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

This manuscript is still work in progress

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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).

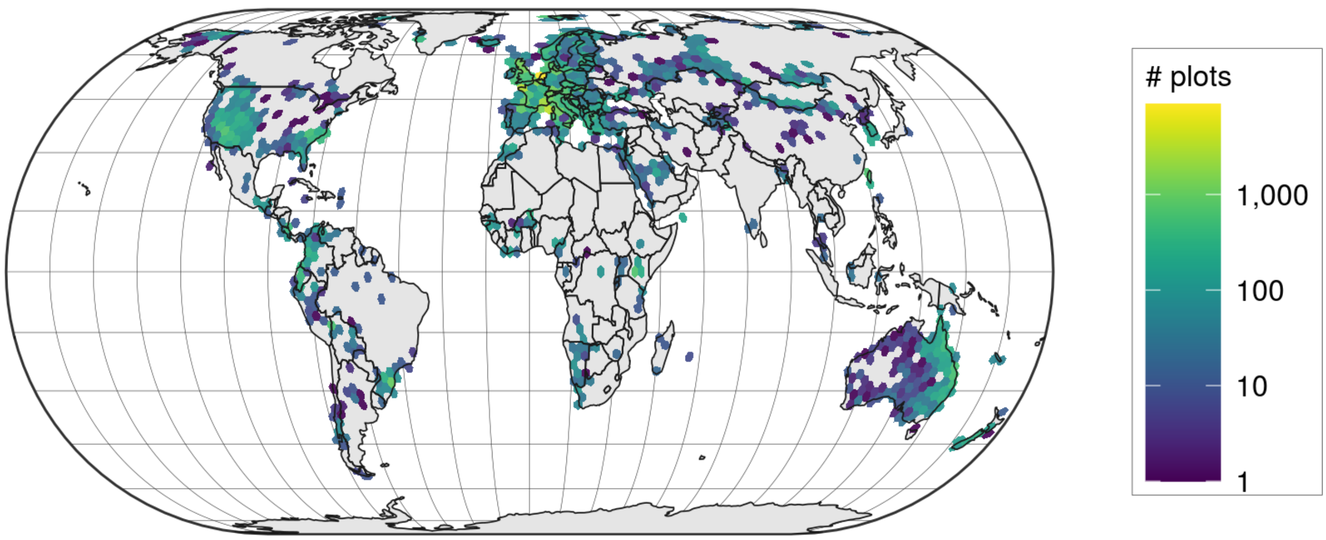

Figure 1: Global map of sPlot Open (n = 91,031) and spatial distribution of vegetation plot density per hexagonal cell with a spatial resolution of approximately 70.000 km². Map projection is Eckert IV.

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). We chose this dissimilarity index because it is not influenced by differences in species richness among vegetation plots. 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 strata, 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 [$m^2 kg^{-1}$]; (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 (1). It only contains the species composition of vascular plants, while information on the composition of mosses or 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).

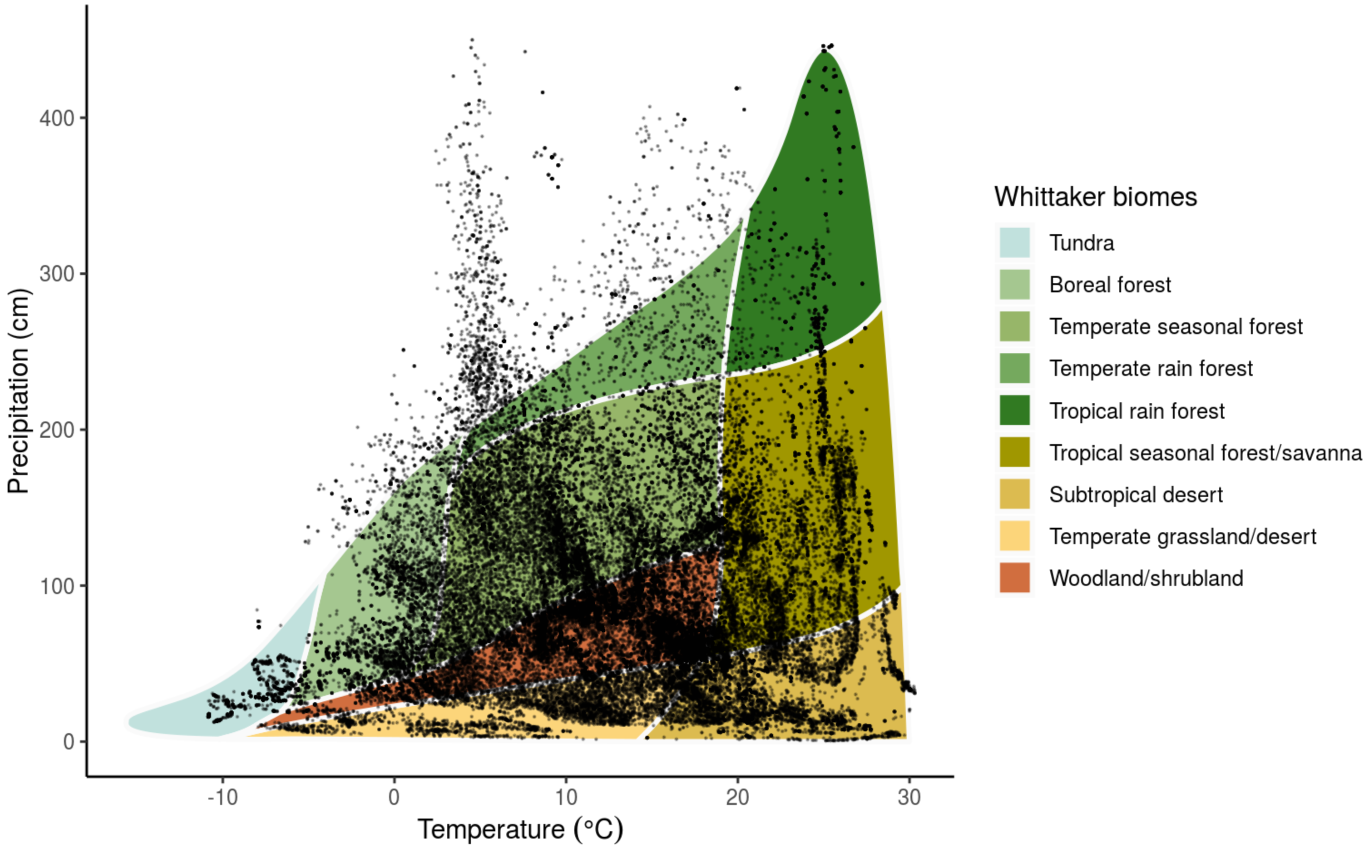

Figure 2: Distribution of vegetation plots in climate space represented by mean annual temperature and mean annual precipitation superimposed onto Whittaker biomes (44)

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). 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 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 furtehr 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 ([45](#)). 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; [46](#); 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 [[47](#)]

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 sPlto 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 ([**???**]). 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.

