AusTraits – a curated plant trait database for the Australian flora

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Abstract

We introduce the AusTraits database - a compilation of measurements of plant traits for taxa in the Australian flora (hereafter AusTraits). AusTraits synthesises data on 375 traits across 29230 taxa from field campaigns, published literature, taxonomic monographs, and individual taxa descriptions. Traits vary in scope from physiological measures of performance (e.g. photosynthetic gas exchange, water-use efficiency) to morphological parameters (e.g. leaf area, seed mass, plant height) which link to aspects of ecological variation. AusTraits contains curated and harmonised individual-, species- and genus-level observations coupled to, where available, contextual information on site properties. This data descriptor provides information on version 2.1.0 of AusTraits which contains data for 937243 trait-by-taxa combinations. We envision AusTraits as an ongoing collaborative initiative for easily archiving and sharing trait data to increase our collective understanding of the Australian flora.

Background and Summary

Species traits are essential metrics for comparing ecological strategies in plants arrayed across environmental space or evolutionary lineages [1, 2, 3, 4]. Broadly, a trait is any measurable property of a plant capturing aspects of its structure or function [5, 6, 7, 8]. Traits thereby provide useful indicators of species' behaviours in communities and ecosystems, regardless of their taxonomy [8, 9]. Through global initiatives the volume of available trait information for plants has grown rapidly in the last two decades [10, 11]. However, the geographic coverage of trait observations across the globe is patchy, limiting detailed analyses of trait variation and diversity in some regions.

One such region is Australia; a continent with a flora of c. 26,000 native higher-plant species [12]. While significant investment has been made in curating and digitising herbarium collections and observation records in Australia over the last two decades (e.g. The Australian Virtual Herbarium houses ~7 million specimen occurrence records; https://avh.ala.org.au), no complementary resource yet exists for consolidating information on plant traits. Moreover, relatively few Australian species are represented in the leading global databases. For example, the international TRY database [11] has observations for only 3830 Australian species across all collated traits. This level of species coverage limits our ability to use traits to understand and ultimately manage Australian vegetation [13]. While initiatives such as TRY [11] and the Open Traits Network [14] are working towards global synthesis of trait data, a stronger representation of Australian plant taxa in these efforts is essential given the high richness and endemicity of this continental flora.

Here we introduce the AusTraits database (hereafter AusTraits), a compilation of plant traits for the Australian flora. Currently, AusTraits draws together 351 primary sources and contains 937243 measurements spread across 375 different traits for 29230 taxa. To assemble AusTraits from diverse primary sources and make data available for reuse, we needed to overcome three main types of challenges (Figure 1): 1) Accessing data from diverse original sources, including field studies, online databases, scientific articles, and published taxonomic floras; 2) Harmonising these diverse sources into a federated resource, with common units, trait names, and data formats; and 3) Distributing versions of the data under suitable license. To meet this challenge, we developed a workflow which draws on emerging community standards and our collective experience building trait databases.

By providing a harmonised and curated dataset on 375 plant traits, AusTraits contributes substantially to filling the gap in Australian and global biodiversity resources. Prior to the development of AusTraits, data on Australian plant traits existed largely as a series of disconnected datasets collected by individual laboratories or initiatives. We envision AusTraits as an on-going collaborative initiative for easily archiving and sharing trait data about the Australian flora. Open access to a comprehensive resource like this will generate significant new knowledge about the Australian flora across multiple scales of interest, as well as reduce duplication of effort in the compilation of plant trait data, particularly for research students and government agencies seeking to access information on traits.

Methods

Primary sources

AusTraits version 2.1.0 was assembled from 351 distinct sources, including published papers, field campaigns, botanical collections, and taxonomic treatments (Table 10). Initially we identified a list of candidate traits of interest, then identified primary sources containing measurements for these traits, before contacting authors for access. As the compilation grew, we expanded the list of traits considered to include any measurable quantity that had been quantified for a moderate number of taxa (n > 20).

Trait definitions

A full list of traits and their sources appears in Table 10 (available online). This list was developed gradually as new datasets were incorporated, drawing from original source publications and a published thesaurus of plant characteristics [15]. We categorised traits based on the tissue where it is measured (bark, leaf, reproductive, root, stem, whole plant) and the type of measurement (allocation, life history, morphology, nutrient, physiological). Version 2.1.0 of AusTraits includes 302 numeric, 71 categorical, and 2 character traits.

Database schema

The schema of AusTraits broadly follows the principles of the established Observation and Measurement Ontology [16] in that, where available, trait data are connected to contextual information about the collection (e.g. location coordinates, light levels) and information about the methods used to derive measurements (e.g. number of replicates, equipment used). The database contains 11 elements, as described in Table 1. This format was developed to include information about the trait measurements, taxa sampled, the methods used, sites, contextual information, the people involved, and citation sources.

For storage efficiency, the main table of traits contains relatively little information (Table 2), but can be cross linked against other tables (Tables 3-8) using identifiers for dataset, site, context, observation and taxon (Table 1). The `dataset_id` is ordinarily the surname of the first author and year of publication associated with the source's primary citation (e.g. `Blackman_2014`). Trait measurements were also recorded as being one of several possible `value_type` (Table 9), reflecting the type of measurement recorded.

Harmonisation

To harmonise each source into the common AusTraits format we applied a reproducible and transparent workflow (Figure 1), written in R [17], using custom code, and the packages `tidyverse` [18], `stringr` [19], `yaml` [20], `remake` [21], `knitr` [22], and `rmarkdown` [23]. In this workflow, we performed a series of operations, including reformatting data into a standardised format, generating observation ids for each individual measured, transforming variable names into common terms, transforming data common units, standardising terms for categorical variables, encoding suitable metadata, and flagging data that did not pass quality checks. Successive versions of AusTraits iterate through the steps in Figure 1, to incorporate new data and correct identified errors, leading to a high-quality, harmonised dataset.

Details from each primary source were saved with minimal modification into two plain text files. The first file, `data.csv`, contains the actual trait data in comma-separated values format. The second file, `metadata.yml`, contains relevant metadata for the study, as well as options for mapping trait names and units onto standard types, and any substitutions applied to the data in processing. These two files provide all the information needed to compile each study into a standardised AusTraits format.

Taxonomy

We developed a custom workflow to clean and standardise taxonomic names using the latest and most comprehensive taxonomic resources for the Australian flora: the Australian Plant Census (APC) [12] and the Australian Plant Names Index (APNI) [24]. While several automated tools exist, such as `taxize` [25], these do not currently include up to date information for Australian taxa. Updates were completed in two steps. In the first step, we used both direct and then fuzzy matching (with up to 2 characters difference) to search for an alignment between reported names and those in three name sets: 1) All accepted taxa in the APC, 2) All known names in the APC, 3) All names in the APNI. Names were aligned without name authorities, as we found this information was rarely reported in the raw datasets provided to us. Second, we used the aligned name to update any outdated names to their current accepted name, using the information provided in the APC. If a name was recorded as being both an accepted name and an alternative (e.g. synonym) we preferred the accepted name, but also noted the alternative records. When a suitable match could not be found, we manually reviewed near matches and web portals such as the Atlas of Living Australia to find a suitable match. The final resource reports both the original and the updated taxon name alongside each trait record (Table 2), as well an additional table summarising all taxonomic names changes (Table 6) and further information from the APC and APNI on all taxa included (Table 7).

Data records

Access

As an evolving data product, successive versions of AusTraits are being released, containing updates and corrections. Versions are labeled using semantic versioning to indicate the change between versions [26]. Static versions of the AusTraits, including version 2.1.0 used in this descriptor, are available on the project website (http://traitecoevo.github.io/austraits.build/) and Zenodo [27]. The latest data can also be downloaded directly from the project website. As validation (see Technical Validation, below) and data entry is ongoing, users are recommended to pull data from the static releases, to ensure results in their downstream analyses remain consistent as the database is updated.

Data is released under a CC-BY license enabling reuse with attribution – being a citation of this descriptor and, where possible, original sources.

Data coverage

The number of accepted vascular plant species in the APC (as of May 2020) is around 24,750 [12]. Version 2.1.0 of AusTraits includes at least one record for 24,148, or about 97% of taxa. Five traits (leaf_length, leaf_width, plant_height, life_history, plant_growth_form) have records for more than 50% of taxa. Across all traits, the median number of taxa with records is 62. Table 10 shows the number of studies, taxa, and families recording data in AusTraits, as well as the number of geo-referenced records, for each trait.

There were substantial differences in coverage among different tissues and trait types, also with respect to number of geo-referenced points (Figure 2). The most common traits are non geo-referenced records from floras. Yet, geo-referenced records were available in several traits for more than 10% of the flora (Figure 2a).

We found that trait records were spread across the climate space of Australia (Figure 3a), as well as geographic locations (Figure 3b). As with most data, in Australia, the density of records was somewhat concentrated around cities or roads in remote regions, particularly for leaf traits.

Figure 4 shows that overall coverage across a phylogenetic tree of Australian plant species is relatively unbiased, though there are some notable exceptions. One exception is for root traits, where taxa within Poaceae have large amounts of information available relative to other plant families. A cluster of taxa within the family Myrtaceae have little leaf information available, while reproductive information is limited for species near the base of the tree.

Comparing coverage in AusTraits to the global database TRY, there were 72 traits overlapping. Of these, AusTraits tended to contain records for more taxa, but not always (Figure 5). Multiple traits had more than 10 times the number of taxa represented in AusTraits. However, there were more records in TRY for 22 traits, in particular physiological leaf traits. Many traits were not overlapping between the two databases (Figure 5). We noted that AusTraits includes more seed and fruit nutrient data; possibly reflecting the interest in Australia in understanding how fruit and seeds are provisioned in nutrient-depauperate environments. AusTraits includes more categorical values, especially variables documenting different components of species' fire response strategies, reflecting the importance of fire in shaping Australian communities and the research to document different strategies species have evolved to succeed in fire-prone environments.

Technical Validation

We implemented three strategies to maintain data quality. First, we conducted a detailed review of each source based on a bespoke report, showing all data and metadata, by both an AusTraits curator and the original contributor (where possible). Observations for each trait were plotted against all other values for the trait in AusTraits, allowing quick identification of outliers. Corrections suggested by contributors were combined back into AusTraits and made available with the next release.

Second, we implemented automated tests for each dataset, to confirm that values for continuous traits fall within the accepted range for the trait, and that values for categorical traits are on a list of accepted values maintained by the creators. Data that did not pass these tests were moved to a separate spreadsheet ("excluded_data") that is also made available for use and review.

Third, we provide a pathway for user feedback. AusTraits is a community resource and we encourage engagement from users on maintaining the quality and usability of the dataset. As such, we welcome reporting of possible errors, as well as additions and edits to the online documentation for AusTraits that make using the existing data, or adding new data, easier for the community. Feedback can be posted as an issue directly at the project.

Usage Notes

Each data release is available in multiple formats: first, as a compressed folder containing text files for each of the main components, second, as a compressed R object, enabling easy loading into R for those using that platform.

Using the taxon names aligned with the APC, data can be queried against location data from the Atlas of Living Australia. To create the phylogenetic tree in Figure 5, we pruned a master tree for all higher plants [28] using the package `V.PhyloMaker` [29] and visualising via `ggtree` [30]. To create Figure 3A, we used the package `plotbiomes` [31] to create the baseline plot of biomes.

Code Availability

All code, raw and compiled data are hosted within GitHub repositories under the Trait Ecology and Evolution organisation (http://traitecoevo.github.io/austraits.build/). The archived material includes all data sources and code for rebuilding the compiled dataset. The code used to produce this paper is available at http://github.com/traitecoevo/austraits_ms. (All code will be made available prior to final publication.)

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Author contributions

RVG, IJW conceived the original idea; RVG, EHW, CB, SA collated data from primary sources; DSF developed the workflow for the harmonising of data and led all coding; EHW, DI, SCA, JL contributed to coding; EHW, SCA, CB, JL error-checked trait observations; DI developed figures for the paper; DSF, RVG, DI, EHW wrote the first draft of the paper. All other authors contributed the raw data and metadata underpinning the resource, reviewed the harmonised data for errors, and reviewed the final paper for publication.

Competing interests

The authors have no conflicts of interest to declare.

Overview

AusTraits harmonises data on 375 traits from 264 different sources, including field campaigns, published literature, taxonomic monographs, and individual taxon descriptions.

This document provides information on the structure of AusTraits and corresponds to version 2.1.0 of the dataset.

Figures & Tables

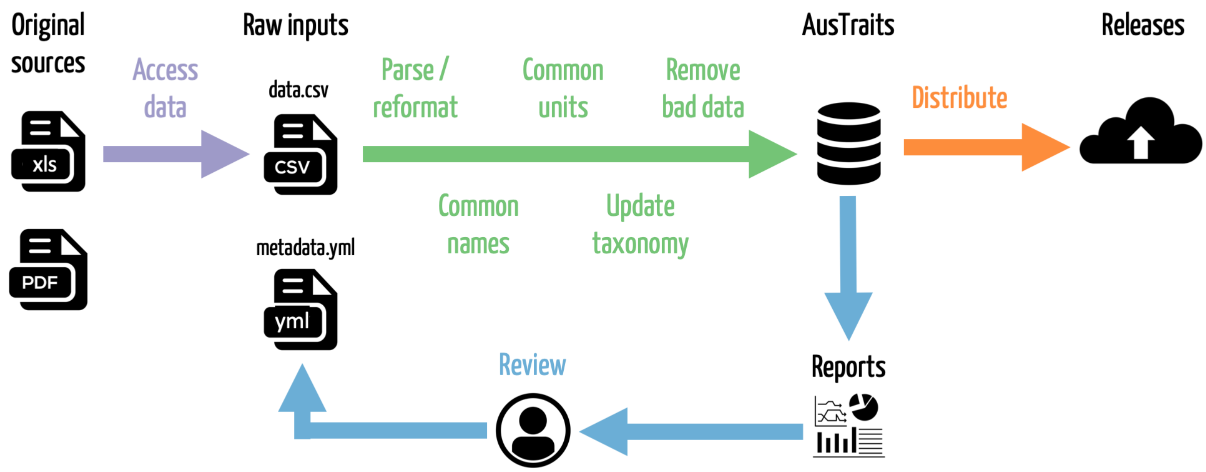

Figure 1: The data curation pathway used to assemble the AusTraits database. Trait observations are accessed from original data sources, including published floras and field campaigns. Features such as variable names, units and taxonomy are harmonised to a common standard. Versioned releases are distributed to users, allowing the dataset to be used and re-used in a reproducible way.

