














SPECIAL ISSUE: ISLAND PLANT COMMUNITIES OPEN ACCESS

A-Islands: A Vascular Plant Dataset for Biodiversity Research and Species Monitoring on Australian Continental Islands

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ABSTRACT

Aims: Australia's coastline is fringed by more than 8000 continental islands. These islands feature a diverse array of landforms, rock and soil types and geological origins. Some of these islands are among the least invaded, most pristine habitats in Australia and support high plant diversity. Here, we present a new Australia-wide curated dataset for plant species occurrences on islands.

Results: Combining information from 1349 species lists and floras, A-Islands includes data on > 6500 plant species from 844 islands ranging in size from 18 m² to 4400 km², exhibiting different degrees of isolation from the mainland, and spanning all major Australian climate zones. Of these, 251 islands have been repeatedly sampled up to 11 times, making it possible to investigate

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temporal compositional change. A-Islands is open access and will be continuously updated. Its simple data structure, consisting of three comma-separated files allows easy integration with other Australian and global plant-occurrence databases and can serve as a repository for island research in Australia.

Conclusions: Knowing which species occur on Australia's islands will provide opportunities for future research, including studying changes in biodiversity and species turnover within and among archipelagos, tests of classical island biogeography theory, and as a baseline for ecological monitoring and conservation.

1 | Introduction

Continental islands serve as valuable models for studying the assembly of species into communities. Continental islands were once part of a continent but are now isolated by rising sea levels, typically located on shallow continental shelves (Whittaker et al. 2023). Within such island environments, the processes and patterns of community assembly and change are comparatively easy to observe. Because the species pools and communities in island ecosystems share similarities with those found on the mainland but differ due to recurring colonisation, speciation, and extinction, thereby allowing the processes involved to be disentangled (MacArthur and Wilson 1967; Abbott 1977; Schrader et al. 2020; Schrader, Wright, Kreft, Weigelt, et al. 2023). Islands also offer a model system to study the ecosystem consequences of fragmentation (Warren et al. 2015), a near-pervasive conservation concern in mainland habitats. Islands are also intrinsically valuable, harbouring high biodiversity that can include endemic species or important populations of threatened species (Fernandez-Palacios et al. 2021; Schrader et al. 2024). Island endemic species also comprise a disproportionate extent of Australia's and the world's extinctions (Woinarski et al. 2019; Fernandez-Palacios et al. 2021). For all these reasons, islands are a top priority for conservation and present unrivalled opportunities for biodiversity research.

To formulate predictions and test hypotheses in island ecology, data sets that include a large number of islands across large geographic gradients are particularly useful. Large-scale approaches are important to pursue as community assembly processes are likely influenced by factors that vary along geographical gradients, such as prevailing dispersal vectors, soil, climate, and degrees of island isolation, and high replication is required to detect community dynamics (Sfenthourakis and Triantis 2009; Schrader et al. 2021; Schrader, Wright, Kreft, Dixon, et al. 2023; Santi et al. 2024). Further, investigating the dynamics of temporal turnover that offer insights into compositional change over time on islands—including testing influential theories such as the Equilibrium Theory of Island Biogeography (MacArthur and Wilson 1967; Schrader, Wright, Kreft, Weigelt, et al. 2023)—requires datasets that hold information on repeatedly sampled islands. However, datasets containing information on island vegetation across different spatial and temporal scales, including resurveyed islands, are scarce, limiting large-scale tests and advancements in island biogeography.

Australia and its many surrounding islands provide a distinct opportunity to assemble a highly standardised database on the distribution of plants on islands. Australia's coastline is fringed by >8000 small- to medium-sized continental islands, which support considerable biodiversity (Moro et al. 2018). Many

of Australia's islands have been monitored extensively in the past seven decades thanks to the diligence of ecologists, botanists, and government agency staff (e.g., Abbott 1980; Harris et al. 2001; Batianoff et al. 2009).

