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The islands of Oceania – Political geography, biogeography, and terrestrial ecosystems

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A B S T R A C T

Humans are dependent upon ecosystems for the production of goods and services necessary for their well-being (Daily, 1997). As the service provider units (SPUs) for these benefits of nature (Anderson et al., 2015), ecosystems need to be managed in a way that maximizes their persistence on the planet. Part of that management effort includes knowing a) what the ecosystem types are, b) where they are located on the landscape and in the seascape, and c) what condition they are in. Mapping of ecosystem occurrences as the SPUs for ecosystems goods and services is therefore an important element of ecosystem accounting, an inherently spatial activity. Maps are also needed of the ecosystem accounting areas within which the accounting is conducted. Standardized maps of ecosystem accounting areas and terrestrial ecosystem SPUs have not previously been available for many islands of the Oceania region. We describe the availability of new island shorelines and ecosystems data for Oceania herein, and encourage consideration and evaluation of the data for ecosystem accounting and other applications.

1. Introduction

As described in several different contributions to this Special Issue, there are many kinds of ecosystems and associated ecosystem goods and services that influence human well-being in Oceania. Coastal and marine ecosystems, including coral reefs, seagrasses, and mangroves, are important sources of livelihoods to islanders as a food source (provisioning ecosystem service). Similarly, terrestrial forests, shrublands, and grasslands provide important food and non-food products. The terrestrial and marine ecosystems of Oceania also provide important biodiversity maintenance and habitat quality services. There are many lands and waters in Oceania that are also considered sacred for their cultural importance, sense of place and spirituality, and aesthetic value. These cultural ecosystem services are recognized for their considerable contribution to human well-being in Oceania.

The southwest region of the Pacific Ocean contains thousands of named and inhabited islands ranging in size from continental-scale landmasses like Australia to tiny islets as small as half of a soccer field. These islands and islets are often collectively referred to as Oceania, a very large area that has been extensively characterized in both sociopolitical (e.g. Lawson, 2016; Scanlon and Wilson, 2018) and ecological (e.g. Jupiter et al., 2014; SPREP, 2016) terms. Geopolitically, Oceania is one of the six (including Africa, the Americas, Antarctica, Asia, Europe, and Oceania) official UN Geographic Regions of the planet as designated by the United Nations Statistics Division (UNSD), which routinely interacts with and collects data from all nations. The six Regions are then subdivided into Sub-regions, each of which is comprised of multiple countries (https://unstats.un.org/unsd/methodology/m49/). Oceania contains four official Sub-regions: Australia and New Zealand, Melanesia, Micronesia, and Polynesia. Some of the islands are sovereign nations and others are territories. The four UN Oceania Sub-regions are depicted in Figs. 1–4, respectively.

Departing somewhat from the geopolitical delineation of Oceania, ecologists and biogeographers recognize four major biogeographic regions, or Realms, in the larger area encompassed by the southwestern Pacific Ocean. In fact, the characterization of the Wallace Line (Wallace, 1860) between the Indonesian islands of Bali and Lombok in the late 1800s catalyzed the emergence of the very discipline of biogeography. Species distributions were shown to vary considerably on either side of the line due to differences in evolutionary history such that the flora and fauna in one biogeographic region can be quite different from another. Today, biogeographers commonly recognize eight global Realms (Neotropical, Nearctic, Afrotropical, Palearctic, Antarctic, Australasian, Indomalayan, and Oceania), of which the latter four occur in the southwestern Pacific Ocean area (Fig. 5; Olson et al., 2001).

