# sPlot open - An environmentally-balanced, open-access, global dataset of vegetation plots

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## Abstract

Vegetation provides the foundation of life on Earth. Assessing biodiversity status and trends in plant communities is therefore critical to understand and quantify the effects of global change on ecosystems. Here, we present the largest dataset of vegetation plots (i.e. species co-occurrence or community composition data) ever released in open access. It contains information on 91,031 vegetation plots recording the cover or abundance of each plant species that occurs in a plot of a given surface area at the date of the botanical survey. Plots were derived from 103 local to regional datasets. To improve the representation of Earth's environmental conditions, plots were resampled from a larger pool of vegetation plots using an environmentally stratified sampling design. Each vegetation plot comes with information on community-weighted means and variances of key plant functional traits. Our open-access dataset can be used to explore global patterns of diversity at the plant community level, as ground truthing data in remote sensing applications or as a baseline for biodiversity monitoring.

## Background & Summary

Biodiversity is facing a global crisis (1). As many as 1 million species are estimated to be already facing extinction, mostly as a consequence of anthropogenic impacts, land-use and climate change (1). The rates of biodiversity redistribution and homogenization are also accelerating (2; 3). Biological assemblages are becoming progressively more similar to each other globally, as local biodiversity and endemic species go extinct and are replaced by introduced exotic species or by more widespread and competitive native species (1; 3). This has profound potential impacts on human and ecosystem health (4; 5). For instance, many terrestrial and marine species are shifting their geographical distribution as a response to climate change (2), including animals hosting pathogens transmissible to humans (6; 7; 8).

Vegetation, i.e., the assemblage of plant species, is no exception to this biodiversity crisis (9; 10; 3). This is worrisome, since terrestrial vegetation accounts for 80% (450 Gt C) of the living biomass on Earth (11). Given the central role of vegetation in ecosystem productivity, stability and functioning (10), assessing biodiversity status and trends in plant communities is paramount, for other life compartments and human societies alike.

Monitoring plant biodiversity trends requires adequate data across a range of scales (12). Large independent collections of plant occurrence data do exist at the global or continental extent via the Botanical Information and Ecology Network (BIEN) (13), the Global Inventory of Floras and Traits (GIFT) (14) or the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/). However, all these occurrence-only databases either neglect how individual plant species co-occur and interact locally to form plant communities, or are collected at spatial resolutions (e.g., one-degree grid cells) which are too coarse to assess biodiversity trends at the most relevant scale of local plant communities (15).

Yet, there is a long-lasting tradition among botanists to record the cover or abundance of each plant species that occurs in a vegetation plot of a given size (i.e. surface area) at a given time (e.g. 16). Compared to species-level data, vegetation-plot data present many advantages. First, they contain information on which plant species co-occur together in the same locality at a given moment in time (17). This built-in feature of vegetation plots is a necessary prerequisite for testing hypotheses related to biotic interactions among plant species (i.e. plant-plant interactions). It can also provide crucial information on where and when a species is absent, therefore improving current species distribution models (18). Being spatially explicit, vegetation plots can be resurveyed through time to assess potential changes in plant species composition relative to a baseline (19; 20, 3). As they normally contain also information on the relative cover or abundance of each species, vegetation plots are more adequate to detect subtle biodiversity changes, compared to data based on the occurrence of individual species only (21).

Vegetation-plot data are very fragmented, though, as they typically stem from a myriad of research projects. As such, these data often suffer from the usual trade-off in biodiversity data: Collections have either fine-grain spatial resolutions but small spatial extents, or vice versa (22). Furthermore, with their disparate sampling protocols, standards and taxonomic resolutions, aggregating and harmonizing vegetation plot data proves extremely challenging (23). It is not surprising, therefore, that these data have only been rarely used in global-scale biodiversity research until recently (24; 25).

The sPlot initiative tries to close this data gap. It leverages on several existing local to regional vegetation-plot datasets, to create a harmonized and comprehensive global geo-database of terrestrial plant species assemblages (26). Established in 2013, sPlot currently contains more than 1.9 million vegetation plots, and is fully integrated with the TRY database (27), from which it derives information on plant functional traits. The sPlot database is increasingly being used to study continental- to global-scale vegetation patterns, such as the relative contribution of regional vs. local factors on the global patterns of fern richness (28), the mechanisms underlying the spread and abundance of native vs. invasive tree species (29), and worldwide trait–environment relationships in plant communities (23).

Here, we provide an open-access data set composed of 91,031 plots, which is representative of the environmental space covered by the sPlot database. Plots stem from 103 databases, and span across 115 countries (Figure 1). This resampled dataset (sPlot Open - hereafter) is composed of: (1) plot-level information, including metadata and basic vegetation structure descriptors; (2) the species composition of each vegetation plot, including species cover or abundance information when available; and (3) community-level functional diversity indices derived from the TRY database (27).