References

1. **Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services**
   IPBES
   IPBES secretariat (2019)
   ISBN: 978-3-947851-13-3

2. **Species better track climate warming in the oceans than on land**
   Jonathan Lenoir, Romain Bertrand, Lise Comte, Luana Bourgeaud, Tarek Hattab, Jérôme Murienne, Gaël Grenouillet
   Nature Ecology & Evolution (2020-05-25) https://doi.org/ggx3np
   DOI: 10.1038/s41559-020-1198-2 · PMID: 32451428

3. **Replacements of small- by large-ranged species scale up to diversity loss in Europe's temperate forest biome**
   Ingmar R. Staude, Donald M. Waller, Markus Bernhardt-Römermann, Anne D. Bjorkman, Jörg Brunet, Pieter De Frenne, Radim Hédl, Ute Jandt, Jonathan Lenoir, František Máliš, … Lander Baeten
   Nature Ecology & Evolution (2020-04-13) https://doi.org/ggrs73
   DOI: 10.1038/s41559-020-1176-8 · PMID: 32284580

4. **Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being**
   Gretta T. Pecl, Miguel B. Araújo, Johann D. Bell, Julia Blanchard, Timothy C. Bonebrake, I-Ching Chen, Timothy D. Clark, Robert K. Colwell, Finn Danielsen, Birgitta Evengård, … Stephen E. Williams
   Science (2017-03-31) https://doi.org/f9xmpm
   DOI: 10.1126/science.aai9214

5. **Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science**
   Timothy C. Bonebrake, Christopher J. Brown, Johann D. Bell, Julia L. Blanchard, Alienor Chauvenet, Curtis Champion, I-Ching Chen, Timothy D. Clark, Robert K. Colwell, Finn Danielsen, … Gretta T. Pecl
   Biological Reviews (2018-02) https://doi.org/gc2dvc
   DOI: 10.1111/brv.12344 · PMID: 28568902

6. **Global trends in emerging infectious diseases**
   Kate E. Jones, Nikkita G. Patel, Marc A. Levy, Adam Storeygard, Deborah Balk, John L. Gittleman, Peter Daszak
   Nature (2008-02) https://doi.org/cbxh9h
   DOI: 10.1038/nature06536 · PMID: 18288193 · PMCID: PMC5960580

7. **The range of Ixodes ricinus and the risk of contracting Lyme borreliosis will increase northwards when the vegetation period becomes longer**
   Thomas G. T. Jaenson, Elisabet Lindgren
   Ticks and Tick-borne Diseases (2011-03) https://doi.org/fmn4dp
   DOI: 10.1016/j.ttbdis.2010.10.006 · PMID: 21771536

8. **Altitudinal Changes in Malaria Incidence in Highlands of Ethiopia and Colombia**
   A. S. Siraj, M. Santos-Vega, M. J. Bouma, D. Yadeta, D. R. Carrascal, M. Pascual

Science (2014-03-06) https://doi.org/f5vb47
DOI: 10.1126/science.1244325 · PMID: 24604201

9. **A Significant Upward Shift in Plant Species Optimum Elevation During the 20th Century**
J. Lenoir, J. C. Gegout, P. A. Marquet, P. de Ruffray, H. Brisse
Science (2008-06-27) https://doi.org/bnhhj8
DOI: 10.1126/science.1156831 · PMID: 18583610

10. **The functional role of producer diversity in ecosystems**
Bradley J. Cardinale, Kristin L. Matulich, David U. Hooper, Jarrett E. Byrnes, Emmett Duffy, Lars Gamfeldt, Patricia Balvanera, Mary I. O'Connor, Andrew Gonzalez
American Journal of Botany (2011-03) https://doi.org/fnh8qs
DOI: 10.3732/ajb.1000364 · PMID: 21613148

11. **The biomass distribution on Earth**
Yinon M. Bar-On, Rob Phillips, Ron Milo
Proceedings of the National Academy of Sciences (2018-06-19) https://doi.org/cp29
DOI: 10.1073/pnas.1711842115 · PMID: 29784790 · PMCID: PMC6016768

12. **Effective Biodiversity Monitoring Needs a Culture of Integration**
Hjalmar S. Kühl, Diana E. Bowler, Lukas Bösch, Helge Bruelheide, Jens Dauber, David. Eichenberg, Nico Eisenhauer, Néstor Fernández, Carlos A. Guerra, Klaus Henle, … Aletta Bonn
One Earth (2020-10) https://doi.org/ghgk4w
DOI: 10.1016/j.oneear.2020.09.010

13. **Cyberinfrastructure for an integrated botanical information network to investigate the ecological impacts of global climate change on plant biodiversity**
Brian J Enquist, Rick Condit, Robert K Peet, Mark Schildhauer, Barbara M. Thiers
PeerJ (2018-01-13) https://doi.org/ghfnsx
DOI: 10.7287/peerj.preprints.2615v2

14. **GIFT – A Global Inventory of Floras and Traits for macroecology and biogeography**
Patrick Weigelt, Christian König, Holger Kreft
Journal of Biogeography (2019-06-09) https://doi.org/gf38t6
DOI: 10.1111/jbi.13623

15. **Distorted Views of Biodiversity: Spatial and Temporal Bias in Species Occurrence Data**
Elizabeth H. Boakes, Philip J. K. McGowan, Richard A. Fuller, Ding Chang-qing, Natalie E. Clark, Kim O'Connor, Georgina M. Mace
PLoS Biology (2010-06-01) https://doi.org/brfdq6
DOI: 10.1371/journal.pbio.1000385 · PMID: 20532234 · PMCID: PMC2879389

16. **Versuch einer Übersicht über die Wiesentypen der Schweiz**
F. G. Stebler, C. Schröter
Landwirt. Jahrb. Schweiz (1893)

17. **European Vegetation Archive (EVA): an integrated database of European vegetation plots**
Milan Chytrý, Stephan M. Hennekens, Borja Jiménez-Alfaro, Ilona Knollová, Jürgen Dengler, Florian Jansen, Flavia Landucci, Joop H. J. Schaminée, Svetlana Aćić, Emiliano Agrillo, … Sergey Yamalov
Applied Vegetation Science (2016-01) https://doi.org/bc7k
DOI: 10.1111/avsc.12191

18. **Sample selection bias and presence-only distribution models: implications for background and pseudo-absence data**
Steven J. Phillips, Miroslav Dudík, Jane Elith, Catherine H. Graham, Anthony Lehmann, John Leathwick, Simon Ferrier
Ecological Applications (2009-01) https://doi.org/dx4s78
DOI: 10.1890/07-2153.1 · PMID: 19323182