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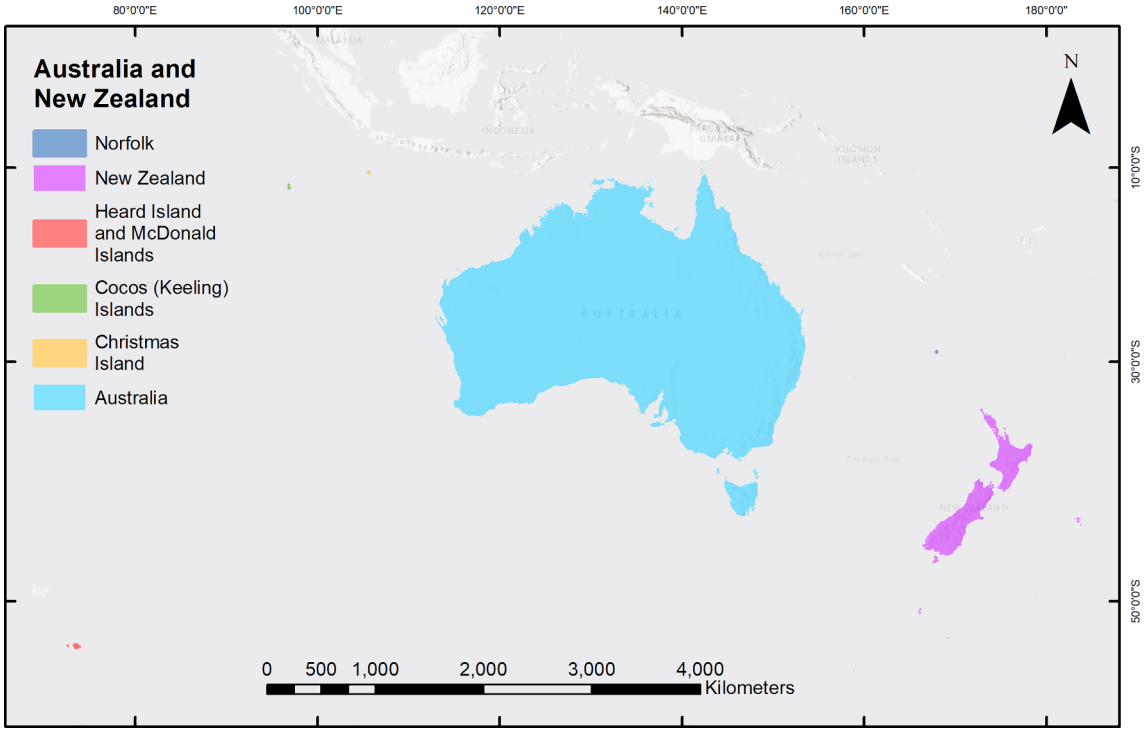

Fig. 1. The islands of the Australia and New Zealand Sub-region of Oceania as identified by the United Nations Statistics Division (https://unstats.un.org/unsd/methodology/m49/).

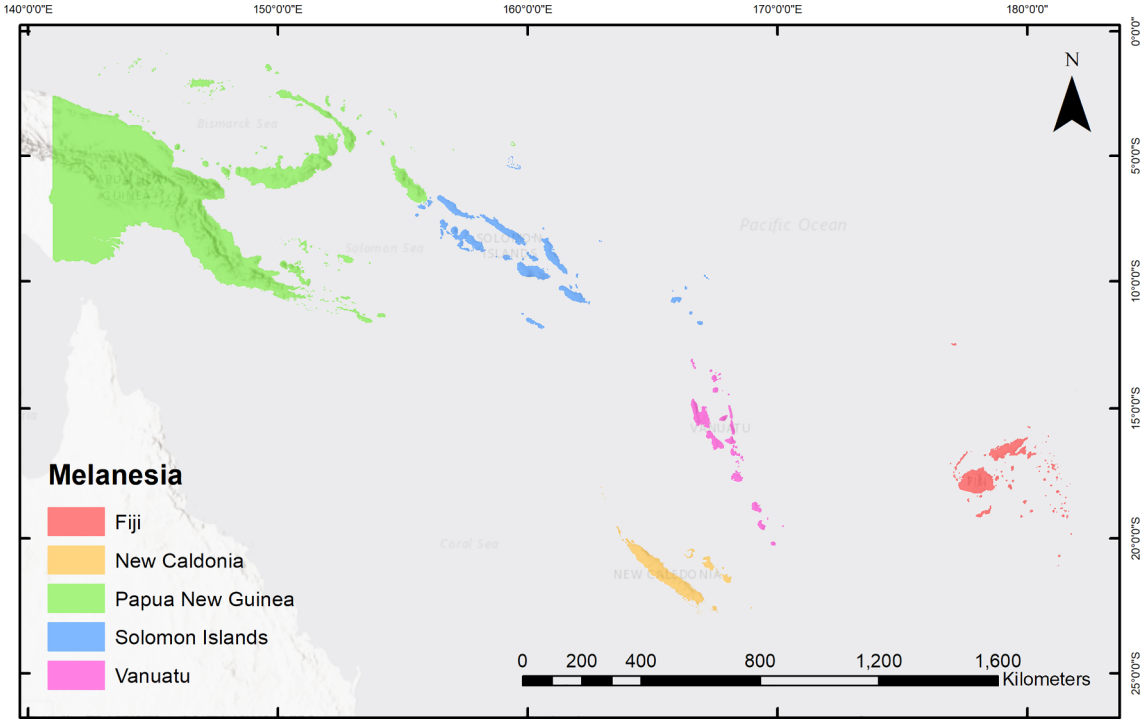

Fig. 2. The islands of the Melanesia Sub-region of Oceania as identified by the United Nations Statistics Division (https://unstats.un.org/unsd/methodology/m49/).

