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TRY plant trait database – enhanced coverage and open access

Correspondence
Jens Kattge, Max Planck Institute for Biogeochemistry, Hans Knöll Str. 10, 07745 Jena, Germany.
Email: jkattge@bgc-jena.mpg.de

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Abstract
Plant traits—the morphological, anatomical, physiological, biochemical and phenological characteristics of plants—determine how plants respond to environmental factors, affect other trophic levels, and influence ecosystem properties and their benefits and detriments to people. Plant trait data thus represent the basis for a vast area of research spanning from evolutionary biology, community and functional ecology, to biodiversity conservation, ecosystem and landscape management, restoration, biogeography and earth system modelling. Since its foundation in 2007, the TRY database of plant traits has grown continuously. It now provides unprecedented data coverage under an open access data policy and is the main plant trait database used by the research community worldwide. Increasingly, the TRY database also supports new frontiers of trait-based plant research, including the identification of data gaps and the subsequent mobilization or measurement of new data. To support this development, in this article we evaluate the extent of the trait data compiled in TRY and analyse emerging patterns of data coverage and representativeness. Best species coverage is achieved for categorical traits—almost complete coverage for 'plant growth form'. However, most traits relevant for ecology and vegetation modelling are characterized by continuous intraspecific variation and trait–environmental relationships. These traits have to be measured on individual plants in their respective environment. Despite unprecedented data coverage, we observe a humbling lack of completeness and representativeness of these continuous traits in many aspects. We, therefore, conclude that reducing data gaps and biases in the TRY database remains a key challenge and requires a coordinated approach to data mobilization and trait measurements. This can only be achieved in collaboration with other initiatives.

KEYWORDS
data coverage, data integration, data representativeness, functional diversity, plant traits, TRY plant trait database

A list of authors and their affiliations appears in the Appendix.

1 | INTRODUCTION

Plant traits—the morphological, anatomical, physiological, biochemical and phenological characteristics of plants measurable at the individual plant level (Violle et al., 2007)—reflect the outcome of evolutionary and community assembly processes responding to abiotic and biotic environmental constraints (Valladares, Gianoli, & Gomez, 2007). Traits and trait syndromes (recurrent coordinated expressions of multiple traits) determine how plants perform and respond to environmental factors (Grime, 1974; Wright et al., 2017), affect other trophic levels (Lavorel et al., 2013; Loranger et al., 2012, 2013), and provide a link from species richness to functional diversity, which influences ecosystem properties and derived benefits and detriments to people (Aerts & Chapin, 2000; Díaz et al., 2004, 2007; Garnier & Navas, 2012; Grime, 2001, 2006; Lavorel et al., 2015; Lavorel & Garnier, 2002). In the context of the Global Earth Observation Biodiversity Observation Network (GEO BON) species traits are considered an Essential Biodiversity Variable to inform policy about biodiversity change (Kissling et al., 2018; Pereira et al., 2013). A focus on traits and trait syndromes, therefore, provides a crucial basis for quantitative and predictive ecology, ecologically informed landscape conservation and the global change science–policy interface (Díaz et al., 2016; McGill, Enquist, Weiher, & Westoby, 2006; Westoby & Wright, 2006). To fully realize this potential, plant trait data not only need to be available and accessible in appropriate quantity and quality but also representative for the scales of inference and research questions (König et al., 2019). Here we analyse where the TRY plant trait database stands with respect to coverage and representativeness after 12 years of operation. We further review the mechanisms and emergent dynamics helping to increase both.

1.1 | A global database of plant traits—A brief history

Before the foundation of TRY in 2007, several research groups had already developed major plant trait databases with remarkable success, e.g. the Ecological Flora of the British Islands (Fitter & Peat, 1994), the Seed Information Database (Royal Botanical Gardens KEW, 2008), BIOPOP (Poschlod, Kleyer, Jackel, Dannemann, & Tackenberg, 2003), GLOPNET (Wright et al., 2004), BiolFlor (Klotz, Kühn, & Durka, 2002, 2017), LEDA (Kleyer et al., 2008), BROT (Paula et al., 2009), USDA PLANTSdata (Green, 2009) and BRIDGE (Baraloto, Timothy Paine, Patino, et al., 2010). However, these databases were either focused on particular regions (BiolFlor, LEDA, BIOPOP, BROT, USDA Plants, Ecological Flora of the British Islands, BRIDGE) or specific traits (GLOPNET, SID). A 'database of databases' was in discussion for some time, but it had been impossible to secure long-term funding for such a project. Finally, at a joint workshop of the International Geosphere-Biosphere Program (IGBP) and DIVERSITAS, the TRY database (TRY—not an acronym, rather a statement of sentiment; https://www.try-db.org; Kattge et al., 2011) was proposed with the explicit assignment to improve the availability and accessibility of plant trait data for ecology and earth system sciences. The Max Planck Institute for Biogeochemistry (MPI-BGC) offered to host the database and the different groups joined forces for this community-driven program. Two factors were key to the success of TRY: the support and trust of leaders in the field of functional plant ecology submitting large databases and the long-term funding by the Max Planck Society, the MPI-BGC and the German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, which has enabled the continuous development of the TRY database.

At the time of the foundation of TRY, data sharing was not yet a common practice in ecology (Kattge et al., 2011; Reichman, Jones, & Schildhauer, 2011). This was an important obstacle for scientific progress. The first important step of the initiative was, therefore, to jointly develop a data sharing policy. This was based on permission of data set owners and a 'give-and-take' system: to keep the TRY database growing, the right to request data was coupled to data contribution. Exceptions were data requests for vegetation modelling projects, as modellers typically do not own plant trait data. At an open workshop in 2013, the members decided to offer the opportunity to make data publicly available and trait data contribution was no longer a requirement for data access. In 2014, this decision was implemented in the TRY Data Portal and was immediately followed by an 'explosion' of the number of data requests (Figure 1a): TRY

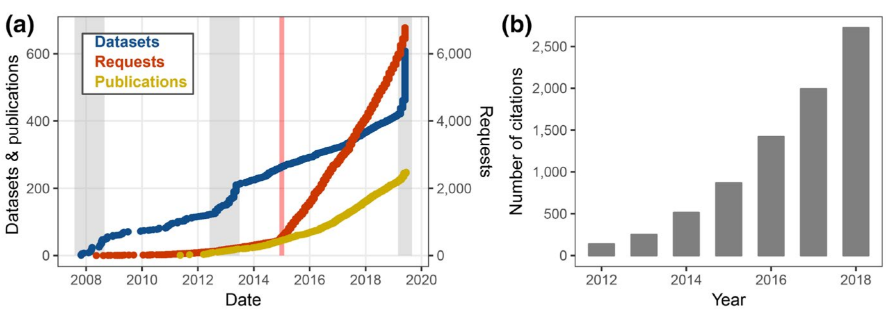

FIGURE 1 TRY performance statistics, status 1 July 2019. (a) Cumulative numbers of data sets and publications (left axis) and data requests (right axis); light grey vertical bars indicate calls for data contribution; the red vertical bar indicates the date of opening TRY to the public. (b) Number of citations for publications using trait data via TRY (Google Scholar)

started to serve more than 1,000 requests per year, so that as of July 2019, about 700 million trait records accompanied by 3 billion ancillary data have been released for 7,000 requests, submitted by more than 5,000 registered users. Since 2019, the TRY database is open access under a Creative Commons Attribution license (CC BY 4.0, https://creativecommons.org/licenses/by/4.0): anyone can use and redistribute data received via TRY under the only condition of appropriate citation of the TRY database and the references of contributing data sets. Restriction of data access now is the exception and limited to 2(+2) years, after which the data sets become public.

Since 2014, the TRY Data Portal (https://www.try-db.org/TryWeb/dp.php) has become the central access point of the TRY database: the portal organizes data uploads, searches and requests, and enables interaction between data contributors, management and users. The portal provides an account for each data set custodian (the individual who directly contributed the data set), which provides precise bookkeeping about the use of his or her trait data via TRY. The TRY Data Portal also provides a link to the TRY File Archive (https://www.try-db.org/TryWeb/Data.php), which offers climate and soil data for TRY measurement sites, standardized

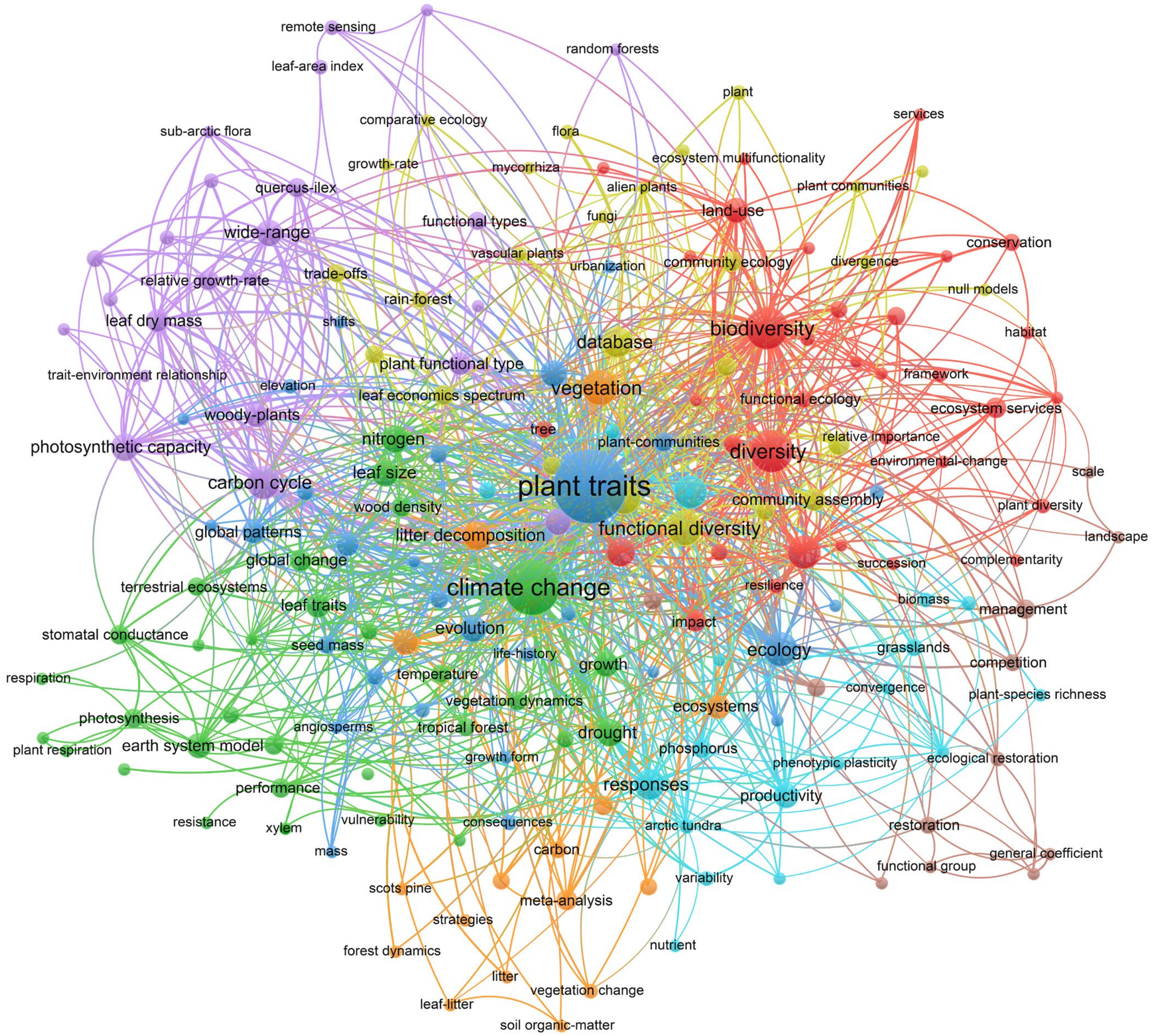

FIGURE 2 Cluster analysis of keywords from peer-reviewed publications using plant trait data via TRY. The size of the circles and letters indicates the frequency of the keywords, colours indicate the eight clusters around the central keywords (from largest to smallest cluster): biodiversity (red), climate change (dark green), plant traits (dark blue), functional diversity (light green), carbon cycle (violet), community (light blue), vegetation (orange) and environmental filtering (brown). The analysis is based on 190 publications with DOIs compiled by ISI Web of Science (https://clarivate.com/products/web-of-science). The analysis was performed with VOSviewer version 1.6.11 (https://www.vosviewer.com) using the default settings and only minor editing of selected terms. The clustering technique used by VOSviewer is discussed by Waltman, van Eck, and Noyons (2010). Due to limited space not all central keywords of small clusters are displayed. Material to display the results in detail using the VOSviewer software is provided in the Supporting Information

categorical traits relevant to attribute species to plant functional types (PFTs), and provides the opportunity to publish plant trait data sets and receive a DOI.

Trait data via TRY contributed to at least 250 scientific applications and publications (Figure 1a), among these 202 peer-reviewed publications in 83 different scientific journals, covering a broad range of topics, from 'Landscape and Urban planning' to 'Geoscientific Model Development'. Twenty publications were directly related to vegetation model development, while 230 were empirical studies. A cluster analysis of keywords from the peer-reviewed publications shows eight clusters around the central keywords biodiversity, climate change, plant traits, functional diversity, carbon cycle, community, vegetation and environmental filtering (Figure 2). Citations of publications using trait data via TRY have increased exponentially, leading to about 10,000 citations and an h-factor of 46 for the TRY database (Figure 1b).

During 12 years of development, versions 1–5 of the TRY database have been released with an increasing number of contributed data sets and trait records (Tables 1 and 2; Figure 1a). Currently, TRY is working on version 6. As of July 2019, the TRY database comprised 588 data sets from 765 data contributors (Table A1). The dynamics of the number of data sets in TRY indicates an increasing success of calls to the scientific community for data contribution in 2007, 2013 and 2019. When the manuscript was submitted, data contributions responding to the call in 2019 were not yet fully integrated into the TRY database. Therefore all analyses presented in this paper are based on versions 1–5 of the TRY database (Table 1). TRY version 5, released on 26 March 2019, contains 387 data sets providing 11.8 million trait records, accompanied by 35 million ancillary data, for 2,091 traits and 280,000 plant taxa, mostly at the species level (Table 2). Data coverage is still driven by a few large (often integrated) databases, but increasingly small data sets (mostly primary data) contribute to the overall coverage (Figure 3a). Plant trait data in TRY can be traced to >10,000 original references. This highlights the breadth of data integrated in the TRY database and its nature as database of databases, a 'second generation of data pooling' (M. Westoby, personal communication, August 24, 2009).

We now observe a tendency that new trait-based research is increasingly planned against the background of the TRY database. Coverage and availability of trait data in TRY stimulate trait-based research, which then often leads to the identification of unexpected data gaps. This motivates data mobilization and/or new measurements, which improve the availability of plant trait data for the research community, and—if contributed to TRY—help the database grow. Examples for such a 'feed-forward data integration loop' are provided in Box 1.

To support this process, in this article, we take stock of the data compiled in the TRY database and present emerging patterns of data coverage and representativeness with a focus on the identification of principal and systematic gaps. Finally, we discuss ways forward and the potential future role of the TRY initiative for the research community.

TABLE 1 TRY database versions

Version	Data acquisition and import	Data release	Status
1	October 2007–July 2009	October 2008–April 2011	Restricted, give-and-take
2	July 2009–April 2011	April 2011–December 2014	Restricted, give-and-take
3	April 2011–April 2014	December 2014–July 2017	Optionally open access
4	April 2014–February 2017	July 2017–March 2019	Optionally open access
5	February 2017–March 2019	March 2019–	Open access
6	March 2019–		Open access

2 | MATERIALS AND METHODS

2.1 | Plant trait data in the TRY database

Plant traits can be classified as categorical (qualitative and ordinal) or quantitative (continuous) traits (Kattge et al., 2011). Some traits are rather stable within species (mostly categorical traits), and some of these can be systematically compiled from species checklists and floras (e.g. Weigelt, König, & Kreft, 2019).

TABLE 2 Data coverage from TRY version 1 to 5

Version	Trait records	Entities	Trait records per entity	Traits	Average number of records per trait	Species	Geo-referenced trait records	Sites	Ancillary data
1	2,077,640	1,110,303	1.87	661	3,143	57,591	682,108	8,276	4,439,783
2	2,376,231	1,207,669	1.97	743	3,198	65,746	871,582	8,513	4,758,033
3	5,783,482	2,246,967	2.57	1,149	5,033	92,146	2,201,242	11,844	11,834,960
4	7,162,252	3,435,238	2.08	1,981	3,615	141,461	2,978,776	16,480	14,644,354
5	11,850,781	5,102,993	2.37	2,091	5,668	279,875	4,952,839	20,953	35,516,190

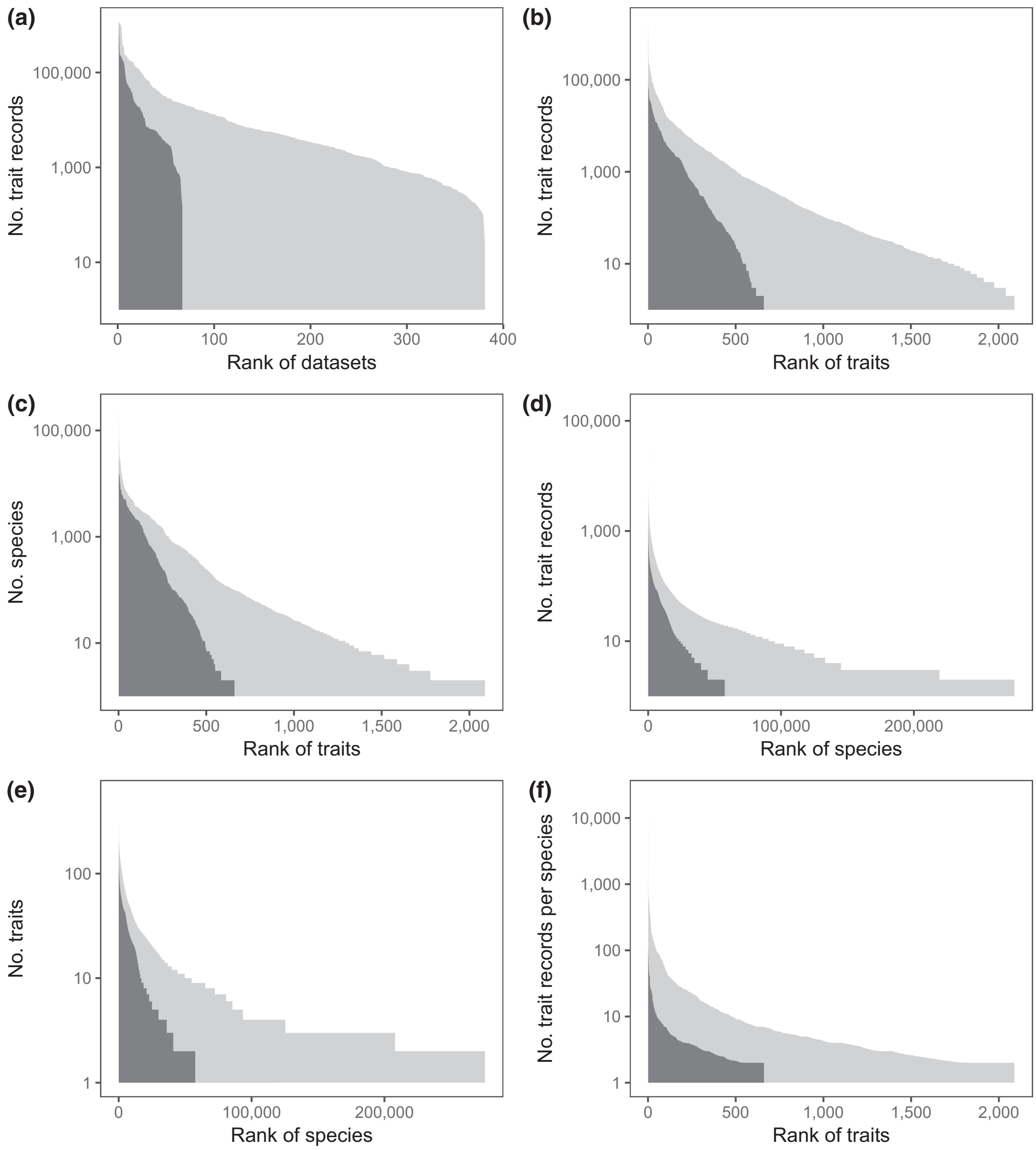

FIGURE 3 Trait data coverage of TRY version 1 (dark grey) and 5 (light grey). Data coverage in TRY is characterized by long-tailed rank-size distributions: (a) rank of dataset by trait records, (b) rank of traits by number of records, (c) rank of traits by number of species, (d) rank of species by trait records, (e) rank of species by number of traits, (f) rank of traits by number of records per species (averaged by trait). Note that *y*-axes are log-scaled

However, most traits relevant to ecology and earth system sciences are characterized by intraspecific variability and trait–environment relationships (mostly quantitative traits). Both kinds of traits are compiled in the TRY database, but with a focus on continuous traits. These traits have to be measured on individual plants in their particular environmental context. Each such trait measurement has high information content as it captures the specific response of a given genome to the prevailing environmental conditions. The collection of these quantitative traits and their essential environmental covariates is important but often tedious and expensive: researchers need to travel to the objects of interest—often to remote places—or they need to develop experiments creating specific environmental conditions. While trait measurements themselves may be relatively simple, the selection of the adequate entity (e.g., a representative plant in a community, or a representative leaf on a tree) and obtaining the relevant ancillary data (taxonomic identification, soil and climate properties, disturbance history, etc.) may require sophisticated instruments and a high degree of expertise and experience. Besides, these data are most often individual measurements with a low level of automation. This not only limits the number of measurements but also causes a high risk of errors, which need to be corrected a posteriori, requiring substantial human work. The

BOX 1 Examples for the 'feed-forward data integration loop' observed in the context of the TRY database

- Iversen et al. (2017) indicated that in the TRY database only 1% of trait records were related to roots. This motivated the development of the Fine-Root Ecology Database (FRED) specializing in the mobilization of fine-root trait records from the literature (Iversen et al., 2017). In the meantime, the first versions of the FRED database have been contributed to the TRY database. The improved number and availability of trait data on roots allowed for a project on root trait functionality in a whole-plant context (https://www.idiv.de/en/sdiv/working_groups/wg_pool/sroot.html), which motivated additional mobilization of root trait data.
- The promising coverage of plant trait data from tundra regions in the TRY database encouraged the inclusion of plant traits in an analysis of tundra ecosystem change, scaling shrub expansion from site to biome (Bjorkman, Myers-Smith, Elmendorf, Normand, Rüger, et al., 2018). In the context of the project, a large number of additional trait data were mobilized by the Tundra Traits Team (Bjorkman, Myers-Smith, Elmendorf, Normand, Thomas, et al., 2018), which have recently been contributed to the TRY database.
- Moreno-Martínez et al. (2018) estimated the worldwide variation of several leaf traits to improve the parameterization of global vegetation models and remote sensing approaches predicting, for example, gross primary productivity. Due to the low representation of traits for crop species in the TRY database, they could not provide estimates for major agricultural regions (see white spots in figure 5 of Moreno-Martínez et al., 2018). The identification of these gaps motivated mobilization of trait data for crop plants and agro-ecosystems (Engemann et al., 2016; Martin, Hale, et al., 2018; Martin & Isaac, 2015), which were then contributed to the TRY database.
- Trait data on plant growth form (tree, shrub, herb, etc.) were compiled by TRY, extended and consolidated in the context of the BIEN initiative (Engemann et al., 2016; Enquist, Condit, Peet, Schildhauer, & Thiers, 2016) and then contributed to the development of the GIFT database (Weigelt, König, & Kreft, 2019). The upgraded plant growth form data were contributed again to TRY.
- Plant species richness is unequally distributed across the globe, with the highest species richness observed in the tropics (von Humboldt, 1817). The highest numbers of species with measurements in TRY are also found in the tropics, but as well the largest gap relative to reported species richness: less than 1% of estimated species richness is represented in TRY (Jetz et al., 2016). This principal and systematic mismatch of data coverage and representativeness has contributed to motivate the development of a 'global biodiversity observatory' of in situ measurements and space-borne remote sensing that tracks temporal changes in plant functional traits around the globe to fill critical knowledge gaps, aid in the assessment of global environmental change and improve predictions of future change (Jetz et al., 2016).
- TRY is involved in the sPlot initiative to establish a global vegetation-plot database (www.idiv.de/en/splot.html). sPlot supports the analysis of plant communities across the world's biomes by combining vegetation-plot data with traits from the TRY database (Bruelheide et al., 2019). This has resulted, for the first time, in global analyses of plant functional community data (Bruelheide et al., 2018). In contrast to single species measurements or trait values aggregated in grid cells, using vegetation-plot data allows understanding the role of traits for biotic interactions and community assembly processes. In turn, trait data measured in the context of sPlot are contributed to TRY.

integration of these data from different sources into a consistent data set requires a carefully designed workflow with sufficient data quality assurance (see Box 2: TRY data integration workflow).

These measurements of quantitative traits are single sampling events for particular individuals at certain locations and times, which preserve relevant information on intraspecific variation and provide the necessary detail to address questions at the level of populations or communities. Within individual field campaigns or experiments, researchers often aim to measure complete sets of these data: all traits of interest for all individuals or species in the analyses. However, across studies and data sets and at large scales, the coverage of these data shows major gaps, which provide major challenges concerning data completeness and representativeness (König et al., 2019).

3 | RESULTS

3.1 | Data coverage

Compared to TRY database version 1 and the state reported in Kattge et al. (2011), TRY version 5 has substantially grown with respect to the number of trait records, traits, species, entities, georeferenced measurement sites and ancillary data (Table 2).

3.2 | Trait records and entities

The numbers of trait records (individual trait measurements) and entities (individual plants or plant organs on which the measurements have been taken) increased by a factor of about 6 for trait

BOX 2 The data integration workflow for the TRY database version 5

Data acquisition

In the context of the TRY initiative, data acquisition so far relies on active contributions by the community—data sets need to be sent by email or uploaded at the TRY website (https://www.try-db.org/TryWeb/Submission.php). From time to time (2007, 2013 and 2019), TRY sends out calls for data contributions to the community. However, so far there has been no systematic screening of public data repositories like DRYAD or PANGAEA for plant trait data.

Data integration

The basic principle of data integration in the TRY database is to preserve the original trait and ancillary data and annotate these with complementing and consolidated information. Data integration consists of three major components: data consolidation, complementation and quality assurance. We here provide a brief overview; a detailed description can be found in Supporting Information and on the TRY website (https://www.try-db.org/TryWeb/Database.php).

Data consolidation

The data structure is transformed into the entity-attribute-value (EAV) model and the OBOE schema (Madin et al., 2007) as used in the TRY database: a long table of trait records and ancillary data where all trait records and ancillary data measured on the same entity (individual plant or plant organ on which the measurements have been taken) are linked by a unique identifier. Plant taxonomy is consolidated using the Taxonomic Names Resolution Service (TNRS; http://tnrs.iplantcollaborative.org; Boyle et al., 2013) with a taxonomic backbone based on the Plant List (http://www.theplantlist.org), Missouri Botanical Garden's Tropicos database (http://www.tropicos.org), the Global Compositae Checklist (https://www.compositae.org/checklist), the International Legume Database and Information Service (http://www.ildis.org), and USDA's Plants Database (http://plants.usda.gov). Trait names and definitions are consolidated across all data sets, based on the TOP thesaurus of plant characteristics (Garnier et al., 2017) or the plant trait handbook (Pérez-Harguindeguy et al., 2013), if possible. For continuous traits with more than 1,000 records, units are standardized and trait values recalculated. Most relevant ancillary data—geo-references, measurement date, exposition, maturity, and health—are consolidated across data sets and, if possible, to external standards, like the decimal representation of latitude and longitude, or ISO 8601 (YYYY-MM-DD) for the date.

Data complementation

After consolidation, additional trait values are derived from contributed trait data where possible; for example, leaf nitrogen content per area from leaf nitrogen content per dry mass and specific leaf area (SLA) if both were measured on the same entity.

Data quality assurance

Continuous traits with >1,000 records in the database are subject to a three-step process: (a) Systematic errors, like a wrong unit for a given trait for all records of a specific data set, are identified across data sets with semi-automated procedures and corrected. (b) *Z*-scores are calculated for each standardized trait value to indicate outliers and potential errors of individual trait records. (c) Duplicate trait records are identified based on consolidated trait names, taxonomy, units and values. Geo-references are checked against the ESA CCI Land Cover Map of Global Water Bodies (https://www.esa-landcover-cci.org/?q=node/162) to assure at least that the provided locations are on land.

After a data set has been integrated into the TRY database, the data set custodian is asked for feedback; that is, whether consolidated trait names are appropriate and consolidated values correct. Data are reformatted for data release and format errors (i.e. tabs and line breaks in database cells) are corrected. Finally, the original and consolidated data (including flags for outliers and duplicates) are released on request as tab-delimited text files.

records and 5 for entities from TRY version 1 (2.1 million trait records measured on 1.1 million entities) to TRY version 5 (11.8 million trait records measured on 5.0 million entities). The average number of trait records per entity increased from 1.9 to 2.4 (Table 2).

3.3 | Traits

The number of traits has grown steadily from TRY version 1 to 5, apart from a steep step from TRY version 3 to 4 (Table 2). This step was caused by the contribution of the FRED database, which added about 700 new traits for roots. Data coverage across traits is characterized by long-tail distributions: a small number of traits is well covered by records and species, while the majority of traits has only very low coverage of records and species (Figure 3). However, the number of continuous traits with more than 1,000 records (which are subject to intense data quality assurance during integration) has increased from about 200 in TRY version 1 to 600 in TRY version 5 (Figure 3b). The number of traits with data for more than 100 species has increased from 300 to 700 (Figure 3c). In parallel, the number of records per trait and species ('intraspecific retakes') has increased from almost zero traits with on average more than 10 records per trait–species combination in TRY version 1 to more than 500 in TRY version 5 (Figure 3f).

The traits with the best species coverage in TRY version 5 are mostly categorical (Table 3). The categorical traits used for the classification of PFTs—plant woodiness, plant growth form, leaf type (broadleaved vs. needle-leaved), leaf phenology type (deciduous vs. evergreen), leaf photosynthesis pathway (C3, C4, CAM)—are still among the best covered. However, the number of species characterized for each of these traits has substantially increased from TRY version 1 to 5, most significantly for plant growth form from 31,327 to 263,357 species, supported by the contribution from the GIFT database (Weigelt, König, & Kreft, 2019).

TABLE 3 Traits with best species coverage. The 30 traits covering the highest number of species in the TRY database version 5 and the number of species represented for these traits in TRY version 1. Data type: cat = categorical; con = continuous. Sorted by the number of species in TRY 5

Trait name	Data type	Number of species	
		TRY 1	TRY 5
Plant growth form	cat	31,327	263,357
Plant woodiness	cat	14,628	79,298
Leaf type	cat	7,934	62,904
Leaf compoundness	cat	7,998	57,922
Leaf photosynthesis pathway	cat	15,609	37,315
Leaflet number per leaf	con	0	30,296
Plant height vegetative	con	13,899	28,944
Leaf phenology type	cat	14,622	28,514
Species tolerance to frost	cat	2,180	28,122
Seed dry mass	con	14,602	27,022
Species occurrence range: native versus invasive	cat	11,313	25,067
Plant lifespan	cat, con	7,617	24,712
Dispersal syndrome	cat	7,528	21,717
Plant nitrogen fixation capacity	cat	10,504	18,247
Leaf area[a]	con	8,873	16,663
Leaf area per leaf dry mass (specific leaf area)[b]	con	7,879	16,460
Plant resprouting capacity	cat	3,320	15,997
Seed germination rate (germination efficiency)	con	6,698	15,822
Plant life form sensu Raunkiaer	cat	7,710	15,766
Pollination syndrome	cat	4,064	15,631
Leaf shape	cat	3,191	15,594
Flower sex	cat	3,572	13,735
Leaf distribution arrangement type	cat	3,998	13,130
Leaf nitrogen content per leaf dry mass	con	6,291	12,238
Stem specific density	con	9,813	11,001
Flower colour	cat	4,747	10,507
Seed storage behaviour	cat	10,161	10,161
Fruit type	cat	3,644	9,573
Leaf margin type	cat	0	9,179
Wood growth ring distinction	cat	5,121	9,103

[a]In case of compound leaves: leaflet, undefined if petiole is included or excluded.

