

REPORT

ReSurveyEurope: A database of resurveyed vegetation plots in Europe

Ilona Knollová¹  | Milan Chytrý¹  | Helge Bruelheide^{2,3}  | Stefan Dullinger⁴  |
 Ute Jandt^{2,3}  | Markus Bernhardt-Römermann^{3,5}  | Idoia Biurrun⁶  |
 Francesco de Bello^{7,8}  | Michael Glaser⁹  | Stephan Hennekens¹⁰  |
 Florian Jansen¹¹  | Borja Jiménez-Alfaro¹²  | Daniel Kadaš¹  | Ekin Kaplan^{9,13}  |
 Klára Klinkovská¹  | Bernd Lenzner⁹  | Harald Pauli^{14,15}  | Marta Gaia Sperandii¹  |
 Kris Verheyen¹⁶  | Manuela Winkler^{14,15}  | Otari Abdaladze¹⁷  | Svetlana Ačić¹⁸  |
 Alicia T. R. Acosta¹⁹  | Audrey Alignier^{20,21}  | Christopher Andrews²²  |
 Raphaël Arlettaz²³  | Fabio Attorre²⁴  | Irena Axmanová¹  | Manuel Babbì²⁵  |
 Lander Baeten¹⁶  | Jakub Baran²⁶  | Elena Barni²⁷  | José-Luis Benito-Alonso^{28,29}  |
 Christian Berg³⁰  | Ariel Bergamini³¹  | Imre Berki³²  | Steffen Boch³¹  |
 Barbara Bock³³  | Frank Bode³⁴  | Gianmaria Bonari³⁵  | Karel Boublík³⁶  |
 Andrea J. Britton³⁷  | Jörg Brunet³⁸  | Vanessa Bruzzaniti^{39,40}  | Serge Buholzer⁴¹  |
 Sabina Burrascano²⁴  | Juan A. Campos⁶  | Bengt-Göran Carlsson⁴²  |
 Maria Laura Carranza⁴³  | Tomáš Černý⁴⁴  | Kévin Charmillot⁴⁵  |
 Alessandro Chiarucci³⁹  | Philippe Choler⁴⁶  | Kryštof Chytrý^{1,4}  |
 Emmanuel Corcket⁴⁷  | Anikó Csecserits⁴⁸  | Maurizio Cutini¹⁹  |
 Marta Czarniecka-Wiera⁴⁹  | Jiří Danihelka^{1,50}  | Maria Carla de Francesco⁴³  |
 Pieter De Frenne¹⁶  | Michele Di Musciano^{39,51}  | Michele De Sanctis²⁴  |
 Balázs Deák⁵²  | Guillaume Decocq⁵³  | Iwona Dembiczyńska⁵⁴  | Jürgen Dengler^{55,56}  |
 Valter Di Cecco⁵⁷  | Jan Dick⁵⁸  | Martin Diekmann⁵⁹  | Hartmut Dierschke^{60,†}  |
 Thomas Dirnböck⁶¹  | Inken Doerfler⁶²  | Jiří Doležal^{63,64}  | Ute Döring⁶⁵  |
 Tomasz Durak⁶⁶  | Ciara Dwyer⁶⁷  | Rasmus Ejrnæs⁶⁸  | Inna Ermakova⁶⁹  |
 Brigitta Erschbamer⁷⁰  | Giuliano Fanelli²⁴  | María-Rosa Fernández-Calzado⁷¹  |
 Thomas Fickert⁷²  | Andrea Fischer⁷³  | Markus Fischer⁷⁴  | Kacper Foremnik⁷⁵  |
 Jan Frouz⁷⁶  | Ricardo García-González²⁹  | Daniel García-Magro⁶  |
 Itziar García-Mijangos⁶  | Rosario G. Gavilán⁷⁷  | Mateja Germ⁷⁸  | Dany Ghosn⁷⁹  |
 Khatuna Gigauri⁸⁰  | Jaroslav Gizela⁸¹  | Aleksandra Golob⁷⁸  | Valentin Golub⁸²  |

†Deceased.

For Affiliation refer page on 12

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2024 The Authors. *Journal of Vegetation Science* published by John Wiley & Sons Ltd on behalf of International Association for Vegetation Science.



Daniel Gómez-García⁸³ ^{ib} | David Gowing⁸⁴ ^{ib} | John-Arvid Grytnes⁸⁵ ^{ib} |
 Behlül Güler⁸⁶ ^{ib} | Alba Gutiérrez-Girón⁷⁷ ^{ib} | Peter Haase^{87,88} ^{ib} | Sylvia Haider^{2,3,89} ^{ib} |
 Michal Hájek¹ ^{ib} | Melinda Halassy⁹⁰ ^{ib} | Martin Harásek⁹¹ | Werner Härdtle⁹² ^{ib} |
 Thilo Heinken⁹³ ^{ib} | Alison Hester³⁷ | Jean-Yves Humbert²³ ^{ib} | Ricardo Ibáñez⁹⁴ ^{ib} |
 Estela Illa⁹⁵ ^{ib} | Bogdan Jaroszewicz⁹⁶ ^{ib} | Kai Jensen⁹⁷ ^{ib} | Anke Jentsch⁹⁸ ^{ib} |
 Martin Jiroušek^{1,99} ^{ib} | Veronika Kalníková¹⁰⁰ ^{ib} | Róbert Kanka¹⁰¹ ^{ib} | Jutta Kapfer¹⁰² ^{ib} |
 George Kazakis⁷⁹ | Janez Kermavnar¹⁰³ ^{ib} | Stefan Kesting¹⁰⁴ | Larisa Khanina¹⁰⁵ ^{ib} |
 Elisabeth Kindermann¹⁰⁶ ^{ib} | Marek Kotrík¹⁰⁷ ^{ib} | Tomáš Koutecký¹⁰⁸ ^{ib} |
 Łukasz Kozub⁵⁴ ^{ib} | Gisbert Kuhn¹⁰⁹ | Lado Kutnar¹⁰³ ^{ib} | Dario La Montagna²⁴ ^{ib} |
 Andrea Lamprecht^{14,15} ^{ib} | Jonathan Lenoir⁵³ ^{ib} | Jan Lepš^{64,110} ^{ib} |
 Christoph Leuschner¹¹¹ | Juan Lorite^{71,112} ^{ib} | Bjarke Madsen^{113,114} ^{ib} |
 Rosina Magaña Ugarte⁷⁷ ^{ib} | Marek Malicki^{115,116} ^{ib} | Tuija Maliniemi¹¹⁷ ^{ib} |
 František Máliš¹⁰⁷ ^{ib} | Alexander Maringer³³ ^{ib} | Robert Marrs¹¹⁸ ^{ib} |
 Silvia Matesanz¹¹⁹ ^{ib} | Katrin Metze¹²⁰ | Stefan Meyer^{121,122} ^{ib} | Jonathan Millett¹²³ ^{ib} |
 Ruth J. Mitchell³⁷ ^{ib} | Jesper Erenskjold Moeslund⁶⁸ ^{ib} | Pavel Moiseev¹²⁴ ^{ib} |
 Umberto Morra di Cella¹²⁵ ^{ib} | Ondřej Mudrák¹²⁶ ^{ib} | Frank Müller¹²⁷ ^{ib} |
 Norbert Müller¹²⁸ ^{ib} | Tobias Naaf¹²⁹ ^{ib} | Laszlo Nagy¹³⁰ | Francesca Napoleone²⁴ ^{ib} |
 Juri Nascimbene³⁹ ^{ib} | Jana Navrátilová¹³¹ | Josep M. Ninot⁹⁵ ^{ib} | Yujie Niu⁹⁸ ^{ib} |
 Signe Normand¹³² ^{ib} | Romá Ogaya^{133,134} ^{ib} | Vladimir Onipchenko⁶⁹ ^{ib} |
 Anna Orczewska¹³⁵ ^{ib} | Adrienne Ortmann-Ajkai¹³⁶ ^{ib} | Robin J. Pakeman³⁷ ^{ib} |
 Iker Pardo⁶ ^{ib} | Ricarda Pätsch¹ ^{ib} | Robert K. Peet¹³⁷ ^{ib} | Josep Penuelas^{133,134} ^{ib} |
 Cord Peppeler-Lisbach⁶² ^{ib} | Javier Pérez-Hernández⁷⁷ ^{ib} | Aaron Pérez-Haase⁹⁵ ^{ib} |
 Alessandro Petraglia¹³⁸ ^{ib} | Petr Petřík^{36,139} ^{ib} | Remigiusz Pielech^{140,141} ^{ib} |
 Hubert Piórkowski¹⁴² ^{ib} | Eulàlia Pladevall-Izard⁹⁵ ^{ib} | Peter Poschlod¹⁴³ ^{ib} |
 Karel Prach⁶⁴ ^{ib} | Safiya Praleskouskaya¹⁴⁴ ^{ib} | Vadim Prokhorov^{145,146} |
 Sam Provoost¹⁴⁷ ^{ib} | Mihai Pușcaș^{148,149} ^{ib} | Štěpánka Pustková¹ ^{ib} |
 Christophe François Randin^{150,151} ^{ib} | Valerijus Rašomavičius¹⁵² ^{ib} |
 Kamila Reczyńska¹¹⁵ ^{ib} | Tamás Rédei⁴⁸ ^{ib} | Klára Řehounková⁶⁴ ^{ib} | Nina Richner¹⁵³ ^{ib} |
 Anita C. Risch¹⁵⁴ ^{ib} | Christian Rixen^{155,156} ^{ib} | Sergey Rosbakh¹⁵⁷ ^{ib} |
 Christiane Roscher^{3,158} ^{ib} | Gert Rosenthal¹⁵⁹ | Graziano Rossi¹⁶⁰ ^{ib} | Harald Rötzer¹⁶¹ |
 Camille Roux¹⁶² ^{ib} | Sabine B. Rumpf¹⁶³ ^{ib} | Eszter Ruprecht¹⁶⁴ ^{ib} | Solvita Rūsiņa¹⁶⁵ ^{ib} |
 Irati Sanz-Zubizarreta⁶ ^{ib} | Meret Schindler⁵⁵ | Wolfgang Schmidt¹⁶⁶ ^{ib} |
 Dirk Schories¹⁶⁷ | Joachim Schrautzer¹⁶⁸ ^{ib} | Hendrik Schubert¹⁶⁹ ^{ib} | Martin Schuetz¹⁵⁴ ^{ib} |
 Angelika Schwabe¹⁷⁰ ^{ib} | Helena Schwaiger⁴ | Peter Schwartz¹⁷¹ ^{ib} | Jan Šebesta¹⁰⁸ ^{ib} |
 Hallie Seiler⁵⁵ ^{ib} | Urban Šilc¹⁷² ^{ib} | Vasco Silva^{173,174} ^{ib} | Petr Šmilauer¹⁷⁵ ^{ib} |
 Marie Šmilauerová⁶⁴ ^{ib} | Thomas Sperle¹⁷⁶ ^{ib} | Alina Stachurska-Swakoń¹⁷⁷ ^{ib} |
 Nils Stanik¹⁵⁹ ^{ib} | Angela Stanisci⁴³ ^{ib} | Kristina Steffen¹⁷⁸ | Christian Storm¹⁷⁰ ^{ib} |
 Hans Georg Stroh¹⁷⁹ ^{ib} | Nadezhda Sugorkina⁶⁹ | Krzysztof Świerkosz¹⁸⁰ ^{ib} |



Sebastian Świerszcz^{49,181} | Magdalena Szymura⁴⁹ | Balázs Teleki¹⁸² |
 Gilles Thébaud¹⁶² | Jean-Paul Theurillat^{183,184} | Lubomír Tichý¹ |
 Urs A. Treier^{113,185} | Pavel Dan Turtureanu^{148,186,187} | Karol Ujházy¹⁰⁷ |
 Mariana Ujházyová¹⁸⁸ | Tudor Mihai Ursu¹⁸⁹ | Aldona K. Uziębło¹⁹⁰ |
 Orsolya Valkó⁵² | Hans Van Calster¹⁹¹ | Koenraad Van Meerbeek^{192,193} |
 Bart Vandevoorde¹⁹⁴ | Vigdis Vandvik⁸⁵ | Marco Varricchione⁴³ | Kiril Vassilev¹⁹⁵ |
 Luis Villar¹⁹⁶ | Risto Virtanen¹⁹⁷ | Pascal Vittoz¹⁹⁸ | Winfried Voigt⁵ |
 Andreas von Hessberg¹⁹⁹ | Goddert von Oheimb²⁰⁰ | Eva Wagner²⁰¹ |
 Gian-Reto Walther²⁰² | Camilla Wellstein¹⁰⁶ | Karsten Wesche^{122,203} |
 Markus Wilhelm²⁰⁴ | Wolfgang Willner⁴ | Sonja Wipf^{155,205} |
 Burghard Wittig^{206,207} | Thomas Wohlgemuth²⁰⁸ | Ben A. Woodcock²⁰⁹ |
 Monika Wulf²¹⁰ | Franz Essl⁹

Correspondence

Franz Essl, Division of BioInvasions, Global Change & Macroecology, Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria.
 Email: franz.essl@univie.ac.at

Abstract

Aims: We introduce ReSurveyEurope — a new data source of resurveyed vegetation plots in Europe, compiled by a collaborative network of vegetation scientists. We describe the scope of this initiative, provide an overview of currently available data, governance, data contribution rules, and accessibility. In addition, we outline further steps, including potential research questions.