Despite the depth of data on Australian island diversity (Kark et al. 2022), no comprehensive database combines plant species lists reported for islands with island properties such as area size and isolation. This hinders scientific advances in island biology. Also, many islands in Australia are severely affected by invasive species and land use, but at the same time, are potential safe havens for the conservation of threatened biota, crucial for protecting the many endangered plant and animal species of the continent from extinction (Legge et al. 2018; Bryant and Harris 2020; Woinarski et al. 2023). Practical conservation programs, such as island translocations, can benefit from information about local abiotic and biotic conditions on islands to improve success rates (Rayner et al. 2021). Predictions of suitability for potential invasive species can assist in guiding biosecurity prioritisation.

Here, we fill this gap for Australian islands and introduce a novel database—A-Islands—for vascular plant occurrences on Australia's coastal islands. Islands considered for A-Islands were any landmass surrounded by ocean or coastal waters, such as marine estuaries, inlets, or harbours, on the Australian shelf smaller than Tasmania. Oceanic islands, like Lord Howe or Norfolk Island, were not considered.

Currently, A-Islands holds information on plant occurrence for 844 islands, which is over 10% of Australia's c. 8000 islands, spanning all major climate zones and biogeographical regions, including 251 repeatedly sampled islands (Figure 1; based on A-Islands version 1.0). Most of the islands included are small and of continental origin, where plant communities are maintained by immigration and extinction dynamics (Abbott and Black 1978; Schrader, Wright, Kreft, Weigelt, et al. 2023). These islands allow for testing hypotheses on community assembly and spatio-temporal turnover dynamics.

We aim to continuously expand A-Islands with special focus on stimulating interest to resample island floras, as well as to conduct surveys on currently unsampled islands. Distinctive features of A-Islands are:

- Open access: all data in A-Islands are freely available, including species-by-island records and spatial island data. New versions will be released as new data accumulate.
- The focus on repeated surveys of island plant species: this is unique among island plant-occurrence databases.

- Standardised taxonomy: records are standardised according to national and global taxonomic references, allowing for easy integration with other databases.

survey information, (2) extracting species names and island information from the original references, (3) if available, providing information on species status (native vs. naturalised) based on the original references, (4) updating and standardising species names and (5) allocating all islands to a consistent spatial shapefile layer, including island coordinates and island area. Applying these steps ensures that A-Islands adheres to FAIR principles and retains the raw data transparency and reproducibility of all analyses. These steps also serve as a framework for integrating

2 | Methods and Database Structure

To collate this database, we completed five major steps (Figure 2): (1) searching for and accessing all relevant island

