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GrassPlot v. 2.00 – first update on the database of multi-scale plant diversity in Palaearctic grasslands

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Abstract: GrassPlot is a collaborative vegetation-plot database organised by the Eurasian Dry Grassland Group (EDGG) and listed in the Global Index of Vegetation-Plot Databases (GIVD ID EU-00-003). Following a previous Long Database Report (Dengler et al. 2018, *Phytocoenologia* 48, 331–347), we provide here the first update on content and functionality of GrassPlot. The current version (GrassPlot v. 2.00) contains a total of 190,673 plots of different grain sizes across 28,171 independent plots, with 4,654 nested-plot series including at least four grain sizes. The database has improved its content as well as its functionality, including addition and harmonization of header data (land use, information on nestedness, structure and ecology) and preparation of species composition data. Currently, GrassPlot data are intensively used for broad-scale analyses of different aspects of alpha and beta diversity in grassland ecosystems.

Keywords: biodiversity; community ecology; Eurasian Dry Grassland Group (EDGG); Global Index of Vegetation-Plot Databases (GIVD); grassland vegetation; GrassPlot; macroecology; nested plot; Palaearctic; scale dependence; species-area relationship (SAR); vegetation-plot database.

Abbreviations: EDGG = Eurasian Dry Grassland Group; EVA = European Vegetation Archive; GIVD = Global Index of Vegetation-Plot Databases; GrassPlot = Database of Scale-Dependent Phytodiversity Patterns in Palaearctic Grasslands; SAR = species-area relationship.

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Introduction

Since 2009, the Eurasian Dry Grassland Group (EDGG) has been conducting Field Workshops in various regions of the Palaearctic realm to collect high-quality multi-scale diversity and composition data of various, mostly dry grassland types (e.g. Turtureanu et al. 2014; Kuzemko et al. 2016; Polyakova et al. 2016; for overview of the sampled data, see Dengler et al. 2016a) following the same sampling methodology (Dengler et al. 2016b). In March 2017, the establishment of the collaborative vegetation-plot database GrassPlot allowed merging the data collected by the EDGG with the previously established "Database Species-Area Relationships in Palaearctic Grasslands" (Dengler et al. 2012). The resulting GrassPlot database is registered in the Global Index of Vegetation-Plot Databases (Dengler et al. 2011) under ID EU-00-003 (Dengler et al. 2018) and contains vegetation-plot data of grasslands in the widest sense (i.e. any vegetation type except forests, tall shrublands, aquatic and segetal communities) from the Palaearctic biogeographic realm (i.e. Europe, North Africa, and West, Central, North and Northeast Asia). The focus of GrassPlot is on data of precisely delimited plots, both multi-grain, nested-plot data of any plot size and single-grain data matching one of eight EDGG standard grain sizes (Dengler et al. 2018).

The purpose of GrassPlot is to provide quality data for broad-scale analyses of various aspects of vegetation diversity. The concept of GrassPlot and the content of its first public version 1.00 have been described by Dengler et al. (2018). Since this publication, GrassPlot data have been intensively used for broad-scale biodiversity analyses, such as species-area relationships (SARs) in continuous vegetation (Dengler et al. 2019), or manuscripts in preparation on small-scale beta diversity, and "benchmarking" Palaearctic grassland diversity. At the same time, the content and functionality of GrassPlot have significantly increased. This paper provides an overview of the improvements in the structure and content of the database since version 1.00.

New functionalities

Addition and harmonization of header data

Information on nestedness. GrassPlot includes both single-grain data (hereafter individual plots) and nested-plot data consisting of subplots of several grain sizes, often replicated per grain size. All subplots of a nested series are included in one macro plot or mother plot, also with a complete species list (hereafter largest subplot). We have added several binary (Y/N) header data to document different aspects of nestedness: *Individual plot*, *Independent plot* (individual plots and largest subplots combined), *Belonging to nested series with at least 2 sizes, Belonging to nested series with at least 4 sizes, Belonging to nested series with at least 7 sizes,* and *Perfect nesting.* The latter indicates if the nested series corresponds to a perfect nesting or not, e.g., if all subplots of a certain size are included in the next larger subplot (Fig. 1). The additional column *Distorting sizes* indicates which are the grain sizes that are impeding the perfect nesting; if these distorting sizes were removed, a perfect nesting would result. Fig. 1 shows schemes of the three main types of nested sampling designs in GrassPlot, two with perfect nesting (Figs. 1a, 1b) and a third one with non-perfect nesting (Fig. 1c).

Grassland types and biomes. Data collected in GrassPlot represent different types of grasslands in the broadest sense. To allow future users and projects to deal with this considerable diversity of vegetation, we created a two-level vegetation typology with 22 vegetation types grouped into six broad groups: natural grasslands, secondary grasslands, azonal habitats, dwarf shrublands, tall forb and ruderal communities, and deserts and semi-deserts (Table 1). We also created expert rules to assign phytosociological syntaxa already included in GrassPlot to these 22 vegetation types (Table 2). Vegetation type was assigned based on phytosociological affinity or on other information provided by data

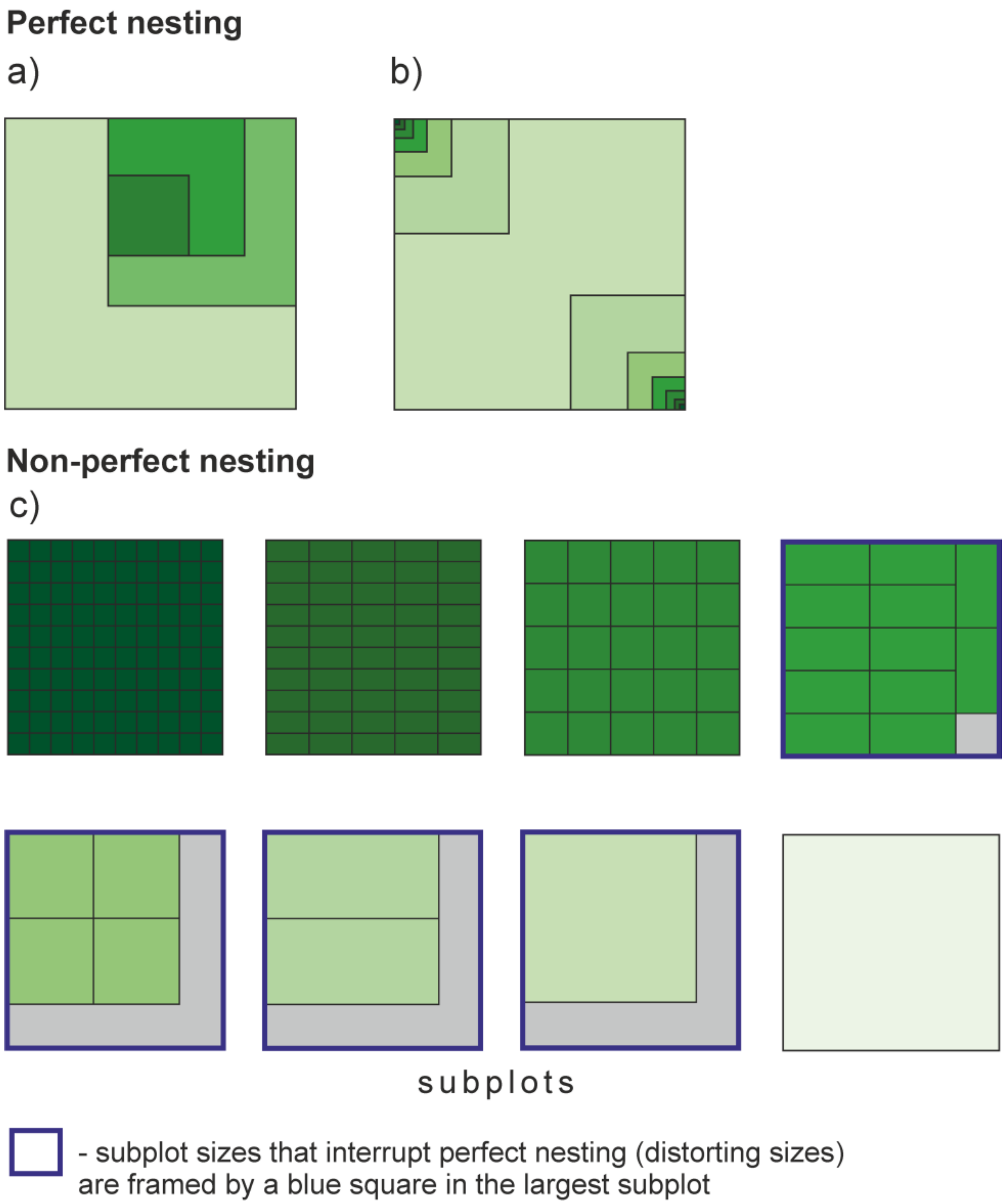


Fig. 1. Examples of nested-plot sampling schemes found in the GrassPlot database: a) perfect nesting with four grain sizes, without replication of the subplots; b) perfect nesting with eight grain sizes and replication at smaller grain sizes (field sampling standard with two replicates of each grain size except the largest, which is used during EDGG Field Workshops; for details see Dengler et al. 2016b), c) non-perfect nesting with eight grain sizes, where the smallest subplots completely tessellate the largest subplot. In this example, a typical GLORIA sampling design is shown (Pauli et al. 2012). Only the smallest subplots and the largest one are actually sampled in the field, while all intermediate subplot sizes are created post hoc by joining species lists of adjacent subplots. To achieve more different grain sizes, we accepted some that did not allow full tessellation of the largest subplot (see grey areas adjacent to subplots of grain sizes 4-7) and thus distorted the perfect nesting. When the distorting sizes of subplots were removed, a perfect nesting would result.