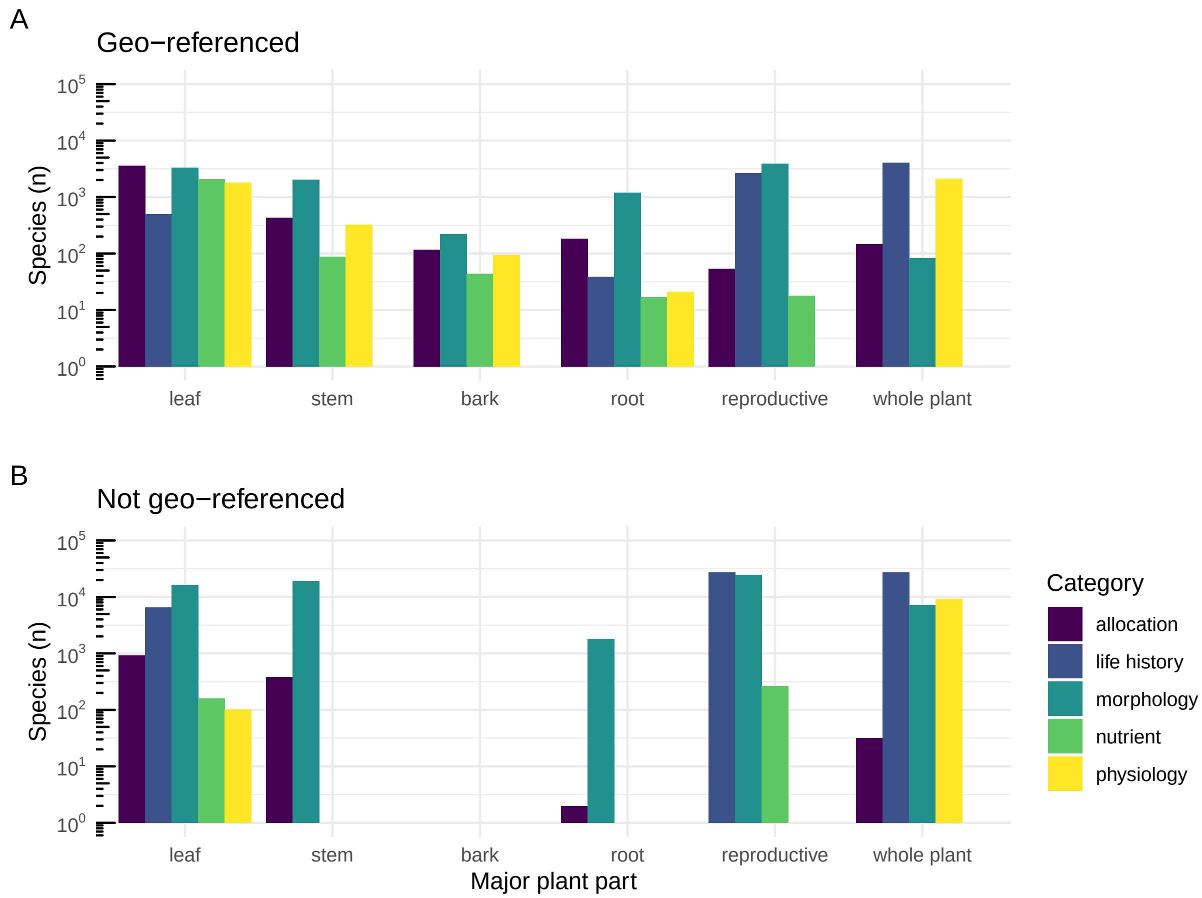

Figure 2: Number of taxa with trait records by plant tissue and trait category, for data that are (A) Geo-referenced, and (B) Not geo-referenced. Many records without a geo-reference come from botanical collections, such as floras.

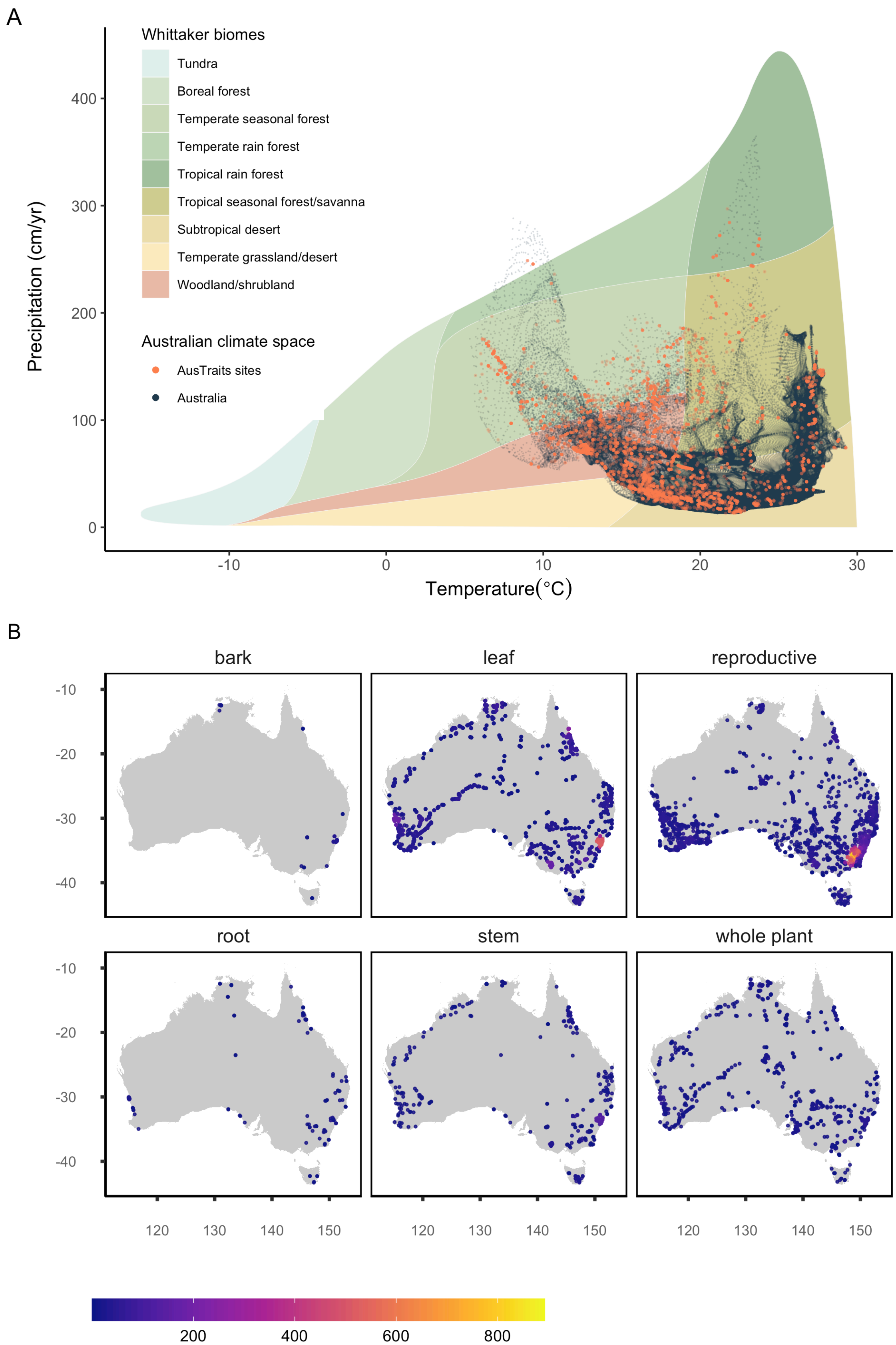

Figure 3: Coverage of geo-referenced trait records across Australian climatic and geographic space for traits in different categories. (A) AusTraits' sites (orange) within Australia's precipitation-temperature space (dark-grey) superimposed upon Whittaker's classifctaion of majore biomes by climate [32]. Climate data were extracted at 10" resolution from WorldClim [33].(B) Locations of geo-referenced records for different plant tissues.

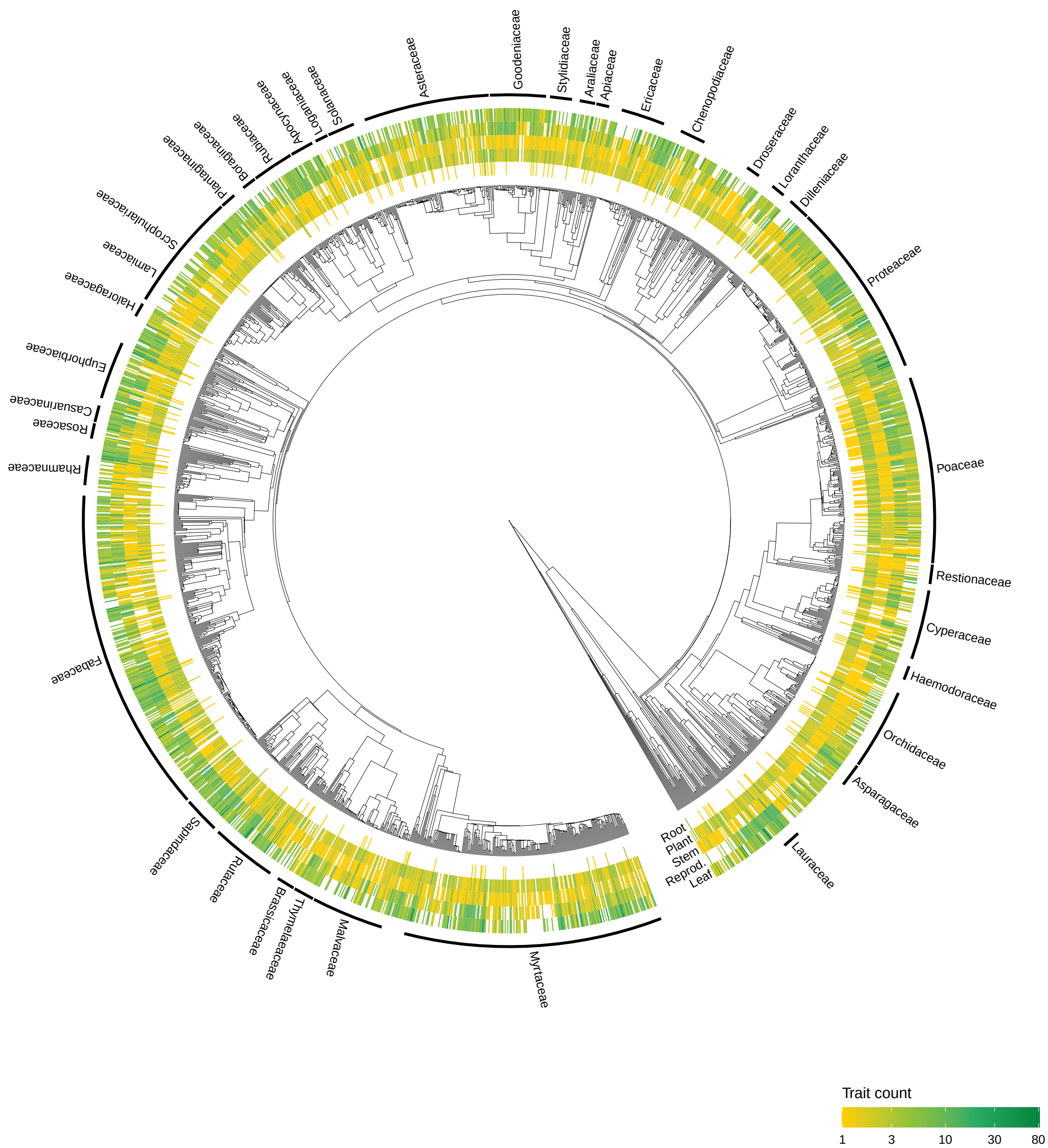

Figure 4: Phylogenetic distribution of trait data in AusTraits for a subset of 2000 randomly sampled taxa. The heatmap colour intensity denotes the number of traits measured within a family for each plant tissue. The most widespread family names (with more than ten taxa) are labelled on the edge of the tree.

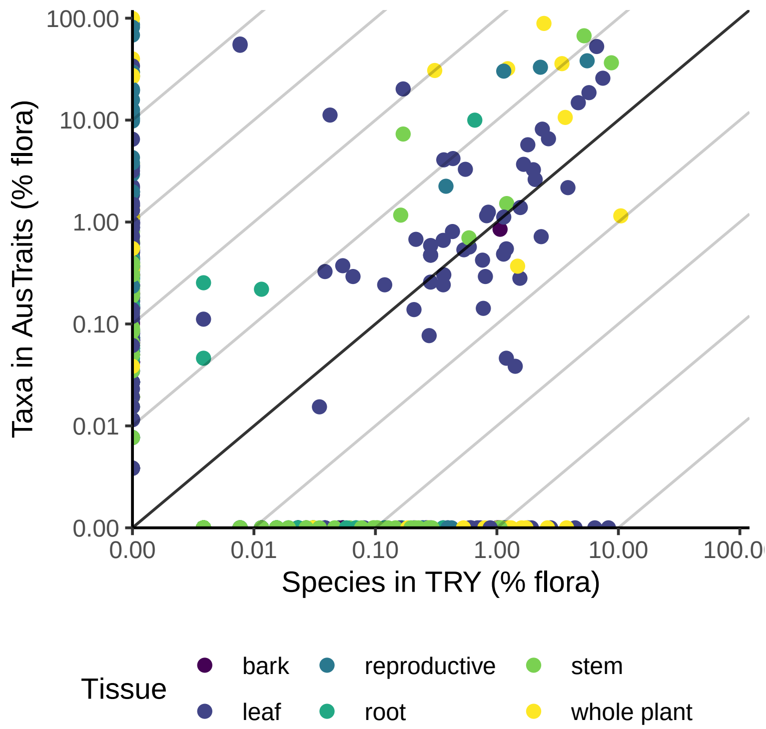

Figure 5: The number of taxa with trait records in AusTraits and global TRY database (accessed 28 May 2020). Each point shows a separate trait.