Results: ReSurveyEurope includes resurveyed vegetation plots from all habitats. Version 1.0 of ReSurveyEurope contains 283,135 observations (i.e., individual surveys of each plot) from 79,190 plots sampled in 449 independent resurvey projects. Of these, 62,139 (78%) are permanent plots, that is, marked in situ, or located with GPS, which allow for high spatial accuracy in resurvey. The remaining 17,051 (22%) plots are from studies in which plots from the initial survey could not be exactly relocated. Four data sets, which together account for 28,470 (36%) plots, provide only presence/absence information on plant species, while the remaining 50,720 (64%) plots contain abundance information (e.g., percentage cover or cover–abundance classes such as variants of the Braun-Blanquet scale). The oldest plots were sampled in 1911 in the Swiss Alps, while most plots were sampled between 1950 and 2020.

Conclusions: ReSurveyEurope is a new resource to address a wide range of research questions on fine-scale changes in European vegetation. The initiative is devoted to an inclusive and transparent governance and data usage approach, based on slightly adapted rules of the well-established European Vegetation Archive (EVA). ReSurveyEurope data are ready for use, and proposals for analyses of the data set can be submitted at any time to the coordinators. Still, further data contributions are highly welcome.

KEYWORDS

biodiversity, community ecology, database, macroecology, monitoring, relevé, species richness, temporal change, time series, vascular plants, vegetation dynamics

1 | INTRODUCTION

Plot-based vegetation samples, called vegetation plots henceforth, document plant species diversity and community composition at a given location at a given time. Such data allow for a wide variety of research questions to be addressed, and accordingly, they have been widely used in vegetation ecology for more than a century (e.g., Braun-Blanquet, 1964; Ellenberg & Leuschner, 2017). More recently, the mobilization of vegetation-plot data, and their compilation in large repositories such as the European Vegetation Archive (EVA, <http://euroveg.org/eva-database>) and the global vegetation database sPlot (<https://www.idiv.de/de/splot.html>) have substantially expanded the availability of these types of data (Schaminée et al., 2009; Dengler et al., 2011).

Vegetation plots also contain metadata (Mucina et al., 2000) that describe properties of the surveyed site (e.g., topography, land use, slope inclination and aspect), the plot (e.g., size, shape), and the sampling (e.g., date of sampling, surveyor name). In most cases, information on the location of the vegetation plot is provided, although this information may be given in a variety of ways and with different geographic accuracies, ranging from vague textual descriptions of localities to highly accurate geographic coordinates based on GPS data or permanent marks in the field.

Increasing human pressures on the natural environment during the last decades have caused substantial changes in the European flora and vegetation (e.g., Richner et al., 2015; Jandt, Bruehlheide, Jansen, et al., 2022). Vegetation-plot data offer excellent opportunities to study temporal vegetation changes with fine resolution across large areas by resurveying historical vegetation plots, or by establishing permanent plots that are revisited on a regular basis. In recent decades, an increasing number of studies have used these approaches for studying large-scale (including continental and global) vegetation change in response to pressures such as land-use change (e.g., Nielsen et al., 2021), climate change (e.g., Gottfried et al., 2012; Steinbauer et al., 2018), eutrophication (e.g., Peppeler-Lisbach et al., 2020; Ridding et al., 2020; Kammer et al., 2022; Staude et al., 2022), and biological invasions (e.g., Del Vecchio et al., 2015).

The number of publications (and corresponding data sets) based on resurveyed vegetation plots in Europe (and elsewhere) has increased strongly since the start of the new millennium (Figure 1). While some initiatives with a focus on specific habitats such as forests (forestREplot, <https://forestreplot.ugent.be/>) and alpine environments (GLORIA, <https://www.gloria.ac.at/hom/>) have integrated a part of these data, many resurvey data sets are not yet integrated into large data repositories that ensure easy access and interoperability of the data. As a consequence, the potential of using existing data to address research questions remains limited. Therefore, we launched ReSurveyEurope in 2020 to fill this gap at the European level. ReSurveyEurope is closely connected to the European Vegetation Archive and aims to build a data repository of fine-scale plot-based plant community resurvey data (relevés, plots). Here, we describe the scope of this initiative, provide

an overview on data, governance rules, accessibility, and outline further steps of how to ensure that ReSurveyEurope stays a living database.

2 | COMPILATION AND CONTENT OF THE ReSurveyEurope 1.0 DATABASE

2.1 | Scope of ReSurveyEurope

The geographic scope of ReSurveyEurope is the continent of Europe, including adjacent, biogeographically similar areas such as the Macaronesian Islands (excluding Cape Verde), Greenland, Georgia, Armenia, Azerbaijan, Anatolia, Cyprus, and the Mediterranean Biome in northern Africa and the Near East. Suitable data sets are fine-grain biodiversity data (e.g., vegetation plots, relevés, transects) from all habitats that document the presence (and ideally also proxies of the cover) of vascular plants (and optionally bryophytes and lichens) with at least two repeated observations (i.e., individual surveys of each plot) in different years. Observations have to be made with identical or at least similar and comparable methods at the same or a similar location close by.

To be suitable for ReSurveyEurope, data sets have to fulfill a set of minimum requirements: (i) a complete list of vascular plants in defined plots, preferably also with information on species cover or proxies for cover such as biomass; (ii) plot location including longitude and latitude, and information on the precision of the coordinates; (iii) sampling date (ideally the precise date, minimum the year); and (iv) plot size (see Appendix S1 for details). Further, information on the methods of data collection, total vegetation cover, elevation, slope inclination and aspect, bedrock, land use, recent land-use change and vegetation or habitat type are welcome to increase the value of the data set.

2.2 | Data preparation, integration and taxonomic standardization

The first data call for ReSurveyEurope was announced on October 6, 2020 (http://euroveg.org/download/ReSurveyEurope_EVA_Call.pdf). Data contributors were asked to ideally provide their data in Turboveg 2 format (Hennekens & Schaminée, 2001), with a set of pre-defined header data fields following the guidelines in Appendix S1. For easier data preparation, providers can download the database structure with the standard database fields from <https://www.synbiosa.alterra.nl/turboveg/> (under Database dictionaries/ReSurvey) using Turboveg 2 version 2.148 or higher.

All databases in ReSurveyEurope are stored and managed in Turboveg 2 using national species lists as the taxonomic backbone for the individual databases. The header data were checked and, if necessary, standardized by the first author of this article before integrating the data sets into ReSurveyEurope. As a next step, all databases were pooled in a single database in Turboveg 3, which

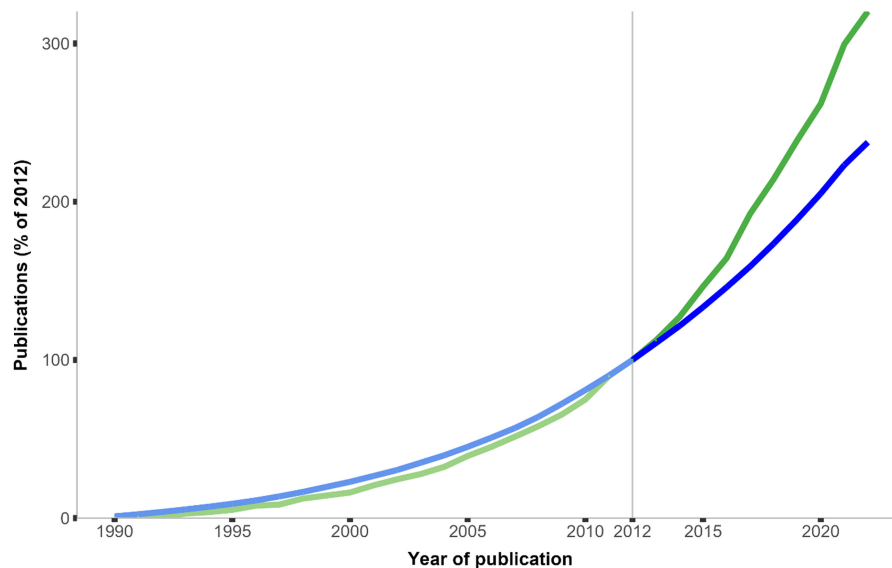


FIGURE 1 Cumulative number of published studies on vegetation change including studies using resurveyed vegetation plots (green) based on 1345 publications indexed in Web of Science (as of December 6, 2022) following the same search criteria as Vellend et al. (2013), compared to the overall number of publications within the field of ecology (blue). Of the former, 420 publications are from 1990–2012 (i.e., the period covered by Vellend et al., 2013; in light green) and an additional 925 papers were published thereafter (in dark green) – an increase by 220% during the last decade. In comparison, overall publications within the field of ecology have only increased by 146% (following a Web of Science search based on the search string: “plant” AND “species” AND “ecology”). The search string used here and by Vellend et al. (2013) was: (“plant community” OR “plant communities” OR “vegetation” OR “forest*” OR “grassland*” OR “wetland*” OR “desert*” OR “savanna*” OR “tundra*” OR “steppe*” OR “shrubland*” OR “prairie*” OR “taiga” OR “rainforest*” OR “woodland*” OR “mangrove*”) AND TITLE-ABS-KEY (“biodiversity” OR “diversity” OR “richness” OR “evenness” OR “composition”) AND ALL (“resurvey*” OR “resample*” OR “revisit*” OR “temporal change”).

has been developed for EVA by S.M. Hennekens to facilitate joint management of databases using different species lists and database dictionaries.

2.3 | Description and characterization of the plots and observations

In total, version 1.0 of ReSurveyEurope contains 79,190 plots with 283,135 observations (i.e., resurveys of individual plots) from 449 independent resurvey projects (Figure 2; see <https://euroveg.org/resurvey/database> for a full list). Of the total number of plots, 62,139 (78%) are from permanent (incl. manipulated) plots, for example, marked or geotagged plots which allow for high spatial accuracy in resurveying (Figure 2b,c). Note that this category also includes plots that are not permanently marked in the field, but were located with high precision (e.g., GPS-measured locations, photos).

The remaining 17,051 (22%) plots are quasi-permanent plots, which in the initial survey had not been sufficiently georeferenced to guarantee their unambiguous retrieval (Figure 2d). Resurveys of such plots rely on the geographic information available from the first survey including geographic coordinates, textual description of plot locations, information from field notes and maps, and surveyors' knowledge of plot locations. These plots are thus associated with higher uncertainties on the location of the initial plots.

Four data sets accounting for 28,470 (35%) plots provide only presence/absence information on plant species; one data set from Denmark is especially large and accounts for most of the presence/absence-only data; however, for this data set, abundance information will be provided in the near future. Of the remaining 50,720 (65%) plots, the majority contain abundance information (e.g., percentage cover or cover-abundance classes such as variants of the Braun-Blanquet scale) with some plots from mixed data sets (i.e., containing abundance information for a subset of plots).

The geographical distribution of plots included in ReSurveyEurope is uneven, with central and northwestern European countries contributing the most data so far (Table 1; Figure 2; Appendix S2). For the full data set (including abundance and presence/absence data sets), Denmark ranks first by a wide margin (35%), followed by the United Kingdom (17%), Germany (15%), Switzerland (7%), and Poland (3%). When only considering the plots with species abundance information, the highest percentages are for the United Kingdom (28%), followed by Germany (25%), Switzerland (10%), Poland (5%), and Spain (4%).

For the full data set, the density of plots (i.e., number of plots per 100 km²) is by far the highest in Denmark (62 plots/100 km²), followed by Switzerland (13), the United Kingdom (6), Belgium (5), and Germany as well as the Czech Republic (3 each) (Table 1, Appendix S2). For observations with species abundance information, Switzerland (12 plots/100 km²) ranks first, followed by the United Kingdom (6), Belgium (5), Germany (3), and the Czech Republic (2).