Differences between the geopolitical and biogeographic delineations of Oceania are mainly that 1) the biogeographic region-derived boundaries allow for a country to be split into two Realms (e.g. Indonesia is split at the Wallace Line into the Indomalayan Realm and the Australasian Realm), and 2) while Australia, New Zealand and the countries of Melanesia belong to the official UN Region of Oceania, biogeographically these islands belong to the Australasian Realm, rather than to the Oceania Realm. The biogeographic Oceania Realm is therefore smaller (contains fewer islands) than the Oceania UN Region.

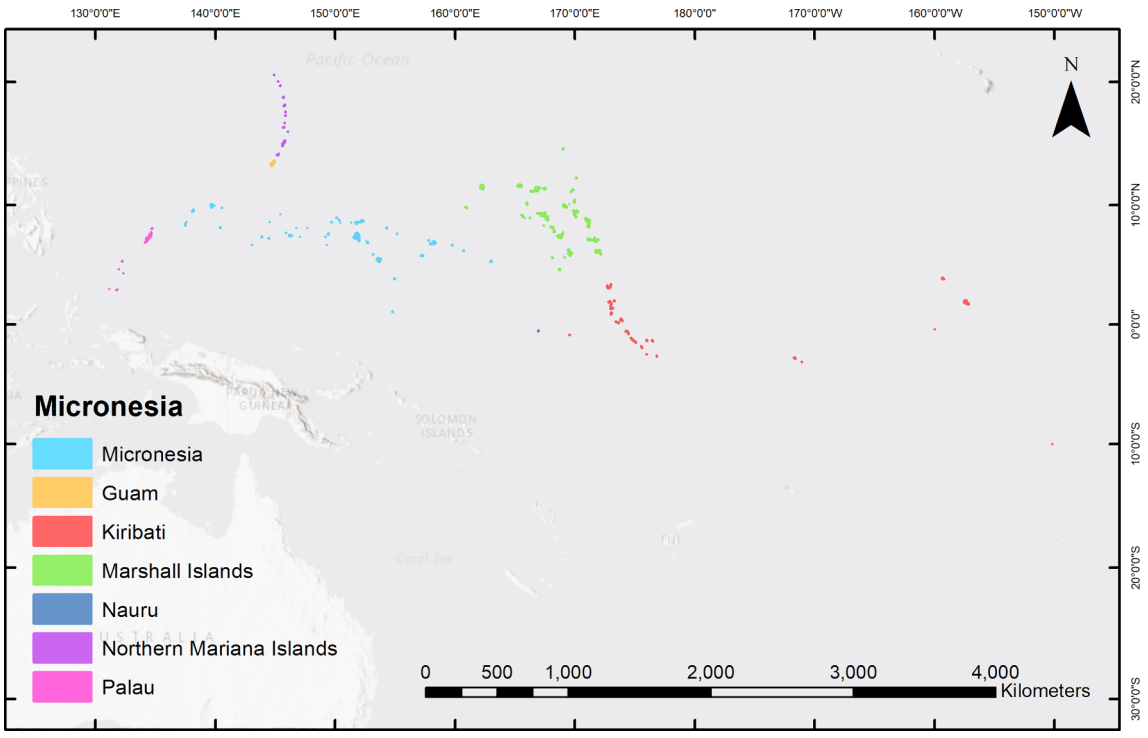

Fig. 3. The islands of the Micronesia Sub-region of Oceania as identified by the United Nations Statistics Division (https://unstats.un.org/unsd/methodology/m49/).