Table 1. Two-level vegetation typology applied in GrassPlot v. 2.00. Since the assignments to the vegetation types and groups were largely based on syntaxonomy, there are some grey zones, e.g. some xeric grasslands might be secondary.

Group	Vegetation type
Natural grasslands	Alpine grasslands
	Alpine steppes
	Rocky grasslands
	Xeric grasslands and steppes
Secondary grasslands	Wet grasslands
	Mesic grasslands
	Meso-xeric grasslands
	Mediterranean grasslands
	Sandy dry grasslands
Azonal habitats	Wetlands
	Saline communities
	Dunes
	Rocks and screes
	Saline steppes and semi-deserts
Dwarf shrublands	Arctic-alpine heathlands
	Lowland heathlands
	Garrigues and thorn cushion communities
Tall forb and ruderal communities	Tall forb and fringe communities
	Ruderal communities
Deserts and semi-deserts	Alpine deserts
	Cold deserts and semi-deserts
	Warm deserts and semi-deserts

collectors, e.g., vernacular names, species composition, localisation, and so on.

We also assigned each plot both to biomes and to geographic regions. For biomes, we used the recent classification by Bruelheide et al. (2019, based on Schultz 2005), which recognizes ten terrestrial biomes, all of them occurring in the Palaearctic realm, except "Tropics with year-round rain". We have assigned all plots in GrassPlot to one of these nine biomes using plot coordinates. As a result, all biomes present in the Palaearctic realm except "Tropics with summer rain", that occurs marginally on the Arabian Peninsula, are represented in GrassPlot. For geographic regionalization, we used Török & Dengler (2018) and Dengler et al. (in press).

Land-use data. Land use is the main current driver of biodiversity change and loss worldwide (Collins et al. 1998). Vegetation survey databases provide spatially explicit information on local biodiversity (richness and/or composition). However, associated land-use information is generally scarce (but see Niedrist et al. 2009; Hudson et al. 2014). The lack of reliably coupled biodiversity and land-use data at a local scale that is available over large geographic extents substantially impedes our understanding of how biodiversity responds to anthropogenic environmental change.

The current version of GrassPlot now includes consistent and standardized information on the land use and land-use intensity of the plots. Information on land-use was provided by data contributors with different degrees of detail. It has been structured into 19 different land-use variables, created to capture as much information as possible from existing datasets. The structure of the land-use data has been developed to meet the needs of future analyses regarding land use-data and to guide future sampling efforts. The 19 land-use variables are structured into four categories: land-use type (seven variables), land-use intensity and details (relative to each land-use type), land destination (for what purpose the land is used) and naturalness degree (see Table 3). Each grassland has one or several land-use types (for example it can be mown and fertilized), and a grassland can be mown for different purposes (land destination) such as farming (feeding cattle) or managing a public park (recreational destination). Land destination is a coarse categorisation which is expected to include several types of management practices.

Importantly, all plots of the GrassPlot database (190,673 plots) now have a land-use type, while other land-use variables are not available for all plots, indicated as NA (Table 3). Moreover, the variable *Naturalness degree* is still under development, and will be added when it is computed.

Environmental and structural data. GrassPlot v. 2.00 has also notably improved the coverage and consistency of several environmental and structural header data, which are stored with standardized measurement units. Topographic data are readily and consistently available for many plots with different degrees of coverage, e.g. 88% for *Elevation*, 34% for *Aspect* and *Inclination,* 5% for *Microrelief*. Microrelief is defined as the maximum distance to the ground when placing a stick on the ground in the most rugged part of the plot, measured perpendicular to the stick. The soil data with better coverage are *pH* H_20 (15%), *Soil texture class* (14%), *Conductivity* (10%) and *Soil depth* (10%). Of the structural header data, *Tree cover* (95%), *Shrub cover* (50%), *Herb cover* (49%), *Total vegetation cover* (39%) and *Cryptogam cover* (37%) are the variables with better coverage. Additionaly, *Litter cover* is provided for 31% of plots, *Proportion of stones, gravel and fine soil* for 21% of plots and *Mean height of the herb layer* for 13% of plots. All environmental and structural data stored in GrassPlot have been directly measured or estimated in the field, or, in the case of soil parameters, in the laboratory using soil samples collected in the plots. Climatic and more complete topographic data can be retrieved from digital models using plot geographic coordinates, but the database is focused on directly measured data. Of course, projects using GrassPlot data may be able to combine them with environmental data extracted from digital models.

Preparation of species composition data

As reported by Dengler et al. (2018), the GrassPlot database also includes species composition data for most datasets (93%). This means that for 90.7% of the plots (Table 4), in addition to species richness data, there is also a complete list of vascular plant species and often also of lichens and

Table 2. Assignment rules for phytosociological syntaxa to the 22 vegetation types as defined in GrassPlot v. 2.00, given at class level. Classes occurring in Europe are named after Mucina et al. (2016), classes from outside Europe according to various sources (Ermakov & Krestov 2009; Wehrden et al. 2009; Ermakov et al. 2014; Noroozi et al. 2014; Reinecke et al. 2017; Hüseynova & Yalçin 2018; Nowak et al. 2018). Classes absent in GrassPlot data are not shown in the table. For the classes with the notation *p.p.*, the assignment is made at order or alliance level (not shown here).

Class	Vegetation type
Adiantetea	Rocks and screes
Ajanio-Cleistogenetea songoricae p.p.	Alpine deserts
Ajanio-Cleistogenetea songoricae p.p.	Cold deserts and semi-deserts
Ammophiletea	Dunes
Artemisietea lerchianae	Cold deserts and semi-deserts
Artemisietea vulgaris	Ruderal communities
Arundinello anomalae-Agrostietea trinii	Mesic grasslands
Asplenietea trichomanis	Rocks and screes
Astragalo microcephali-Brometea tomentelli p.p.	Garrigues and Thorn cushion communities
Astragalo microcephali-Brometea tomentelli p.p.	Xeric grasslands and steppes
Bidentetea	Ruderal communities
Cakiletea maritimae	Dunes
Calamagrostietea langsdorfii	Wet grasslands
Calluno-Ulicetea	Lowland heathlands
Carici rupestris-Kobresietea bellardii	Alpine grasslands
Chenopodietea	Ruderal communities
Cleistogenetea squarrosae	Xeric grasslands and steppes
Crithmo-Staticetea	Saline communities
Didymophyso aucheri-Dracocephaletea aucheri	Rocks and screes
Digitario sanguinalis-Eragrostietea minoris	Ruderal communities
Elyno-Seslerietea	Alpine grasslands
Epilobietea angustifolii	Ruderal communities
Festucetea indigestae p.p	Alpine grasslands
Festucetea indigestae p.p	Sandy dry grasslands
Festuco hystricis-Ononidetea striatae p.p.	Rocky grasslands
Festuco hystricis-Ononidetea striatae p.p.	Garrigues and Thorn cushion communities
Festuco-Brometea p.p.	Xeric grasslands and steppes
Festuco-Brometea p.p.	Meso-xeric grasslands
Festuco-Brometea p.p.	Rocky grasslands
Festuco-Puccinellietea	Saline steppes and semi-deserts
Helianthemetea guttati	Mediterranean grasslands
Helichryso-Crucianelletea maritimae	Dunes
Isoëto-Nanojuncetea	Wetlands
Juncetea maritimi	Saline communities
Juncetea trifidi	Alpine grasslands
Kleinio-Euphorbietea canariensis	Warm deserts and semi-deserts
Koelerio-Corynephoretea canescentis	Sandy dry grasslands
Littorelletea uniflorae	Wetlands
Loiseleurio procumbentis-Vaccinietea	Arctic-alpine heathlands
Lygeo sparti-Stipetea tenacissimae	Mediterranean grasslands
Molinio-Arrhenatheretea p.p.	Mesic grasslands
Molinio-Arrhenatheretea p.p.	Tall forb and fringe communities
Molinio-Arrhenatheretea p.p.	Wet grasslands
Montio-Cardaminetea	Wetlands
Mulgedio-Aconitetea	Tall forb and fringe communities
Nardetea strictae p.p.	Mesic grasslands
Nardetea strictae p.p.	Wet grasslands
Onobrychidetea cornutae	Garrigues and Thorn cushion communi-ties
Ononido-Rosmarinetea	Garrigues and Thorn cushion communi-ties
Oxycocco-Sphagnetea	Wetlands
Oxytropidetea persicae	Arctic-alpine heathlands
Papaveretea rhoeadis	Ruderal communities
Phragmito-Magnocaricetea	Wetlands
Poetea bulbosae	Mediterranean grasslands
Polygono-Poetea annuae	Ruderal communities
Polypodietea	Rocks and screes
Prangetea ulopterae	Tall forb and fringe communities
Rhododendro hirsuti-Ericetea carneae	Arctic-alpine heathlands
Rumici-Astragaletea siculi	Garrigues and Thorn cushion communi-ties
Saginetea maritimae	Saline communities
Salicetea herbaceae	Arctic-alpine heathlands
Salicornietea fruticosae	Saline communities
Scheuchzerio palustris-Caricetea fuscae	Wetlands
Sedo-Scleranthetea	Rocky grasslands
Sisymbrietea	Ruderal communities
Spartinetea maritimae	Saline communities
Stipo giganteae-Agrostietea castellanae	Mediterranean grasslands
Stipo-Trachynietea distachyae	Mediterranean grasslands
Therosalicornietea	Saline communities
Thlaspietea rotundifolii	Rocks and screes
Trifolio-Geranietea sanguinei	Tall forb and fringe communities