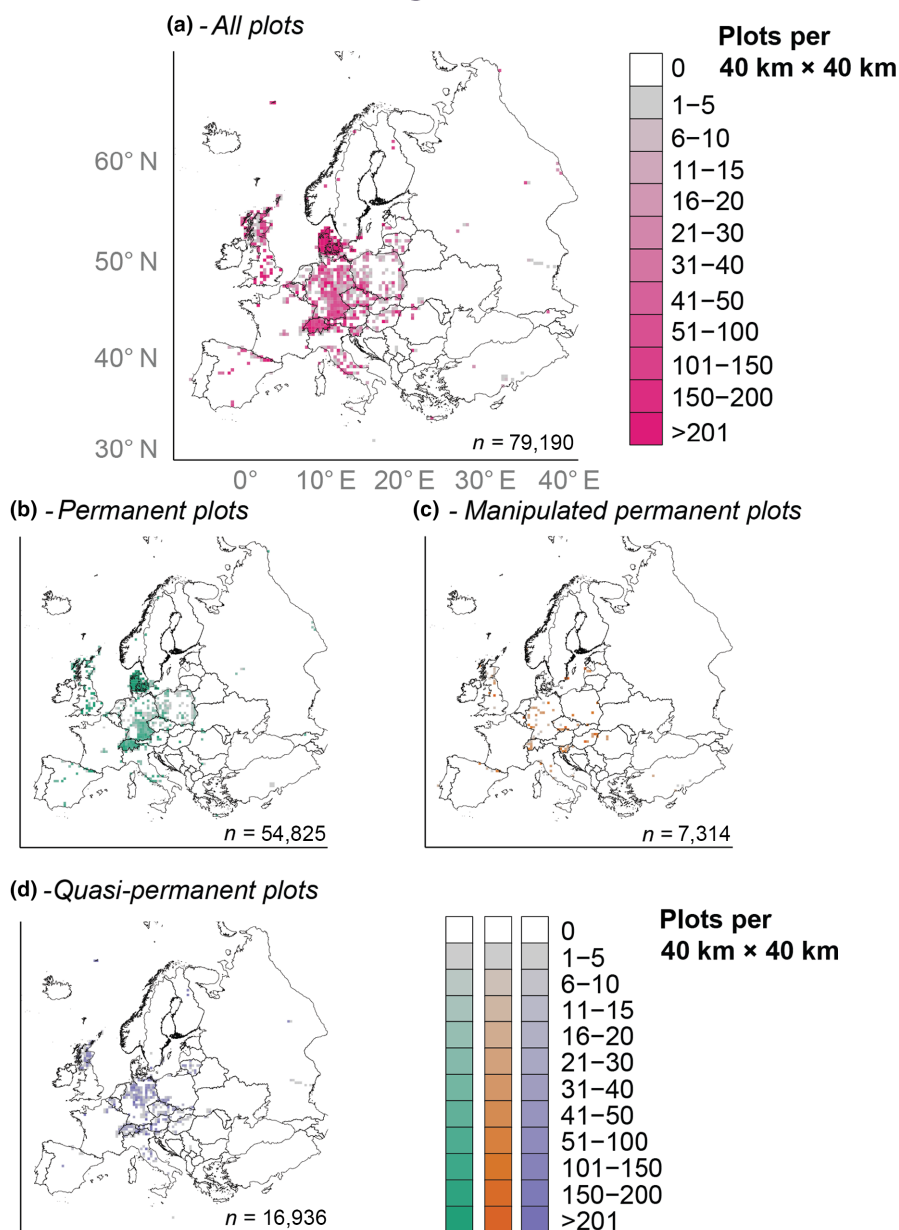


FIGURE 2 Geographic distribution of the 79,190 plots contained in ReSurveyEurope version 1.0 (a). Plots grouped by different study designs corresponding to (b) permanent plots, (c) manipulated permanent plots, and (d) quasi-permanent plots, in which plots of the initial survey have not been precisely georeferenced.

The oldest plot included was sampled in 1911 in the Swiss Alps (data set “DISEQUALP”, Braun-Blanquet, 1913; Rumpf et al., 2018), while the latest resurveys are from 2022 (Figure 3, Appendix S3). Thus, the total time span covered by ReSurveyEurope is 111 years. The mean time span between sampling the first and the last observation is 26 years across all the 449 projects. Mean starting dates within data sets are more recent, as often first observations of plots within a data set have been done in different years (Appendix S3). Four projects started with the first plots until 1930, 21 additional projects by 1950, and another 84 projects by 1970. The longest mean time span covered by one data set is 104 years (data set “DISEQUALP”).

The assignment of the data in ReSurveyEurope 1.0 to EUNIS Level 1 habitat classes using the classification expert system EUNIS-ESy (Chytrý et al., 2020) (Figure 4) shows that for 36,333 plots (46%) an assignment to a EUNIS habitat class was not possible—most often this was the case because the assignment to a habitat type is

not possible for plots without species cover information. A total of 21,357 plots (27%) were assigned to grasslands, followed by 8976 (11%) assigned to multiple habitat groups (i.e., as a result of change of habitat types over time due to e.g., succession, land-use change or disturbance), forests (6936 plots; 9%), heathlands, scrub and tundra (1363 plots; 2%), vegetated man-made habitats (1126 plots; 1%), and wetlands (1020 plots; 1%); all other EUNIS classes are represented by lower numbers of observations.

Plot size differed substantially between plots, with plots located in forests being larger on average than plots in non-forest vegetation types (Figure 5b). In non-forest vegetation, median plot size is 2 m² (minimum: 0.001 m²; maximum: 2500 m², mean: 26 m²), while the median plot size for forest plots is 100 m² (minimum: 3 m²; maximum: 2500 m², mean: 153 m²).

Spatial uncertainty of plot locations varies between 0 and 15,000 m (Figure 5c). By far the highest number of observations has

TABLE 1 Overview of the top 10 countries ranked by plots included in ReSurveyEurope.

Rank	Country	Country area [km ²]	Plots	Observations	Plots [%]	Observations [%]	Plots per 100 km ²	Observations per 100 km ²
All data								
1	Denmark	44,493	27,777	99,650	35	35	62	224
2	United Kingdom	242,495	13,747	40,164	17	14	6	17
3	Germany	357,386	12,057	40,393	15	14	3	11
4	Switzerland	41,285	5365	11,208	7	4	13	27
5	Poland	312,685	2618	6612	3	2	0.8	2
6	Sweden	450,295	2296	12,446	3	4	0.5	3
7	Spain	498,511	1977	7510	3	2	0.4	2
8	Italy	301,318	1754	5012	2	2	0.6	2
9	Czech Republic	78,866	1544	14,242	2	5	2	18
10	Belgium	30,510	1543	2425	2	0.9	5	8
Only data with species abundance information								
1	United Kingdom	242,495	13,747	40,164	17	14	6	17
2	Germany	357,386	11,994	40,267	15	14	3	11
3	Switzerland	41,285	5088	10,499	6	4	12	25
4	Poland	312,685	2618	6612	3	2	1	2
5	Spain	498,511	1968	7348	2	3	0.4	1
6	Italy	301,318	1754	5012	2	3	0.6	2
7	Belgium	30,510	1543	2425	2	1	5	8
8	Russian Federation ^a	3,968,200	1523	8179	2	4	0.04	0.2
9	Czech Republic	78,866	1508	13,543	2	5	2	17
10	Austria	83,858	1474	3876	2	1	2	5

Note: Countries are ranked by the number of plots within their borders. For the full list of countries, see Appendix S2.
^aFor the Russian Federation, only the European territory is considered.

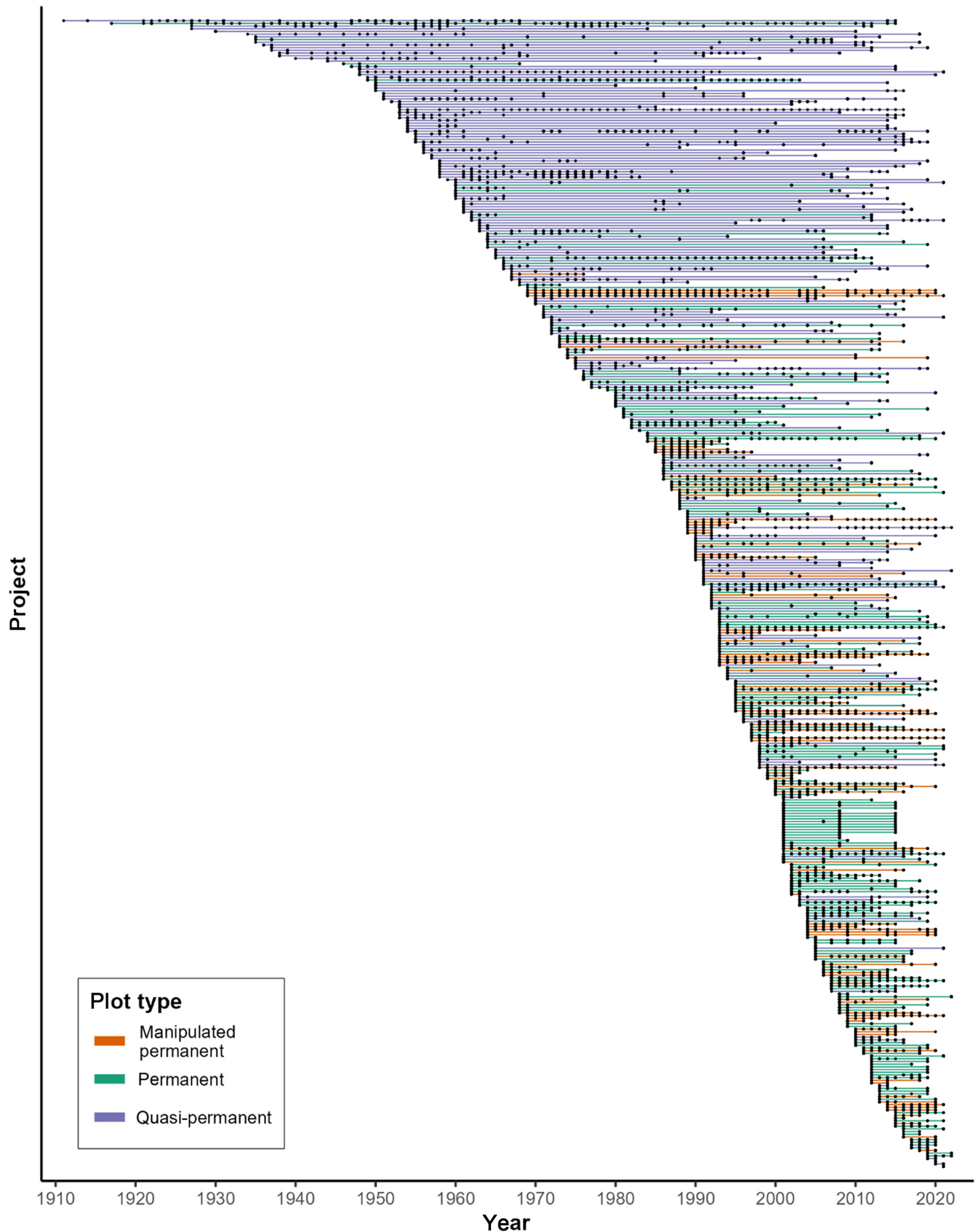
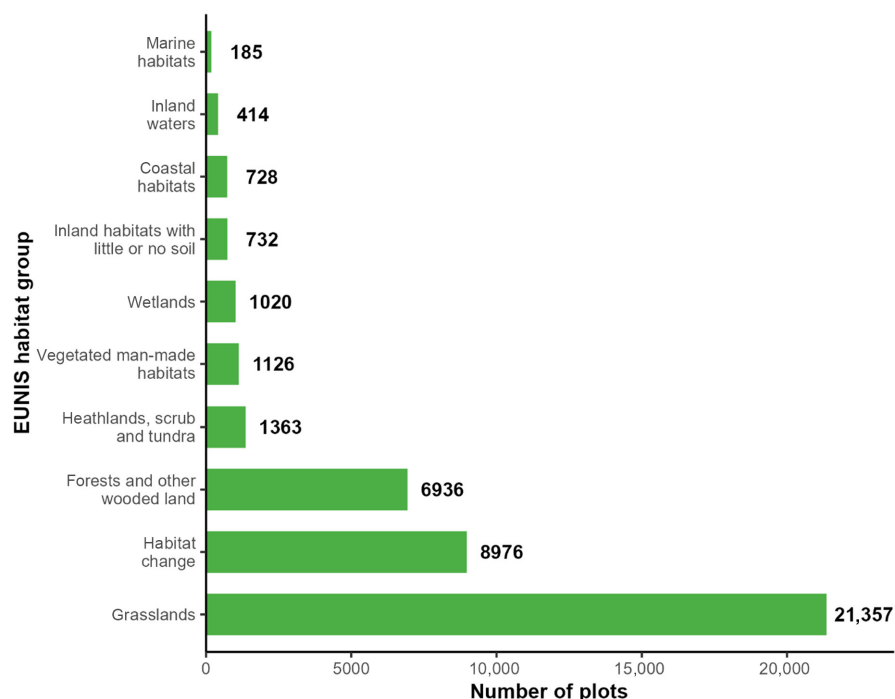


FIGURE 3 Time period covered by the 449 individual projects in ReSurveyEurope 1.0. Projects with permanent, manipulated permanent and quasi-permanent plots are shown in different colors. Note that manipulated permanent projects may also contain some unmanipulated (=control) plots. Black points indicate sampling times.



FIGURE 4 Distribution of 42,837 plots in ReSurveyEurope across habitat types defined as EUNIS Level 1 habitat classes classified using EUNIS-ESy (Chytrý et al., 2020). The category “habitat change” refers to plots that were assigned to different habitat types over the course of their observations. The remaining plots (not shown in the figure) are those without species cover information, which cannot be classified using EUNIS-ESy.



a spatial uncertainty of less than 10m (53,252 plots). These plots are either permanently marked in the field or located using GPS or photos. On the opposite side of uncertainty, there are 975 plots with an uncertainty of 100–1000m, and 117 plots with an uncertainty greater than 1000m. Typically, these spatially most uncertain observations were from plots established several decades ago and (re-)located post-hoc based on historical materials like maps or descriptive textual information given in the original source.