Table 1: Main elements of the harmonised AusTraits database. See Tables 2-8 for details on each component.

Element	Contents
traits	A table containing measurements of plant traits.
sites	A table containing observations of site characteristics associated with information in `traits`. Cross referencing between the two dataframes is possible using combinations of the variables `dataset_id`, `site_name`.
contexts	A table containing observations of contextual characteristics associated with information in `traits`. Cross referencing between the two dataframes is possible using combinations of the variables `dataset_id`, `context_name`.
methods	A table containing details on methods with which data were collected, including time frame and source.
excluded_data	A table of data that did not pass quality test and so were excluded from the master dataset.
taxa	A table containing details on taxa associated with information in `traits`. This information has been sourced from the APC (Australian Plant Census) and APNI (Australian Plant Names Index) and is released under a CC-BY3 license.
definitions	A copy of the definitions for all tables and terms. Information included here was used to process data and generate any documentation for the study.
sources	Bibtex entries for all primary and secondary sources in the compilation.
contributors	A table of people contributing to each study.
taxonomic_updates	A table of all taxonomic changes implemented in the construction of AusTraits. Changes are determined by comapring against the APC (Australian Plant Census) and APNI (Australian Plant Names Index).
build_info	A description of the computing environment used to create this version of the dataset, including version number, git commit and R session_info.

Table 2: Structure of the `traits` table, containing measurements of plant traits.

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
taxon_name	Currently accepted name of taxon in the Australian Plant Census or, for unplaced species, in the Australian Plant Names Index.
site_name	Name of site where individual was sampled. Cross-references between similar columns in `sites` and `traits`.
context_name	Name of contextual senario where individual was sampled. Cross-references between similar columns in `contexts` and `traits`.
observation_id	A unique identifier for the observation, useful for joining traits coming from the same `observation_id`. These are assigned automatically, based on the `dataset_id` and row number of the raw data.
trait_name	Name of trait sampled. Allowable values specified in the table `traits`.
value	Measured value.
unit	Units of the sampled trait value after aligning with AusTraits standards.
date	Date sample was taken, in the format `yyyy-mm-dd`, but with days and months only when specified.
value_type	A categorical variable describing the type of trait value recorded.
replicates	Number of replicate measurements that comprise the data points for the trait for each measurement. A numeric value (or range) is ideal and appropriate if the value type is a `mean`, `median`, `min` or `max`. For these value types, if replication is unknown the entry should be `unknown`. If the value type is `raw_value` the replicate value should be 1. If the value type is `expert_mean`, `expert_min`, or `expert_max` the replicate value should be `.na`.
original_name	Name given to taxon in the original data supplied by the authors

Table 3: Structure of the `sites` table, containing observations of site characteristics associated with information in `traits`. Cross referencing between the two dataframes is possible using combinations of the variables `dataset_id`, `site_name`.

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
site_name	Name of site where individual was sampled. Cross-references between similar columns in `sites` and `traits`.
site_property	The site characteristic being recorded. Name should include units of measurement, e.g. `longitude (deg)`. Ideally we have at least these variables for each site - `longitude (deg)`, `latitude (deg)`, `description`.
value	Measured value.

Table 4: Structure of the `contexts` table, containing observations of contextual characteristics associated with information in `traits`. Cross referencing between the two dataframes is possible using combinations of the variables `dataset_id`, `context_name`.

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
context_name	Name of contextual senario where individual was sampled. Cross-references between similar columns in `contexts` and `traits`.
context_property	The contextual characteristic being recorded. Name should include units of measurement, e.g. `elevation (m)`.
value	Measured value.

Table 5: Structure of the `methods` table, containing details on methods with which data were collected, including time frame and source.

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
trait_name	Name of trait sampled. Allowable values specified in the table `traits`.
methods	A textual description of the methods used to collect the trait data. Whenever available, methods are taken near-verbatim from referenced source. Methods can include descriptions such as 'measured on botanical collections','data from the literature', or a detailed description of the field or lab methods used to collect the data.
year_collected_start	The year data collection commenced.
year_collected_end	The year data collection was completed.
description	A 1-2 sentence description of the purpose of the study.
collection_type	A field to indicate where the majority of plants on which traits were measured were collected - in the `field`, `lab`, `glasshouse`, `botanical collection`, or `literature`. The latter should only be used when the data were sourced from the literature and the collection type is unknown.
sample_age_class	A field to indicate if the study was completed on `adult` or `juvenile` plants.
sampling_strategy	A written description of how study sites were selected and how study individuals were selected. When available, this information is lifted verbatim from a published manuscript. For botanical collections, this field ideally indicates which records were 'sampled' to measure a specific trait.
source_primary_citation	Citation for primary source. This detail is generated from the primary source in the metadata.
source_primary_key	Citation key for primary source in `sources`. The key is typically of format `Surname_year`.
source_secondary_citation	Citations for secondary source. This detail is generated from the secondary source in the metadata.
source_secondary_key	Citation key for secondary source in `sources`. The key is typically of format `Surname_year`.

Table 6: Structure of the `taxonomic_updates` table, of all taxonomic changes implemented in the construction of AusTraits. Changes are determined by comapring against the APC (Australian Plant Census) and APNI (Australian Plant Names Index).

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
original_name	Name given to taxon in the original data supplied by the authors
cleaned_name	Name of the taxon after implementing any changes encoded for this taxon in the metadata file in the specified correpsonding `dataset_id`.
taxonIDClean	Where it could be indentified, the `taxonID` of the cleaned_name for this taxon in the APC.
taxonomicStatusClean	Taxonomic status of the taxon identified by `taxonIDClean` in the APC.
alternativeTaxonomicStatusClean	The status of alternative records with the name `cleaned_name` in the APC.
acceptedNameUsageID	ID of the accepted name for taxon in the APC or APNI.
taxon_name	Currently accepted name of taxon in the Australian Plant Census or, for unplaced species, in the Australian Plant Names Index.

Table 7: Structure of the `taxa` table, containing details on taxa associated with information in `traits`. This information has been sourced from the APC (Australian Plant Census) and APNI (Australian Plant Names Index) and is released under a CC-BY3 license.

key	value
taxon_name	Currently accepted name of taxon in the Australian Plant Census or, for unplaced species, in the Australian Plant Names Index.
source	Source of taxnonomic information, either APC or APNI.
acceptedNameUsageID	Identifier for the accepted name of the taxon.
scientificNameAuthorship	Authority for accepted of the taxon indicated under taxon_name.
taxonRank	Rank of the taxon.
taxonomicStatus	Taxonomic status of the taxon.
family	Family of the taxon.
genus	Genus of the taxon.
taxonDistribution	Known distribution of the taxon.
ccAttributionIRI	Source of taxonomic information.

Table 8: Structure of the `contributors` table, of people contributing to each study.

key	value
dataset_id	Primary identifier for each study contributed into AusTraits; most often these are scientific papers, books, or online resources. By default should be name of first author and year of publication, e.g. `Falster_2005`.
name	Name of contributor
institution	Last known institution or affiliation
role	Their role in the study

Table 9: Possible value types of trait records.

key	value
raw_value	Value is a direct measurement
site_min	Value is the minimum of measurements on multiple individuals of the taxon at a single site
site_mean	Value is the mean or median of measurements on multiple individuals of the taxon at a single site
site_max	Value is the maximum of measurements on multiple individuals of the taxon at a single site
multisite_min	Value is the minimum of measurements on multiple individuals of the taxon across multiple sites
multisite_mean	Value is the mean or median of measurements on multiple individuals of the taxon across multiple sites
multisite_max	Value is the maximum of measurements on multiple individuals of the taxon across multiple sites
expert_min	Value is the minimum observed for a taxon across its range or in this particular dataset, as estimated by an expert based on their knowledge of the taxon. Data fitting this category include estimates from flora that represent a taxon's entire range, and values for categorical variables obtained from a reference book, or identified by an expert.
expert_mean	Value is the mean observed for a taxon across its range or in this particular dataset, as estimated by an expert based on their knowledge of the taxon. Data fitting this category include estimates from flora that represent a taxon's entire range, and values for categorical variables obtained from a reference book, or identified by an expert.
expert_max	Value is the maximum observed for a taxon across its range or in this particular dataset, as estimated by an expert based on their knowledge of the taxon. Data fitting this category include estimates from flora that represent a taxon's entire range, and values for categorical variables obtained from a reference book, or identified by an expert.
experiment_min	Value is the minimum of measurements from an experimental study either in the field or a glasshouse
experiment_mean	Value is the mean or median of measurements from an experimental study either in the field or a glasshouse
experiment_max	Value is the maximum of measurements from an experimental study either in the field or a glasshouse
individual_mean	Value is a mean of replicate measurements on an individual (usually for experimental ecophysiology studies)
individual_max	Value is a maximum of replicate measurements on an individual (usually for experimental ecophysiology studies)
literature_source	Value is a site or multi-site mean that has been sourced from an unknown literature source
unknown	Value type is not currently known

Table 10: Details on all traits represented in version 2.1.0 of AusTraits. Note the count of studies is less than the number of references when studies are linked to multiple references.