Table 3. Land-use variables in GrassPlot v. 2.00 and the percentage of plots for which the information is available (% F). The percentages refer to the independent plots (*N* = 28,171). For binary variables, the column "% 1 in F" indicates the percentage frequency of the management technique among the plots that have this land-use information. Some plots have a combined land use (mown and grazed; natural and grazed; etc.), so the sum of plots in each specific land use can exceed the total number of plots in GrassPlot. "NA" indicates missing information.

Variable group	Variable name	Variable type	Possible values	% F (no NA)	% 1 in F (no 0, no NA)
Land-use type	Mown	binary	0/1	90.3	11.3
	Grazed	binary	0/1	89.3	62.8
	Burnt	binary	0/1	69.2	2.3
	Fertilized	binary	0/1	65.0	2.2
	Abandoned	binary	0/1	67.2	19.1
	Natural	binary	0/1	45.0	49.0
	Other	text	free		
Land-use intensity and details	Grazing intensity	numeric	0 to 1	28.6	
	Grazing load	numeric	0 to infinity	9.8	
	Grazing animal	text	free	18.3	
	Mowing frequency	numeric	0 to infinity	10.4	
	Burning frequency	numeric	0 to 1	2.3	
	Fertilization intensity	numeric	0 to 1	12.9	
	Fertilization type	text	synthetic/natural	0.9	
	Fertilization details	text	free	0.9	
	Years since abandonment	numeric	0 to infinity	2.2	
	Abandonment: former land use	text	arable, mown, grazed	7.1	
Land destination	Land destination	text	cropland, farmland, recreational	33.2	
Naturalness	Naturalness degree	numeric	0 to 3	-	

bryophytes, either as presence/absence or cover-abundance information. This is the result of the work carried out between GrassPlot versions 1.00 and 2.00 to integrate the species composition data into a single uniform structure.

Most of the datasets were supplied as species × plot matrices ("wide tables"). Since such wide format data are neither suitable for merging into a single dataset nor can be filtered for functional groups or vegetation layers, they were transformed into a "long format" (see example in Appendix 1) using different packages suitable for data manipulation in R (e.g. *plyr, dplyr* and *tidyr*) (Wickham et al. 2017; Wickham & Henry 2019). In the long format, each row consists of a species record, i.e., an occurrence of a species in a plot or subplot. Additional columns provide information on plant group, vegetation layer, species abundance and abundance-scale. *Abundance-scale* is a binary column, indicating whether the value in *Abundance* column is a presence/absence value (P/A = 0/1) or a cover-abundance value at the percentage scale (cover: 0-100). Cover abundance values

Table 4. Overview of some key parameters of GrassPlot v. 2.00 covering access regime, methodological aspects and temporal and elevational distribution. The column "NA" indicates the fraction of plots in GrassPlot v. 2.00 for which the respective field is currently without content. The percentages refer to the independent plots (*N* = 28,171).

Parameter	NA	Frequency distribution of parameter values
Availability of data		
Access regime	< 0.1%	1 – restricted access (12.0%); 2 – semi-restricted access (86.2%); 3 – free access (1.7%)
Availability of compositional data	–	Yes-ready (10.0%); Yes-in preparation (80.7); to be provided later (5.4%); no (3.8%)
Methodological aspects		
Recording method	0.2%	Shoot presence (69.9%); rooted presence (29.9%)
Plot shape	0.1%	Squares (81.6%); rectangles 1:1.6 (0.2%); rectangles more elongated than 1:2 (0.3%); circles (18.0%)
Accuracy of coordinates	0.4%	≤ 1 m (18.3%); 1.1–10 m (47.5%); 11–100 m (12.3%); 101–1,000 m (16.4%); > 1,000 m (5.2%)
Spatio-temporal distribution		
Year of recording	-	Before 1980 (0.1%); 1980–1989 (10.5%); 1990–1999 (13.3%); 2000–2009 (17.7%); 2010 and later (59.3%)
Elevation	12.0%	≤ 10 m a.s.l. (14.9%); 11–100 m a.s.l. (9.2%); 101–1,000 m a.s.l. (28.8%); 1,001–2,000 m a.s.l. (20.1%); 2,001–3,000 m a.s.l. (8.5%); 3,001–4,000 m a.s.l. (3.7%); > 4,000 m a.s.l. (2.8%)

that were originally measured by means of categorical scales (e.g. different variants of Br.-Bl., Londo, and so on) have already been transformed to percentage during the wide data format by choosing the midpoint of the upper and lower boundaries of a cover class. The original cover-abundance scale has been stored in the database together with all other plot-level metadata, plus geographic, environmental, land-use and structural data. Species composition long-format tables also maintain relevant metadata such as the GrassPlot ID of the single plot or subplot of a nested-series, the ID of the largest subplot within which the subplot is nested (only for nested-plots) and its grain size. This data structure allows data to be combined within and across datasets for later analyses on species composition either by using the long format or reshaping it into a wide format of species × plot matrices.

While the data are being prepared in a long format, progress is also being made to develop a process to semi-automatically adjust species nomenclature, i.e. correcting typographical errors and homogenizing different levels of identification detail and differences in species name format (e.g. removing authorities from taxon names). This allows taxon names to be standardized according to "The Plant List" (www.theplantlist.org), using the *taxonstand* package (Cayuela et al. 2012) in R (R Core Team 2019). In addition, we plan to add a column named "determ_qual" to indicate for each taxon its quality of determination: 1 – determined to the species level (e.g. *Viola arvensis*), 0.5 – determination to species level not certain (e.g. *Viola arvensis aggr.*, *Viola cf. arvensis, Viola arvensis/kitaibeliana*), 0.2 – species unknown (species epithet missing); 0 – genus unknown (e.g. *Violaceae*). This would allow us to calculate a "species composition quality" index for each plot as follows: the sum of the "determ_qual" values of each species in the plot divided by the total number of species. This "species composition quality" index ranges from 1 (all taxa are determined at least to the species level) to 0 (taxa at family level). The proportion of species determined to different levels will be calculated for each plot and various thresholds (based on project aims) can be used to filter out plots that do not meet species composition quality criteria.

The last step in the process of harmonizing the composition data involves dealing with homonyms and synonyms originating from different concepts of species names. Many contributed datasets also provide information on the reference flora, but collaboration with data providers will be crucial in this last step.

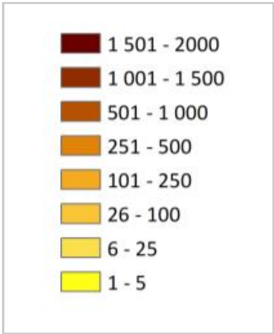
Currently, 76 out of the 171 datasets for which composition data have been provided to GrassPlot are already available in long format.

Content of GrassPlot v. 2.00

The current GrassPlot version 2.00 of 7 November 2019 contains data from 184 contributing datasets, i.e. 59 (47%) more compared to GrassPlot version 1.00 (Dengler et al. 2018). The newly contributed datasets are listed in Appendix 2. In total, the database now contains 190,673 plots of different grain sizes (+21,676 plots or 13% added to version 1.00), corresponding to 28,171 independent plots. Among these are 22,422 individual plots (single-grain data) and 5,749 nested-plot series with at least two grain sizes (often consisting of several subseries), of which 4,654 contain at least four grain sizes (+1,857 or 66%) and 2,057 even seven and more grain sizes. Most contributors have assigned their plots to the "semi-restricted access" regime, but a few have allocated their plots to the "restricted access" or "free access" categories (Table 4).