[b]Undefined if petiole is included or excluded.

The quantitative traits with the highest species coverage are still the six traits which were already prominent in TRY version 1 and involved in the analysis of the global spectrum of plant form and function (Díaz et al., 2016): plant height, seed mass, leaf area, leaf area per dry mass, leaf nitrogen content per dry mass and stem specific density (SSD). However, in general, the coverage of continuous traits already present in TRY 1 has substantially improved. This facilitates a more robust characterization of frequency distributions (Figure 4). In most cases, the range of observed trait values did not change much from TRY version 1 to 5, but the shapes of frequency distributions became more regular and pronounced, especially for multimodal frequency distributions like plant height and leaf Δ13C. Noteworthy, the examples in Figure 4 lack several kinds of traits because they are missing relevant numbers of trait records, like roots (only one trait), flowers and dead plant material (litter), secondary metabolites or data related to trophic interactions.

The 30 traits that were most often requested (Table 4) are dominated by continuous traits related to the global spectrum of plant form and function (Díaz et al., 2016), the leaf economics spectrum (Wright et al., 2004) and rooting depth. Only seven categorical traits are among these 30 traits. This indicates a switch between well covered—categorical—traits (Table 3) and most frequently requested—continuous—traits (Table 4). The first five most documented traits are categorical whereas among the 10 most requested traits, only one is categorical. However, within continuous traits, there is, in general, a good match between traits characterized for most species and traits most often requested. To some extent this may be influenced by the amount of available data for the individual traits. However, a noteworthy exception is rooting depth, as 10% of requests ask for this trait, while it is 'only' covered for 3,886 species, mostly contributed via the Global Dataset of Maximum Rooting Depth (Fan, Miguez-Macho, Jobbágy, Jackson, & Otero-Casal, 2017). This mismatch indicates a demand for more data on the most relevant below-ground traits.

3.4 | Species

From TRY version 1 to 4, the number of species increased slowly, but almost doubled to version 5 due to the contribution of plant growth form data from the GIFT database, which added about 100,000 new species. As in the case of traits, the data coverage for species is characterized by long-tail distributions: few species are covered well by measurements and traits, while the majority

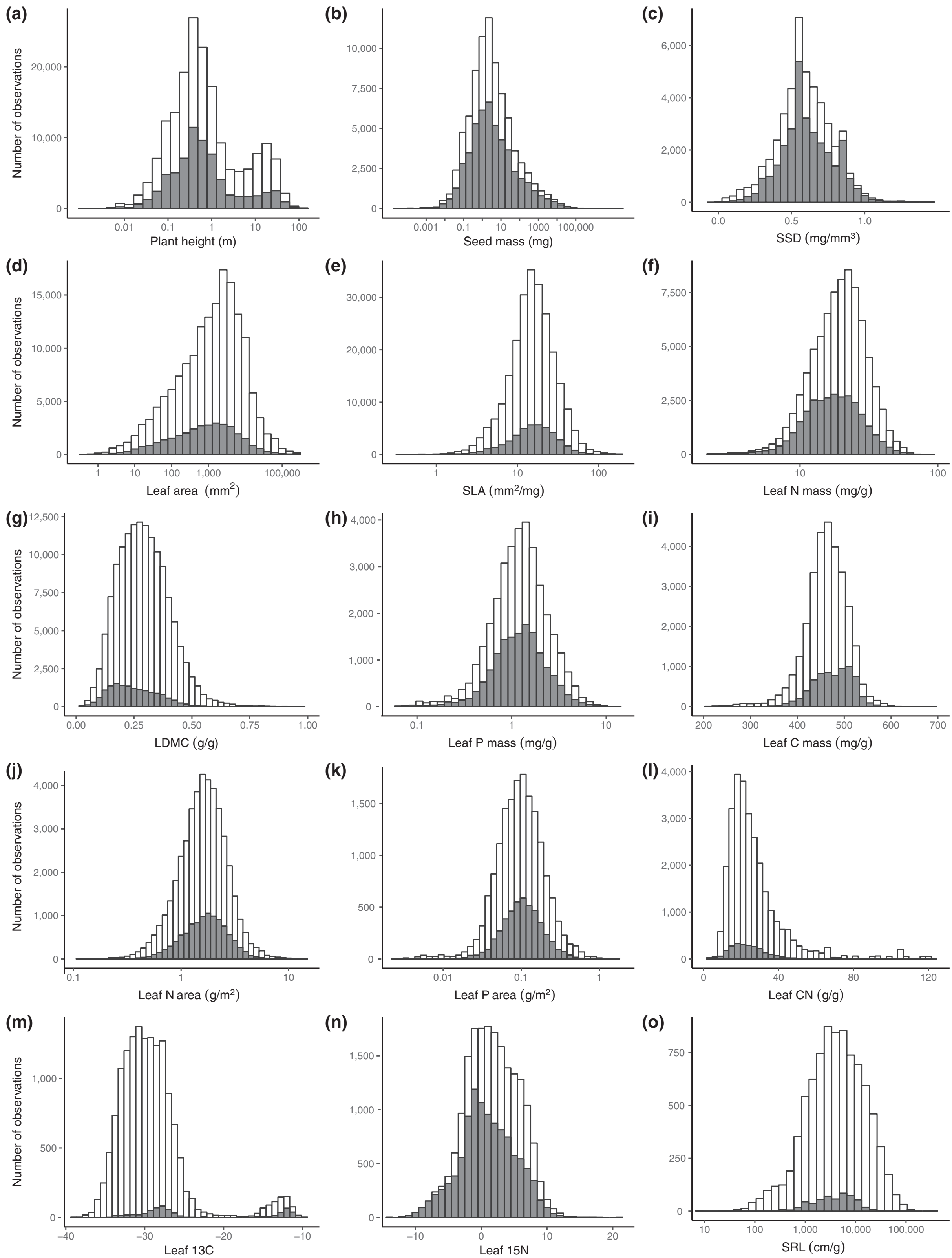

FIGURE 4 Frequency distributions of observations for 15 ecologically relevant and well sampled continuous traits from different plant organs. Grey: TRY version 1; white: TRY version 5. (a) Plant height, (b) Seed mass, (c) SSD: stem dry mass per stem fresh volume (stem specific density), (d) Leaf area, (e) SLA: leaf area per leaf dry mass (specific leaf area), (f) Leaf N mass: leaf nitrogen content per leaf dry mass (leaf nitrogen concentration), (g) LDMC: leaf dry mass per leaf fresh mass (leaf dry matter content), (h) Leaf P mass: leaf phosphorus content per leaf dry mass, (i) Leaf C mass: leaf carbon content per leaf dry mass, (j) Leaf N area: leaf nitrogen content per leaf area, (k) Leaf P area: leaf phosphorus content per leaf area, (l) Leaf CN: leaf carbon content per leaf nitrogen content, (m) Leaf 13C: leaf 13C carbon isotope signature, leaf Δ13C, (n) Leaf 15N: leaf 15N nitrogen isotope signature, (o) SRL: root length per root dry mass (specific root length)

TABLE 4 Most often requested traits. The 30 traits with the highest number of requests (status 1 October 2019). Number of requests and in parentheses the percentage relative to all 7,330 requests

Trait	Data type	Number of requests
Leaf area per leaf dry mass (specific leaf area or 1/LMA)[a]	con	2,977 (41%)
Plant height vegetative	con	2,159 (29%)
Leaf nitrogen (N) content per leaf dry mass	con	1,938 (26%)
Leaf area[b]	con	1,676 (23%)
Plant growth form	cat	1,625 (22%)
Seed dry mass	con	1,580 (22%)
Leaf nitrogen (N) content per leaf area	con	1,221 (17%)
Leaf phosphorus (P) content per leaf dry mass	con	1,170 (16%)
Plant lifespan (longevity)	con	1,168 (16%)
Leaf dry mass per leaf fresh mass (leaf dry matter content)	con	1,147 (16%)
Leaf phenology type	cat	1,047 (14%)
Leaf carbon (C) content per leaf dry mass	con	973 (13%)
Dispersal syndrome	cat	958 (13%)
Stem specific density	con	951 (13%)
Leaf photosynthesis rate per leaf area	con	896 (12%)
Leaf dry mass (single leaf)	con	896 (12%)
Leaf photosynthesis pathway	cat	874 (12%)
Leaf thickness	con	852 (12%)
Plant nitrogen (N) fixation capacity	con	833 (11%)
Leaf carbon/nitrogen (C/N) ratio	con	817 (11%)
Plant life form sensu Raunkiaer	cat	801 (11%)
Leaf lifespan (longevity)	con	790 (11%)
Root rooting depth	con	733 (10%)
Plant growth rate	con	727 (10%)
Leaf type	cat	727 (10%)
Leaf phosphorus (P) content per leaf area	con	719 (10%)
Plant functional type	cat	710 (10%)
Plant woodiness	cat	708 (10%)
Leaf photosynthesis rate per leaf dry mass	con	701 (10%)
Plant reproductive phenology timing	con	672 (9%)

[a]Undefined if petiole is included or excluded.

[b]In case of compound leaves: leaflet, undefined if petiole is included or excluded.

TABLE 5 Species with best trait coverage. The 30 species with the highest number of traits in the TRY database version 5 and number of traits represented for these species in TRY version 1 and 5. Sorted by the number of traits in TRY 5

Species	Plant growth form	Number of traits	
		TRY 1	TRY 5
Pinus sylvestris	Tree	264	569
Fagus sylvatica	Tree	237	517
Picea abies	Tree	252	475
Quercus robur	Tree	194	435
Acer saccharum	Tree	139	430
Betula pendula	Tree	265	429
Achillea millefolium	Herb	209	403
Acer pseudoplatanus	Tree	186	397
Trifolium pratense	Herb	181	395
Quercus rubra	Tree	190	388
Dactylis glomerata	Herb	193	387
Plantago lanceolata	Herb	156	386
Vaccinium vitis-idaea	Shrub	189	382
Trifolium repens	Herb	173	380
Fraxinus excelsior	Tree	196	378
Acer platanoides	Tree	186	378
Quercus petraea	Tree	194	368
Poa pratensis	Herb	195	366
Holcus lanatus	Herb	178	364
Tilia cordata	Tree	153	362
Calluna vulgaris	Shrub	190	360
Lotus corniculatus	Herb	153	360
Pseudotsuga menziesii	Tree	141	356
Medicago lupulina	Herb	145	351
Festuca rubra	Herb	175	347
Sorbus aucuparia	Tree	197	335
Phleum pratense	Herb	179	335
Quercus ilex	Tree	195	333
Betula papyrifera	Tree	126	332
Vaccinium uliginosum	Shrub	169	330

of species has only very low data coverage (Figure 3d–f). The species characterized by the most traits tend to be northern temperate trees or globally distributed pasture species (Table 5). Out of the top 30 species with the best trait coverage, 27 (90%) originate in Central or Northern Europe.

3.5 | Entity × trait and species × trait matrices

The trait data in the TRY database can be represented by two two-dimensional matrices: the entity × trait matrix, with entities in rows and traits in columns; and the species × trait matrix, with species in rows and traits in columns. Both matrices are characterized as large but sparse: high numbers of entities, species and traits in TRY make the two matrices large, but many cells in the matrices are empty. From TRY version 1 to 5 the size of the matrices has grown by a factor of 15, but at the same time the number of trait records to fill the cells increased only by a factor of about 5 and thus the matrices became even sparser: the fractional coverage decreased from 0.4% to 0.1% (entity × trait) and 1.4% to 0.4% (species × trait; Figure 5a). This sparsity together with the observed long-tail distributions has consequences, especially for multivariate analyses. Given that on average only two to three traits of the 2,091 traits in TRY version 5 are measured on an individual plant (entity), a multivariate analysis based on individuals is indeed practically impossible, as mentioned by Shan et al. (2012). Even after aggregation at the species level, the decline of the number of species with complete trait coverage when adding a new trait, for example for multivariate analysis, is surprisingly high (Figure 5b). Additionally, the final number of species represented in the analysis is determined by the trait with the lowest species coverage. Therefore multivariate analyses with more than about six traits are still very much limited by the number of species. The same applies when species have to be classified by several categorical traits, like for example in the context of PFTs.

3.6 | Ancillary data

The numbers of ancillary data, geo-referenced trait records and trait records with measurement date increased by a factor of almost 10 from TRY version 1 to TRY version 5 (Table 2). The ratio of ancillary data to trait records, therefore, increased from TRY version 1 to 5 from 2:1 to 3:1 and the fraction of geo-referenced trait records from about 33% to 42% (Table 2). The number of geo-referenced trait records with information on measurement date that could be standardized to year, month and day increased from 290,000 in TRY version 1 (15% of all trait records) to 2.5 million records in TRY version 5 (20%). The increasing ratio of ancillary data to trait records indicates growing awareness for the relevance of environmental conditions during plant growth and trait measurements. In this context, geo-references (and date) are crucial, as they allow trait records to be related to information on climate, soil or biome type from external sources.

The geographic coverage of trait measurements has substantially improved from TRY version 1 (8,276 measurement sites representing 1,260 1° × 1° grid-cells) to TRY version 5 (20,953 sites representing

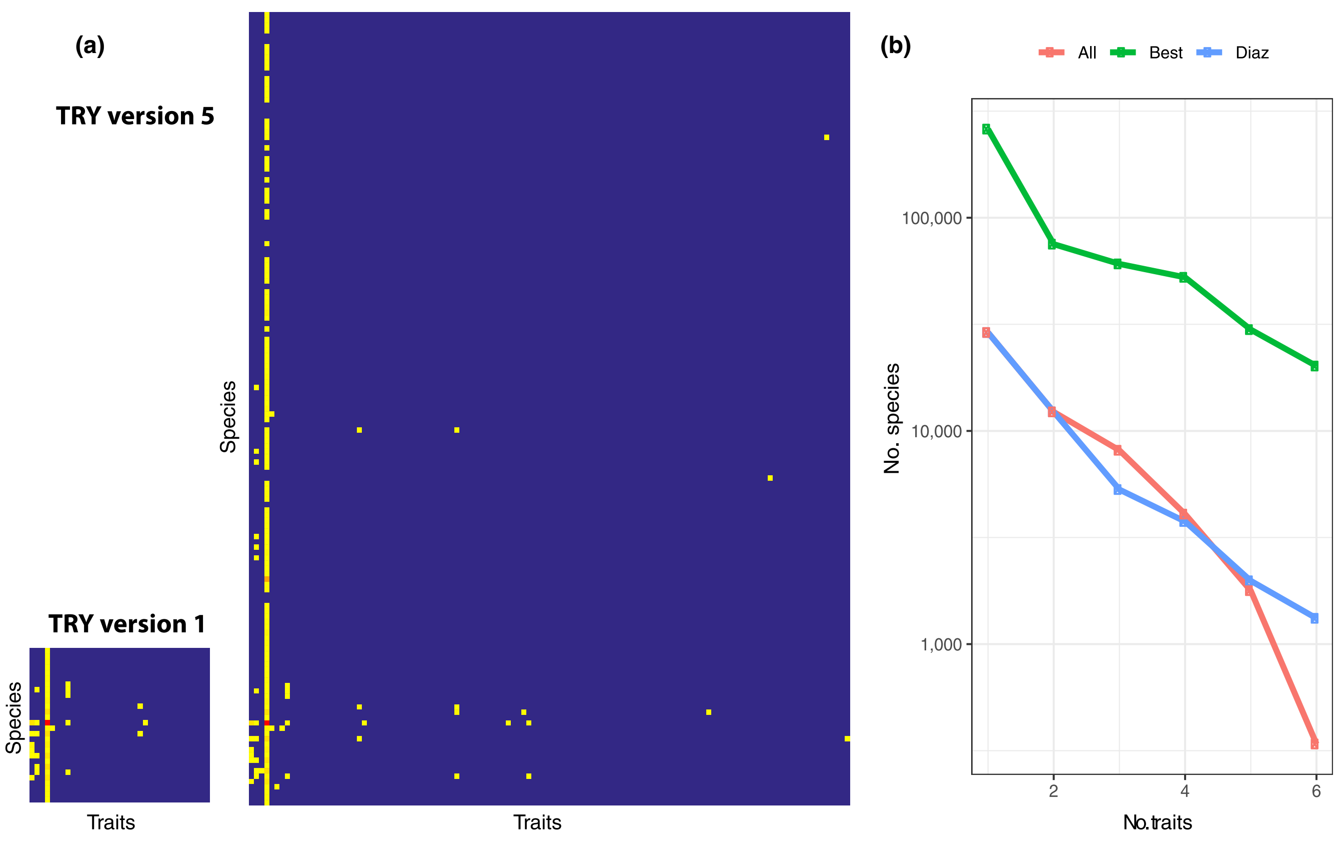

FIGURE 5 (a) Comparison of the species × trait matrix from TRY version 1 and version 5. The sizes of the boxes represent the numbers of species and traits. Blue: missing data; bright colour: the presence of data (yellow to red indicating an increasing number of measurements). For visibility, only 5% of traits and 0.05% of species are shown (randomly selected, with TRY version 1 as a subsample of TRY version 5; ordering of species and traits by submission date). 'Plant growth form' with entries for almost all species has been selected coincidentally. (b) Multivariate analyses: the decline of the number of common species with an increasing number of traits. Green: the six best covered traits in TRY version 5 (categorical traits: plant growth form, plant woodiness, leaf type, leaf compoundness, leaf photosynthetic pathway, leaflet number per leaf); blue: six traits representing plant form and function in Díaz et al. (2016); red: the best covered quantitative traits representing each of the six plant parts (see Figure 6): shoot (plant height vegetative), reproductive organs (seed dry mass), whole plant (plant lifespan), leaves (SLA), roots (rooting depth) and dead material (litter decomposition rate)

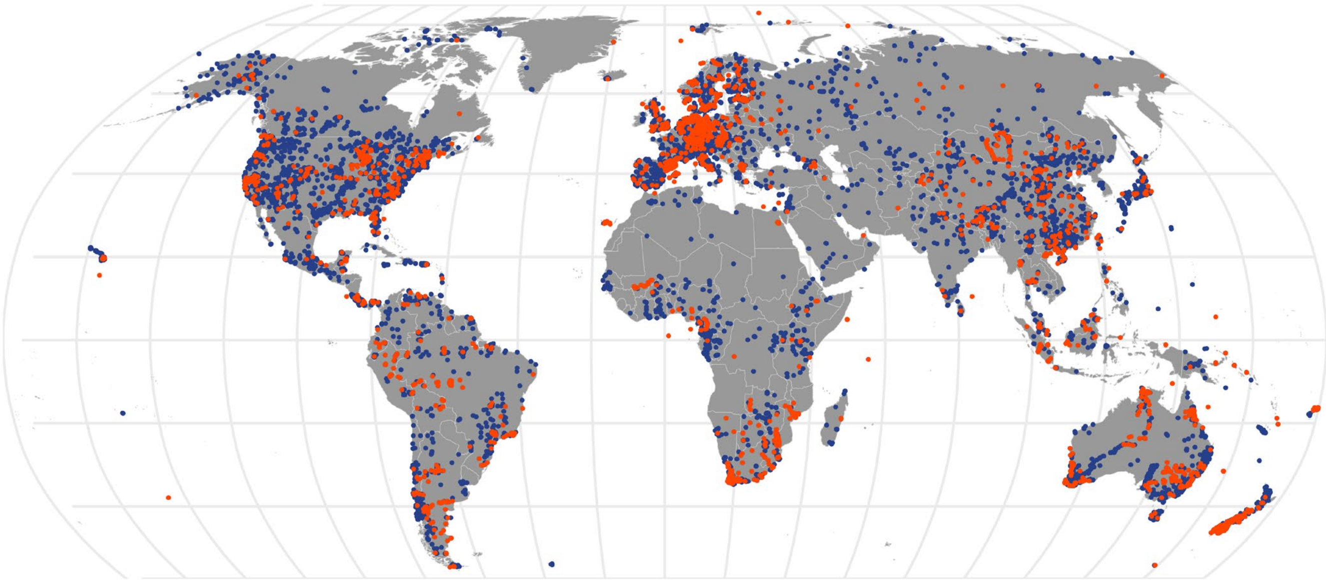

FIGURE 6 Geographic coverage of measurement sites in TRY version 1 (red) and additional measurement sites in TRY version 5 (blue)

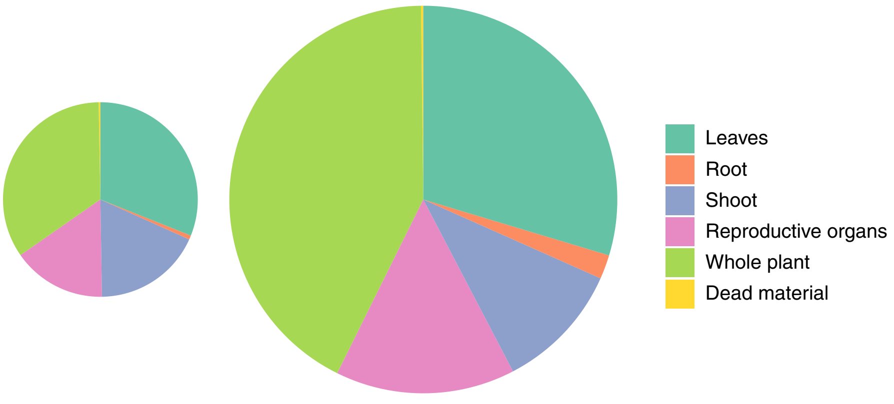

FIGURE 7 Distribution of trait records among plant parts. Different sizes of circles indicate different data coverage in TRY version 1 (left, 2.1 million trait records) and TRY version 5 (right, 11.8 million trait records)

3,320 1° × 1° grid-cells; Table 2; Figure 6). Europe still has the highest density of measurement sites, but TRY version 5 also provides good coverage for the United States and China. The number of measurement sites has substantially improved for several other regions as well, for example Central America, Russia, Asia and parts of central Africa. However, there are still obvious gaps in boreal regions (Canada, East Russia) and some parts of the tropics and subtropics, particularly in Africa (Figure 6).

3.7 | Data completeness and representativeness

To progress from a description of data coverage towards an analysis of representativeness, we need a baseline for comparison. At the global scale, this information has been lacking. Reference data sets have become available only recently for plant growth form (Weigelt, König, & Kreft, 2019) and phylogeny (Smith & Brown, 2018) representing about 260,000 and 356,000 of the 400,000 extant species. Together with estimations for the global distribution of plant species richness (Kier et al., 2005), it seems now possible and timely to explicitly address representativeness of plant trait data in the TRY database along five key dimensions: (a) Are trait data in TRY well distributed among plant parts? (b) Are the species in TRY and for individual traits representative for global plant growth forms and functional types? (c) Are the species in TRY and for individual traits representative according to phylogeny? (d) Does the geographic distribution of species richness in TRY represent the estimated pattern of global species richness? (e) Is data coverage sufficient to represent intraspecific variation?

3.8 | Distribution of trait records among plant parts

Trait records in the TRY database are very unequally distributed among different plant parts (Figure 7): leaves and the whole plant are well represented; shoot and reproductive organs are moderately represented; roots and dead material (morphological and chemical feature of litter and coarse woody debris, but also decomposition rates) are not well represented. Within reproductive organs, seeds are better represented than floral traits, mostly due to contributions from the Seed Information Database. The skewed distribution of trait records to the different parts of the plants has only changed little from TRY version 1 to 5. However, the fraction of records for root traits has substantially increased (from 0.7% to 2.0%), due to the contribution of the FRED database.

3.9 | Plant growth form and PFTs

The most basic approach to characterize functional groups of plant species and their impact on vegetation and ecosystem function is the plant growth form, with its simplest classification to herbs, shrubs and trees. We compare here the fraction of the different plant growth forms for trait measurements in TRY version 5 to a comprehensive baseline of plant growth form for >280,000 of the extant 400,000 species, which is currently developed in the context of the GIFT database project.

In GIFT, about 50% of species are currently assigned to herbs, 30% to trees and 20% to shrubs (Figure 8). This distribution is well reflected by the species in TRY (excluding data from the GIFT database). However, the six best covered continuous traits in TRY indicate that this distribution is very much trait dependent, with a bias towards trees versus herbs, while the fraction of shrubs is surprisingly constant and close to the fraction in the GIFT database (Figure 8). The overrepresentation of trees is most obvious for SSD, which is not surprising because SSD is a more general concept derived from wood density, a trait relevant for forestry, timber industry and estimates of forest vegetation biomass. However, the tendency of relatively more data for trees compared to other growth forms is also obvious for SLA, leaf nitrogen content per dry mass and leaf area, but opposite for root length per root dry mass (specific root length), which is frequently reported for herbs.

Apart from plant growth form, three additional categorical traits are relevant to determine PFTs commonly used in global vegetation models: leaf type (broadleaved vs. needle-leaved) and leaf phenology type (deciduous vs. evergreen) for tree species, and photosynthetic pathway (C3, C4, CAM) for herbaceous species. TRY provides leaf type and leaf phenology type, for about 10% of the estimated 130,000 tree species worldwide and photosynthetic pathway for about 6% of estimated 200,000 herb species.

3.10 | Phylogeny

Smith and Brown (2018) published a series of broadly inclusive seed plant phylogenies. Here we chose the most comprehensive phylogeny (ALLMB), containing 356,305 taxa, as a baseline to visualize the coverage of TRY in a phylogenetic context. Taxa in ALLMB were cut to binomials and consolidated using the TNRS with TPL, GCC, ILDIS, TROPICOS and USDA as the taxonomic backbone (the same approach as for TRY). After consolidation, we could match the taxa in the phylogeny to 208,406 of the 279,875 taxa in TRY. Higher level taxonomy is based on Zanne et al. (2014).

Visually, the 208,000 species with data in TRY are well distributed across the 350,000 species represented in the phylogeny of seed plants (Figure 9). An ancestral state reconstruction (ASR) of species trait number confirms that the long-tail distribution previously seen at the species level also holds in a phylogenetic context: some clades are covered very well (bright colours), while most clades have lower data coverage (dark colours). The ASR additionally shows how deep in phylogeny data gaps are rooted. This indicates the potential for, and limits to, phylogenetically or taxonometically informed gap-filling (Schrodt et al., 2015). Examples of high-coverage clades are (parts of) the Pinales, Poales and Asterales. When looking at the six best-covered continuous traits individually, we find these too are well distributed across the phylogeny (Figure 9).

3.11 | Geographic distribution of species richness

Jetz et al. (2016) reported a latitudinal gradient in disparities between plant species with regional measurements in TRY and estimated species richness, with the largest gap observed in the tropics, because these are especially rich in species. To address this in more detail, we

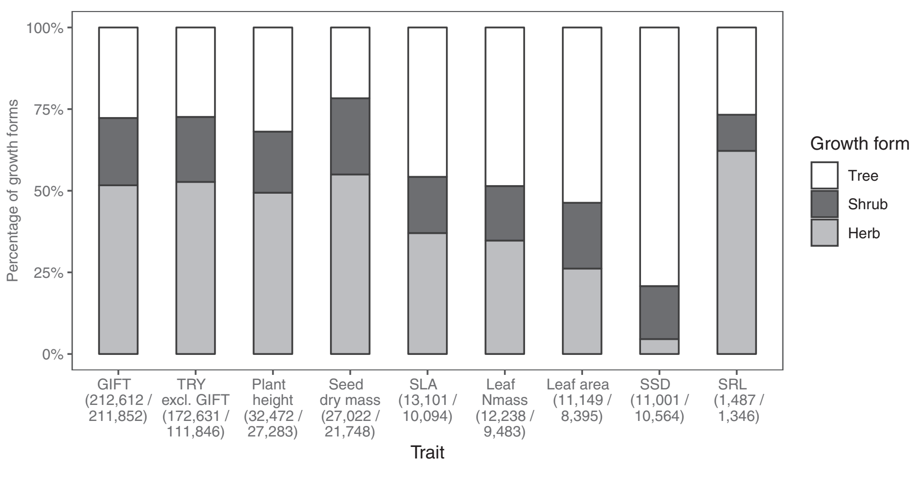

FIGURE 8 Fraction of species with plant growth forms herb, shrub and tree in the GIFT database, in TRY version 5 (excl. GIFT) and for the six best covered continuous traits in TRY version 5: plant height, seed dry mass, leaf area per leaf dry mass (SLA), leaf N per dry mass, leaf area and stem specific density (SSD), and one well covered root trait: specific root length (SRL). In parentheses: the number of species with data for the trait and the number of species for which the growth form could be determined as tree, shrub or herb

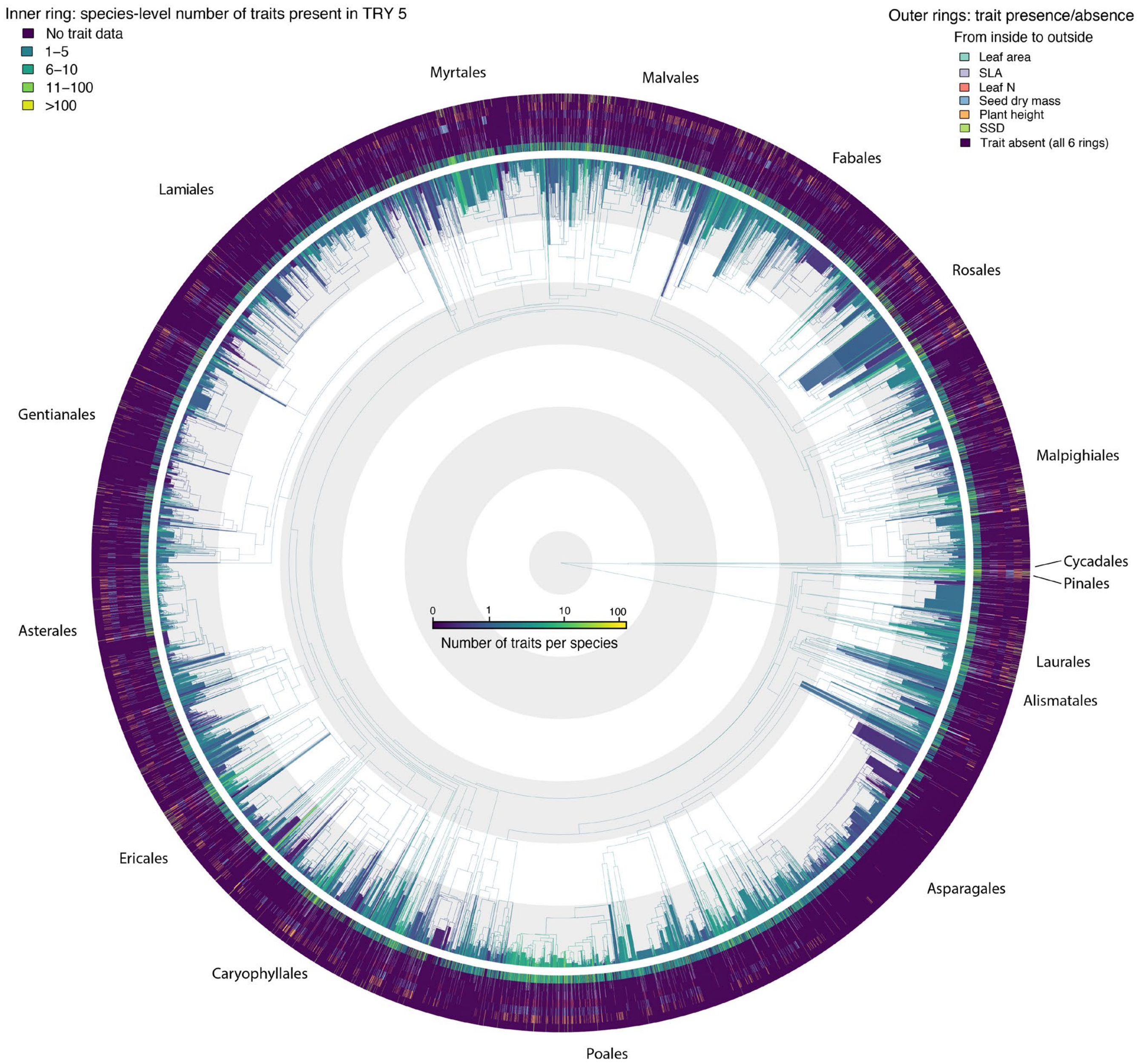

FIGURE 9 Trait coverage per species projected on a global phylogeny. The presence of trait data for plant species in the TRY database version 5 matched to the global ALLMB phylogeny published by Smith and Brown (2018). Rings surrounding the phylogeny indicate from inside outwards: (i) number of traits per species (innermost ring); (ii) presence of data for six of the best covered continuous traits, specifically: leaf area, leaf area per leaf dry mass (SLA), leaf nitrogen content per dry mass (LeafN), seed dry mass, plant height and stem specific density (SSD). Colours of phylogeny branches represent an ancestral state reconstruction of the number of traits per species. White and grey circles indicate periods of 50 million years. For visibility, only 5% of species (randomly selected) are presented

here ask if the TRY database provides trait information for a relevant number of plant species in the different regions worldwide. To characterize regions in an ecologically meaningful way we adopt the ecoregions introduced by Olson et al. (2001), which are defined as relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities before major land-use change. The ecoregions are nested within biomes with biotic communities formed in response to a shared physical climate, most importantly temperature and rainfall. We compare the number of species, which have trait measurements in an ecoregion in TRY version 5 to species numbers per ecoregion estimated by Kier et al. (2005). This approach accounts to some extent for intraspecific trait variation, as it counts only species with at least one trait measurement in the given ecoregion.