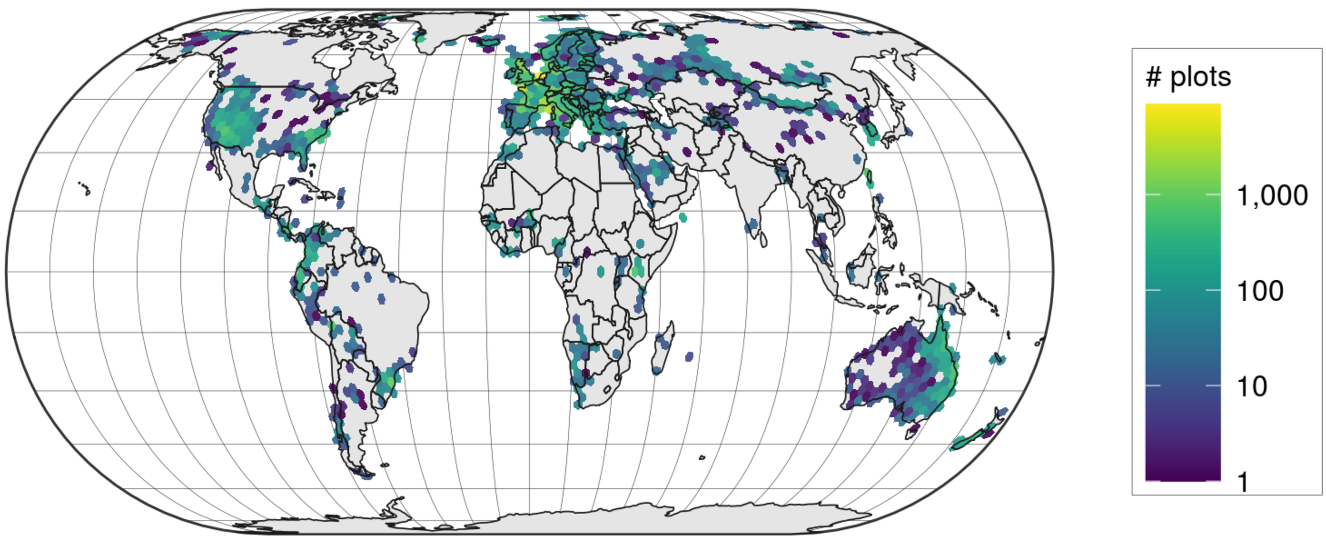


**Figure 1:** Global map of sPlot Open (n = 91,031) and spatial distribution of vegetation plot density per hexagonal cell with a spatial resolution of approximately 70.000 km². Map projection is Eckert IV.

# Methods

## Vegetation plot data sources

We started from the sPlot database v2.1 (created October 2016), which contains 1,121,244 vegetation plots and 23,586,216 species records stemming from 110 different vegetation-plot datasets of regional, national or continental extent. Some of the 110 datasets stem from regional or continental initiatives (see 26 for more information). For instance: 48 vegetation-plot datasets derive from the European Vegetation Archive (EVA) (17), three major African datasets from the Tropical African Vegetation Archive (TAVA), multiple vegetation datasets in the USA from the VegBank archive (30; 31). Data from other continents (South America, Asia) or countries were contributed as separate datasets. The metadata of each individual vegetation-plot dataset stored in sPlot are managed through the Global Index of Vegetation-Plot Databases (GIVD; 32), using the GIVD identifier as the unique dataset identifier.

## Resampling method

Data in the sPlot database are unevenly distributed across continents and biomes (see 23). Mid-latitude regions in developing countries (mostly Europe, the USA and Australia) are overrepresented, while regions in the tropics and subtropics are underrepresented, which is a typical geographical bias in biodiversity data (e.g., 33; 2). To reduce this imbalance to the extent possible, we performed a stratified resampling approach, using several environmental variables available at the global extent as sampling strata. We considered 30 climatic and soil variables. For climate we complemented the 19 bioclimatic variables from CHELSA (34), as well as two variables reflecting growing-season warmth (growing degree days above 1 °C - GDD1 - and 5 °C - GDD5), which we calculated based on CHELSA bioclimatic variables. In addition we considered an index of aridity (AR) and a model for Potential Evapotranspiration (PET - 35). For soil, we extracted seven variables from the SOILGRIDS database (36), namely: soil organic carbon content in the fine earth fraction, cation exchange capacity, pH, as well as the fractions of coarse fragments, sand, silt and clay.

We stratified our sampling effort based on the following procedure. First we ran a global principal component analysis (PCA) of the 30 above-mentioned environmental variables. We considered the full environmental space of all terrestrial habitats on Earth at a spatial resolution of 2.5 arcmin, totaling 8,384,404 terrestrial grid cells, irrespective of whether a grid cell hosted vegetation plots from the sPlot database v2.1 or not. We then subdivided the environmental space represented by the first two principal components (PC1–PC2), accounting for 47% and 23% of the total variation on PC1 and PC2, respectively, into a 100 × 100 grid. This PC1-PC2 bidimensional space was subsequently used to balance our sampling effort across all PC1-PC2 grid cells for which vegetation plots are available. Before projecting vegetation plots from the sPlot database v2.1 onto this PC1-PC2 environmental space, we removed vegetation plots: from wetlands; from anthropogenic vegetation types; without geographical coordinates; and with a location uncertainty higher than 3 km for those having geographical coordinates. This led to a total of 799,400 out of the initial set of 1,121,244 vegetation plots. When projecting the 799,400 vegetation plots in the PC1-PC2 grid, we calculated how many vegetation plots occurred in each PC1-PC2 grid cell. For those grid cells with more than 50 vegetation plots (n = 858), we randomly selected up to 50 vegetation plots using the heterogeneity-constrained random resampling algorithm from [37]. This approach optimizes the selection of a random subset of vegetation plots that encompasses the highest variability in species composition while avoiding peculiar and rare communities, which may represent outliers. We based the quantification of variability in plant species composition among the 50 randomly selected vegetation plots by computing the mean and the variance of the Jaccard's dissimilarity index (38) between all possible pairs of vegetation plots for a given random selection of 50 vegetation plots (n = 1225). More precisely, for a given PC1-PC2 grid cell containing more than 50 vegetation plots, we generated 1,000 random selections of 50 vegetation plots and ranked the 1,000 random selections according to the mean (ascending order) and variance (descending order) value. Ranks from both sortings were summed for each random selection, and the random selection with the lowest summed rank was considered as the most representative of the focal grid cell. In case a grid cell contained fewer than 50 plots, we retained all of them. In this way, we reduced the imbalance towards over-sampled climate types, while ensuring the resampled dataset to be representative of the entire environmental gradient covered by the sPlot database. We repeated the resampling procedure three times to get three different possibilities of a random selection of 50 vegetation plots per PC1-PC2 grid cell with, initially, more than 50 vegetation plots. Vegetation plots selected during the first iteration were our first choice, while we considered the vegetation plots additionally selected in the second and third iteration as reserves when asking for the permission to release the data as open access to each dataset's contributor(s).