The number of observations per plot varies among data sets. The majority of data sets have been surveyed twice (mostly resurveying studies) or at most a few times (mostly studies with permanent plots), while a few, mostly small data sets have high numbers of observations (Table 2).

2.4 | Taxonomic and nomenclatural standards and recommendations for data usage

ReSurveyEurope applied the EVA approach of simultaneously using a set of nationally used plant taxonomic and nomenclatural concepts to best represent individual data sets. A total of 31 species lists are used for storing species data in particular databases. Some species lists are fully taxonomically standardized and follow taxonomic concepts of particular countries (e.g., GermanySL 1.4, Czechia_Slovakia_2015), other lists are not fully standardized. In different species lists, the same name can refer to different taxa, different names can refer to the same taxon, and taxa can be circumscribed and ranked differently. To unify different taxonomic concepts, species lists were matched to the taxonomic and nomenclatural backbone of the Euro+Med PlantBase (Euro+Med, 2006) using the SynBioSys Taxon Database developed for EVA. Some taxa (e.g., non-European aliens, aggregates, unresolved names from the

original data sets) that are not included in Euro+Med were retained in the data set. Both the original and harmonized taxonomies are preserved so that users can decide which of them they prefer to use. For cryptogams (lichens, bryophytes), taxonomy and nomenclature are so far largely unresolved across data sets in EVA and ReSurveyEurope.

The harmonized nomenclature for vascular plants according to Euro+Med can be further adjusted using the expert system EUNIS-ESy (Chytrý et al., 2020) to merge multiple taxonomic levels (e.g., subspecies) to the level of species and aggregates for groups of closely related species that are often identified inconsistently across vegetation plots. This adjustment can be performed using JUICE 7 (Tichý, 2002), Turboveg 3 (Hennekens, 2015) or an R script developed by Bruehlheide et al. (2021). Before analyses, different observations from the same plot should also be checked for possible inconsistencies (e.g., the same taxon can be identified to the level of aggregate in the first sampling and to the level of species in the second sampling). In any case of doubt about correct taxonomic interpretation, the users should check the taxonomy and nomenclature used in the original data set.

2.5 | Cooperations and side projects

ReSurveyEurope makes use of pre-existing infrastructure, procedures and expertise developed and employed by EVA, and it is embedded in the EVA governance structure. Data integration and storage are coordinated and conducted at Masaryk University in Brno. EVA data are formally divided into EVA core databases (non-repeated observations) and ReSurveyEurope. There is some overlap between these two subsets. Some databases contain mostly non-repeated observations but also a small part of repeatedly

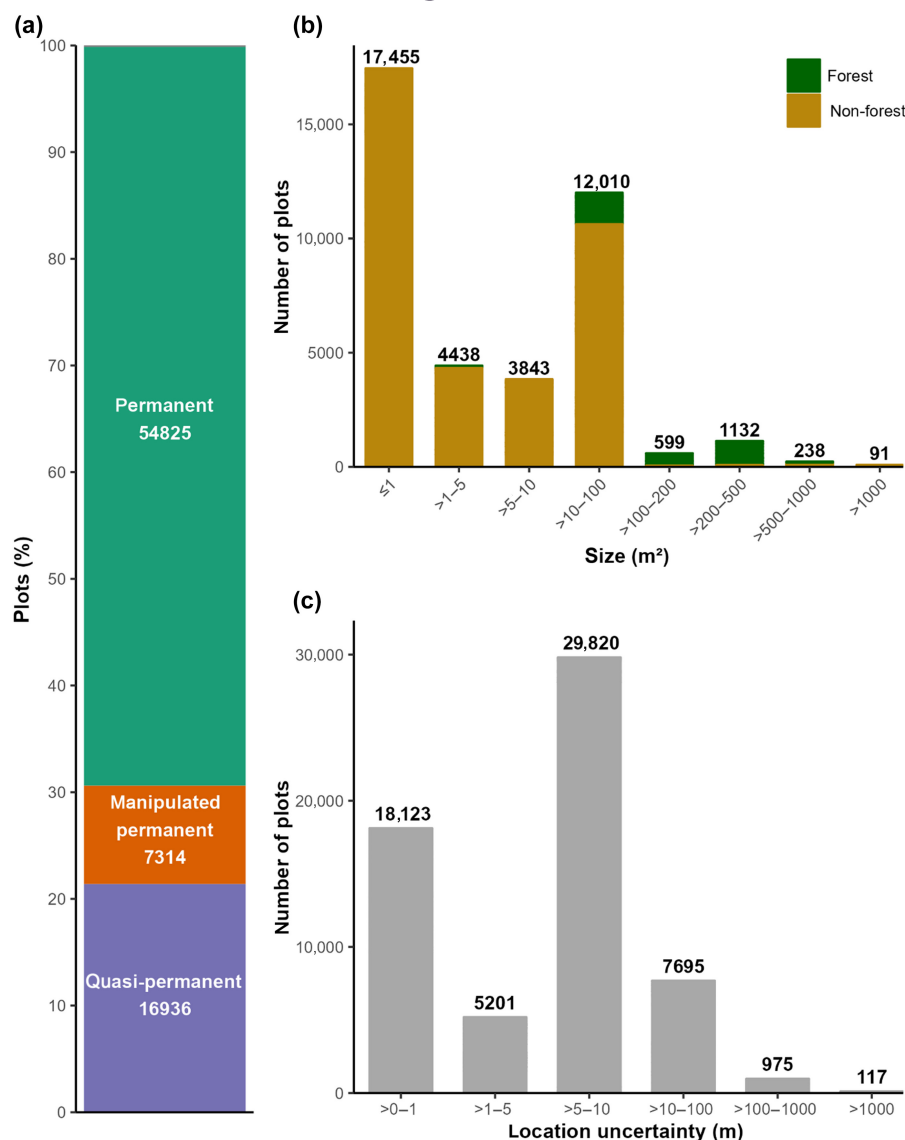


FIGURE 5 Key attributes of plots ($n=79,190$) in ReSurveyEurope 1.0. (a) Percentage of resurveying methods, 115 plots with mixed methods of resurveying not shown (see text). (b) Plot size distribution (forests are given as a separate category as the plot sizes are usually larger). (c) Distribution of the plot location uncertainty.

sampled plots included in ReSurveyEurope. Other databases (e.g., EU-GB-004 Floodplain Meadows, EU-GB-005 Scottish Coastal Survey or EU-GB-006 Scottish Vegetation Resurvey) include only repeated plots but from vegetation types and areas that are otherwise poorly represented in EVA, and therefore they are included both in EVA core databases and ReSurveyEurope. Both EVA core databases and ReSurveyEurope can be provided for projects using the same data request form, in which the project proponent indicates the data selection criteria.

ReSurveyEurope has established a number of cooperation agreements on data-sharing and possible joint analyses with other initiatives. These include, in particular: forestREplot, a database of forest resurvey plots in temperate zones (Verheyen et al., 2017; <https://forestreplot.ugent.be/>), the Global Observation Research Initiative in Alpine Environments (GLORIA) network (Pauli et al., 2015; <https://www.gloria.ac.at/home>), and the Long-term Vegetation Sampling (LOTVS; Sperandii et al., 2022; <https://lotvs.csic.es/>). Most European data sets from these global networks were integrated into ReSurveyEurope with the help of database managers and based on the consent of owners

or providers of the individual original data sets. ReSurveyEurope also integrated the ReSurveyGermany database, developed in parallel with the development of ReSurveyEurope and using the same structure (Jandt, Bruehlheide, Berg, et al., 2022). Further, a cooperation has been initiated with the Nutrient Status Initiative, which explores the role of nutrient availability on local plant diversity. A joint data call has been launched (http://euroveg.org/download/ReSurveyEurope_NutrientStatus_DataCall2021.pdf).

2.6 | Strengths, gaps, limitations, and pitfalls

ReSurveyEurope represents the first European data set of vegetation plots resurveyed at least once from a wide range of habitats. The original data were in most cases sampled for different purposes, by using a range of methodologies applied within the respective projects. Despite the harmonization of basic attributes upon integration of the data sets into ReSurveyEurope, there is substantial variation in many relevant features such as the accuracy of plot location, plot



TABLE 2 Overview on the 10 largest projects by number of plots included in ReSurveyEurope 1.0.

	Name	Country	Abundance information	Number of plots	Number of observations	Start year	End year
1	NOVANA: Danish National Monitoring data	DK	No	27,689	99,298	1988	2020
2	UK floodplain meadows long-term monitoring	UK	Yes	9316	25,867	1986	2020
3	Scottish Coastal Survey	UK	Yes	2539	5064	1976	2010
4	Bavarian grassland monitoring	DE	Yes	2509	5159	2002	2013
5	Monitoring Effectiveness of Habitat Conservation	CH	Yes	1961	3921	2011	2019
6	Mechanisms of coexistence in species-rich grasslands: Öland site	SE	Mixed	1920	11,220	1985	1997
7	DISEQALP	CH	Yes	1516	3032	1911	2015
8	Monitoring Effectiveness of Agrienvironmental Schemes	PL	Yes	1200	2376	2012	2019
9	Monitoring tidal marshes Zeeschele	BE	Yes	819	819	1995	
10	Mechanisms of coexistence in species-rich grasslands	NL	No	750	4500	1985	1994

Note: The full list of projects is given in Appendix S3.

size, species abundance, recording of cryptogams, intervals between surveys and experimental manipulations.

Accordingly, it is crucial to clarify which data are suitable for specific analyses and to select—and possibly edit—data sets accordingly (Chytrý et al., 2014; Kapfer et al., 2017). Perhaps most importantly, it is necessary to know whether particular plots represent non-manipulated vegetation, or experimental plots after some manipulation (e.g., nutrient addition, experimental disturbance) or a successional series. If the aim is to study spontaneous vegetation change, it may be necessary to select only control plots from experiments. Even then, researchers have to be careful about selecting the suitable subset of data (e.g., in regularly mown areas, experimental manipulation can be abandonment with a mown plot as a control, whereas in abandoned areas, manipulation can be mowing with an abandoned plot as a control).

Further, individual studies should only compare changes over identical periods, in terms of both the interval between two samplings and between the starting or mean date. For example, two resurvey data sets, one collected between the 1960s and 1980s and the other collected between the 1990s and 2010s, can show different trends, although the interval length between the first and last survey is the same.

Resurveyed vegetation plots provide a valuable resource for the study of vegetation dynamics and their responses to environmental change in Europe. A particular strength of ReSurveyEurope is that empirical time-series data are provided for largely exact locations, which makes them ideal for calibrating or validating models. For example, the plot records might be linked to remote-sensing information on land-use change or change in habitat quality. They may also allow assessing the change in the conservation status of Annex 1 habitats of the EU Habitats Directive. At times of global climate and land-use change, ReSurveyEurope is an important archive of past vegetation composition. Such data can be used to inform conservation and management decisions, improve our understanding

of ecosystem dynamics and help develop strategies to mitigate the impacts of climate change.

3 | PROPERTY RIGHTS, DATA USAGE AND ACCESS

ReSurveyEurope is devoted to an inclusive and transparent governance, collaboration, co-authorship, and data usage approach. ReSurveyEurope Data Property and Governance Rules (approved at the first ReSurveyEurope workshop in Vienna in April 2022; http://euroveg.org/download/ReSurveyEurope_Rules.pdf) are based on experience gathered in similar community-based initiatives, and basically are slightly modified rules of EVA. Thus, (i) data owners/contributors have control over the use of their data in any specific analysis (allowing them to opt-in for individual projects according to specific criteria such as the number of plots used in the analysis), and (ii) colleagues not directly involved in ReSurveyEurope can submit proposals for analyses, which will be subject to approval by the ReSurveyEurope Board consisting of the initiators of ReSurveyEurope and elected members of the EVA Coordinating Board (<https://euroveg.org/resurvey/>). The data request form is available at <http://euroveg.org/download/eva-data-request-form.docx>.

4 | FUTURE DEVELOPMENTS AND OUTLOOK

ReSurveyEurope is intended to be a living and dynamic resource, and thus, we expect that it will further grow and mature in the years to come. While a large number of existing resurvey data sets from Europe have already been included in ReSurveyEurope 1.0, we expect and hope that further data sets will become mobilized



and contributed. In addition, several studies resurveying historic vegetation-plot data are underway or have been proposed. Thus, we expect that further data sets will be sampled and, hopefully, contributed to ReSurveyEurope. As regular data updates are foreseen, we highly encourage colleagues to provide additional data once they become available. Submission of data sets is possible at any time (see <https://euroveg.org/resurvey/> for further information).

In addition, we believe that there is substantial potential for developing further collaborations or joint activities with colleagues and initiatives to expand the scope of ReSurveyEurope. This may include (i) expanding the geographic scope, (ii) expanding the taxonomic scope, and (iii) standardizing and expanding metadata content in ReSurveyEurope.