The 839 ecoregions defined by Olson et al. (2001) are very different in size, from 6 km^2 (San Felix-San Ambrosio Islands temperate forests) to 4,639,920 km^2 (Sahara desert) with species numbers ranging from 0 (St. Peter and St. Paul rocks and the Maudlandia Antarctic desert) to 10,000 (Borneo lowland rain forests). The TRY database contains no trait measurements for 271 mostly small ecoregions and up to 1,400 species for some ecoregions in Europe (Alps conifer and mixed forests) and tropical South America (Napo moist forests, Tapajos-Xingu moist forests). In general, high absolute numbers of species with trait measurements for ecoregions are found in Europe, East Asia, Oceania, Australia, tropical South America and the United States (Figure 10a). East Asia, Oceania and tropical South America are also the regions with the highest numbers of species per ecoregions estimated by Kier et al. (2005; Figure 10b).

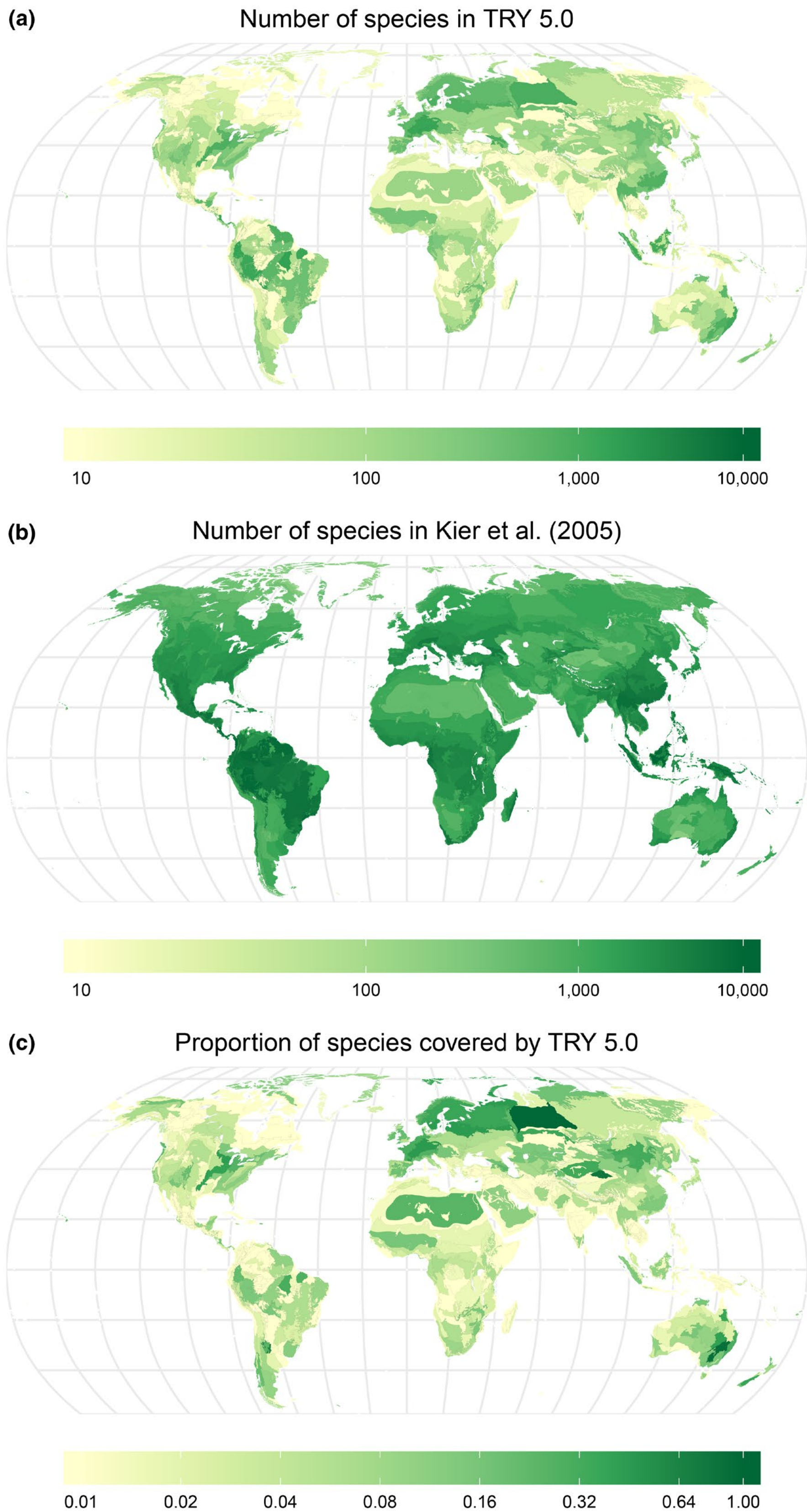

FIGURE 10 Geographic representativeness: (a) the number of species with at least one trait measurement in an ecoregion in TRY version 5; (b) number of species per ecoregion estimated by Kier et al. (2005); (c) fraction of species represented in TRY version 5 versus number of species per ecoregion estimated by Kier et al. (2005)

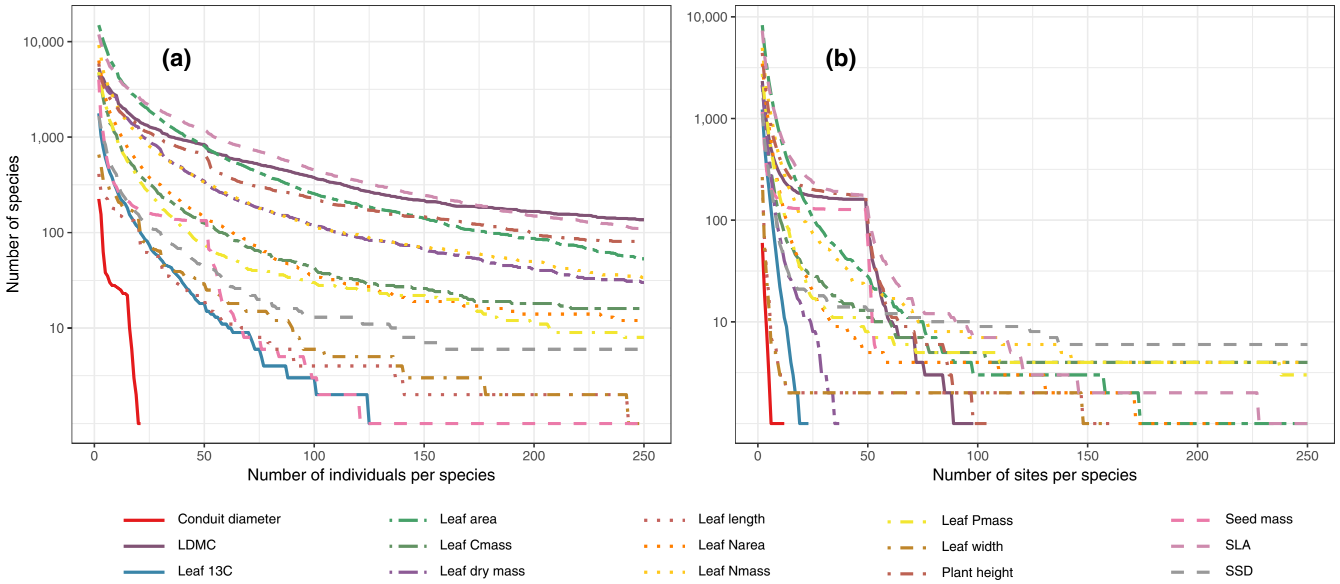

FIGURE 11 Data coverage enabling examination of intraspecific variation: impact of the minimum number of individuals per species (a) and measurement sites per species (b) on the number of species available for analyses of intraspecific variation. Measurement sites were classified as different if they differed at least by 0.01 degrees in latitude or longitude. LDMC: leaf dry matter content; Leaf 13C: Leaf carbon (C) isotope signature (leaf Δ13C); Leaf C mass: leaf carbon content per leaf dry mass; Leaf N area: leaf nitrogen content per leaf area; Leaf N mass: leaf nitrogen content per leaf dry mass; Leaf P mass: leaf phosphorus content per leaf dry mass; SLA: leaf area per leaf dry mass (specific leaf area); SSD: stem specific density

The best relative coverage in TRY (Figure 10c) is provided for the Marielandia Antarctic tundra (two species estimated and in TRY) and for a large ecoregion in Central Russia (West Siberian taiga, 900 species estimated, 885 in TRY). The species in the Russian ecoregion are measured at several sites relatively well distributed across the ecoregion, but dominated by just one trait, 'mycorrhiza infection intensity' contributed by the mycorrhizal intensity database (Akhmetzhanova et al., 2012). Some other ecoregions are also well covered with data for more than 50% of estimated species (Southeast Australia temperate savanna, Qaidam Basin semi-desert, Córdoba forests and mountain grasslands). Apart from these individual ecoregions spread across the world, large parts of Europe are well covered, with trait data for about 30% of the species number estimated by Kier et al. (2005). Some ecoregions in East Asia, Australia, tropical South America, the Sahara, and the United States are also well covered, providing data for about 20% of estimated species richness. Very low relative coverage (<2%) is observed for major parts of Canada, Africa, western Asia (Iran, Iraq, Pakistan, Afghanistan) and major parts of India.

3.12 | Intraspecific variation

Understanding and predicting intraspecific variation for a relevant number of traits and species is still in its infancy. Given that TRY is collecting trait measurements on individual plants, the TRY data set might be suited to address these questions. A precondition for such analyses is a minimum number of measurements on different individual plants at different sites per trait and species. To assess this issue, we plotted the number of species for which TRY version 5 contains a minimum number of individual measurements (Figure 11a) and the number of species for which TRY version 5 contains measurements from a minimum number of individual sites (Figure 11b) for the 15 best-covered continuous traits. By increasing the minimum number of individuals or sites, the number of species available for analysis decreases sharply (more than exponentially), whereas the exact slope is trait specific. The characterization of intraspecific variation in Kattge et al. (2011) relied on at least 20 individuals per species. Based on this criterion, TRY 5 provides information for hundreds to thousands of species for 14 out of the 15 traits (Figure 11a). Assuming a more realistic limit of 100 individuals per species, SLA and LDMC are sufficiently covered for about 300 species, and four other traits for more than 100 species. Assuming a minimum number of 200 individuals per species, four traits still allow for an analysis of 100 species, and nine traits allow for the analysis of intraspecific variation of more than 10 species. However, the numbers are more humbling if the environmental context is taken into account (Figure 11b). If we assume that trait records from a minimum number of 50 sites per species are necessary to represent intraspecific variation, four traits are sufficiently covered for about 100 species. If 100 sites are necessary, no trait is covered by data for more than 10 species.

4 | DISCUSSION

Plant trait data provide a wealth of information directly relevant in several scientific contexts, from conservation, ecology and evolution to earth system sciences. To fully realize this potential, the TRY initiative was initiated in 2007 as a 'database of databases' and leading groups in the field of functional plant ecology joined forces for this community-driven program. The TRY database now provides an unprecedented number of consolidated plant trait data, which have become easily accessible at the TRY Data Portal under an open access data policy.

The TRY database is well accepted by the scientific community and has facilitated progress in different aspects of research, for example in global vegetation modelling from static PFTs to a more continuous representation of biodiversity (e.g. Peaucelle, Bellassen, Ciais, Peñuelas, & Viovy, 2016; Sakschewski et al., 2015, 2016; Verheijen et al., 2013, 2015), extending macroecology and biodiversity by functional aspects (e.g. Bjorkman, Myers-Smith, Elmendorf, Normand, Rüger, et al., 2018; Bruelheide et al., 2018; Craven et al., 2018; Newbold et al., 2015), linking soil characteristics to vegetation attributes (e.g. Boeddinghaus et al., 2019; de Vries et al., 2012; Delgado-Baquerizo et al., 2018) and providing data for global maps of plant traits (e.g. Butler et al., 2017; Moreno-Martínez et al., 2018). The central keywords of the cluster analysis in Figure 2 (biodiversity, climate change, plant traits, functional diversity, carbon cycle, community, vegetation and environmental filtering) seem to reflect the expectation that improved knowledge of plant functional diversity, mediated by plant traits, contributes to a better understanding of vegetation feedbacks to climate change and drivers and consequences of plant biodiversity loss.

Data coverage of the TRY database is characterized by four attributes: (a) long-tail distributions, (b) sparse matrices, (c) increasing number of ancillary data per trait record and (d) increasing geographic coverage. So far the size of the two sparse matrices (entity × trait and species × trait) has increased faster than the number of trait records to fill the matrices. Therefore the sparseness of the matrices has increased from TRY version 1 to 5 (the fractional coverage declined). Rather than converging in a small number of traits, the scientific community continues to measure a large, diverse number of traits, following equally diverse motivations.

However, given the number of species has a natural limit and assuming the number of traits will continue to grow, but more slowly, once the most obvious ones have been covered, we expect that the sparseness of the entity × trait matrix will become stable: new data adding new rows for entities, but not many new columns for traits. In comparison, the sparseness of the species × trait matrix should decline in the future; new data will mostly contribute to filling the matrix and increasing the number of species with data per trait. This reduced sparseness of the species × traits matrix will systematically improve the applicability of trait data for macroecology and earth system modelling and will facilitate multivariate analyses for an increasing number of traits. In parallel, the number of records per species–trait combination is increasing: between TRY 1 and 5 it already doubled and will further increase in the future. This increasing number of records per species–trait combination will improve data coverage for analyses of intraspecific trait variation and trait–environment relationships accounting for intraspecific variation. It is noteworthy that the matrix will not only become more complete, but the traits will increasingly be able to inform each other. The 'usual suspects' (i.e. the best covered continuous traits) might not be masters of all traits, but they surely will be very useful as baseline traits and provide a background against which other—maybe more influential—traits can be analysed for coverage, representativeness, orthogonality, etc.

4.1 | Data completeness and representativeness

Despite unprecedented and continuously growing data coverage, we observe a humbling lack of completeness and representativeness in many aspects. The best species coverage is achieved for categorical traits relevant to determine PFTs commonly used in global vegetation models. For the traits 'woodiness' and 'plant growth form', even full species coverage is within reach, due to the contribution of data from the GIFT database. For the first time, this provides a global baseline for these traits, which are relevant to understand basic patterns of variation for several other traits (Díaz et al., 2016). With this baseline, future analyses will be able to address representativeness in addition to coverage, which will substantially contribute to better understand the global pattern of plant traits relevant for biodiversity and ecosystem function (König et al., 2019).

Most traits directly relevant for ecology and vegetation modelling are characterized by intraspecific variation and trait–environmental relationships; for these traits, completeness at the global scale is impossible and representativeness is challenging. We find that in the current version of the TRY database, these traits are biased against roots, floral traits and dead organic material, like litter or coarse woody debris. Plant growth forms and phylogeny are generally well represented, but there are significant biases for individual traits. The global distribution of species richness is only marginally reflected by trait measurements. We observe a general bias towards temperate biomes. In contrast to Jetz et al. (2016), the tropics do not stand out as especially underrepresented in our analysis; apart from Europe, all continents contain major regions that are very sparsely represented in TRY.

So far we addressed representativeness in a geographic context only based on species richness, the number of species observed in an ecoregion. To address representativeness in an ecologically more meaningful context, species identity and species abundance should be taken into account. Both aspects are relevant to community attributes and ecosystem function. There is ample evidence in the literature of the high influence, at the level of community structure and ecosystem dynamics, of species that represent a large proportion of the total local biomass (consisting of large individuals and/or large total cover). Such species have a particularly large impact on the community weighted mean trait value (Garnier et al., 2004), and particularly large individual trees may overrule remaining trees' attributes (Ali et al., 2019). Initial evidence indicates that abundant species are better covered in TRY than rare species. Bruelheide et al. (2019) show that the 25% most dominant or most frequent species compiled in the sPlot vegetation-plot database are better represented by trait data in the TRY database than species observed on the plots overall. We also checked this for the 227 hyperdominant species of the Amazonia tree flora identified by ter Steege et al. (2013). After the consolidation of species names via TNRS, all 227 hyperdominant species are present in the TRY database, with on average 69 traits per species, which is far above average (see Figure 3e). We therefore conclude that the coverage of trait data in TRY is biased towards the more abundant species in the respective ecoregions—which is reasonable and welcome for many kinds of analyses.

We have reported that intraspecific variation in space is increasingly well covered, but variation in time is hard to estimate. Nevertheless, intraspecific variation in time is relevant for several traits to characterize the seasonal variation of plant and ecosystem function (Xu & Baldocchi, 2003; Xu & Griffin, 2006) and long-term trends to inform policy about biodiversity change (Kissling et al., 2018). About half of the geo-referenced trait records have information on the sampling date that could be standardized to year, month and day, but systematic replicates over time ('time series') are rare (but see e.g. the 'Photosynthesis Traits Database'; Xu & Baldocchi, 2003). In principle, 'non-time series' data allow detection of trait changes over time (Craine et al., 2018), but these analyses are very challenging, as most traits demonstrate stronger variation in geographic space along climate and soil gradients than over time. In addition, the variations of traits on different time scales (diurnal, seasonal, inter-annual variation and long-term trends) are superimposed and hard to disentangle. Apart from this, there is a need to collect and report repeated trait measurements from the same location or population to monitor biodiversity change and inform policy, for example in the context of GEO BON (Kissling et al., 2018).

4.2 | Ways forward

Figure 1 shows the most obvious way to mobilize additional trait data: the TRY initiative should regularly send calls for data contribution to the wider scientific community, that is the network of more than 6,000 researchers contributing and using trait data via TRY. These calls should be combined with regular publications of respective reference papers. This can be combined with (a) a systematic collection of data sets from public data repositories, which is becoming more effective with the general move by many journals to require that authors make their data open access; and (b) systematic extraction of trait data from the ecological literature, floras and herbarium specimens, which is a promising task, especially for its potential to open a window into the past. In parallel, TRY should further support the 'feed-forward data integration loop' outlined above: using trait data via TRY, identifying gaps, mobilizing and/or measuring new data, contributing additional data to TRY. This has proven very effective for focused data mobilization. If relevant gaps are detected, TRY can also send specific calls to the community.

As TRY has been designed as a community cyber-infrastructure based on the idea of incentive-driven data sharing (Kattge, Díaz, & Wirth, 2014), the collaboration and data exchange with other plant trait databases will continue to be the key to achieve a comprehensive representation of plant traits. TRY is, therefore, collaborating with many more recent trait database initiatives, such as, for example, FRED, GIFT, BIEN and the Tundra Trait Team, and since the early days of TRY—GLOPNET, LEDA, SID, BiolFlor, BIOPOP, BROT, the Ecological Flora of the British Isles, eHALOPH, USDA PLANTSdata, BRIDGE and many others. Importantly, these collaborations need to provide mutual benefit. Based on these collaborations, the TRY database may serve as a central node for plant traits in an overarching network of trait databases, currently emerging in the context of the Open Traits Network (Gallagher et al., in press). Finally, new techniques and approaches are gradually becoming available, which may substantially change how plant trait data are collected: remote sensing, citizen sciences, microbiological and molecular screening, etc.

4.3 | Towards a third generation of plant trait data integration and sharing

We expect that the combination of (a) systematic involvement of the TRY network towards extraction and mobilization of legacy and recent trait data from public repositories, ecological literature, floras and herbaria, (b) facilitation of the 'feed-forward data integration loop' and (c) intensified collaboration of all plant trait-related initiatives, including new approaches and techniques, will be effective towards an increasingly comprehensive representation of plant traits. After the development of integrated databases focused on specific regions or topics, and the development of a 'database of databases', such a joined effort might be leading towards a third generation of plant trait data integration and sharing.

5 | CONCLUSION

TRY has received institutional support since 2007 and is still growing considerably in quantity and quality. While TRY may be considered a success and potentially a role model for database initiatives, it is important to realize that this development needed time and patience. It took until 2011 for the first TRY publications to appear because the early years of TRY were mostly devoted to the development of the database, organizing the community process towards a joint data sharing policy and building trust. This process involved initially dozens and later hundreds of scientist when it came to agree on moving towards open access. These dynamics do not fit into 3 year funding cycles as typically offered by national funding agencies. A key lesson of TRY is that the development of a database that is trusted by the community and accepted for its service and quality also needs the trust of the funders, that is long-term support, at the scale of decades rather than years. It also needs journals that are willing to accept long author lists and extended references lists to adequately acknowledge the original contributions that are the building blocks of communal databases.

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CONFLICT OF INTEREST

All authors declare no conflict of interest.

AUTHOR CONTRIBUTION

Jens Kattge, Gerhard Bönisch, Sandra Díaz, Sandra Lavorel, Iain Colin Prentice, Paul Leadley and Christian Wirth developed the concept and draft manuscript. Susanne Tautenhahn and Gijsbert Werner contributed analyses and plots for Figures 9, 10 and 11. The other authors contributed plant trait data and/or supported data curation and analysis. All 729 authors contributed to writing.

ORCID

Jens Kattge https://orcid.org/0000-0002-1022-8469
Sandra Díaz https://orcid.org/0000-0003-0012-4612
Susanne Tautenhahn https://orcid.org/0000-0002-2753-3443
Gijsbert D. A. Werner https://orcid.org/0000-0002-5426-2562
Tuomas Aakala https://orcid.org/0000-0003-0160-6410
Mehdi Abedi https://orcid.org/0000-0002-1499-0119
Alicia T. R. Acosta https://orcid.org/0000-0001-6572-3187
George C. Adamidis https://orcid.org/0000-0001-8704-6623
Masahiro Aiba https://orcid.org/0000-0002-5966-1562
Cécile H. Albert https://orcid.org/0000-0002-0991-1068
Julio M. Alcántara https://orcid.org/0000-0002-8003-7844
Carolina Alcázar C https://orcid.org/0000-0002-9366-8098
Izabela Aleixo https://orcid.org/0000-0001-9220-8965
Hamada Ali https://orcid.org/0000-0002-7062-9344
Christian Ammer https://orcid.org/0000-0002-4235-0135
Carolyn Anderson https://orcid.org/0000-0003-4211-5765
Deborah Mattos Guimarães Apgaua https://orcid.org/0000-0002-6303-6989
Tia-Lynn Ashman https://orcid.org/0000-0002-9884-5954
Gregory P. Asner https://orcid.org/0000-0001-7893-6421
Michael Aspinwall https://orcid.org/0000-0003-0199-2972
Owen Atkin https://orcid.org/0000-0003-1041-5202
Isabelle Aubin https://orcid.org/0000-0002-5953-1012
Lars Baastrup-Spohr https://orcid.org/0000-0001-8382-984X
Khadijeh Bahalkeh https://orcid.org/0000-0003-1485-0316
Michael Bahn https://orcid.org/0000-0001-7482-9776
William J. Baker https://orcid.org/0000-0001-6727-1831
Jan P. Bakker https://orcid.org/0000-0001-7475-5906
Dennis Baldocchi https://orcid.org/0000-0003-3496-4919
Jennifer Baltzer https://orcid.org/0000-0001-7476-5928
Jos Barlow https://orcid.org/0000-0003-4992-2594
Diego R. Barneche https://orcid.org/0000-0002-4568-2362
Zdravko Baruch https://orcid.org/0000-0002-7264-4812
Denis Bastianelli https://orcid.org/0000-0002-6394-5920
John Battles https://orcid.org/0000-0001-7124-7893
William Bauerle https://orcid.org/0000-0003-3090-234X
Marijn Bauters https://orcid.org/0000-0003-0978-6639
Michael Beckmann https://orcid.org/0000-0002-5678-265X
Hans Beeckman https://orcid.org/0000-0001-8954-6277
Carl Beierkuhnlein https://orcid.org/0000-0002-6456-4628
Gavin Belfry https://orcid.org/0000-0003-3405-5950
Michael Belluau https://orcid.org/0000-0001-6707-546X
Mirela Beloiu https://orcid.org/0000-0002-3592-8170
Raquel Benavides https://orcid.org/0000-0003-2328-5371
Lahcen Benomar https://orcid.org/0000-0001-9301-5655
Mary Lee Berdugo-Lattke https://orcid.org/0000-0002-6662-6458
Erika Berenguer https://orcid.org/0000-0001-7357-8805
Rodrigo Bergamin https://orcid.org/0000-0002-2405-9977
Joana Bergmann https://orcid.org/0000-0002-2008-4198
Marcos Bergmann Carlucci https://orcid.org/0000-0002-5868-7090
Logan Berner https://orcid.org/0000-0001-8947-0479
Markus Bernhardt-Römermann https://orcid.org/0000-0002-2740-2304
Christof Bigler https://orcid.org/0000-0003-3757-6356
Anne D. Bjorkman https://orcid.org/0000-0003-2174-7800
Carolina Blanco https://orcid.org/0000-0002-8959-2633
Benjamin Blonder https://orcid.org/0000-0002-5061-2385
Dana Blumenthal https://orcid.org/0000-0001-7496-0766
Kelly T. Bocanegra-González https://orcid.org/0000-0001-7177-5856
Pascal Boeckx https://orcid.org/0000-0003-3998-0010
Katrin Böhning-Gaese https://orcid.org/0000-0003-0477-5586
Laura Boisvert-Marsh https://orcid.org/0000-0002-0939-8196
William Bond https://orcid.org/0000-0002-3441-2084
Ben Bond-Lamberty https://orcid.org/0000-0001-9525-4633
Arnoud Boom https://orcid.org/0000-0003-1299-691X
Coline C. F. Boonman https://orcid.org/0000-0003-2417-1579
Kauane Bordin https://orcid.org/0000-0003-3871-6293
Elizabeth H. Boughton https://orcid.org/0000-0003-0932-280X
Vanessa Boukili https://orcid.org/0000-0002-5950-2123

Sandra Bravo https://orcid.org/0000-0001-6098-7255
Marco Richard Brendel https://orcid.org/0000-0003-4356-4597
Martin R. Broadley https://orcid.org/0000-0003-3964-7226
Kerry A. Brown https://orcid.org/0000-0002-6342-8966
Helge Bruelheide https://orcid.org/0000-0003-3135-0356
Federico Brumnich https://orcid.org/0000-0002-0502-6694
Hans Henrik Bruun https://orcid.org/0000-0003-0674-2577
David Bruy https://orcid.org/0000-0002-7339-0375
Solveig Franziska Bucher https://orcid.org/0000-0002-2303-4583
Nina Buchmann https://orcid.org/0000-0003-0826-2980
Robert Buitenwerf https://orcid.org/0000-0003-3356-2301
Daniel E. Bunker https://orcid.org/0000-0002-7234-3403
Sabina Burrascano https://orcid.org/0000-0002-6537-3313
David F. R. P. Burslem https://orcid.org/0000-0001-6033-0990
Bradley J. Butterfield https://orcid.org/0000-0003-0974-9811
Chaeho Byun https://orcid.org/0000-0003-3209-3275
Marcia Marques https://orcid.org/0000-0002-1003-9596
Marina C. Scalon https://orcid.org/0000-0003-2069-8226
Marco Caccianiga https://orcid.org/0000-0001-9715-1830
Marc Cadotte https://orcid.org/0000-0002-5816-7693
Maxime Cailleret https://orcid.org/0000-0001-6561-1943
James Camac https://orcid.org/0000-0003-4785-0742
Jesús Julio Camarero https://orcid.org/0000-0003-2436-2922
Giandiego Campetella https://orcid.org/0000-0001-6126-522X
Juan Antonio Campos https://orcid.org/0000-0001-5992-2753
Roberto Canullo https://orcid.org/0000-0002-9913-6981
Michele Carbognani https://orcid.org/0000-0001-7701-9859
Fabio Carvalho https://orcid.org/0000-0002-6305-5602
Fernando Casanoves https://orcid.org/0000-0001-8765-9382
Bastien Castagneyrol https://orcid.org/0000-0001-8795-7806
Jane A. Catford https://orcid.org/0000-0003-0582-5960
Jeannine Cavender-Bares https://orcid.org/0000-0003-3375-9630
Bruno E. L. Cerabolini https://orcid.org/0000-0002-3793-0733
Marco Cervellini https://orcid.org/0000-0002-0853-2330
Eduardo Chacón-Madrigal https://orcid.org/0000-0002-8328-5456
Kenneth Chapin https://orcid.org/0000-0002-8382-4050
F. Stuart Chapin https://orcid.org/0000-0002-2558-9910
Stefano Chelli https://orcid.org/0000-0001-7184-8242
Si-Chong Chen https://orcid.org/0000-0002-6855-2595
Anping Chen https://orcid.org/0000-0003-2085-3863
Paolo Cherubini https://orcid.org/0000-0002-9809-250X
Francesco Chianucci https://orcid.org/0000-0002-5688-2060
Brendan Choat https://orcid.org/0000-0002-9105-640X
Kyong-Sook Chung https://orcid.org/0000-0002-4464-4698
Milan Chytrý https://orcid.org/0000-0002-8122-3075
Daniela Ciccarelli https://orcid.org/0000-0001-9715-9779
Luisa Conti https://orcid.org/0000-0001-8047-1467
David Coomes https://orcid.org/0000-0002-8261-2582
Johannes H. C. Cornelissen https://orcid.org/0000-0002-2346-1585
William K. Cornwell https://orcid.org/0000-0003-4080-4073
Piermaria Corona https://orcid.org/0000-0002-8105-0792
Joseph Craine https://orcid.org/0000-0001-6561-3244
Dylan Craven https://orcid.org/0000-0003-3940-833X
Anikó Csecserits https://orcid.org/0000-0002-0538-4520
Katarina Cufar https://orcid.org/0000-0002-7403-3994
Matthias Cuntz https://orcid.org/0000-0002-5966-1829
Ana Carolina da Silva https://orcid.org/0000-0002-1285-640X
Kyla M. Dahlin https://orcid.org/0000-0002-6016-2605
Matteo Dainese https://orcid.org/0000-0001-7052-5572
Igor Dalke https://orcid.org/0000-0001-5711-9916
Michele Dalle Fratte https://orcid.org/0000-0002-7907-1586
Anh Tuan Dang-Le https://orcid.org/0000-0002-9794-0669
Jirí Danihelka https://orcid.org/0000-0002-2640-7867
Masako Dannoura https://orcid.org/0000-0003-0389-871X
Samantha Dawson https://orcid.org/0000-0001-5165-9591
Angel De Frutos https://orcid.org/0000-0002-5250-9488
Jonathan R. De Long https://orcid.org/0000-0002-7951-4818
Benjamin Dechant https://orcid.org/0000-0001-5171-2364
Nicolas Delpierre https://orcid.org/0000-0003-0906-9402
Géraldine Derroire https://orcid.org/0000-0001-7239-2881
Arildo S. Dias https://orcid.org/0000-0002-5495-3435
Milton Hugo Diaz-Toribio https://orcid.org/0000-0003-1675-2699
Panayiotis G. Dimitrakopoulos https://orcid.org/0000-0002-8374-4392
Mark Dobrowolski https://orcid.org/0000-0001-5586-4023
Pavel Dřevojan https://orcid.org/0000-0003-0802-3509
Ning Dong https://orcid.org/0000-0003-0793-8854
Leandro Duarte https://orcid.org/0000-0003-1771-0407
Stefan Dullinger https://orcid.org/0000-0003-3919-0887
Walter Durka https://orcid.org/0000-0002-6611-2246
Olga Dymova https://orcid.org/0000-0003-2008-6350
Anna E-Vojtkó https://orcid.org/0000-0001-6370-680X
Rolf Lutz Eckstein https://orcid.org/0000-0002-6953-3855
Hamid Ejtehadi https://orcid.org/0000-0002-6128-2481
James Elser https://orcid.org/0000-0002-1460-2155
Thaise Emilio https://orcid.org/0000-0001-5415-1822
Kristine Engemann https://orcid.org/0000-0003-1431-1726
Mohammad Bagher Erfanian https://orcid.org/0000-0002-8671-9037
Adriane Esquivel-Muelbert https://orcid.org/0000-0001-5335-1259
Marc Estiarte https://orcid.org/0000-0003-1176-8480
Tomas F. Domingues https://orcid.org/0000-0003-2857-9838
William F. Fagan https://orcid.org/0000-0003-2433-9052
Jaime Fagúndez https://orcid.org/0000-0001-6605-7278
Daniel S. Falster https://orcid.org/0000-0002-9814-092X
Ying Fan https://orcid.org/0000-0002-0024-7965
Emmanuele Farris https://orcid.org/0000-0002-9843-5998
Fatih Fazlioglu https://orcid.org/0000-0002-4723-3640
Yanhao Feng https://orcid.org/0000-0003-0460-4883
Fernando Fernandez-Mendez https://orcid.org/0000-0001-8693-790X
Joice Ferreira https://orcid.org/0000-0002-4008-2341
Alessandra Fidelis https://orcid.org/0000-0001-9545-2285
Jennifer Firn https://orcid.org/0000-0001-6026-8912
Timothy J. Flowers https://orcid.org/0000-0002-2712-9504
Dan F. B. Flynn https://orcid.org/0000-0002-2978-5257
Estelle Forey https://orcid.org/0000-0001-6082-3023
Cristiane Forgiarini https://orcid.org/0000-0002-0319-7430
Louis François https://orcid.org/0000-0001-8292-8360