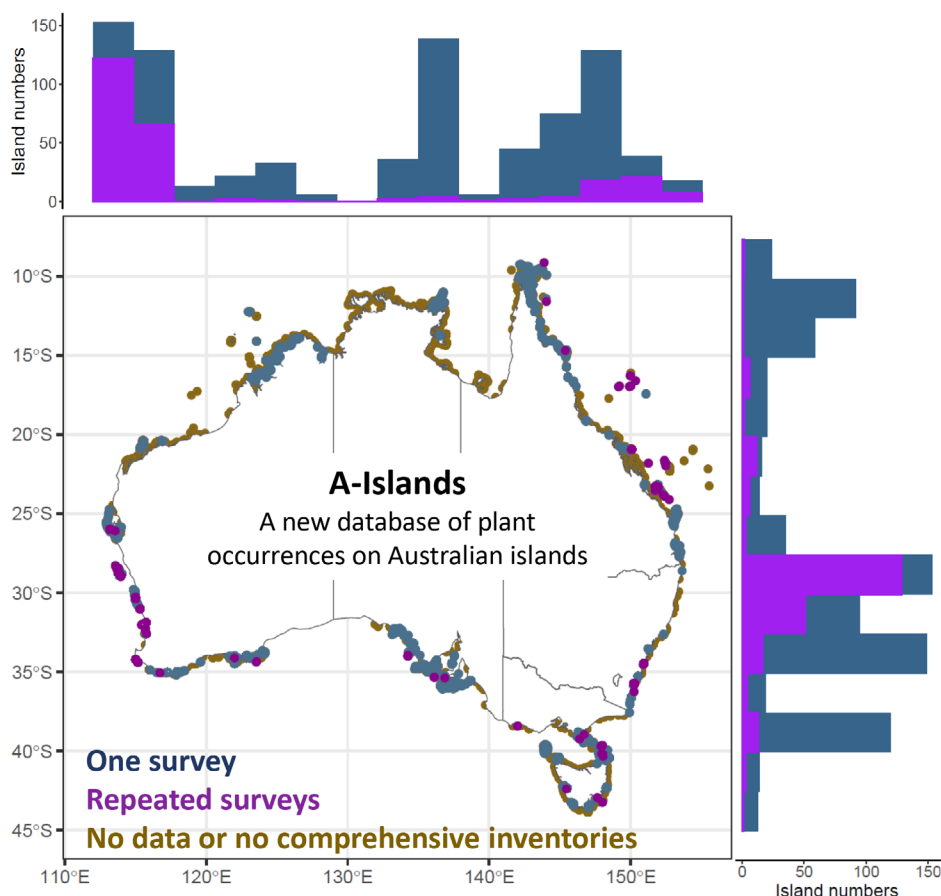


FIGURE 1 | Island coverage in A-Islands, distinguishing between all islands that have been sampled once (blue; $n = 592$) and sampled more than once (purple; $n = 251$). Brown are islands not included in A-Islands so far as they have not been (comprehensively) surveyed or no surveys were found. C. 10% of all Australian islands are included in the current version of the database spanning all major Australian climate zones. Histograms indicate latitudinal and longitudinal representation of islands in the database.

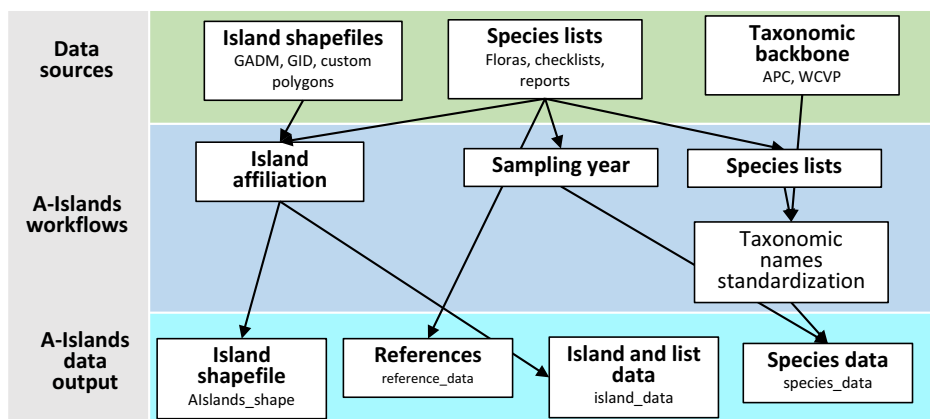


FIGURE 2 | Workflows, data sources and data output in A-Islands.

new data and maintaining the database in the long run. All workflows are transparent and reproducible by linking to and retaining all original data (species names, status and island locations).