19. **Global environmental change effects on plant community composition trajectories depend upon management legacies**
Michael P. Perring, Markus Bernhardt-Römermann, Lander Baeten, Gabriele Midolo, Haben Blondeel, Leen Depauw, Dries Landuyt, Sybryn L. Maes, Emiel De Lombaerde, Maria Mercedes Carón, … Kris Verheyen
Global Change Biology (2018-04) https://doi.org/gc6mjp
DOI: 10.1111/gcb.14030 · PMID: 29271579

20. **Accelerated increase in plant species richness on mountain summits is linked to warming**
Manuel J. Steinbauer, John-Arvid Grytnes, Gerald Jurasinski, Aino Kulonen, Jonathan Lenoir, Harald Pauli, Christian Rixen, Manuela Winkler, Manfred Bardy-Durchhalter, Elena Barni, … Sonja Wipf
Nature (2018-04-04) https://doi.org/gdfwk3
DOI: 10.1038/s41586-018-0005-6 · PMID: 29618821

21. **Exploring large vegetation databases to detect temporal trends in species occurrences**
Ute Jandt, Henrik von Wehrden, Helge Bruelheide
Journal of Vegetation Science (2011-12) https://doi.org/d8b4jv
DOI: 10.1111/j.1654-1103.2011.01318.x

22. **Biodiversity data integration—the significance of data resolution and domain**
Christian König, Patrick Weigelt, Julian Schrader, Amanda Taylor, Jens Kattge, Holger Kreft
PLOS Biology (2019-03-18) https://doi.org/c3xz
DOI: 10.1371/journal.pbio.3000183 · PMID: 30883539 · PMCID: PMC6445469

23. **Global trait–environment relationships of plant communities**
Helge Bruelheide, Jürgen Dengler, Oliver Purschke, Jonathan Lenoir, Borja Jiménez-Alfaro, Stephan M. Hennekens, Zoltán Botta-Dukát, Milan Chytrý, Richard Field, Florian Jansen, … Ute Jandt
Nature Ecology & Evolution (2018-11-19) https://doi.org/gfj595
DOI: 10.1038/s41559-018-0699-8 · PMID: 30455437

24. **Big data for forecasting the impacts of global change on plant communities**
Janet Franklin, Josep M. Serra-Diaz, Alexandra D. Syphard, Helen M. Regan
Global Ecology and Biogeography (2017-01) https://doi.org/f9hdp3
DOI: 10.1111/geb.12501

25. **Achievements and challenges in the integration, reuse and synthesis of vegetation plot data**
Susan K. Wiser
Journal of Vegetation Science (2016-09) https://doi.org/ghfnr5
DOI: 10.1111/jvs.12419

26. **sPlot – A new tool for global vegetation analyses**
Helge Bruelheide, Jürgen Dengler, Borja Jiménez-Alfaro, Oliver Purschke, Stephan M. Hennekens, Milan Chytrý, Valério D. Pillar, Florian Jansen, Jens Kattge, Brody Sandel, … Andrei Zverev
Journal of Vegetation Science (2019-04-08) https://doi.org/gfvhkm
DOI: 10.1111/jvs.12710

27. **TRY plant trait database – enhanced coverage and open access**
Jens Kattge, Gerhard Bönisch, Sandra Díaz, Sandra Lavorel, Iain Colin Prentice, Paul Leadley, Susanne Tautenhahn, Gijsbert D. A. Werner, Tuomas Aakala, Mehdi Abedi, … Christian Wirth
Global Change Biology (2020) https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14904
DOI: 10.1111/gcb.14904

28. **Global fern and lycophyte richness explained: How regional and local factors shape plot richness**
Anna Weigand, Stefan Abrahamczyk, Isabelle Aubin, Claudia Bita-Nicolae, Helge Bruelheide, Cesar I. Carvajal-Hernández, Daniele Cicuzza, Lucas Erickson Nascimento da Costa, János Csiky, Jürgen Dengler, … Michael Kessler
Journal of Biogeography (2019-12-30) https://doi.org/ggf4gr
DOI: 10.1111/jbi.13782

29. **Similar factors underlie tree abundance in forests in native and alien ranges**
Masha T. Sande, Helge Bruelheide, Wayne Dawson, Jürgen Dengler, Franz Essl, Richard Field, Sylvia Haider, Mark Kleunen, Holger Kreft, Joern Pagel, … Tiffany M. Knight
Global Ecology and Biogeography (2019-12) https://doi.org/ggftj7
DOI: 10.1111/geb.13027 · PMID: 32063745 · PMCID: PMC7006795

30. **Vegetation-plot database of the Carolina Vegetation Survey**
Richard K. Peet, Michael T. Lee, M. Forbes Boyle, Thomas R. Wentworth, Michael P. Schafale, Alan S. Weakley
Vegetation databases for the 21st century (2012) https://doi.org/10.7809/b-e.00081

31. **VegBank – a permanent, open-access archive for vegetation-plot data**
Richard K. Peet, M. T. Lee, M. D. Jennings, D. Faber-Langendoen
Vegetation databases for the 21st century (2012) https://doi.org/10.7809/b-e.00080

32. **The Global Index of Vegetation-Plot Databases (GIVD): a new resource for vegetation science**
Jürgen Dengler, Florian Jansen, Falko Glöckler, Robert K. Peet, Miquel De Cáceres, Milan Chytrý, Jörg Ewald, Jens Oldeland, Gabriela Lopez-Gonzalez, Manfred Finckh, … Nick Spencer
Journal of Vegetation Science (2011-08) https://doi.org/ctx2s7
DOI: 10.1111/j.1654-1103.2011.01265.x

33. **Climate-related range shifts - a global multidimensional synthesis and new research directions**
J. Lenoir, J.-C. Svenning
Ecography (2015-01) https://doi.org/f6xz9h
DOI: 10.1111/ecog.00967

34. **Climatologies at high resolution for the earth's land surface areas**
Dirk Nikolaus Karger, Olaf Conrad, Jürgen Böhner, Tobias Kawohl, Holger Kreft, Rodrigo Wilber Soria-Auza, Niklaus E. Zimmermann, H. Peter Linder, Michael Kessler
Scientific Data (2017-09-05) https://doi.org/gbvksk
DOI: 10.1038/sdata.2017.122 · PMID: 28872642 · PMCID: PMC5584396

35. **Global High-Resolution Soil-Water Balance**
Antonio Trabucco, Robert J. Zomer
figshare (2019) https://figshare.com/articles/Global_High-Resolution_Soil-Water_Balance/7707605/3
DOI: 10.6084/m9.figshare.7707605.v3

36. **SoilGrids250m: Global gridded soil information based on machine learning**
Tomislav Hengl, Jorge Mendes de Jesus, Gerard B. M. Heuvelink, Maria Ruiperez Gonzalez, Milan Kilibarda, Aleksandar Blagotić, Wei Shangguan, Marvin N. Wright, Xiaoyuan Geng, Bernhard Bauer-Marschallinger, … Bas Kempen
PLOS ONE (2017-02-16) https://doi.org/f9qc5p
DOI: 10.1371/journal.pone.0169748 · PMID: 28207752 · PMCID: PMC5313206