Marcelo Frangipani https://orcid.org/0000-0001-8050-8282
Grégoire T. Freschet https://orcid.org/0000-0002-8830-3860
Ellen L. Fry https://orcid.org/0000-0001-7513-2006
Nikolaos M. Fyllas https://orcid.org/0000-0002-5651-5578
Guilherme G. Mazzochini https://orcid.org/0000-0002-6932-8544
Rachael Gallagher https://orcid.org/0000-0002-4680-8115
Pablo García-Palacios https://orcid.org/0000-0002-6367-4761
Verónica Gargaglione https://orcid.org/0000-0002-0797-1868
Eric Garnier https://orcid.org/0000-0002-9392-5154
Jose Luis Garrido https://orcid.org/0000-0002-6859-4234
André Luís de Gasper https://orcid.org/0000-0002-1940-9581
Guillermo Gea-Izquierdo https://orcid.org/0000-0003-0148-3721
David Gibson https://orcid.org/0000-0002-0308-7506
Andrew N. Gillison https://orcid.org/0000-0003-2781-1500
Aelton Giroldo https://orcid.org/0000-0001-7850-0011
Sean Gleason https://orcid.org/0000-0002-5607-4741
Mariana Gliesch https://orcid.org/0000-0003-3226-6762
Erika Gonzalez-Akre https://orcid.org/0000-0001-8305-6672
Jose L. Gonzalez-Andujar https://orcid.org/0000-0003-2356-4098
Ana González-Robles https://orcid.org/0000-0003-3135-8905
Bente Jessen Graae https://orcid.org/0000-0002-5568-4759
Elena Granda https://orcid.org/0000-0002-9559-4213
Sarah Graves https://orcid.org/0000-0003-3805-4242
Thomas Gregor https://orcid.org/0000-0001-7692-8348
Nicolas Gross https://orcid.org/0000-0001-9730-3240
Greg R. Guerin https://orcid.org/0000-0002-2104-6695
Alvaro G. Gutiérrez https://orcid.org/0000-0001-8928-3198
Lillie Haddock https://orcid.org/0000-0003-3432-6191
Jefferson Hall https://orcid.org/0000-0003-4761-9268
Wenxuan Han https://orcid.org/0000-0001-8678-7147
Sandy P. Harrison https://orcid.org/0000-0001-5687-1903
Joseph E. Hawes https://orcid.org/0000-0003-0053-2018
Pengcheng He https://orcid.org/0000-0001-9531-531X
Jacob Mason Heberling https://orcid.org/0000-0003-0756-5090
Aveliina Helm https://orcid.org/0000-0003-2338-4564
Bruno Hérault https://orcid.org/0000-0002-6950-7286
Ana-Maria Hereş https://orcid.org/0000-0002-1839-1770
Katharina Herz https://orcid.org/0000-0001-5676-3646
Myriam Heuertz https://orcid.org/0000-0002-6322-3645
Peter Hietz https://orcid.org/0000-0002-0458-6593
Pedro Higuchi https://orcid.org/0000-0002-3855-555X
Andrew L. Hipp https://orcid.org/0000-0002-1241-9904
Maria Hock https://orcid.org/0000-0001-8401-7309
James Aaron Hogan https://orcid.org/0000-0001-9806-3074
Karen Holl https://orcid.org/0000-0003-2893-6161
Olivier Honnay https://orcid.org/0000-0002-4287-8511
Enqing Hou https://orcid.org/0000-0003-4864-2347
Nate Hough-Snee https://orcid.org/0000-0003-4581-0931
Knut Anders Hovstad https://orcid.org/0000-0002-7108-0787
Tomoaki Ichie https://orcid.org/0000-0002-1979-5806
Boris Igić https://orcid.org/0000-0002-6302-8030
Estela Illa https://orcid.org/0000-0001-7136-6518
Marney Isaac https://orcid.org/0000-0002-5975-833X
Masae Ishihara https://orcid.org/0000-0002-8365-7766
Leonid Ivanov https://orcid.org/0000-0001-6900-5086
Larissa Ivanova https://orcid.org/0000-0003-2363-9619
Colleen M. Iversen https://orcid.org/0000-0001-8293-3450
Jordi Izquierdo https://orcid.org/0000-0002-3949-1295
Robert B. Jackson https://orcid.org/0000-0001-8846-7147
Benjamin Jackson https://orcid.org/0000-0001-6405-8111
Hervé Jactel https://orcid.org/0000-0002-8106-5310
Andrzej M. Jagodzinski https://orcid.org/0000-0001-6899-0985
Steven Jansen https://orcid.org/0000-0002-4476-5334
Thomas Jenkins https://orcid.org/0000-0002-3036-971X
Anke Jentsch https://orcid.org/0000-0002-2345-8300
Guo-Feng Jiang https://orcid.org/0000-0002-3221-8608
Jesper Liengaard Johansen https://orcid.org/0000-0001-7602-316X
David Johnson https://orcid.org/0000-0003-2299-2525
Eric J. Jokela https://orcid.org/0000-0002-1819-1285
Carlos Alfredo Joly https://orcid.org/0000-0002-7945-2805
Gregory J. Jordan https://orcid.org/0000-0002-6033-2766
Grant Stuart Joseph https://orcid.org/0000-0002-8731-9828
Decky Junaedi https://orcid.org/0000-0001-5846-6135
Robert R. Junker https://orcid.org/0000-0002-7919-9678
Eric Justes https://orcid.org/0000-0001-7390-7058
Jeffrey Kane https://orcid.org/0000-0003-1453-9608
Zdenek Kaplan https://orcid.org/0000-0003-1707-7461
Teja Kattenborn https://orcid.org/0000-0001-7381-3828
Elizabeth Kearsley https://orcid.org/0000-0003-0046-3606
Anne Kempel https://orcid.org/0000-0002-0563-901X
Tanaka Kenzo https://orcid.org/0000-0002-4856-7204
Mohammed I. Khalil https://orcid.org/0000-0002-9310-2780
Nicole L. Kinlock https://orcid.org/0000-0002-2917-5133
Wilm Daniel Kissling https://orcid.org/0000-0002-7274-6755
Kaoru Kitajima https://orcid.org/0000-0001-6822-8536
Thomas Kitzberger https://orcid.org/0000-0002-9754-4121
Rasmus Kjøller https://orcid.org/0000-0002-2027-4119
Tamir Klein https://orcid.org/0000-0002-3882-8845
Michael Kleyer https://orcid.org/0000-0002-0824-2974
Jitka Klimešová https://orcid.org/0000-0003-0123-3263
Joice Klipel https://orcid.org/0000-0003-3936-9692
Brian Kloeppel https://orcid.org/0000-0003-0215-4671
Takashi Kohyama https://orcid.org/0000-0001-7186-8585
Fumito Koike https://orcid.org/0000-0002-6588-6485
Johannes Kollmann https://orcid.org/0000-0002-4990-3636
Kimberly Komatsu https://orcid.org/0000-0001-7056-4547
Christian König https://orcid.org/0000-0003-0585-5983
Nathan J. B. Kraft https://orcid.org/0000-0001-8867-7806
Koen Kramer https://orcid.org/0000-0002-1402-2775
Holger Kreft https://orcid.org/0000-0003-4471-8236
Ingolf Kühn https://orcid.org/0000-0003-1691-8249
Dushan Kumarathunge https://orcid.org/0000-0003-1309-4731
Jonas Kuppler https://orcid.org/0000-0003-4409-9367
Hiroko Kurokawa https://orcid.org/0000-0001-8778-8045
Yoko Kurosawa https://orcid.org/0000-0002-1419-7575
Shem Kuyah https://orcid.org/0000-0001-7692-585X

Jean-Paul Laclau https://orcid.org/0000-0002-2506-214X
Eric Lamb https://orcid.org/0000-0001-5201-4541
Andrea Lamprecht https://orcid.org/0000-0002-8719-026X
Daniel J. Larkin https://orcid.org/0000-0001-6378-0495
Daniel Laughlin https://orcid.org/0000-0002-9651-5732
Yoann Le Bagousse-Pinguet https://orcid.org/0000-0002-5615-5541
Guerric le Maire https://orcid.org/0000-0002-5227-958X
Peter C. le Roux https://orcid.org/0000-0002-7941-7444
Elizabeth le Roux https://orcid.org/0000-0001-8468-8284
Tali Lee https://orcid.org/0000-0002-3933-6607
Frederic Lens https://orcid.org/0000-0002-5001-0149
Simon L. Lewis https://orcid.org/0000-0002-8066-6851
Yuanzhi Li https://orcid.org/0000-0002-5258-877X
Jeremy W. Lichstein https://orcid.org/0000-0001-5553-6142
Jun Ying Lim https://orcid.org/0000-0001-7493-2159
Juan Carlos Linares https://orcid.org/0000-0001-8375-6353
Daijun Liu https://orcid.org/0000-0002-0993-0832
Udayangani Liu https://orcid.org/0000-0002-6192-1319
Madelon Lohbeck https://orcid.org/0000-0002-3959-1800
Álvaro López-García https://orcid.org/0000-0001-8267-3572
Gabriela Lopez-Gonzalez https://orcid.org/0000-0002-0814-8830
Zdeňka Lososová https://orcid.org/0000-0001-9152-7462
Frédérique Louault https://orcid.org/0000-0002-9430-4261
Balázs A. Lukács https://orcid.org/0000-0002-3163-1281
Michele Lussu https://orcid.org/0000-0002-1313-4732
Camilla Maciel Rabelo Pereira https://orcid.org/0000-0002-7027-7430
Vincent Maire https://orcid.org/0000-0002-3245-2568
Annikki Mäkelä https://orcid.org/0000-0001-9633-7350
Harri Mäkinen https://orcid.org/0000-0002-1820-6264
Ana Claudia Mendes Malhado https://orcid.org/0000-0003-3621-779X
Azim Mallik https://orcid.org/0000-0002-6275-6255
Peter Manning https://orcid.org/0000-0002-7940-2023
Stefano Manzoni https://orcid.org/0000-0002-5960-5712
Zuleica Marchetti https://orcid.org/0000-0002-9241-9217
Vinicius Marcilio-Silva https://orcid.org/0000-0002-5276-2838
Eric Marcon https://orcid.org/0000-0002-5249-321X
Michela Marignani https://orcid.org/0000-0002-8420-5454
Lars Markesteijn https://orcid.org/0000-0003-3046-3121
Adam Martin https://orcid.org/0000-0002-7207-4004
Cristina Martínez-Garza https://orcid.org/0000-0002-9310-564X
Jordi Martínez-Vilalta https://orcid.org/0000-0002-2332-7298
Tereza Mašková https://orcid.org/0000-0001-8386-5146
Kelly Mason https://orcid.org/0000-0003-3426-3178
Itay Mayrose https://orcid.org/0000-0002-8460-1502
James McCarthy https://orcid.org/0000-0003-3060-1678
M. Luke McCormack https://orcid.org/0000-0002-8300-5215
Katherine McCulloh https://orcid.org/0000-0003-0801-3968
Ian R. McFadden https://orcid.org/0000-0002-4508-7272
Mara Y. McPartland https://orcid.org/0000-0002-1242-0438
Belinda Medlyn https://orcid.org/0000-0001-5728-9827
Zia Mehrabi https://orcid.org/0000-0001-9574-0420
Patrick Meir https://orcid.org/0000-0002-2362-0398
Felipe P. L. Melo https://orcid.org/0000-0002-1271-3214
Maurizio Mencuccini https://orcid.org/0000-0003-0840-1477
Céline Meredieu https://orcid.org/0000-0002-2950-2253
Julie Messier https://orcid.org/0000-0003-1637-6793
Sean T. Michaletz https://orcid.org/0000-0003-2158-6525
Chrysanthi Michelaki https://orcid.org/0000-0001-9217-0063
Ruben Milla https://orcid.org/0000-0001-8912-4373
Jesse E. D. Miller https://orcid.org/0000-0002-2316-779X
Vanessa Minden https://orcid.org/0000-0002-4933-5931
Ray Ming https://orcid.org/0000-0002-9417-5789
Karel Mokany https://orcid.org/0000-0003-4199-3697
Angela T. Moles https://orcid.org/0000-0003-2041-7762
Attila Molnár https://orcid.org/0000-0001-7096-9579
Jane Molofsky https://orcid.org/0000-0001-7927-516X
Arnaud Monty https://orcid.org/0000-0003-1910-6748
Alvaro Moreno-Martínez https://orcid.org/0000-0003-2990-7768
Marco Moretti https://orcid.org/0000-0002-5845-3198
Akira S. Mori https://orcid.org/0000-0002-8422-1198
Shigeta Mori https://orcid.org/0000-0001-5604-2443
Dave Morris https://orcid.org/0000-0002-5739-0594
Jane Morrison https://orcid.org/0000-0002-4055-4679
Ladislav Mucina https://orcid.org/0000-0003-0317-8886
Christopher D. Muir https://orcid.org/0000-0003-2555-3878
Sandra Cristina Müller https://orcid.org/0000-0002-6316-2897
François Munoz https://orcid.org/0000-0001-8776-4705
Isla H. Myers-Smith https://orcid.org/0000-0002-8417-6112
Balachandran Natesan https://orcid.org/0000-0001-6396-3865
Luka Negoita https://orcid.org/0000-0003-3225-7575
Andrew S. Nelson https://orcid.org/0000-0001-8715-7825
Eike Lena Neuschulz https://orcid.org/0000-0001-7526-2580
Jian Ni https://orcid.org/0000-0001-5411-7050
Georg Niedrist https://orcid.org/0000-0002-7511-6273
Ülo Niinemets https://orcid.org/0000-0002-3078-2192
Rachael Nolan https://orcid.org/0000-0001-9277-5142
Henning Nottebrock https://orcid.org/0000-0003-2238-2700
Yann Nouvellon https://orcid.org/0000-0003-1920-3847
Alexander Novakovskiy https://orcid.org/0000-0003-4105-7436
Kristin Odden Nystuen https://orcid.org/0000-0003-1027-469X
Kevin O'Hara https://orcid.org/0000-0002-3800-9188
Andrew O'Reilly-Nugent https://orcid.org/0000-0003-2071-6279
Simon Oakley https://orcid.org/0000-0002-5757-7420
Walter Oberhuber https://orcid.org/0000-0002-5197-7044
Toshiyuki Ohtsuka https://orcid.org/0000-0002-9032-7933
Ricardo Oliveira https://orcid.org/0000-0001-8044-3458
Kinga Öllerer https://orcid.org/0000-0003-3142-0000
Mark E. Olson https://orcid.org/0000-0003-3715-4567
Vladimir Onipchenko https://orcid.org/0000-0002-1626-1171
Yusuke Onoda https://orcid.org/0000-0001-6245-2342
Renske E. Onstein https://orcid.org/0000-0002-2295-3510
Ivika Ostonen https://orcid.org/0000-0001-9043-6083
Gianluigi Ottaviani https://orcid.org/0000-0003-3027-4638
Sarah Otto https://orcid.org/0000-0003-3042-0818
Gerhard E. Overbeck https://orcid.org/0000-0002-8716-5136
Wim A. Ozinga https://orcid.org/0000-0002-6369-7859

C. E. Timothy Paine https://orcid.org/0000-0001-8705-3719
Robin J. Pakeman https://orcid.org/0000-0001-6248-4133
Aristotelis C. Papageorgiou https://orcid.org/0000-0001-6657-7820
Meelis Pärtel https://orcid.org/0000-0002-5874-0138
Susana Paula https://orcid.org/0000-0001-5405-6155
Juraj Paule https://orcid.org/0000-0001-5375-7689
Harald Pauli https://orcid.org/0000-0002-9842-9934
Juli G. Pausas https://orcid.org/0000-0003-3533-5786
Begoña Peco https://orcid.org/0000-0003-2149-1438
Josep Penuelas https://orcid.org/0000-0002-7215-0150
Antonio Perea https://orcid.org/0000-0001-8351-9358
Pablo Peri https://orcid.org/0000-0002-5398-4408
Ana Carolina Petisco-Souza https://orcid.org/0000-0002-2393-6210
Alessandro Petraglia https://orcid.org/0000-0003-4632-2251
Any Mary Petritan https://orcid.org/0000-0003-3683-1108
Oliver L. Phillips https://orcid.org/0000-0002-8993-6168
Simon Pierce https://orcid.org/0000-0003-1182-987X
Valério D. Pillar https://orcid.org/0000-0001-6408-2891
Jan Pisek https://orcid.org/0000-0003-0396-2072
Hendrik Poorter https://orcid.org/0000-0001-9900-2433
Angelika Portsmuth https://orcid.org/0000-0002-5100-2888
Peter Poschlod https://orcid.org/0000-0003-4473-7656
A. Shafer Powell https://orcid.org/0000-0002-9622-0061
Sally A. Power https://orcid.org/0000-0002-2723-8671
Giacomo Puglielli https://orcid.org/0000-0003-0085-4535
Petr Pyšek https://orcid.org/0000-0001-8500-442X
Valerie Raevel https://orcid.org/0000-0002-9631-114X
Courtenay A. Ray https://orcid.org/0000-0002-2276-5915
Peter B. Reich http://orcid.org/0000-0003-4424-662X
Douglas E. B. Reid https://orcid.org/0000-0002-0967-5122
Maxime Réjou-Méchain https://orcid.org/0000-0003-2824-267X
Victor Resco de Dios https://orcid.org/0000-0002-5721-1656
Sabina Ribeiro https://orcid.org/0000-0002-4504-3050
Sarah Richardson https://orcid.org/0000-0002-4097-0381
Matthias C. Rillig https://orcid.org/0000-0003-3541-7853
Fiamma Riviera https://orcid.org/0000-0003-2505-8180
Elisabeth M. R. Robert https://orcid.org/0000-0002-3611-7265
Bjorn Robroek https://orcid.org/0000-0002-6714-0652
Adam Roddy https://orcid.org/0000-0002-4423-8729
Arthur Vinicius Rodrigues https://orcid.org/0000-0003-2656-558X
Alistair Rogers https://orcid.org/0000-0001-9262-7430
Emily Rollinson https://orcid.org/0000-0003-3428-2352
Victor Rolo https://orcid.org/0000-0001-5854-9512
Christine Römermann https://orcid.org/0000-0003-3471-0951
Dina Ronzhina https://orcid.org/0000-0003-0854-0223
Christiane Roscher https://orcid.org/0000-0001-9301-7909
Julieta A. Rosell https://orcid.org/0000-0001-5741-8027
Milena Fermina Rosenfield https://orcid.org/0000-0002-1799-2822
David B. Roy https://orcid.org/0000-0002-5147-0331
Samuel Royer-Tardif https://orcid.org/0000-0001-7809-6485
Nadja Rüger https://orcid.org/0000-0003-2371-4172
Ricardo Ruiz-Peinado https://orcid.org/0000-0003-0126-1651
Sabine B. Rumpf https://orcid.org/0000-0001-5909-9568
Masahiro Ryo https://orcid.org/0000-0002-5271-3446
Lawren Sack https://orcid.org/0000-0002-7009-7202
Beatriz Salgado-Negret https://orcid.org/0000-0002-3103-9878
Roberto Salguero-Gomez https://orcid.org/0000-0002-6085-4433
Ignacio Santa-Regina https://orcid.org/0000-0002-7312-3605
Ana Carolina Santacruz-García https://orcid.org/0000-0002-3340-4859
Joaquim Santos https://orcid.org/0000-0002-2160-4968
Jordi Sardans https://orcid.org/0000-0003-2478-0219
Brandon Schamp https://orcid.org/0000-0002-6885-2029
Michael Scherer-Lorenzen https://orcid.org/0000-0001-9566-590X
Matthias Schleuning https://orcid.org/0000-0001-9426-045X
Bernhard Schmid https://orcid.org/0000-0002-8430-3214
Marco Schmidt https://orcid.org/0000-0001-6087-6117
Sylvain Schmitt https://orcid.org/0000-0001-7759-7106
Julio V. Schneider https://orcid.org/0000-0002-9823-6569
Simon D. Schowanek https://orcid.org/0000-0001-6036-7507
Julian Schrader https://orcid.org/0000-0002-8392-211X
Franziska Schrodt https://orcid.org/0000-0001-9053-8872
Frank Schurr https://orcid.org/0000-0002-4518-0602
Galia Selaya Garvizu https://orcid.org/0000-0003-1920-7450
Marina Semchenko https://orcid.org/0000-0001-6196-3562
Julia C. Sfair https://orcid.org/0000-0003-3823-7233
Christine S. Sheppard https://orcid.org/0000-0002-7847-2310
Serge Sheremetiev https://orcid.org/0000-0002-0318-6766
Satomi Shiodera https://orcid.org/0000-0002-6849-8568
Bill Shipley https://orcid.org/0000-0002-7026-3880
Tanvir Ahmed Shovon https://orcid.org/0000-0003-3311-1797
Alrun Siebenkäs https://orcid.org/0000-0001-9676-7094
Carlos Sierra https://orcid.org/0000-0003-0009-4169
Vasco Silva https://orcid.org/0000-0003-2729-1824
Mateus Silva https://orcid.org/0000-0002-4281-3400
Tommaso Sitzia https://orcid.org/0000-0001-6221-4256
Henrik Sjöman https://orcid.org/0000-0002-5526-6303
Martijn Slot https://orcid.org/0000-0002-5558-1792
Nicholas G. Smith https://orcid.org/0000-0001-7048-4387
Darwin Sodhi https://orcid.org/0000-0003-2119-2681
Pamela Soltis https://orcid.org/0000-0001-9310-8659
Douglas Soltis https://orcid.org/0000-0001-8638-4137
Ben Somers https://orcid.org/0000-0002-7875-107X
Grégory Sonnier https://orcid.org/0000-0002-0614-7033
Mia Vedel Sørensen https://orcid.org/0000-0002-2225-6117
Enio Egon Sosinski https://orcid.org/0000-0001-6310-9474
Nadejda A. Soudzilovskaia https://orcid.org/0000-0002-9584-2109
Alexandre F. Souza https://orcid.org/0000-0001-7468-3631
Marko Spasojevic https://orcid.org/0000-0003-1808-0048
Marta Gaia Sperandii https://orcid.org/0000-0002-2507-5928
Amanda B. Stan https://orcid.org/0000-0001-6111-0578
James Stegen https://orcid.org/0000-0001-9135-7424
Klaus Steinbauer https://orcid.org/0000-0002-3730-9920
Jörg G. Stephan https://orcid.org/0000-0001-6195-7867
Dejan B. Stojanovic https://orcid.org/0000-0003-2967-2049
Jens-Christian Svenning https://orcid.org/0000-0002-3415-0862
Ivana Svitková https://orcid.org/0000-0002-5671-0330

Marek Svitok https://orcid.org/0000-0003-2710-8102
Miroslav Svoboda https://orcid.org/0000-0003-4050-3422
Nathan Swenson https://orcid.org/0000-0003-3819-9767
Marcelo Tabarelli https://orcid.org/0000-0001-7573-7216
Kentaro Takagi https://orcid.org/0000-0002-1321-2841
Ulrike Tappeiner https://orcid.org/0000-0002-0195-7459
Rubén Tarifa https://orcid.org/0000-0002-0288-1978
Simon Tauugourdeau https://orcid.org/0000-0001-6561-3228
Cagatay Tavsanoglu https://orcid.org/0000-0003-4447-6492
Mariska te Beest https://orcid.org/0000-0003-3673-4105
Leho Tedersoo https://orcid.org/0000-0002-1635-1249
Nelson Thiffault https://orcid.org/0000-0003-2017-6890
Dominik Thom https://orcid.org/0000-0001-8091-6075
Evert Thomas https://orcid.org/0000-0002-7838-6228
Peter E. Thornton https://orcid.org/0000-0002-4759-5158
Wilfried Thuiller https://orcid.org/0000-0002-5388-5274
Lubomír Tichý https://orcid.org/0000-0001-8400-7741
David Tissue https://orcid.org/0000-0002-8497-2047
Mark G. Tjoelker https://orcid.org/0000-0003-4607-5238
David Yue Phin Tng https://orcid.org/0000-0001-5135-0922
Joseph Tobias https://orcid.org/0000-0003-2429-6179
Péter Török https://orcid.org/0000-0002-4428-3327
Tonantzin Tarin https://orcid.org/0000-0001-5125-579X
José M. Torres-Ruiz https://orcid.org/0000-0003-1367-7056
Béla Tóthmérész https://orcid.org/0000-0002-4766-7668
Martina Treurnicht https://orcid.org/0000-0002-0853-0247
Franck Trolliet https://orcid.org/0000-0003-1472-2592
Volodymyr Trotsiuk https://orcid.org/0000-0002-8363-656X
James L. Tsakalos https://orcid.org/0000-0001-5067-196X
Ioannis Tsiripidis https://orcid.org/0000-0001-9373-676X
Vladimir Usoltsev http://orcid.org/0000-0003-4587-8952
Matthew Vadeboncoeur https://orcid.org/0000-0002-8269-0708
Fernando Valladares https://orcid.org/0000-0002-5374-4682
Jana Vamosi https://orcid.org/0000-0002-2376-0729
Peter M. van Bodegom https://orcid.org/0000-0003-0771-4500
Michiel van Breugel https://orcid.org/0000-0003-2778-7803
Elisa Van Cleemput https://orcid.org/0000-0002-5305-9749
Stephni van der Merwe https://orcid.org/0000-0002-6385-8536
Masha T. van der Sande https://orcid.org/0000-0002-6845-2308
Mark van Kleunen https://orcid.org/0000-0002-2861-3701
Koenraad Van Meerbeek https://orcid.org/0000-0002-9260-3815
Kim André Vanselow https://orcid.org/0000-0003-3299-6220
Laura Varone https://orcid.org/0000-0002-9989-5283
Maribel Yesenia Vasquez Valderrama https://orcid.org/0000-0001-7839-7229
Kiril Vassilev https://orcid.org/0000-0003-4376-5575
Mark Vellend https://orcid.org/0000-0002-2491-956X
Erik J. Veneklaas https://orcid.org/0000-0002-7030-4056
Hans Verbeeck https://orcid.org/0000-0003-1490-0168
Kris Verheyen https://orcid.org/0000-0002-2067-9108
Alexander Vibrans https://orcid.org/0000-0002-8789-5833
Ima Vieira https://orcid.org/0000-0003-1233-318X
Jaime Villacís https://orcid.org/0000-0001-7752-8506
Cyrille Violle https://orcid.org/0000-0002-2471-9226
Katrin Wagner https://orcid.org/0000-0003-4326-1086
Anthony P. Walker https://orcid.org/0000-0003-0557-5594
Martyn Waller https://orcid.org/0000-0003-3876-2492
Han Wang https://orcid.org/0000-0003-2482-1818
Feng Wang https://orcid.org/0000-0003-3595-515X
Weiqi Wang https://orcid.org/0000-0001-8503-0978
Harry Watkins https://orcid.org/0000-0002-4038-7145
James T. Weedon https://orcid.org/0000-0003-0491-8719
Liping Wei https://orcid.org/0000-0002-4296-9851
Patrick Weigelt https://orcid.org/0000-0002-2485-3708
Evan Weiher https://orcid.org/0000-0002-5375-9964
Aidan W. Wells https://orcid.org/0000-0002-2209-3282
Camilla Wellstein https://orcid.org/0000-0001-6994-274X
Mark Westoby https://orcid.org/0000-0001-7690-4530
Philip John White https://orcid.org/0000-0003-0827-288X
Mathew Williams https://orcid.org/0000-0001-6117-5208
Daniel E. Winkler https://orcid.org/0000-0003-4825-9073
Ian J. Wright https://orcid.org/0000-0001-8338-9143
S. Joseph Wright https://orcid.org/0000-0003-4260-5676
Justin Wright https://orcid.org/0000-0002-9102-5347
Bruno X. Pinho https://orcid.org/0000-0002-6588-3575
Fabiano Ximenes https://orcid.org/0000-0003-0516-9414
Toshihiro Yamada https://orcid.org/0000-0001-9307-6255
Keiko Yamaji https://orcid.org/0000-0003-2875-5619
Ruth Yanai https://orcid.org/0000-0001-6987-2489
Amy E. Zanne https://orcid.org/0000-0001-6379-9452
David Zelený https://orcid.org/0000-0001-5157-044X
Jingming Zheng https://orcid.org/0000-0002-8517-9999
Ji Zheng https://orcid.org/0000-0003-4936-1168
Kasia Ziemińska https://orcid.org/0000-0001-7750-4758
Chad R. Zirbel https://orcid.org/0000-0002-9289-1722
Irié Casimir Zo-Bi https://orcid.org/0000-0003-0982-8579
Gerhard Zotz https://orcid.org/0000-0002-6823-2268

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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APPENDIX