To conclude, the ReSurveyEurope consortium is open and interested in discussing suggestions for extending the initiative and thus encourages colleagues to bring any such ideas forward. As ReSurveyEurope data have become ready for use, several projects have already been initiated, and further proposals for analyses can be submitted to the coordinators.

AUTHOR CONTRIBUTIONS

Franz Essl, Ilona Knollová, Milan Chytrý, Helge Bruelheide, and Stefan Dullinger conceived the original idea for ReSurveyEurope, which was jointly developed by a core team also including Bernd Lenzner, Ilona Knollová, Florian Jansen, Ute Jandt and Stephan Hennekens. Stephan Hennekens, Milan Chytrý, Helge Bruelheide, Ute Jandt and Ilona Knollová designed the database structure. Ilona Knollová compiled the database with help from Stephan Hennekens. Ilona Knollová, Ekin Kaplan, Michael Glaser and Bernd Lenzner created the figures and tables for this article. Franz Essl led the writing of the manuscript with substantial contributions of Milan Chytrý, Helge Bruelheide, Stefan Dullinger, Ute Jandt, and Ilona Knollová. All other authors (ordered alphabetically) contributed plot data and commented on an advanced version of the manuscript. All authors agreed with the final manuscript.

AFFILIATIONS

- ¹Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic
- ²Institute of Biology/Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, Germany
- ³German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany
- ⁴Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria
- ⁵Institute of Ecology and Evolution, Friedrich Schiller University, Jena, Germany
- ⁶Department of Plant Biology and Ecology, Faculty of Science and Technology, University of the Basque Country UPV/EHU, Bilbao, Spain
- ⁷Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic
- ⁸Centro de Investigaciones sobre Desertificación (CSIC-UV-GV), Valencia, Spain
- ⁹Division of BioInvasions, Global Change & Macroecology, Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria
- ¹⁰Wageningen Environmental Research, Wageningen, Netherlands
- ¹¹Faculty of Agricultural and Environmental Sciences, University of Rostock,

Rostock, Germany

¹²Biodiversity Research Institute (Univ.Oviedo-CSIC-Princ.Asturias), University of Oviedo, Gijón, Spain

¹³Vienna Doctoral School of Ecology and Evolution, University of Vienna, Vienna, Austria

¹⁴Gloria co-ordination, Institute for Interdisciplinary Mountain Research, Austrian Academy of Sciences, Vienna, Austria

¹⁵Gloria co-ordination, Department of Integrative Biology and Biodiversity Research, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

¹⁶Forest & Nature Lab, Department of Environment, Ghent University, Gontrode, Belgium

¹⁷Institute of Ecology, School of Natural Sciences and Medicine, Ilia State University, Tbilisi, Georgia

¹⁸Department of Botany, Faculty of Agriculture, University of Belgrade, Belgrade, Serbia

¹⁹Department of Sciences, University of Rome Tre, Rome, Italy

²⁰UMR BAGAP, INRAE - Institut Agro - ESA, Rennes, France

²¹LTSEZ Zone Atelier Armorique, Rennes, France

²²Ecology, Evolution & Environmental Change, UK Centre for Ecology & Hydrology, Edinburgh, UK

²³Division of Conservation Biology, Institute of Ecology and Evolution, University of Bern, Bern, Switzerland

²⁴Department of Environmental Biology, Sapienza University of Rome, Rome, Italy

²⁵Institute of Natural Resource Management, Zurich University of Applied Sciences, Wädenswil, Switzerland

²⁶Research and Education Laboratory, Ojców National Park, Ojców, Poland

²⁷Department of Life Sciences and Systems Biology, University of Torino, Torino, Italy

²⁸Jolube Consultor Botánico, Jaca, Spain

²⁹Instituto Pirenaico de Ecología IPE-CSIC, Jaca, Spain

³⁰Institute of Biology, Graz University, Graz, Austria

³¹Biodiversity and Conservation Biology, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

³²Department of Earth Sciences, University of Sopron, Sopron, Hungary

³³Department of Nature Conservation and Research, Gesäuse National Park, Admont, Austria

³⁴Forschungsförderung, Karlsruhe Institute of Technology, Karlsruhe, Germany

³⁵Department of Life Sciences, University of Siena, Siena, Italy

³⁶Faculty of Environmental Sciences, Czech University of Life Sciences, Prague, Czech Republic

³⁷Department of Ecological Sciences, James Hutton Institute, Aberdeen, UK

³⁸Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Lomma, Sweden

³⁹BIOME Lab, Department of Biological, Geological & Environmental Sciences, Alma Mater Studiorum, University of Bologna, Bologna, Italy

⁴⁰LifeWatch ERIC Research Infrastructure, Lecce, Italy

⁴¹Agroscope, Research Division Agroecology and Environment, Zürich, Switzerland

⁴²County Administrative Board of Jämtland, Environment and Water, Östersund, Sweden

⁴³EnvixLab – Department of Biosciences and Territory, University of Molise, Termoli and Pesche, Termoli, Italy

⁴⁴Department of Forest Ecology, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences, Prague, Czech Republic

⁴⁵Vegetation Ecology Group, Institute of Natural Resource Sciences (IUNR), Zurich University of Applied Sciences, Delémont, Switzerland

⁴⁶Université Grenoble Alpes, Université Savoie Mont Blanc, CNRS, LECA, Grenoble, France

⁴⁷IMBE - Institut Méditerranéen de Biodiversité et d'Écologie, Aix Marseille Univ, Avignon Univ, CNRS, IRD, Marseille, France

⁴⁸Large-Scale Vegetation Ecology Research Group, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary

⁴⁹Institute of Agroecology and Plant Production, Wrocław University of Environmental and Life Sciences, Wrocław, Poland

⁵⁰Institute of Botany of the Czech Academy of Sciences, Průhonice, Czech Republic



- ⁵¹Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy
- ⁵²Lendület Seed Ecology Research Group, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary
- ⁵³Ecologie et Dynamique des Systèmes Anthropisés (EDYSAN, UMR CNRS 7058), Jules Verne Université de Picardie, Amiens, France
- ⁵⁴Institute of Environmental Biology, Faculty of Biology, University of Warsaw, Warsaw, Poland
- ⁵⁵Vegetation Ecology Research Group, Institute of Natural Resource Sciences, Zurich University of Applied Sciences, Wädenswil, Switzerland
- ⁵⁶Plant Ecology, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, Germany
- ⁵⁷Maiella Seed Bank, Maiella National Park, Sulmona, Italy
- ⁵⁸Biodiversity, UK Centre for Ecology & Hydrology, Edinburgh, UK
- ⁵⁹Vegetation Ecology, University of Bremen, Bremen, Germany
- ⁶⁰Vegetation and Phytodiversity Analysis, Albrecht-von-Haller-Institute of Plant Sciences, University of Göttingen, Göttingen, Germany
- ⁶¹Ecosystem Research and Environmental Information Management, Environment Agency Austria, Vienna, Austria
- ⁶²Faculty V, School of Mathematics, Institute of Biology and Environmental Sciences, Carl von Ossietzky University Oldenburg, Oldenburg, Germany
- ⁶³Department of Functional Ecology, Institute of Botany, Czech Academy of Sciences, Třeboň, Czech Republic
- ⁶⁴Department of Botany, Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic
- ⁶⁵Independent researcher, Göttingen, Germany
- ⁶⁶Institute of Biology, University of Rzeszów, Rzeszów, Poland
- ⁶⁷Center for Environmental and Climate Science, Lund University, Lund, Sweden
- ⁶⁸Department of Ecoscience, Aarhus University, Aarhus, Denmark
- ⁶⁹Moscow, Russia
- ⁷⁰Department of Botany, University of Innsbruck, Innsbruck, Austria
- ⁷¹Department of Botany, University of Granada, Granada, Spain
- ⁷²German Alpine Club, Baden-Wuerttemberg Branch, Nature Conservation Unit, Stuttgart, Germany
- ⁷³Institute for Interdisciplinary Mountain Research, Austrian Academy of Sciences, Innsbruck, Austria
- ⁷⁴Institute of Plant Sciences, University of Bern, Bern, Switzerland
- ⁷⁵Department of Forest Biodiversity, University of Agriculture in Krakow, Kraków, Poland
- ⁷⁶Institute of Soil Biology and Biogeochemistry, Biology Centre of the Czech Academy of Sciences, České Budějovice, Czech Republic
- ⁷⁷Botany Unit, Department of Pharmacology, Pharmacognosy and Botany, Faculty of Pharmacy, Complutense University Madrid, Madrid, Spain
- ⁷⁸Biotechnical Faculty, Department of Biology, University of Ljubljana, Ljubljana, Slovenia
- ⁷⁹Department of Geoinformation in Environmental Management, CIHEAM-Mediterranean Agronomic Institute of Chania, Chania, Greece
- ⁸⁰School of Government, Georgian Institute of Public Affairs, Tbilisi, Georgia
- ⁸¹Forest Management, National Forest Center, Zvolen, Slovakia
- ⁸²Tolyatti, Russia
- ⁸³Departamento de Conservación de Ecosistemas Naturales, Instituto Pirenaico de Ecología IPE-CSIC, Jaca, Spain
- ⁸⁴School of Environment, Earth and Ecosystem Sciences, The Open University, Walton Hall, Milton Keynes, UK
- ⁸⁵Department of Biological Sciences, University of Bergen, Bergen, Norway
- ⁸⁶Biology Education, Dokuz Eylul University, Izmir, Turkey
- ⁸⁷River Ecology and Conservation, Senckenberg Research Institute and Natural History Museum Frankfurt, Gelnhausen, Germany
- ⁸⁸Faculty of Biology, University of Duisburg-Essen, Essen, Germany
- ⁸⁹Institute of Ecology, Leuphana University of Lüneburg, Lüneburg, Germany
- ⁹⁰Restoration Ecology Group, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary
- ⁹¹Gymnázium Brno Křenová, Brno, Czech Republic
- ⁹²Institute of Ecology, University of Lüneburg, Lüneburg, Germany
- ⁹³General Botany, Institute for Biochemistry and Biology, University of Potsdam, Potsdam, Germany
- ⁹⁴Departamento de Biología Ambiental, Universidad de Navarra, Pamplona, Spain
- ⁹⁵Department of Evolutionary Biology, Ecology and Environmental Sciences, Institute for Research in Biodiversity (IRBio), University of Barcelona, Barcelona, Spain
- ⁹⁶Białowieża Geobotanical Station, Faculty of Biology, University of Warsaw, Białowieża, Poland
- ⁹⁷Institute of Plant Science and Microbiology, University of Hamburg, Hamburg, Germany
- ⁹⁸Department of Disturbance Ecology, Bayreuth Center of Ecology and Environmental Research, University of Bayreuth, Bayreuth, Germany
- ⁹⁹Department of Plant Biology, Mendel University in Brno, Brno, Czech Republic
- ¹⁰⁰Beskydy Protected Landscape Area Administration, Nature Conservation Agency of the Czech Republic, Rožnov pod Radhoštěm, Czech Republic
- ¹⁰¹Department of Ecological Analyses, Institute of Landscape Ecology, Slovak Academy of Sciences, Bratislava, Slovakia
- ¹⁰²Department of Wildlife and Rangelands, Norwegian Institute of Bioeconomy Research, Tromsø, Norway
- ¹⁰³Department of Forest Ecology, Slovenian Forestry Institute, Ljubljana, Slovenia
- ¹⁰⁴Grassland, Grazing Animal Farming, Saxon State Office for Environment, Agriculture and Geology, Pöhl, Germany
- ¹⁰⁵Pushchino, Russia
- ¹⁰⁶Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, Bolzano, Italy
- ¹⁰⁷Department of Phytology, Faculty of Forestry, Technical University in Zvolen, Zvolen, Slovakia
- ¹⁰⁸Department of Forest Botany, Dendrology and Geobiocoenology, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, Czech Republic
- ¹⁰⁹Institute for Agroecology and Organic Farming, Bavarian State Research Center for Agriculture, Freising, Germany
- ¹¹⁰Institute of Entomology, Biology Centre of the Czech Academy of Sciences, České Budějovice, Czech Republic
- ¹¹¹Plant Ecology, University of Göttingen, Göttingen, Germany
- ¹¹²Andalusian Inter-University Institute for Earth System Research, University of Granada, Granada, Spain
- ¹¹³Section for Ecoinformatics & Biodiversity, Department of Biology, Aarhus University, Aarhus, Denmark
- ¹¹⁴Biology - Center for Sustainable Landscapes under Global Change, Aarhus University, Aarhus, Denmark
- ¹¹⁵Department of Botany, Faculty of Biological Sciences, University of Wrocław, Wrocław, Poland
- ¹¹⁶Botanical Garden of Medicinal Plants, Department of Pharmaceutical Biology and Biotechnology, Wrocław Medical University, Wrocław, Poland
- ¹¹⁷Geography Research Unit, University of Oulu, Oulu, Finland
- ¹¹⁸School of Environmental Sciences, University of Liverpool, Liverpool, UK
- ¹¹⁹Área de Biodiversidad y Conservación, Rey Juan Carlos University, Móstoles, Spain
- ¹²⁰Ministerium für Wissenschaft, Energie, Klimaschutz und Umwelt des Landes Sachsen-Anhalt, Magdeburg, Germany
- ¹²¹Plant Ecology and Ecosystems Research, Albrecht von Haller Institute for Plant Sciences, University of Göttingen, Göttingen, Germany
- ¹²²Department of Botany, Senckenberg Museum of Natural History Görlitz, Görlitz, Germany
- ¹²³Geography and Environment, Loughborough University, Loughborough, UK
- ¹²⁴Yekaterinburg, Russia
- ¹²⁵Climate Change Department, Environmental Protection Agency of Aosta Valley Region, Saint-Christophe, Italy
- ¹²⁶Institute for Environmental Studies, Charles University, Prague, Czech Republic
- ¹²⁷Institute of Botany, Technical University Dresden, Dresden, Germany
- ¹²⁸Department of Landscape Management and Restoration Ecology, Fachhochschule Erfurt, Erfurt, Germany
- ¹²⁹Research Area 2, Leibniz Centre for Agricultural Landscape Research, Müncheberg, Germany
- ¹³⁰Department of Animal Biology, Institute of Biology, University of Campinas, Campinas, Brazil
- ¹³¹Experimental Garden and Gene Pool Collections Třeboň, Institute of