## Permission to release the data as open access

The resampling procedure resulted in a preliminary potential selection of 98,383 vegetation plots (first choice) and 51,634 vegetation plots flagged as reserves (second or third choice for the subset of PC1-PC2 grid cells with more than 50 vegetation plots available). Being the sPlot database a consortium of independent datasets, whose copyright belongs to the data contributor, we used this preliminary potential selection to ask each dataset's custodian (i.e., either the owner of a dataset or its authorized representative in case of a collective dataset) for permission to release the data of each selected vegetation plot as open access. For 8,070 vegetation plots, permission could not be granted, for instance because the data are unpublished, confidential or sensitive. For these vegetation plots, we used the reserve pool to randomly select replacements, for which such permission could be granted. We imposed the constraint that each vegetation plot in the reserve should belong to the same environmental stratum, i.e., the same PC1-PC2 grid cell, of the confidential vegetation plot. Note that 2,380 PC1-PC2 grid cells (11.7% of total) had one more confidential vegetation plots (median = 1, mean = 3.4, max = 171) that could not be replaced from the reserve pool.

## Trait information

For each vegetation plot for which open access has been granted, we computed the community weighted means for eighteen plant functional traits derived from the TRY database v3.0 (27). These traits were selected among those traits that describe the leaf, wood and seed economics spectra (39; 40), and are known to either affect different key ecosystem processes or respond to macroclimatic drivers or both (26). The eighteen plant functional traits were: (1) leaf area [$mm^2$]; (2) stem specific density [g $cm^{-3}$]; (3) specific leaf area [$m^2kg^{-1}$]; (4) leaf carbon concentration [mg $g^{-1}$]; (5) leaf nitrogen concentration [mg $g^{-1}$]; (6) leaf phosphorus concentration [mg $g^{-1}$]; (7) plant height [m]; (8) seed mass [mg]; (9) seed length [mm]; (10) leaf dry matter content [g $g^{-1}$]; (11) leaf nitrogen per area [g $m^{-2}$]; (12) leaf N:P ratio [g $g^{-1}$]; (13) leaf $\delta^{15}N$ [per million]; (14) seed number per reproductive unit; (15) leaf fresh mass [g]; (16) stem conduit density [$mm^{-2}$]; (17) dispersal unit length [mm]; and (18) conduit element length [µm].

Because missing values were particularly widespread in the species-trait matrix, we employed a gap-filling procedure based on hierarchical Bayesian modeling (R package 'BHPMF', 41; 42). Gap-filling was performed at the level of individual observations. We then log-transformed all gap-filled trait values and averaged each trait by taxon (i.e., at species, or genus level). Additional information on the gap-filling procedure are available in [26].

Community-weighted means (CWM) and the variances (CWV) were calculated for every plant functional trait j and every vegetation plot k as follows (43):

$$CWM_{j,k} = \sum_{i}^{n_k} p_{i,k} t_{i,j} \tag{1}$$

$$CWV_{j,k} = \sum_{i}^{n_k} p_{i,k} (t_{i,j} - CWM_{j,k})^2 \tag{2}$$

where $n_k$ is the number of species with trait information in vegetation plot k, $p_{i,k}$ is the relative abundance of species i in vegetation plot k calculated as the species' fraction in cover or abundance of total cover or abundance, and $t_{i,j}$ is the mean value of species i for trait j.

## Data Records

The final dataset that is provided here as open access contains 91,031 vegetation plots from 115 countries and all continents except Antarctica (Figure 1) and stems from 103 constitutive datasets (Table 1). It only contains the species composition of vascular plants, while information on the composition of bryophytes and lichens was discarded since it was only available for a minority of plots (n = 4,963 and n = 3,045, respectively). Information on the size (surface area) of the vegetation survey is available for 61,898 vegetation plots, and ranges between 0.01 $m^2$ and 4 ha (mean = 270 $m^2$; median = 78.5 $m^2$). The average number of vascular plant species per vegetation plot ranges between 1 (i.e. monospecific stands) and 270 species (mean = 17.6; median = 13).

By reducing the overrepresentation of vegetation plots in specific environmental conditions, the resampling procedure described above strongly reduced the bias in the distribution of vegetation plots within the environmental niche space. Yet, due to the lack or scarcity of data from some geographical regions, like the tropics, the spatial distribution of vegetation plots remains unbalanced across geographical regions (Figure 1). This is evident when comparing the number of plots across continents or biomes. Europe is by far the best represented continent, with 53,884 vegetation plots. In contrast, Africa and South America have only 4,507 and 5,515 vegetation plots, respectively. The representation of biomes is equally unbalanced. The biomes 'Temperate midlatitudes' and 'Subtropics with winter rain' have 37,507 and 16,510 vegetation plots, respectively, while none of the other biomes have more than 10,000 vegetation plots (Figure 2).