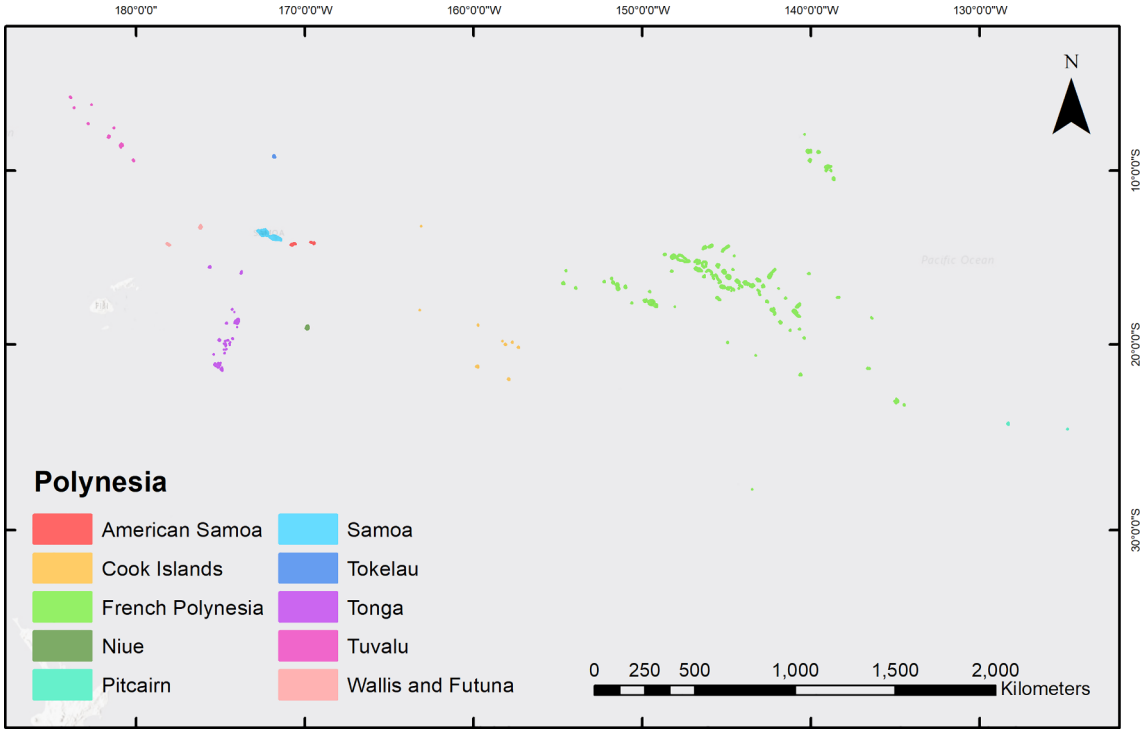

Fig. 4. The islands of the Polynesia Sub-region of Oceania as identified by the United Nations Statistics Division (https://unstats.un.org/unsd/methodology/m49/).

Regardless of political or biogeographic affiliation, the islands of Oceania are numerous and widespread, and many are remote. Until recently, high spatial resolution, standardized, globally comprehensive data on island locations, sizes, and coastline lengths and configurations have been lacking. A new global islands resource (Sayre et al., 2018, 2019) permits spatially explicit comparisons of islands and their ecosystems. This resource is freely available in the public domain and is intended to be useful for, among other things, assessments of the economic and non-economic value of island-derived ecosystem goods and services. All the islands of Oceania that are greater than 1 km^2 (called