1. *Searching for and accessing all relevant island survey information:* We conducted specific literature searches (Google Scholar, scanning of local Australian nature journals such as *Western Australian Naturalist*, *Papers and Proceedings of the Royal Society of Tasmania* or *Atoll Research Bulletin*) to detect and include as many island surveys as possible. Our search also included reaching out to researchers, botanists, and environmental and government agencies who conducted island surveys in the past. We reached out to all major state herbaria within Australia, requesting information on island inventories. As such, data sources used include peer-reviewed publications ($n = 84$), reports including environmental assessments ($n = 46$), books ($n = 2$) and websites ($n = 2$). All information on the reference types and sources can be found in the data repository.
2. *Extraction of species names and island information:* We extracted species names and island-related information from the original references. We included only those surveys where the original authors stated that the species list encompassed all species encountered on the island, rather than a subset or specific taxonomic lineages. Consequently, if this information was lacking or it was evident that only certain regions or taxa were targeted, we considered the lists floristically incomplete. This approach enables A-Islands to facilitate biological analyses requiring thorough floristic accounts for individual islands. Many of these lists were compiled during specific field trips, with the database additionally providing the sampling year when available. Moreover, a number of islands have been sampled repeatedly, either by the same or by different authors, allowing for comparisons of species diversity over time. For each island, both the name provided in the original reference and, if applicable, a new name are included. In cases where some smaller islands lack official names, we used the IDs from the original references.
3. *Inclusion of species status information:* The majority of the original species lists included information about species status, indicating whether a species was native or naturalised. Some lists also contained details about species endemism. We retained and documented this information for each list, specifying whether species status was included, and for each species entry, whether it was categorised as native or naturalised. It is important to note that species status can be contentious or not conclusively resolved. Also, some species native to eastern Australia could, for example, be introduced on western Australian islands. We therefore also included the current status of these species as stated by the Australian Plant Census. However, it is recommended to verify the original inference as supplied by the authors of the species lists with authoritative and continuously updated lists before using the Australian Plant Census, which is also continuously being updated (<https://biodiversity.org.au>; APC).
4. *Standardisation of species taxonomy:* As species lists within A-Islands were compiled in various years, some dating back to the 1930s, differences in species taxonomy exist between records. To address this, we standardised the species taxonomy using two distinct taxonomic backbones. First, using the R package *APCalign* (Wenk et al. 2024), all species names were matched with the APC; this holds the most current and authoritative plant species taxonomy for Australia. The APC includes both currently accepted taxon names and outdated taxonomy (i.e., synonyms, basionyms, and misapplied names), and *APCalign* first aligns species names to any scientific name within the APC (correcting typos, standardising syntax), then updates the names to a currently accepted taxon concept. Updating names to those considered current by the APC facilitates seamless integration with other Australian plant databases, such as the trait database AusTraits (Falster et al. 2021) or the plot database HavPlot (Mokany et al. 2022), both of which also use the APC taxonomy. However, 615 taxa could not be matched with the APC. For these cases, we used the World Checklist of Vascular Plants (Govaerts et al. 2021). For 201 taxa that we could not match to either of the two taxonomies, we used the original name (mostly for species only identified to the genus or family level). We preserved all original species names from the references, allowing for ongoing taxonomic updates.
5. *Islands' attributes, geospatial assignment, and archipelago allocation:* Each island was allocated a polygon within a GIS shapefile. This process involved cross-referencing with the Global Island Database (<http://globa-lislands.net>) and the Global Administrative Areas database (<https://gadm.org>). We checked visually whether Google Maps satellite image outlines corresponded with the polygons. Subsequently, we used the best-matching polygon from either the Global Island Database or the Global Administrative Areas. In cases where no suitable polygon existed or where there was poor correspondence with satellites' shapes and the available polygons, or any of the two shapefiles, we delineated a new polygon based on the satellite image. We then extracted island coordinates and island areas using the *sf* package in R. Island locations in the GIS shapefile allow for the calculation of other geo-environmental variables such as isolation or perimeter, or matching with climate and environmental raster layers. We refrained from including geo-environmental data from other databases due to their continuous updates and variations in spatial and temporal resolution. Instead, using the provided island shapefile ensures seamless matching with other spatial data resources. We also assigned all islands to archipelagos or island groups based on predefined archipelagos or shared attributes such as biogeographical region, substrate, or proximity. Recognising potential ambiguity in archipelago delineation, we established two hierarchical archipelago levels. The first contains 13 archipelagos, encompassing large biogeographical regions like tropical Queensland or the entirety of the Bass Strait between mainland Australia and Tasmania. The second level comprises 35 archipelagos and provides finer-scale divisions,

including smaller regions such as the Houtman Abrolhos archipelago in Western Australia or the Capricornia Cays in Queensland's Great Barrier Reef.