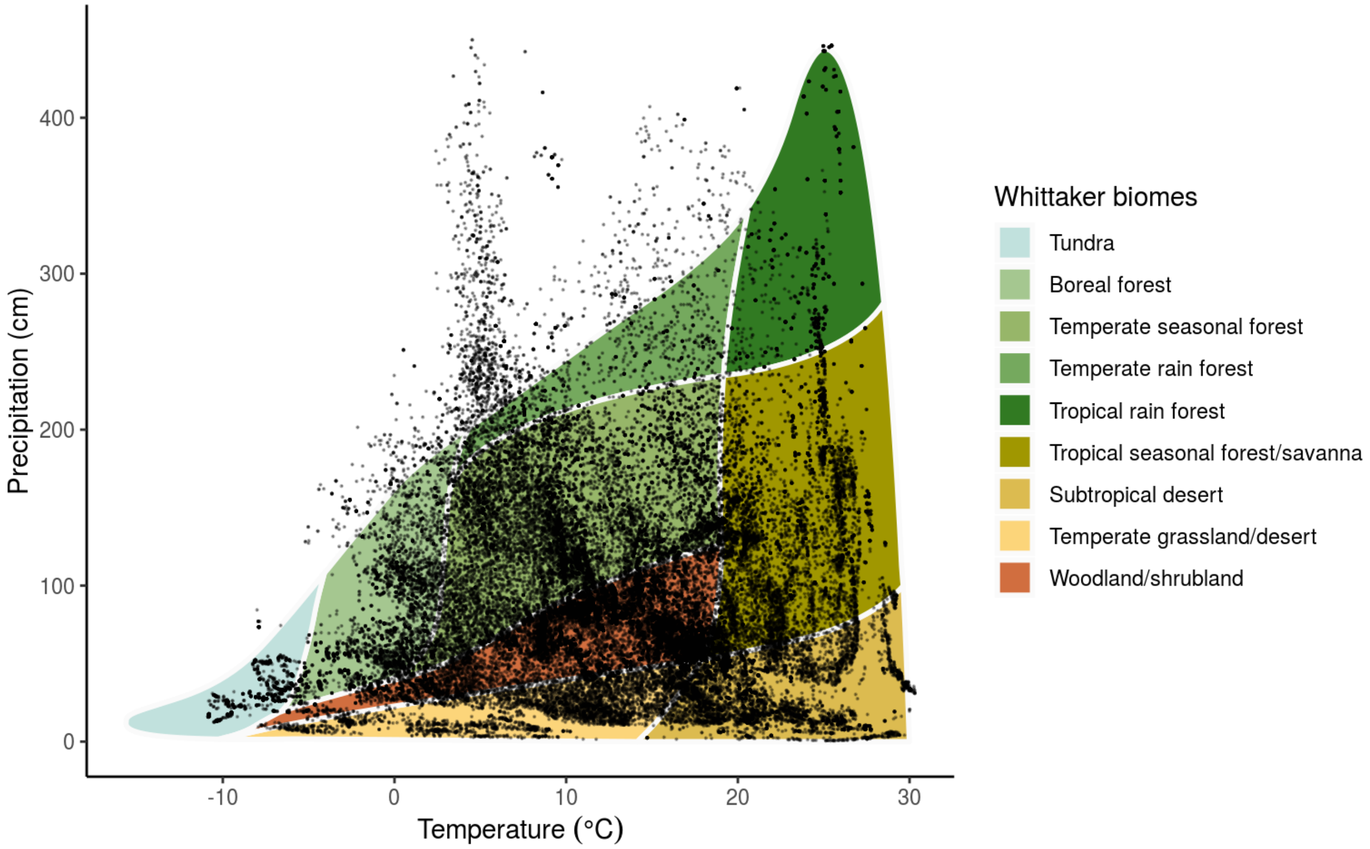


**Figure 2:** Distribution of vegetation plots in climate space represented by mean annual temperature and mean annual precipitation superimposed onto Whittaker biomes (44)

Finally, the dataset contains a relatively balanced number of forest (n = 25,832) vs. non forest (n = 38,203) vegetation plots, with a minor proportion of plots remaining unassigned (n = 10,050). The assignment of plots to forests and non-forests is based on multiple lines of evidence, including the plot-level information on the cover of the tree layer, as well as traits of species composing a plot, such as growth form and height. In short, a plot record was considered a forest if the cover of the tree layer, or alternatively, the sum of the relative cover of all tree taxa, was greater than 0.25. It was instead considered a non-forest record if the sum of relative cover of low-stature, non-tree and non-shrub taxa was greater than 0.90. For an extensive explanation on this classification scheme, we refer the reader to [26]. Even if the proportion of forest vs. non-forest vegetation plots is relatively well-balanced, the geographical distribution of vegetation plots belonging to different vegetation types is likely not balanced in the geographical space, as it depends on the idiosyncrasies of the constitutive datasets composing the sPlot database. For instance, the data from New Zealand only include plots collected in non-forest ecosystems, while data from Chile only refer to forests. We invite potential users to carefully read the description of each individual dataset in GIVD, or to contact the custodians of each dataset, before using sPlot Open.

# Database Organization

sPlot Open is organized into three main matrices.

The **'header'** matrix contains plot level information for the 91,031 vegetation plots provided in this open access dataset, including metadata (e.g., plot ID, ownership, sampling date, geographical location, positional accuracy), sampling design information (e.g., the total surface area used during the vegetation survey), and a plot-level description of vegetation structure (e.g., vegetation type, percentage cover of each vegetation layer), and vegetation type. Plots in Europe are also classified according to the EUNIS habitat classification (column *'ESY'*), based on the habitat classification expert system described in [45]. For each vegetation plot we further provide information on the dataset it stems from, based on the IDs used in the Global Index of Vegetation-Plot Databases. A brief description of all the 43 variables contained in the header matrix is provided in Table 2.

The **'DT'** matrix contains data on the species composition of each plot. It is structured in a long format and contains 1,608,610 records, from 39,997 vascular plant taxa, mostly resolved at the species level. For each record we report both the taxon name as originally contributed by the data custodian (column *'Original_scpecies'*), and the taxon name after taxonomic standardization (column *'Species'*). For each entry, we report the species cover//abundance values. These follow different standards across the datasets constituting the sPlot database. We therefore provide both the cover//abundance value as reported in the original data (column *'Original_abundance'*), together with the abundance scale that was originally used (column *'Abundance_scale'*). This can take seven values: 'CoverPerc' = percentage cover, 'pa' = presence-absence, 'x_BA' = basal area ($m^2$/ha, only for woody species), 'x_IC' = individual count, i.e., number of individuals in plot, 'x_SC' = stem count, i.e., number of stems in plot, 'x_IV' = importance value index, 'x_PF' = presence frequency. The great majority of entries, however, use the percentage cover scale (n= 1,397,109). Finally, for each entry we calculated a *'Relative_cover'*, i.e., the cover//abundance of a given taxon divided by the total cover//abundance of all taxa in that vegetation plot.