GrassPlot comprises data over a wide geographic range, from the Canary Islands (Tenerife) in the west (16.3° W) to Kamchatka in the east (161.7° E) and from Nepal in the south (28.2° N) to Svalbard (Norway) in the north (77.9° N). The highest density of plots were recorded in temperate Europe (Figs. 2 and 3). In total, the plots originate from 47 countries, with Spain having the highest number (58,977 plots) and Austria the highest density (16.58 plots per 100 km²) of the total plots. Switzerland has the highest number (5,172 plots) and Andorra the highest density (16.45 plots per 100 km²) of independent plots (Table 5). Data locations range from sea level to 5,750 m a.s.l., with the largest fraction of independent plots coming from 101–1,000 m a.s.l. (Table 4). Sampling year is one of the metadata included for each plot, and this shows that data were sampled between 1948 and 2018, with 59.3% of all independent plots surveyed between 2010–2019 (Table 4). Currently, 98% of all independent plots have been assigned to one of 22 vegetation types (Table 6), with 79% of plots being syntaxonomically assigned to a class and/or subordinate syntaxa. Natural grasslands, secondary grasslands and azonal habitats are the most frequent broad groups. Within these groups, alpine grasslands and xeric grasslands and steppes, meso-xeric and mesic grasslands and saline communities and wetlands, respectively, are the most frequent vegetation types (Table 6). With respect to azonal communities, *Juncetea maritimi* and *Scheuchzerio palustris-Caricetea fuscae* are the most frequent phytosociological classes in saline communities and wetlands, respectively. The distribution of phytosociological classes across the natural and secondary grassland types is shown in Fig. 4. The temperate dry grassland class *Festuco-Brometea* (23%) is present in rocky grasslands, meso-xeric grasslands and xeric grasslands and steppes, but most plots correspond to meso-xeric grasslands. The class *Molinio-Arrhenatheretea* (12%) is well represented in mesic and wet grasslands, while the best-represented classes in alpine and sandy dry grasslands are *Juncetea trifidi* and *Koelerio-Corynephoretea canescentis*, respectively (Fig. 4).

The most frequent standard-plot sizes are 0.01 m², followed by 1 m² and 9–10 m² (Table 7). Data of the complete vegetation (vascular plants, and terricolous bryophytes and lichens) are available for 16,515 plots (8.7%) (Table 7). Methodologically, the majority of contributors used shoot sampling rather than rooted sampling (Table 4), which can make a big difference for the assessment of vascular plant richness at small spatial grains (Dengler 2008; Güler et al. 2016; Cancellieri et al. 2017). Among plot shapes, squares were



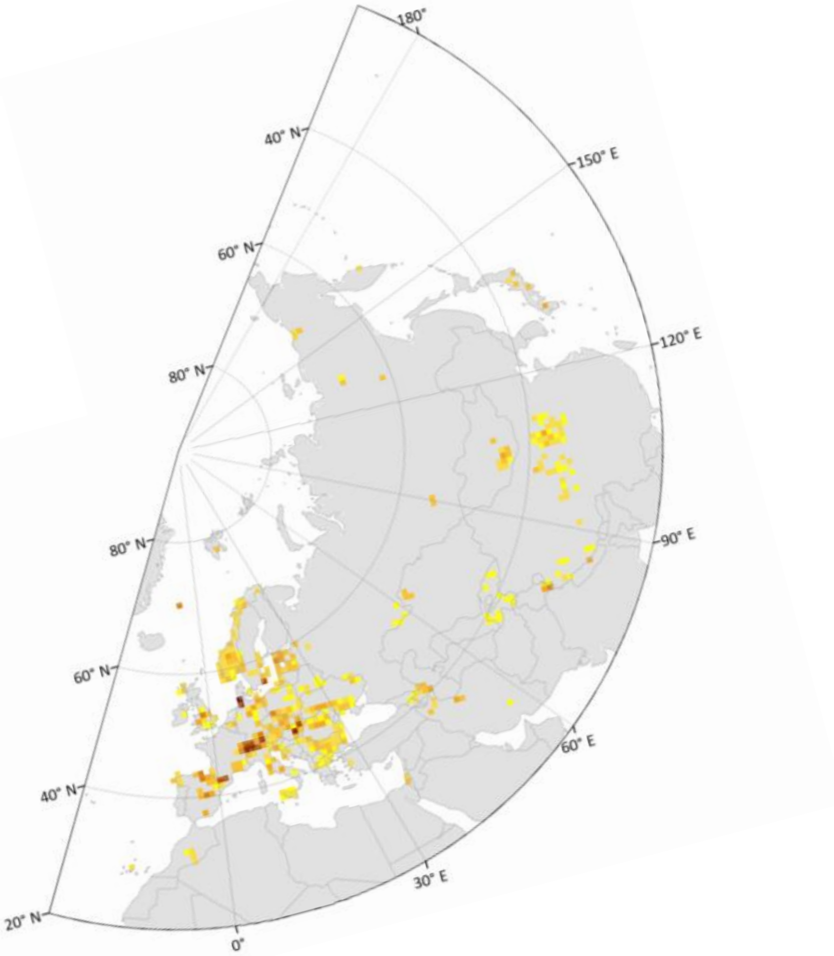
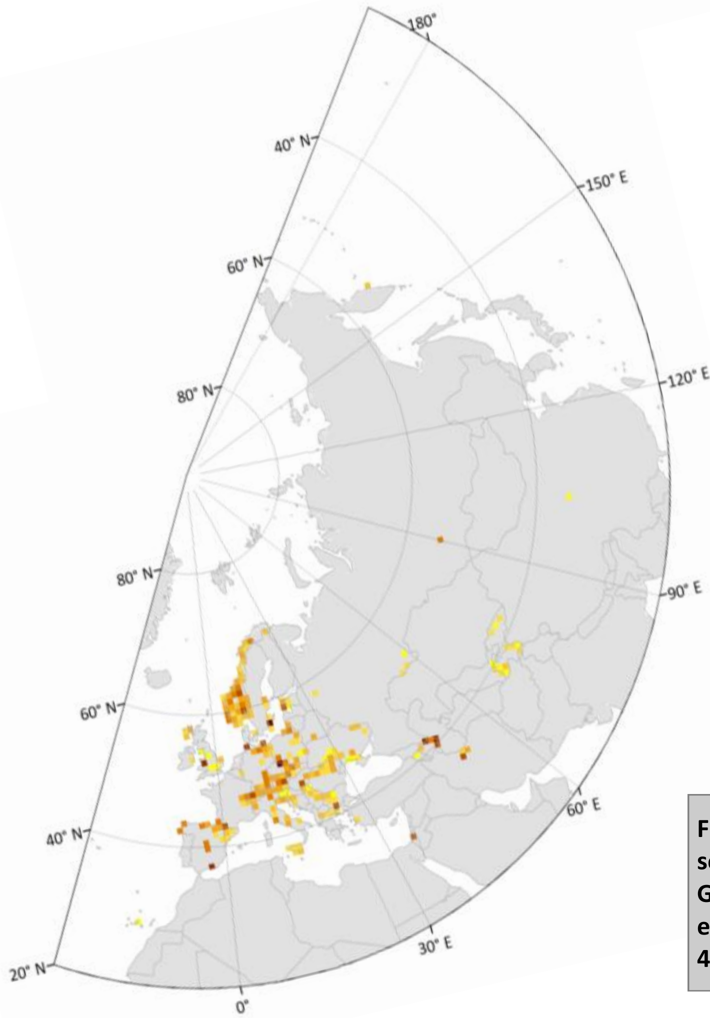


Fig. 2. Spatial distribution of the independent plots contained in GrassPlot v. 2.00 shown as plot density in equally-sized grid cells of 10,000 km^2 (*N* = 28,171).



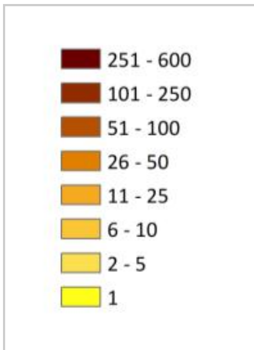


Fig. 3. Spatial distribution of the nested-plot series with at least four grain sizes contained in GrassPlot v. 2.00 shown as plot density in equally-sized grid cells of 10,000 km^2 (*N* = 4,654).

Table 5. Number (*N*) and density of plots per country (or dependent territory), sorted by decreasing density of independent plots (*N* = 28,171). The twenty five countries with the highest densities are listed. Area [km²] refers to the size of the respective territory. For comparison columns N_{all} and N_{all} / 100 km² provide numbers and densities of all plots for the listed countries (N_{all} = 190,673).