The output data are three data tables and one shapefile. The first data table (*island_data*) comprises island-level information, featuring a unique identifier for each island (*island_ID*), island names, island area (km²), longitude and latitude for the island center, and the assigned archipelago (both levels 1 and 2). The second data table (*species_data*) encompasses all species (original and standardised names), their status (if applicable: native, endemic, naturalised), the corresponding island identifier (*island_ID*) for each island where a species was recorded, and an ID for each list (*list_ID*; links to *island_data* and *reference_data*) a species was recorded in. The third data table (*reference_data*) provides information on the original references (linked via the *list_ID* to the species-level data). These data tables are provided in comma-separated files (.csv). The shapefile includes polygons for each of the islands (linked by *island_ID*; note the geographic location of one island with species information could not be identified). Detailed information on these three data tables can be found in Tables 1–3.

3 | Recorded Data

A-Islands contains species lists referring to 844 islands collated from 1349 separate lists, with 251 islands (30%) having been sampled at least twice (Figure 3A,B). Numbers of resurveys on the islands range from two (147 islands) to 11 (one island) with a mean of 3 and a median of 2 over all resurveyed islands (Figure 3A). Of these, 150 lists are linked to a specific sampling year and can be used for analyses on temporal change in species diversity. All lists in A-Islands originated from 134 references and contain 59,773 species-by-island records. All numbers and figures reported here are based on A-Islands version 1.0. Newer versions will be released on Zenodo as they become available.

The number of unique original species names amounts to 7711, which reduces to 6291 after taxonomic standardisation at the species level, which is c. one fourth of all c. 24,000 Australian plant species (Chapman 2009). 45 islands only support a single species, whereas Kangaroo Island is the most species-rich island, with 1160 species (Figure 3C). The islands are spread along the whole coastline of Australia, with most islands (352) from Western Australia (Figure 1).

In total, 12 taxa were originally identified as endemic to an island. However, we recommend revisiting their status for two

reasons. First, A-Islands only includes taxonomy down to the species level, which may overlook endemism at lower ranks, such as subspecies or varieties. Second, taxonomic updates may have reclassified taxa previously considered distinct species, meaning some once-endemic species might now also occur on the mainland.

A-Islands version 1.0 includes 844 islands. These islands are part of all coastal biogeographical regions of Australia (Thackway and Cresswell 1997), covering the whole coastline of the continent. A-Islands focuses on coastal islands, where plant assemblages are shaped by rapid and recurrent turnover dynamics, sometimes leading to a complete turnover of the flora within decades (Abbott 1977; Panitsa et al. 2008; Schrader, Wright, Kreft, Weigelt, et al. 2023). These high rates of immigration- and extinction-driven assembly differ from the dynamics of oceanic islands, which typically experience slower turnover rates (Whittaker et al. 2023). Further, the flora of all Australian oceanic islands is represented in the GIFT database (Weigelt et al. 2020) and in Schrader et al. (2024).

The smallest island included has an area of 18 m², whereas K'gari (1669 km²) and Kangaroo islands (4400 km²) are the largest (Figure 3A). It is important to note that we did not include Tasmania in our dataset due to its much larger size and higher species richness compared to the smaller islands that are the focus of this dataset. For other large and iconic islands, such as Tiwi and Melville Islands, comprehensive species lists are not yet available and were therefore not included in this database.

4 | Technical Validation

Technical validation consisted of three parts: (i) taxonomic, (ii) biogeographical, and (iii) geographical validation.

First, we validated the taxonomy by matching all species against the Australian Plant Census (<https://biodiversity.org.au>) and the World Checklist of Vascular Plants (Govaerts et al. 2021). Species names that could not be matched with at least one of these databases were checked manually for typographical and/or spelling errors and, if applicable, were corrected manually. This step was repeated until all species were regarded as correct (corrections were always checked against the original reference).