- Botany, Czech Academy of Sciences, Třeboň, Czech Republic
- ¹³²Center for Sustainable Landscapes Under Global Change, Department of Biology, Aarhus University, Aarhus, Denmark
- ¹³³CSIC, Global Ecology Unit, CREAM-CSIC-UAB, Bellaterra, Catalonia, Spain
- ¹³⁴CREAF, Cerdanyola del Vallés, Catalonia, Spain
- ¹³⁵Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia, Katowice, Poland
- ¹³⁶Department of Hydrobiology, Institute of Biology, University of Pécs, Pécs, Hungary
- ¹³⁷Department of Biology, University of North Carolina, Chapel Hill, North Carolina, USA
- ¹³⁸Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parma, Italy
- ¹³⁹Department of Vegetation Ecology, Institute of Botany, Czech Academy of Sciences, Průhonice, Czech Republic
- ¹⁴⁰Institute of Botany, Faculty of Biology, Jagiellonian University, Kraków, Poland
- ¹⁴¹Foundation for Biodiversity Research, Wrocław, Poland
- ¹⁴²Department of Life Sciences, Institute of Technology and Life Sciences, National Research Institute, Raszyn, Poland
- ¹⁴³Ecology and Conservation Biology, Institute of Plant Sciences, University of Regensburg, Regensburg, Germany
- ¹⁴⁴Department of Chemistry, Biology and Biotechnology, University of Perugia, Perugia, Italy
- ¹⁴⁵Kazan, Russia
- ¹⁴⁶Elabuga, Russia
- ¹⁴⁷Landscape Ecology and Nature Management, Research Institute for Nature and Forest, Brussels, Belgium
- ¹⁴⁸A. Borza Botanic Garden, Babeş-Bolyai University, Cluj-Napoca, Romania
- ¹⁴⁹Faculty of Biology and Geology, Babeş-Bolyai University, Cluj-Napoca, Romania
- ¹⁵⁰Interdisciplinary Centre for Mountain Research, Department of Ecology & Evolution, University of Lausanne, Lausanne, Switzerland
- ¹⁵¹Centre Alpin de Phytogéographie CAP, Fondation Jean-Marcel Aubert, Champex-Lac, Switzerland
- ¹⁵²Institute of Botany, Nature Research Centre, Vilnius, Lithuania
- ¹⁵³FORNAT AG, Zürich, Switzerland
- ¹⁵⁴Community Ecology, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland
- ¹⁵⁵Mountain Ecosystems Group, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
- ¹⁵⁶Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre CERC, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
- ¹⁵⁷Department of Plant and Environmental Sciences, University of Copenhagen, Copenhagen, Denmark
- ¹⁵⁸Physiological Diversity, UFZ, Helmholtz Centre for Environmental Research, Leipzig, Germany
- ¹⁵⁹Department of Landscape and Vegetation Ecology, University of Kassel, Kassel, Germany
- ¹⁶⁰Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy
- ¹⁶¹AVL - Agency for Vegetation Ecology and Landscape Planning, Wien, Austria
- ¹⁶²UniVegE-Herbier CLF, University of Clermont Auvergne, Clermont-Ferrand, France
- ¹⁶³Department of Environmental Sciences, University of Basel, Basel, Switzerland
- ¹⁶⁴Hungarian Department of Biology and Ecology, Babeş-Bolyai University, Cluj-Napoca, Romania
- ¹⁶⁵Faculty of Geography and Earth Sciences, University of Latvia, Riga, Latvia
- ¹⁶⁶Department of Silviculture and Forest Ecology of the Temperate Zones, University of Göttingen, Göttingen, Germany
- ¹⁶⁷Sustainable Land Management, DLR Projektträger, Bonn, Germany
- ¹⁶⁸Research Group Applied Ecology, Institute for Ecosystem Research, Kiel University, Kiel, Germany
- ¹⁶⁹Institute for Biosciences, Ecology, University of Rostock, Rostock, Germany
- ¹⁷⁰Department of Biology, Vegetation and Restoration Ecology, Technical University Darmstadt, Darmstadt, Germany
- ¹⁷¹Biologische Station Kreis Steinfurt, Tecklenburg, Germany
- ¹⁷²Jovan Hadži Institute of Biology, Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU), Ljubljana, Slovenia
- ¹⁷³Centre for Applied Ecology Prof. Baeta Neves, School of Agriculture, University of Lisbon, Lisbon, Portugal
- ¹⁷⁴Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health and Science, Caparica, Portugal
- ¹⁷⁵Department of Ecosystem Biology, University of South Bohemia, České Budějovice, Czech Republic
- ¹⁷⁶Waldkirch, Germany
- ¹⁷⁷Department of Plant Ecology, Institute of Botany, Faculty of Biology, Jagiellonian University, Kraków, Poland
- ¹⁷⁸Blütenbunt-Insektenreich, Deutscher Verband für Landschaftspflege, Kiel, Germany
- ¹⁷⁹büro áchero Vegetation and Environmental Consulting, Uslar, Germany
- ¹⁸⁰Museum of Natural History, University of Wrocław, Wrocław, Poland
- ¹⁸¹Botanical Garden, Center for Biological Diversity Conservation, Polish Academy of Sciences, Warsaw, Poland
- ¹⁸²HUN-REN-UD Biodiversity and Ecosystem Services Research Group, University of Debrecen, Debrecen, Hungary
- ¹⁸³Department of Plant Sciences, University of Geneva, Chambésy, Switzerland
- ¹⁸⁴Fondation J.-M. Aubert, Champex-Lac, Switzerland
- ¹⁸⁵Center for Sustainable Landscapes under Global Change, Department of Biology, Aarhus University, Aarhus, Denmark
- ¹⁸⁶Centre for Systems Biology, Biodiversity and Bioresources (3B), Babeş-Bolyai University, Cluj-Napoca, Romania
- ¹⁸⁷Emil G. Racoviță Institute, Babeş-Bolyai University, Cluj-Napoca, Romania
- ¹⁸⁸Department of Applied Ecology, Technical University in Zvolen, Zvolen, Slovakia
- ¹⁸⁹Institute of Biological Research Cluj, National Institute for Research and Development for Biological Sciences, Cluj-Napoca, Romania
- ¹⁹⁰Faculty of Natural Sciences, Institute of Biology, Biotechnology and Environmental Protection, University of Silesia, Katowice, Poland
- ¹⁹¹Flemish Government Research Institute for Nature and Forest, Brussels, Belgium
- ¹⁹²Department of Earth and Environmental Sciences, KU Leuven, Leuven, Belgium
- ¹⁹³KU Leuven Plant Institute, KU Leuven, Leuven, Belgium
- ¹⁹⁴Flanders Environment Department, Research Institute for Nature and Forest, Brussels, Belgium
- ¹⁹⁵Department of Plant and Fungal Diversity and Resources, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Science, Sofia, Bulgaria
- ¹⁹⁶Conservación de la Biodiversidad y Restauración de Ecosistemas, Instituto Pirenaico de Ecología IPE-CSIC, Jaca, Spain
- ¹⁹⁷Ecology & Genetics, University of Oulu, Oulu, Finland
- ¹⁹⁸Institute of Earth Surface Dynamics, Faculty of Geosciences and Environment, University of Lausanne, Lausanne, Switzerland
- ¹⁹⁹Department of Disturbance Ecology and Vegetation Dynamics, Bayreuth Center of Ecology and Environmental Research, University of Bayreuth, Bayreuth, Germany
- ²⁰⁰Faculty of Environmental Sciences, TUD Dresden University of Technology, Tharandt, Germany
- ²⁰¹Melle, Germany
- ²⁰²Bern, Switzerland
- ²⁰³International Institute Zittau, Technical University Dresden, Zittau, Germany
- ²⁰⁴Institute of Education in Science and Social Studies, University of Teacher Education Lucerne, Lucerne, Switzerland
- ²⁰⁵Department of Research and Monitoring, Swiss National Park SNP, Zerne, Switzerland
- ²⁰⁶Außenstelle Naturschutzstation Wümme, Betriebsstelle Lüneburg, Geschäftsbereich Naturschutz, Lower Saxony Water Management, Coastal Protection and Nature Conservation Agency, Brockel, Germany
- ²⁰⁷Vegetation Ecology and Conservation Biology, Institute of Ecology, FB 2, University of Bremen, Bremen, Germany



²⁰⁸Forest Dynamics, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

²⁰⁹UK Centre for Ecology & Hydrology, Crowmarsh Gifford, Wallingford, UK

²¹⁰Research Area 2, Leibniz Center for Agricultural Landscape Research, Müncheberg, Germany

ACKNOWLEDGEMENTS

We would like to thank the many colleagues who sampled historical field data that were later resurveyed and became the basis for the ReSurveyEurope initiative. We also thank Petr Novotný for an update of the EVA website to include ReSurveyEurope information. We appreciate the comments of two anonymous reviewers on the manuscript.

FUNDING INFORMATION

Ilona Knollová, Milan Chytrý and Lubomír Tichý were funded by the Czech Science Foundation (19-28491X). Bernd Lenzner and Franz Essl appreciate funding by the Global Plant Invasions-project funded by the Austrian Science Foundation (FWF; pr.no. I 5825-B). Helge Bruelheide and Ute Jandt appreciate the support of the German Research Foundation for funding sPlot as one of the iDiv (DFG FZT 118, 202548816) research platforms. Ekin Kaplan appreciates funding from the Vienna Doctoral School of Ecology and Evolution (VDSEE). Michael Glaser appreciates funding from the Austrian Climate Research Program (FA772033 “AgriWeedClim”). Stefan Dullinger received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 883669). Idoia Biurrun, Juan A. Campos, Itziar García-Mijangos and Irati Sanz-Zubizarreta were funded by the Basque Government (IT1487-22). Manuela Winkler received funding from the Austrian Academy of Sciences under the Earth System Sciences program (project “MEDIALPS”). Harald Pauli appreciates funding from the Austrian Climate Research Programme (ACRP 6: GZ B368633, KR13AC6K11076). Solvita Rūsiņa was supported by the LIFE Integrated Project LatViaNature LIFE19 IPE/LV/000010. Marta Gaia Sperandii acknowledges funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101090344. Borja Jiménez-Alfaro received funding from the Spanish Agency of Research (AEI), grant MCI-20-PID2019-108636GA-I00. Alessandro Chiarucci was supported by the “National Biodiversity Future Center–NBFC” (Next Generation EU. Project code CN_00000033, CUP J33C22001190001). Róbert Kanka is supported by the VEGA 2/0048/22 grant.

DATA AVAILABILITY STATEMENT

The data used in this paper are derived from the ReSurveyEurope 1.0 database (accession date: 1 May 2023). They can be requested from ReSurveyEurope following the Data Property and Governance Rules of ReSurveyEurope available at <https://euroveg.org/resurvey/>.