37. **Heterogeneity-constrained random resampling of phytosociological databases**
Attila Lengyel, Milan Chytrý, Lubomír Tichý
Journal of Vegetation Science (2011-02) https://doi.org/dvjzbz
DOI: 10.1111/j.1654-1103.2010.01225.x

38. **The relationship between species replacement, dissimilarity derived from nestedness, and nestedness**
Andrés Baselga
Global Ecology and Biogeography (2012-12) https://doi.org/gddc72
DOI: 10.1111/j.1466-8238.2011.00756.x

39. **A leaf-height-seed (LHS) plant ecology strategy scheme**
Mark Westoby
Plant and Soil (1998-02-01) https://doi.org/10.1023/A:1004327224729
DOI: 10.1023/a:1004327224729

40. **The world-wide “fast-slow” plant economics spectrum: a traits manifesto**
Peter B. Reich
Journal of Ecology (2014-03) https://doi.org/gfc4z9
DOI: 10.1111/1365-2745.12211

41. **Uncertainty Quantified Matrix Completion Using Bayesian Hierarchical Matrix Factorization**
Farideh Fazayeli, Arindam Banerjee, Jens Kattge, Franziska Schrodt, Peter B. Reich
Institute of Electrical and Electronics Engineers (IEEE) (2014-12) https://doi.org/ghfnw3
DOI: 10.1109/icmla.2014.56

42. **BHPMF - a hierarchical Bayesian approach to gap-filling and trait prediction for macroecology and functional biogeography**
Franziska Schrodt, Jens Kattge, Hanhuai Shan, Farideh Fazayeli, Julia Joswig, Arindam Banerjee, Markus Reichstein, Gerhard Bönisch, Sandra Díaz, John Dickie, … Peter B. Reich
Global Ecology and Biogeography (2015-12) https://doi.org/f76qw8
DOI: 10.1111/geb.12335

43. **Scaling from Traits to Ecosystems**
Brian J. Enquist, Jon Norberg, Stephen P. Bonser, Cyrille Violle, Colleen T. Webb, Amanda Henderson, Lindsey L. Sloat, Van M. Savage
Advances in Ecological Research (2015) https://doi.org/ghfnsw
DOI: 10.1016/bs.aecr.2015.02.001

44. **Communities and Ecosystems**
R. H. Whittaker
Macmillan Publishing Co. Inc. (1975)

45. **TURBOVEG, a comprehensive data base management system for vegetation data**
Stephan M. Hennekens, Joop H. J. Schaminée

Journal of Vegetation Science (2001-02-24) https://doi.org/cgmn6m
DOI: 10.2307/3237010

46. **The taxonomic name resolution service: an online tool for automated standardization of plant names**
Brad Boyle, Nicole Hopkins, Zhenyuan Lu, Juan Antonio Raygoza Garay, Dmitry Mozzherin, Tony Rees, Naim Matasci, Martha L Narro, William H Piel, Sheldon J Mckay, … Brian J Enquist
BMC Bioinformatics (2013-01-16) https://doi.org/gb8vxz
DOI: 10.1186/1471-2105-14-16 · PMID: 23324024 · PMCID: PMC3554605

47. **Oliverpurschke/Taxonomic_Backbone: First Release Of The Workflow To Generate The Taxonomic Backbone For Splot V.2.1 And Try V.3.0**
Oliver Purschke
Zenodo (2017-08-18) https://doi.org/ghf4ph
DOI: 10.5281/zenodo.845445

48. **Database Dry Grasslands in the Nordic and Baltic Region**
Jürgen Dengler, Solvita Rūsiņa
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcv
DOI: 10.7809/b-e.00114

49. **Vegetation-Plot Database of the University of the Basque Country (BIOVEG)**
Idoia Biurrun, Itziar García-Mijangos, Juan Campos, Mercedes Herrera, Javier Loidi
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9d
DOI: 10.7809/b-e.00121

50. **Balkan Dry Grasslands Database**
Kiril Vassilev, Zora Dajiś, Renata Cušterevska, Erwin Bergmeier, Iva Apostolova
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcw
DOI: 10.7809/b-e.00123

51. **The Mediterranean *Ammophiletea* Database: a comprehensive dataset of coastal dune vegetation**
Corrado Marcenò, Borja Jiménez-Alfaro
Phytocoenologia (2016) https://doi.org/ghgt83
DOI: 10.1127/phyto/2016/0133

52. **Local temperatures inferred from plant communities suggest strong spatial buffering of climate warming across Northern Europe**
Jonathan Lenoir, Bente Jessen Graae, Per Arild Aarrestad, Inger Greve Alsos, W. Scott Armbruster, Gunnar Austrheim, Claes Bergendorff, H. John B. Birks, Kari Anne Bråthen, Jörg Brunet, … Jens-Christian Svenning
Global Change Biology (2013-05) https://doi.org/f24bdd
DOI: 10.1111/gcb.12129 · PMID: 23504984

53. **Balkan Vegetation Database: historical background, current status and future perspectives**
Kiril Vassilev, Hristo Pedashenko, Alexandra Alexandrova, Alexandar Tashev, Anna Ganeva, Anna Gavrilova, Asya Gradevska, Assen Assenov, Antonina Vitkova, Borislav Grigorov, … Vladimir Vulchev
Phytocoenologia (2016-06-01) https://doi.org/f8sjft
DOI: 10.1127/phyto/2016/0109

54. **WetVegEurope: a database of aquatic and wetland vegetation of Europe**
Flavia Landucci, Marcela Řezníčková, Kateřina Šumberová, Milan Chytrý, Liene Aunina, Claudia Biţă-

Nicolae, Alexander Bobrov, Lyubov Borsukevych, Henry Brisse, Andraž Čarni, … Wolfgang Willner
Phytocoenologia (2015-07-01) https://doi.org/bdmw
DOI: 10.1127/phyto/2015/0050

55. **European Mire Vegetation Database: a gap-oriented database for European fens and bogs**
Tomáš Peterka, Martin Jiroušek, Michal Hájek, Borja Jiménez-Alfaro
Phytocoenologia (2015-11-01) https://doi.org/f724p4
DOI: 10.1127/phyto/2015/0054

56. **Vegetation Database of Albania**
Michele De Sanctis, Giuliano Fanelli, Alfred Mullaj, Fabio Attorre
Phytocoenologia (2017-01-01) https://doi.org/ghgt85
DOI: 10.1127/phyto/2017/0178

57. **Austrian Vegetation Database**
Wolfgang Willner, Christian Berg, Paul Heiselmayer
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcx
DOI: 10.7809/b-e.00125

58. **Bulgarian Vegetation Database: historic background, current status and future prospects**
Iva Apostolova, Desislava Sopotlieva, Hristo Pedashenko, Nikolay Velev, Kiril Vasilev
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvch
DOI: 10.7809/b-e.00069