			Number of records					
Trait	Description	Type	all	geo.	studies	taxa	families	refs
Bark (allocation)								
bark_density	Bark dry mass per unit bark fresh volume (bark density)	num.	62	62	1	62	32	[34]
bark_water_content_per_saturated_mass	Ratio of water in a saturated bark (maximal water holding capacity at full turgidity) to bark saturated mass	num.	64	64	1	58	15	[35, 36, 37, 38]
Bark (morphology)								
bark_mass_area	Bark mass per unit surface area of stem	num.	27	27	1	26	5	[39]
bark_thickness	Thickness of the bark of the stem	num.	1548	1548	9	221	49	[39, 40, 41, 42, 43] [34, 35, 44, 45, 46] [36, 37, 38, 47]
Bark (nutrient)								
bark_C_per_dry_mass	Bark carbon (C) content per unit bark dry mass	num.	170	170	1	17	7	[47]
bark_Ca_per_dry_mass	Bark calcium (Ca) content per unit bark dry mass	num.	34	34	2	11	3	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
bark_K_per_dry_mass	Bark potassium (K) content per unit bark dry mass	num.	34	34	2	11	3	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
bark_Mg_per_dry_mass	Bark magnesium (Mg) content per unit bark dry mass	num.	34	34	2	11	3	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
bark_N_per_dry_mass	Bark nitrogen (N) content per unit bark dry mass	num.	364	364	4	44	13	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [41, 58, 59, 60, 61] [62, 63, 64, 65, 66] [47, 67, 68]
bark_Na_per_dry_mass	Bark sodium (Na) content per unit bark dry mass	num.	25	25	2	7	3	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
bark_P_per_dry_mass	Bark phosphorus (P) content per unit bark dry mass	num.	195	195	3	27	9	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [41, 58, 59, 60, 61] [62, 63, 64, 65, 66] [67, 68]
Bark (physiology)								
bark_delta13C	Bark carbon stable isotope signature	num.	170	170	1	17	7	[47]
bark_delta15N	Bark nitrogen stable isotope signature	num.	170	170	1	17	7	[47]
modulus_of_elasticity_bark	A measure of the force required to bend bark	num.	192	192	2	92	35	[34, 46]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
photosynthetic_bark	Binary variable indicating whether or not bark is photosynthetic	cat.	62	62	1	62	32	[34]
Leaf (allocation)								
leaf_area_ratio	Ratio of leaf area to total plant dry mass	num.	708	705	9	116	32	[69, 70, 71, 72, 73] [74, 75, 76, 77, 78]
leaf_density	Leaf tissue density	num.	334	334	5	73	23	[79, 80, 81, 82, 83] [84]
leaf_dry_matter_content	Leaf dry mass per unit leaf fresh mass. (See also leaf_water_content_per_mass, the ratio of water content to leaf dry mass, recorded by some studies.)	num.	4881	4872	27	1092	140	[40, 85, 86, 87, 88] [89, 90, 91, 92, 93] [79, 94, 95, 96, 97] [76, 81, 82, 98, 99] [77, 100, 101, 102, 103] [78, 104, 105, 106, 107] [108]
leaf_fresh_mass	Leaf fresh mass	num.	2053	2053	11	374	97	[87, 89, 91, 109, 110] [92, 95, 97, 99, 111] [102]
leaf_fresh_mass_per_area	Leaf fresh mass per leaf area	num.	108	108	1	19	12	[93]
leaf_mass_fraction	Ratio of leaf dry mass to total plant dry mass	num.	785	782	5	97	31	[71, 77, 78, 92, 95] [47]
leaf_mass_to_stem_mass	Ratio of leaf dry mass to stem dry mass	num.	395	395	3	79	31	[47, 95, 112]
leaf_water_content_per_area	Ratio of the mass of water in a leaf to leaf surface area; leaf succulence	num.	119	116	3	55	17	[77, 78, 99, 113]
leaf_water_content_per_dry_mass	Ratio of the mass of water in a leaf to leaf dry mass. (See also leaf_dry_matter_content, the ratio of a leaf's dry mass to fresh mass, that is recorded by a greater number of studies.)	num.	1098	1098	6	210	73	[109, 114, 115, 116, 117] [81, 82, 118, 119, 120] [102, 104, 121, 122]
leaf_water_content_per_fresh_mass	Ratio of the mass of water in a leaf to leaf fresh mass. (See also leaf_dry_matter_content, the ratio of a leaf's dry mass to fresh mass, that is recorded by a greater number of studies.)	num.	385	385	3	158	61	[81, 82, 89, 123]
leaf_water_content_per_saturated_mass	Ratio of water in a saturated leaf (maximal water holding capacity at full turgidity) to leaf saturated mass	num.	447	447	4	79	20	[35, 36, 84, 92, 124] [37, 38]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
specific_leaf_area	Leaf area per unit leaf dry mass; SLA	num.	31573	24962	122	3852	179	[48, 49, 50, 85, 125] [51, 52, 53, 54, 55] [86, 87, 126, 127, 128] [109, 129, 130, 131, 132] [40, 133, 134, 135, 136] [56, 137, 138, 139, 140] [88, 89, 90, 141, 142] [143, 144, 145, 146, 147] [148, 149, 150, 151, 152] [110, 153, 154, 155, 156] [57, 157, 158, 159, 160] [91, 92, 161, 162, 163] [69, 70, 164, 165, 166] [93, 114, 167, 168, 169] [58, 59, 71, 113, 170] [39, 115, 171, 172, 173] [41, 60, 94, 174, 175] [112, 116, 117, 123, 176] [35, 61, 72, 177, 178] [73, 74, 79, 179, 180] [62, 63, 181, 182, 183] [95, 96, 184, 185, 186] [64, 97, 118, 187, 188] [80, 189, 190, 191, 192] [65, 75, 98, 124, 193] [81, 82, 99, 194, 195] [66, 76, 119, 196, 197] [120, 198, 199, 200, 200] [102, 201, 202, 203, 204] [83, 121, 122, 205, 206] [77, 207, 208, 209, 210] [67, 78, 104, 211, 212] [84, 105, 106, 213, 214] [107, 108, 215, 215, 216] [36, 37, 38, 217, 218] [47, 219, 220, 221, 222]
Leaf (life history)								
leaf_lifespan	Leaf lifespan (longevity)	num.	428	425	6	139	39	[48, 49, 50, 51, 52] [53, 54, 55, 56, 90] [41, 57, 58, 59, 60] [35, 61, 62, 63, 64] [65, 66, 67, 81, 82] [36, 37, 38, 104]
leaf_phenology	Variable indicating whether a plant has deciduous versus evergreen leaves; different types of deciduousness included as trait values	cat.	8383	515	26	6702	206	[48, 49, 50, 51, 223] [52, 53, 54, 55, 224] [56, 88, 137, 138, 225] [148, 149, 150, 151, 152] [57, 58, 59, 171, 226] [60, 61, 62, 63, 227] [64, 65, 124, 228, 229] [66, 81, 82, 100, 230] [100, 101, 199, 203, 231] [67, 77, 78, 232, 233] [104, 234]
Leaf (morphology)								
cell_cross-sectional_area	Cell cross sectional area	num.	38	38	1	38	11	[88]
cotyledon_position	Binary variable distinguishing between seedlings where the cotyledon remains within the seed coat versus emerges from the seed coat at germination.	cat.	1731	0	1	1688	124	[235]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
cotyledon_type	Binary variable distinguishing between glabrous versus hairy cotyledons	cat.	584	0	1	580	93	[235]
epidermal_cell_density_abaxial	Epidermal cell density on the lower leaf surface	num.	90	90	1	1	1	[72]
epidermal_cell_density_adaxial	Epidermal cell density on the upper leaf surface	num.	90	90	1	1	1	[72]
epidermal_cell_density_both_sides	Epidermal cell density averaged across the upper and lower leaf surfaces	num.	58	58	1	1	1	[83]
epidermis_thickness	Thickness of the epidermis, leaf surface not specified	num.	111	60	2	52	2	[83, 131, 132, 172, 173]
epidermis_thickness_lower_leaf_surface	Thickness of the epidermis on the lower leaf surface	num.	241	241	4	131	20	[72, 88, 144, 171]
epidermis_thickness_upper_leaf_surface	Thickness of the epidermis on the upper leaf surface	num.	239	239	4	130	20	[72, 88, 144, 171]
glaucous	Variable indicating if a plant's leaves are glaucous or not	cat.	5	0	1	5	4	[228]
guard_cell_length	Length of guard cells	num.	339	0	1	338	1	[131, 132, 172, 173]
hypocotyl_type	Binary variable distinguishing between glabrous versus hairy hypocotyls (the embryonic axis to which the cotyeledons are attached).	cat.	567	0	1	563	88	[235]
leaf_angle	Leaf angle, relative to horizontal	num.	1539	1539	3	187	68	[95, 102, 236]
leaf_area	Area of the leaf surface	num.	27165	19131	84	4839	200	[85, 125, 127, 128, 237] [87, 109, 129, 130, 131] [132, 133, 134, 135, 136] [89, 142, 143, 144, 151] [110, 152, 153, 154, 236] [155, 156, 158, 159, 162] [69, 70, 91, 92, 163] [164, 165, 166, 167, 168] [71, 171, 172, 173, 238] [94, 115, 174, 175, 239] [116, 117, 123, 176, 240] [35, 177, 179, 182, 241] [183, 184, 185, 242, 243] [95, 96, 118, 186, 244] [97, 187, 188, 189, 245] [80, 98, 124, 246, 247] [75, 81, 194, 195, 248] [82, 99, 119, 196, 249] [111, 120, 200, 201, 203] [102, 103, 121, 122, 205] [77, 78, 210, 212, 250] [105, 106, 107, 214, 215] [36, 37, 215, 216, 217] [38, 47, 219, 220]
leaf_arrangement	Describes leaf arrangement on the stem	cat.	5990	0	1	5261	196	[230]
leaf_cell_wall_fraction	Fraction of total leaf biomass that is cell wall material	num.	85	85	3	36	12	[79, 83, 113]
leaf_compoundness	Indicates whether or not a leaf is compound; different 'simple' terminology used by different studies	cat.	20837	253	26	13719	256	[48, 49, 50, 51, 223] [52, 53, 54, 55, 224] [56, 131, 132, 148, 251] [149, 150, 151, 152, 236] [57, 58, 59, 172, 173] [60, 61, 62, 226, 227] [63, 64, 243, 252, 253] [65, 81, 228, 229, 246] [66, 82, 99, 196, 230] [67, 203, 217, 233, 234] [254, 255]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_division	Detailed description of leaf divisions, beyond what is captured in leaf_compoundness (simple versus compound) and leaf_margin (entire, toothed, lobed). Includes pinnation	cat.	275	0	2	274	2	[131, 132, 172, 173, 255]
leaf_dry_mass	Leaf dry mass	num.	11656	8651	33	1707	134	[87, 109, 129, 133, 134] [89, 135, 142, 143, 144] [110, 153, 154, 158, 159] [70, 91, 92, 163, 256] [115, 116, 117, 176, 179] [95, 97, 118, 187, 194] [99, 111, 119, 120, 195] [102, 121, 122, 200, 201] [47, 205, 212, 214]
leaf_hairs_adult	Binary variable describing whether or not adult leaves have hairs	cat.	137	137	2	126	39	[96, 186]
leaf_hairs_juvenile	Binary variable describing whether or not juvenile leaves have hairs	cat.	75	75	1	72	31	[96]
leaf_length	Length of the leaf, including petiole and rachis in compound leaves	num.	41180	1708	39	14503	265	[223, 224, 251, 257, 258] [89, 225, 259, 260, 261] [168, 226, 262, 263, 264] [95, 227, 243, 252, 253] [228, 230, 265, 266, 267] [268, 269, 270, 271, 272] [102, 233, 273, 274, 275] [84, 254, 255, 276]
leaf_margin	Description of leaf margin as lobed, toothed or entire.	cat.	10512	0	6	8832	239	[131, 132, 172, 173, 261] [226, 228, 230, 254]
leaf_shape	Leaf shape	cat.	3225	32	15	2915	154	[129, 131, 132, 224, 257] [168, 172, 251, 261, 262] [173, 228, 233, 271, 273] [254, 255, 275]
leaf_thickness	Thickness of the leaf lamina	num.	3352	3261	28	848	106	[87, 129, 131, 132, 136] [88, 89, 144, 151, 152] [113, 168, 171, 172, 173] [115, 116, 117, 174, 175] [35, 72, 79, 118, 123] [80, 81, 82, 124, 187] [99, 111, 119, 120, 196] [83, 84, 102, 121, 122] [36, 37, 38, 107]
leaf_type	Broad definitions of leaf type	cat.	612	376	12	566	43	[48, 49, 50, 51, 223] [52, 53, 54, 55, 224] [56, 57, 58, 129, 261] [59, 60, 61, 174, 175] [62, 63, 64, 227, 228] [65, 66, 124, 203, 232] [67, 104]
leaf_width	Longest width axis of a leaf; orthogonal to its length	num.	40311	2790	41	14103	256	[223, 224, 251, 257, 258] [88, 225, 259, 260, 261] [89, 158, 159, 168, 262] [226, 227, 252, 263, 264] [95, 228, 230, 243, 253] [265, 266, 267, 268, 269] [102, 270, 271, 272, 273] [84, 233, 274, 275, 276] [254, 255]
leaf_work_to_punch	Measure of how much force (work) is required to punch through a leaf; units same as J/m2; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	60	60	3	43	26	[79, 99, 151, 152]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_work_to_punch_adjusted	Measure of how much force (work) is required to punch through a leaf, adjusted for leaf thickness; units same as J/m2; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	60	60	3	43	26	[79, 99, 151, 152]
leaf_work_to_shear	Measures of how much force (work) is required to shear a leaf; equivalent to cutting a leaf with scissors; units same as J/m; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	192	192	5	137	46	[35, 79, 123, 151, 152] [36, 37, 38, 99]
leaf_work_to_shear_adjusted	Measures of how much force (work) is required to shear a leaf, adjusted to leaf thickness; same units as J/m2; also referred to as 'fracture toughness'; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	192	192	5	137	46	[35, 79, 123, 151, 152] [36, 37, 38, 99]
lower_cuticle_thickness	Thickness of the lower cuticle	num.	264	160	5	229	20	[88, 131, 132, 144, 171] [124, 172, 173]
lower_hypodermis_thickness	Thickness of the lower hypodermis	num.	4	4	2	3	2	[88, 144]
lower_palisade_cell_thickness	Thickness (length) of lower palisade cells	num.	62	62	2	51	8	[88, 144]
palisade_cell_length	Length of individual palisade cells	num.	59	59	1	1	1	[83]
palisade_cell_width	Width of individual palisade cells	num.	107	59	2	49	2	[83, 131, 132, 172, 173]
palisade_layer_number	Number of layers of palisade cells	num.	60	60	1	1	1	[83]
pendulous_leaves	Binary variable describing whether or not leaves are pendulous	cat.	95	95	1	95	37	[89]
physical_defence	Physical defences	cat.	291	290	2	291	89	[203, 242]
seedling_first_leaf	Binary variable distinguishing between seedlings where the first leaf is scale-like (cataphyll) versus leaf-like.	cat.	938	0	1	925	98	[235]
seedling_first_node	Binary variable distinguishing between seedlings where the leaves at the first node are single versus paired.	cat.	838	0	1	827	98	[235]
spongy_mesophyll_thickness	Thickness of the spongy mesophyll cells	num.	75	75	2	63	11	[88, 144]
stomatal_density_abaxial	Stomatal density on the lower leaf surface	num.	209	148	3	63	3	[72, 131, 132, 172, 173] [83]
stomatal_density_adaxial	Stomatal density on the upper leaf surface	num.	98	90	2	9	2	[72, 131, 132, 172, 173]
stomatal_density_average	Stomatal density averaged across both leaf surfaces	num.	63	18	3	63	6	[131, 132, 170, 172, 173] [124]
stomatal_distribution	Distribution of stomatal across the two leaf surfaces	cat.	390	0	1	389	1	[131, 132, 172, 173]
upper_cuticle_thickness	Thickness of the upper cuticle	num.	268	163	5	231	21	[88, 131, 132, 144, 171] [124, 172, 173]
upper_hypodermis_thickness	Thickness of the upper hypodermis	num.	8	8	2	7	4	[88, 144]
upper_palisade_cell_thickness	Thickness (length) of upper palisade cells	num.	95	95	2	81	11	[88, 144]
vein_angle_secondary	Angle of secondary veins	num.	287	287	1	229	1	[214]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
vein_density	Count of veins per distance	num.	298	254	2	252	2	[131, 132, 172, 173, 214]
vessel_density_leaves	Count of vessels per area in leaves	num.	151	151	1	34	13	[127, 128, 130, 164, 165] [166, 167]
vessel_diameter_leaves	Diameter of xylem vessels in leaves	num.	160	160	1	36	13	[127, 128, 130, 164, 165] [166, 167]
Leaf (nutrient)								
carotenoid_per_area	Leaf carotenoid content per unit leaf area	num.	93	93	1	38	12	[277]
carotenoid_per_dry_mass	Leaf carotenoid content per unit leaf dry mass	num.	163	163	2	67	12	[107, 277]
cell_epidermis_Ca_per_fresh_mass	Ca content of epidermal cells	num.	20	20	1	7	1	[278]
cell_epidermis_P_per_fresh_mass	P content of epidermal cells	num.	20	20	1	7	1	[278]
cell_hypodermis_Ca_per_fresh_mass	Ca content of hypodermis cells	num.	9	9	1	3	1	[278]
cell_hypodermis_P_per_fresh_mass	P content of hypodermis cells	num.	9	9	1	3	1	[278]
cell_internal_parenchyma_Ca_per_fresh_mass	Ca content of internal parenchyma cells	num.	12	12	1	4	1	[278]
cell_internal_parenchyma_P_per_fresh_mass	P content of internal parenchyma cells	num.	12	12	1	4	1	[278]
cell_palisade_mesophyll_Ca_per_fresh_mass	Ca content of palisade mesophyll cells	num.	20	20	1	7	1	[278]
cell_palisade_mesophyll_P_per_fresh_mass	P content of palisade mesophyll cells	num.	20	20	1	7	1	[278]
cell_rubisco_concentration	Concentration of Rubisco	num.	68	68	1	29	1	[107]
cell_rubisco_N_per_total_N	Percentage of N accounted for by Rubisco	num.	68	68	1	29	1	[107]
cell_sclerenchyma_Ca_per_fresh_mass	Ca content of sclerenchyma cells	num.	17	17	1	7	1	[278]
cell_sclerenchyma_P_per_fresh_mass	P content of sclerenchyma cells	num.	17	17	1	7	1	[278]
cell_spongy_mesophyll_Ca_per_fresh_mass	Ca content of spongy mesophyll cells	num.	9	9	1	3	1	[278]
cell_spongy_mesophyll_P_per_fresh_mass	P content of spongy mesophyll cells	num.	9	9	1	3	1	[278]
