1995).

One of the main goals of the EVS group in its early years was to establish a standard format for storing vegetation-plot data and to provide data management software that would use that format. It was decided to adopt Turboveg, a program developed by Stephan Hennekens (Fig. 3) for the Dutch national vegetation survey project (Hennekens, 1995). At that time, Turboveg (running under the DOS operating system) was the most elaborate and flexible management system for vegetation-plot data. Moreover, Stephan Hennekens generously provided it at no cost to international EVS collaborators and offered technical support. Turboveg was demonstrated at the EVS meeting in 1994, and new functions were added based on user feedback. In 1995, Turboveg had already been installed in 10 European countries, including the Netherlands, Austria, Germany, Greece, Italy, Poland, Slovakia, Slovenia, Spain, and the United Kingdom (Schaminée & Hennekens, 1995). In 1998, Stephan Hennekens wrote version 2, which ran under Microsoft Windows (Hennekens & Schaminée, 2001). This version was also provided free to EVS members.

Darwin Initiative project

To support the development of European vegetation databases, John Rodwell secured funding from the Darwin Initiative, a UK government grant scheme for biodiversity conservation in low and middle income countries. In the 1990s, post-communist countries of Central and Eastern Europe were eligible. Therefore, the project "Safeguarding the Biodiversity of Eastern Europe" (1995–1998) aimed to foster collaboration between the Unit of Vegetation Science at Lancaster University and vegetation scientists from Albania, the Czech Republic, Latvia, Russia, and Slovakia. The idea was to invite early-career vegetation scientists from these countries for internships at Lancaster University, train them in vegetation-plot database management, motivate them to establish national vegetation-plot databases, create national communities of contributors and users of these data in the respective countries, and collaborate internationally within the European Vegetation Survey. I was lucky to be invited to this project as a national coordinator for the Czech Republic. In early 1996, we spent a month of intensive training at Lancaster University together with Petrit Hoda from Albania, Mara Pakalne from Latvia, Ayzik Solomeshch from Russia, and Milan Valachovič from Slovakia. John Rodwell shared his experience with us from the development of the British vegetation-plot database and its application in creating the National Vegetation Classification. His database assistant, Julian Dring, supported our technical work. Nevertheless, the turning point that reshaped our perspectives was the short visit of Stephan Hennekens, who was invited by John Rodwell to Lancaster to give us an introductory tutorial on Turboveg. He authorized us to provide Turboveg free of charge to all collaborators involved in vegetation database development in each of our countries. Subsequently, we prepared national versions of Turboveg by compiling standardized lists of species, authors, and bibliographic references, and distributed them to our collaborators. Some of these collaborators were also invited for short-term visits at Lancaster University, others were invited to Turboveg courses organized in each of the project countries. All of these courses were also attended by John Rodwell and Julian Dring. For the Czech Republic and Slovakia, we organized a joint course in Brno in February 1997. It was attended by 52 vegetation scientists and helped establish active national vegetation database networks in both countries. These networks supported projects of national vegetation classifications (Valachovič et al., 1995 et seq.; Chytrý 2007–2013) and became active in other applications of vegetation databases in the following years.

Databases of individual plots or species constancy tables?

In parallel to these database initiatives, Sandro Pignatti aimed to revive, for the second time, the idea of the Prodromus of European Plant Communities (Pignatti, 1990). However, he was aware that creating a European vegetation classification by analyzing a representative database of vegetation plots across Europe was still premature in the 1990s. The main reason was the lack of a continental-scale vegetation database, but there was also a lack of appropriate statistical methods, software, and experience in analyzing datasets of hundreds of thousands of vegetation plots, which would require considerable computer power. Therefore, in his Manifesto-style article in Annali di Botanica, Pignatti

Figure 3. Two innovators who have changed the game in European vegetation databanking and analyses of large vegetation-plot datasets: Stephan Hennekens, author of the Turboveg program for vegetation-plot data management (right), and Lubomír Tichý, author of the Juice program for analysis of these data (left). Photo from a short nature walk during a break in a workshop focused on developing technical solutions for the European Vegetation Archive, Brno, September 2012