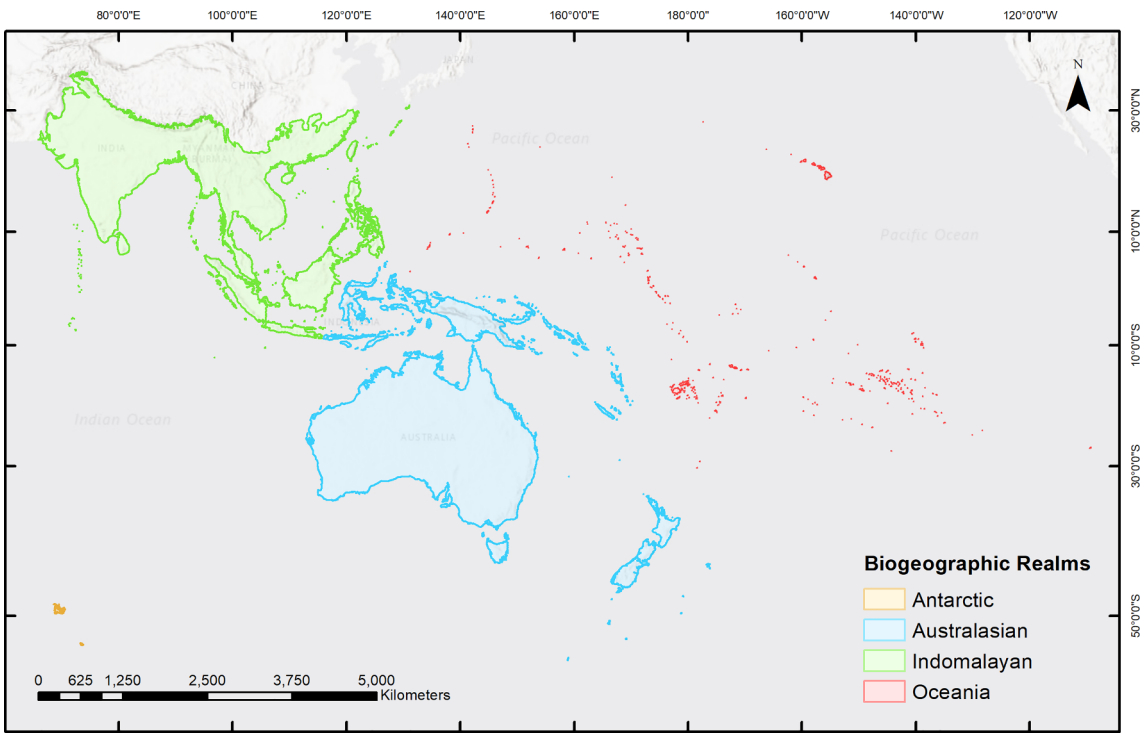

Fig. 5. The islands of the four Biogeographic Realms of the southwestern Pacific Ocean (Olson et al., 2001).

big islands) or smaller than 1 km^2 but greater than the minimum mapping size of 3600 m^2 (called small islands) are available as spatially explicit accounting areas (Anderson et al., 2015) from which ecosystem goods and services (Daily, 1997) are produced. The islands data, when combined with distribution and condition data on terrestrial, freshwater, and marine ecosystems, can be used for ecosystem accounting as encouraged by the UN SEEA (UN System for Economic and Environmental Accounting; UN, 2014) protocol. As an initial step in support of ecosystems accounting in Oceania, we characterized the number of islands belonging to each nation or territory and then assessed the types, numbers, and areas of terrestrial ecosystems distributed on these islands.

2. Data and analysis

High spatial resolution (30 m) polygon data on all the islands of Oceania (UN definition, see above) are available in the public domain at https://rmgsc.cr.usgs.gov/ecosystems/datadownload.shtml. Similarly, raster data on the distribution of terrestrial ecosystems that occur on these islands are also available in the public domain at https://rmgsc.cr.usgs.gov/ecosystems/datadownload.shtml. Polygons representing the islands of Oceania were extracted from the new global islands resource (Sayre et al., 2018) and attributed to the UN Oceania Sub-region country and territory groupings. Islands were allocated to UN island/territory groupings by visual inspection, based on Google Earth imagery and attribution. For terrestrial ecosystems, the climate, landforms, and land cover data used to generate the global ecological land units (ELUs – Sayre et al., 2014) were used to identify forests, grasslands, shrublands, croplands, sparsely or non-vegetated areas, and settlements. As an example of the terrestrial ecosystems that were mapped for each island, Fig. 6 shows the ecosystems of New Caledonia. For each UN-designated country/territory in Oceania, statistical analysis was conducted to determine the number of islands by size class, and the types and total areas of their terrestrial ecosystems.

3. Results

Table 1 shows the number of big (> 1 km^2) and small (< 1 km^2) islands for each country or territory in Oceania, as well as the numbers of types and total areas of forests, grasslands, shrublands, croplands, sparsely or non-vegetated areas, and settlements on these islands. Table 1 allows for an inter-country/territory comparison of terrestrial ecosystems on the islands of Oceania and provides input data for the construction of ecosystem extent accounts (UN, 2014).

There is considerable variation in the number of islands belonging to each of the 28 countries/territories on the UN list. Not surprisingly owing to its size, Australia has the largest number of both big (775) and small (6996) islands. Five other countries/territories have a total number of islands (number of big islands plus number of small islands) over 1000: New Zealand (93 big, 1562 small); Papua New Guinea (355 big, 1524 small); Solomon Islands (173 big, 1551 small); Marshall Islands (41 big, 1196 small); and French Polynesia (203 big, 1856 small). Conversely, three UN island/territory units (Christmas Island, Nauru, and Niue) are relatively small, single islands.