59. **Swiss Forest Vegetation Database**
Thomas Wohlgemuth
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcz
DOI: 10.7809/b-e.00131

60. **Czech National Phytosociological Database: basic statistics of the available vegetation-plot data**
M. Chytrý, M. Rafajová
Preslia (2003)

61. **VegMV – the vegetation database of Mecklenburg-Vorpommern**
Florian Jansen, Jürgen Dengler, Christian Berg
Biodiversity & Ecology (2012-09-10) https://doi.org/gftw54
DOI: 10.7809/b-e.00070

62. **VegetWeb – the national online-repository of vegetation plots from Germany**
Jörg Ewald, Rudolf May, Martin Kleikamp
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcj
DOI: 10.7809/b-e.00073

63. **German Vegetation Reference Database (GVRD)**
Ute Jandt, Helge Bruelheide
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvc2
DOI: 10.7809/b-e.00146

64. **Hellenic Natura 2000 Vegetation Database (HelNatVeg)**
Panayotis Dimopoulos, Ioannis Tsiripidis
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvc3
DOI: 10.7809/b-e.00177

65. **Hellenic Woodland Database**
Georgios Fotiadis, Ioannis Tsiripidis, Erwin Bergmeier, Panayotis Dimopolous
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvc4
DOI: 10.7809/b-e.00178

66. **Phytosociological Database of Non-Forest Vegetation in Croatia**
Zvjezdana Stancic
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9f
DOI: 10.7809/b-e.00180

67. **Hungarian Phytosociological database (COENODATREF): sampling methodology, nomenclature and its actual stage**
K Lájer, Z. Botta-Dukát, J. Csiky, F. Horváth, F. Szmorad, I. Bagi, T. Rédei
Annali di Botanica, Nuova Serie (2008)

68. **VegItaly: The Italian collaborative project for a national vegetation database**
F. Landucci, A. T. R. Acosta, E. Agrillo, F. Attorre, E. Biondi, V. E. Cambria, A. Chiarucci, E. Del Vico, M. De Sanctis, L. Facioni, … R. Venanzoni
Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology (2012-12) https://doi.org/ghgt8x
DOI: 10.1080/11263504.2012.740093

69. **Italian National Vegetation Database (BVN/ISPRA)**
Laura Casella, Pietro Massimiliano Bianco, Pierangela Angelini, Emi Morroni
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvc6
DOI: 10.7809/b-e.00192

70. **Nationwide Vegetation Plot Database – Sapienza University of Rome: state of the art, basic figures and future perspectives**
Emiliano Agrillo*, Nicola Alessi, Marco Massimi, Francesco Spada, Michele De Sanctis
Phytocoenologia (2017-07-20) https://doi.org/gbsxm9
DOI: 10.1127/phyto/2017/0139

71. **Semi-natural Grassland Vegetation Database of Latvia**
Solvita Rūsiņa
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9g
DOI: 10.7809/b-e.00197

72. **Schatten voor de natuur. Achtergronden, inventaris en toepassingen van de Landelijke Vegetatie Databank**
J. H. J. Schaminée, J. A. M. Janssen, R. Haveman, S. M. Hennekens, G. B. M. Heuvelink, H. P. J. Huiskes, E. J. Weeda
KNNV Uitgeverij (2006)

73. **The Polish Vegetation Database: structure, resources and development**
Zygmunt Kącki, Michał Śliwiński
Acta Societatis Botanicorum Poloniae (2012) https://doi.org/f34f3k
DOI: 10.5586/asbp.2012.014

74. **Romanian Forest Database: a phytosociological archive of woody vegetation**
Adrian Indreica, Pavel Dan Turtureanu, Anna Szabó, Irina Irimia
Phytocoenologia (2017-12-01) https://doi.org/ghgt86
DOI: 10.1127/phyto/2017/0201

75. **The Romanian Grassland Database (RGD): historical background, current status and future perspectives**
Kiril Vassilev, Eszter Ruprecht, Valeriu Alexiu, Thomas Becker, Monica Beldean, Claudia Biță-Nicolae, Anna Mária Csergő, Iliana Dzhovanova, Eva Filipova, József Pál Frink, … Jürgen Dengler
Phytocoenologia (2018-03-01) https://doi.org/gc79hp
DOI: 10.1127/phyto/2017/0229

76. **Vegetation Database Grassland Vegetation of Serbia**
Svetlana Aćić, Milicia Petrović, Urban Šilc, Zora Dajić Stevanović
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9h
DOI: 10.7809/b-e.00206

77. **Lower Volga Valley Phytosociological Database**
Alexey Sorokin, Valentin Golub, Kseniya Starichkova, Lyudmila Nikolaychuk, Viktoria Bondareva, Tatyana Ivakhnova
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9j
DOI: 10.7809/b-e.00207

78. **Vegetation Database of the Volga and the Ural Rivers Basins**
Tatiana Lysenko, Olga Kalmykova, Anna Mitroshenkova
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvc7
DOI: 10.7809/b-e.00208

79. **Vegetation Database of Tatarstan**
Vadim Prokhorov, Tatiana Rogova, Maria Kozhevnikova
Phytocoenologia (2017-09-27) https://doi.org/ghgt84
DOI: 10.1127/phyto/2017/0172

80. **Vegetation Database of Slovenia**
Urban Šilc
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9k
DOI: 10.7809/b-e.00215

81. **Slovak Vegetation Database**
Jozef Šibík
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgt9m
DOI: 10.7809/b-e.00216

82. **The West African Vegetation Database**
Marco Schmidt, Thomas Janßen, Stefan Dressler, Karen Hahn, Mipro Hien, Souleymane Konaté, Anne Mette Lykke, Ali Mahamane, Bienvenu Sambou, Brice Sinsin, … Georg Zizka
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcf
DOI: 10.7809/b-e.00065

83. **Zur Vegetationsökologie der Savannenlandschaften im Sahel Burkina Fasos**
J. Müller
FB Biologie und Informatik, J.W. Goethe-Universität Frankfurt a.M (2003)

84. **ForestPlots.net: a web application and research tool to manage and analyse tropical forest plot data**
Gabriela Lopez-Gonzalez, Simon L. Lewis, Mark Burkitt, Oliver L. Phillips
Journal of Vegetation Science (2011-08) https://doi.org/dz6zb3
DOI: 10.1111/j.1654-1103.2011.01312.x

85. **Plot-scale evidence of tundra vegetation change and links to recent summer warming**
Sarah C. Elmendorf, Gregory H. R. Henry, Robert D. Hollister, Robert G. Björk, Noémie Boulanger-Lapointe, Elisabeth J. Cooper, Johannes H. C. Cornelissen, Thomas A. Day, Ellen Dorrepaal, Tatiana G. Elumeeva, … Sonja Wipf
Nature Climate Change (2012-04-08) https://doi.org/f223nb
DOI: 10.1038/nclimate1465