Second, we constructed a species-area relationship across all islands (Figure 4). The *z*-values—a useful index for comparing species-area relationships (Matthews et al. 2016)—were 0.31 for all

TABLE 1 | Information provided in data table *reference_data*. All references used are listed here, including information on whether native, naturalised, and endemic (at the island level) species are indicated in the original reference.

Ref_ID	Full_ref	Native_indicated	Naturalised_indicated	Endemics_indicated
Unique ID for each reference that links to <i>island_data</i>	Full reference	Includes information on native species (0, 1)	Includes information on naturalised species (0, 1)	Includes information on endemism at island level (0, 1)

TABLE 2 | Information provided in data table island_data. All islands and all sampling events are listed including information on island name, year of each species survey (if provided) coordinates, area and archipelago affiliation. Links to reference_data via ref_ID.

Ref_ID	List_ID	Island_ID	Island_name	Survey_year	Several_samplings	X	Y	Area	Arch_lvl_1	Arch_lvl_1
Links to reference_data	Unique ID for each species-island list	Unique ID for each island	Name of island	Year an island was surveyed (empty if not provided)	Indicates (0, 1) if survey has been done in a single year.	coordinates (longitude) of island	coordinates (latitude) of island	Area (km ²) of island	Name of archipelago (level 1)	Name of archipelago (level 2)

TABLE 3 | Information provided in data table species_data. All species from each list are shown here including their original name (as used in original reference), an updated name based on the most recent taxonomy and whether the species is native, naturalised or endemic on the respective island (if information provided). Links are to island_data via list_ID.

List_ID	Species_original	Species_update	Native	Family	Naturalised	Endemic	Status_APC
Links to island_data	Species name as supplied by original reference	Updated species name based on the APC and WCVP	Native or not (0, 1); empty if information was not provided	Species family based on WCVP	Naturalised or not (0, 1); empty if information was not provided	Endemic or not (0, 1); empty if information was not provided	Species status based on the Australian Plan Census APC

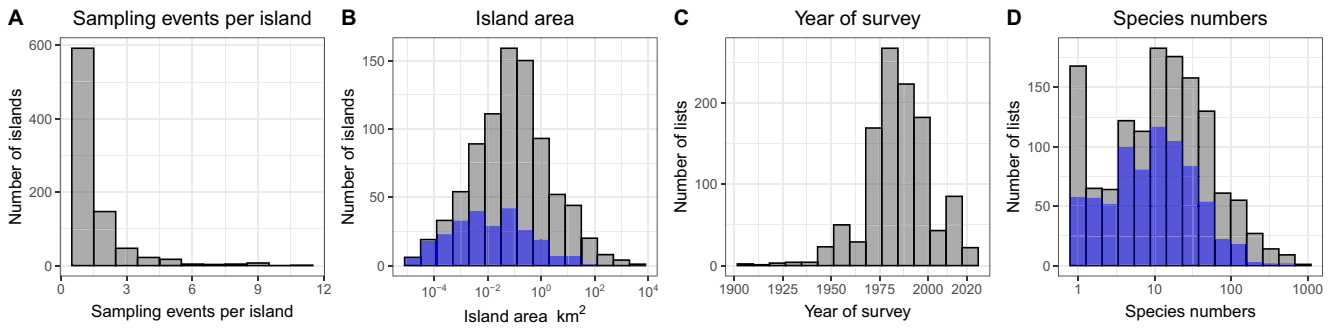


FIGURE 3 | Quantity and distribution of data available in A-Islands for (A) numbers of resurveys for all islands, (B) island area (844 islands; geographic location needed to calculate area could not be identified), (C) year that a survey was conducted (1108 island species lists) and (D) species richness (for 1349 island species lists). Grey indicates total number of islands and lists and blue indicates islands that were repeatedly sampled and species lists from repeatedly sampled islands. All lists are coloured in blue that were done on resurveyed islands.