(1995) proposed a pragmatic solution for creating a coarse classification of European vegetation based on the analysis of constancy columns of phytosociological synoptic tables. In this way, data from individual vegetation plots would be replaced by lists of species constancy (i.e., occurrence frequency) in previously defined plant community types in individual European regions. This approach would require much less digitization effort than digitizing individual plot data and would make data handling easier. Consequently, European vegetation classification could be completed within a timeframe of years rather than decades. The primary source of data for this work was the so-called Tabellarium, as Pignatti called it, i.e., a large phytosociological library in his office at the Botanical Garden of Rome. With collaborators from his group, including Enzo Dominici and Andrea Savoia Ubrizsy, he started digitizing constancy columns and preparing draft chapters for selected vegetation classes as prototypes for the future monograph of European vegetation. These prototypes were distributed to the participants of the European Vegetation Survey workshop in 1998. Stephan Hennekens also supported this work by adding an option for storing constancy columns in Turboveg.

However, this initiative of Pignatti was not followed by other members of the European Vegetation Survey. Most of those involved in vegetation databanking were already digitizing data from individual vegetation plots to create fine-scale vegetation classifications in their respective countries. Based on a questionnaire survey of database managers, Ewald (2001) estimated that at the turn of the 21st century, there were 775,000 digitized vegetation-plot observations (relevés) from Europe, although more than 60% were from the Netherlands and France. In contrast, the work on the European vegetation prodrome shifted to the compilation of databases of names of previously described vegetation units, excluding the underlying data from vegetation plots or constancy tables. This work began with an overview of European vegetation classes by Mucina (1997), continued with the creation of a database of European syntaxa by Julian Dring in John Rodwell‘s group (Rodwell et al. 2002), and culminated in a comprehensive hierarchical list of European vegetation units, colloquially known as EuroVegChecklist (Mucina et al., 2016).

New uses and perspectives for vegetation databases (2000s)

Analytical methods for large vegetation-plot databases: the Juice program

The growth of national vegetation databases brought new challenges for their users. These large volumes of data soon reached the limits of the dataset sizes accepted by analytical software available at the time, such as TWINSPAN (Hill, 1979), DECORANA (Hill & Gauch, 1980), PC-ORD (McCune, 1986), CANOCO (ter Braak, 1988), SYN-TAX (Podani, 1993), and MULVA (Wildi & Krüsi, 1993). Not only software but also existing analytical methods were developed for small (up to a few hundred vegetation plots) and relatively homogeneous datasets and were not always directly applicable to large, heterogeneous datasets collected from multiple sources. These problems were handled and partly resolved in large vegetation survey projects of the 1990s, namely in Britain (Rodwell, 1991–2000), the Netherlands (Schaminée et al., 1995a et seq.), and the German federal state Mecklenburg-Vorpommern (Berg et al., 2004; Dengler et al., 2005). However, many limitations persisted.

Inspired by these challenges, Lubomír Tichý (Fig. 3) at Masaryk University in Brno has begun developing the analytical program Juice since December 1998 (Tichý, 2002). Juice is a menu-driven software designed to handle large sets of vegetation-plot data, primarily for classification. Over time, a broad range of analytical methods, many of them original and also applicable beyond classification, were added (e.g., Chytrý et al., 2002; Kočí et al., 2003, Tichý & Chytrý, 2006; Roleček et al., 2009; Tichý et al., 2010; Lengyel et al., 2011). From the beginning, Juice was available as freeware online. In January and February 2001, Lubomír Tichý and I organized an international workshop on vegetation analysis using Juice in Brno, and over the next ten years, we repeated these courses in several universities and research centers in Europe and on other continents (e.g., Anchorage, Bilbao, Bratislava, Kyiv, Prague, Rennes, Roma, Stellenbosch, and Vácrátót). This software quickly spread among vegetation scientists thanks to its intuitive interface, clearly displayed data, and the availability of methods for vegetation analysis that were not available in other software packages at that time. Juice further stimulated the development of European vegetation-plot databases by providing tools to analyze these data, thereby motivating several vegetation scientists to create them. Some methods originally developed in Juice were later implemented in different R packages and code (e.g., Bruelheide et al., 2021; De Cáceres et al., 2025; von Lampe & Schellenberg, 2026).