86. **Database of Masaryk University's Vegetation Research in Siberia**
Milan Chytrý
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcp
DOI: 10.7809/b-e.00088

87. **BIOTA Southern Africa Biodiversity Observatories Vegetation Database**
Gerhard Muche, Ute Schmiedel, Norbert Jürgens
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcg
DOI: 10.7809/b-e.00066

88. **Vegetation Database of the Okavango Basin**
Rasmus Revermann, Amândio Luis Gomes, Francisco Maiato Gonçalves, Johannes Wallenfang, Torsten Hoche, Norbert Jürgens, Manfred Finckh
Phytocoenologia (2016-06-01) https://doi.org/ghgt82
DOI: 10.1127/phyto/2016/0103

89. **Conventional tree height–diameter relationships significantly overestimate aboveground carbon stocks in the Central Congo Basin**
Elizabeth Kearsley, Thales de Haulleville, Koen Hufkens, Alidé Kidimbu, Benjamin Toirambe, Geert Baert, Dries Huygens, Yodit Kebede, Pierre Defourny, Jan Bogaert, … Hans Verbeeck
Nature Communications (2013-08-05) https://doi.org/ghgt8w
DOI: 10.1038/ncomms3269 · PMID: 23912554

90. **Responses of plant functional types to environmental gradients in the south-west Ethiopian highlands**
Desalegn Wana, Carl Beierkuhnlein
Journal of Tropical Ecology (2011-03-10) https://doi.org/b6mtmx
DOI: 10.1017/s0266467410000799

91. **Vegetation Database of Southern Morocco**
Manfred Finckh
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcq
DOI: 10.7809/b-e.00094

92. **{Das Weidepotential im Gutu-Distrikt (Zimbabwe) – Möglichkeiten und Grenzen der Modellierung unter Verwendung von Landsat TM-5**
C. Samimi
Karlsruher Schriften zur Geographie und Geoökologie (2003)

93. **Classification of Korean forests: patterns along geographic and environmental gradients**
Tomáš Černý, Martin Kopecký, Petr Petřík, Jong-Suk Song, Miroslav Šrůtek, Milan Valachovič, Jan Altman, Jiří Doležal
Applied Vegetation Science (2015-01) https://doi.org/ghgt8z
DOI: 10.1111/avsc.12124

94. **Vegetation of Middle Asia – the project state of art after ten years of survey and future perspectives**
Arkadiusz Nowak, Marcin Nobis, Sylwia Nowak, Agnieszka Nobis, Grzegorz Swacha, Zygmunt Kącki
Phytocoenologia (2017-12-01) https://doi.org/gctffg
DOI: 10.1127/phyto/2017/0208

95. **Vegetation of the woodland-steppe transition at the southeastern edge of the Inner Mongolian Plateau**
Hongyan Liu, Haiting Cui, Richard Pott, Martin Speier
Journal of Vegetation Science (2000-08) https://doi.org/cxr92b
DOI: 10.2307/3246582

96. **Combined effects of livestock grazing and abiotic environment on vegetation and soils of grasslands across Tibet**
Yun Wang, Gwendolyn Heberling, Eugen Görzen, Georg Miehe, Elke Seeber, Karsten Wesche
Applied Vegetation Science (2017-07) https://doi.org/gbkd6v
DOI: 10.1111/avsc.12312

97. **Community assembly during secondary forest succession in a Chinese subtropical forest**
Helge Bruelheide, Martin Böhnke, Sabine Both, Teng Fang, Thorsten Assmann, Martin Baruffol, Jürgen Bauhus, François Buscot, Xiao-Yong Chen, Bing-Yang Ding, … Bernhard Schmid
Ecological Monographs (2011-02) https://doi.org/dmwpsm
DOI: 10.1890/09-2172.1

98. **Vegetation Database of Sinai in Egypt**
Mohamed Hatim
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcr
DOI: 10.7809/b-e.00099

99. **Eurosiberian meadows at their southern edge: patterns and phytogeography in the NW Tien Shan**
Viktoria Wagner
Journal of Vegetation Science (2009-03-25) https://doi.org/ftq2r6
DOI: 10.1111/j.1654-1103.2009.01032.x

100. **Plant communities of the southern Mongolian Gobi**
Henrik von Wehrden, Karsten Wesche, Georg Miehe
Phytocoenologia (2009-10-21) https://doi.org/ddvj9h
DOI: 10.1127/0340-269x/2009/0039-0331

101. **Wetland Vegetation Database of Baikal Siberia (WETBS)**
Victor Chepinoga
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcs
DOI: 10.7809/b-e.00107

102. **Eastern Pamirs – A vegetation-plot database for the high mountain pastures of the Pamir Plateau (Tajikistan)**
Kim André Vanselow
Phytocoenologia (2016-06-01) https://doi.org/f952sp
DOI: 10.1127/phyto/2016/0122

103. **Socotra Vegetation Database**
Michele De Sanctis, Fabio Attorre

Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvct
DOI: 10.7809/b-e.00111

104. **Terrestrial Ecosystem Research Infrastructures**
Informa UK Limited
(2017-03-03) https://doi.org/ghgt87
DOI: 10.1201/9781315368252

105. **Structural and floristic diversity of mixed tropical rain forest in New Caledonia: new data from the New Caledonian Plant Inventory and Permanent Plot Network (NC-PIPPN)**
Thomas Ibanez, Jérôme Munzinger, Gilles Dagostini, Vanessa Hequet, Frédéric Rigault, Tanguy Jaffré, Philippe Birnbaum
Applied Vegetation Science (2014-07) https://doi.org/f57bfw
DOI: 10.1111/avsc.12070

106. **Managing biodiversity information: development of New Zealand's National Vegetation Survey databank**
S. K. Wiser, P. J. Bellingham, L. E. Burrows
New Zealand Journal of Ecology (2001)

107. **Species Richness, Forest Structure, and Functional Diversity During Succession in the New Guinea Lowlands**
Timothy J. S. Whitfeld, Jesse R. Lasky, Kipiro Damas, Gibson Sosanika, Kenneth Molem, Rebecca A. Montgomery
Biotropica (2014-09) https://doi.org/f6hf36
DOI: 10.1111/btp.12136

108. **The Tree Biodiversity Network (BIOTREE-NET): prospects for biodiversity research and conservation in the Neotropics**
Luis Cayuela, Lucía Gálvez-Bravo, Ramón Pérez Pérez, Fábio de Albuquerque, Duncan Golicher, Rakan Zahawi, Neptalí Ramírez-Marcial, Cristina Garibaldi, Richard Field, José Rey Benayas, … Regino Zamora
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvck
DOI: 10.7809/b-e.00078

109. **Timberline meadows along a 1000-km transect in NW North America: species diversity and community patterns**
Viktoria Wagner, Toby Spribille, Stefan Abrahamczyk, Erwin Bergmeier
Applied Vegetation Science (2014-01) https://doi.org/f5mpvm
DOI: 10.1111/avsc.12045