The **'CWM_CWV'** matrix contains the community-weighted means and variances calculated for each of the 18 functional traits mentioned above. It also contains three additional columns. The column *'Species_richness'* returns the number of species recorded in each plot. The columns *'Trait_coverage_cover'* and *'Trait_coverage_pa'* return respectively the proportion of total cover and species in a plot for which functional trait information was available.

Functional trait information was available for 20,932 species. The average proportion of species in each plot for which we have functional trait information is 0.88 (median = 1). For 47,177 plots the coverage is complete, while only in one plot we have no functional trait information for any of the occurring species. When considering relative cover, the average trait coverage is 0.89. As many as 68,234 and 74,388 plots have functional trait information for more than 80% of the species or 80% of relative cover, respectively.

sPlot Open contains two additional objects. The **'metadata'** matrix contains plot-level metadata, which provide information on the origin of each individual vegetation plot. This object contains 15 columns, with information on Plot ID, dataset of origin (column *'GIVD_ID'* - 32), author or surveyor names (columns *'Releve_author'* and *'Releve_coauthor'*), bibliographic references both at the dataset (column *'DB_BIBTEXKEY'*) and plot level (*'Plot_Biblioreference'* and *'BIBTEXKEY'*). Similarly, the column *'Project_name'* provide information on the project in which a vegetation plot was collected. When available, we also provide information on the numbering of the plots in the publication where they originally appeared (columns *'Nr_table_in_publ'*, *'Nr_releve_in_table'*), or in the dataset where they were initially stored (*'Original_nr_in_database'*). In case of nested plots (n=1,786), we also provide the original plot and subplot IDs (columns: *'Original_plotID'*, *'Original_subplotID'*). The last two columns report plot-level *'Remarks'*, and the unique identifier produced by Turboveg when the vegetation plot was first stored (*'GUID'*).

Finally, the object **'references'**, contains all the bibliographic references formatted according to a BibTex standard. Each reference is tagged with a key corresponding to the fields *'DB_BIBTEXKEY'* and *'BIBTEXKEY'* in the metadata. We further provide an R function (*'sPlotOpen_citation'*) to create reference lists, based on a selection of plots and\or datasets.

With the exception of the 'reference' file (format .bib), all objects are provided in tab-delimited .txt files. All objects, including the 'sPlotOpen_citation' function are also compiled inside an .RData object.

## Technical Validation

The sPlot database has a nested structure, and is composed of several individual datasets, each validated and maintained by its respective dataset custodian. In same cases, individual datasets are also collections, whose vegetation plots were provided by their respective owners (the person who performed the actual vegetation survey) or by someone who digitized the original data from the scientific or grey literature. We obviously have no direct control on the individual vegetation plots that we provide here in an open access dataset. Yet, each of these vegetation plots stem from trained professional botanists, or published scientific work, and are accompanied by detailed information on the sampling protocols used, thus ensuring data quality and reliability.

Before having been integrated into the sPlot database, each dataset was further checked for consistency and, if having a different format, was converted to a Turboveg 2 database (46). During this conversion, we checked that all datasets contained the required metadata information, and cross-checked that each plot was located within the geographic scopes of its respective dataset. Finally, we harmonized all the taxonomic names from all datasets, based on the sPlot's taxonomic backbone (Purschke 2017). This backbone matched all the taxonomic names (without nomenclatural authors) from all datasets in sPlot 2.1 and TRY v3.0 (27) to their resolved version based on the Taxonomic Name Resolution Service web application (TNRS version 4.0; 47; iPlant Collaborative, 2015). This allowed to (1) harmonize all datasets to a common nomenclature, and (2) link the sPlot database to the TRY database (27). All taxa originally denoted at taxonomic ranks lower than species, were aggregated at species level. Additional detail on the taxonomic resolution is reported in [26], while a description of the workflow, including R-code, is available in [48]

## Usage Notes

The sPlot Open database can be downloaded from https://www.idiv.de (link to PlantHub). Users are invited to cite the original sources when using sPlot Open. For some datasets (e.g., AF-00-009, AF-CD-001) the identification of taxa at species level is still in progress. As a rule, we recommend sPlot Open users to get in touch with the custodian(s) of the data they are planning to use (custodian names are reported in https://www.idiv.de/sPlot). The use of data contained in BioTIME should cite original data citations in addition to the present paper. The data included in the present paper represent the subset of sPlot for which we were able to secure permission for making these data open. The additional data in sPlot are available under sPlot's Governance and Data Property Rules (www.idiv.de/sPlot).

## Code Availability

The R code used to produce sPlot Open from the sPlot 2.1 database is contained in the *sPlotOpen_code* GitHub repository: (https://github.com/fmsabatini/sPlotOpen_Code/). This manuscript was produced using the Manubot workflow (49). The code for reproducing this manuscript is stored in the *sPlotOpen_manuscript* GitHub repository: (https://github.com/fmsabatini/sPlotOpen_Manuscript).

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## Author contributions

FMS wrote the first draft of the manuscript, with considerable input from JL and HB. JL and TH wrote the resampling algorithm. FMS set up the GiHub projects, curated the database, and produced the graphs. He also coordinated the sPlot consortium. SMH wrote the Turboveg v3 software, which holds the sPlot database. JK provided the trait data from TRY and FS performed the trait data gap filling. HB secured the funding for sPlot as a strategic project of iDiv. All other authors contributed data. All authors contributed to revising the manuscript.

# Competing interests

The authors declare no competing interests.