Code	Country	Area [km²]	*N*	*N* / 100 km²	N_{all}	N_{all} / 100 km²
AD	Andorra	468	77	16.45	77	16.45
CH	Switzerland	41,285	5,172	12.52	6,134	14.86
HU	Hungary	93,030	2,638	2.84	4,320	4.64
EE	Estonia	45,100	832	1.84	1,578	3.50
AT	Austria	83,855	1,401	1.67	13,899	16.58
DE	Germany	356,840	3,684	1.03	8,359	2.34
ES	Spain	504,790	3,451	0.68	58,977	11.68
AZ	Azerbaijan	86,600	408	0.47	2,033	2.35
SJ	Svalbard and Jan Mayen	61,397	280	0.46	280	0.46
IL	Israel	20,724	82	0.39	1,795	8.66
LV	Latvia	64,589	250	0.39	250	0.39
CZ	Czech Republic	78,864	280	0.36	1,396	1.77
BE	Belgium	30,688	90	0.29	90	0.29
BG	Bulgaria	110,910	315	0.28	844	0.76
HR	Croatia	56,594	160	0.28	227	0.40
NO	Norway	323,758	911	0.28	15,292	4.72
SK	Slovakia	49,035	139	0.28	477	0.97
IT	Italy	301,245	742	0.25	15,120	5.02
UK	United Kingdom	244,587	586	0.24	3,756	1.54
SE	Sweden	440,940	1,000	0.23	26,219	5.95
PL	Poland	312,685	620	0.20	3,148	1.01
RO	Romania	238,397	436	0.18	1,354	0.57
SI	Slovenia	20,273	37	0.18	37	0.18
UA	Ukraine	603,628	765	0.13	2677	0.44
RS	Serbia	77,453	119	0.15	533	0.69

most frequently employed (82%), followed by circles (18%) but rectangles are rarer. GrassPlot's geographic coordinates most often have an accuracy of < 1 km and in 18%, of < 1 m (Table 4).

As explained above, header data in GrassPlot also hold many structural (e.g. cover and height of vegetation layers, biomass) and ecological (e.g. topography, soil, land use) parameters that have harmonized terminology and units of measurement. The distribution of plots across biomes and regions is shown in Fig. 5 and Table 8, respectively.

Governance, applications and outlook

GrassPlot is a self-governed consortium, associated with the Eurasian Dry Grassland Group (EDGG). The data contributors remain owners of their data and become members of the consortium. Every two years, the consortium elects from its members a seven-strong Governing Board. Since 27 February 2019, the Governing Board is composed of Jürgen Dengler (Switzerland; custodian), Idoia Biurrun (Spain, deputy custodian and database manager), Sabina Burrascano (Italy), Iwona Dembicz (Poland and Switzerland), Riccardo Guarino (Italy), Jutta Kapfer (Norway) and Remigiusz Pielech (Poland). Other consortium members act as additional data managers, such as Itziar García-Mijangos, Salza Palpurina, Anne Mimet, Corrado Marcenò and Vincent Pellissier. Rights and duties of data contributors and data users are regulated in Bylaws, of which a slightly modified version was adopted by the GrassPlot Consortium on 1 January 2019. The GrassPlot website is currently hosted at the Ecoinformatics Portal Bayreuth (https://bit.ly/2HvVkgu), but will be transferred shortly to the new EDGG website (http://www.edgg.org).

As already mentioned, the purpose of GrassPlot is to provide high-quality data for broad-scale analyses of various aspects of vegetation diversity. According to the GrassPlot Bylaws, members of the consortium can request data for research projects (and non-members can join up with a member to do so). Currently, one such paper project has been completed and three are under way. Dengler et al. (2019) recently analysed which function best describes species-area relationships (SARs) in Palaearctic grasslands. In a follow-up paper (J. Dengler, I. Dembicz et al., in prep.), the authors will test how the exponent of the power function (*z*-value) as a measure of small-scale beta-diversity depends on taxonomic group, vegetation type and site conditions. Furthermore, an overview of mean, minimum and maximum richness data of Palaearctic grasslands across regions, vegetation types, taxa and scales will serve as a major benchmarking tool both for fundamental research and conservation and is well-developed (I. Biurrun et al. in prep.). In addition, an online reference database is planned for publication along with this study. Finally, the relationship between sampling grain and beta-diversity is now being tested

Table 6. Distribution of plots in GrassPlot v. 2.00 across the 22 vegetation types and five broad groups. *N* = number of independent plots in each vegetation type and broad group; % GP = proportion of independent plots of each vegetation type in GrassPlot; % VT = proportion of independent plots of a phytosociological class inside each vegetation type. If the values in % VT do not sum up to 100% within one vegetation type, this is due to plots without assignment to a phytosociological class, and also due to the fact that only classes with more than 10% VT are shown (with some exceptions). [NA] in the column *Group* indicates the number of plots that have not been assigned to any vegetation type. [NA] in the column *Phytosociological class* indicates that plots of this vegetation type do not have phytosociological assignment; assignation to vegetation type has been made manually.

Group	Vegetation type	*N*	% GP	Phytosociological class	% VT
Natural grasslands (*N* = 6,222)	Alpine grasslands	3,023	10.7	*Elyno-Seslerietea*	12.5
				Festucetea indigestae	7.3
				Juncetea trifidi	50.5
	Alpine steppes	89	0.3	[NA]	-
	Rocky grasslands	948	3.4	*Festuco hystricis-Ononidetea striatae*	24.6
				Festuco-Brometea	56.6
				Sedo-Scleranthetea	14.1
	Xeric grasslands and steppes	2,162	7.7	*Cleistogenetea squarrosae*	7.2
				Festuco-Brometea	67.5
Secondary grasslands (*N* = 11,902)	Wet grasslands	1,375	4.9	*Molinio-Arrhenatheretea*	79.2
	Mesic grasslands	3,627	12.9	*Molinio-Arrhenatheretea*	59.9
	Meso-xeric grasslands	4,542	16.1	*Festuco-Brometea*	96.7
	Mediterranean grasslands	817	2.9	*Lygeo sparti-Stipetea tenacissimae*	18.7
				Stipo-Trachynietea distachyae	72.7
	Sandy dry grasslands	1,541	5.5	*Koelerio-Corynephoretea canescentis*	88.3
Azonal habitats (*N* = 7,333)	Wetlands	2,700	9.6	*Oxycocco-Sphagnetea*	10.9
				Phragmito-Magnocaricetea	13.2
				Scheuchzerio palustris-Caricetea fuscae	70.9
	Saline communities	2,931	10.4	*Juncetea maritimi*	70.5
	Dunes	953	3.4	*Ammophiletea*	43.7
				Helichryso-Crucianelletea maritimae	50.1
	Rocks and screes	356	1.3	*Didymophyso aucheri-Dracocephaletea aucheri*	22.1
				Thlaspietea rotundifolii	27.2
	Saline steppes and semi-deserts	393	1.4	*Festuco-Puccinellietea*	100
Dwarf shrublands (*N* = 900)	Arctic-alpine heathlands	451	1.6	*Loiseleurio procumbentis-Vaccinietea*	20.6
	Lowland heathlands	116	0.4	*Calluno-Ulicetea*	31.8
	Garrigues and Thorn cushion communities	333	1.2	*Festuco hystricis-Ononidetea striatae*	2.4
				Onobrychidetea cornutae	2.4
				Ononido-Rosmarinetea	3.6
Tall forb and ruderal communities (*N* = 724)	Tall forb and fringe communities	271	1.0	*Molinio-Arrhenatheretea*	35.4
				Mulgedio-Aconitetea	28.0
				Trifolio-Geranietea sanguinei	26.9
	Ruderal communities	453	1.6	*Artemisietea vulgaris*	18.9
				Epilobietea angustifolii	34.4
Deserts and semi-deserts (*N* = 559)	Alpine deserts	11	< 0.1	*Ajanio-Cleistogenetea songoricae*	72.7
	Cold deserts and semi-deserts	519	1.8	[NA]	-
	Warm deserts and semi-deserts	29	0.1	*Kleinio-Euphorbietea canariensis*	44.8
[NA]	-	531	1.9		

Table 7. Number of plots (*N*), mean richness (S_{mean}) with standard deviation (S_{SD}) and maximum richness (S_{max}) in GrassPlot v. 2.00 across different plot sizes, and for vascular plants and complete terricolous vegetation (vascular plants, bryophytes and lichens), respectively. All plots and subplots have been considered, thus a total of 190,673 plots. Non-standard plot sizes include all other plot sizes (which are collected only in case of nested-plot series). Note that due to different sample sizes (see column *N*), maxima of larger plot sizes can be lower than for maxima of smaller plot sizes or that maxima of complete terricolous vegetation can be lower than maxima of vascular plants only. Information on plot sizes that deviate by a maximum of 10% (e.g. 9 m² vs. 10 m²), is combined in one row because, based on species-area relationships with typical *z*-values between 0.15 and 0.30, the relative difference in richness would only be about 1.6–3.2%, i.e. negligible given the overall variability of the data.