110. **How resilient are northern hardwood forests to human disturbance? An evaluation using a plant functional group approach**
I. Aubin, S. Gachet, C. Messier, A. Bouchard
Ecoscience (2007)

111. **Vegetation and altitudinal zonation in continental West Greenland**
B. Sieg, B. Drees, F. J. A. Daniëls
Meddelelser om Grønland Bioscience (2006)

112. **VegBank – a permanent, open-access archive for vegetation-plot data**
Robert Peet, Michael Lee, Michael Jennings, Don Faber-Langendoen

Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcm
DOI: 10.7809/b-e.00080

113. **Vegetation-plot database of the Carolina Vegetation Survey**
Robert Peet, Michael Lee, Forbes Boyle, Thomas Wentworth, Michael Schafale, Alan Weakley
Biodiversity & Ecology (2012-09-10) https://doi.org/ghgvcn
DOI: 10.7809/b-e.00081

114. **The Alaska Arctic Vegetation Archive (AVA-AK)**
Donald A. Walker, Amy L. Breen, Lisa A. Druckenmiller, Lisa W. Wirth, Will Fisher, Martha K. Raynolds, Jozef Šibík, Marilyn D. Walker, Stephan Hennekens, Keith Boggs, … Donatella Zona
Phytocoenologia (2016-09-01) https://doi.org/f877ht
DOI: 10.1127/phyto/2016/0128

115. **VegPáramo, a flora and vegetation database for the Andean páramo**
Gwendolyn Peyre, Henrik Balslev, David Martí, Petr Sklenář, Paul Ramsay, Pablo Lozano, Nidia Cuello, Rainer Bussmann, Omar Cabrera, Xavier Font
Phytocoenologia (2015-07-01) https://doi.org/f7m9cj
DOI: 10.1127/phyto/2015/0045

116. **The Floristic and Forest Inventory of Santa Catarina State (IFFSC): methodological and operational aspects**
A. C. Vibrans, L. Sevgnani, D. V. Lingner, A. L. Gasper, S. Sabbagh
Pesquisa Florestal Brasileira (2010)

117. **Plant Invasions in Protected Areas**
Springer Netherlands
(2013) https://doi.org/ghgt8v
DOI: 10.1007/978-94-007-7750-7

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	DB_name GIVD	n_Plots	contributed_plots	Citation
00-00-004	Vegetation Database of Eurasian Tundra	1132	600	
00-RU-003	Database Meadows and Steppes of Southern Ural	2354	99	
00-TR-001	Forest Vegetation Database of Turkey - FVDT	919	15	
EU-00-002	Nordic-Baltic Grassland Vegetation Database (NBGVD)	7675	931	48
EU-00-011	Vegetation-Plot Database of the University of the Basque Country (BIOVEG)	18441	1694	49
EU-00-013	Balkan Dry Grasslands Database	7683	224	50
EU-00-016	Mediterranean Ammophiletea Database	7359	3713	51
EU-00-017	European Coastal Vegetation Database	4624	1369	
EU-00-018	The Nordic Vegetation Database	5477	1755	52
EU-00-019	Balkan Vegetation Database	9118	211	53
EU-00-020	WetVegEurope	14111	61	54
EU-00-022	European Mire Vegetation Database	10147	1843	55
EU-AL-001	Vegetation Database of Albania	290	99	56
EU-AT-001	Austrian Vegetation Database	34458	950	57
EU-BE-002	INBOVEG	25665	48	
EU-BG-001	Bulgarian Vegetation Database	5254	74	58
EU-CH-005	Swiss Forest Vegetation Database	14193	1409	59
EU-CZ-001	Czech National Phytosociological Database	104697	579	60
EU-DE-001	VegMV	53822	5	61
EU-DE-013	VegetWeb Germany	23078	199	62

GIVD ID	DB_name GIVD	n_Plots	contributed_plots	Citation
EU-DE-014	German Vegetation Reference Database (GVRD)	30840	286	63
EU-DK-002	National Vegetation Database of Denmark	24264	1181	
EU-ES-001	Iberian and Macaronesian Vegetation Information System (SIVIM) - Wetlands	6560	292	
EU-FR-003	SOPHY	209864	13322	
EU-GB-001	UK National Vegetation Classification Database	28533	5457	
EU-GR-001	KRITI	292	43	
EU-GR-005	Hellenic Natura 2000 Vegetation Database (HelNatVeg)	5168	777	64
EU-GR-006	Hellenic Woodland Database	3199	4	65
EU-HR-001	Phytosociological Database of Non-Forest Vegetation in Croatia	5057	213	66
EU-HR-002	Croatian Vegetation Database	8734	688	
EU-HU-003	CoenoDat Hungarian Phytosociological Database	8505	17	67
EU-IT-001	VegItaly	15332	2712	68
EU-IT-010	Italian National Vegetation Database (BVN/ISPRA)	3562	155	69
EU-IT-011	Vegetation-Plot Database Sapienza University of Rome (VPD-Sapienza)	12780	1003	70
EU-LT-001	Lithuanian Vegetation Database	7821	119	
EU-LV-001	Semi-natural Grassland Vegetation Database of Latvia	5594	306	71
EU-MK-001	Vegetation Database of the Republic of Macedonia	1417	10	
EU-NL-001	Dutch National Vegetation Database	102327	10223	72
EU-PL-001	Polish Vegetation Database	22229	464	73
EU-RO-007	Romanian Forest Database	6017	60	74
EU-RO-008	Romanian Grassland Database	1921	44	75
EU-RS-002	Vegetation Database Grassland Vegetation of Serbia	5587	57	76

GIVD ID	DB_name GIVD	n_Plots	contributed_plots	Citation
EU-RU-002	Lower Volga Valley Phytosociological Database	14853	149	77
EU-RU-003	Vegetation Database of the Volga and the Ural Rivers Basins	1516	96	78
EU-RU-011	Vegetation Database of Tatarstan	7471	94	79
EU-SI-001	Vegetation Database of Slovenia	10986	435	80
EU-SK-001	Slovak Vegetation Database	36405	893	81
EU-UA-006	Vegetation Database of Ukraine and Adjacent Parts of Russia	3326	479	
AF-00-001	West African Vegetation Database	3129	184	82
AF-00-008	PANAF Vegetation Database	2469	942	
AF-BF-001	Sahel Vegetation Database	1079	279	83
00-00-001	ForestPlots.net	1827	108	84
00-00-003	SALVIAS	4883	2860	
00-00-005	Tundra Vegetation Plots (TundraPlot)	577	227	85
00-RU-002	Database of Masaryk University`s Vegetation Research in Siberia	1547	128	86
AF-00-003	BIOTA Southern Africa Biodiversity Observatories Vegetation Database	1666	562	87
AF-00-006	SWEA-Dataveg	2704	1211	
AF-00-009	Vegetation Database of the Okavango Basin	590	202	88
AF-CD-001	Forest Database of Central Congo Basin	292	97	89
AF-ET-001	Vegetation Database of Ethiopia	74	59	90
AF-MA-001	Vegetation Database of Southern Morocco	1337	266	91
AF-ZW-001	Vegetation Database of Zimbabwe	36	17	92
AS-00-001	Korean Forest Database	4885	766	93
AS-00-003	Vegetation of Middle Asia	1381	128	94