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## Supplementary Material

**Table 1:** List of databases contributing to the open access dataset extracted from the sPlot database. Databases are ordered based on their ID in the Global Index of Vegetation Databases (GVID ID).

| GIVD ID | Dataset name | Custodian | Deputy custodian | Nr. OA plots | Ref |
|---|---|---|---|---|---|
| 00-00-004 | Vegetation Database of Eurasian Tundra | Risto Virtanen | | 600 | |
| 00-RU-003 | Database Meadows and Steppes of Southern Ural | Sergey Yamalov | Mariya Lebedeva | 99 | |
| 00-TR-001 | Forest Vegetation Database of Turkey - FVDT | Ali Kavgacı | | 15 | |
| EU-00-002 | Nordic-Baltic Grassland Vegetation Database (NBGVD) | Jürgen Dengler | Łukasz Kozub | 931 | 50 |
| EU-00-011 | Vegetation-Plot Database of the University of the Basque Country (BIOVEG) | Idoia Biurrun | Itziar García-Mijangos | 1694 | 51 |
| EU-00-013 | Balkan Dry Grasslands Database | Kiril Vassilev | Armin Macanović | 224 | 52 |
| EU-00-016 | Mediterranean Ammophiletea Database | Corrado Marcenò | Borja Jiménez-Alfaro | 3713 | 53 |
| EU-00-017 | European Coastal Vegetation Database | John Janssen | | 1369 | |
| EU-00-018 | The Nordic Vegetation Database | Jonathan Lenoir | Jens-Christian Svenning | 1755 | 54 |
| EU-00-019 | Balkan Vegetation Database | Kiril Vassilev | Hristo Pedashenko | 211 | 55 |
| EU-00-020 | WetVegEurope | Flavia Landucci | | 61 | 56 |
| EU-00-022 | European Mire Vegetation Database | Tomáš Peterka | Martin Jiroušek | 1843 | 57 |
| EU-AL-001 | Vegetation Database of Albania | Michele De Sanctis | Giuliano Fanelli | 99 | 58 |
| EU-AT-001 | Austrian Vegetation Database | Wolfgang Willner | Christian Berg | 950 | 59 |
| EU-BE-002 | INBOVEG | Els De Bie | | 48 | |
| EU-BG-001 | Bulgarian Vegetation Database | Iva Apostolova | Desislava Sopotlieva | 74 | 60 |
| EU-CH-005 | Swiss Forest Vegetation Database | Thomas Wohlgemuth | | 1409 | 61 |
| EU-CZ-001 | Czech National Phytosociological Database | Milan Chytrý | Ilona Knollová | 579 | 62 |
| EU-DE-001 | VegMV | Florian Jansen | Christian Berg | 5 | 63 |
| EU-DE-013 | VegetWeb Germany | Florian Jansen | Jörg Ewald | 199 | 64 |
| EU-DE-014 | German Vegetation Reference Database (GVRD) | Ute Jandt | Helge Bruelheide | 286 | 65 |
| EU-DK-002 | National Vegetation Database of Denmark | Jesper Erenskjold Moeslund | Rasmus Ejrnæs | 1181 | |
| EU-ES-001 | Iberian and Macaronesian Vegetation Information System (SIVIM) - Wetlands | Aaron Pérez-Haase | Xavier Font | 292 | |
| EU-FR-003 | SOPHY | Emmanuel Garbolino | Patrice De Ruffray | 13322 | |

| GIVD ID | Dataset name | Custodian | Deputy custodian | Nr. OA plots | Ref |
|---|---|---|---|---|---|
| EU-GB-001 | UK National Vegetation Classification Database | John S. Rodwell | | 5457 | |
| EU-GR-001 | KRITI | Erwin Bergmeier | | 43 | |
| EU-GR-005 | Hellenic Natura 2000 Vegetation Database (HelNatVeg) | Panayotis Dimopoulos | Ioannis Tsiripidis | 777 | 66 |
| EU-GR-006 | Hellenic Woodland Database | Ioannis Tsiripidis | Georgios Fotiadis | 4 | 67 |
| EU-HR-001 | Phytosociological Database of Non-Forest Vegetation in Croatia | Zvjezdana Stančić | | 213 | 68 |
| EU-HR-002 | Croatian Vegetation Database | Željko Škvorc | Daniel Krstonošić | 688 | |
| EU-HU-003 | CoenoDat Hungarian Phytosociological Database | János Csiky | Zoltán Botta-Dukát | 17 | 69 |
| EU-IT-001 | VegItaly | Roberto Venanzoni | Flavia Landucci | 2712 | 70 |
| EU-IT-010 | Italian National Vegetation Database (BVN/ISPRA) | Laura Casella | Pierangela Angelini | 155 | 71 |
| EU-IT-011 | Vegetation-Plot Database Sapienza University of Rome (VPD-Sapienza) | Emiliano Agrillo | Fabio Attorre | 1003 | 72 |
| EU-LT-001 | Lithuanian Vegetation Database | Valerijus Rašomavičius | Domas Uogintas | 119 | |
| EU-LV-001 | Semi-natural Grassland Vegetation Database of Latvia | Solvita Rūsiņa | | 306 | 73 |
| EU-MK-001 | Vegetation Database of the Republic of Macedonia | Renata Ćušterevska | | 10 | |
| EU-NL-001 | Dutch National Vegetation Database | Joop H.J. Schaminée | Stephan M. Hennekens | 10223 | 74 |
| EU-PL-001 | Polish Vegetation Database | Zygmunt Kącki | Grzegorz Swacha | 464 | 75 |
| EU-RO-007 | Romanian Forest Database | Adrian Indreica | Pavel Dan Turtureanu | 60 | 76 |
| EU-RO-008 | Romanian Grassland Database | Eszter Ruprecht | Kiril Vassilev | 44 | 77 |
| EU-RS-002 | Vegetation Database Grassland Vegetation of Serbia | Svetlana Aćić | Zora Dajić Stevanović | 57 | 78 |
| EU-RU-002 | Lower Volga Valley Phytosociological Database | Valentin Golub | Viktoria Bondareva | 149 | 79 |
| EU-RU-003 | Vegetation Database of the Volga and the Ural Rivers Basins | Tatiana Lysenko | | 96 | 80 |
| EU-RU-011 | Vegetation Database of Tatarstan | Vadim Prokhorov | Maria Kozhevnikova | 94 | 81 |
| EU-SI-001 | Vegetation Database of Slovenia | Urban Šilc | Filip Küzmič | 435 | 82 |
| EU-SK-001 | Slovak Vegetation Database | Milan Valachovič | Jozef Šibík | 893 | 83 |
| EU-UA-006 | Vegetation Database of Ukraine and Adjacent Parts of Russia | Viktor Onyshchenko | Vitaliy Kolomiychuk | 479 | |
| AF-00-001 | West African Vegetation Database | Marco Schmidt | Georg Zizka | 184 | 84 |
| AF-00-008 | PANAF Vegetation Database | Hjalmar Kühl | TeneKwetche Sop | 942 | |