	Vascular plants				Complete terricolous vegetation			
Plot size (m^2)	*N*	S_{mean}	S_{SD}	S_{max}	*N*	S_{mean}	S_{SD}	S_{max}
0.0001	2,534	1.9	1.6	11	1,797	2.1	1.7	10
0.001 or 0.0009	3,838	3.3	2.1	19	1,738	3.5	13.4	19
0.01	69,525	3.9	17.0	24	2,491	6.6	20.5	29
0.1 or 0.09	4,963	11.3	30.4	43	1,763	11.1	32.5	46
1	22,121	13.9	55.9	79	2,672	18.6	58.0	82
10 or 9	9,964	27.6	75.0	106	2,617	34.5	71.4	101
100	4,634	29.6	89.1	127	962	48.5	94.0	134
1,000 or 900 or 1,024	187	48.0	17.7	134	45	59.0	85.6	123
Non-standard plot sizes	72,907				2,430			
Total	190,673				16,515			

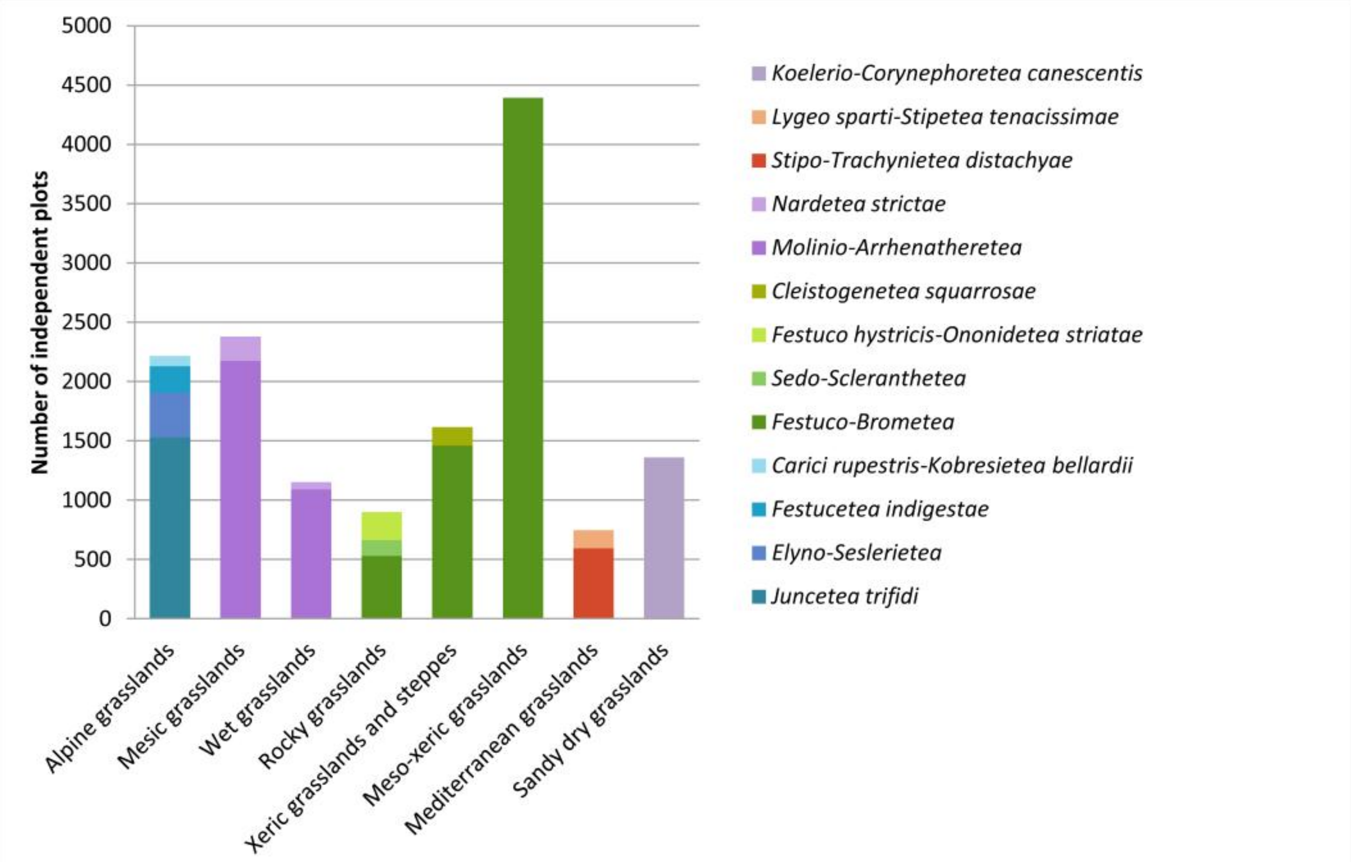


Fig. 4. Frequency of the natural and secondary grassland types and their assignment to phytosociological classes in GrassPlot v. 2.00. Alpine steppes are not represented as they are not assigned to any phytosociological class in GrassPlot. Only independent plots have been considered (*N* = 28,171). Absolute numbers are shown, so that the presence of each class in different vegetation types can be compared.

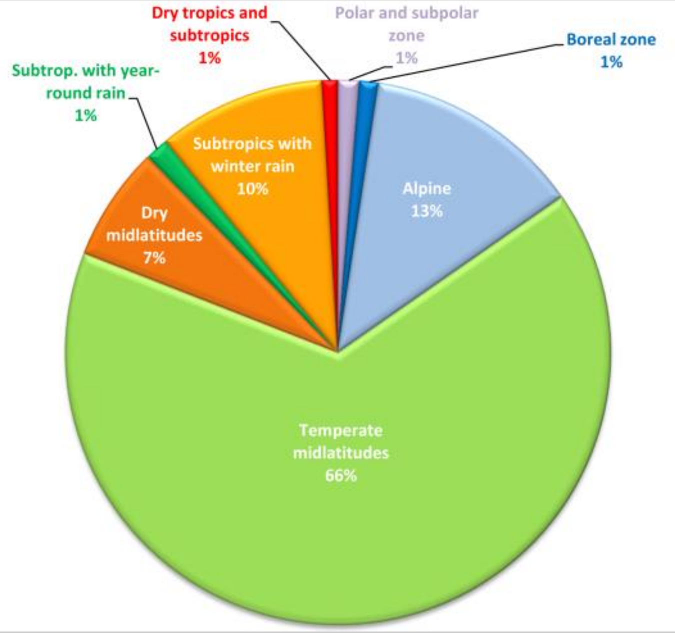


Fig. 5. Distribution of independent plots contained in GrassPlot v. 2.00 (*N* = 28,171) across biomes as defined by Bruelheide et al. (2019).

Table 8. Distribution of independent plots in GrassPlot v. 2.00 according to the regionalization used in *Grasslands of the world* (Török & Dengler 2018) and *Encyclopedia of the world's biomes* (Dengler et al. in press).

Grasslands of the world	*N*	%
Western and Northern Europe	13,343	47.4
Eastern Europe	6,598	23.4
Mediterranean and Middle East	5,301	18.8
China and Mongolia	1,762	6.3
Russia	522	1.9
Japan	418	1.5
Kazakhstan and Middle Asia	227	0.8
Encyclopedia of the world's biomes	*N*	%
Western Europe	14,042	49.8
Eastern Europe	5,455	19.4
Northern Europe	3,281	11.6
Mediterranean	1,779	6.3
China	1,291	4.6
Middle East and Caucasus	685	2.4
Russia	522	1.9
Mongolia	471	1.7
Japan and Korea	418	1.5
Kazakhstan and Middle Asia	227	0.8

across different spatial extents and vegetation types based on composition data (S. Burrascano et al. in prep.).

GrassPlot represents work in progress. Therefore, we welcome new data contributions that meet the specific criteria of GrassPlot (Dengler et al. 2018; GrassPlot website, http://bit.ly/2NZ6A9d). Of particular value are datasets that (largely) follow the standardised EDGG multi-scale sampling (Dengler et al. 2016b), specifically if they come from under-represented regions or vegetation types (see Figs. 2 and 3, Table 6). However, as GrassPlot does not have external funding, data preparation and harmonisation has to be undertaken voluntarily by the Governing Board and other members and thus it might take a while from data provision to actual inclusion. Likewise, we are also working on improving the completeness and consistency of the header data (methodological, geographic, abiotic, land use, structural information) of the contained plots and increasing the fraction of plots with readily available compositional data. We have agreed with the European Vegetation Archive (EVA; Chytrý et al. 2016) and the global vegetation database "sPlot" (Bruelheide et al. 2019) to contribute GrassPlot data not yet included in these two databases once the compositional data are ready and provided the data owners contribute. This step will fill important data gaps in EVA and sPlot and give our data contributors the opportunity of additional benefit. Last but not least, we hope that the publication of the first macroecological paper from GrassPlot (Dengler et al. 2019) will raise the awareness of the unique qualities of GrassPlot for such studies and spur many more exciting research proposals to be submitted to the Governing Board.

Author contributions

I.B. is the database manager of GrassPlot; she and J.D. planned and led this paper. S.B., I.D., R.G., J.K. and R.P. as further members of the GrassPlot Governing Board as well as I.G.M., V.W., S.P., A.M., V.P, C.M. and A.N. contributed substantially to data preparation, analyses and writting. A.B., S.Bo., A.M.C. J.A.G., A.K., J.A.C., B.E., B.J.A., Z.K., M.M., G.S and K.M added helpful comments, and all other authors contributed data to GrassPlot after v. 1.00, checked and approved the manuscript.

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Appendix 1. Example of species composition in a nested-plot series prepared in long format in GrassPlot v. 2.00.