The number of terrestrial ecosystem types on the UN list is also reflective of size. Excluding croplands and settlements, and summing the number of different types of forestlands, shrublands, grasslands, and sparsely or non-vegtated (bare) areas, Australia has the highest total number of terrestrial ecosystem types (125), followed by New Zealand (59) and Papua New Guinea (40). The number of ecosystems in each class (forests, shrublands, grasslands, and bare areas) was similar across Australia (33, 33, 32, and 27, respectively) and New Zealand (15, 13, 16, and 15, respectively), but for most smaller island nations and territories forest ecosystem types dominated in both number of types and total area.

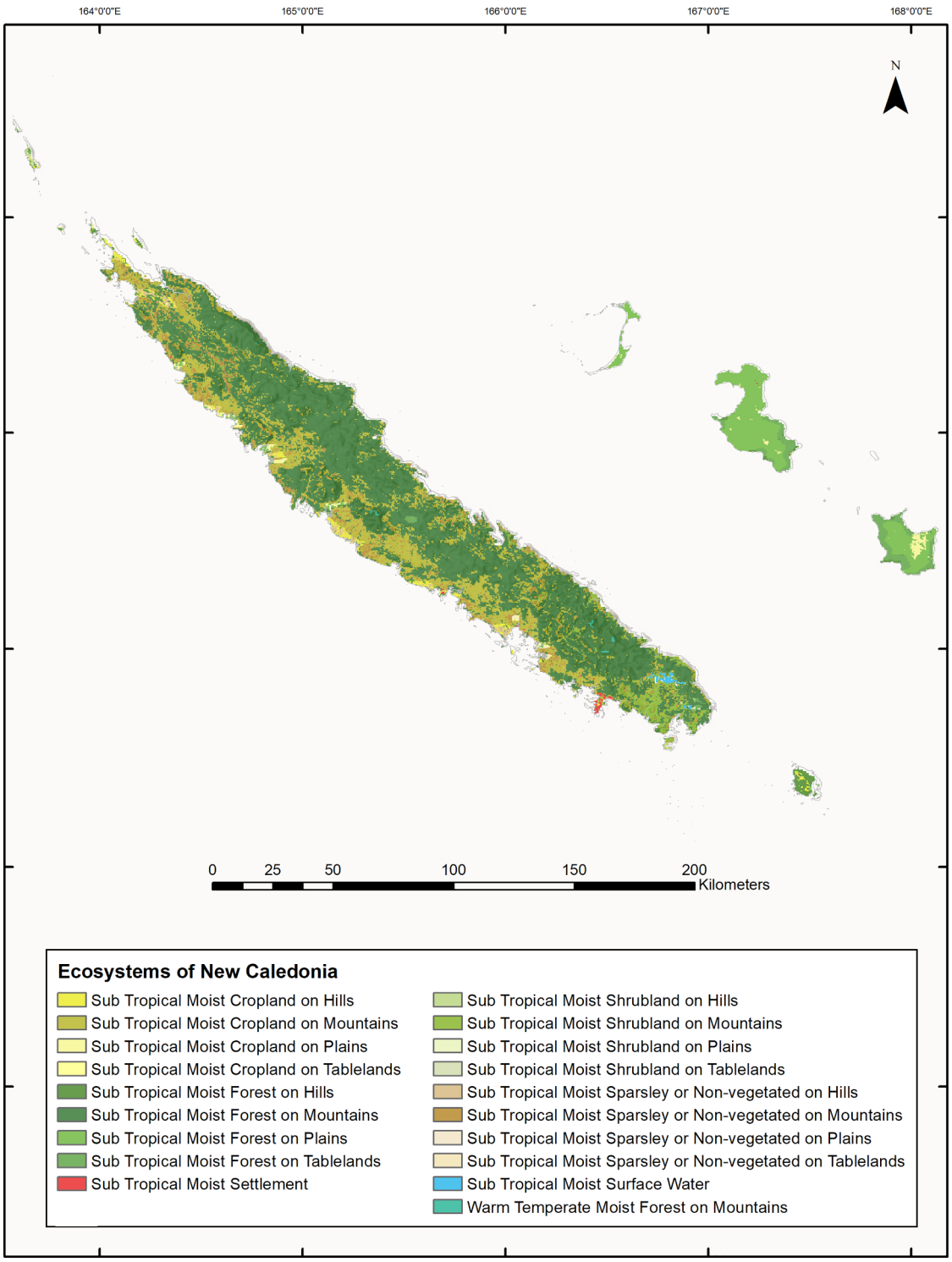

Fig. 6. The terrestrial ecosystems of New Caledonia.