| GIVD ID | Dataset name | Custodian | Deputy custodian | Nr. OA plots | Ref |
|---|---|---|---|---|---|
| AF-BF-001 | Sahel Vegetation Database | Jonas V. Müller | Marco Schmidt | 279 | 85 |
| 00-00-001 | ForestPlots.net | Oliver L. Phillips | Aurora Levesley | 108 | 86 |
| 00-00-003 | SALVIAS | Brian Enquist | Brad Boyle | 2860 | |
| 00-00-005 | Tundra Vegetation Plots (TundraPlot) | Anne D. Bjorkman | Sarah Elmendorf | 227 | 87 |
| 00-RU-002 | Database of Masaryk University`s Vegetation Research in Siberia | Milan Chytrý | | 128 | 88 |
| AF-00-003 | BIOTA Southern Africa Biodiversity Observatories Vegetation Database | Norbert Jürgens | Ute Schmiedel | 562 | 89 |
| AF-00-006 | SWEA-Dataveg | Miguel Alvarez | Michael Curran | 1211 | |
| AF-00-009 | Vegetation Database of the Okavango Basin | Rasmus Revermann | Manfred Finckh | 202 | 90 |
| AF-CD-001 | Forest Database of Central Congo Basin | Kim Sarah Jacobsen | Hans Verbeeck | 97 | 91 |
| AF-ET-001 | Vegetation Database of Ethiopia | Desalegn Wana | Anke Jentsch | 59 | 92 |
| AF-MA-001 | Vegetation Database of Southern Morocco | Manfred Finckh | | 266 | 93 |
| AF-ZW-001 | Vegetation Database of Zimbabwe | Cyrus Samimi | | 17 | 94 |
| AS-00-001 | Korean Forest Database | Tomáš Černý | Jiri Dolezal | 766 | 95 |
| AS-00-003 | Vegetation of Middle Asia | Arkadiusz Nowak | Marcin Nobis | 128 | 96 |
| AS-00-004 | Rice Field Vegetation Database | Arkadiusz Nowak | | 31 | |
| AS-BD-001 | Tropical Forest Dataset of Bangladesh | Mohammed A.S. Arfin Khan | Fahmida Sultana | 82 | |
| AS-CN-001 | China Forest-Steppe Ecotone Database | Hongyan Liu | Fengjun Zhao | 97 | 97 |
| AS-CN-002 | Tibet-PaDeMoS Grazing Transect | Karsten Wesche | | 27 | 98 |
| AS-CN-003 | Vegetation Database of the BEF China Project | Helge Bruelheide | | 18 | 99 |
| AS-CN-004 | Vegetation Database of the Northern Mountains in China | Zhiyao Tang | | 70 | |
| AS-EG-001 | Vegetation Database of Sinai in Egypt | Mohamed Z. Hatim | | 98 | 100 |
| AS-ID-001 | Sulawesi Vegetation Database | Michael Kessler | | 24 | |
| AS-IR-001 | Vegetation Database of Iran | Jalil Noroozi | Parastoo Mahdavi | 105 | |
| AS-KZ-001 | Database of Meadow Vegetation in the NW Tien Shan Mountains | Viktoria Wagner | | 3 | 101 |
| AS-MN-001 | Southern Gobi Protected Areas Database | Henrik von Wehrden | Karsten Wesche | 688 | 102 |
| AS-RU-001 | Wetland Vegetation Database of Baikal Siberia (WETBS) | Victor Chepinoga | | 6 | 103 |
| AS-RU-002 | Database of Siberian Vegetation (DSV) | Andrey Korolyuk | Andrei Zverev | 2150 | |

| GIVD ID | Dataset name | Custodian | Deputy custodian | Nr. OA plots | Ref |
|---|---|---|---|---|---|
| AS-RU-004 | Database of the University of Münster - Biodiversity and Ecosystem Research Group's Vegetation Research in Western Siberia and Kazakhstan | Norbert Hölzel | Wanja Mathar | 85 | |
| AS-SA-001 | Vegetation Database of Saudi Arabia | Mohamed Abd El-Rouf Mousa El-Sheikh | | 607 | |
| AS-TJ-001 | Eastern Pamirs | Kim André Vanselow | | 174 | 104 |
| AS-TW-001 | National Vegetation Database of Taiwan | Ching-Feng Li | Chang-Fu Hsieh | 897 | |
| AS-YE-001 | Socotra Vegetation Database | Michele De Sanctis | Fabio Attorre | 190 | 105 |
| AU-AU-002 | AEKOS | Anita Smyth | Ben Sparrow | 7443 | 106 |
| AU-NC-001 | New Caledonian Plant Inventory and Permanent Plot Network (NC-PIPPN) | Jérôme Munzinger | Philippe Birnbaum | 98 | 107 |
| AU-NZ-001 | New Zealand National Vegetation Databank | Susan Wiser | | 983 | 108 |
| AU-PG-001 | Forest Plots from Papua New Guinea | Timothy Whitfeld | George D. Weiblen | 53 | 109 |
| NA-00-002 | Tree Biodiversity Network (BIOTREE-NET) | Luis Cayuela | | 208 | 110 |
| NA-CA-003 | Database of Timberline Vegetation in NW North America | Viktoria Wagner | Toby Spribille | 38 | 111 |
| NA-CA-004 | Understory of Sugar Maple Dominated Stands in Quebec and Ontario (Canada) | Isabelle Aubin | | 9 | 112 |
| NA-CA-005 | Boreal Forest of Canada | Yves Bergeron | Louis De Grandpré | 44 | |
| NA-GL-001 | Vegetation Database of Greenland | Birgit Jedrzejek | Fred J.A. Daniëls | 340 | 113 |
| NA-US-002 | VegBank | Robert K. Peet | Michael T. Lee | 6456 | 114 |
| NA-US-006 | Carolina Vegetation Survey Database | Robert K. Peet | Michael T. Lee | 2317 | 115 |
| NA-US-014 | Alaska-Arctic Vegetation Archive | Donald A. Walker | Amy Breen | 467 | 116 |
| SA-00-002 | VegPáramo | Gwendolyn Peyre | Xavier Font | 1591 | 117 |
| SA-AR-002 | Vegetation Database of Central Argentina | Melisa Giorgis | Alicia Acosta | 42 | |
| SA-BO-003 | Bolivia Forest Plots | Michael Kessler | Sebastian Herzog | 18 | |
| SA-BR-002 | Forest Inventory, State of Santa Catarina, Brazil (IFFSC Project) | Alexander Christian Vibrans | André Luis de Gasper | 1345 | 118 |
| SA-BR-003 | Grasslands of Rio Grande do Sul, Brazil | Eduardo Vélez-Martin | Valério De Patta Pillar | 271 | |
| SA-BR-004 | Grassland Database of Campos Sulinos | Gerhard E. Overbeck | Valério De Patta Pillar | 111 | |
| SA-CL-002 | SSAForests_Plots_db | Alvaro G. Gutierrez | | 163 | |
| SA-CL-003 | Chilean Park Transects - Fondecyt 1040528 | Aníbal Pauchard | Alicia Marticorena | 33 | 119 |
| SA-EC-001 | Ecuador Forest Plot Database | Jürgen Homeier | | 156 | |