cell_thylakoid_N_per_total_N	Percentage of N accounted for by thylakoid proteins	num.	70	70	1	29	1	[107]
chlorophyll_A_B_ratio	Ratio of leaf chlorophyll A to chlorophyll B	num.	630	630	5	153	48	[70, 83, 102, 107, 277]
insoluable_protein_per_area	Mass of insoluble protein per leaf area	num.	30	30	1	1	1	[83]
leaf_Al_per_dry_mass	Leaf aluminium (Al) content per unit leaf dry mass	num.	548	548	6	112	36	[197, 218, 231, 278, 279] [47]
leaf_B_per_dry_mass	Leaf boron (B) content per unit leaf dry mass	num.	658	658	7	214	40	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 59, 165, 166, 167] [60, 61, 62, 63, 64] [65, 66, 67, 197, 231] [47, 218]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_C_per_dry_mass	Leaf carbon (C) content per unit leaf dry mass	num.	4419	4417	24	1060	113	[87, 127, 128, 130, 135] [136, 141, 142, 143, 157] [70, 92, 164, 165, 166] [35, 72, 123, 167, 280] [80, 100, 101, 181, 231] [83, 200, 201, 203, 281] [36, 37, 38, 218, 220] [47]
leaf_Ca_per_dry_mass	Leaf calcium (Ca) content per unit leaf dry mass	num.	1097	1089	15	292	49	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 279] [59, 256, 278, 280, 282] [60, 61, 62, 283, 284] [63, 64, 65, 66, 197] [47, 67, 68, 218, 231]
leaf_cell_wall_N	Proportion of leaf cell wall material that is nitrogen	num.	29	29	1	22	5	[113]
leaf_cell_wall_N_fraction	Proportion of all N in leaves that is found in the leaf cell walls	num.	29	29	1	22	5	[113]
leaf_Cl_per_dry_mass	Leaf chlorine (Cl) content per unit leaf dry mass	num.	6	6	2	6	2	[68, 256]
leaf_CN_ratio	Leaf carbon/nitrogen (C/N) ratio	num.	720	720	5	79	37	[72, 87, 123, 141, 280]
leaf_Cu_per_dry_mass	Leaf copper (Cu) content per unit leaf dry mass	num.	977	977	11	257	46	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 60, 61, 256, 278] [62, 63, 64, 65, 197] [66, 67, 68, 218, 231] [47]
leaf_Fe_per_dry_mass	Leaf iron (Fe) content per unit leaf dry mass	num.	975	975	11	256	46	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 60, 61, 256, 278] [62, 63, 64, 65, 197] [66, 67, 68, 218, 231] [47]
leaf_K_per_area	Leaf potassium (K) content per unit leaf area	num.	18	15	1	18	5	[77, 78]
leaf_K_per_dry_mass	Leaf potassium (K) content per unit leaf dry mass	num.	1875	1782	17	341	54	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 157] [58, 164, 165, 166, 167] [59, 256, 278, 280, 282] [60, 61, 62, 283, 284] [63, 64, 65, 66, 197] [67, 77, 78, 211, 231] [47, 68, 218]
leaf_lignin_per_dry_mass	Leaf lignin per unit leaf dry mass	num.	77	63	2	52	28	[123, 283]
leaf_Mg_per_dry_mass	Leaf magnesium (Mg) content per unit leaf dry mass	num.	1067	1059	14	288	48	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 256, 278, 282, 283] [60, 61, 62, 63, 284] [64, 65, 66, 197, 231] [47, 67, 68, 218]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_Mn_per_dry_mass	Leaf manganese (Mn) content per unit leaf dry mass	num.	975	975	11	256	46	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 60, 61, 256, 278] [62, 63, 64, 65, 197] [66, 67, 68, 218, 231] [47]
leaf_Mo_per_dry_mass	Leaf molybdenum (Mo) content per unit leaf dry mass	num.	330	330	3	77	22	[90, 127, 128, 130, 164] [165, 166, 167, 280]
leaf_N_per_area	Leaf nitrogen (N) content per unit leaf area	num.	3940	3928	28	681	83	[48, 49, 50, 51, 52] [53, 54, 55, 86, 135] [56, 140, 141, 142, 143] [148, 149, 150, 151, 152] [57, 58, 59, 160, 169] [35, 60, 115, 116, 117] [61, 62, 63, 118, 181] [64, 65, 80, 81, 187] [66, 82, 99, 119, 196] [83, 120, 121, 122, 199] [67, 77, 78, 104, 212] [36, 37, 84, 107, 108] [38, 220]
leaf_N_per_dry_mass	Leaf nitrogen (N) content per unit leaf dry mass	num.	10869	10628	77	2121	142	[48, 49, 50, 51, 125] [52, 53, 54, 55, 127] [86, 87, 109, 128, 130] [56, 135, 136, 140, 141] [88, 142, 143, 148, 149] [150, 151, 152, 153, 155] [57, 156, 157, 160, 163] [70, 92, 164, 165, 166] [93, 114, 167, 169, 285] [58, 59, 113, 256, 280] [41, 115, 282, 283, 284] [60, 94, 116, 174, 175] [112, 117, 123, 176, 178] [35, 61, 62, 72, 181] [63, 64, 118, 187, 191] [65, 80, 81, 82, 124] [66, 99, 119, 196, 197] [100, 100, 101, 120, 231] [199, 200, 200, 201, 202] [83, 102, 203, 204, 281] [121, 122, 207, 208, 286] [67, 77, 78, 209, 211] [84, 104, 107, 108, 212] [36, 37, 38, 68, 218] [47, 220]
leaf_Na_per_dry_mass	Leaf sodium (Na) content per unit leaf dry mass	num.	767	767	10	243	45	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 130, 164, 165] [58, 166, 167, 256, 278] [59, 60, 61, 62, 94] [63, 64, 65, 66, 197] [47, 67, 68, 218, 231]
leaf_Ni_per_dry_mass	Leaf nickel (Ni) content per unit leaf dry mass	num.	55	55	2	15	4	[90, 197]
leaf_P_per_area	Leaf phosphorus (P) content per unit leaf area	num.	2493	2490	16	361	64	[48, 49, 50, 51, 52] [53, 54, 55, 86, 135] [56, 90, 141, 151, 152] [57, 58, 59, 160, 169] [35, 60, 61, 62, 63] [64, 65, 80, 81, 82] [66, 77, 78, 99, 196] [36, 37, 38, 67, 108] [220]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_P_per_dry_mass	Leaf phosphorus (P) content per unit leaf dry mass	num.	5408	5253	41	958	104	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 86, 130, 135, 141] [57, 90, 151, 152, 157] [160, 163, 164, 165, 166] [93, 167, 169, 279, 285] [58, 59, 256, 278, 280] [41, 60, 282, 283, 284] [35, 61, 174, 175, 178] [62, 63, 64, 65, 80] [81, 82, 99, 196, 197] [66, 102, 203, 204, 231] [67, 77, 78, 211, 286] [36, 37, 68, 108, 218] [38, 47, 220]
leaf_S_per_dry_mass	Leaf sulphur (S) content per unit leaf dry mass	num.	974	966	12	263	46	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 60, 256, 278, 284] [61, 62, 63, 64, 65] [66, 67, 68, 197, 231] [47, 218]
leaf_soluable_starch_per_mass	Mass of soluble starch per leaf mass	num.	87	87	3	13	11	[71, 108, 287]
leaf_soluable_sugars_per_mass	Mass of soluble sugars per leaf mass	num.	43	43	2	2	2	[71, 287]
leaf_total_non-structural_carbohydrates_per_area	Total non-structural carbohydrates per leaf area	num.	22	22	1	11	10	[108]
leaf_total_non-structural_carbohydrates_per_mass	Total non-structural carbohydrates per leaf mass	num.	22	22	1	11	10	[108]
leaf_Zn_per_dry_mass	Leaf zinc (Zn) content per unit leaf dry mass	num.	971	971	11	257	46	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 57, 90, 130, 164] [58, 165, 166, 167, 280] [59, 60, 61, 256, 278] [62, 63, 64, 65, 197] [66, 67, 68, 218, 231] [47]
N_to_P_ratio	Ratio of N to P per unit leaf dry mass	num.	1583	1583	5	110	36	[86, 93, 108, 135, 141]
resorption_leaf_N	Nitrogen resorption from leaves	num.	86	86	1	14	7	[93]
resorption_leaf_P	Phosphorus resorption from leaves	num.	90	90	1	14	7	[93]
senesced_leaf_Ca_per_dry_mass	Senesced leaf calcium (Ca) content per unit leaf dry mass	num.	257	257	2	21	10	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 280] [62, 63, 64, 65, 66] [67]
senesced_leaf_Cu_per_dry_mass	Senesced leaf copper (Cu) content per unit leaf dry mass	num.	254	254	1	18	10	[280]
senesced_leaf_Fe_per_dry_mass	Senesced leaf iron (Fe) content per unit leaf dry mass	num.	254	254	1	18	10	[280]
senesced_leaf_K_per_dry_mass	Senesced leaf potassium (K) content per unit leaf dry mass	num.	257	257	2	21	10	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 280] [62, 63, 64, 65, 66] [67]
senesced_leaf_Mg_per_dry_mass	Senesced leaf magnesium (Mg) content per unit leaf dry mass	num.	257	257	2	21	10	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 280] [62, 63, 64, 65, 66] [67]
senesced_leaf_Mn_per_dry_mass	Senesced leaf manganese (Mn) content per unit leaf dry mass	num.	254	254	1	18	10	[280]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
senesced_leaf_Mo_per_dry_mass	Senesced leaf molybdenum (Mo) content per unit leaf dry mass	num.	176	176	1	18	10	[280]
senesced_leaf_N_per_dry_mass	Senesced leaf nitrogen (N) content per unit leaf dry mass	num.	459	459	5	47	18	[48, 49, 50, 51, 52] [53, 54, 55, 56, 141] [57, 58, 59, 93, 280] [41, 60, 61, 62, 63] [64, 65, 66, 67]
senesced_leaf_P_per_dry_mass	Senesced leaf phosphorus (P) content per unit leaf dry mass	num.	470	470	5	51	20	[48, 49, 50, 51, 52] [53, 54, 55, 56, 141] [57, 58, 59, 93, 280] [41, 60, 61, 62, 63] [64, 65, 66, 67]
senesced_leaf_S_per_dry_mass	Senesced leaf sulphur (S) content per unit leaf dry mass	num.	254	254	1	18	10	[280]
senesced_leaf_Zn_per_dry_mass	Senesced leaf zinc (Zn) content per unit leaf dry mass	num.	254	254	1	18	10	[280]
soluable_protein_per_area	Mass of soluble protein per leaf area	num.	66	66	2	2	1	[70, 83]
soluable_starch_per_area	Mass of soluble starch per leaf area	num.	83	83	2	13	10	[70, 108]
soluable_sugars_per_area	Mass of soluble sugars per leaf area	num.	112	112	3	13	10	[70, 83, 108]
starch_per_area	Mass of starch per leaf area	num.	30	30	1	1	1	[83]
Leaf (physiology)								
ca	Ambient CO2 concentration (external CO2 concentration)	num.	801	801	3	113	31	[35, 36, 37, 38, 80] [47]
cc	CO2 concentration inside chloroplasts	num.	90	90	1	37	11	[80]
chlorophyll_A_per_area	Leaf chlorophyll A content per leaf area	num.	93	93	1	38	12	[277]
chlorophyll_A_per_dry_mass	Leaf chlorophyll A content per unit leaf dry mass	num.	494	494	2	123	48	[102, 277]
chlorophyll_B_per_area	Leaf chlorophyll B content per leaf area	num.	93	93	1	38	12	[277]
chlorophyll_B_per_dry_mass	Leaf chlorophyll B content per unit leaf dry mass	num.	494	494	2	123	48	[102, 277]
chlorophyll_per_area	Sum of chlorophyll A and B per leaf area	num.	416	416	7	63	21	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 70, 112] [61, 62, 63, 64, 176] [65, 66, 81, 82, 83] [67, 277]
chlorophyll_per_dry_mass	Leaf chlorophyll content per unit leaf dry mass	num.	778	778	4	172	55	[81, 82, 102, 107, 277]
ci	CO2 concentration in interstitial spaces under ambient conditions	num.	43	43	2	29	13	[84, 104]
ci_at_Amax	CO2 concentration in interstitial spaces during Amax measurement	num.	1347	1347	5	118	33	[70, 71, 80, 83, 86]
ci_at_Asat	CO2 concentration in interstitial spaces during Asat measurement	num.	3575	3575	16	248	53	[40, 86, 87, 135, 287] [70, 92, 113, 154, 169] [35, 71, 72, 83, 108] [36, 37, 38, 47]
ci_over_ca	Ratio of internal to external CO2 concentrations	num.	2913	2913	14	481	78	[86, 87, 135, 142, 143] [35, 92, 113, 169, 287] [36, 72, 80, 104, 207] [37, 38, 47]
fluorescence_Jmax_over_Vcmax	Ratio of photosynthetic electron transport capacity to maximum Rubisco activity, measured through chlorophyll fluorescence	num.	90	90	1	37	11	[80]
fluorescence_Jmax_per_mass	Capacity for photosynthetic electron transport, measured through chlorophyll fluorescence, on a per mass basis	num.	90	90	1	37	11	[80]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
fluorescence_Vcmax_per_mass	Maximum carboxylase activity of ribulose 1,5-bisphosphate carboxylase/oxygenase (Rubisco), measured through chlorophyll fluorescence, on a per mass basis	num.	90	90	1	37	11	[80]
fv_over_fm	Chlorophyll fluorescence measurement that indicates whether plant stress affects photo-system II in a dark adapted state	num.	153	153	2	3	3	[69, 110]
Jmax_per_area	Capacity for photosynthetic electron transport, calculated from an A-Ci response curve, on an area basis	num.	245	245	3	76	38	[135, 136, 140]
leaf_absorption	Proportion of incoming visible light (between 400-700 nm) that is absorbed by the leaf	num.	99	99	1	37	12	[277]
leaf_dark_respiration_per_area	Leaf respiration rate per unit leaf area, in the dark	num.	2205	2058	13	325	64	[40, 86, 127, 128, 130] [135, 148, 164, 165, 287] [93, 166, 167, 169, 178] [80, 104, 108, 204]
leaf_dark_respiration_per_dry_mass	Leaf respiration rate per unit leaf dry mass, in the dark	num.	1585	1585	8	300	52	[86, 127, 128, 130, 148] [164, 165, 166, 167, 169] [35, 36, 80, 93, 104] [37, 38]
leaf_dark_transpiration_per_area	Leaf transpiration rate per unit leaf area, in the dark	num.	1027	1027	1	78	31	[86]
leaf_delta13C	Leaf carbon stable isotope signature	num.	4981	4946	31	1490	116	[48, 49, 50, 51, 125] [52, 53, 54, 55, 127] [87, 128, 130, 135, 136] [56, 57, 142, 143, 153] [92, 164, 165, 166, 167] [58, 59, 60, 94, 113] [35, 61, 62, 72, 112] [63, 64, 65, 80, 288] [66, 100, 100, 101, 197] [199, 200, 200, 201, 231] [202, 203, 210, 232, 281] [36, 67, 84, 107, 212] [37, 38, 47]
leaf_delta15N	Leaf nitrogen stable isotope signature	num.	2538	2537	15	856	103	[87, 94, 136, 142, 143] [35, 72, 80, 100, 197] [100, 101, 199, 203, 231] [36, 37, 38, 47, 281]
leaf_delta18O	Leaf oxygen stable isotope signature	num.	15	15	1	1	1	[84]
leaf_hydraulic_conductivity	Measure of how efficiently water is transported through the leaf, determined as the ratio of water flow rate through the leaf to the difference in water potential across the leaf, standardised to leaf area.	num.	81	81	2	79	22	[126, 127, 128, 130, 164] [165, 166, 167]
leaf_hydraulic_vulnerability	Leaf water potential value at which leaf hydraulic conductance has declined by 50% from the mean maximum rate	num.	20	20	1	20	9	[126]
leaf_light_respiration_per_area	Leaf respiration rate per unit leaf area, in the light	num.	106	106	2	9	8	[93, 140]
leaf_mesophyll_conductance_per_area	Rate of CO2 movement between chloroplasts and sub-stomatal cavities (intracellular space), per unit leaf area	num.	90	90	1	37	11	[80]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
leaf_mesophyll_conductance_per_mass	Rate of CO2 movement between chloroplasts and sub-stomatal cavities (intracellular space), per unit leaf mass	num.	90	90	1	37	11	[80]
leaf_photosynthetic_nitrogen_use_efficiency_maximum	Ratio of photosynthesis (CO2 assimilation rate) to leaf nitrogen content at saturating light and CO2 conditions	num.	99	99	1	19	12	[93]
leaf_photosynthetic_nitrogen_use_efficiency_saturated	Ratio of photosynthesis (CO2 assimilation rate) to leaf nitrogen content at saturating light conditions but ambient CO2 conditions	num.	1410	1408	8	160	48	[86, 87, 93, 148, 160] [77, 78, 84, 113]
leaf_photosynthetic_phosphorus_use_efficiency_maximum	Ratio of photosynthesis (CO2 assimilation rate) to leaf phosphorus content at saturating light and CO2 conditions	num.	73	73	1	14	7	[93]
leaf_photosynthetic_phosphorus_use_efficiency_saturated	Ratio of photosynthesis (CO2 assimilation rate) to leaf phosphorus content at saturating light conditions but ambient CO2 conditions	num.	1269	1269	3	108	37	[86, 93, 160]
leaf_PRI	Photochemical reflectance index measures plant responses to stress, by indicating changes in carotenoid pigments in live foliage.	num.	552	552	2	38	12	[125, 277]
leaf_reflectance	Proportion of incoming visible light (between 400-700 nm) that is reflected by the leaf	num.	194	194	2	132	44	[89, 277]
leaf_reflectance_near_infrared	Proportion of incoming near infra-red light (between 750-10500 nm) that is reflected by the leaf	num.	95	95	1	95	37	[89]
leaf_specific_conductivity	Kl; the ratio of leaf hydraulic conductivity to the leaf area distil to the segment	num.	387	387	6	148	32	[127, 128, 130, 137, 138] [164, 165, 166, 167, 289] [181, 207, 221, 290]
leaf_transmission	Proportion of incoming visible light (between 400-700 nm) that is transmitted through the leaf	num.	98	98	1	37	12	[277]
leaf_transpiration	Rate of water loss from leaf under ambient conditions	num.	180	180	1	4	4	[137, 138]
leaf_transpiration_at_Amax	Rate of water loss from leaf during Amax measurement	num.	1351	1351	5	89	31	[70, 71, 83, 86, 135]
leaf_transpiration_at_Asat	Rate of water loss from leaf during Asat measurement	num.	2440	2440	13	176	47	[40, 86, 135, 148, 287] [35, 70, 71, 92, 176] [36, 37, 72, 83, 108] [38]
leaf_turgor_loss_point	Water potential at which a leaf loses turgor	num.	166	166	3	85	23	[35, 36, 37, 126, 153] [38]
leaf_work_to_tear	Measures of how much force (work) is required to tear/rip a leaf; units same as J/m; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	16	16	1	16	14	[99]