GrassPlot.plotID	Area.m2	GrassPlot.ID.largest.nested	Species.original	Group	Layer	Abundance	Abundance_Scale
EU_F_N001_0.0001aa	0.0001	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.0001ab	0.0001	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A
EU_F_N001_0.0001ab	0.0001	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.0001bb	0.0001	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.001aa	0.001	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.001ab	0.001	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A
EU_F_N001_0.001ab	0.001	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.001bb	0.001	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.01aa	0.01	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.01ab	0.01	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A
EU_F_N001_0.01ab	0.01	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.01ab	0.01	EU_F_N001_100	Euphorbia paralias	V	H	1	P/A
EU_F_N001_0.01ba	0.01	EU_F_N001_100	Galium arenarium	V	H	1	P/A
EU_F_N001_0.01bb	0.01	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.1aa	0.1	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.1aa	0.1	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	1	P/A
EU_F_N001_0.1aa	0.1	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.1ab	0.1	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A
EU_F_N001_0.1ab	0.1	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.1ab	0.1	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.1ab	0.1	EU_F_N001_100	Euphorbia paralias	V	H	1	P/A
EU_F_N001_0.1ab	0.1	EU_F_N001_100	Hieracium eriophorum	V	H	1	P/A
EU_F_N001_0.1ba	0.1	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A

Appendix 1. Continuation.

GrassPlot.plotID	Area.m2	GrassPlot.ID.largest.nested	Species.original	Group	Layer	Abundance	Abundance_Scale
EU_F_N001_0.1ba	0.1	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.1ba	0.1	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_0.1ba	0.1	EU_F_N001_100	Galium arenarium	V	H	1	P/A
EU_F_N001_0.1bb	0.1	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_0.1bb	0.1	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Calystegia soldanella	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Eryngium maritimum	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Euphorbia paralias	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Galium arenarium	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Hieracium eriophorum	V	H	1	P/A
EU_F_N001_100	100	EU_F_N001_100	Leontodon saxatilis subsp. saxatilis	V	H	1	P/A
EU_F_N001_10a	10	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	5	Cover
EU_F_N001_10a	10	EU_F_N001_100	Calystegia soldanella	V	H	10	Cover
EU_F_N001_10a	10	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	20	Cover
EU_F_N001_10a	10	EU_F_N001_100	Eryngium maritimum	V	H	10	Cover
EU_F_N001_10a	10	EU_F_N001_100	Euphorbia paralias	V	H	2.5	Cover
EU_F_N001_10a	10	EU_F_N001_100	Hieracium eriophorum	V	H	2.5	Cover
EU_F_N001_10b	10	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	5	Cover
EU_F_N001_10b	10	EU_F_N001_100	Calystegia soldanella	V	H	2.5	Cover
EU_F_N001_10b	10	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	10	Cover
EU_F_N001_10b	10	EU_F_N001_100	Eryngium maritimum	V	H	10	Cover
EU_F_N001_10b	10	EU_F_N001_100	Euphorbia paralias	V	H	2.5	Cover
EU_F_N001_10b	10	EU_F_N001_100	Galium arenarium	V	H	5	Cover
EU_F_N001_10b	10	EU_F_N001_100	Hieracium eriophorum	V	H	2.5	Cover

Appendix 1. Continuation.

GrassPlot.plotID	Area.m2	GrassPlot.ID.largest.nested	Species.original	Group	Layer	Abundance	Abundance_Scale
EU_F_N001_10b	10	EU_F_N001_100	Leontodon saxatilis subsp. saxatilis	V	H	2.5	Cover
EU_F_N001_1aa	1	EU_F_N001_100	Calystegia soldanella	V	H	4	Cover
EU_F_N001_1aa	1	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	12	Cover
EU_F_N001_1aa	1	EU_F_N001_100	Eryngium maritimum	V	H	8	Cover
EU_F_N001_1aa	1	EU_F_N001_100	Euphorbia paralias	V	H	8	Cover
EU_F_N001_1aa	1	EU_F_N001_100	Hieracium eriophorum	V	H	1	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	35	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Calystegia soldanella	V	H	6	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	4	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Eryngium maritimum	V	H	4	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Euphorbia paralias	V	H	2	Cover
EU_F_N001_1ab	1	EU_F_N001_100	Hieracium eriophorum	V	H	1	Cover
EU_F_N001_1ba	1	EU_F_N001_100	Ammophila arenaria subsp. australis	V	H	10	Cover
EU_F_N001_1ba	1	EU_F_N001_100	Calystegia soldanella	V	H	6	Cover
EU_F_N001_1ba	1	EU_F_N001_100	Eryngium maritimum	V	H	8	Cover
EU_F_N001_1ba	1	EU_F_N001_100	Galium arenarium	V	H	20	Cover
EU_F_N001_1ba	1	EU_F_N001_100	Leontodon saxatilis subsp. saxatilis	V	H	1	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Calystegia soldanella	V	H	3	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Elytrigia juncea subsp. boreoatlantica	V	H	5	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Eryngium maritimum	V	H	1	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Euphorbia paralias	V	H	3	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Galium arenarium	V	H	0.5	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Hieracium eriophorum	V	H	1	Cover
EU_F_N001_1bb	1	EU_F_N001_100	Leontodon saxatilis subsp. saxatilis	V	H	1	Cover

Appendix 2. Overview of the new datasets in GrassPlot v. 2.00 compared to GrassPlot v. 1.00, including datasets with increased plot numbers (CH_B, with 2,700 additional plots, ES_P, with 3,104 additional plots; UA_F, 115; IR_A, 102; RU_I, 39). See below for quoted references. N_{all} = total number of plots ; N_{ind} = independent plots; N_{nes} = nested-plot series with at least four grain sizes.

Dataset ID	Short dataset name	Country/ies	Province: location	Data owner(s)	Reference(s)	N_{all}	N_{ind}	N_{nes}
EDGG Expeditions/Field Workshops:								
AT_E	EDGG Eastern Alps	Austria	Tyrol, Styria and Carinthia	Martin Magnes, Elías Afif, Christian Berg, Philipp Kirschner, Ermin Mašić, Helmut Mayrhofer	Magnes et al. (2018)	232	52	15
Individually contributed datasets:								
AS_A	Nowak_Kyrgyzstan & Tajikistan	Tajikistan, Kyrgyzstan	Eastern Tajikistan and whole Kyrgyzstan	Arkadiusz Nowak, Ewelina Klichowska, Marcin Nobis, Anna Wróbel		156	12	12
AT_D	Essl, Austria old plots	Austria		Franz Essl		29	29	0
AT_F	Mayer_Obergurgl	Austria	Northern Tyrol: Obergurgl	Roland Mayer, Brigitta Erschbamer	Mayer et al. (2009); Mayer & Erschbamer (2017)	216	108	0
AZ_A	Etzold Caucasus	Azerbaijan	Eastern Greater Caucasus: Shahdag	Jonathan Etzold, Tobias Dahms, Michael Manthey, Jan Peters	Etzold et al. (2016)	1,013	204	204
AZ_B	Peper Gobustan	Azerbaijan	Gobustan region: Gobustan and Jeiranchel	Jan Peper, Michael Manthey	Peper et al. (2010a, b)	1,020	204	204
BE_A	Van Meerbeek_Flanders	Belgium	Flanders	Koenraad Van Meerbeek	Van Meerbeek et al. (2014)	90	90	0
BG_B	BioBio_Bulgaria	Bulgaria	Rhodope Mountains	Idoia Biurrun	Lüscher et al. (2016)	272	68	68
CH_B	Bergamini Switzerland	Switzerland		Ariel Bergamini, Steffen Boch, Klaus Ecker	Bergamini et al. (2013, 2016); Tillé & Ecker (2014); Boch et al. (2018, 2019a, b)	4,779	4,779	0
CH_C	Dengler Wädenswil	Switzerland	Canton of Zürich: Campus Grüental, Wädenswil	Jürgen Dengler, Stefan Widmer	Dengler & Widmer (2018)	227	18	18
CH_D	Dengler_Ausserberg	Switzerland	Valais: Ausserberg	Jürgen Dengler, Manuel Babbi, Regula Billeter, Iwona Dembicz	Dengler et al. (2019)	61	25	3
CH_E	Dengler Alp Glivers	Switzerland	Grisons: Sumvtig-Cumpadinals, Alp Glivers	Jürgen Dengler, Daniel Hepenstrick, Stefan Widmer	Hepenstrick et al. (2018)	39	3	3
CH_F	BioBio_Switzerland	Switzerland	Obwalden: Sarden	Philippe Jeanneret	Lüscher et al. (2016)	260	65	65
CH_G	Meier Switzerland	Switzerland		Eliane Meier	Meier & Hofer (2016)	540	270	0
CN_D	Deng_Mu Us desert	China	Shaanxi: Dingbian, Mu Us Desert	Lei Deng	Deng et al. (2014)	36	36	0
CN_E	Deng_Loess Plataeu	China		Lei Deng	Deng et al. (2016)	330	330	0
CZ_J	Doležal Sumava	Czech Republic	Bohemian Forest Mts., Sumava	Jiří Doležal	Mašková et al. (2009); Doležal et al. (2011)	225	15	15
CZ_K	Doležal_Benesov	Czech Republic	Benesov	Jiří Doležal, Jan Lepš	Lepš et al. (2007)	60	60	0
DE_S	BioBio CSR Germany	Germany	Southern Bavaria: near Ausburgo	Sebastian Wolfrum	Lüscher et al. (2016)	164	41	41
DE_T	Manthey Greifswald	Germany	Western Pomerania: Greifswald	Michael Manthey		913	83	83
ES_P	Alfaro Picos de Europa	Spain	Asturias and Cantabria: Picos de Europa	Borja Jiménez-Alfaro, Alvaro Bueno, Corrado Marcenò	Jímenez-Alfaro et al. (2010)	3,120	16	16

Appendix 2. Continuation.