Jens Kattge[1,2], Gerhard Bönisch[1], Sandra Díaz[3], Sandra Lavorel[4], Iain Colin Prentice[5], Paul Leadley[6], Susanne Tautenhahn[1], Gijsbert D. A. Werner[7,8], Tuomas Aakala[9], Mehdi Abedi[10], Alicia T. R. Acosta[11], George C. Adamidis[12,13], Kairi Adamson[14], Masahiro Aiba[15], Cécile H. Albert[16], Julio M. Alcántara[17], Carolina Alcázar C[18], Izabela Aleixo[19], Hamada Ali[20], Bernard Amiaud[21], Christian Ammer[22,23], Mariano M. Amoroso[24,25], Madhur Anand[26], Carolyn Anderson[27,28], Niels Anten[29], Joseph Antos[30], Deborah Mattos Guimarães Apgaua[31], Tia-Lynn Ashman[32], Degi Harja Asmara[33], Gregory P. Asner[34], Michael Aspinwall[35], Owen Atkin[36], Isabelle Aubin[37], Lars Baastrup-Spohr[38], Khadijeh Bahalkeh[10], Michael Bahn[39], Timothy Baker[40], William J. Baker[41], Jan P. Bakker[42], Dennis Baldocchi[43], Jennifer Baltzer[44], Arindam Banerjee[45], Anne Baranger[46], Jos Barlow[47], Diego R. Barneche[48], Zdravko Baruch[49], Denis Bastianelli[50,51], John Battles[52], William Bauerle[53], Marijn Bauters[54,55], Erika Bazzato[56], Michael Beckmann[57], Hans Beeckman[58], Carl Beierkuhnlein[59], Renee Bekker[60], Gavin Belfry[61,62], Michael Belluau[63], Mirela Beloiu[64], Raquel Benavides[65], Lahcen Benomar[66], Mary Lee Berdugo-Lattke[67,68], Erika Berenguer[69], Rodrigo Bergamin[70], Joana Bergmann[71,72], Marcos Bergmann Carlucci[73], Logan Berner[74], Markus Bernhardt-Römermann[75], Christof Bigler[76], Anne D. Bjorkman[77], Chris Blackman[78], Carolina Blanco[79], Benjamin Blonder[80,62], Dana Blumenthal[81], Kelly T. Bocanegra-González[82], Pascal Boeckx[83], Stephanie Bohlman[84], Katrin Böhning-Gaese[85,86], Laura Boisvert-Marsh[37], William Bond[87,88], Ben Bond-Lamberty[89], Arnoud Boom[90], Coline C. F. Boonman[91], Kauane Bordin[92], Elizabeth H. Boughton[93], Vanessa Boukili[94], David M. J. S. Bowman[95], Sandra Bravo[96], Marco Richard Brendel[97], Martin R. Broadley[98], Kerry A. Brown[99], Helge Bruelheide[100,2], Federico Brumnich[25,101], Hans Henrik Bruun[38], David Bruy[102,103], Serra W. Buchanan[104], Solveig Franziska Bucher[105], Nina Buchmann[76], Robert Buitenwerf[106,107], Daniel E. Bunker[108], Jana Bürger[109], Sabina Burrascano[110], David F. R. P. Burslem[111], Bradley J. Butterfield[112], Chaeho Byun[113], Marcia Marques[114], Marina C. Scalon[115], Marco Caccianiga[116], Marc Cadotte[104], Maxime Cailleret[117,118,119], James Camac[120], Jesús Julio Camarero[121], Courtney Campany[122], Giandiego Campetella[123], Juan Antonio Campos[124], Laura Cano-Arboleda[125,68], Roberto Canullo[123], Michele Carbognani[126], Fabio Carvalho[47], Fernando Casanoves[127], Bastien Castagneyrol[128], Jane A. Catford[129], Jeannine Cavender-Bares[130], Bruno E. L. Cerabolini[131], Marco Cervellini[123,132], Eduardo Chacón-Madrigal[133], Kenneth Chapin[134], F. Stuart Chapin[135], Stefano Chelli[123], Si-Chong Chen[136], Anping Chen[137], Paolo Cherubini[138,139], Francesco Chianucci[140], Brendan Choat[141], Kyong-Sook Chung[142], Milan Chytrý[143], Daniela Ciccarelli[144], Lluís Coll[145,146], Courtney G. Collins[147], Luisa Conti[148,149], David Coomes[150], Johannes H. C. Cornelissen[151], William K. Cornwell[152], Piermaria Corona[140], Marie Coyea[153], Joseph Craine[154], Dylan Craven[155], Joris P. G. M. Cromsigt[156,157], Anikó Csecserits[158], Katarina Cufar[159], Matthias Cuntz[160], Ana

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Walker[482], Martyn Waller[99], Gabriel Walther[75], Han Wang[615], Feng Wang[616], Weiqi Wang[617], Harry Watkins[618], James Watkins[619], Ulrich Weber[1], James T. Weedon[620], Liping Wei[346], Patrick Weigelt[334], Evan Weiher[353], Aidan W. Wells[62,621], Camilla Wellstein[622], Elizabeth Wenk[199], Mark Westoby[181], Alana Westwood[623], Philip John White[624,625], Mark Whitten[239], Mathew Williams[402], Daniel E. Winkler[626,627], Klaus Winter[246], Chevonne Womack[169], Ian J. Wright[181], S. Joseph Wright[246], Justin Wright[628], Bruno X. Pinho[563], Fabiano Ximenes[629], Toshihiro Yamada[630], Keiko Yamaji[631], Ruth Yanai[632], Nikolay Yankov[476], Benjamin Yguel[633], Kátia Janaina Zanini[634], Amy E. Zanne[635], David Zelený[636], Yun-Peng Zhao[637], Jingming Zheng[638], Ji Zheng[361,362], Kasia Ziemińska[5], Chad R. Zirbel[130], Georg Zizka[86,182], Irié Casimir Zo-Bi[639], Gerhard Zotz[246,640], Christian Wirth[1,2,358]

[1]Max Planck Institute for Biogeochemistry, Jena, Germany, [2]German Center for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany, [3]Consejo Nacional de Investigaciones Científicas y Técnicas, Instituto Multidisciplinario de Biología Vegetal (IMBIV), and Factulad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba, Argentina, [4]Univ. Grenoble Alpes, CNRS, Univ. Savoie Mont Blanc, LECA, Grenoble, France, [5]Imperial College, London, UK, [6]Ecologie Systématique Evolution, CNRS, AgroParisTech, University of Paris-Sud, Université Paris-Saclay, Orsay, France, [7]Department of Zoology, University of Oxford, Oxford, UK, [8]Balliol College, University of Oxford, Oxford, UK, [9]University of Helsinki, Helsinki, Finland, [10]Department of Range Management, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Iran, [11]University of

Roma Tre, Rome, Italy, [12]Biodiversity Conservation Laboratory, Department of Environment, University of the Aegean, Mytilene, Greece, [13]Institute of Ecology and Evolution, University of Bern, Bern, Switzerland, [14]Tartu Observatory, University of Tartu, Tartumaa, Estonia, [15]Graduate School of Life Sciences, Tohoku University, Sendai, Japan, [16]Aix Marseille Univ, Univ Avignon, CNRS, IRD, IMBE, Marseille, France, [17]Universidad de Jaén, Jaén, Spain, [18]Instituto Alexander Von Humboldt, Bogota, Colombia, [19]National Institute of Amazonian Research (INPA), Manaus, Brazil, [20]Botany Department, Faculty of Science, Suez Canal University, Ismailia, Egypt, [21]Université de Lorraine, Lorraine, France, [22]Forest Sciences, University of Göttingen, Göttingen, Germany, [23]Centre for Biodiversity and Sustainable Land-use, University of Göttingen, Göttingen, Germany, [24]Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural (IRNAD), Universidad Nacional de Río Negro, El Bolsón, Argentina, [25]Conicet-Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires, Argentina, [26]University of Guelph, Guelph, ON, Canada, [27]Pacific Northwest National Laboratory, Richland, WA, USA, [28]University of Massachusetts Amherst, Amherst, MA, USA, [29]Centre for Crop Systems Analysis, Wageningen University, Wageningen, The Netherlands, [30]University of Victoria, Victoria, BC, Canada, [31]College of Science & Engineering, James Cook University, Smithfield, Qld, Australia, [32]University of Pittsburgh, Pittsburgh, PA, USA, [33]Centre for Forest Research, Institute for Integrative Systems Biology, Université Laval, Quebec, QC, Canada, [34]Arizona State University, Tempe, AZ, USA, [35]Department of Biology, University of North Florida, Jacksonville, FL, USA, [36]ARC Centre for Excellence in Plant Energy Biology, Australian National University, Acton, ACT, Australia, [37]Great Lakes Forestry Centre, Canadian Forest Service, Natural Resources Canada, Sault Ste. Marie, ON, Canada, [38]Department of Biology, University of Copenhagen, Copenhagen, Denmark, [39]Department of Ecology, University of Innsbruck, Innsbruck, Austria, [40]School of Geography, University of Leeds, Leeds, UK, [41]Royal Botanic Gardens Kew, Richmond, UK, [42]Conservation Ecology, Groningen Institute for Evolutionary Life Sciences (GELIFES), University of Groningen, Groningen, The Netherlands, [43]Department of Environmental Science, Policy and Management, University of California Berkeley, Berkeley, CA, USA, [44]Biology Department, Wilfrid Laurier University, Waterloo, ON, Canada, [45]Department of Forest Resources, University of Minnesota, St. Paul, MN, USA, [46]AgroParisTech, Paris, France, [47]Lancaster Environment Centre, Lancaster University, Lancaster, UK, [48]College of Life and Environmental Sciences, University of Exeter, Penryn, UK, [49]School of Biological Sciences, The University of Adelaide, Adelaide, SA, Australia, [50]CIRAD, UMR SELMET, Montpellier, France, [51]SELMET, CIRAD, INRA, Univ Montpellier, Montpellier SupAgro, France, [52]University of California at Berkeley, Berkeley, CA, USA, [53]Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO, USA, [54]Department of Green Chemistry and Technology, Ghent University, Gent, Belgium, [55]Department of Environment, Ghent University, Gent, Belgium, [56]Department of Life and Environmental Sciences, Botany Division, University of Cagliari, Cagliari, Italy, [57]Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany, [58]Royal Museum for Central Africa, Tervuren, Belgium, [59]University of Bayreuth, Bayreuth, Germany, [60]Groningen Institute of Archaeology (GIA), University of Groningen, Groningen, The Netherlands, [61]Department of Biological Sciences, University of Tennessee, Knoxville, TN, USA, [62]Rocky Mountain Biological Laboratory, Crested Butte, CO, USA, [63]Département des Science, Université du Québec À Montréal, Montreal, QC, Canada, [64]Department of Biogeography, University of Bayreuth, Bayreuth, Germany, [65]Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain, [66]Université Laval, Quebec, QC, Canada, [67]Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogota, Colombia, [68]Fundación Natura, Bogota, Colombia, [69]Environmental Change Institute, University of Oxford, Oxford, UK, [70]Laboratório de Estudos em Vegetação Campestre (LEVCamp), Programa de Pós-Graduação em Botânica, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, [71]Institut für Biologie, Freie Universität Berlin, Berlin, Germany, [72]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, Germany, [73]Laboratório de Ecologia Funcional de Comunidades (LABEF), Departamento de Botânica, Universidade Federal do Paraná, Curitiba, Brazil, [74]School of Informatics, Computing, and Cyber Systems, Northern Arizona University, Flagstaff, AZ, USA, [75]Institute of Ecology and Evolution, Friedrich Schiller University Jena, Jena, Germany, [76]ETH Zurich, Zurich, Switzerland, [77]Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden, [78]PIAF, INRA, Université Clermont-Auvergne, Clermont-Ferrand, France, [79]Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, [80]School of Life Sciences, Arizona State University, Tempe, AZ, USA, [81]USDA-ARS Rangeland Resources & Systems Research Unit, Fort Collins, CO, USA, [82]Grupo de Investigación en Biodiversidad y Dinámica de Ecosistémas Tropicales - Universidad del Tolima, Ibagué, Colombia, [83]Isotope Bioscience Laboratory - ISOFYS, Ghent University, Gent, Belgium, [84]School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA, [85]Senckenberg Biodiversity and Climate Research Centre, Frankfurt am Main, Germany, [86]Department of Biological Sciences, Goethe Universität Frankfurt, Frankfurt am Main, Germany, [87]Department of Biological Sciences, University of Cape Town, Cape Town, South Africa, [88]SAEON Fynbos Node, Claremont, South Africa, [89]Pacific Northwest National Laboratory, College Park, MD, USA, [90]School of Geography, Geology and Environment, University of Leicester, Leicester, UK, [91]Department of Environmental Science, Institute for Water and Wetland Research, Radboud University, Nijmegen, The Netherlands, [92]Laboratório de Ecologia Vegetal (LEVEG), Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, [93]Archbold Biological Station's Buck Island Ranch, FL, Lake Placid, USA, [94]Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT, USA, [95]University of Tasmania, Hobart, Tas., Australia, [96]Facultad de Ciencias Forestales, Universidad Nacional de Santiago del Estero, Santiago del Estero, Argentina, [97]Institute of Landscape and Plant Ecology, University of Hohenheim, Stuttgart, Germany, [98]School of Geography, University of Nottingham, Nottingham, UK, [99]Department of Geography and Geology, Kingston University, Kingston upon Thames, UK, [100]Institute of Biology/Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, Germany, [101]Facultad de Ingeniería y Ciencias Hídricas, Universidad Nacional del Litoral (FICH-UNL), Santa Fe, Argentina, [102]AMAP, CIRAD, CNRS, IRD, INRA, Université de Montpellier, Montpellier, France, [103]AMAP, IRD, Herbier de Nouvelle-Calédonie, Nouméa, New Caledonia, [104]University of Toronto Scarborough, Scarborough, ON, Canada, [105]Friedrich-Schiller-Universität Jena, Jena, Germany, [106]Section for Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Aarhus, Denmark, [107]Center for Biodiversity Dynamics in a Changing World (BIOCHANGE), Department of Bioscience, Aarhus University, Aarhus, Denmark, [108]New Jersey Institute of Technology, Newark, NJ, USA, [109]Faculty of Agricultural and Environmental Sciences, University of Rostock, Rostock, Germany, [110]Sapienza University of Rome, Rome, Italy, [111]School of Biological Sciences, University of Aberdeen, Aberdeen, UK, [112]Center for Ecosystem Science and Society, Northern Arizona University, Flagstaff, AZ, USA, [113]School of Civil and Environmental Engineering, Yonsei University, Seoul, Korea, [114]Departamento de Botânica, SCB, UFPR – Federal University of Parana, Curitiba, Brazil, [115]Centro Politécnico, Universidade Federal do Paraná, Curitiba, Brazil, [116]Dipartimento di Bioscienze, Università degli Studi di Milano, Milano, Italy, [117]IRSTEA Aix-en-Provence, UMR RECOVER, Aix-Marseille University, Aix-en-Provence, France, [118]Department of Environmental Systems Science, ETH Zürich, Zürich, Switzerland, [119]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland, [120]Centre of Excellence for Bioscurity Risk Analysis, The University of Melbourne, Melbourne, Vic., Australia, [121]Instituto Pirenaico de Ecología (IPE-CSIC), Zaragoza, Spain, [122]Colgate University, Hamilton, NY, USA, [123]School of Biosciences and Veterinary Medicine, Plant Diversity and Ecosystems Management Unit, University of Camerino, Camerino, Italy, [124]Department of Plant Biology and Ecology, University of the Basque Country UPV/EHU, Bilbao, Spain, [125]Departamento de Geociencias y Medio Ambiente, Universidad Nacional de Colombia, Medellin, Colombia, [126]Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parma, Italy, [127]CATIE-Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica, [128]Univ. Bordeaux, INRAE, BIOGECO, Cestas, France, [129]Department of Geography, King's College London, London, UK, [130]Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, MN, USA, [131]Department of Biotechnology and Life Sciences, University of Insubria, Varese, Italy, [132]BIGEA, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum – University of Bologna, Bologna, Italy, [133]Escuela de Biología, Universidad de Costa Rica, San José, Costa Rica, [134]The University of Arizona, Tucson, AZ, USA, [135]Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, USA, [136]Royal Botanic Gardens, Kew, West Sussex, UK, [137]Department of Biology, Colorado State University, Fort Collins, CO, USA, [138]WSL Swiss Federal Research Institute, Birmensdorf, Switzerland, [139]Faculty of Forestry, University of British Columbia, Vancouver, BC, Canada, [140]CREA – Research Centre for Forestry and Wood, Arezzo, Italy, [141]Hawkesbury Institute for the Environment, Western Sydney University, Sydney, NSW, Australia, [142]Jungwon University, Goesan, Chungbuk, Korea, [143]Department of Botany and Zoology, Masaryk University, Brno, Czech Republic, [144]Department of Biology, University of Pisa, Pisa, Italy, [145]Department of Agriculture and Forest Engineering (EAGROF), University of Lleida, Lleida, Spain, [146]Joint Research Unit CTFC – AGROTECNIO, Solsona, Spain, [147]University of California Riverside, Riverside, CA, USA, [148]Faculty of Environmental Sciences, University of Life Sciences Prague, Praha-Suchdol, Czech Republic, [149]Institute of Botany, Czech Academy of Sciences, Třeboň, Czech Republic, [150]Department of Plant Sciences, University of Cambridge, Cambridge, UK, [151]Systems Ecology, Department of Ecological Science, Vrije Universiteit, Amsterdam, The Netherlands, [152]School of Biological, Earth and Environmental Sciences, UNSW Sydney, Sydney, NSW, Australia, [153]Faculté de foresterie, de géographie et de géomatique, Université Laval, Quebec, QC, Canada, [154]Jonah Ventures, Boulder, CO, USA, [155]Centro de Modelación y Monitoreo de Ecosistemas, Universidad Mayor, Santiago, Chile, [156]Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences, Umeå, Sweden, [157]Centre for African Conservation Ecology, Department of Zoology, Nelson Mandela University, Port Elizabeth, South Africa, [158]MTA Centre for Ecological Research, Tihany, Hungary, [159]Biotechnical Faculty, University of Ljubljana, Ljubljana, Slovenia, [160]Université de Lorraine, AgroParisTech, INRAE, UMR Silva, Nancy, France, [161]Santa Catarina State University, Lages, SC, Brazil, [162]Department of Geography, Environment, and Spatial Sciences, Michigan State University, East Lansing, MI, USA, [163]Eurac Research, Institute for Alpine Environment, Bozen-Bolzano, Italy, [164]Institute of Biology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Syktyvkar, Komi Republic, Russia, [165]University of Science – Vietnam National University Ho Chi Minh City, Ho Chi Minh City, Vietnam, [166]Graduate School of Agriculture, Kyoto University, Kyoto, Japan, [167]Graduate School of Global Environmental Studies, Kyoto University, Kyoto, Japan, [168]Swedish Species Information Centre, Swedish University of Agricultural Sciences, Uppsala, Sweden, [169]Department of Plant and Soil Sciences, University of Pretoria, Pretoria, South Africa, [170]Department of Terrestrial Ecology, Netherlands Institute of Ecology, Wageningen, The Netherlands, [171]Department Computational Landscape Ecology, UFZ – Helmholtz Centre for Environmental Research, Leipzig, Germany, [172]Department Computational Hydrosystems, UFZ – Helmholtz Centre for Environmental Research, Leipzig, Germany, [173]Department of Landscape Architecture and Rural Systems Engineering, Seoul National University, Seoul, Republic of Korea, [174]Institute of Temperate Forest Sciences (ISFORT), Ripon, QC, Canada, [175]UQO, Department of Natural Sciences, Ripon, QC, Canada, [176]Cirad, UMR EcoFoG (Agroparistech, CNRS, INRA, Université des Antilles, Université de la Guyane), Kourou, French Guiana, France, [177]Institut für Physische Geographie, Biogeography and Biodiversity Lab, Goethe-Universität Frankfurt, Frankfurt am Main, Germany, [178]Department of Biology, University of Florida, Gainesville, FL, USA, [179]Iluka Resources, Perth, WA, Australia, [180]School of Biological Sciences, The University of Western Australia, Perth, WA, Australia, [181]Department of Biological Sciences, Macquarie University, Sydney, NSW, Australia, [182]Department of Botany and Molecular Evolution, Senckenberg Research Institute and Natural History Museum, Frankfurt am Main, Germany, [183]Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria, [184]Helmholtz Centre for Environmental Research – UFZ, Halle, Germany, [185]Department of Botany, Faculty of Sciences, University of South Bohemia, Ceske Budejovice, Czech Republic, [186]Department of Environmental and Life Sciences – Biology, Karlstad University, Karlstad, Sweden, [187]Quantitative Plant Ecology and Biodiversity Research Laboratory, Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran, [188]Flathead Lake Biological Station, University of Montana, Polson, MT, USA, [189]School of Sustainability, Arizona State University, Tempe, AZ, USA, [190]Programa Nacional de Pós-Doutorado (PNPD), Programa de Pós Graduação em Ecologia, Institute of Biology, University of Campinas UNICAMP, Brazil, [191]Institute for Ecosystem Research/Geobotany, Kiel University, Kiel, Germany, [192]School of Geography, Earth and Environmental Sciences – University of Birmingham, Birmingham, UK, [193]Institute for Plant Ecology, Justus Liebig University, Giessen, Germany, [194]Spanish National Research Council – CSIC, Catalonia, Spain, [195]CREAF, Catalonia, Spain, [196]Department of Biology – FFCLRP/USP, Ribeirão Preto, Brazil, [197]University of Maryland, College Park, MD, USA, [198]Campus da Zapateira, University of A Coruña, A Coruña, Spain, [199]Evolution & Ecology Research Centre, and School of Biological, Earth and Environmental Sciences, UNSW Sydney, Sydney, NSW, Australia, [200]Rutgers University, Piscataway, NJ, USA, [201]Peking University, Beijing, China, [202]Department of Chemistry and Pharmacy, University of Sassari, Sassari, Italy, [203]Faculty of Arts and Sciences, Molecular Biology and Genetics, Ordu University, Ordu, Turkey, [204]State Key Laboratory of Grassland Agro-ecosystems, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou, China, [205]Centro Forestal Tropical Bajo Calima, Universidad del Tolima, Buenaventura, Colombia, [206]Embrapa Amazônia Oriental, Belém, Brazil, [207]Instituto de Biociências, Laboratory of Vegetation Ecology, Universidade Estadual Paulista (UNESP), Rio Claro, Brazil, [208]Queensland University of Technology (QUT), Brisbane, Australia, [209]School of Life Sciences, University of Sussex, Brighton, UK, [210]Arnold Arboretum of Harvard University, Boston, MA, USA, [211]Laboratoire ECODIV URA, IRSTEA/EA 1293, Normandie Université, UFR ST, Université de Rouen, Mont Saint-Aignan, France, [212]Department of Botany, Biosciences Institute, Federal University of Rio Grande do Sul, Porto Alegre, Brazil, [213]Unit of Research SPHERES, University of Liège, Liège, Belgium, [214]Géopole de l'Université de Sherbrooke, Quebec, QC, Canada, [215]Theoretical and Experimental Ecology Station, CNRS, Paul Sabatier University Toulouse, Moulis, France, [216]School of Earth and Environment Science, University of Manchester, Manchester, UK, [217]Department of Plant Biology, Institute of Biology, University of Campinas, Campinas, Brazil, [218]Universidade Federal do Rio Grande do Norte – UFRN, Natal, RN, Brazil, [219]Departamento de Biología y Geología, Física y Química Inorgánica y Analítica, Universidad Rey Juan Carlos, Móstoles, Spain, [220]Instituto Nacional de Tecnología Agropecuaria, Consejo Nacional de Invetigaciones Científicas y Técnicas, Universidad Nacional de La Patagonia Austral, Río Gallegos, Argentina, [221]UMR 5175 CEFE, Univ. Montpellier, CNRS, EPHE, IRD, Univ. Paul Valéry, Montpellier, France, [222]Estación Experimental del Zaidín, Consejo Superior de Investigaciones Científicas, Granada, Spain, [223]Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, Sevilla, Spain, [224]Universidade Regional de Blumenau, Blumenau, SC, Brazil, [225]INIA-CIFOR, Madrid, Spain, [226]School of Biological Sciences, Southern Illinois University Carbondale, Carbondale, IL, USA, [227]Center for Biodiversity Management, Yungaburra, Qld, Australia, [228]Instituto Federal de Educação Ciência e Tecnologia do Ceará, Crateús, Brazil, [229]The Morton Arboretum, Lisle, IL, USA, [230]Water Management and Systems Research Unit, United States Department of Agriculture, Agricultural Research Service, Fort Collins, CO, USA, [231]Institute of Integrative Biology, ETH Zürich (Swiss Federal Institute of Technology), Zürich, Switzerland, [232]Department of Ecology, Evolution & Behavior, University of Minnesota, Minneapolis, MN, USA, [233]Smithsonian Conservation Biology Institute, Front Royal, VA, USA, [234]CSIC – Institute for Sustainable Agriculture (IAS), Cordoba, Spain, [235]Facultad de Ciencias Naturales y Matemáticas, Universidad del Rosario, Bogota, Colombia, [236]Departamento de Biología Animal, Biología Vegetal y Ecología, Universidad de Jaén, Jaén, Spain, [237]Norwegian University of Science and Technology NTNU, Trondheim, Norway, [238]Department of Life Sciences, University of Alcalá, Alcala de Henares, Spain, [239]University of Florida, Gainesville, FL, USA, [240]Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA, [241]UCA, INRA, VetAgro Sup, UMR Ecosystème Prairial, Clermont-Ferrand, France, [242]Departamento de Biología y Geología, Física y Química Inorgánica, Escuela Superior de Ciencias Experimentales y Tecnología, Universidad Rey Juan Carlos, Móstoles, Spain, [243]Departamento de Ciencias Ambientales y Recursos Naturales Renovables, Facultad de Ciencias Agronómicas, Universidad de Chile, Santiago, Chile, [244]Pacific Northwest National Laboratory, Joint Global Change Research Institute, College Park, MD, USA, [245]The University of Manchester, Manchester, UK, [246]Smithsonian Tropical Research Institute, Balboa, Ancon, Republic of Panama, [247]Unit of research SPHERES, University of Liège, Liège, Belgium, [248]College of Resources and Environmental Sciences, China Agricultural University, Beijing, China, [249]Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, China, [250]Research Center for Ecology and Environment of Central Asia, Chinese Academy of Sciences, Urumqi, China, [251]University of Reading, Reading, UK, [252]School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa, [253]Applied Ecology Research Group, School of Life Sciences, Anglia Ruskin University, Cambridge, UK, [254]Faculty of Environmental