leaf_work_to_tear_adjusted	Measures of how much force (work) is required to tear/rip a leaf, adjusted to leaf thickness; units same as J/m2; slight variation in methods used will mean that, in some cases, values are not perfectly comparable across studies	num.	36	36	2	31	20	[99, 151, 152]
leaf_xylem_delta15N	Xylem nitrogen stable isotope signature from leaves	num.	78	78	1	18	3	[281]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
osmotic__potential	Potential for water to move across a semi-permeable membrane based on solute concentration	num.	80	80	1	4	2	[153]
photosynthetic__rate__per__area__ambient	Rate at which a plant consumes carbon dioxide through photosynthesis, per unit leaf area	num.	198	198	2	10	6	[137, 138, 197]
photosynthetic__rate__per__area__maximum	Rate at which a plant consumes carbon dioxide through photosynthesis at saturating light and CO2 conditions, per unit leaf area	num.	1559	1559	7	144	37	[70, 72, 86, 93, 135] [80, 83]
photosynthetic__rate__per__area__saturated	Rate at which a plant consumes carbon dioxide through photosynthesis at saturating light conditions but ambient CO2 conditions, per unit leaf area	num.	5132	4916	36	519	88	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [40, 86, 87, 130, 135] [56, 136, 140, 148, 287] [57, 149, 150, 154, 160] [70, 92, 164, 165, 166] [58, 93, 113, 167, 169] [35, 59, 60, 176, 178] [61, 62, 72, 73, 181] [63, 64, 65, 81, 82] [66, 76, 83, 197, 204] [67, 77, 78, 207, 211] [36, 37, 84, 104, 108] [38, 47]
photosynthetic__rate__per__dry__mass__maximum	Maximum rate at which a plant consumes carbon dioxide through photosynthesis at saturating light and CO2 conditions, per unit leaf dry mass	num.	1377	1377	4	142	37	[80, 86, 93, 169]
photosynthetic__rate__per__dry__mass__saturated	Maximum rate at which a plant consumes carbon dioxide through photosynthesis at saturating light conditions but ambient CO2 conditions, per unit leaf dry mass	num.	3084	2871	20	399	75	[48, 49, 50, 51, 52] [53, 54, 55, 127, 128] [56, 86, 87, 130, 148] [57, 149, 150, 160, 164] [58, 93, 165, 166, 167] [35, 59, 60, 176, 178] [61, 62, 181, 289, 290] [63, 64, 65, 81, 82] [66, 77, 78, 207, 211] [36, 37, 67, 84, 104] [38, 47]
stomatal__conductance__per__area__ambient	Rate of water loss through stomata under ambient conditions, per unit leaf area	num.	217	217	3	12	7	[110, 137, 138, 197]
stomatal__conductance__per__area__at__Amax	Rate of water loss through stomata, per unit leaf area under saturated light and CO2 conditions	num.	1386	1386	6	90	32	[70, 71, 72, 86, 135] [83]
stomatal__conductance__per__area__at__Asat	Rate of water loss through stomata, per unit leaf area under saturated light conditions	num.	4415	4203	28	378	81	[48, 49, 50, 51, 52] [53, 54, 55, 86, 87] [40, 56, 135, 136, 140] [57, 92, 148, 154, 287] [58, 59, 60, 70, 169] [35, 61, 72, 176, 178] [62, 63, 64, 65, 73] [66, 76, 83, 197, 207] [67, 77, 78, 104, 211] [36, 37, 38, 84, 108] [47]
Vcmax__per__area	Maximum carboxylase activity of ribulose 1,5-bisphosphate carboxylase/oxygenase (Rubisco), calculated from an A-Ci response curve, on an area basis	num.	245	245	3	76	38	[135, 136, 140]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
water_band_index	Water band index, the ratio of the reflectance at 970 nm / 900 nm, recorded from the spectro-radiometer.	num.	453	453	1	1	1	[125]
water_potential_midday	A plant's water potential during the heat of the day	num.	588	580	8	188	33	[127, 128, 130, 291, 292] [137, 137, 138, 293, 294] [110, 153, 164, 165, 295] [35, 166, 167, 289, 296] [36, 188, 290, 297, 298] [37, 38]
water_potential_predawn	A plant's water potential just before sunrise	num.	308	300	5	163	32	[127, 128, 130, 137, 138] [35, 164, 165, 166, 167] [36, 37, 188, 289, 290] [38]
water_use_efficiency_integrated	WUE; Rate of carbon dioxide uptake relative to water loss, per unit leaf area. This measures how much biomass is produced relative to transpiration, and is therefore an integrated measure of water use efficiency. (Calculated as biomass production / transpiration)	num.	111	111	1	97	19	[127, 128, 130, 164, 165] [166, 167]
water_use_efficiency_intrinsic	PWUE calculated as Aarea/gs; Ratio of photosynthesis (CO2 assimilation rate) to stomatal conductance (gs). This is intrinsic water use efficiency.	num.	503	437	5	105	31	[35, 76, 77, 78, 87] [36, 37, 38, 211]
water_use_efficiency_photosynthetic	PWUE calculated as Aarea/E; Ratio of photosynthesis (CO2 assimilation rate) to leaf transpiration (E; water loss). This is also termed instantaneous water use efficiency.	num.	3398	3331	7	189	53	[35, 86, 87, 92, 160] [36, 37, 38, 84, 211]
Reproductive (allocation)								
accessory_cost_fraction	Fraction of total reproductive investment required to mature a seed that is invested in non-seed tissues	num.	47	47	1	47	13	[299]
accessory_cost_mass	Mass of seed accessory costs, the proportion of a fruit that does not develop into a seed	num.	47	47	1	47	13	[299]
flower_count_maximum	Maximum flower number produced	num.	7	7	1	7	4	[191]
Reproductive (life history)								
dispersal_syndrome	Type of dispersal syndrome displayed by taxon, although the list includes many dispersal appendages and fruit types. Many definitions come from Kew Botanic Gardens website.	cat.	12621	1039	27	8593	209	[85, 133, 134, 223, 300] [145, 162, 301, 302, 303] [239, 304, 305, 306, 307] [177, 183, 308, 309, 310] [184, 185, 242, 243, 253] [189, 193, 246, 311, 312] [206, 215, 233, 313, 314] [315]
dispersers	Types of animals dispersing fruit	cat.	913	234	2	765	101	[198, 316]
fire_cued_seeding	Distinguishes between plants that do and do not have fire-cued seeding	cat.	3329	5	3	2947	143	[317, 318, 319]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
flowering_time	Months during which taxon is flowering; keyed as a sequences of 12 0s (not flowering) and 1s (flowering) starting with January	chr.	27844	0	28	17770	267	[223, 224, 257, 258, 320] [259, 260, 261, 305, 316] [228, 229, 230, 264, 321] [265, 266, 267, 268, 269] [233, 270, 271, 273, 274] [234, 275, 276, 314]
fruiting_time	Months during which taxon is fruiting; keyed as a sequences of 12 0s (not flowering) and 1s (flowering) starting with January	chr.	3514	36	6	3262	197	[228, 230, 261, 316, 322] [233]
germination	Proportion of seeds that germinate	num.	7644	872	5	2549	119	[154, 323, 324, 325, 326] [327]
ploidy	Chromosome ploidy	num.	62	22	1	61	1	[328]
pollination_syndrome	Pollination syndrome	cat.	8973	285	5	7866	191	[242, 243, 253, 323, 324] [314]
pollination_system	Pollination system	cat.	915	0	1	902	108	[145, 193, 206]
regen_strategy	Different regeneration strategies displayed by plants. Trait values include both generic terms and quite specific ones. See Pausus, Lamont et al. 2018, doi.org/10.1111/nph.14982 for trait values used and detailed desciptions of recolonization ability and level of fire protection provided by each regeneration strategy. This trait includes terminology for storage organs and regeneration strategies following fire. The trait "fire_response" is a binary trait distinguishing between fire-killed and regenerating taxa.	cat.	9261	1044	18	7002	200	[90, 145, 317, 319, 329] [183, 184, 240, 323, 324] [97, 185, 242, 243, 253] [189, 193, 330, 331, 332] [100, 206, 271, 314, 333] [334]
seed_longevity	Seed longevity	cat.	8937	0	2	7207	173	[314, 318]
seed_release	When a fruit or cone only releases its seeds following an environmental trigger, often fire; ; see also 'seed_longevity', 'seed_storage_location', 'soil_seedbank', 'canopy_seedbank', and 'serotiny'	cat.	7925	0	1	7053	168	[314]
seed_storage_location	Location where seeds are stored at maturity; see also 'seed_longevity', 'soil_seedbank', 'canopy_seedbank', and 'serotiny'	cat.	587	587	1	584	72	[286]
seed_viability	Proportion of seeds that are viable	num.	145	145	2	104	20	[154, 335]
serotiny	Categorical variable describing whether a fruit or cone only releases its seeds following an environmental trigger, often fire	cat.	1048	472	8	993	79	[90, 336, 337, 338, 339] [305, 308, 323, 324, 340] [330, 331, 334, 341, 342]
sex_type	Plant sex type	cat.	24382	0	5	21205	227	[243, 253, 343, 344, 345]
soil_seedbank	Binary variable indicating if seeds present in soil seedbank; see also 'seed_longevity', 'seed_storage_location', 'canopy_seedbank', and 'serotiny'	cat.	522	334	4	515	62	[308, 336, 337, 338, 339] [310, 313, 315]
Reproductive (morphology)								
diaspore_mass	Mass of seed including dispersal appendages	num.	314	314	2	283	50	[240, 335]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
dispersal_appendage	Type of dispersal appendage present	cat.	3316	615	11	2920	108	[161, 162, 261, 320, 346] [227, 243, 253, 344, 347] [228, 233]
embryo_colour	Binary variable distinguishing between embryos that are green versus colourless	cat.	296	0	1	293	53	[235]
flower_colour	Flower colour, with six possible outcomes	cat.	8667	0	1	5037	195	[230]
fruit_breadth	Shorter width dimension of a fruit; orthogonal to the length	num.	86	0	2	47	2	[243, 253]
fruit_length	Longest fruit dimension or if clearly recognizable the length from its base to its apex	num.	6639	340	10	3289	177	[261, 262, 316, 320, 322] [194, 243, 253, 323, 324] [255]
fruit_mass	Dry mass of a fruit, including the seed	num.	495	400	7	138	5	[256, 322, 323, 324, 348] [176, 194, 195]
fruit_type	Fruit types	cat.	31299	519	9	22403	248	[242, 253, 316, 320, 343] [198, 235, 243, 345]
fruit_type_botanical	Binary variable, dividing fruits into 'dry' versus 'fleshy' based on botanical descriptions of the true fruit	cat.	5350	0	2	5126	149	[320, 344]
fruit_type_functional	Binary variable dividing fruits into dry versus fleshy based on their dispersal units. Fruits classified as 'fleshy' if the true fruit, accessory fruits (such as the receptacle in Podocarpus) and appendages (e.g. the sarcotesta in Cycads) were fleshy when mature (e.g. aril, thalamus, receptacle, calyx, rachis or bract or succulent pedicel); otherwise, they are classified as 'non-fleshy'	cat.	4126	0	1	4106	82	[320]
fruit_wall_width	Width of the fruit wall	num.	329	329	1	16	1	[194]
fruit_width	Longest width dimension of a fruit; orthogonal to the length	num.	5438	340	9	2643	162	[261, 262, 316, 320, 322] [194, 253, 255, 323, 324]
germination_treatment	Seed treatment required for germination	cat.	3530	738	2	1116	63	[327, 346]
seed_breadth	Shorter width axis of a seed; orthogonal to its length	num.	3859	2574	14	881	75	[154, 223, 224, 251, 261] [226, 227, 228, 262, 306] [233, 267, 269, 273]
seed_length	Longest seed dimension	num.	20964	3720	33	7693	211	[223, 224, 257, 258, 346] [225, 251, 259, 316, 320] [154, 261, 262, 263, 306] [226, 227, 228, 253, 344] [265, 266, 267, 268, 269] [198, 233, 270, 271, 273] [255, 275, 276]
seed_mass	Seed dry mass	num.	40362	20574	49	9935	228	[85, 133, 134, 346, 349] [90, 139, 145, 146, 154] [155, 156, 162, 323, 324] [256, 299, 304, 340, 348] [239, 240, 284, 325, 350] [177, 180, 182, 241, 309] [183, 184, 185, 242, 310] [243, 244, 253, 351, 352] [189, 190, 193, 245, 353] [194, 195, 249, 341, 354] [76, 286, 342, 355, 356] [206, 208, 209, 250, 313] [36, 215, 215, 315]
seed_mass_reserve	Energy reserves stored in seeds that are mobilized at the time of germination; on a carbon dry mass basis	num.	104	58	2	73	18	[36, 215, 216]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
seed_shape	Possible seed shapes. Note that some terms currently used refer to 2-dimensional shapes, not 3-dimensional shapes.	cat.	2978	983	8	2713	109	[223, 224, 251, 261, 346] [227, 228, 233]
seed_texture	Texture of a seed	cat.	960	942	1	939	83	[346]
seed_volume	Volume of a seed	num.	516	0	1	511	80	[235]
seed_width	Longest width dimension of a seed; orthogonal to the length	num.	12066	3584	27	5207	190	[223, 224, 251, 320, 346] [154, 225, 259, 261, 262] [226, 227, 228, 306, 344] [265, 266, 267, 268, 269] [233, 270, 271, 273, 275] [255, 276]
Reproductive (nutrient)								
flower_N_per_dry_mass	Flower nitrogen (N) content per unit flower dry mass	num.	8	8	1	1	1	[176]
fruit_Ca_per_dry_mass	Fruit calcium (Ca) content per unit fruit dry mass	num.	19	11	3	19	1	[256, 284, 348]
fruit_K_per_dry_mass	Fruit potassium (K) content per unit fruit dry mass	num.	19	11	3	19	1	[256, 284, 348]
fruit_Mg_per_dry_mass	Fruit magnesium (Mg) content per unit fruit dry mass	num.	19	11	3	19	1	[256, 284, 348]
fruit_N_per_dry_mass	Fruit nitrogen (N) content per unit fruit dry mass	num.	23	15	4	20	2	[176, 256, 284, 348]
fruit_P_per_dry_mass	Fruit phosphorus (P) content per unit fruit dry mass	num.	21	13	4	21	3	[256, 284, 322, 348]
fruit_S_per_dry_mass	Fruit sulphur (S) content per unit fruit dry mass	num.	19	11	3	19	1	[256, 284, 348]
seed_Ca_concentration	Seed calcium (Ca) content per unit seed mass	num.	23	15	4	23	2	[256, 284, 348, 351]
seed_K_concentration	Seed potassium (K) content per unit seed mass	num.	43	15	5	40	2	[256, 284, 348, 351, 352]
seed_Mg_concentration	Seed magnesium (Mg) content per unit seed mass	num.	23	15	4	23	2	[256, 284, 348, 351]
seed_N_concentration	Seed nitrogen (N) content per unit seed mass	num.	43	15	5	40	2	[256, 284, 348, 351, 352]
seed_oil_content	Seed oil content as a fraction of total seed weight, usually on a dry weight basis	num.	327	0	2	230	41	[284, 357]
seed_P_concentration	Seed phosphorus (P) content per unit seed mass	num.	115	51	7	44	2	[90, 256, 284, 340, 348] [341, 342, 351, 352]
seed_protein_content	Seed protein content as a fraction of total seed weight	num.	154	0	2	85	24	[284, 358]
seed_S_concentration	Seed sulphur (S) content per unit seed mass	num.	19	11	3	19	1	[256, 284, 348]
Root (allocation)								
root_distribution_ coefficient	Root biomass depth distribution coefficient ('B' from Gale & Grigal (1987), where high values indicate root biomass allocated deeper in the soil).	num.	75	75	1	75	33	[95]
root_dry_matter_ content	Root dry mass per unit root fresh mass	num.	124	124	2	96	39	[95, 103]
root_fine_root_ coarse_root_ratio	Volume of fine root (<0.5mm diametre) / Volume of coarse root (>0.5mm diametre)	num.	41	41	1	14	5	[95]
root_mass_fraction	Fraction of plant dry mass comprised of root material	num.	1983	1906	6	57	19	[69, 71, 74, 92, 154] [211]
root_shoot_ratio	Ratio of root dry mass to shoot dry mass	num.	1996	1996	7	113	37	[70, 71, 92, 154, 287] [76, 95]
specific_root_area	Root area per unit root dry mass	num.	102	102	1	75	33	[95]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
specific_root_length	Root length per unit root dry mass; SRL	num.	201	201	4	66	26	[91, 95, 103, 160]
specific_taproot_length	Taproot length per unit root dry mass. This trait measures the efficiency of taproot length per unit mass during the very early stage of growth when seedlings need to reach reliable water.	num.	188	158	1	12	4	[211]
thickest_root_diameter	Diameter of the thickest root	num.	264	264	1	71	30	[95]
Root (life history)								
sprout_depth	Depth of resprouting shoots	num.	4349	4349	1	39	13	[359]
Root (morphology)								
root_morphology	Categorical root descriptions sensu Cannon 1949, A Tentative Classification of Root Systems, Ecology, doi.org/10.2307/1932458	cat.	15	15	1	12	8	[160]
root_structure	Specific specialized types of root structures and root symbioses. https://www.mycorrhizas.info/ provides detailed information for types of mycorrhizal associations.	cat.	3152	1290	14	2599	164	[94, 145, 160, 183, 280] [184, 185, 242, 243, 253] [189, 193, 197, 332, 360] [100, 100, 101, 206, 286]
root_wood_density	Root wood dry mass per unit root wood fresh volume	num.	199	137	3	99	31	[91, 103, 188]
tap_root	Binary variable describing whether or not a plant has a tap root	cat.	67	67	1	67	28	[95]
Root (nutrient)								
root_C_per_dry_mass	Root carbon (C) content per unit root dry mass	num.	61	61	2	15	5	[72, 281]
root_N_per_dry_mass	Root nitrogen (N) content per unit root dry mass	num.	64	64	2	15	5	[72, 281]