Beyond classification: vegetation-plot databases for ecological research

With the increasing availability of large vegetation-plot databases, it has become clear that they have much broader potential for research and applications than simply creating vegetation classifications. Early examples of using large vegetation-plot databases to address questions other than classification included studies on broad-scale environmental gradients in species composition (Duckworth et al., 2000; Lososová et al., 2004), long-term vegetation change (Schaminée et al., 2002), identifying species pools and suitable habitats for individual species (Ewald, 2002; Chytrý et al., 2003; Münzbergová & Herben, 2004), analysing patterns of alpha and beta diversity (Willner et al., 2004), and the assessment of plant invasions across habitats (Chytrý et al., 2005).

An active forum discussing broader applications of vegetation-plot databases emerged within the German Working Group „Vegetationsdatenbanken“, organized by Jörg Ewald. Starting in 2002, this group held annual conferences hosted by different German universities, each dedicated to a broad research topic that can be studied using vegetation-plot databases. Although these meetings were mainly attended by German vegetation ecologists, they were open to international participants and also established collaborations with the IAVS Ecoinformatics Working Group.

To promote broader use of vegetation-plot databases within the European Vegetation Survey group, which had traditionally focused mainly on vegetation classification and survey, my colleagues at Masaryk University and I organized the 2008 European Vegetation Survey conference in Brno, with the topic "Using phytosociological data to address ecological questions" (Chytrý, 2008). This well-attended conference (with over 200 participants, one of the largest EVS conferences ever) contributed to the broad acceptance of vegetation-plot databases among European vegetation scientists as a resource not only for vegetation classification but also for (macro)ecological research.

An ambitious vision for the use of vegetation-plot data was developed by Joop Schaminée and Stephan Hennekens, who proposed SynBioSys, an information system integrating vegetation databases with data on species distributions, plant community types, and landscape characteristics into a single platform serving research and nature conservation. They developed SynBioSys for the Netherlands and intended to extend it to Europe (Schaminée et al., 2007). In the early 2000s, Joop Schaminée actively pushed this project forward, with support from several colleagues from the European Vegetation Survey. We held several workshops in Wageningen, during which we began preparatory work, in particular, matching plant taxon names and concepts used in different countries and Turboveg databases to a single standardized list (SynBioSys Taxon Database). However, we failed to secure funding for this project, and external circumstances were not yet optimal for this project on a European scale. Most notably, European vegetation-plot data were not yet integrated into a single database, were unavailable for several countries, and no up-to-date taxonomic list of European flora was available (Euro+Med PlantBase was incomplete at that time). Therefore, the SynBioSys Europe project was not realized.

Integration and consolidation: the European Vegetation Archive (2010s)

Collecting information about existing vegetation databases

Although vegetation-plot databases had been established in several European research groups by the late 2000s, there were obstacles to their use for European-scale syntheses. Part of these obstacles related to data property rights and the limited willingness of some database owners to share the data. Other obstacles were purely technical: each database managed in Turboveg used a different (national or regional) species list, and some databases were managed in custom-made software. Integration of such data required substantial effort. Moreover, there was no centralized or comprehensive body of information documenting the existence of databases across different European research groups and institutions. Consequently, it was difficult to determine not only where specific databases were maintained, but also what kind of data they contained, who managed them, and how they could be accessed. To summarize information on existing European databases, we sent a questionnaire to European vegetation scientists in 2008–2009 (Schaminée et al., 2009). Based on their responses, we identified the main national and regional databases and estimated that European databases contained data from more than 1,800,000 vegetation plots, of which approximately 60% were stored in Turboveg databases. The largest number of digitized plots per country existed in the Netherlands (~600,000), followed by France, the Czech Republic, and the UK.