ORCID

Ilona Knollová <https://orcid.org/0000-0003-4074-789X>
 Milan Chytrý <https://orcid.org/0000-0002-8122-3075>
 Helge Bruelheide <https://orcid.org/0000-0003-3135-0356>
 Stefan Dullinger <https://orcid.org/0000-0003-3919-0887>
 Ute Jandt <https://orcid.org/0000-0002-3177-3669>
 Markus Bernhardt-Römermann <https://orcid.org/0000-0002-2740-2304>
 Idoia Biurrun <https://orcid.org/0000-0002-1454-0433>
 Francesco de Bello <https://orcid.org/0000-0001-9202-8198>
 Michael Glaser <https://orcid.org/0000-0002-4695-6150>
 Stephan Hennekens <https://orcid.org/0000-0003-1221-0323>
 Florian Jansen <https://orcid.org/0000-0002-0331-5185>
 Borja Jiménez-Alfaro <https://orcid.org/0000-0001-6601-9597>
 Daniel Kadaš <https://orcid.org/0009-0002-5491-8223>
 Ekin Kaplan <https://orcid.org/0000-0002-7303-5883>
 Klára Klinkovská <https://orcid.org/0000-0002-1644-2140>
 Bernd Lenzner <https://orcid.org/0000-0002-2616-3479>
 Harald Pauli <https://orcid.org/0000-0002-9842-9934>
 Marta Gaia Sperandii <https://orcid.org/0000-0002-2507-5928>
 Kris Verheyen <https://orcid.org/0000-0002-2067-9108>
 Manuela Winkler <https://orcid.org/0000-0002-8655-9555>
 Otari Abdaladze <https://orcid.org/0000-0001-8140-0900>
 Svetlana Aćić <https://orcid.org/0000-0001-6553-3797>
 Alicia T. R. Acosta <https://orcid.org/0000-0001-6572-3187>
 Audrey Alignier <https://orcid.org/0000-0002-7619-7124>
 Christopher Andrews <https://orcid.org/0000-0003-2428-272X>
 Raphaël Arlettaz <https://orcid.org/0000-0001-6360-5339>
 Fabio Attorre <https://orcid.org/0000-0002-7744-2195>
 Irena Axmanová <https://orcid.org/0000-0001-9440-7976>
 Lander Baeten <https://orcid.org/0000-0003-4262-9221>
 Jakub Baran <https://orcid.org/0000-0001-5455-9158>
 Elena Barni <https://orcid.org/0000-0001-7256-0064>
 José-Luis Benito-Alonso <https://orcid.org/0000-0003-1086-8834>
 Christian Berg <https://orcid.org/0000-0002-0587-3316>
 Ariel Bergamini <https://orcid.org/0000-0001-8816-1420>
 Imre Berki <https://orcid.org/0000-0002-0858-1327>
 Steffen Boch <https://orcid.org/0000-0003-2814-5343>
 Barbara Bock <https://orcid.org/0009-0008-8529-5683>
 Gianmaria Bonari <https://orcid.org/0000-0002-5574-6067>
 Karel Boublík <https://orcid.org/0000-0002-8587-4238>
 Andrea J. Britton <https://orcid.org/0000-0002-0603-7432>
 Jörg Brunet <https://orcid.org/0000-0003-2667-4575>
 Serge Buholzer <https://orcid.org/0000-0002-5588-6641>
 Sabina Burrascano <https://orcid.org/0000-0002-6537-3313>
 Juan A. Campos <https://orcid.org/0000-0001-5992-2753>
 Maria Laura Carranza <https://orcid.org/0000-0001-5753-890X>
 Tomáš Černý <https://orcid.org/0000-0003-2637-808X>
 Kévin Charmillot <https://orcid.org/0000-0002-2311-6386>
 Alessandro Chiarucci <https://orcid.org/0000-0003-1160-235X>
 Philippe Choler <https://orcid.org/0000-0002-9062-2721>



- Kryštof Chytrý <https://orcid.org/0000-0003-4113-6564>
- Emmanuel Corcket <https://orcid.org/0000-0002-8586-2202>
- Anikó Csecserits <https://orcid.org/0000-0002-0538-4520>
- Maurizio Cutini <https://orcid.org/0000-0002-8597-8221>
- Marta Czarniecka-Wiera <https://orcid.org/0000-0003-3294-5853>
- Jiří Danihelka <https://orcid.org/0000-0002-2640-7867>
- Maria Carla de Francesco <https://orcid.org/0000-0002-5238-1154>
- Pieter De Frenne <https://orcid.org/0000-0002-8613-0943>
- Michele Di Musciano <https://orcid.org/0000-0002-3130-7270>
- Michele De Sanctis <https://orcid.org/0000-0002-7280-6199>
- Balázs Deák <https://orcid.org/0000-0001-6938-1997>
- Guillaume Decocq <https://orcid.org/0000-0001-9262-5873>
- Iwona Dembicz <https://orcid.org/0000-0002-6162-1519>
- Jürgen Dengler <https://orcid.org/0000-0003-3221-660X>
- Valter Di Cecco <https://orcid.org/0000-0001-9862-1267>
- Jan Dick <https://orcid.org/0000-0002-4180-9338>
- Martin Diekmann <https://orcid.org/0000-0001-8482-0679>
- Hartmut Dierschke <https://orcid.org/0000-0002-8955-926X>
- Thomas Dirnböck <https://orcid.org/0000-0002-8294-0690>
- Inken Doerfler <https://orcid.org/0000-0001-9624-1922>
- Jiří Doležal <https://orcid.org/0000-0002-5829-4051>
- Ute Döring <https://orcid.org/0000-0001-7249-3279>
- Tomasz Durak <https://orcid.org/0000-0003-4053-3699>
- Ciara Dwyer <https://orcid.org/0000-0002-7558-3664>
- Rasmus Ejrnæs <https://orcid.org/0000-0003-2538-8606>
- Giuliano Fanelli <https://orcid.org/0000-0002-3143-1212>
- Thomas Fickert <https://orcid.org/0000-0001-6748-4431>
- Andrea Fischer <https://orcid.org/0000-0003-1291-8524>
- Markus Fischer <https://orcid.org/0000-0002-5589-5900>
- Kacper Foremnik <https://orcid.org/0000-0002-2654-4204>
- Jan Frouz <https://orcid.org/0000-0002-0908-8606>
- Ricardo García-González <https://orcid.org/0000-0001-5625-8690>
- Itziar García-Mijangos <https://orcid.org/0000-0002-6642-7782>
- Rosario G. Gavilán <https://orcid.org/0000-0002-1022-445X>
- Mateja Germ <https://orcid.org/0000-0002-4422-1257>
- Dany Ghosn <https://orcid.org/0000-0003-1898-9681>
- Khatuna Gigauri <https://orcid.org/0000-0002-6707-0818>
- Aleksandra Golob <https://orcid.org/0000-0001-9903-112X>
- Valentin Golub <https://orcid.org/0000-0003-3973-6608>
- Daniel Gómez-García <https://orcid.org/0000-0002-9738-8720>
- David Gowing <https://orcid.org/0000-0001-7845-035X>
- John-Arvid Grytnes <https://orcid.org/0000-0002-6365-9676>
- Behlül Güler <https://orcid.org/0000-0003-2638-4340>
- Alba Gutiérrez-Girón <https://orcid.org/0000-0002-0988-3343>
- Peter Haase <https://orcid.org/0000-0002-9340-0438>
- Sylvia Haider <https://orcid.org/0000-0002-2966-0534>
- Michal Hájek <https://orcid.org/0000-0002-5201-2682>
- Melinda Halassy <https://orcid.org/0000-0001-8523-3169>
- Werner Härdtle <https://orcid.org/0000-0002-5599-5792>
- Thilo Heinken <https://orcid.org/0000-0002-1681-5971>
- Jean-Yves Humbert <https://orcid.org/0000-0002-5756-6748>
- Ricardo Ibáñez <https://orcid.org/0000-0002-1772-4473>
- Estela Illa <https://orcid.org/0000-0001-7136-6518>
- Bogdan Jaroszewicz <https://orcid.org/0000-0002-2042-8245>
- Kai Jensen <https://orcid.org/0000-0001-7846-5519>
- Anke Jentsch <https://orcid.org/0000-0002-2345-8300>
- Martin Jiroušek <https://orcid.org/0000-0002-4293-478X>
- Veronika Kalníková <https://orcid.org/0000-0003-2361-0816>
- Róbert Kanka <https://orcid.org/0000-0002-7071-7280>
- Jutta Kapfer <https://orcid.org/0000-0002-8077-8917>
- Janez Kermavnar <https://orcid.org/0000-0001-8052-4653>
- Larisa Khanina <https://orcid.org/0000-0002-8937-5938>
- Elisabeth Kindermann <https://orcid.org/0000-0003-4390-1303>
- Marek Kotrík <https://orcid.org/0000-0002-8921-3891>
- Tomáš Koutecký <https://orcid.org/0000-0003-0929-794X>
- Łukasz Kozub <https://orcid.org/0000-0002-6591-8045>
- Lado Kutnar <https://orcid.org/0000-0001-9785-1263>
- Dario La Montagna <https://orcid.org/0000-0002-7124-493X>
- Andrea Lamprecht <https://orcid.org/0000-0002-8719-026X>
- Jonathan Lenoir <https://orcid.org/0000-0003-0638-9582>
- Jan Lepš <https://orcid.org/0000-0002-4822-7429>
- Juan Lorite <https://orcid.org/0000-0003-4617-8069>
- Bjarke Madsen <https://orcid.org/0000-0002-4490-8710>
- Rosina Magaña Ugarte <https://orcid.org/0000-0003-0628-3251>
- Marek Malicki <https://orcid.org/0000-0003-0517-3560>
- Tuija Maliniemi <https://orcid.org/0000-0003-1218-6554>
- František Máliš <https://orcid.org/0000-0003-2760-6988>
- Alexander Maringer <https://orcid.org/0000-0002-4522-2462>
- Robert Marrs <https://orcid.org/0000-0002-0664-9420>
- Silvia Matesanz <https://orcid.org/0000-0003-0060-6136>
- Stefan Meyer <https://orcid.org/0000-0002-1395-5004>
- Jonathan Millett <https://orcid.org/0000-0003-4701-3071>
- Ruth J. Mitchell <https://orcid.org/0000-0001-8151-2769>
- Jesper Erenskjold Moeslund <https://orcid.org/0000-0001-8591-7149>
- Pavel Moiseev <https://orcid.org/0000-0003-4808-295X>
- Umberto Morra di Cella <https://orcid.org/0000-0003-4250-9705>
- Ondřej Mudrák <https://orcid.org/0000-0001-7775-0414>
- Frank Müller <https://orcid.org/0000-0001-9482-9423>
- Norbert Müller <https://orcid.org/0000-0002-2543-4046>
- Tobias Naaf <https://orcid.org/0000-0002-4809-3694>
- Francesca Napoleone <https://orcid.org/0000-0002-3807-7180>
- Juri Nascimbene <https://orcid.org/0000-0002-9174-654X>
- Josep M. Ninot <https://orcid.org/0000-0002-3712-0810>
- Yujie Niu <https://orcid.org/0000-0002-0912-8401>
- Signe Normand <https://orcid.org/0000-0002-8782-4154>
- Romá Ogaya <https://orcid.org/0000-0003-4927-8479>
- Vladimir Onipchenko <https://orcid.org/0000-0002-1626-1171>
- Anna Orczewska <https://orcid.org/0000-0002-7924-9794>
- Adrienne Ortmann-Ajkai <https://orcid.org/0000-0002-6677-2666>



Robin J. Pakeman <https://orcid.org/0000-0001-6248-4133>
 Iker Pardo <https://orcid.org/0000-0001-7005-6411>
 Ricarda Pätsch <https://orcid.org/0000-0002-3349-0910>
 Robert K. Peet <https://orcid.org/0000-0003-2823-6587>
 Josep Penuelas <https://orcid.org/0000-0002-7215-0150>
 Cord Peppeler-Lisbach <https://orcid.org/0000-0001-8209-8539>
 Javier Pérez-Hernández <https://orcid.org/0000-0001-8265-1955>
 Aaron Pérez-Haase <https://orcid.org/0000-0002-5974-7374>
 Alessandro Petraglia <https://orcid.org/0000-0003-4632-2251>
 Petr Petřík <https://orcid.org/0000-0001-8518-6737>
 Remigiusz Pielech <https://orcid.org/0000-0001-8879-3305>
 Hubert Piórkowski <https://orcid.org/0009-0003-4258-3486>
 Eulàlia Pladevall-Izard <https://orcid.org/0000-0002-6693-5314>
 Peter Poschlod <https://orcid.org/0000-0003-4473-7656>
 Karel Prach <https://orcid.org/0000-0002-0317-7800>
 Safiya Praleskouskaya <https://orcid.org/0000-0002-0893-4663>
 Sam Provoost <https://orcid.org/0000-0003-2751-5269>
 Mihai Puşcaş <https://orcid.org/0000-0002-2632-640X>
 Štěpánka Pustková <https://orcid.org/0000-0002-9384-4872>
 Christophe François Randin <https://orcid.org/0000-0002-4171-0178>
 Valerijus Rašomavičius <https://orcid.org/0000-0003-1314-4356>
 Kamila Reczyńska <https://orcid.org/0000-0002-0938-8430>
 Tamás Rédei <https://orcid.org/0000-0003-2767-2643>
 Klára Řehouňková <https://orcid.org/0000-0002-0916-6977>
 Nina Richner <https://orcid.org/0000-0002-5828-0098>
 Anita C. Risch <https://orcid.org/0000-0003-0531-8336>
 Christian Rixen <https://orcid.org/0000-0002-2486-9988>
 Sergey Rosbakh <https://orcid.org/0000-0002-4599-6943>
 Christiane Roscher <https://orcid.org/0000-0001-9301-7909>
 Graziano Rossi <https://orcid.org/0000-0002-5102-5019>
 Camille Roux <https://orcid.org/0000-0002-3101-3977>
 Sabine B. Rumpf <https://orcid.org/0000-0001-5909-9568>
 Eszter Ruprecht <https://orcid.org/0000-0003-0122-6282>
 Solvita Rūsiņa <https://orcid.org/0000-0002-9580-4110>
 Irati Sanz-Zubizarreta <https://orcid.org/0009-0000-9816-2574>
 Wolfgang Schmidt <https://orcid.org/0000-0001-5356-4684>
 Joachim Schrautzer <https://orcid.org/0000-0001-6355-7234>
 Hendrik Schubert <https://orcid.org/0000-0001-6309-2609>
 Angelika Schwabe <https://orcid.org/0000-0003-0698-5763>
 Jan Šebesta <https://orcid.org/0000-0003-2891-2346>
 Hallie Seiler <https://orcid.org/0000-0002-9333-5226>
 Urban Šilc <https://orcid.org/0000-0002-3052-699X>
 Vasco Silva <https://orcid.org/0000-0003-2729-1824>
 Petr Šmilauer <https://orcid.org/0000-0003-3065-5721>
 Marie Šmilauerová <https://orcid.org/0000-0002-0349-4179>
 Thomas Sperle <https://orcid.org/0000-0002-5836-8241>
 Alina Stachurska-Swakoń <https://orcid.org/0000-0003-0381-4520>
 Nils Stanik <https://orcid.org/0000-0002-9717-3826>
 Angela Stanisci <https://orcid.org/0000-0002-5302-0932>
 Christian Storm <https://orcid.org/0000-0001-9662-8131>