root_soluable_starch_per_mass	Mass of soluble starch per root mass	num.	43	43	2	2	2	[71, 287]
root_soluable_sugars_per_mass	Mass of soluble sugars per root mass	num.	43	43	2	2	2	[71, 287]
Root (physiology)								
root_delta13C	Root carbon stable isotope signature	num.	61	61	2	15	5	[72, 281]
root_delta15N	Root nitrogen stable isotope signature	num.	60	60	2	15	5	[72, 281]
root_xylem_delta15N	Xylem nitrogen stable isotope signature from roots	num.	67	67	1	16	3	[281]
Stem (allocation)								
basal_diameter	Diameter at the base of the plant, usually "DBH" except in short plants; only "maximum" values are included	num.	401	18	2	395	66	[208, 209, 316]
branch_mass_fraction	Fraction of plant dry mass comprised of branch material	num.	45	45	1	45	23	[155]
huber_value	Sapwood area to leaf area ratio	num.	1171	1171	15	304	54	[40, 127, 128, 130, 137] [138, 153, 155, 156, 164] [41, 165, 166, 167, 289] [75, 76, 181, 207, 290] [219, 221, 222]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
stem_count_categorical	Number of stems present, expressed in groups, where categories were 1=1; 2-3=2; 4-10=3; 11-30=4; and >30=5. Used by Peter Vesk.	num.	140	140	2	61	16	[212, 359]
stem_dry_matter_content	Stem dry mass per unit stem fresh mass	num.	390	390	2	53	15	[45, 46]
stem_mass_fraction	Ratio of stem dry mass to total plant dry mass	num.	1126	1123	3	49	11	[71, 77, 78, 154]
stem_water_content_per_saturated_mass	Ratio of water in a saturated stem (maximal water holding capacity at full turgidity) to stem saturated mass	num.	137	137	2	61	15	[35, 36, 37, 38, 76]
twig_area	Cross-sectional area of the terminal twig	num.	58	58	1	57	15	[215, 216]
twig_length	Length of the terminal twig	num.	33	33	1	33	8	[215, 216]
Stem (morphology)								
bark_morphology	Description of bark morphology	cat.	276	0	1	243	1	[314]
plant_height	Vegetative plant height	num.	42347	3430	65	17477	266	[48, 49, 50, 51, 85] [52, 53, 54, 223, 257] [55, 127, 128, 130, 224] [133, 134, 137, 251, 258] [138, 225, 259, 260, 316] [56, 139, 145, 146, 261] [57, 156, 164, 165, 262] [58, 59, 166, 167, 263] [39, 226, 239, 264, 305] [35, 60, 61, 177, 240] [62, 63, 227, 241, 252] [183, 184, 185, 242, 253] [64, 188, 189, 243, 244] [192, 228, 229, 245, 311] [65, 193, 194, 195, 230] [66, 249, 265, 266, 267] [268, 269, 270, 271, 272] [198, 206, 208, 209, 273] [210, 233, 274, 275, 276] [67, 106, 215, 234, 250] [36, 37, 38, 254, 255]
stem_density	Stem dry mass per unit stem fresh volume, specifically for non-woody or partially woody stems that otherwise are outliers for wood density	num.	880	880	1	27	6	[154]
vessel_density	Count of vessels per area in stems	num.	496	496	5	148	38	[41, 137, 138, 361, 362] [222]
vessel_diameter	Diameter of xylem vessels in stems	num.	531	531	7	171	42	[41, 137, 138, 179, 361] [73, 222, 362]
vessel_diameter_hydraulic	Hydraulic diameter (hydraulically weighted diameter) is based on the equivalent circle diameter D and has been introduced to reflect the actual conductance of conduits. Based on the Hagen–Poiseuille law, a few large conduits may transport an equal amount of water as many small ones.	num.	488	488	5	148	38	[41, 137, 138, 361, 362] [222]
vessel_lumen_fraction	Fraction of xylem vessels comprised of lumen	num.	503	503	5	161	39	[41, 179, 222, 361, 362]
vessel_non_lumen_fraction	Fraction of xylem vessels comprised of non-lumen	num.	19	19	1	16	9	[179]
vessel_wall_fraction	Fraction of xylem vessels comprised of cell wall	num.	278	278	2	87	32	[222, 362]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
wood_axial_ parenchyma_fraction	Fraction of wood comprised of axial parenchyma	num.	435	435	3	103	33	[41, 222, 362]
wood_conduit_fraction	Fraction of wood comprised of all conduits	num.	157	157	1	16	8	[41]
wood_density	Stem dry mass per unit stem fresh volume (stem specific density or SSD or wood density)	num.	8017	4068	40	1899	117	[125, 126, 127, 128, 363] [87, 130, 137, 364, 365] [138, 147, 366, 367, 368] [91, 153, 155, 156, 369] [164, 165, 166, 167, 370] [39, 226, 361, 371, 372] [41, 45, 179, 373, 374] [46, 182, 188, 242, 375] [34, 75, 194, 248, 376] [198, 205, 207, 208, 377] [209, 210, 217, 219, 378] [47, 220, 221, 379, 379] [222, 362]
wood_fibre_fraction	Fraction of wood comprised of fibres	num.	435	435	3	103	33	[41, 222, 362]
wood_ray_fraction	Fraction of wood comprised of rays	num.	435	435	3	103	33	[41, 222, 362]
wood_tracheid_ fraction	Fraction of wood comprised of tracheids	num.	72	72	1	23	8	[362]
woodiness	A plant's degree of lignification in stems	cat.	14134	215	14	9494	240	[131, 132, 262, 300, 319] [162, 172, 306, 328, 344] [173, 229, 230, 246, 252] [100, 203, 380]
Stem (nutrient)								
dead_wood_Ca_per_dry mass	Dead wood calcium (Ca) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
dead_wood_K_per_dry_ mass	Dead wood potassium (K) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
dead_wood_Mg_per_dry mass	Dead wood magnesium (Mg) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
dead_wood_N_per_dry_ mass	Dead wood nitrogen (N) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
dead_wood_Na_per_dry mass	Dead wood sodium (Na) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
dead_wood_P_per_dry_ mass	Dead wood phosphorus (P) content per unit dead wood dry mass	num.	5	5	2	5	1	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
stem_C_per_dry_mass	Stem carbon (C) content per unit stem dry mass	num.	82	82	1	22	8	[45]
stem_N_per_dry_mass	Stem nitrogen (N) content per unit stem dry mass	num.	82	82	1	22	8	[45]
stem_soluable_starch_ per_mass	Mass of soluble starch per stem mass	num.	43	43	2	2	2	[71, 287]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
stem_soluable_sugars_per_mass	Mass of soluble sugars per stem mass	num.	43	43	2	2	2	[71, 287]
wood_C_per_dry_mass	Wood carbon (C) content per unit wood dry mass	num.	280	280	4	36	19	[47, 72, 87, 141]
wood_Ca_per_dry_mass	Wood calcium (Ca) content per unit wood dry mass	num.	48	48	2	13	4	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
wood_K_per_dry_mass	Wood potassium (K) content per unit wood dry mass	num.	48	48	2	13	4	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
wood_Mg_per_dry_mass	Wood magnesium (Mg) content per unit wood dry mass	num.	45	45	2	13	4	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
wood_N_per_dry_mass	Wood nitrogen (N) content per unit wood dry mass	num.	568	568	7	68	24	[48, 49, 50, 51, 52] [53, 54, 55, 56, 87] [41, 57, 58, 59, 141] [60, 61, 62, 63, 72] [64, 65, 66, 67, 68] [47]
wood_Na_per_dry_mass	Wood sodium (Na) content per unit wood dry mass	num.	31	31	2	9	4	[48, 49, 50, 51, 52] [53, 54, 55, 56, 57] [58, 59, 60, 61, 62] [63, 64, 65, 66, 67] [68]
wood_P_per_dry_mass	Wood phosphorus (P) content per unit wood dry mass	num.	299	299	4	33	9	[48, 49, 50, 51, 52] [53, 54, 55, 56, 141] [41, 57, 58, 59, 60] [61, 62, 63, 64, 65] [66, 67, 68]
Stem (physiology)								
bulk_modulus_of_elasticity	In leaves, the ratio of the change in cell turgor to the change in cell volume as a plant dries out; calculated from a pressure-volume curve	num.	66	66	1	61	17	[35, 36, 37, 38]
hydraulic_safety_margin_50	Difference between minimum observed water potential and water potential at which 50% of conductivity is lost.	num.	24	24	1	24	7	[137, 291, 292, 293, 294] [295, 296, 297, 298]
modulus_of_elasticity_stem	A measure of the force required to bend a stem; This is the modulus of a compound tissue made up of bark and wood (or xylem) and potentially pith; could also be called structural modulus of elasticity	num.	222	222	2	93	35	[34, 46]
modulus_of_elasticity_xylem	A measure of xylem's resistance to being deformed elastically (i.e., non-permanently) when a stress is applied to it; definition for measurements on wood (secondary xylem)	num.	549	549	4	208	44	[127, 128, 130, 164, 165] [34, 46, 166, 167, 222]
modulus_of_rupture	A measure of the force required to rupture xylem vessels	num.	347	347	3	165	40	[127, 128, 130, 164, 165] [34, 46, 166, 167]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
sapwood_specific_conductivity	Ks; Describes the flow rate of water (kg/s) along a stem for a given drop in pressure (1/MPa), normalised to the length of the segment (1/m). Calculated as hydraulic conductivity divided by the sapwood cross-sectional area where the measurement is taken.	num.	608	608	9	182	40	[127, 128, 130, 137, 138] [164, 165, 166, 167, 361] [41, 73, 181, 289, 290] [207, 221]
stem_hydraulic_conductivity	Kh; Measure of how efficiently water is transported through the leaf, determined as the ratio of water flow rate through the leaf to the difference in water potential across the leaf, standardised to leaf area; units same as mg*m/s/MPa	num.	261	261	5	51	18	[137, 138, 181, 289, 290] [207, 221]
stem_respiration_per_dry_mass	Stem respiration rate per unit dry mass	num.	212	212	1	4	2	[40]
stem_water_delta18O	Oxygen stable isotope signature of stem water	num.	95	95	1	17	14	[87]
transverse_branch_area_specific_conductivity	Describes the flow rate of water (kg/s) along a stem for a given drop in pressure (1/MPa), normalised to the length of the segment (1/m). Calculated as hydraulic conductivity divided by the transverse branch area where the measurement is taken.	num.	112	112	2	10	6	[181, 289, 290]
water_potential_50percent_lost_conductivity	Xylem pressure at which 50% of conductivity is lost	num.	99	99	2	97	25	[127, 128, 130, 291, 292] [137, 164, 293, 294, 295] [165, 166, 167, 296, 297] [298]
water_potential_88percent_lost_conductivity	Xylem pressure at which 88% of conductivity is lost	num.	81	81	2	79	20	[127, 128, 130, 291, 292] [137, 164, 293, 294, 295] [165, 166, 167, 296, 297] [298]
wood_delta13C	Wood carbon stable isotope signature	num.	274	274	3	35	19	[47, 72, 87]
wood_delta15N	Wood nitrogen stable isotope signature	num.	274	274	3	35	19	[47, 72, 87]
Whole plant (allocation)								
plant_width	Width of the plant canopy	num.	648	610	3	100	24	[192, 208, 209, 261]
support_fraction	Fraction of shoot dry mass that is stems (versus leaves)	num.	588	588	1	79	40	[102]
Whole plant (life history)								
calcicole_status	Dichotonmous variable, defining plants as calcifuge (intolerant of basic soils) versus calcicole (tolerant of basic soils, such as calcareous sands and limestone derived soils)	cat.	280	0	1	251	21	[314]
competitive_stratum	Categorical descriptions of a taxon's relative stature in its community, used to assess competitive heirarchies within a community (definition based on Keith 2007, Gosper 2012)	cat.	344	344	1	344	44	[336, 337]
dormancy_type	Classification for seed dormancy	cat.	5	3	1	5	5	[353]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
fire_and_establishing	Variable capturing post-fire time frame during which species' establishes. Includes trait values for a broad range of responses, from species that establish immediately following fire to those that only establish in mature forest stands.	cat.	1612	0	1	1587	118	[318]
fire_response	Distinguishes between plants that are killed by fire and resprout following fire	cat.	15246	1843	24	10367	212	[90, 261, 317, 318, 319] [156, 329, 336, 337, 338] [308, 323, 324, 339, 340] [39, 183, 184, 185, 242] [97, 189, 330, 331, 381] [100, 200, 201, 333, 341] [106, 286, 314, 334, 342]
fire_response_ detailed	Detailed information distinguishing between plants that are killed by fire and resprout following fire	cat.	46	46	1	46	17	[106]
fire_response_ juvenile	Variable summarising how juvenile plants respond to fire	cat.	1306	0	1	1283	102	[318]
fire_response_on_ maturity	Variable summarising how plants' maturity status changes following fire	cat.	1306	0	1	1283	102	[318]
flood_regime_ classification	Functional group classification scheme used to categorise taxa into seven groups based on their growth and germination responses to flood regime. Based on Brock and Casanova (1997) and Casanova and Brock (2000).	cat.	144	144	1	143	39	[133, 134]
genome_size	Mass of the plant's genome	num.	1081	1035	3	975	3	[161, 328, 382]
growth_habit	Variable that defines a combination of growth habit and plant vegetative reproductive potential	cat.	307	125	4	299	35	[97, 133, 134, 316, 321]
inundation_tolerance	Ability of taxon to tolerate being under water	cat.	7415	0	1	6601	168	[314]
life_form	Raunkiaer classification; Categorical classification of plants according to shoot-apex or bud protection	cat.	4107	617	12	2764	156	[145, 160, 318, 338, 339] [183, 184, 185, 242, 310] [95, 189, 243, 253, 311] [193, 206, 313, 314, 315]
life_history	Categorical description of plant's life history	cat.	46854	1889	49	23101	280	[131, 132, 223, 224, 257] [133, 134, 258, 259, 318] [89, 139, 160, 260, 338] [172, 305, 328, 339, 344] [173, 227, 240, 264, 310] [97, 242, 245, 311, 335] [228, 229, 246, 321, 332] [230, 265, 266, 267, 268] [100, 101, 269, 270, 271] [233, 273, 286, 345, 356] [234, 274, 275, 276, 313] [254, 255, 315]
lifespan	Broad categories of plant life span, in years	cat.	10041	574	4	7678	176	[239, 314, 318, 336, 337]
parasitic	Whether or not a plant is parasitic	cat.	7965	8	8	7074	170	[224, 239, 305, 338, 339] [228, 240, 254, 314]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
plant_growth_form	Different growth forms displayed by plants, including both standard plant growth form descriptors (tree, shrub, etc.) and specific plant characteristics (i.e. parasitic)	cat.	63775	4261	78	25838	284	[48, 49, 50, 51, 85] [52, 53, 54, 223, 257] [55, 87, 133, 134, 224] [136, 225, 251, 258, 316] [56, 89, 259, 260, 261] [145, 148, 149, 150, 151] [57, 152, 157, 158, 159] [160, 262, 336, 337, 338] [58, 59, 304, 305, 339] [60, 94, 226, 239, 264] [61, 177, 178, 179, 240] [62, 63, 227, 252, 309] [64, 96, 228, 242, 335] [65, 98, 124, 193, 229] [66, 81, 82, 230, 383] [265, 266, 267, 268, 269] [100, 100, 270, 271, 360] [101, 199, 231, 312, 345] [206, 232, 273, 281, 286] [67, 233, 274, 275, 276] [104, 105, 106, 213, 359] [215, 234, 254, 255, 314]
plant_type_by_resource_use	Plants categories referencing their ability to tolerate/obtain water and/or salt in their environment	cat.	292	0	1	292	60	[350]
reproductive_maturity	Age of plants at reproductive maturity, by category. For several big compilations with fire response data, this is neitherthe time to first flowering, nor to first seed set, but instead reproductive maturity refers to a seed load or a group of suckers sufficient to replace the adult population.	cat.	9581	0	2	7309	174	[314, 318]
resprouting_proportion_individuals	Proportion of individuals that resprout following a fire across a population; this trait is generally used in studies looking at resprouting vs. death following a fire	num.	260	260	4	96	11	[97, 329, 333, 381]
resprouting_strength	Ratio of stem count post-fire to pre-fire at an individual or population level; this trait is appropriate to use for plants that have many stems from the base (shrubs, herbs, graminoids) where the number of stems before and after fire is censused. It is effectively a continuous measure of resprouting strength conditioned on initial size	num.	780	780	1	52	1	[97]
snow_tolerance	Description of a taxon's tolerance to snow cover	cat.	7909	0	1	7039	168	[314]
time_from_fire_to_fruit	Elapsed time from fire to fruiting	num.	10	10	2	10	3	[336, 337, 338, 339]
vegetative_regeneration	Ability to regenerate and spread through the growth and division of vegetative material. Although most taxa displaying vegetative spread resprout following fire, this trait is not explicitly about fire response; traits better suited to capture a taxon's response to fire are "fire_response", "fire_response_detailed", and "regen_strategy"	cat.	9979	212	8	7984	177	[133, 134, 183, 184, 310] [185, 189, 243, 253, 311] [230, 313, 314, 315]