The effort of documenting existing vegetation-plot databases was further developed by Jürgen Dengler and Florian Jansen. At the 9th Meeting of the German Working Group Vegetation Databases in Hamburg in February 2010, which was attended by many international participants, they proposed establishing the Global Index of Vegetation-plot Database (GIVD), an online platform with standardized metadata for each database. The platform, developed by Florian Jansen at www.givd.info, was quickly accepted by the international community of vegetation scientists. Only by the end of 2010 had 132 databases containing more than 2.4 million vegetation plots been registered (Dengler et al., 2011). A proceeding volume from the Hamburg meeting (Dengler et al., 2012) contained a series of reports on individual databases, some in a short format, including an abstract with a metadata table, others in a long format with a text describing the history, scope, and content of the database. Since then, such database reports have continued to be published in the journals Phytocoenologia (until 2020) and Vegetation Classification and Survey (since 2020).

European Vegetation Archive (EVA)

Once metadata about vegetation databases became available on a single platform, the time was ripe to integrate the data. I invited representatives of several large European databases, GIVD founders, and colleagues with taxonomic expertise to a meeting in Brno in February 2012. At this meeting, we discussed options for integrating European vegetation databases into a single platform that would provide consolidated datasets for continental-scale analyses. The culture of data sharing had not yet been established in the European vegetation science community: several database owners were reluctant to share their databases, which they had developed with significant effort, with other groups. Therefore, we adopted the model of the newly established TRY database of plant traits (Kattge et al., 2011): a semi-open database accessible only to those who contributed their data or received a recommendation from data contributors. Moreover, we prepared Data Property and Governance Rules declaring that the future European vegetation database will be a community initiative with an elected Coordinating Board and that all database providers will retain all rights to their data. These incentives worked well. At the 21st conference of the European Vegetation Survey in Vienna in May 2012, I could announce the foundation of the European Vegetation Archive (EVA), an integrated database of European vegetation plots, which at that time already contained nine databases with a total of 893,000 vegetation plots. Managers of most other databases recognized EVA‘s potential for future international research and expressed interest in joining this database.

Although a broad agreement on integrating European vegetation-plot databases was reached, technical solutions had yet to be developed. In particular, it was necessary to develop a database management system capable of handling multiple vegetation-plot databases that use different taxon lists. Stephan Hennekens took over this task and developed Turboveg 3 (Hennekens, 2015), which was not an update to Turboveg 2 (Hennekens & Schaminée, 2001) but a completely new program in which data are stored in a single SQL file rather than across multiple DBF files. In addition to features enabling the work with multiple taxonomies, Turboveg 3 also includes GIS features and many other new functions. The first data managers of EVA were Stephan Hennekens in Alterra, Wageningen, and Borja Jiménez-Alfaro and Ilona Knollová at Masaryk University, Brno. They performed extensive technical work converting the database formats received from multiple data contributors into a standardized format in Turboveg 3. This work also included quality control and often required time-consuming manual data editing. We regularly held management team meetings in Wageningen or Brno to coordinate our activities and address pending issues. At the same time, considerable effort was devoted to taxonomic matching across different databases. As the Euro+Med PlantBase was still incomplete, we used the SynBioSys Taxon Database, previously developed with significant input from experts in regional floras (Erwin Bergmeier, Jiří Danihelka, W. Bernard Dickoré, Nikolai Ermakov, and Rense Haveman). In the preparatory phase of EVA, this database was updated by Erwin Bergmeier, Luis Carlón, Jiří Danihelka, Jürgen Dengler, and Florian Jansen. Thanks to their efforts, as well as to many data contributors and teams of individual contributing databases, we could release the first version of EVA in spring 2014 and begin providing consolidated datasets of European vegetation plots to various research and applied projects (Chytrý et al., 2016).