**Table 2:** Description of the variables contained in the 'header' matrix, together with their range (if numeric) or possible levels (if nominal or binary). Variable types can be n - nominal (i.e. qualitative variable), q - quantitative, or b - binary (i.e., boolean), or d - date.

| Variable | Range/Levels | Unit of Measurement | Nr. Records | Type |
|---|---|---|---|---|
| GIVD_ID | | | 91031 | n |
| Dataset | | | 91031 | n |
| Continent | Africa, Asia, Australia, Europe, North America, Oceania, South America | | 90729 | n |
| Country | | | 91031 | n |
| Biome | Alpine, Boreal zone, Dry midlatitudes, Dry tropics and subtropics, Polar and subpolar zone, Subtrop. with year-round rain, Subtropics with winter rain, Temperate midlatitudes, Tropics with summer rain, Tropics with year-round rain | | 91031 | n |
| Date | -29764 - 16469 | | 75798 | q |
| Latitude | -54.73863 - 80.149116 | ° (WGS84) | 91031 | q |
| Longitude | -162.741433 - 179.590053 | ° (WGS84) | 91031 | q |
| Location_uncertainty | 1 - 2500 | m | 91002 | q |
| Releve_area | 0.01 - 40000 | $m^2$ | 61898 | q |
| Herbs_identified | FALSE = 4876; TRUE = 6323 | | 11199 | b |
| Plant_recorded | All trees & dominant understory, All vascular plants, All vascular plants and dominant cryptogams, All woody plants, Dominant trees, Only dominant species, Dominant woody plants >= 2.5 cm dbh, Woody plants >= 10 cm dbh, Woody plants >= 1 m height, Woody plants >= 1 cm dbh, Woody plants >= 20 cm dbh, Woody plants >= 2.5 cm dbh, Woody plants >= 5 cm dbh, NA | | 91015 | n |
| Elevation | -25 - 4819 | m a.s.l. | 52121 | q |
| Aspect | 0 - 360 | ° | 30796 | q |
| Slope | 0 - 99 | ° | 37784 | q |
| is_forest | FALSE = 20396; TRUE = 25832 | | 46228 | b |
| is_nonforest | FALSE = 50870; TRUE = 38203 | | 89073 | b |
| ESY | | | 55457 | n |
| Naturalness | 1 - 2 | | 68011 | q |
| Forest | FALSE = 38295; TRUE = 23735 | | 62030 | b |
| Shrubland | FALSE = 38233; TRUE = 11081 | | 49314 | b |
| Grassland | FALSE = 10213; TRUE = 46947 | | 57160 | b |
| Sparse_vegetation | FALSE = 33381; TRUE = 11315 | | 44696 | b |
| Wetland | FALSE = 29078; TRUE = 18038 | | 47116 | b |
| Cover_total | 1 - 313 | % | 24712 | q |
| Cover_tree_layer | 0.5 - 150 | % | 7245 | q |
| Cover_shrub_layer | 0.5 - 145 | % | 10197 | q |
| Cover_herb_layer | 0.2 - 180 | % | 26679 | q |
| Cover_moss_layer | 1 - 100 | % | 9643 | q |

| Variable | Range/Levels | Unit of Measurement | Nr. Records | Type |
|---|---|---|---|---|
| Cover_lichen_layer | 1 - 95 | % | 734 | q |
| Cover_algae_layer | 1 - 100 | % | 221 | q |
| Cover_litter_layer | 1 - 100 | % | 4500 | q |
| Cover_bare_rocks | 1 - 100 | % | 1897 | q |
| Cover_cryptogams | 1 - 95 | % | 593 | q |
| Cover_bare_soil | 0.1 - 99 | % | 1412 | q |
| Height_trees_highest | 1 - 99 | m | 6115 | q |
| Height_trees_lowest | 1 - 90 | m | 221 | q |
| Height_shrubs_highest | 0.1 - 9.9 | m | 2880 | q |
| Height_shrubs_lowest | 0.1 - 9 | m | 328 | q |
| Height_herbs_average | 0.1 - 440 | cm | 10125 | q |
| Height_herbs_lowest | 1 - 250 | cm | 2785 | q |
| Height_herbs_highest | 1 - 600 | cm | 1733 | q |