(continued)

Trait	Description	Type	all	geo.	studies	taxa	families	refs
water_logging_tolerance	Ability of taxon to tolerate water-logged soils	cat.	7779	0	1	6925	166	[314]
Whole plant (morphology)								
spinescence	Degree to which a plant is defended by spines, thorns and/or prickles; definition and trait values based on Perez-Harguindeguy 2016.	cat.	8976	86	3	7129	173	[96, 145, 193, 206, 314]
vine_climbing_mechanism	Mechanism vines use to climb	cat.	92	0	1	92	36	[162]
Whole plant (physiology)								
modified_NDVI	Modified normalized difference vegetation index (modified NDVI), based on Landsat data	num.	453	453	1	1	1	[125]
nitrogen_fixing	Binary variable describing whether or not a plant hosts a nitrogen-fixing bacteria	cat.	11067	2217	29	8311	200	[48, 49, 50, 51, 52] [53, 54, 55, 56, 88] [142, 143, 145, 148, 149] [57, 150, 151, 152, 160] [58, 59, 60, 94, 280] [61, 62, 63, 183, 184] [64, 95, 185, 189, 242] [65, 80, 81, 193, 332] [66, 82, 99, 197, 360] [100, 100, 101, 199, 231] [67, 203, 206, 232, 286] [104, 220, 314]
photosynthetic_pathway	Type of photosynthetic pathway displayed by plants	cat.	13535	1113	22	9319	204	[48, 49, 50, 51, 52] [53, 54, 55, 56, 88] [144, 145, 148, 149, 150] [57, 58, 59, 113, 350] [60, 61, 62, 63, 242] [64, 95, 97, 243, 253] [65, 81, 193, 288, 384] [66, 82, 100, 100, 101] [67, 104, 206, 231, 232] [314]
salt_tolerance	Salt-tolerance categories; Also see 'soil_salinity_tolerance' for studies reporting actual soil salinity levels taxa can tolerate. Kew data on salt tolerance included in 'water_tolerance' trait	cat.	7788	0	2	6869	174	[314, 350]
soil_salinity_tolerance	Maximum salinity tolerated by a taxon, reported as the conductivity of the soil	num.	99	0	1	99	34	[350]

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