Sciences and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway, [255]School of Molecular and Life Sciences, Curtin University, Perth, WA, Australia, [256]College of Science, Health, Engineering and Education, Murdoch University, Murdoch, WA, Australia, [257]South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, China, [258]Carnegie Museum of Natural History, Pittsburgh, PA, USA, [259]Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia, [260]Herbarium Haussknecht, Friedrich-Schiller-Universität Jena, Jena, Germany, [261]Cirad, Université de Montpellier, Montpellier, France, [262]Institut National Polytehcnique Félix Houphouet-Boigny, INP-HB, Yamoussoukro, Ivory Coast, [263]Department of Forest Sciences, Transilvania University of Brasov, Brasov, Romania, [264]BC3 - Basque Centre for Climate Change, Scientific Campus of the University of the Basque Country, Leioa, Spain, [265]Department of Physical Geography, Goethe University, Frankfurt am Main, Germany, [266]Institute of Botany, University of Natural Resources and Life Sciences, Vienna, Austria, [267]The Field Museum, Chicago, IL, USA, [268]University Centre Myerscough, Preston, UK, [269]Department of Biological Sciences, Florida International University, Miami, FL, USA, [270]Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, TN, [271]University of California, Santa Cruz, Santa Cruz, CA, USA, [272]Plant Conservation and Population Biology, Department of Biology, KU Leuven, Leuven, Belgium, [273]Division of Ecology, Evolution and Biodiversity Conservation, Heverlee, Belgium, [274]Four Peaks Environmental Science and Data Solutions, Wenatchee, WA, USA, [275]Department of Landscape and Biodiversity, Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway, [276]Kochi University, Nankoku, Japan, [277]University of Illinois at Chicago, Chicago, IL, USA, [278]Department of Evolutionary Biology, Ecology and Environmental Sciences, Biodiversity Research Institute (IRBio), Universitat de Barcelona, Barcelona, Spain, [279]University of Toronto, Toronto, ON, Canada, [280]Ashiu Forest Research Station, Field Science Education and Research Center, Kyoto University, Kyoto, Japan, [281]Institute Botanic Garden, Ural Branch of the Russian Academy of Sciences, Ekaterinburg, Russia, [282]Tyumen State University, Tyumen, Russia, [283]Oak Ridge National Laboratory, Oak Ridge, TN, USA, [284]Barcelona School of Agricultural Engineering, Universitat Politècnica de Catalunya, Catalonia, Spain, [285]Earth System Science Department, Stanford University, Stanford, CA, USA, [286]Global Academy of Agriculture and Food Security, University of Edinburgh, Midlothian, Scotland, [287]Institute of Dendrology, Polish Academy of Sciences, Kornik, Poland, [288]Department of Game Management and Forest Protection, Faculty of Forestry, Poznan University of Life Sciences, Poznan, Poland, [289]Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, Germany, [290]Institute of Systematic Botany and Ecology, Ulm University, Ulm, Germany, [291]BayCEER, Department of Disturbance Ecology, University of Bayreuth, Bayreuth, Germany, [292]Department of Biology, University of Copenhagen, Frederiksberg C, Denmark, [293]Plant Ecophysiology & Evolution Group, Guangxi Key Laboratory of Forest Ecology and Conservation, College of Forestry, Guangxi University, Nanning, Guangxi, PR China, [294]State Key Laboratory for Conservation and Utilization of Subtropical Agro-bioresources, Guangxi University, Nanning, PR China, [295]Terrestrial Ecology Section, Department of Biology, University of Copenhagen, Denmark, [296]State University of Campinas/UNICAMP, Campinas, SP, Brazil, [297]Biological Sciences, University of Tasmania, Hobart, Australia, [298]Department of Zoology, School of Mathematical and Natural Science, University of Venda, Thohoyandou, South Africa, [299]Department of Biological Sciences, DST/NRF Centre of Excellence, Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch, South Africa, [300]Cibodas Botanical Garden – Indonesian Institute of Sciences (LIPI), Jl. Kebun Raya Cibodas, Cipanas, Indonesia, [301]Centre of Excellence for Biosecurity Risk Analysis (CEBRA), School Of Biosciences, University of Melbourne, Parkville, Vic., Australia, [302]Evolutionary Ecology of Plants, Department Biology, Philipps-University Marburg, Marburg, Germany, [303]Department of Bioscience, University Salzburg, Salzburg, Austria, [304]PERSYST Department, CIRAD, Montpellier Cedex 5, France, [305]BC Ministry Forest, Lands, Natural Resource Operations and Rural Development, Dawson Creek, BC, Canada, [306]Humboldt State University, Arcata, CA, USA, [307]Institute of Botany, The Czech Academy of Sciences, Prùhonice, Czech Republic, [308]Department of Botany, Faculty of Science, Charles University, Prague, Czech Republic, [309]Institute of Geography and Geoecology, Karlsruhe Institute of Technology, Karlsruhe, Germany, [310]Samara National Research University, Samara, Russia, [311]CAVElab - Computational and Applied Vegetation Ecology, Ghent University, Ghent, Belgium, [312]Institute of Plant Sciences, Bern, Switzerland, [313]Forestry and Forest Products Research Institute, Tsukuba, Japan, [314]Kenyon College, Gambier, OH, USA, [315]Department of Biology, University of Garmian, Kalar, Iraq, [316]School of Biological Sciences and Center for Ecology, Southern Illinois University Carbondale, Carbondale, IL, USA, [317]Department of Ecology and Evolution, State University of New York at Stony Brook, Stony Brook, NY, USA, [318]Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, Amsterdam, The Netherlands, [319]Instituto de Investigaciones en Biodiversidad y Medioambiente (INIBIOMA), CONICET, Bariloche, Argentina, [320]Departamento de Ecología, Universidad Nacional del Comahue, Bariloche, Argentina, [321]Department of Plant and Environmental Sciences, Weizmann Institute of Science, Rehovot, Israel, [322]Landscape Ecology Group, Institute of Biology and Environmental Sciences, University of Oldenburg, Oldenburg, Germany, [323]Faculty of Sciences, Charles University, Praha, Czech Republic, [324]Laboratório de Ecologia Vegetal (LEVEG), Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, [325]Department of Geosciences and Natural Resources, Western Carolina University, Cullowhee, NC, USA, [326]Department of Community Ecology, Helmholtz Centre for Environmental Research-UFZ, Halle (Saale), Germany, [327]Health and Environmental Sciences, Xi'an Jiaotong Liverpool University, Suzhou, Jiangsu, China, [328]Hokkaido University, Sapporo, Japan, [329]Graduate School of Environment and Information Sciences, Yokohama National University, Yokohama, Japan, [330]Technical University of Munich, Freising, Germany, [331]Institut d Estudis Andorrans, Andorra, [332]Smithsonian Environmental Research Center, Edgewater, MD, USA, [333]Department of Geography, Humboldt University of Berlin, Berlin, Germany, [334]Biodiversity, Macroecology and Biogeography, University of Goettingen, Göttingen, Germany, [335]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, CA, USA, [336]Wageningen University & Research, Wageningen, The Netherlands, [337]Land Life Company, Amsterdam, The Netherlands, [338]Centre of Biodiversity and Sustainable Land Use (CBL), University of Goettingen, Göttingen, Germany, [339]Martin Luther University Halle-Wittenberg, Halle, Germany, [340]Plant Physiology Division, Coconut Research Institute of Sri Lanka, Lunuwila, Sri Lanka, [341]Institute of Evolutionary Ecology and Conservation Genomics, Ulm University, Ulm, Germany, [342]Yamagata University, Yamagata, Japan, [343]Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya, [344]CIRAD, UMR Eco&Sols, Montpellier, France, [345]Eco&Sols, CIRAD, INRA, IRD, SupAgro, University of Montpellier, Montpellier, France, [346]Institut de recherche sur les forêts, Université du Québec en Abitibi-Témiscamingue, Rouyn-Noranda, QC, Canada, [347]Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK, Canada, [348]GLORIA-Coordination, Institute for Interdisciplinary Mountain Research, Austrian Academy of Sciences & Department of Integrative Biology and Biodiversity Research, University of Natural Resources and Life Sciences Vienna, Vienna, Austria, [349]Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, MN, USA, [350]Botany Department, University of Wyoming, Laramie, WY, USA, [351]Aix Marseille Univ, Univ Avignon, CNRS, IRD, IMBE, Marseille, France, [352]Nelson Mandela University, Port Elizabeth, South Africa, [353]University of Wisconsin Eau Claire, Eau Claire, WI, USA, [354]Naturalis Biodiversity Center, Leiden, The Netherlands, [355]Department of Geography, University College London, London, UK, [356]Sun Yat-sen University, Guangzhou, China, [357]Yangzhou University, Yangzhou, Jiangsu, China, [358]University of Leipzig, Leipzig, Germany, [359]Macquarie University, North Ryde, NSW, Australia, [360]University Pablo de Olavide, Seville, Spain, [361]School of Agriculture and Biology, Shanghai Jiao Tong University, Shanghai, P. R. China, [362]Shanghai Urban Forest Ecosystem Research Station, National Forestry and Grassland Administration, Shanghai, P.R. China, [363]Universitat Autònoma de Barcelona, Barcelona, Spain, [364]Forest Ecology and Forest Management Group, Wageningen University and Research, Wageningen, The Netherlands, [365]World Agroforestry (ICRAF), Nairobi, Kenya, [366]Dept. Animal Biology, Plant Biology and Ecology, University of Jaén, Jaén, Spain, [367]water@leeds, School of Geography, University of Leeds, Leeds, UK, [368]Department for Tisza River Research, MTA Centre for Ecological Research, DRI, Debrecen, Hungary, [369]Global Change Research Institute AS CR, Brno, Czech Republic, [370]Department of Ecology, School of Horticulture and Plant Protection, Yangzhou University, Yangzhou, China, [371]State Key Laboratory of Urban and Regional Ecology, Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China, [372]University of Copenhagen, Copenhagen, Denmark, [373]Université du Québec à Trois-Rivières, Trois-Rivières, Canada, [374]Institute of Atmospheric and Earth System Research (INAR), University of Helsinki, Helsinki, Finland, [375]Natural Resources Institute Finland, Espoo, Finland, [376]Federal University of Alagoas, Maceió, AL, Brazil, [377]Lakehead University, Thunder Bay, ON, Canada, [378]Department of Physical Geography, Stockholm University, Stockholm, Sweden, [379]Bolin Centre for Climate Research, Stockholm, Sweden, [380]Universidade Federal do Paraná, Curitiba, PR, Brazil, [381]School of Natural Sciences, Bangor University, Bangor, UK, [382]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada, [383]Centro de Investigación en Biodiversidad y Conservación, Universidad Autónoma del Estado de Morelos, Morelos, Mexico, [384]Universitat Autònoma de Barcelona, Catalonia, Spain, [385]Centre for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, UK, [386]Manaaki Whenua - Landcare Research, Hamilton, New Zealand, [387]Department of Scientific Services, Gorongosa National Park, Beira, Sofala Province, Mozambique, [388]Institut de recherche en biologie végétale, Montréal, QC, Canada, [389]Université de Montréal, Montréal, QC, Canada, [390]School of Plant Sciences and Food Security, George S. Wise Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel, [391]School of Biological Sciences, The University of Queensland, Brisbane, Qld, Australia, [392]CSIRO, Canberra, ACT, Australia, [393]Manaaki Whenua – Landcare Research, Lincoln, New Zealand, [394]Center For Tree Science, The Morton Arboretum, Lisle, IL, USA, [395]Department of Botany, University of Wisconsin-Madison, Madison, WI, USA, [396]University of Maine, Orono, ME, USA, [397]Department of Geography, Environment & Society, University of Minnesota, Minneapolis, MN, USA, [398]Holden Arboretum, Kirtland, Ohio, USA, [399]Université Libre de Bruxelles, Bruxelles, Belgium, [400]Institute for Resources Environment and Sustainability, University of British Columbia, Vancouver, BC, Canada, [401]Research School of Biology, The Australian National University, Canberra, ACT, Australia, [402]School of Geosciences, The University of Edinburgh, Edinburgh, UK, [403]Universidade Federal de Pernambuco, Recife, PE, Brazil, [404]ICREA, Barcelona, Spain, [405]CREAF, Barcelona, Spain, [406]INRA, UEFP, Cestas, France, [407]Department of Biology, University of Waterloo, Waterloo, ON, Canada, [408]Department of Botany, Faculty of Science and Technology, University of Debrecen, Debrecen, Hungary, [409]Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB, Canada, [410]Department of Botany and Biodiversity Research Centre, University of British Columbia, Vancouver, BC, Canada, [411]Tulipan s/n, Móstoles-Madrid, Spain, [412]Department of Biology, Stanford University, Stanford, CA, USA, [413]Institute of Biology and Environmental Sciences, University of Oldenburg, Oldenburg, Germany, [414]Department of Biology, Vrije Universiteit Brussel, Brussels, Belgium, [415]University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, USA, [416]CSIRO, Canberra, ACT, Australia, [417]Department of Botany, University of Debrecen, Hungary, [418]University of Vermont, Burlington, VT, USA, [419]Fundação Zoobotânica do Rio Grande do Sul, Porto Allegre, Brazil, [420]University of Minnesota, St. Paul, MN, USA, [421]Gembloux Agro-Bio Tech, Biodiversity and landscape, University of Liège, Belgium, [422]Department of Invasion Ecology, Institute of Botany, Czech Academy of Sciences, Průhonice, Czech Republic, [423]Numerical Terradynamic Simulation Group (NTSG), College of Forestry and Conservation, University of Montana, Missoula, USA, [424]Ontario Ministry of Natural Resources and Forestry, Centre for Northern Forest Ecosystem Research, Thunder Bay, ON, Canada, [425]Universitat Politècnica de Catalunya, Castelldefels, Spain, [426]Harry Butler Institute, Murdoch University, Perth, WA, Australia, [427]Dept of Geography & Environmental Studies, Stellenbosch University, Matieland, Stellenbosch, South Africa, [428]Geobotany, Faculty of Biology, University of Freiburg, Freiburg im Breisgau, Germany, [429]Department of Botany, University of Hawai'i, Honolulu, HI, USA, [430]Laboratório de Ecologia Vegetal, Departamento de Ecologia, Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, [431]Laboratoire d'Ecologie Alpine, Université Grenoble-Alpes, Grenoble Cedex 9, France, [432]French Institute of Pondicherry, Puducherry, India, [433]Biology Department, Oklahoma State University, Oklahoma, OK, USA, [434]Osaka City University, Osaka, Japan, [435]Department of Ecology, French Institute of Pondicherry, Pondicherry, India, [436]Galápagos Verde 2050, Charles Darwin Foundation, Charles Darwin Research Station, Galapagos, Ecuador, [437]Forest, Rangeland, and Fire Sciences Department, University of Idaho, Moscow, ID, USA, [438]College of Chemistry and Life Sciences, Zhejiang Normal University, Jinhua, China, [439]Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogota, Colombia, [440]Universidad Distrital Francisco José de Caldas, Bogota, Colombia, [441]Estonian University of Life Sciences, Tartu, Estonia, [442]Plant Ecology, University of Bayreuth, Bayreuth, Germany, [443]Faculty of Biosciences and Aquaculture, NORD University, Steinkjer, Norway, [444]Department of Biology, Norwegian University of Science and Technology, NTNU, Trondheim, Norway, [445]CSIRO Land and Water, Hobart Tas, Tas., Australia, [446]Institute of Applied Ecology, University of Canberra, Canberra, ACT, Australia, [447]University of Innsbruck, Innsbruck, Austria, [448]River Basin Research Center, Gifu University, Gifu, Gifu, Japan, [449]Departamento de Botânica, Universidade Federal do Paraná, Curitiba, Brazil, [450]Institute of Biology Bucharest, Romanian Academy, Bucharest, Romania, [451]Institute of Ecology and Botany, MTA Centre for Ecological Research, Vácrátót, Hungary, [452]Instituto de Biología, Tercer Circuito s/n de Ciudad Universitaria, Mexico City, Mexico, [453]Universidad Nacional Autónoma de México, Coyoacán, Mexico, [454]Department of Ecology and Plant Geography, Faculty of Biology, Moscow Lomonosov State University, Moscow, Russia, [455]Kyoto University, Kyoto, Japan, [456]Facultad de Ingeniería Agroindustrial, Universidad de las Américas, Quito, Equador, [457]Meijo University, Nagoya, Aichi, Japan, [458]Department of Zoology, University of British Columbia, Vancouver, BC, Canada, [459]Wageningen Environmental Research, Wageningen, The Netherlands, [460]Restoration Ecology, Technische Universität München, München, Germany, [461]University of New England, Armidale, NSW, Australia, [462]The James Hutton Institute, Aberdeen, UK, [463]Department for Molecular Biology and Genetics, Democritus University of Thrace, Alexandroupolis, Greece, [464]University of Tartu, Tartu, Estonia, [465]Instituto de Ciencias Ambientales y Evolutivas, Universidad Austral de Chile, Valdivia, Chile, [466]Desertification Research Center (CIDE-CSIC), Valencia, Spain, [467]Departamento de Ecología, Centro de Investigación en Biodiversidad y Cambio Global (CIBC), Universidad Autónoma de Madrid, Madrid, Spain, [468]Global Ecology Unit CREAF-CSIC, Universitat Autònoma de Barcelona, Barcelona, Spain, [469]University of Jaén, Jaén, Spain, [470]Instituto Nacional de Tecnología Agropecuaria (INTA), Río Gallegos, Santa Cruz, Argentina, [471]Universidad Nacional de la Patagonia Austral (UNPA), CONICET, Rio Gallegos, Argentina, [472]Pós-graduação em Ecologia e Conservação, Universidade Federal do Paraná, Curitiba, PR, Brazil, [473]National Institute for Research-Development in Forestry, Voluntari, Romania, [474]Department of Agricultural and Environmental Sciences (DiSAA), University of Milan, Milano, Italy, [475]Department of Ecology, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, [476]Botanical Garden of the Samara University, Samara, Russia, [477]Plant Sciences (IBG2), Forschungszentrum Jülich GmbH, Jülich, Germany, [478]Institute of Ecology, Tallinn University, Tallinn, Estonia, [479]Ecology and Conservation Biology, Institute of Plant Sciences, University of Regensburg, Regensburg, Germany, [480]McGill University, Montreal, QC, Canada, [481]Morton Arboretum, Lisle, IL, USA, [482]Environmental Sciences Division & Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA, [483]Research Unit ECOBIO – Ecosystèmes, Biodiversité, Evolution, Université Rennes 1/CNRS, Rennes, France, [484]Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic, [485]CEFE, CNRS, EPHE, Université de Montpellier, Université Paul Valéry, Montpellier, France, [486]TUM School of Life Sciences Weihenstephan, Technical University of Munich, Freising, Germany, [487]School of Life Science and Engineering, Southwest University of Science and Technology, Mianyang, China, [488]Department of Crop and Forest Sciences & Agrotecnio Center, Universitat de Lleida, Lleida, Spain, [489]Universidade Federal do Acre, Rio Branco, AC, Brazil, [490]Manaaki Whenua-Landcare Research, Lincoln, New Zealand, [491]Freie Universität Berlin, Berlin, Germany, [492]The University of Western Australia, Crawley, WA, Australia, [493]Centre for Ecological Research and Forestry Applications (CREAF), Cerdanyola del Vallès, Spain, [494]Ecology and Biodiversity, Vrije Universiteit Brussel, Brussels, Belgium, [495]Laboratory of Wood Biology and Xylarium, Royal Museum for Central-Africa (RMCA), Tervuren, Belgium, [496]Department of Forestry, Mississippi State University, Starkville, MS, USA, [497]School of Biological Sciences, University of Southampton, Southampton, UK, [498]Aquatic Ecology and Environmental Biology, Radboud University Nijmegen, Nijmegen, The Netherlands, [499]School of Forestry & Environmental Studies, Yale University, New Haven, CT, USA, [500]Programa de pós-graduação em Ecologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brasil, [501]Environmental and Climate Sciences Department, Brookhaven National Laboratory, NY, Upton, USA, [502]Department of Biological Sciences, East Stroudsburg University, East Stroudsburg, PA, USA, [503]Forest Research Group, INDEHESA, University of Extremadura, Plasencia, Spain, [504]Physiological Diversity, Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany, [505]Laboratorio Nacional de Ciencias de la Sostenibilidad, Instituto de Ecología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Mexico City, Mexico, [506]School of Environmental Sciences, University of Guelph, Guelph, ON, Canada, [507]Remote Sensing Laboratories, Department of Geography, University of Zurich, Zurich, Switzerland, [508]Research Unit Community Ecology, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland, [509]Department of Research and Geoinformation, Swiss National Park, Chastè Planta-Wildenberg, Zernez, Switzerland, [510]Centre for Ecology & Hydrology (CEH), Wallingford, Oxfordshire, UK, [511]Natural Resources Canada, Canadian Forest Service, Québec, QC, Canada, [512]Departamento de Dinamica y Gestion Forestal, INIA-CIFOR, Madrid, Spain, [513]Sustainable Forest Management Research Institute, University of Valladolid-INIA, Madrid, Spain, [514]Department of Ecology and Evolution, University of Lausanne, Lausanne, Switzerland, [515]Norwegian Institute for Nature Research, Trondheim, Norway, [516]Departamento de Biología, Universidad Nacional de Colombia, Bogota, Colombia, [517]Oxford University, Oxford, UK, [518]Instituto de Recursos Naturales y Agrobiología de Salamanca (IRNASA-CSIC), Salamanca, Spain, [519]Centre for Functional Ecology, Departamento de Ciências da Vida, Universidade de Coimbra, Coimbra, Portugal, [520]Algoma University, Sault Ste. Marie, ON, Canada, [521]Department of Geography, University of Zurich, Zürich, Switzerland, [522]Senckenberg Biodiversität und Klima Forschungszentrum (SBiK-F), Frankfurt, Germany, [523]Palmengarten der Stadt Frankfurt am Main, Frankfurt, Germany, [524]Entomology III, Senckenberg Research Institute and Natural History Museum, Frankfurt am Main, Germany, [525]Julius-von-Sachs-Institute for Biological Sciences, Chair of Ecophysiology and Vegetation Ecology, University of Wuerzburg, Wuerzburg, Germany, [526]Herencia, Santa Cruz, Bolivia, [527]Department of Earth and Environmental Sciences, University of Manchester, Manchester, UK, [528]South African National Biodiversity Institute, Pretoria, South Africa, [529]Federal University of Pernambuco, Recife, PE, Brazil, [530]Sharplex Services, Edgecomb, ME, USA, [531]Komarov Botanical Institute RAS, St. Petersburg, Russia, [532]Research Institute for Humanity and Nature, Kyoto, Japan, [533]Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan, [534]Université de Sherbrooke, Sherbrooke, QC, Canada, [535]Department of Biology, University of Regina, Regina, SK, Canada, [536]Technische Universität Ilmenau, Ilmenau, Germany, [537]Centre for Applied Ecology “Professor Baeta Neves” (CEABN), School of Agriculture, University of Lisbon, Lisbon, Portugal, [538]Department of Biology, Federal University of Lavras, Lavras, MG, Brazil, [539]Department Land, Environment, Agriculture and Forestry, Università degli Studi di Padova, Padua, Italy, [540]Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, Alnarp, Sweden, [541]Gothenburg Botanical Garden, Gothenburg, Sweden, [542]Gothenburg Global Biodiversity Centre, Gothenburg, Sweden, [543]Texas Tech University, Lubbock, TX, USA, [544]Forest Sciences Centre, Faculty of Forestry and Conservation Science, University of British Columbia, Vancouver, BC, Canada, [545]Florida Museum of Natural History, University of Florida, Gainesville, FL, USA, [546]Department of Earth and Environmental Sciences, KU Leuven, Leuven, Belgium, [547]Archbold Biological Station, Venus, FL, USA, [548]Embrapa Recursos Genéticos e Biotecnologia, Brasilia, DF, Brazil, [549]Institute of Environmental Sciences, Leiden University, Leiden, The Netherlands, [550] Departamento de Ecologia, Universidade Federal do Rio Grande do Norte, Natal, RN, Brazil, [551]Department of Evolution, Ecology, and Organismal Biology, University of California Riverside, Riverside, CA, USA, [552]Department of Geography, Planning and Recreation, Northern Arizona University, Flagstaff, AZ, USA, [553]Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden, [554]Forest Ecology and Forest Management Group, Wageningen University, The Netherlands, [555]Institute of Lowland Forestry and Environment, University of Novi Sad, Novi Sad, Serbia, [556]Stockholm University, Stockholm, Sweden, [557]Instituto de Investigaciones en Biodiversidad y Medioambiente-CONICET, Universidad Nacional del Comahue, Bariloche, Argentina, [558]Institute of Botany, Plant Science and Biodiversity Center, Slovak Academy of Sciences, Bratislava, Slovakia, [559]Department of Ecology and General Biology, Faculty of Ecology and Environmental Sciences, Technical University in Zvolen, Zvolen, Slovakia, [560]Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Ceske Budejovice, Czech Republic, [561]Faculty of Forestry and Wood Sciences, Czech University of Life Sciences, Prague, Czech Republic, [562]Department of Biology, University of Maryland, College Park, MD, USA, [563]Departamento de Botânica, Universidade Federal de Pernambuco, Recife, PE, Brazil, [564]Teshio Experimental Forest, Hokkaido University, Horonobe, Japan, [565]Departamento de Ecología Funcional y Evolutiva, Estación Experimental de Zonas Áridas (CSIC), La Cañada de San Urbano, Spain, [566]CIRAD-UMR SELMET-PZZS, Dakar, Senegal, [567]Department of Biology, Hacettepe University, Ankara, Turkey, [568]Environmental Sciences, Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands, [569]Centre for African Conservation Ecology, Nelson Mandela University, Port Elizabeth, South Africa, [570]Natural Resources Canada, Canadian Wood Fibre Centre, Quebec, QC, Canada, [571]Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA, [572]Bioversity International, Lima, Peru, [573]Department of Animal and Plant Sciences, University of Sheffield, Sheffield, UK, [574]Centre for Rainforest Studies, The School for Field Studies, Yungaburra, Qld, Australia, [575]Department of Life Sciences, Imperial College London, Silwood Park, Ascot, UK, [576]MTA-DE Lendület Functional and Restoration Ecology Research Group, Debrecen, Hungary, [577]Department of Ecology, University of Debrecen, Debrecen, Hungary, [578]Department of Soil and Plant Sciences, University of Delaware, Newark, DE, USA, [579]INRA – Université Clermont-Auvergne, UMR PIAF, Clermont-Ferrand, France, [580]MTA-TKI Biodiversity and Ecosystem Services Research Group, Debrecen, Hungary, [581]Department of Conservation Ecology and Entomology, Stellenbosch University, Matieland, South Africa, [582]Illinois Natural

History Survey, Prairie Research Institute, University of Illinois, Champaign, IL, USA, [583]Unit for Modelling of Climate and Biogeochemical Cycles, UR-SPHERES, University of Liège, Liège, Belgique, [584]Institute of Agricultural Sciences, Department of Environmental Systems Science, ETH Zurich, Zurich, Switzerland, [585]School of Biological Sciences, The University of Western Australia, Crawley, WA, Australia, [586]School of Biology, Department of Botany, Aristotle University of Thessaloniki, Greece, [587]CIRAD, UMR EcoFoG (Agroparistech, CNRS, INRA, Université des Antilles, Université de la Guyane), Kourou, France, [588]Osaka Natural History Center, Osaka, Japan, [589]Ural State Forest Engineering University, Ekaterinburg, Russia, [590]Botanical Garden of Ural Branch of Russian Academy of Sciences, Ekaterinburg, Russia, [591]University of New Hampshire, Durham, NH, USA, [592]Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran, [593]Department of Biological Sciences, University of Calgary, Calgary, AB, Canada, [594]College Environmental Studies, Yale University, New Haven, CT, USA, [595]Department of Biological Sciences, National University of Singapore, Singapore, Singapore, [596]Smithsonian Tropical Research Institute, Panama City, Panama, [597]School of Geosciences, Edinburgh University, Edinburgh, UK, [598]Systematic Botany and Functional Biodiversity, Institute of Biology, Leipzig University, Leipzig, Germany, [599]Institute for Global Ecology, Florida Institute of Technology, Melbourne, FL, USA, [600]Department of Biology, University of Konstanz, Konstanz, Germany, [601]Zhejiang Provincial Key Laboratory of Plant Evolutionary Ecology and Conservation, Taizhou University, Taizhou, China, [602]Institute of Geography, University of Erlangen-Nuremberg, Erlangen, Germany, [603]Department of Environmental Biology, Sapienza University of Rome, Rome, Italy, [604]Laboratorio de invasiones Biológicas, Universidad de Concepcion, Concepcion, Chile, [605]Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria, [606]School of Biological Sciences and School of Agriculture and Environment, The University of Western Australia, Crawley, WA, Australia, [607]Department of Environment, Forest & Nature Lab, Ghent University, Gontrode-Melle, Belgium, [608]Museu Paraense Emilio Goeldi, Belém, PA, Brazil, [609]Departamento de Ciencias de la Vida, Universidad de las Fuerzas Armadas (ESPE), Sangolquí, Ecuador, [610]Department of Botany, Goa University, Goa, India, [611]Department of Ecology and Environmental Sciences, Pondicherry University, Puducherry, India, [612]Carl von Ossietzky University of Oldenburg, Oldenburg, Germany, [613]Zoology Department, Edward Grey Institute, Oxford University, Oxford, UK, [614]Department of Zoology, Cambridge University, Cambridge Conservation Initiative, Cambridge, UK, [615]Ministry of Education Key Laboratory for Earth System Modeling, Department of Earth System Science, Tsinghua University, Beijing, China, [616]Institute of Desertification Studies, Chinese Academy of Forestry, Beijing, China, [617]Institute of Geography, Fujian Normal University, Fuzhou, China, [618]Department of Landscape Architecture, University of Sheffield, Sheffield, UK, [619]Department of Biology, Colgate University, Hamilton, NY, USA, [620]Ecological Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands, [621]Maritime and Science Technology Academy, Miami, FL, USA, [622]Free University of Bozen-Bolzano, Bolzano, Italy, [623]University of Winnipeg, Winnipeg, Manitoba, Canada, [624]The James Hutton Institute, Dundee, UK, [625]King Saud University, Riyadh, Saudi Arabia, [626]University of California – Irvine, Irvine, CA, USA, [627]Southwest Biological Science Center, U. S. Geological Survey, Moab, UT, USA, [628]Department of Biology, Duke University, Durham, NC, USA, [629]NSW Department of Primary Industries, Parramatta, NSW, Australia, [630]Hiroshima University, Higashi-Hiroshima, Japan, [631]Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Japan, [632]SUNY-College of Environmental Science and Forestry, Syracuse, NY, USA, [633]Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum National d'Histoire Naturelle, Centre National de la Recherche Scientifique, Sorbonne-Université, Paris, France, [634]Laboratório de Ecologia Vegetal (LEVEG), Porto Alegre, RS, Brazil, [635]Biological Sciences, George Washington University, Washington, DC, USA, [636]National Taiwan University, Taipei, Taiwan, [637]College of Life Sciences, Zhejiang University, Hangzhou, China, [638]Forestry College, Beijing Forestry University, Beijing, China, [639]Institut National Polytechnique Félix Houphouët-Boigny (INP-HB), Yamoussoukro, Côte d'Ivoire, [640]Institute for Biology and Environmental Sciences, University Oldenburg, Oldenburg, Germany

TABLE A1 Datasets contributed to the TRY plant trait database. Sorted by custodian surname. ID: Dataset ID in the TRY database, Name, Custodian, TRY version to which the dataset was submitted (in parentheses first submission), availability of the dataset (status 1.10.2019), reference