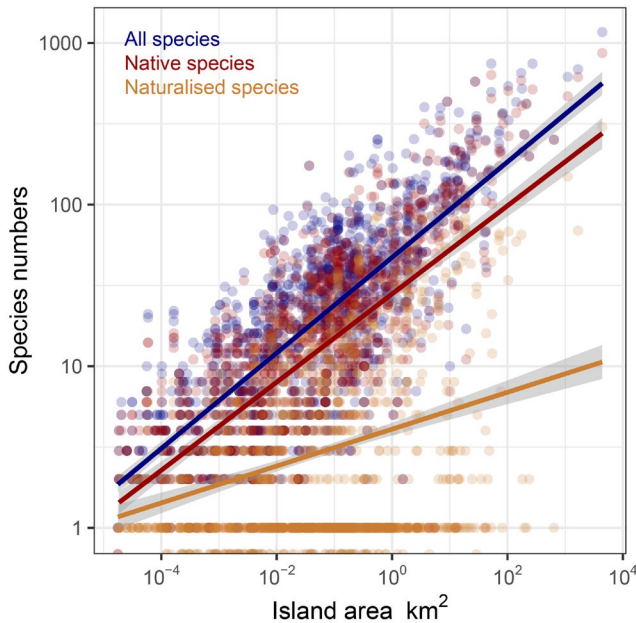


FIGURE 4 | Species-area relationships for all 1349 island surveys in A-Islands for native species (red), naturalised species (orange) and native and naturalised species combined (blue) against island area (\log_{10} -transformed). Note that each point denotes a single sampling event on an island. Islands with > 1 sampling event occur multiple times.

species, 0.28 for native species only, and 0.12 for naturalised species only on the islands. The species-area relationship describes the increase in species richness with island area and is a strong pattern in ecology, holding true across nearly all island systems worldwide (Kreft et al. 2008; Matthews et al. 2019). We did this to visually test for outliers from the species-area relationship. Original references for these outliers were then checked to validate whether the species list was accurately transferred to A-Islands and to assess whether the respective lists can be regarded as taxonomically comprehensive. We included only those lists to A-Islands that were considered comprehensive by the original author(s).

Third, we validated the geographical assignment of each island by testing whether islands covered in the same reference were spatially close together (all original references covered either a single island or two or more neighbouring islands).

5 | Usage Notes

A-Islands taxonomy aligns with the Australian Plant Census, which is Australia's authoritative list of vascular plant taxonomy. This shared taxonomy facilitates integration with prominent Australian plant databases like AusTraits (Falster et al. 2021) or HavPlot (Mokany et al. 2022) which share this taxonomic backbone. Additionally, A-Islands can be effectively linked with the Global Inventory of Floras and Traits database (Weigelt et al. 2020), as both databases share a similar structure. Taxonomy can be updated using the function *create_taxonomic_update_lookup* from the R package *APCalign* (Wenk et al. 2024) (against the Australian Plant Census) and the *TNRS* package (Maitner and Boyle 2023) (against the World Checklist of Vascular Plants).

Author Contributions

J.S. and M.W. conceived the original idea; J.S. developed the workflows for the harmonising of data with support from D.C.; I.A., S.B., R.B., D.M.C., S.H., H.H., B.J., K.M., J.K., P.K.L., J.N., M.V., J.C.Z.W., S.W., and I.Z. contributed data; J.S. and D.C. cleaned all data. J.S. analysed the data and wrote the first draft of the manuscript with support from M.W.; all authors critically revised the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The A-Islands database is available on Zenodo (<https://doi.org/10.5281/zenodo.10775809>). This data description is based on A-Islands version 1.0, with newer versions to be released on Zenodo as they become available.

Code Availability

All code used for maintaining and updating A-Islands will be made available upon request. Openly available R (v.4.2.1) packages and functions cited in the paper have been used for all major steps of data processing, including taxonomic standardisation and spatial analyses (see Section 2 for details).

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