The list of all contributing databases and descriptions of all projects that use EVA data have been published on the EVA website (https://euroveg.org/eva-database). This makes the system fully transparent. EVA data are also available to partners who do not contribute data,

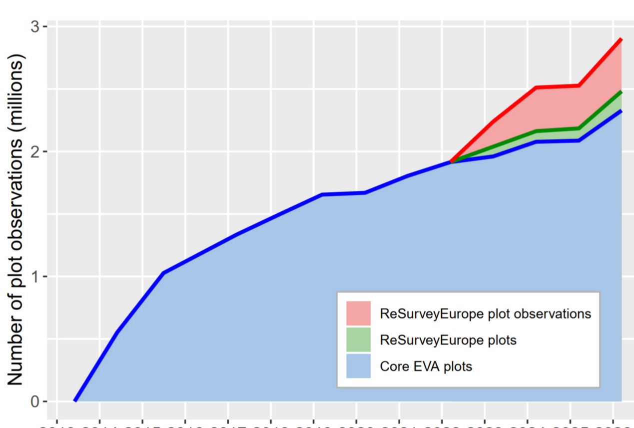

Figure 4. The increase in vegetation-plot observations in EVA, including ReSurveyEurope, over time. The core EVA plots are single-time records (observations) from individual plots. ReSurveyEurope counts are divided into plots (initial sampling) and (additional) plot observations (additional sampling of the same plots).

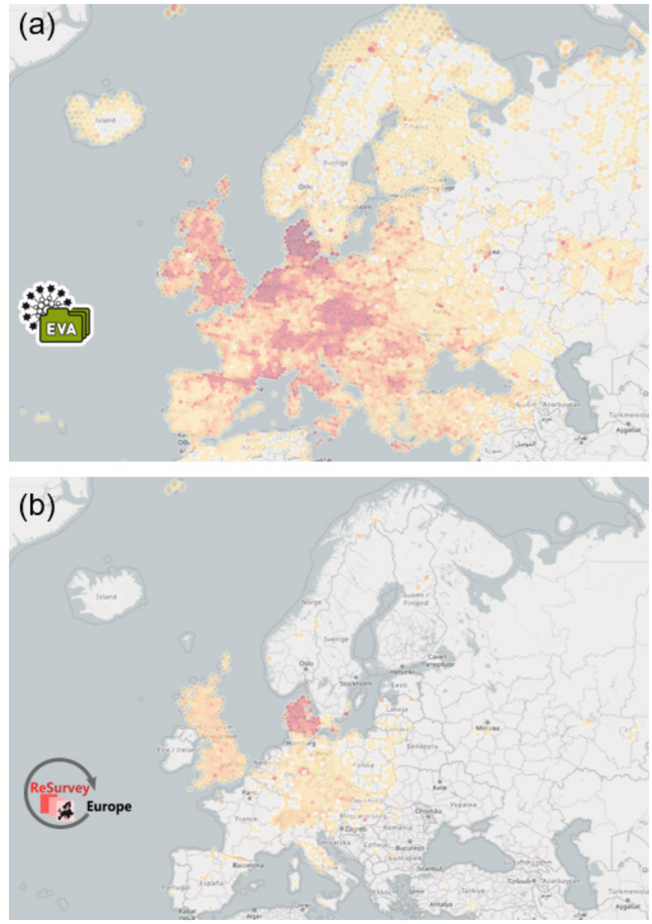

Figure 5. Distribution and density of vegetation plots in the European Vegetation Archive (ReSurveyEurope excluded; a) and ReSurveyEurope (b) in March 2026. Red colors indicate higher plot density. Map source: www.evamap.eu