ID	Dataset name	Custodian	Version	Availability	Reference
403	Iranian Plant Trait Dataset	Mehdi Abedi	5	Public	Unpublished
429	TraitDunes	Alicia T.R. Acosta	5	Restricted	Unpublished
553	Herbaceous leaf traits database from Mediterranean serpentine and non-serpentine soils	George Adamidis	6	Restricted	Adamidis, Kazakou, Fyllas, and Dimitrakopoulos (2014)
152	Functional Traits of Graminoids in Semi-Arid Steppes Database	Peter Adler	3	Public	Adler, Milchunas, Lauenroth, Sala, and Burke (2004)
285	Functional traits explaining variation in plant life history strategies	Peter Adler	4	Public	Adler et al. (2013)
582	Guisane2080	Cécile Albert	6	Restricted	Albert et al. (2010)
583	Ecophy	Cécile Albert	6	Restricted	Albert et al. (2011)
268	Seed Longevity of European Early Successional Species	Harald Albrecht	3	Public	Unpublished
535	Annual mortality rate of mature trees in central Amazon rainforest over 5 decades of monitoring	Izabela Aleixo	6	Restricted	Aleixo et al. (2019)
559	Haean_South_Korea_Traits	Hamada Ali	6	Public	Ali, Reineking, and Münkemüller (2017)
150	French Weeds Trait Database	Bernard Amiaud	3	Public	Unpublished
376	Biomass allocation in beech and spruce seedlings	Christian Ammer	4	Public	Schall, Lödige, Beck, and Ammer (2012)
100	Plant Traits in Pollution Gradients Database	Madhur Anand	2	Restricted	Unpublished
624	CPCRW Carbon Dynamics Along Permafrost Gradient: Specific Leaf Area of Alder and Spruce	Carolyn Anderson	6	Public	Unpublished
622	Daintree Rainforest Functional Traits Data	Deborah Apgaua	6	Public	Apgaua et al. (2015)
97	Plant Physiology Database	Owen Atkin	1	Public	Campbell et al. (2007)
286	Global Respiration Database	Owen Atkin	4	Public	Atkin et al. (2015)
405	JACARE A-Ci leaf trait database 2017	Owen Atkin	5	Restricted	Bahar et al. (2016)
629	Traits of Plants in Canada (TOPIC)	Isabelle Aubin	4 (6)	Restricted	Aubin et al. (2012)
666	Iranian Marl database	Khadijeh Bahalkeh	6	Public	Unpublished
76	European Mountain Meadows Plant Traits Database	Michael Bahn	1	Restricted	Bahn et al. (1999)
101	Photosynthesis Traits Database	Dennis Baldocchi	2	Public	Xu and Baldocchi (2003)
154	Leaf Photosynthesis and Nitrogen at Oak Ridge Dataset	Dennis Baldocchi	2	Public	Wilson, Baldocchi, and Hanson (2000)
269	The Bridge Database	Chris Baraloto	3	Public	Baraloto, Timothy Paine, Poorter, et al. (2010)
422	Hawaii native and non-indigenous species. Traits and environment	Zdravko Baruch	5	Public	Baruch and Goldstein (1999)
576	Bauerle Vcmax and Jmax data	William Bauerle	6	Restricted	Bauerle et al. (2012)
502	Yangambi arboretum	Marijn Bauters	6	Restricted	Bauters et al. (2015)
504	Djolu	Marijn Bauters	6	Restricted	Bauters et al. (2019)
505	Nyungwe_Rwanda	Marijn Bauters	6	Restricted	Bauters et al. (2017)
654	Plant height of Mediterranean herb layer communities, Sardinia, Italy	Erika Bazzato	6	Restricted	Unpublished
277	UV-B Radiation Sensitivity of Hieracium Pilosella	Michael Beckmann	3	Public	Beckmann, Hock, Bruelheide, and Erfmeier (2012)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
631	*Pinus* traits from Beloiu	Carl Beierkuhnlein	6	Restricted	Unpublished
379	Stomatal conductance photosynthesis, soil water content & survival along a water stress experiment	Michaël Belluau	4	Public	Belluau and Shipley (2017)
425	Linking hard and soft traits	Michaël Belluau	5	Public	Belluau and Shipley (2018)
373	Leaf vein density of Fagus sylvatica L. and *Quercus* faginea Lam.	Raquel Benavides	4	Public	Unpublished
515	A-Ci curves	Lahcen Benomar	6	Public	Benomar et al. (2018)
658	Functional Traits of Tropical Dry Forest Colombia) Fundación Natura and Enel-Emgesa	Mary Berdugo	6	Restricted	Unpublished
225	Diameter at Breast Height and Life Form of Amazonian Flora	Erika Berenguer	3	Restricted	Unpublished
397	Fine root traits of 141 Central European grass-land species	Joana Bergmann	5	Public	Bergmann, Ryo, Prati, Hempel, and Rillig (2017)
294	Siberian shrub allometry	Logan Berner	4	Public	Berner et al. (2015)
381	Leaf traits from Baltic Island species	Markus Bernhardt-Römermann	4	Restricted	Unpublished
411	Fall Velocity from Baltic Island species	Markus Bernhardt-Römermann	5	Restricted	Unpublished
450	BryForTrait—A life-history trait database of for-est bryophytes	Markus Bernhardt-Römermann	5	Public	Bernhardt-Römermann, Poschlod, and Hentschel (2018)
178	PLANTATT—Attributes of British and Irish Plants	Biological Records Centre (BRC)	3	Public	Hill, Preston, and Roy (2004)
468	Tundra Trait Team Database	Anne Bjorkman	6	Public	Bjorkman et al. (2018)
102	Photosynthesis and Leaf Characteristics Database	Benjamin Blonder	2	Public	Unpublished
226	Leaf Structure, Venation and Economic Spectrum	Benjamin Blonder	3	Public	Blonder, Violle, Bentley, and Enquist (2010)
295	Leaf functional traits in the Hawaiian sil-versword alliance	Benjamin Blonder	4	Public	Blonder, Baldwin, Enquist, and Robichaux (2015)
359	Plant traits of Arabidopsis thaliana	Benjamin Blonder	4	Public	Blonder, Vasseur, et al. (2015)
360	Fossil Leaf Traits	Benjamin Blonder	4	Public	Blonder, Royer, Johnson, Miller, and Enquist (2014)
361	Angiosperm leaf venation networks	Benjamin Blonder	4	Public	Blonder and Enquist (2014)
362	Leaf economics spectrum and venation net-works in Populus tremuloides	Benjamin Blonder	4	Public	Blonder, Violle, and Enquist (2013)
517	Mt Baldy whole plant traits	Benjamin Blonder	6	Public	Blonder et al. (2018)
296	Northern mixed-grass prairie species traits—Wyoming, USA	Dana Blumenthal	4	Public	Unpublished
242	Ellenberg Indicator Values	Gerhard Boenisch	3	Restricted	Ellenberg and Leuschner (2010)
47	South African Woody Plants Database (ZLTP)	William Bond	1	Public	Unpublished
156	Plant Traits of Canadian Forests	Benjamin Bond-Lamberty	3	Public	Bond-Lamberty, Wang, Gower, and Norman (2002)
157	Litter N Content of Canadian Forests	Benjamin Bond-Lamberty	3	Public	Bond-Lamberty, Gower, Wang, Cyr, and Veldhuis (2006)
420	Chinese savanna trees—aboveground trait data	Coline Boonman	5	Restricted	Unpublished
297	Traits of Polygonum viviparum L.	Florian Boucher	4	Public	Boucher, Thuiller, Arnoldi, Albert, and Lavergne (2013)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
636	La Selva FT Data	Vanessa Boukili	6	Public	Boukili and Chazdon (2017)
421	LECA—Traits of the European Alpine Flora	Louise Boulangeat	5	Public	Unpublished
3	Australian Fire Ecology Database	Ross Bradstock	1	Public	Unpublished
165	Leaf Traits From Madagascar	Kerry Brown	3	Restricted	Brown et al. (2013)
428	Trait and biomass data 2014 and 2015 of the BE_LOW project	Helge Bruelheide	5	Public	Herz et al. (2017)
641	Parana Tree Traits (2015)	Federico Brumnich	6	Public	Brumnich, Marchetti, and Pereira (2019)
298	Plant traits from Greby, Oeland, Sweden	Hans Henrik Bruun	4	Restricted	Baastrup-Spohr, Sand-Jensen, Nicolajsen, and Bruun (2015)
545	Dataset on reproductive traits of Scandinavian alpine plants	Hans Henrik Bruun	6	Public	Bruun (2019)
632	Atractocarpus from new Caledonia	David Bruy	6	Public	Bruy et al. (2018)
427	Coffea arabica var. Caturra—leaf traits	Serra Willow Buchanan	5	Public	Buchanan, Isaac, Van den Meersche, and Martin (2018)
416	Garmisch-Partenkirchen elevational gradients	Solveig Franziska Bucher	5	Restricted	Bucher et al. (2016)
7	Cedar Creek Plant Physiology Database	Daniel Bunker	1	Restricted	Unpublished
585	Arable weed trait data set	Jana Bürger	6	Restricted	Unpublished
158	Plant Traits from Circeo National Park, Italy	Sabina Burrascano	3	Public	Burrascano et al. (2015)
159	Traits of US Desert Woody Plant Species	Bradley Butterfield	3	Public	Butterfield and Briggs (2010)
160	SLA and LDMC for Canadian Wetland Species	Chaeho Byun	3	Restricted	Byun, de Blois, and Brisson (2012)
447	Herbaceous plants of Rouge National Urban Park	Marc Cadotte	5	Public	Sodhi, Livingstone, Carboni, and Cadotte (2019)
448	Cadotte 2017 Ecology Letters: herbaceous traits measured in the filed	Marc Cadotte	5	Public	Cadotte (2017)
446	Ring-width dataset of dead and living trees	Maxime Cailleret	5	Restricted	Cailleret et al. (2017)
522	Ecophysiology of Selaginella and fern species in a Costa Rica wet tropical forest floor	Courtney Campany	6	Public	Campany, Martin, and Watkins (2018)
161	Leaf Traits in Central Apennines Beech Forests	Giandiego Campetella	3	Public	Campetella et al. (2011)
220	Leaf Traits in Italian Central Apennines Beech Forests	Giandiego Campetella	3	Public	Campetella et al. (2011)
406	Whole plant traits and leaf traits of four grass-land species in Central Apennines (Italy)	Giandiego Campetella	5	Restricted	Wellstein et al. (2013)
600	Bay of Biscay dunes	Juan Antonio Campos	6	Restricted	Torca, Campos, and Herrera (2019)
503	Leaf and whole plant traits of Val Cervara old growth beech forest (Central Apennine, Italy)	Roberto Canullo	6	Restricted	Unpublished
649	Alpine tundra plants—Effects of climate warming on traits of species in mid-latitude snowbeds	Michele Carbognani	6	Public	Unpublished
595	UFPR Atlantic Forest Tree Traits	Marcos Carlucci	6	Restricted	Unpublished
670	Fabio Carvalho lowland fen peatland	Fabio Carvalho	6	Restricted	Carvalho, Brown, Waller, and Boom (2019); Carvalho, Brown, Waller, Bunting, et al. (2019)
299	Traits related to riparian plant invasion in South East Australia	Jane Catford	4	Restricted	Catford, Morris, Vesk, Gippel, and Downes (2014)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
354	Cedar Creek prairie plants (leaf, seed, dispersule, height, plant, root)	Jane Catford	4 (5)	Restricted	Catford et al. (2019)
54	Floridian Leaf Traits Database	Jeannine Cavender-Bares	1	Public	Cavender-Bares, Keen, and Miles (2006)
227	Leaf Structure and Economics Spectrum	Bruno E. L. Cerabolini	3 (4)	Restricted	Pierce, Ceriani, De Andreis, Luzzaro, and Cerabolini (2007)
228	Flora d'Italia Functional Traits Hoard (FIFTH)	Bruno E. L. Cerabolini	3	Restricted	Cerabolini et al. (2010)
229	Hydrophytes Traits Database	Bruno E. L. Cerabolini	3 (4)	Restricted	Pierce, Brusa, Sartori, and Cerabolini (2012)
371	Olive Lawn Orchid Trait Database (OLO)	Bruno E. L. Cerabolini	4	Restricted	Pierce, Vagge, Brusa, and Cerabolini (2014)
372	Malga San Simone Trait Database (MSS)	Bruno E. L. Cerabolini	4	Restricted	Cerabolini, Pierce, Luzzaro, and Ossola (2009)
377	Functional Traits of Trees in Golfo Dulce, Costa Rica	Eduardo Chacon	4	Public	Chacón-Madrigal, Wanek, Hietz, and Dullinger (2018)
300	Leaf traits from the Loess Plateau region of northern Shaanxi in China	Yongfu Chai	4	Restricted	Unpublished
120	Tropical Respiration Database	Jeffrey Chambers	2	Public	Chambers et al. (2004)
73	Tundra Plant Traits Database	F Stuart Chapin III	1	Public	Unpublished
501	Leaf traits of beech forest understory species	Stefano Chelli	6	Restricted	Unpublished
611	Temperate tree species in New Jersey USA	Anping Chen	6	Public	Chen, Lichstein, Osnas, and Pacala (2014)
498	Fruit type, fruit dimension and flowering time	Si-Chong Chen	6	Public	Chen, Cornwell, Zhang, and Moles (2017)
499	Growth form data for 3581 Australian species	Si-Chong Chen	6	Public	Chen et al. (2017)
491	Leaf inclination angle	Francesco Chianucci	6	Public	Chianucci et al. (2018)
370	Trait Data from Niwot Ridge LTER (2016)	Adam Chmurzynski	4	Public	Unpublished
489	Pladias: Ellenberg-type indicator values for the Czech flora	Milan Chytrý	6	Public	Chytrý, Tichý, Dřevojan, Sádlo, and Zelený (2018)
349	Mediterranean psammophytes	Daniela Ciccarelli	4	Public	Ciccarelli (2015)
394	Great Basin sagebrush seedlings-greenhouse experiment	Courtney Collins	5	Public	Unpublished
1	Abisko and Sheffield Database	Johannes Cornelissen	1	Public	Cornelissen et al. (2004)
37	Sheffield Database	Johannes Cornelissen	1	Public	Cornelissen, Diez, and Hunt (1996)
72	Sheffield and Spain Woody Database	Johannes Cornelissen	1	Public	Castro-Díez, Puyravaud, Cornelissen, and Villar-Salvador (1998)
121	Fern Spore Mass Database	Johannes Cornelissen	2	Public	Unpublished
55	Jasper Ridge Californian Woody Plants Database	Will Cornwell	1	Public	Preston, Cornwell, and DeNoyer (2006)
89	ArtDeco Database	Will Cornwell	1(2)	Restricted	Cornwell et al. (2008)
430	A Global Dataset of Leaf Δ13C Data	Will Cornwell	5	Public	Cornwell et al. (2018)
280	Global Woodiness Database	William Cornwell	3	Public	Zanne et al. (2014)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
10	Roots Of the World (ROW) Database	Joseph Craine	1	Public	Craine, Lee, Bond, Williams, and Johnson (2005)
130	Global 15N Database	Joseph Craine	1	Public	Craine et al. (2009)
163	Plant Traits for Grassland Species (Konza Prairie, Kansas, USA)	Joseph Craine	3	Public	Craine et al. (2011)
230	Panama Tree Traits	Dylan Craven	3	Public	Craven et al. (2007)
378	Traits of the Hungarian flora	Anikó Csecserits	4	Public	Lhotsky, Csecserits, Kovács, and Botta-Dukát (2016)
293	Jasper Ridge leaf chemistry data	Kyla Dahlin	4	Public	Dahlin, Asner, and Field (2013)
164	Italian Alps Plant Traits Database	Matteo Dainese	3	Public	Dainese and Bragazza (2012)
346	Leaf traits of Dipterocarpus alatus Roxb. ex. G. Don	Anh Tuan Dang-Le	4	Public	Dang-Le, Edelin, and Le-Cong (2013)
500	Pladias: Life forms and heights of the Czech flora	Jiri Danihelka	6	Public	Kaplan et al. (2019)
388	Leaf traits (and a few seed weights) collected from plants in the Macquarie Marshes, Australia	Samantha Dawson	5	Restricted	Dawson et al. (2017)
224	LBA-ECO CD-02 C and N Isotopes in Leaves and Atmospheric CO_2, Amazonas, Brazil	Alessandro de Araujo	3	Public	de Araujo et al. (2012)
643	Lapalala grass trait data 2019	Arend de Beer	6	Restricted	Unpublished
289	Cabo de Gata-Níjar Natural Park	Angel de Frutos	4	Restricted	de Frutos, Navarro, Pueyo, and Alados (2015)
167	Leaf N-Retention Database	Franciska de Vries	3	Public	de Vries and Bardgett (2016)
525	Arboretum Grosspoessna 2014 leaf chemical and photosynthesis traits	Benjamin Dechant	6	Restricted	Dechant, Cuntz, Vohland, Schulz, and Doktor (2017)
644	*Quercus petraea* Photosynthesis Seasonal Climate Chambers Dataset	Nicolas Delpierre	6	Restricted	Verdier et al. (2014)
645	Barbeau Leaf Minerals, *Quercus petraea*, *Carpinus betulus*	Nicolas Delpierre	6	Restricted	Delpierre, Berveiller, Granda, and Dufrêne (2015)
166	Traits of Hemiparastic Plants	Andreas Demey	3	Public	Demey et al. (2013)
368	Wood traits of trees and lianas from the Brazilian Atlantic Forest	Arildo Dias	4	Restricted	Unpublished
542	Smilax auriculata nonstructural carbohydrates under-ground	Milton Diaz	6	Restricted	Unpublished
86	Sheffield-Iran-Spain Database	Sandra Díaz	1	Public	Díaz et al. (2004)
189	Mycorrhiza Database	Ian Dickie	3	Public	Koele, Dickie, Oleksyn, Richardson, and Reich (2012)
231	TROBIT West Africa	Tomas Domingues	3	Restricted	Domingues et al. (2010)
232	LBA ECO CD02: Tapajos Leaf Water Potential	Tomas Domingues	3	Restricted	Almeida et al. (2001)
255	LBA ECO Tapajos: Leaf Characteristics and Photosynthesis	Tomas Domingues	3	Restricted	Domingues, Martinelli, and Ehleringer (2007)
614	Ausplot traits	Ning Dong	6	Public	Dong et al. (2017)
169	Traits for Submerged Species (Aquatic Macrophytes)	Matthew Dunkle	3	Public	Unpublished
301	Specific leaf area responses to environmental gradients through space and time	John Dwyer	4	Public	Dwyer, Hobbs, and Mayfield (2014)
467	Data on chlorophylls and carotenoids in plants and lichens at the European Northeast of Russia	Olga Dymova	6	Restricted	Golovko, Dymova, Yatsco, and Tabalenkova (2011)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
462	RBG Kew Palm leaf traits	Thaise Emilio	6	Restricted	Unpublished
380	Plant growth form dataset for the New World	Kristine Engemann	4	Public	Engemann et al. (2016)
129	The Americas N&P database	Brian Enquist	2	Public	Kerkhoff, Fagan, Elser, and Enquist (2006)
488	IR_DowlatAbad	Mohammad Bagher Erfanian	6	Restricted	Unpublished
171	Seed Characteristics of Ericaceae	Jaime Fagundez	3	Public	Fagúndez and Izco (2008); Fagúndez, Juan, Fernández, Pastor, and Izco (2010)
431	BAAD: a biomass and allometry database for woody plants	Daniel Falster	4	Public	Falster et al. (2015)
432	Global Dataset of Maximum Rooting Depth	Ying Fan Reinfelder	5	Public	Fan et al. (2017)
53	Chinese Leaf Traits Database	Jingyun Fang	1	Restricted	Han, Fang, Guo, and Zhang (2005)
594	Traits Arum pictum Farris UNISS	Emmanuele Farris	6	Public	Unpublished
477	Fazlioglu et al. 2018_raw data	Fatih Fazlioglu	6	Public	Fazlioglu, Wan, and Bonser (2018)
478	Fazlioglu 2011, MSc Thesis	Fatih Fazlioglu	6	Public	Fazlioglu (2011)
480	Fazlioglu 2008	Fatih Fazlioglu	6	Public	Fazlioglu (2008)
481	Fazlioglu et al. 2016	Fatih Fazlioglu	6	Public	Fazlioglu, Al-Namazi, and Bonser (2016)
482	Fazlioglu et al. 2017	Fatih Fazlioglu	6	Public	Fazlioglu, Wan, and Bonser (2016)
490	Fazlioglu et al. 2016-Data-synthesis	Fatih Fazlioglu	6	Public	Fazlioglu and Bonser (2016)
271	Plant Trait Database from Bajo Calima Region (Buenaventura, Colombia)	Fernando Fernández-Méndez	3	Public	Bocanegra-González, Fernández-Méndez, and Galvis-Jiménez (2015)
513	Traits of urban trees of Ibague, Colombia	Fernando Fernández-Méndez	6	Public	Unpublished
668	Traits of urban species from Ibagué Colombia	Fernando Fernández-Méndez	6	Public	Núñez-Florez, Pérez-Gómez, and Fernández-Méndez (2019)
74	Costa Rica Rainforest Trees Database	Bryan Finegan	1	Public	Finegan et al. (2015), Chain-Guadarrama, Imbach, Vilchez-Mendoza, Vierling and Finegan (2017)
561	Nutrient Network leaf trait dataset	Jennifer Firn	6	Public	Firn et al. (2019)
172	Leaf Characteristics of *Pinus sylvestris* and *Picea abies*	Katrin Fleischer	3	Restricted	Unpublished
104	Categorical Plant Traits Database	Olivier Flores	2	Public	Unpublished
414	eHALOPH—Halophytes Database (2018)	Tim Flowers	3 (4,5)	Public	Flowers, Santos, Jahns, Warburton, and Reed (2017)
302	Traits from Semi-Arid Mediterranean Ecosystems	Daniel Flynn	4	Public	de Frutos et al. (2015)
366	Plant Traits from LTER Matsch (Mazia), Italy	Veronika Fontana	4	Restricted	Unpublished
174	Ecological Flora of the British Isles	Henry Ford	3	Public	Fitter and Peat (1994)
272	Plant Coastal Dune Traits (France, Aquitaine)	Estelle Forey	3	Public	Unpublished
170	Plant Functional Traits of Arid Steppes in Eastern Morocco (ECWP-Morocco)	Cedric Frenette-Dussault	3	Public	Frenette-Dussault, Shipley, Léger, Meziane, and Hingrat (2011)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
105	Traits from Subarctic Plant Species Database	Gregoire Freschet	2	Public	Freschet, Cornelissen, van Logtestijn, and Aerts (2010)
234	Leaf Traits Mount Hutt, New Zealand	Gregoire Freschet	3	Public	Kichenin, Wardle, Peltzer, Morse, and Freschet (2013)
507	Freschet et al. 2018	Gregoire Freschet	6	Public	Freschet et al. (2018)
510	Freschet et al. 2015—VU greenhouse	Gregoire Freschet	6	Public	Freschet, Swart, and Cornelissen (2015)
511	Freschet et al. 2015—Mount Hutt	Gregoire Freschet	6	Public	Freschet, Kichenin, and Wardle (2015)
661	Mediterranean Forests in Transition (MEDIT) dataset	Nikolaos Fyllas	6	Restricted	Fyllas et al. (2017)
175	BASECO: a floristic and ecological database of Mediterranean French flora	Sophie Gachet	3	Public	Gachet, Véla, and Tatoni (2005)
106	Climbing Plants Trait Database	Rachael Gallagher	2	Public	Gallagher, Leishman, and Moles (2011)
176	Climbing plants trait dataset	Rachael Gallagher	3	Public	Gallagher and Leishman (2012)
177	Litter Traits Dataset	Pablo García-Palacios	3	Public	García-Palacios, Maestre, Kattge, and Wall (2013)
45	The VISTA Plant Trait Database	Eric Garnier	1	Restricted	Garnier et al. (2007)
383	Species and trait shifts in Apennine grasslands	Eleonora Giarrizzo	4	Public	Giarrizzo et al. (2016)
664	Khalil Prairie Plant Traits	David Gibson	6	Public	Khalil, Gibson, Baer, and Willand (2018)
382	Species able to reproduce after fire in a Brazilian Savanna	Aelton B. Giroldo	4	Restricted	Giroldo (2016)
514	Macquarie xylem leaf site hydraulics	Sean Gleason	6	Public	Unpublished
304	Leaf traits from North West Italy	Giovanni Gligora	4	Restricted	Unpublished
348	Leaf traits data (SLA) for 56 woody species at the Smithsonian Conservation Biology Institute-Forest	Erika B. Gonzalez-Akre	4	Public	Gonzalez-Akre, McShea, Bourg, and Anderson-Teixeira (2015)
267	Functional Traits for Restoration Ecology in the Colombian Amazon	Andres Gonzalez-Melo	3	Restricted	Unpublished
529	Diurnal and nocturnal gas exchange *Quercus* spp.	Elena Granda	6	Restricted	Unpublished
530	Seasonal gas exchange photoperiod *Quercus* spp.	Elena Granda	6	Restricted	Granda et al. (2020)
92	PLANTSdata USDA	Walton Green	1	Public	Green (2009)
512	Chromosome numbers of the Flora of Germany	Thomas Gregor	6	Public	Paule et al. (2017)
275	Plant Traits From Spanish Mediterranean shrublands	Nicholas Gross	3	Public	Unpublished
460	TRY Categorical Traits Dataset (update 2018)	Angela Guenther	5	Public	Unpublished
179	Leaf Gross Morphometrics Within one Species in Relation to Latitude, Altitude and Time	Greg Guerin	3	Public	Guerin, Wen, and Lowe (2012)
123	Virtual Forests Trait Database	Alvaro G. Gutierrez	2	Public	Gutiérrez and Huth (2012)
609	SERC-PREMIS Leaf Trait Dataset	Lillie Haddock	6	Public	Unpublished
586	Cedrus atlantica traits	Alain Hambuckers	6	Restricted	Unpublished
180	Leaf Ash Content in China's Terrestrial Plants	Wenxuan Han	3	Public	Han et al. (2012)
181	Leaf Nitrogen and Phosphorus for China's Terrestrial Plants	Wenxuan Han	3	Public	Chen, Han, Tang, Tang, and Fang (2013)
236	Chinese Traits	Sandy Harrison	3	Public	Prentice et al. (2010)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
237	Harze Trait Intravar: SLA, LDMC and Plant Height for Calcareous Grassland Species in South Belgium	Mélanie Harzé	3	Public	Unpublished
183	Komati Leaf Trait Data	Wesley Hattingh	3	Restricted	Unpublished
541	Rede Amazônia Sustentável	Joseph Hawes	6	Public	Unpublished
184	Cold Tolerance, Seed Size and Height of North American Forest Tree Species	Bradford Hawkins	3	Public	Unpublished
367	Tree species functional traits from Dinghushan Biosphere Reserve, southern China	Pengcheng He	4	Public	Li et al. (2015)
669	Leaf Economics Traits of Woody Species in Dinghushan Biosphere Reserve, Southern China	Pengcheng He	6	Public	He et al. (2019)
238	Fire-Related Traits in Proteaceae and Pinaceae	Tianhua He	3	Public	He, Lamont, and Downs (2011); He, Pausas, Belcher, Schwilk, and Lamont (2012)
434	Seed mass and nutrient concentration in *Grevillea* and *Hakea* species	Tianhua He	5	Public	He, Fowler, and Causley (2015)
472	Traits data for plant species from Western Australia	Tianhua He	6	Public	Unpublished
628	Peel Forest New Zealand Sycamore dataset	Mason Heberling	6	Public	Heberling and Mason (2018)
634	Trillium Trail Forest Wildflower Carbon Gain Phenology	Mason Heberling	6	Public	Heberling, Cassidy, Fridley, and Kalisz (2019)
546	Bark, Leaf and Root traits of tropical trees from the semi-deciduous forests of TENE, West Africa	Bruno Herault	6	Restricted	Unpublished
115	Herbaceous Traits from the Öland Island Database	Thomas Hickler	2	Restricted	Hickler (1999)
384	Panama wood anatomy	Peter Hietz	4	Restricted	Hietz, Rosner, Hietz-Seifert, and Wright (2016)
48	Dispersal Traits Database	Steve Higgins	1	Restricted	Unpublished
305	Araucaria Forest Database	Pedro Higuchi	3	Public	Unpublished
567	LABDENDRO Brazilian Subtropical Forest Traits Database [Dataset IV]	Pedro Higuchi	6	Restricted	Unpublished
185	cDNA Content of Carex	Andrew Hipp	3	Public	Chung, Hipp, and Roalson (2012)
671	Morton Arboretum Experimental Prairie traitset 1, 2019	Andrew Hipp	6	Public	Hipp et al. (2018)
659	Sjöman-Hirons Leaf Turgor Loss with Osmotic Potential at Full Turgor	Andrew Hirons	6	Restricted	Sjöman, Hirons, and Bassuk (2015)
509	Leaf functional traits for tropical saplings from Jianfengling, Hainan Island, China	J. Aaron Hogan	6	Public	Hogan, Valverde-Barrantes, Ding, Xu, and Baraloto (2019)
306	Plant traits from Costa Rica	Karen Holl	4	Public	Unpublished
291	MARGINS—leaf traits database	Daniel Hornstein	4	Public	Unpublished
476	Leaf traits and litter properties in Dinghu mountain, Guangdong province, China	Enqing Hou	6	Public	Hou, Chen, McGroddy, and Wen (2012)
287	Biomass allocation of Carex obnupta and Carex stipata	Nate Hough-Snee	4	Public	Hough-Snee, Nackley, Kim, and Ewing (2015)
355	Knautia arvensis; Mid-Norway	Knut Hovstad	4	Restricted	Unpublished
580	Alpyr	Estela Illa	6	Restricted	Unpublished
551	Coffee traits	Marney Isaac	6	Public	Isaac et al. (2017)
463	Leaf Chlorophyll and Carotenoids Database	Leonid Ivanov	6	Restricted	Unpublished

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
339	FRED—Fine-Root Ecology Database	Colleen Iversen	4 (5)	Public	Iversen et al. (2017)
606	Colt Park Mesocosms	Benjamin Jackson	6	Public	De Long et al. (2019)
240	Nutrient Resorption Efficiency Database	Robert Jackson	3	Public	Vergutz, Manzoni, Porporato, Novais, and Jackson (2012)
186	Growth and Herbivory of Juvenile Trees	Hervé Jactel	3	Public	Unpublished
579	Effect of drought on pine needle traits	Hervé Jactel	6	Public	Unpublished
81	Global Leaf Element Composition Database	Steven Jansen	1	Public	Watanabe et al. (2007)
82	Global Wood Anatomy Database 2	Steven Jansen	1	Public	Unpublished
187	Xylem Functional Traits (XFT) Database: Nature Subset	Steven Jansen	3	Public	Choat et al. (2012)
241	Xylem Functional Traits (XFT) Database	Steven Jansen	3	Public	Choat et al. (2012)
389	Leaf element composition of ferns and lycophytes	Steven Jansen	5	Public	Schmitt et al. (2017)
673	Wagenführ Woodatlas	Steven Jansen	6	Public	Wagenführ (2007)
650	SLA data La Palma 2019 (MIREN project)	Anke Jentsch	6	Public	Unpublished
651	SLA data La Palma 2019 (SLA project)	Anke Jentsch	6	Public	Unpublished
523	SLA and height data of exotic plant species in highland forest of Java and Bali	Decky Indrawan Junaedi	6	Restricted	Unpublished
524	AlpinePlants Austria	Robert R. Junker	6	Restricted	Unpublished
516	Pladias: Flowering time of the Czech flora	Zdenek Kaplan	6	Public	Kaplan et al. (2019)
449	KIT herbaceous functional gradient (median)	Teja Kattenborn	5	Restricted	Kattenborn, Fassnacht, and Schmidtlein (2018)
526	KIT herbaceous functional gradient (weekly measurements)	Teja Kattenborn	6	Restricted	Kattenborn and Schmidtlein (2019)
67	Leaf Physiology Database	Jens Kattge	1	Public	Kattge, Knorr, Raddatz, and Wirth (2009)
398	Yangambi (DR Congo) tropical forest tree traits	Elizabeth Kearsley	5	Restricted	Kearsley et al. (2016)
404	Leaf nutrients and SLA for old field shrubs and small trees from northeastern Connecticut, USA	Nicole Kinlock	5	Public	Unpublished
60	KEW African Plant Traits Database	Don Kirkup	1	Restricted	Kirkup, Malcolm, Christian, and Paton (2005)
188	Orchid Trait Dataset	Yael Kisel	3	Public	Kisel et al. (2012)
540	PalmTraits 1.0	W. Daniel Kissling	6	Public	Kissling et al. (2019)
336	Ecophysiological traits of *Pinus halepensis* Miller	Tamir Klein	4	Public	Klein, Di Matteo, Rotenberg, Cohen, and Yakir (2012)
25	The LEDA Traitbase	Michael Kleyer	1 (3)	Public	Kleyer et al. (2008)
243	CLO-PLA: a Database of Clonal Growth in Plants	Jitka Klimešová	3	Public	Klimešová and de Bello (2009)
273	Plant Trait Database in East and South-East Asia	Fumito Koike	3	Restricted	Koike (2001)
308	Plant traits from Andorra	Benjamin Komac	4	Restricted	Komac, Pladevall, Domènech, and Fanlo (2014)
552	Plants of the Experimental forest of the Botanical Garden Institute FEB RAS (Vladivostok, Russia)	Kirill Korznikov	6	Public	Unpublished
190	Yasuni Ecuador Leaves	Nathan Kraft	3	Public	Kraft, Valencia, and Ackerly (2008)
191	Baccara—Plant Traits of European Forests	Koen Kramer	2	Public	Unpublished
4	BiolFlor Database	Ingolf Kühn	1	Public	Klotz, Kühn, and Durka (2002, 2017)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
469	ACi-TGlob V1.0: A Global dataset of photosynthetic CO_2 response curves of terrestrial plants	Dushan Kumarathunge	6	Public	Kumarathunge et al. (2019)
528	Hawaii Floral traits	Jonas Kuppler	6	Restricted	Kuppler et al. (2017)
52	Traits of Bornean Trees Database	Hiroko Kurokawa	1	Restricted	Kurokawa and Nakashizuka (2008), unpublished
309	Plant traits of grassland species	Kim La Pierre	4	Public	La Pierre and Smith (2014)
265	Saskatchewan Plant Trait Database	Eric Lamb	3	Public	Guy, Mischkolz, and Lamb (2013); Letts, Lamb, Mischkolz, and Romo (2015)
192	Meadow Plant Traits: Biomass Allocation, Rooting depth	Vojtech Lanta	3	Public	Unpublished
193	Plant Traits for *Pinus* and *Juniperus* Forests in Arizona	Daniel Laughlin	1 (3)	Public	Laughlin, Fulé, Huffman, Crouse, and Laliberté (2011)
536	NZ kettehole plant traits	Daniel Laughlin	6	Public	Purcell, Lee, Tanentzap, and Laughlin (2018)
538	NZ tree traits	Daniel Laughlin	6	Public	Jager, Richardson, Bellingham, Clearwater, and Laughlin (2015)
310	French Alps Trait Data	Sandra Lavorel	4	Public	Lavorel et al. (2010)
98	New South Wales Plant Traits Database	Michelle Leishman	1	Public	Unpublished
244	Global Wood Anatomy Database 1	Frederic Lens	1 (3,4)	Public	Lens, Endress, Baas, Jansen, and Smets (2008); Lens, Gasson, Smets, and Jansen (2003); Lens et al. (2011)
274	Crown Architecture Database	Felipe Lenti	3	Public	Unpublished
663	Plant three traits (SLA, LA, Height) of 14 plots in Eastern Tibetan subalpine meadow	Xine Li	6	Public	Li, Nie, Song, Zhang, and Wang (2011)
419	Sherbrooke Dataset	Yuanzhi Li	5	Public	Li and Shipley (2018)
642	USA-China Biodiversity (USA samples)	Jeremy Lichstein	6	Restricted	Unpublished
435	Functional Resilience of Temperate Forests Dataset	Mario Liebergesell	5	Public	Liebergesell et al. (2016)
436	Global Leaf Gas Exchange Database (I)	Yan-Shih Lin	5	Public	Lin et al. (2015)
646	AM fungi and plant growth	Daijun Liu	6	Public	Unpublished
647	Observation of Ginkgo tree morphological difference	Daijun Liu	6	Public	Unpublished
565	Seed Information Database, Royal Botanic Gardens, Kew	Udayangani Liu	1 (3,6)	Public	Royal Botanic Gardens Kew (2019)
34	The RAINFOR Plant Trait Database	Jon Lloyd	1	Restricted	Fyllas et al. (2009)
602	Chajul secondary forest species	Madelon Lohbeck	6	Restricted	Lohbeck et al. (2012)
657	Plant traits along primary succession	Alvaro Lopez-Garcia	6	Restricted	Unpublished
413	Extension of Zanne et al. Global wood density database	Gabriela Lopez-Gonzalez	5	Public	Unpublished
195	Leaf Herbivores, Fibres and Secondary Compounds For European Grassland Species	Jessy Loranger	3	Public	Loranger et al. (2012)
508	Pladias: leaf traits in the Czech flora	Zdeňka Lososová	6	Public	Findurová (2018)
80	French Massif Central Grassland Trait Database	Frédérique Louault	1	Public	Louault, Pillar, Aufrère, Garnier, and Soussana (2005)
311	Structural and biochemical leaf traits of boreal tree species in Finland	Petr Lukes	4	Public	Lukeš, Stenberg, Rautiainen, Mõttus, and Vanhatalo (2013)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
312	Traits of temperate rainforest tree seedlings from New Zealand	Chris Lusk	4	Restricted	Lusk, Kaneko, Grierson, and Clearwater (2013)
667	Intraspecific variation leaf traits temperate rainforest	Chris Lusk	6	Public	Lusk (2019)
605	Terrestrial Mediterranean Orchids Functional Traits	Michele Lussu	6	Restricted	Unpublished
342	Photosynthesis Traits Worldwide	Vincent Maire	4	Public	Maire et al. (2015)
196	RAINFOR Leaf Shape, Driptip, Compoundness and Size Database	Ana Malhado	3	Public	Malhado et al. (2012); Malhado, Malhi, et al. (2009); Malhado, Whittaker, et al. (2009); Malhado et al. (2010)
108	The DIRECT Plant Trait Database	Peter Manning	2	Public	Fry, Power, and Manning (2013)
245	Ecotron Species Composition and Global Change Experiment	Peter Manning	3	Public	Manning et al. (2006)
197	Plant Hydraulic Traits	Stefano Manzoni	3	Public	Manzoni, Vico, Porporato, and Katul (2013)
607	Sardinia elevation gradient	Michela Marignani	6	Public	Campetella et al. (2019)
313	Wood carbon content database	Adam Martin	4	Public	Thomas and Martin (2012)
423	Leaf economic traits in wheat and maize	Adam Martin	5	Public	Martin, Hale, et al. (2018)
433	Wood carbon database	Adam Martin	5	Public	Martin, Doraisami, and Thomas (2018)
438	Crop Trait Database	Adam Martin	5	Public	Martin, Hale, et al. (2018)
548	Leaf economic traits in soy	Adam Martin	6	Public	Hayes et al. (2018)
549	Soy root traits	Adam Martin	6	Public	Martin et al. (2019)
550	Leaf economic traits in coffee	Adam Martin	6	Public	Martin et al. (2017)
344	Los Tuxtlas functional traits	Cristina Martínez-Garza	4	Public	Martínez-Garza, Bongers, and Poorter (2013)
527	CNP seed stoichiometry	Tereza Mašková	6	Restricted	Unpublished
109	Leaf Chemical Defense Database	Tara Joy Massad	2	Public	Unpublished
357	Functional traits of woody species in the Brazilian semi-arid region	Guilherme Mazzochini	4	Public	Unpublished
475	Woody plant traits from southeast Queensland, Australia	James McCarthy	6	Public	McCarthy, Dwyer, and Mokany (2019)
459	Yasuni Ecuador Leaf Drought Tolerance and Mechanical Toughness	Ian McFadden	5	Restricted	McFadden et al. (2019)
465	Yasuni Ecuador Leaf ITV	Ian McFadden	6	Public	Fortunel, McFadden, Valencia, and Kraft (2019)
281	Minimum Freezing Exposure Database	Daniel McGlinn	3	Public	Zanne et al. (2014)
408	Alaska Peatland Experiment PFT values	Mara McPartland	5	Public	Unpublished
390	*Rhododendron* leaf and root economics traits	Juliana Medeiros	5	Public	Medeiros, Burns, Nicholson, Rogers, and Valverde-Barrantes (2017)
12	ECOCRAFT	Belinda Medlyn	1	Public	Medlyn et al. (1999)
437	Global Leaf Gas Exchange Database (II)	Belinda Medlyn	5	Public	Knauer et al. (2017)
314	Shoot dry mass of annual grassland species	Zia Mehrabi	3	Restricted	Unpublished
278	Photosynthetic Capacity Dataset	Patrick Meir	1	Public	Meir et al. (2002)
198	Global Leaf-Sapwood Area Ratios	Maurizio Mencuccini	3	Public	Unpublished
199	Whole Plant Hydraulic Conductance	Maurizio Mencuccini	3	Public	Mencuccini (2003)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
113	Panama Leaf Traits Database	Julie Messier	2	Public	Messier, McGill, and Lechowicz (2010)
592	Mont Mégantic Individual Traits 2016–2017	Julie Messier	6	Public	Messier, Violle, Enquist, Lechowicz and McGill (2018)
315	Leaf traits for *Picea glauca* and *Pinus sylvestris* on University of Calgary (Canada) campus	Sean Michaletz	4	Public	Michaletz and Johnson (2006)
539	Thermo-Mediterranean species along Greece	Chrysanthi Michelaki	6	Restricted	Michelaki et al. (2019)
200	Altitudinal Vicariants Spain	Ruben Milla	3	Public	Milla and Reich (2011)
415	Ozark glade grassland plants	Jesse Miller	5	Public	Miller, Ives, Harrison, and Damschen (2017)
247	Traits of Halophytic Species in North-West-Germany	Vanessa Minden	3	Restricted	Minden and Kleyer (2011)
290	Traits of halophytic species	Vanessa Minden	4	Restricted	Minden and Kleyer (2015)
316	Element contents of plant organs of halophytic species, NW-Germany	Vanessa Minden	4	Restricted	Minden and Kleyer (2014)
456	Trait-responses of Impatiens species to light and nutrients	Vanessa Minden	5	Restricted	Minden and Gorschlüter (2016)
457	Antibiotics-effects on plant traits	Vanessa Minden	5	Restricted	Minden, Deloy, Volkert, Leonhardt, and Pufal (2017)
458	Antibiotics-effects on plant elements	Vanessa Minden	5	Restricted	Minden, Schnetger, Pufal, and Leonhardt (2018)
518	Plant traits along NPK gradients	Vanessa Minden	6	Restricted	Minden and Olde Venterink (2019)
317	Traits of Hypochaeris radicata under shade and drought conditions	Rachel Mitchell	4	Public	Unpublished
28	Global Seed Mass, Plant Height Database	Angela Moles	1	Public	Moles et al. (2005); Moles et al. (2009)
201	Phalaris arundinacea Genotypes	Jane Molofsky	3	Restricted	Lavergne and Molofsky (2007)
266	Hawaiian Lobeliad	Rebecca Montgomery	3	Public	Givnish, Montgomery, and Goldstein (2004)
202	Traits from the Wildfire Project	Marco Moretti	3	Public	Moretti and Legg (2009)
307	Hokkaido leaf traits	Akira Mori	4	Restricted	Mori et al. (2015)
537	Hokkaido plant traits 2	Akira Mori	6	Restricted	Unpublished
555	Teshio grassland plant traits	Akira Mori	6	Restricted	Unpublished
556	Utanai forest tree traits	Akira Mori	6	Restricted	Unpublished
557	Kuujjuarapik-Whapmagoostui	Akira Mori	6	Restricted	Unpublished
655	Functional Flowering Plant Traits	Jane Morrison	6	Public	Unpublished
318	Leaf traits related to mesophyll conductance in wild relatives of tomato (*Solanum lycopersicon*)	Christopher Muir	3	Public	Muir, Hangarter, Moyle, and Davis (2013)
648	LEVEG-UFRGS	Sandra Müller	6	Restricted	Unpublished
353	Old fields of Eastern US (Siefert Data)	Luka Negoita	4	Public	Siefert, Fridley, and Ritchie (2014)
484	Larix occidentalis branch section, specific leaf area and dry mass	Andrew Nelson	6	Restricted	Williams and Nelson (2018)
409	Seed trait data from Neuschulz et al. 2016	Eike Lena Neuschulz	5	Restricted	Neuschulz et al. (2016)
560	Fruit Traits Ecuador	Eike Lena Neuschulz	6	Public	Quitián et al. (2018)
49	Tree Tolerance Database	Ülo Niinemets	1	Restricted	Niinemets and Valladares (2006)