Hans Georg Stroh <https://orcid.org/0000-0002-2521-7172>
 Krzysztof Świerkosz <https://orcid.org/0000-0002-5145-178X>
 Sebastian Świercz <https://orcid.org/0000-0003-2035-0035>
 Magdalena Szymura <https://orcid.org/0000-0002-5726-7393>
 Balázs Teleki <https://orcid.org/0000-0002-2417-0413>
 Gilles Thébaud <https://orcid.org/0000-0002-3522-9732>
 Jean-Paul Theurillat <https://orcid.org/0000-0002-1843-5809>
 Lubomír Tichý <https://orcid.org/0000-0001-8400-7741>
 Urs A. Treier <https://orcid.org/0000-0003-4027-739X>
 Pavel Dan Turtureanu <https://orcid.org/0000-0002-7422-3106>
 Karol Ujházy <https://orcid.org/0000-0002-0228-1737>
 Mariana Ujházyová <https://orcid.org/0000-0002-5546-1547>
 Tudor Mihai Ursu <https://orcid.org/0000-0002-4898-6345>
 Aldona K. Uziebło <https://orcid.org/0000-0002-7531-6064>
 Orsolya Valkó <https://orcid.org/0000-0001-7919-6293>
 Hans Van Calster <https://orcid.org/0000-0001-8595-8426>
 Koenraad Van Meerbeek <https://orcid.org/0000-0002-9260-3815>
 Vigdis Vandvik <https://orcid.org/0000-0003-4651-4798>
 Marco Varricchio <https://orcid.org/0000-0003-4716-6609>
 Kiril Vassilev <https://orcid.org/0000-0003-4376-5575>
 Risto Virtanen <https://orcid.org/0000-0002-8295-8217>
 Pascal Vittoz <https://orcid.org/0000-0003-4218-4517>
 Winfried Voigt <https://orcid.org/0000-0003-3658-8611>
 Andreas von Hessberg <https://orcid.org/0009-0007-0303-3624>
 Goddert von Oheimb <https://orcid.org/0000-0001-7408-425X>
 Camilla Wellstein <https://orcid.org/0000-0001-6994-274X>
 Karsten Wesche <https://orcid.org/0000-0002-0088-6492>
 Markus Wilhelm <https://orcid.org/0000-0002-6792-1395>
 Wolfgang Willner <https://orcid.org/0000-0003-1591-8386>
 Sonja Wipf <https://orcid.org/0000-0002-3492-1399>
 Burghard Wittig <https://orcid.org/0000-0002-5969-9851>
 Thomas Wohlgemuth <https://orcid.org/0000-0002-4623-0894>
 Ben A. Woodcock <https://orcid.org/0000-0003-0300-9951>
 Monika Wulf <https://orcid.org/0000-0001-6499-0750>
 Franz Essl <https://orcid.org/0000-0001-8253-2112>

REFERENCES

- Braun-Blanquet, J. (1913) *Die Vegetationsverhältnisse der Schneestufe in den Rätisch-lepontischen Alpen*. Basel: Georg & Cie.
- Braun-Blanquet, J. (1964) *Pflanzensoziologie. Grundzüge der Vegetationskunde*. Vienna: Springer.
- Bruelheide, H., Tichý, L., Chytrý, M. & Jansen, F. (2021) Implementing the formal language of the vegetation classification expert systems (ESy) in the statistical computing environment R. *Applied Vegetation Science*, 24, e12562. Available from: <https://doi.org/10.1111/avsc.12562>
- Chytrý, M., Tichý, L., Hennekens, S.M., Knollová, I., Janssen, J.A.M., Rodwell, J.S. et al. (2020) EUNIS habitat classification: expert system, characteristic species combinations and distribution maps of European habitats. *Applied Vegetation Science*, 23, 648–675. Available from: <https://doi.org/10.1111/avsc.12519>
- Chytrý, M., Tichý, L., Hennekens, S.M. & Schaminée, J.H.J. (2014) Assessing vegetation change using vegetation-plot databases: a risky business. *Applied Vegetation Science*, 17, 32–41. Available from: <https://doi.org/10.1111/avsc.12050>



- Del Vecchio, S., Pizzo, L. & Buffa, G. (2015) The response of plant community diversity to alien invasion: evidence from a sand dune time series. *Biodiversity and Conservation*, 24, 371–392. Available from: <https://doi.org/10.1007/s10531-014-0814-3>
- Dengler, J., Jansen, F., Glöckler, F., Peet, R.K., De Cáceres, M., Chytrý, M. et al. (2011) The Global Index of Vegetation-plot Databases (GIVD): a new resource for vegetation science. *Journal of Vegetation Science*, 22, 582–597. Available from: <https://doi.org/10.1111/j.1654-1103.2011.01265.x>
- Ellenberg, H. & Leuschner, C. (2017) *Ecology of central European non-forest vegetation: coastal to alpine, natural to man-made habitats*. Springer, Stuttgart: Springer.
- Euro+Med. (2006) [continuously updated]: Euro+Med PlantBase—the information resource for Euro-Mediterranean plant diversity. Published at <http://www.europlusmed.org> [02.2023]
- Gottfried, M., Pauli, H., Futschik, A., Akhalkatsi, M., Barančok, P., Benito Alonso, J.L. et al. (2012) Continent-wide response of mountain vegetation to climate change. *Nature Climate Change*, 2, 111–115. Available from: <https://doi.org/10.1038/nclimate1329>
- Hennekens, S.M. (2015) Turboveg v. 3 – a gateway to EVA and other databases. In: Chytrý, M., Zelený, D. & Hettnerbergerová, E. (Eds.) *58th Annual symposium of the International Association for Vegetation Science: understanding broad-scale vegetation patterns – Abstracts*. Brno: Masaryk University, p. 152.
- Hennekens, S.M. & Schaminée, J.H.J. (2001) TURBOVEG, a comprehensive data base management system for vegetation data. *Journal of Vegetation Science*, 12, 589–591. Available from: <https://doi.org/10.2307/3237010>
- Jandt, U., Bruelheide, H., Berg, C., Bernhardt-Römermann, M., Blüml, V., Bode, F. et al. (2022) ReSurveyGermany: vegetation-plot time-series over the past hundred years in Germany. *Scientific Data*, 9, 631. Available from: <https://doi.org/10.1038/s41597-022-01688-6>
- Jandt, U., Bruelheide, H., Jansen, F., Bonn, A., Grescho, V., Klenke, R.A. et al. (2022) More losses than gains during one century of plant biodiversity change in Germany. *Nature*, 611, 512–518. Available from: <https://doi.org/10.1038/s41586-022-05320-w>
- Kammer, P.M., Rihm, B. & Schöb, C. (2022) Decreasing nitrogen deposition rates: good news for oligotrophic grassland species? *Basic and Applied Ecology*, 63, 125–138. Available from: <https://doi.org/10.1016/j.baec.2022.06.001>
- Kapfer, J., Hédli, R., Jurasinski, G., Kopecký, M., Schei, F.H. & Grytnes, J.-A. (2017) Resurveying historical vegetation data—opportunities and challenges. *Applied Vegetation Science*, 20, 164–171. Available from: <https://doi.org/10.1111/avsc.12269>
- Mucina, L., Schaminée, J.H.J. & Rodwell, J.S. (2000) Common data standards for recording relevés in field survey for vegetation classification. *Journal of Vegetation Science*, 11, 769–772. Available from: <https://doi.org/10.2307/3236581>
- Nielsen, T.F., Sand-Jensen, K. & Bruun, H.H. (2021) Drier, darker and more fertile: 140 years of plant habitat change driven by land-use intensification. *Journal of Vegetation Science*, 32, e13066. Available from: <https://doi.org/10.1111/jvs.13066>
- Pauli, H., Gottfried, M., Lamprecht, A., Niessner, S., Winkler, M., Steinbauer, K. et al. (2015) *The GLORIA field manual*. 5th Edition. Vienna.
- Peppler-Lisbach, C., Stanik, N., Könitz, N. & Rosenthal, G. (2020) Long-term vegetation changes in Nardus grasslands indicate eutrophication, recovery from acidification, and management change as the main drivers. *Applied Vegetation Science*, 23, 508–521. Available from: <https://doi.org/10.1111/avsc.12513>
- Richner, N., Holderegger, R., Linder, H.P. & Walter, T. (2015) Reviewing change in the arable flora of Europe: a meta-analysis. *Weed Research*, 55, 1–13. Available from: <https://doi.org/10.1111/wre.12123>
- Ridding, L.E., Bullock, J.M., Pescott, O.L., Hawes, P., Walls, R., Pereira, M.G. et al. (2020) Long-term change in calcareous grassland vegetation and drivers over three time periods between 1970 and 2016. *Plant Ecology*, 221, 377–394. Available from: <https://doi.org/10.1007/s11258-020-01016-1>
- Rumpf, S.B., Hülber, K., Klöner, G., Moder, D., Schütz, M., Wessely, J. et al. (2018) Range dynamics of mountain plants decrease with elevation. *Proceedings of the National Academy of Sciences of the United States of America*, 115, 1848–1853. Available from: <https://doi.org/10.1073/pnas.1713936115>
- Schaminée, J.H.J., Hennekens, S.M., Chytrý, M. & Rodwell, J.S. (2009) Vegetation-plot data and databases in Europe: an overview. *Preslia*, 81, 173–185.
- Sperandii, M.G., de Bello, F., Valencia, E., Götzenberger, L., Bazzichetto, M., Galland, T. et al. (2022) LOTVS: a global collection of permanent vegetation plots. *Journal of Vegetation Science*, 33, e13115. Available from: <https://doi.org/10.1111/jvs.13115>
- Staupe, I.R., Pereira, H.M., Daskalova, G.N., Bernhardt-Römermann, M., Diekmann, M., Pauli, H. et al. (2022) Directional turnover towards larger-ranged plants over time and across habitats. *Ecology Letters*, 25, 466–482. Available from: <https://doi.org/10.1111/ele.13937>
- Steinbauer, M.J., Grytnes, J.-A., Jurasinski, G., Kulonen, A., Lenoir, J., Pauli, H. et al. (2018) Accelerated increase in plant species richness on mountain summits is linked to warming. *Nature*, 556, 231–234. Available from: <https://doi.org/10.1038/s41586-018-0005-6>
- Tichý, L. (2002) JUICE, software for vegetation classification. *Journal of Vegetation Science*, 13, 451–453. Available from: <https://doi.org/10.1111/j.1654-1103.2002.tb02069.x>
- Vellend, M., Baeten, L., Myers-Smith, I.H., Elmendorf, S.C., Beausejour, R., Brown, C.D. et al. (2013) Global meta-analysis reveals no net change in local-scale plant biodiversity over time. *Proceedings of the National Academy of Sciences of the United States of America*, 110, 19456–19459. Available from: <https://doi.org/10.1073/pnas.1312779110>
- Verheyen, K., De Frenne, P., Baeten, L., Waller, D.M., Hédli, R., Perring, M.P. et al. (2017) Combining biodiversity resurveys across regions to advance global change research. *Bioscience*, 67, 73–83. Available from: <https://doi.org/10.1093/biosci/biw150>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Definitions of the fields in the ReSurveyEurope 1.0 database.

Appendix S2. Overview of the distribution of plots and observations in ReSurveyEurope across countries.

Appendix S3. Overview of all datasets included in ReSurveyEurope 1.0.

How to cite this article: Knollová, I., Chytrý, M., Bruelheide, H., Dullinger, S., Jandt, U., Bernhardt-Römermann, M. et al. (2024) ReSurveyEurope: A database of resurveyed vegetation plots in Europe. *Journal of Vegetation Science*, 35, e13235. Available from: <https://doi.org/10.1111/jvs.13235>