upon recommendation by the custodian of one of the contributing databases. The very essence of EVA lies in the collaboration among research project leaders, data analysts, and data contributors. If data contributors express interest in a project that uses a significant portion of their data, they can be invited to help develop the study's concept, interpret the results, or provide other kinds of intellectual input. This is essential because data from different parts of Europe can be influenced by regionally unique ecological or biogeographical features, as well as by methodological approaches specific to certain regions. For the correct interpretation of broad-scale analyses, this regional knowledge of data contributors is often essential.Since 2017, the EVA Coordinating Board has also been publishing annual reports on EVA activities. These reports show the growth of the EVA database (Fig. 4), although there are considerable regional differences in data density (Fig. 5a). Publications based on EVA data are also listed on the EVA website (Fig. 6). This publication list demonstrates that EVA-based research is broadly accepted in top international scientific journals (e.g., Jiménez-Alfaro et al., 2018; Kambach et al., 2023; Leblanc et al., 2025; Midolo et al., 2026). Apart from purely scientific research in vegetation science, macroecology, and related fields, EVA data have also been used in applied research. Most notably, the European Environment Agency contracted a team of European Vegetation Survey experts to revise the EUNIS classification of European habitats (Rodwell et al., 2018) and characterize individual habitat types in terms of their distribution and species composition. This work, carried out from 2012 to 2021 under the leadership of Joop Schaminée, resulted in the EUNIS-ESy expert system, which classifies the entire EVA database into EUNIS habitat types, facilitating the use of EVA data in both conservation and habitat-contextualized research (Chytrý et al., 2020).

sPlot – a global vegetation database

The EVA database also helped to start sPlot, the global vegetation database. The idea of this database was proposed by Helge Bruelheide at a workshop in the newly established iDiv, German Centre for Integrative Biodiversity Research, in Leipzig in March 2013. We agreed that EVA would become an exclusive integrator of European databases for sPlot. The original idea of the sPlot team was to develop an entirely new online database management platform, but, as it proved too complicated, sPlot adopted Turboveg 3, the database management system developed by Stephan Hennekens for EVA. Also, the first two data managers of sPlot, Jürgen Dengler, and later on Borja Jiménez-Alfaro,

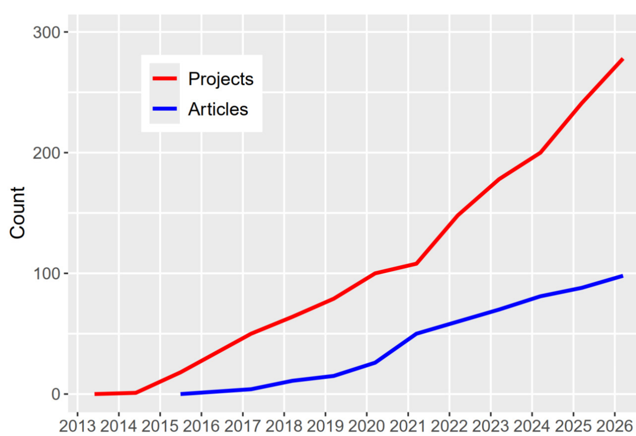

Figure 6. Cumulative counts of EVA (including ReSurveyEurope) projects and published journal articles. The number of articles lags behind the number of projects because some applied projects do not aim to produce scientific publications, and other projects have been canceled by their proponents or replaced by projects with modified data selection. Note a steeper increase in published articles between the COVID-19 years 2020 and 2021

were previously involved in EVA. Consequently, not only EVA data but also various EVA workflows were included in sPlot. sPlot reveals a huge concentration of digitized vegetation plots in Europe compared with other parts of the world. For example, sPlot version 2.1 contained data from 1,121,244 vegetation plots, of which 950,001 (85%) were from EVA (Bruelheide et al., 2019).

New databases, vegetation change, and open science (2020s)

FloraVeg.EU – a database of European syntaxa, habitat types, and flora

In 2016, after two decades of work, experts from the European Vegetation Survey, led by Ladislav Mucina, completed the EuroVegChecklist, a standard syntaxonomic classification of European vegetation (Mucina et al., 2016). This list comprised 1396 alliances nested in 377 orders and 149 classes. This large number of vegetation units with different kinds of associated information required a database, which was designed by Stephan Hennekens, who also developed an online browser published soon after the publication of the EuroVegChecklist article.