Dataset ID	Short dataset name	Country/ies	Province: location	Data owner(s)	Reference(s)	N_{all}	N_{ind}	N_{nes}
ES_Q	Löbel Tenerife	Spain	Canary islands, Tenerife: Anaga Mts.	Swantje Löbel, Jürgen Dengler	Löbel & Dengler (2002)	18	13	1
ES_R	de Bello NE Spain	Spain	Catalonia and Aragón: Ebro valley to Pyrenees	Idoia Biurrun	de Bello et al. (2007)	75	15	15
ES_S	Biurrun Urumea	Spain	Basque Country: Urumea stream	Idoia Biurrun	Aramburu (2017)	34	34	0
ES_T	Campos Zalama	Spain	Basque Country: Zalama Mt.	Juan Antonio Campos, Idoia Biurrun		24	24	0
ES_U	Pladevall Pyrenean fens	Spain	Catalonia: Pyrenees	Eulàlia Pladevall-Izard, Aaron Pérez-Haase		859	859	0
EU_E	Roleček Hungary-Romania	Hungary, Romania	Mátra Mts., Bükk Mts., Transylvania, Cluj	Jan Roleček, Pavel Dřevojan, Michal Hájek	Roleček et al. (2019)	5	5	0
EU_J	Janišová Carpathians	Romania, Slovakia	Carpathians: Borišov, Veľká Fatra Mts; Ciosa, Caliman Mts; Poiana Fagului, Hargita	Monika Janišová, Martin Magnes		204	17	17
EU_K	Essl Europe	Austria, Belarus, Bosnia, Croatia, Germany, Ireland, Italy, Serbia		Franz Essl		766	239	159
EU_L	Perez Haase_Pyrenean mires	Spain, Andorra	Pyrenees	Aaron Pérez-Haase, Josep Maria Ninot		376	376	0
FR_B	Van Mechelen_Languedoc	France	Languedoc-Roussillon, Provence-Alpes-Côte d'Azur	Carmen Van Mechelen	Van Mechelen et al. (2014)	253	253	0
HU_F	BioBio_Hungary	Hungary	Homokhátság	Idoia Biurrun	Lüscher et al. (2016)	316	79	79
HU_G	Bátori Hungarian dolines	Hungary	N Hungarian mountains: Aggtelek Karst and Bükk Mts.	Zoltán Bátori, Tünde Farkas, András Vojtkó	Bátori et al. (2017)	356	356	0
IN_A	Doležal Ladakh unpublished	India	Jammu & Kashmir: East Ladakh, SW Tibetan Plateau	Jiří Doležal		369	369	0
IN_B	Doležal Ladakh nested	India	Jammu & Kashmir: East Ladakh, SW Tibetan Plateau	Jiří Doležal	Dvorský et al. (2011)	384	192	0
IR_A	Naqinezhad Central Alborz	Iran	Alborz Mts.: Central Alborz, Damavand	Alireza Naqinezhad, Amir Talebi	Talebi (2019)	459	27	27
IT_Q	EGC Sulmona	Italy	Chieti province: Palena: San Nicola	Giampiero Ciaschetti, Sabina Barruscano	Burrascano et al. (2018)	13	1	1
IT_R	Filibeck_Picinisco	Italy	Central Apennines, Picinisco	Goffredo Filibeck, Laura Cancellieri		83	83	0
KZ_A	Deak Kazhkstan	Kazakhstan	Kostanay oblast: Rudny, Karamendi, Alexandrovskaya	Orsolya Valkó, Zoltán Bátori, Balázs Deák, András Kelemen, Csaba Tölgyesi	Deák et al. (2017)	200	200	0
NO_C	Grytnes North Norway	Norway	Troms: Dividalen	John-Arvid Grytnes		231	33	33
NO_D	Grytnes South Norway	Norway	Sogn og Fjordane: Lærdal	John-Arvid Grytnes		70	10	10
NO_E	Landscape Monitoring Norway	Norway		Wenche Dramstad, Wendy Fjellstad, Jutta Kapfer, Christian Pedersen, Hanne Sickel, Grete Stokstad		2,276	569	569
NP_A	Bhatta Nepal	Nepal	Langtang National Park	Kuber Prasad Bhatta, John-Arvid Grytnes, Ole Reidar Vetaas	Bhatta et al. (2018a, b)	252	126	0

Appendix 2. Continuation.

Dataset ID	Short dataset name	Country/ies	Province: location	Data owner(s)	Reference(s)	N_{all}	N_{ind}	N_{nes}
PL_D	Pielech nested	Poland	SW Poland: Karkonosze Mts.	Remigiusz Pielech, Marek Malicki		130	10	10
PL_E	Kozub Biebrza	Poland	Podlaskie	Łukasz Kozub, Iwona Dembicz, Katarzyna Skłodowska		195	15	15
PT_A	Lomba_Ecochange	Portugal	Viana do Castelo: Castro Laboreiro	Ângela Lomba, João Honrado		24	24	0
RO_D	Csergó_Transylvania	Romania	SE Carpathians: Somlyó Valley (Csík Basin) and Kolos (Csík Mountains)	Anna Mária Csergő, László Demeter	Csergő & Demeter (2012); Csergő et al. (2013); Maseyk et al. (2017)	196	196	0
RU_I	Belonovskaya Novgorodskaya	Russia	Novgorodskaya oblast: Valday hills	Elena Belonovskaya, Nadezda Tsarevskaya	Belonovksaya & Tsarevskaya (2018)	49	7	4
RU_K	Mirin Belogorie	Russia	Belgorod region: reserve Belogorie	Denis Mirin, Ekaterina Zlotnikova		26	2	2
RU_L	Dolnik South Ural	Russia	Orenburg and Chelyabinsk regions	Christian Dolnik		91	7	7
RU_M	Doležal Kamchatka	Russia	Kamchatka: Koryto Glacier Valley	Jiří Doležal		80	10	10
SE_E	Alatalo Subarctic Sweden	Sweden	Norbotten: Latnjajaure	Juha M. Alatalo, Annika Jägerbrand, Ulf Molau	Alatalo et al. (2014 a, b; 2015a, b; 2016; 2017)	20	20	0
SE_F	Waldén Sweden restoration	Sweden	SE Sweden	Emelie Waldén, Regina Lindborg	Waldén & Lindborg (2016)	50	50	0
TJ_A	Nowak_Tajikistan	Tajikistan	Western Tajikistan	Arkadiusz Nowak, Iwona Dembicz, Zygmunt Kącki, Grzegorz Swacha, Sebastian Świerszcz		195	15	15
TR_B	Güler Buca İzmir	Turkey	İzmir	Behlül Güler		50	14	3
UA_F	Vasheniak Dniester Canyon	Ukraine	Dniester Canyon and tributaries	Iuliia Vashenyak	Vasheniak (2018)	329	329	0
UA_H	Kuzemko Byzky Gard	Ukraine	Mykolaiv: Buzky Gard NNP	Anna Kuzemko, Ganna Kolomients, Dariia Shyriaieva		26	2	2
UA_I	Kuzemko Kreida	Ukraine	Kharkiv: Oskol River and Vovcha River valleys	Anna Kuzemko, Olga Bezrodnova, Vladimir Ronkin, Galina Savchenko		104	8	8
UA_J	Vynokurov Southern Ukraine	Ukraine	Southern Ukraine	Denys Vynokurov, Ivan Y. Moysiyenko, Dariia Shyriaieva		242	110	11
UA_K	Savchenko Kharkiv & Donetsk	Ukraine	Kharkiv and Donetsk regions	Galina Savchenko, Vladimir Ronkin		143	11	11
UA_L	Dembicz nested Ukraine	Ukraine	Kherson region	Iwona Dembicz, Łukasz Kozub, Ivan Y. Moysiyenko, Viktor Shapoval		156	12	12
UK_C	BioBio_United Kingdom	United Kingdom	Wales	Idoia Biurrun	Lüscher et al. (2016)	432	108	108
UK_D	Stevens Sheffield acidic	United Kingdom	England: Sheffield	Carly Stevens	Stevens et al. (2016)	196	196	0
UK_E	Stevens Sheffield calcareous	United Kingdom	England: Sheffield	Carly Stevens	Stevens et al. (2016)	242	242	0

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