(Continues)

TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
87	Global Leaf Robustness and Physiology Database	Ülo Niinemets	1	Restricted	Niinemets (2001)
426	Ti Tree Database	Rachael Nolan	5	Public	Nolan et al. (2017)
453	European North Russia	Alexander Novakovskiy	5	Public	Dalke, Novakovskiy, Maslova, and Dubrovskiy (2018)
656	Decomposition experiment with standard sub-strate. Functional traits (SLA, LDMC and SSD)	Ricardo Oliveira	6	Restricted	Oliveira, Marques, and Marques (2019)
203	Plant Traits from Romania	Kinga Öllerer	3	Public	Ciocârlan (2009), Sanda, Bita-Nicolae and Barabas (2003)
635	Olson PNAS 2018	Mark E. Olson	6	Restricted	Olson, Soriano, et al. (2018)
637	Rosell Olson Self Non self VD scaling	Mark E. Olson	6	Restricted	Rosell and Olson (2014)
638	Olson et al. AnnBot 2018 Corners Rules	Mark E. Olson	6	Restricted	Olson, Rosell, Zamora Muñoz, and Castorena (2018)
640	Olson et al. EcoLett Vessel diameter scaling	Mark E. Olson	6	Restricted	Olson et al. (2014)
124	Leaf Biomechanics Database	Yusuke Onoda	2	Restricted	Onoda et al. (2011)
410	Onoda 2017 leaf traits dataset	Yusuke Onoda	5	Public	Onoda et al. (2017)
319	Plant Traits from Fynbos Forests in the Cape Region	Renske Onstein	4	Public	Onstein, Carter, Xing, and Linder (2014)
88	The Netherlands Plant Traits Database	Jenny Ordonez	1	Public	Ordoñez et al. (2010)
520	Pinnacle Reserve, ACT	Andrew OReilly-Nugent	6	Public	OReilly-Nugent et al. (2019)
604	Absorptive root morphological traits of boreal and hemi-boreal alder, birch and spruce forests	Ivika Ostonen	6	Public	Ostonen et al. (2013); Ostonen, Tedersoo, Suvi, and Lõhmus (2009)
603	Plant traits of granite outcrops' vegetation of Southwestern Australia	Gianluigi Ottaviani	6	Restricted	Ottaviani, Marcantonio, and Mucina (2016)
365	Tree of sex: a database of sexual systems	Sarah Otto	4	Public	The Tree of Sex Consortium ()
116	The Netherlands Plant Height Database	Wim Ozinga	2	Restricted	Unpublished
204	Impatiens glandulifera Dataset	Anna Pahl	3	Public	Pahl, Kollmann, Mayer, and Haider (2013)
439	Functional Traits of Trees	C. E. Timothy Paine	5	Public	Paine et al. (2015)
464	Leaf traits of selected trees and Liana traits	Vivek Pandi	6	Public	Unpublished
623	Fagus sylvatica Paggeo Greece	Aristotelis C. Papageorgiou	6	Public	Unpublished
320	Grassland Plant Trait Database	Meelis Pärtel	3 (4)	Public	Takkis (2014)
27	BROT Plant Trait Database	Juli Pausas	1	Public	Paula et al. (2009)
440	P50R—A global P50 and Resprouting Database	Juli Pausas	5	Public	Pausas et al. (2015)
441	BBB—A global Belowground Bud Bank database	Juli Pausas	5	Public	Pausas, Lamont, Paula, Appezzato-da-Glória, and Fidelis (2018)
474	BROT 2.0	Juli Pausas	6	Public	Tavşanoğlu and Pausas (2018)
270	Plant Traits of Acidic Grasslands in Central Spain	Begoña Peco	3	Public	Peco, de Pablos, Traba, and Levassor (2005)
91	Catalonian Mediterranean Forest Trait Database	Josep Peñuelas	1	Restricted	Ogaya and Peñuelas (2003)
114	Hawaiian Leaf Traits Database	Josep Peñuelas	2	Restricted	Peñuelas et al. (2009)
131	Catalonian Mediterranean Shrubland Trait Database	Josep Peñuelas	1	Restricted	Unpublished
493	Weiqi-Sardans-Peñuelas China plants	Josep Peñuelas	6	Restricted	Unpublished
496	Garraf-Peñuelas	Josep Peñuelas	6	Restricted	Peñuelas et al. (2017)
497	Prades-Peñuelas	Josep Peñuelas	6	Restricted	Peñuelas et al. (2018)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
591	Mediterranean mixed forest	Antonio Jesus Perea	6	Restricted	Unpublished
75	ECOQUA South American Plant Traits Database	Valerio Pillar	1	Restricted	Müller, Overbeck, Pfadenhauer, and Pillar (2006)
387	LEVA-UFPE plant trait database	Bruno Pinho	5	Restricted	Unpublished
470	Neotropical woody plants functional trait database	Bruno Pinho	6	Restricted	Unpublished
533	Atlantic forest and Mexican forests	Bruno Pinho	6	Restricted	Pinho et al. (2017)
321	Leaf angles	Jan Pisek	3	Public	Pisek, Sonnentag, Richardson, and Mõttus (2013)
417	Leaf angles Raabe et al. 2015	Jan Pisek	5	Public	Raabe et al. (2015)
168	Traits for Herbaceous Species from Andorra	Clara Pladevall	3	Restricted	Unpublished
95	The Tansley Review LMA Database	Hendrik Poorter	1	Restricted	Poorter, Niinemets, Poorter, Wright, and Villar (2009)
110	Categorical Plant Traits Database	Hendrik Poorter	2	Public	Unpublished
248	Photosynthesis Type Database	Hendrik Poorter	3	Public	Kapralov, Smith, and Filatov (2012)
684	Biomass Allocation Database	Hendrik Pooter	6	Public	Poorter et al. (2015)
33	Tropical Rainforest Traits Database	Lourens Poorter	1	Restricted	Poorter and Bongers (2006)
71	BIOPOP: Functional Traits for Nature Conservation	Peter Poschlod	1	Restricted	Poschlod et al. (2003)
151	Aluminium Tolerance Dataset	Peter Poschlod	3	Public	Abedi, Bartelheimer, and Poschlod (2012)
615	Yarramundi species trait data	Sally Power	6	Restricted	Unpublished
263	Costa Rican Tropical Dry Forest Trees	Jennifer Powers	3	Public	Powers and Tiffin (2010)
205	Leaf Allometry Dataset	Charles Price	3	Public	Price and Enquist (2007)
506	Functional traits of Cistus species leaf cohorts	Giacomo Puglielli	6	Public	Puglielli and Varone (2018)
578	Reproductive traits of neophytes in the Czech Republic	Petr Pyšek	6	Restricted	Moravcová, Pyšek, Jarošík, Havlíčková, and Zákravský (2010)
544	Mediterranean Roadcut Trait Data	Valerie Raevel	6	Public	Raevel, Violle, and Munoz (2012)
626	Bolivian Bofedal TraitData	Valerie Raevel	6	Public	Raevel, Anthelme, Meneses, and Munoz (2018)
59	Frost Hardiness Database	Anja Rammig	1	Restricted	Unpublished
639	Mt Baldy seed traits	Courtenay Ray	6	Restricted	Unpublished
206	Maxfield Meadow, Rocky Mountain Biological Laboratory—LMA	Quentin Read	3	Public	Unpublished
323	Rocky Mountain Biological Laboratory WSR/gradient plant traits	Quentin Read	4	Public	Unpublished
35	Reich-Oleksyn Global Leaf N, P Database	Peter Reich	1	Restricted	Reich, Oleksyn, and Wright (2009)
70	Cedar Creek Savanna SLA, C, N Database	Peter Reich	1	Restricted	Willis et al. (2010)
94	Global A, N, P, SLA Database	Peter Reich	1	Restricted	Reich et al. (2009)
96	Global Respiration Database	Peter Reich	1	Restricted	Reich et al. (2008)
494	Poblet Ecophysiology	Víctor Resco de Dios	6	Public	Nolan, Hedo, Arteaga, Sugai, and Resco de Dios (2018)
495	Live fuel moisture data at a pine forest	Víctor Resco de Dios	6	Public	Soler Martin et al. (2017)
571	New Zealand Bark Thickness	Sarah Richardson	6	Public	Richardson et al. (2015)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
572	New Zealand Nothofagus leaf and stem traits	Sarah Richardson	6	Public	Richardson et al. (2013)
573	New Zealand Alpine Granite Leaf Nutrient Concentrations	Sarah Richardson	6	Public	Richardson et al. (2012)
343	Sphagnum tissue CNP	Bjorn Robroek	4	Public	Unpublished
620	Leaf and flower pressure volume curve data	Adam Roddy	6	Public	Roddy, Jiang, Cao, Simonin, and Brodersen (2019)
442	Plant Trait Dataset for Tree-Like Growth Forms	Arthur Vinicius Rodrigues	5	Public	Rodrigues et al. (2018)
207	Herbaceous Plants Traits From Southern Germany	Christine Roemermann	3	Public	Unpublished
400	Leaf Mass Area, Leaf Carbon and Nitrogen Content from Barrow, Alaska	Alistair Rogers	5	Public	Rogers, Serbin, Ely, Sloan, and Wullschleger (2017)
401	Arctic Leaf Photosynthetic Parameters Vcmax and Jmax Estimated from CO_2 Response Curves	Alistair Rogers	5	Public	Rogers et al. (2017)
402	Arctic Photosynthetic parameter Vcmax Estimated Using the 1-Point Method	Alistair Rogers	5	Public	Rogers et al. (2017)
325	Rollinson DBH	Emily Rollinson	4	Public	Unpublished
326	Leaf nutrient concentrations	Victor Rolo Romero	3	Public	Rolo, López-Díaz, and Moreno (2012)
396	Rehabilitating Coastal dune forest	Victor Rolo Romero	5	Restricted	Rolo, Olivier, and van Aarde (2016)
590	Leaf Traits of Aquatic Plants	Dina Ronzhina	6	Public	Ronzhina and P'Yankov (2001)
589	Jena Experiment Traits	Christiane Roscher	6	Public	Gubsch et al. (2011); Lipowsky et al. (2015); Roscher, Schmid, Buchmann, Weigelt, and Schulze (2011)
391	Dataset for Rosell 2016 New Phytologist	Julieta Rosell	5	Restricted	Rosell (2016)
392	Dataset for Rosell et al. 2017 New Phytologist	Julieta Rosell	5	Restricted	Rosell et al. (2017)
613	Inner bark and wood NSC concentrations, density, height, phenology, bark photosynthesis, bark thickness	Julieta Rosell	6	Restricted	Unpublished
633	Bark Wood traits New Phytol 2014 and Oecologia 2015	Julieta Rosell	6	Restricted	Rosell, Gleason, Méndez-Alonzo, Chang, and Westoby (2013)
519	Swiss National Park, Engadine	Christian Rossi	6	Restricted	Rossi (2017)
208	Response of Tree Growth to Light and Size, Barro Colorado Island, Panama	Nadja Rüger	3	Public	Rüger, Berger, Hubbell, Vieilledent, and Condit (2011)
283	Response of Tree Mortality to Light, Size and Past Growth, Barro Colorado Island, Panama	Nadja Rüger	3	Public	Rüger, Huth, Hubbell, and Condit (2011)
284	Response of Tree Recruitment to Light, Barro Colorado Island, Panama	Nadja Rüger	3	Public	Rüger, Huth, Hubbell, and Condit (2009)
672	DISEQU-ALP	Sabine Rumpf	6	Public	Rumpf et al. (2018)
111	Leaf and Whole-Plant Traits Database	Lawren Sack	2	Restricted	Nakahashi, Frole, and Sack (2005)
675	Salguero-Gomez Cistus albidus 2019	Rob Salguero-Gomez	6	Public	Unpublished
249	California Coastal Grassland Database	Brody Sandel	3	Public	Sandel, Corbin, and Krupa (2011)
543	Functional traits related to flammability	Carolina Santacruz	6	Restricted	Unpublished
407	Leaf nutrient concentrations from Scalon et al. 2017	Marina Scalon	5	Public	Scalon et al. (2017)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
209	Leaf Area, Dry Mass and SLA Dataset	Brandon Schamp	3	Restricted	Unpublished
211	BIOTREE Trait Shade Experiment	Michael Scherer-Lorenzen	3	Public	Scherer-Lorenzen, Schulze, Don, Schumacher, and Weller (2007)
350	Trait Data for African Plants—A Photo Guide	Marco Schmidt	4	Public	Dressler, Schmidt, and Zizka (2014)
531	Paracou ITV	Sylvain Schmitt	6	Restricted	Unpublished
532	Uppangala Traits	Sylvain Schmitt	6	Restricted	Unpublished
395	Senckenberg leaf venation data of West African Plants	Julio Schneider	5	Restricted	Unpublished
584	Traits of Woody Plants in Hluhluwe-iMfolozi Park, South Africa	Simon D. Schowanek	6	Restricted	Unpublished
587	Raja Ampat tree dataset	Julian Schrader	6	Public	Unpublished
593	Branch anatomy	Bernhard Schuldt	6	Public	Schuldt, Leuschner, Brock, and Horna (2013)
250	FYNBASE—Database of Plant Traits From the South African Fynbos Biome	Frank Schurr	3	Restricted	Schurr et al. (2007)
251	The Xylem/Phloem Database	Fritz Schweingruber	3	Public	Schweingruber and Landolt (2005)
356	Aboveground morphological traits of grassland species	Marina Semchenko	4	Restricted	Abakumova, Zobel, Lepik, and Semchenko (2016)
351	Miombo tree species—SLA, leaf and seed size	Colleen Seymour	4	Public	Joseph, Seymour, Cumming, Cumming, and Mahlangu (2014)
352	Miombo tree species—Leaf nutrients	Colleen Seymour	4	Public	Seymour et al. (2014)
485	Catimbau National Park, Brazil	Julia Sfair	6	Restricted	Sfair, de Bello, de França, Baldauf, and Tabarelli (2018)
374	Traits of fertile (spore bearing) leaves of rainforest ferns from El Verde Field, Puerto Rico	Joanne Sharpe	4	Public	Unpublished
375	Traits of sterile (non-spore bearing) leaves of rainforest ferns from El Verde Field, Puerto Rico	Joanne Sharpe	4	Public	Unpublished
574	Traits of 48 native and alien Asteraceae in Germany (common-garden experiment)	Christine Sheppard	6	Restricted	Unpublished
212	Herbs Water Relations on Soil Moisture Gradients	Serge Sheremetev	3	Public	Sheremetiev and Chebotareva (2018)
412	The Global Leaf Traits Database	Serge Sheremetev	5	Public	Unpublished
471	Species Growth Forms (Angiosperms)—Update 9	Serge Sheremetev	6	Public	Sheremetiev and Chebotareva (2018)
483	A Geological Age of an Angiosperm Genera and Families	Serge Sheremetev	6	Public	Sheremetiev and Chebotareva (2018)
99	Tropical Traits from West Java Database	Satomi Shiodera	1	Public	Shiodera, Rahajoe, and Kohyama (2008)
50	Leaf and Whole Plant Traits Database	Bill Shipley	1	Public	Shipley (2002)
252	Leaf Structure and Chemistry	Bill Shipley	3	Public	Auger and Shipley (2012)
608	Traits of understory plants of western Canadian forest	Tanvir Ahmed Shovon	6	Restricted	Shovon et al. (2019)
616	Div Resource Pot Experiment	Alrun Siebenkäs	6	Restricted	Siebenkäs, Schumacher, and Roscher (2015)
133	New York Old Field Plant Traits Database	Andrew Siefert	2	Restricted	Siefert (2011)
327	Eastern US Old Field Plant Traits Database	Andrew Siefert	4	Public	Siefert et al. (2014)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
253	Allometric Coefficients of Aboveground Tree Biomass	Carlos Sierra	3	Public	Zapata-Cuartas, Sierra, and Alleman (2012)
393	LABDENDRO Brazilian Subtropical Forest Traits Database [Dataset II]	Ana Carolina Silva	5	Restricted	Souza et al. (2017)
568	LABDENDRO Brazilian Subtropical Forest Traits Database [Dataset III]	Ana Carolina Silva	6	Restricted	Soboleski et al. (2017)
466	Leaf and stem traits of Eremanthus erythropappus	Mateus Silva	6	Public	Silva, Teodoro, Bragion, and van der Berg (2019)
534	Silva el al. 2019	Vasco Silva	6	Restricted	Silva, Catry, et al. (2019)
358	Leaf Respiration Acclimation in Panama	Martijn Slot	4	Public	Slot, Rey-Sánchez, Winter, and Kitajima (2014)
385	Photosynthesis Temperature Response Panama	Martijn Slot	5	Restricted	Slot and Winter (2017)
213	Day and Night Gas Exchange of Deciduous Tree Seedlings in Response to Experimental Warming and Precipitation	Nick Smith	3	Public	Smith, Pold, Goranson, and Dukes (2016)
424	LCE: Leaf carbon exchange dataset for tropical, temperate, and boreal species of North and Central America	Nick Smith	5	Public	Smith and Dukes (2017)
328	Root Traits of Grassland Species	Stuart William Smith	4	Public	Smith, Woodin, Pakeman, Johnson, and van der Wal (2014)
558	Sonnier and Boughton ABS	Gregory Sonnier	6	Public	Unpublished
454	Leaf traits from ECOSHRUB Dovrefjell Norway	Mia Vedel Sørensen	5	Public	Unpublished
77	FAPESP Brazil Rainforest Database	Enio Sosinski	1 (3)	Restricted	Unpublished
84	Causasus Plant Traits Database	Nadejda Soudzilovskaia	1	Restricted	Unpublished
162	Mycorrhizal Intensity Database Across the Former Soviet Union	Nadejda Soudzilovskaia	3	Public	Akhmetzhanova et al. (2012)
329	Plant traits from alpine plants on Mt. Malaya Khatipara	Nadejda Soudzilovskaia	3	Restricted	Soudzilovskaia et al. (2013)
369	Traits and ecological strategies of 66 subtropical tree species in the Brazilian Atlantic Forest	Alexandre Souza	4	Public	Forgiarini, Souza, Longhi, and Oliveira (2014)
256	Niwot Alpine Plant Traits	Marko Spasojevic	3	Public	Spasojevic and Suding (2012)
418	Ozark Tree leaf traits	Marko Spasojevic	5	Public	Spasojevic, Turner, and Myers (2016)
674	Staples et al. Australian Reforestation Tree Database	Timothy Staples	6	Public	Staples, Dwyer, England, and Mayfield (2019)
547	Traits of Alpine species in GLORIA regions Hochschwab, Schrankogel, Majella and Lefka Ori	Klaus Steinbauer	6	Restricted	Unpublished
364	Plant species high elevation dataset	Christien Steyn	4	Public	Steyn, Greve, Robertson, Kalwij, and le Roux (2016)
577	Marion Island Fine Scale	Tanya Strydom	6	Restricted	Unpublished
610	Ash Free Dry Mass of Ceratophyllum submersum	Ivana Svitkova	6	Restricted	Unpublished
51	Tropical Plant Traits From Borneo Database	Emily Swaine	1	Public	Swaine (2007)
214	Maximum Height of Chinese Tree Species (from Silva Sinica)	Nathan Swenson	3	Public	Zheng (1983)
288	CTFS Luquillo Forest Dynamics Plot	Nathan Swenson	4	Public	Swenson, Anglada-Cordero, and Barone (2010)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
581	Charidemi Database	Ruben Tarifa	6	Restricted	Unpublished
345	CIRAD Selmet Tree LNC Sahel	Simon Taugourdeau	4	Public	Unpublished
451	NodDB—A global database of plants with root-symbiotic nitrogen fixation	Leho Tedersoo	5	Public	Tedersoo et al. (2018)
662	Thom 2019	Dominik Thom	6	Public	Unpublished
473	Functional trait data Colombian dry Forest trees	Evert Thomas	6	Public	Thomas et al. (2017)
625	Tng et al. 2013 Traits	David Tng	6	Public	Tng et al. (2013)
575	Myricaria germanica	Sitzia Tommaso	6	Restricted	Sitzia, Michielon, Iacopino, and Kotze (2016)
665	Species patch metrics	Sitzia Tommaso	6	Public	Sitzia, Dainese, Krüsi, and McCollin (2017)
492	Xylem anatomical traits for different Cistus species	Jose M. Torres-Ruiz	6	Public	Torres-Ruiz et al. (2017)
215	Plant Functional Traits From the Province of Almeria (Spain)	Alexia Totte	3	Public	Unpublished
338	Leaf Traits and Seed Mass of Cover Crops	Hélène Tribouillois	4	Public	Tribouillois et al. (2015)
598	Soft traits of the Northern Swan Coastal Plain and Geraldton Sandplain kwongan vegetation, Western Australia	James Tsakalos	6	Restricted	Unpublished
685	Tree and Forest Biomass Distribution	Vladimir Usoltsev	6	Public	Usoltsev (2010)
216	Traits for Common Grasses and Herbs in Spain	Fernando Valladares	3	Public	Unpublished
56	Wetland Dunes Database	Peter van Bodegom	1	Restricted	van Bodegom, Sorrell, Oosthoek, Bakke, and Aerts (2008)
90	Ukraine Wetlands Plant Traits Database	Peter van Bodegom	1 (2)	Restricted	Unpublished
117	Categorical Plant Traits Database	Peter van Bodegom	2	Public	Unpublished
330	Traits of Ukraine native and invasive plant species	Peter van Bodegom	4	Restricted	Unpublished
617	Forbs and grasses in North East Belgium	Elisa Van Cleemput	6	Public	Van Cleemput, Roberts, Honnay, and Somers (2019)
332	Photosynthetic parameters, respiration and leaf traits of a Peruvian tropical montane cloud forest	Marjan van de Weg	4	Public	van de Weg, Meir, Grace, and Ramos (2011)
333	LMA, leaf tissue density and N&P content along the Amazon-Andes gradient in Peru	Marjan van de Weg	4	Public	van de Weg, Meir, Grace, and Atkin (2009)
618	Montane grassland Functional Traits	Stephni van der Merwe	6	Restricted	Unpublished
619	Sub Antarctic tundra_Functional Traits	Stephni van der Merwe	6	Restricted	Unpublished
331	Traits of savannah trees in the Hluhluwe-iMfolozi Game reserve, South Africa	Fons van der Plas	4	Public	Van der Plas, Howison, Reinders, Fokkema, and Olff (2013)
599	Trait data Pibiri—Masha van der Sande	Masha van der Sande	6	Public	van der Sande et al. (2017)
562	1000 Seedweight	Mark van Kleunen	6	Public	Chrobock, Kempel, Fischer, and van Kleunen (2011)
563	Germination	Mark van Kleunen	6	Public	Chrobock et al. (2011)
564	Competition	Mark van Kleunen	6	Public	Kempel, Chrobock, Fischer, Rohr, and van Kleunen (2013)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
597	shade (for TRY)_mvk	Mark van Kleunen	6	Public	Feng and van Kleunen (2014)
461	Western Pamirs	Kim André Vanselow	6	Public	Vanselow, Samimi, and Breckle (2016)
627	Functional traits of native and invasive species in tropical dry forest	Maribel Vasquez	6	Public	Vásquez-Valderrama (2016)
264	Functional Traits Of Bulgarian Grasslands	Kiril Vassilev	3	Restricted	Vassilev, Pedashenko, Nikolov, Apostolova, and Dengler (2011)
217	Canopy Traits for Temperate Tree Species Under High N-Deposition	Kris Verheyen	3	Public	Adriaenssens (2012)
653	Rasgos funcionales especies arboreas cuenca Amazonica	Jaime Villacís	6	Public	Unpublished
122	Plant Habit Database	Cyrille Violle	2	Public	Unpublished
588	Leaf trait records of rare and endangered plant species in the Pannonian flora	Anna Vojtko	6	Public	Unpublished
218	Plant Traits, Virginia, USA	Betsy von Holle	3	Public	Von Holle and Simberloff (2004)
334	A Global Data Set of Leaf Photosynthetic Rates, Leaf N and P, and Specific Leaf Area	Anthony Walker	4	Public	Walker et al. (2014)
443	The China Plant Trait Database	Han Wang	5	Public	Wang et al. (2018)
219	Seed Mass from Literature	Zhonglei Wang	3	Restricted	Unpublished
630	Watkins, Sjoman and Hitchmough CSR ordination of trees	Harry Watkins	6	Public	Unpublished
258	Global Wood Decomposition Database (version 1.1)	James Weedon	3	Public	Weedon et al. (2009)
347	Traits of 59 grassland species	Alexandra Weigelt	4	Public	Schroeder-Georgi et al. (2015)
455	Gift—Plant Growth Form Dataset	Patrick Weigelt	5	Restricted	Weigelt, König, and Kreft (2019)
66	Midwestern and Southern US Herbaceous Species Trait Database	Evan Weiher	1	Restricted	Unpublished
335	Plant traits from Wisconsin, USA	Evan Weiher	4	Restricted	Unpublished
444	Symbiotic N2-Fixation Database	Gijsbert Werner	5	Public	Werner, Cornwell, Sprent, Kattge, and Kiers (2014)
445	Mycorrhizal Association Database	Gijsbert Werner	5	Public	Werner et al. (2018)
79	BIOME-BGC Parameterization Database	Michael White	1	Public	White, Thornton, Running, and Nemani (2000)
259	Angiosperm Shoot Ionomes Dataset	Philip White	3	Public	White et al. (2012)
262	LBA-ECO CD-09 Soil and Vegetation Characteristics, Tapajos National Forest, Brazil	Mathew Williams	3	Public	Williams, Shimabokuro, and Rastetter (2012)
486	Brassica tournefortii	Daniel Winkler	6	Public	Winkler, Gremer, Chapin, Kao, and Huxman (2018)
487	Sasa kurilensis	Daniel Winkler	6	Public	Winkler, Amagai, Huxman, Kaneko, and Kudo (2016)
521	Heterotheca brandegei traits	Daniel Winkler	6	Restricted	Winkler, Lin, Delgadillo, Chapin, and Huxman (2019)
68	The Functional Ecology of Trees (FET) Database—Jena	Christian Wirth	1 (3)	Public	Wirth and Lichstein (2009)
20	GLOPNET—Global Plant Trait Network Database	Ian Wright	1	Public	Wright et al. (2004)
57	Categorical Plant Traits Database	Ian Wright	1	Public	Unpublished
63	Fonseca/Wright New South Wales Database	Ian Wright	1	Public	Fonseca, Overton, Collins, and Westoby (2000)

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TABLE A1 (Continued)

ID	Dataset name	Custodian	Version	Availability	Reference
64	Neotropic Plant Traits Database	Ian Wright	1	Public	Wright et al. (2006)
65	Overton/Wright New Zealand Database	Ian Wright	1	Public	Unpublished
279	Global Leaf Phenology Database	Ian Wright	3	Public	Zanne et al. (2014)
340	Global leaf size dataset	Ian Wright	4	Public	Wright et al. (2017)
601	Ian Wright NT savanna Traits	Ian Wright	6	Public	Wright et al. (2018)
221	Leaf Economic Traits Across Varying Environmental Conditions	Justin Wright	3	Public	Wright and Sutton-Grier (2012)
112	Panama Plant Traits Database	S. Joseph Wright	2	Public	Wright et al. (2010)
612	Ecophysiological parameters of tree and shrub leaves in forest-steppe plantings	Nikolai Yankov	6	Public	Kavelenova, Rozno, Kireyeva, and Smirnov (2007); Pomogaybin and Pomogaybin
125	*Quercus* Leaf C&N Database	Benjamin Yguel	2	Public	Yguel et al. (2011)
322	Shoot N/P stoichiometry of Inner Mongolia grassland species	Qiang Yu	3	Public	Yu et al. (2011)
61	Global Wood Density Database	Amy Zanne	1	Public	Chave et al. (2009)
62	Global Vessel Anatomy Database	Amy Zanne	1	Public	Zanne et al. (2010)
554	Leaf functional traits from Sino-US Dimension project (Chinese collaborators)	Yunpeng Zhao	6	Restricted	Unpublished
621	Metasequoia glyptostroboides from Shanghai China	Ji Zheng	6	Public	Zheng et al. (2018)
337	Tree Anatomy China	Jingming Zheng	4	Public	Zheng and Martínez-Cabrera (2013)
596	Wood anatomy and wood density—Australia	Kasia Ziemińska	6	Public	Ziemińska, Butler, Gleason, Wright, and Westoby (2013); Ziemińska, Westoby, and Wright (2015)
569	SW Michigan restored prairies	Chad Zirbel	6	Public	Zirbel, Bassett, Grman, and Brudvig (2017)
570	CLE_restored_prairie_greenhouse_traits	Chad Zirbel	6	Public	Unpublished
223	San Lorenzo Epiphyte Leaf Traits Database	Gerhard Zotz	3	Public	Petter et al. (2016)