Just after the publication of the EuroVegChecklist, pan-European revisions of individual broad vegetation types based on EVA data began to appear, starting with Peterka et al. (2017) and Willner et al. (2017). As several of these studies proposed changes to the classification accepted in the EuroVegChecklist, it was necessary to make decisions and keep the standard European classification up to date. Therefore, the EVS group established the European Vegetation Classification Committee in 2017, which reviews these proposals and decides whether to accept them.

To track EuroVegChecklist changes and present its latest version, our Brno group developed an online database called FloraVeg.EU (Chytrý et al., 2024), which contains numbered versions of EuroVegChecklist and is updated after each decision of the European Vegetation Classification Committee. For this database, launched in spring 2022, we complemented the EuroVegChecklist with distribution maps and standardized, categorized attributes of 12 variables for all 1106 alliances dominated by vascular plants (Preislerová et al., 2022, 2024). We also incorporated into FloraVeg.EU the results of our previous work on EUNIS habitats, including habitat distribution maps and characteristic species combinations, and cross-linked EuroVegChecklist syntaxa with EUNIS habitat types. Finally, as FloraVeg.EU included information from Mucina et al. (2016) and Chytrý et al. (2020) on the affinities of a large number of plant species to individual vegetation classes and habitat types, we also included available information on biology, ecology, and biogeography of European plant species. Among others, species data included original datasets of indicator values (Midolo et al., 2023; Tichý et al., 2023) and plant dispersal (Lososová et al., 2023). In this way, FloraVeg.EU finally realized some of the ideas that we discussed twenty years earlier in the context of SynBioSys Europe.

ReSurveyEurope – a database of vegetation time series

Most data stored in European vegetation-plot databases are based on one-time records, typically collected for vegetation description. However, some of these records were made repeatedly in the same plots to study temporal vegetation change (Smits et al., 2002). As many databases were originally digitized for vegetation classification, these records were unfortunately often not identified as such during digitization, or their identification was inconsistent. Consequently, the potential of these data to study vegetation change across Europe was limited, with the exception of specialized databases such as forestREplot (deciduous forests; Verheyen et al., 2017), GLORIA (alpine summits; Pauli et al., 2015), and LOTVS (multiple records from the same plots; Sperandii et al., 2022).

In the meantime, research interest in vegetation change over time increased, especially in the context of global change research. When Joop Schaminée, Stephan Hennekens, John Rodwell, and I first presented the idea of the European Vegetation Archive at the European Environment Agency (EEA) in Copenhagen in 2012, we proposed it as a data source for the future revision of the EUNIS Habitat Classification. However, EEA officers considered assessing biodiversity change a more pressing task and asked us to conduct, in addition to working on EUNIS, a pilot study of vegetation change based on vegetation-plot databases. However, our tests showed that comparisons of older and newer records across different vegetation plots can often be misleading. Consequently, we considered assessing vegetation change from standard vegetation databases with non-revisited plots "risky business" and recommended that such assessments be based on data from permanent monitoring plots or resurveys of historical vegetation plots (Chytrý et al., 2014).

In the forthcoming years, as EVA became operational, we were fully occupied with exploring and using this unprecedented database for continental-scale revisions of vegetation and habitat classification, as well as for macroecological analyses. Therefore, the idea of using EVA to study vegetation change was temporarily put on hold. We revived this idea in discussions with Helge Bruelheide and Franz Essl in 2019 and 2020. We developed an idea of creating ReSurveyEurope, a European database of repeatedly sampled vegetation plots. In October 2020, we sent out a data call to EVA database custodians and many other colleagues across Europe who were known to us for their research on vegetation change. We received an overwhelming response, indicating that EVA was considered a trustworthy platform that helped create a data-sharing culture among European vegetation scientists. The timing during the COVID-19 lockdowns in 2020–2022 also contributed to the success of the ReSurveyEurope initiative, as during the period of restricted travel options, canceled conferences, and limited personal contact, many people had more time to prepare their datasets for inclusion in a continental database.