GIVD ID	DB_name GIVD	n_Plots	contributed_plots	Citation
AS-00-004	Rice Field Vegetation Database	179	31	
AS-BD-001	Tropical Forest Dataset of Bangladesh	211	82	
AS-CN-001	China Forest-Steppe Ecotone Database	148	97	95
AS-CN-002	Tibet-PaDeMoS Grazing Transect	146	27	96
AS-CN-003	Vegetation Database of the BEF China Project	27	18	97
AS-CN-004	Vegetation Database of the Northern Mountains in China	485	70	
AS-EG-001	Vegetation Database of Sinai in Egypt	926	98	98
AS-ID-001	Sulawesi Vegetation Database	24	24	
AS-IR-001	Vegetation Database of Iran	2335	105	
AS-KZ-001	Database of Meadow Vegetation in the NW Tien Shan Mountains	94	3	99
AS-MN-001	Southern Gobi Protected Areas Database	1516	688	100
AS-RU-001	Wetland Vegetation Database of Baikal Siberia (WETBS)	2381	6	101
AS-RU-002	Database of Siberian Vegetation (DSV)	9116	2150	
AS-RU-004	Database of the University of Münster - Biodiversity and Ecosystem Research Group's Vegetation Research in Western Siberia and Kazakhstan	445	85	
AS-SA-001	Vegetation Database of Saudi Arabia	919	607	
AS-TJ-001	Eastern Pamirs	282	174	102
AS-TW-001	National Vegetation Database of Taiwan	930	897	
AS-YE-001	Socotra Vegetation Database	396	190	103
AU-AU-002	AEKOS	21261	7443	104
AU-NC-001	New Caledonian Plant Inventory and Permanent Plot Network (NC-PIPPN)	201	98	105
AU-NZ-001	New Zealand National Vegetation Databank	1895	983	106
AU-PG-001	Forest Plots from Papua New Guinea	63	53	107

GIVD ID	DB_name GIVD	n_Plots	contributed_plots	Citation
NA-00-002	Tree Biodiversity Network (BIOTREE-NET)	1757	208	108
NA-CA-003	Database of Timberline Vegetation in NW North America	110	38	109
NA-CA-004	Understory of Sugar Maple Dominated Stands in Quebec and Ontario (Canada)	156	9	110
NA-CA-005	Boreal Forest of Canada	89	44	
NA-GL-001	Vegetation Database of Greenland	664	340	111
NA-US-002	VegBank	67352	6456	112
NA-US-006	Carolina Vegetation Survey Database	17221	2317	113
NA-US-014	Alaska-Arctic Vegetation Archive	1363	467	114
SA-00-002	VegPáramo	2643	1591	115
SA-AR-002	Vegetation Database of Central Argentina	218	42	
SA-BO-003	Bolivia Forest Plots	75	18	
SA-BR-002	Forest Inventory, State of Santa Catarina, Brazil (IFFSC Project)	1669	1345	116
SA-BR-003	Grasslands of Rio Grande do Sul, Brazil	320	271	
SA-BR-004	Grassland Database of Campos Sulinos	161	111	
SA-CL-002	SSAForests_Plots_db	261	163	
SA-CL-003	Chilean Park Transects - Fondecyt 1040528	165	33	117
SA-EC-001	Ecuador Forest Plot Database	172	156	

Table 2: Description of the variables contained in the 'header' matrix, together with their range (if numeric) or possible levels (if nominal or boolean). Variable type can be c - character (i.e. text), f - factor (i.e. qualitative or ordinal variable), i - integer (e.g. binomial), n - numeric (i.e., double) or l - logical (i.e., boolean).

Variable	Range/Levels	Unit of Measurement	Nr. Records	Type
GIVD_ID			91031	nominal
Dataset			91031	nominal
Continent	Africa, Asia, Australia, Europe, North America, Oceania, South America		90729	nominal
Country			91031	nominal

Variable	Range/Levels	Unit of Measurement	Nr. Records	Type
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	nominal
Date_of_recording	1888-07-05 - 2015-02-03	dd-mm-yyyy	75798	date
Latitude	-54.73863 - 80.149116	° (WGS84)	91031	quantitative
Longitude	-162.741433 - 179.590053	° (WGS84)	91031	quantitative
Location_uncertainty	1 - 2500	m	91002	quantitative
Releve_area	0.01 - 40000	m^2	61898	quantitative
Herbs_identified	FALSE = 4876; TRUE = 6323		11199	binary
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	nominal
Elevation	-25 - 4819	m a.s.l.	52121	quantitative
Aspect	0 - 360	°	30796	quantitative
Slope	0 - 99	°	37784	quantitative
is_forest	FALSE = 20396; TRUE = 25832		46228	binary
is_nonforest	FALSE = 50870; TRUE = 38203		89073	binary
ESY			55457	nominal
Naturalness	1 - 2		68011	quantitative
Forest	FALSE = 38295; TRUE = 23735		62030	binary
Shrubland	FALSE = 38233; TRUE = 11081		49314	binary
Grassland	FALSE = 10213; TRUE = 46947		57160	binary
Sparse_vegetation	FALSE = 33381; TRUE = 11315		44696	binary
Wetland	FALSE = 29078; TRUE = 18038		47116	binary
Cover_total	1 - 313	%	24712	quantitative
Cover_tree_layer	0.5 - 150	%	7245	quantitative
Cover_shrub_layer	0.5 - 145	%	10197	quantitative

Variable	Range/Levels	Unit of Measurement	Nr. Records	Type
Cover_herb_layer	0.2 - 180	%	26679	quantitative
Cover_moss_layer	1 - 100	%	9643	quantitative
Cover_lichen_layer	1 - 95	%	734	quantitative
Cover_algae_layer	1 - 100	%	221	quantitative
Cover_litter_layer	1 - 100	%	4500	quantitative
Cover_bare_rocks	1 - 100	%	1897	quantitative
Cover_cryptogams	1 - 95	%	593	quantitative
Cover_bare_soil	0.1 - 99	%	1412	quantitative
Height_trees_highest	1 - 99	m	6115	quantitative
Height_trees_lowest	1 - 90	m	221	quantitative
Height_shrubs_highest	0.1 - 9.9	m	2880	quantitative
Height_shrubs_lowest	0.1 - 9	m	328	quantitative
Height_herbs_average	0.1 - 440	cm	10125	quantitative
Height_herbs_lowest	1 - 250	cm	2785	quantitative
Height_herbs_highest	1 - 600	cm	1733	quantitative