As in the initial phase of EVA, some technical preparations and extensive manual or semi-automatic work were required to integrate individual datasets. Stephan Hennekens was again helpful in extending the database structure for resurvey data, and most of the technical work was done by Ilona Knollová. However, because we used EVA's established infrastructure and associated workflows, the process was relatively smooth. ReSurveyEurope data have been released for projects since December 2022. The first ReSurveyEurope version contained 449 resurvey datasets, comprising 79,190 vegetation plots and 283,135 plot observations, i.e., repeated surveys of individual plots (Knollová et al., 2024). By March 2026, it contained 529 datasets, 153,480 plots, and 575,799 plot observations, and continued to grow (Fig. 5b).

Towards open science

Following the example of the TRY database, EVA was founded as a semi-closed database, i.e., custodians of individual databases retained the right to deny access to data in specific cases, but in practice, this has rarely happened. This arrangement, along with the possibility for data providers to participate in some research projects that use their data, was an attractive incentive that motivated many colleagues to spend time collecting and editing data for a community database. Individual data contributors have also benefited from various kinds of technical support from the EVA database managers. Nevertheless, the intention of the EVA initiative is to gradually move vegetation-plot data from a restricted-access regime to a fully open-access regime, in line with the FAIR principles of open science (Wilkinson et al., 2016). However, decisions about opening each dataset are fully in the hands of the respective data owners and providers.

All EVA versions and data selections for individual projects are stored in the EVA repository to enable reproducibility of research. To ensure these datasets are findable, they have been stored with Digital Object Identifiers (DOIs) since February 2023.

Large parts of the EVA database have already been opened. First, a stratified selection of 15,920 European vegetation plots was published permanently online as a part of sPlotOpen, an environmentally balanced global dataset of vegetation plots (Sabatini et al., 2021). In spring 2025, we published the header data of EVA vegetation plots in the online application EVA-MAP (Mertel et al., 2025). This application allows users to select EVA plot subsets using user-defined filters, display their locations on an interactive map, view various metadata fields, and export metadata to a spreadsheet. The willingness of EVA data providers to publish their datasets openly reflects a broader commitment within the EVA community to move gradually toward full data openness.

Some databases went even further. In 2018, the Dutch Vegetation Database, the largest European vegetation-plot database, was published in full open access through the Global Biodiversity Information Facility (GBIF) (Hennekens, 2018). Although the GBIF database primarily serves as a repository of species occurrence data, it enables structuring data as sampling events, meaning that species records from the same vegetation plot are kept together. The Dutch example was followed by the Polish Vegetation Database (Swacha et al., 2025) and the Czech Vegetation Database (Chytrý et al., 2026a). The entire Czech Vegetation Database was also published in different formats in Zenodo (https://doi.org/10.5281/zenodo.18289905) and on a dedicated website (https://czechveg.github.io), which also contain an environmentally balanced, stratified-resampled subset prepared for analyses at the national level, as well as tutorials for data analyses (Chytrý et al., 2026b). Other vegetation-plot databases publish open species occurrence data without preserving plot-level information (Kuzemko et al., 2024). It is likely that these examples will be followed by other databases in the future.

Conclusions

Over a century of vegetation-plot sampling in Europe created an empirical legacy unmatched anywhere in the world, but only in the past three decades have vegetation scientists begun to unlock its full potential. The digitization wave of the 1990s, catalyzed by the availability of Turboveg software, transformed scattered paper archives into interoperable datasets. Then, the establishment of the European Vegetation Archive in the 2010s was a turning point that created a new, collaborative culture in European vegetation science.

The future of vegetation databases will be shaped by new technologies, including machine learning and Artificial Intelligence (e.g., Leblanc et al., 2025; Si-Moussi et al., 2025), but it will also depend on researchers' willingness to adopt the FAIR principles of open science and collaborate across borders and disciplines, as well as on the continuation of high-quality field sampling. If this momentum continues, European vegetation-plot databases can become essential components of dynamic, multi-layered infrastructures capable of tracking biodiversity change with high spatial and temporal resolution.

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