4. Conclusion

Standardized, rigorous, high spatial resolution (30 m) data on the shorelines/islands of Oceania was previously nonexistent. Similarly, standardized data on the distribution of terrestrial ecosystem types across Oceania did not previously exist. Both island location data and ecosystem data are necessary of ecosystem accounting. These data are now available and are provided as a standardized resource for use in terrestrial ecosystem accounting in the Oceania region. The data are likely very useful for countries which may lack shoreline or terrestrial ecosystem data. The standardized nature of the data render them particularly useful for comparison of ecosystem accounting analyses across multiple countries and territories.

Table 1
Numbers of big (> 1 km^2) and small (< 1 km^2) islands, and numbers and areas (km^2) of terrestrial ecosystem types for each island or territory in the UN-designated Sub-regions of Oceania. Bare areas refers to sparsely or non-vegetated land surfaces. (nd = no data).

Country or Territory	Forestlands		Grasslands		Shrublands		Croplands		Bare Areas		**Settlements**	
Name (number of islands > 1 km^2, number of islands < 1 km^2)	*Number of Forestland Types*	*Total Area (km^2) Forestlands*	*Number of Grassland Types*	*Total Area (km^2) Grasslands*	*Number of Shrubland Types*	*Total Area (km^2) Shrublands*	*Number of Cropland Types*	*Total Area (km^2) Croplands*	*Number of Bare Area Types*	*Total Area (km^2) of Bare Areas*	*Number of Settlements*	*Total Area (km^2) of Settlements*
Sub-region: Australia and New Zealand												
Australia (775, 6996)	33	664,245	32	800,062	33	1,256,198	33	512,118	27	2,167,144	28	9072
Christmas Island (1, 0)	3	50	0	0	0	0	3	21	0	0	0	0
Cocos (Keeling) Islands (4, 40)	0	0	0	0	0	0	1	0.48	0	0	0	0
Heard Island and McDonald Islands (2, 10)	0	0	1	15	0	0	0	0	1	95	0	0
New Zealand (93, 1562)	15	82,699	16	130,667	13	32,330	16	6524	15	12,716	14	2514
Norfolk (2, 3)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sub-region: Melanesia												
Fiji (98, 341)	8	7095	0	0	0	0	6	3268	4	30	3	18
New Caledonia (37, 444)	5	7757	0	0	4	423	4	2509	4	656	3	23
Papua New Guinea (355, 1524)	13	224,387	4	6	10	1037	14	32,443	13	2483	7	145
Solomon Islands (173, 1551)	6	14,448	0	0	2	1	4	272	2	1	3	4
Vanuatu (57, 82)	7	6291	1	0.12	0	0	7	361	3	19	4	2
Sub-region: Micronesia												
Guam (1, 15)	2	0.48	4	272	0	0	3	23	1	0.12	0	0
Kiribati (42, 351)	0	0	0	0	0	0	1	17	2	2	0	0
Marshall Islands (41, 1196)	0	0	0	0	0	0	1	1	1	0.59	0	0
Micronesia (29, 536)	4	251	0	0	0	0	3	20	0	0	3	18
Nauru (1, 0)	0	0	0	0	0	0	1	4	1	0.48	0	0
Northern Mariana Islands (13, 19)	4	31	3	77	0	0	5	113	1	0.36	1	0.12
Palau (16, 212)	3	147	0	0	0	0	3	60	0	0	1	0.36
Sub-region: Polynesia												
American Samoa (5, 2)	2	36	0	0	0	0	3	59	0	0	0	0
Cook Islands (6, 10)	3	44	0	0	0	0	3	30	1	0.24	0	0
French Polynesia (203, 1856)	5	574	0	0	0	0	6	752	4	25	1	2
Niue (1, 0)	2	113	0	0	0	0	3	40	0	0	1	0.24
Pitcairn (2, 2)	0	0	0	0	0	0	1	21	0	0	0	0
Samoa (4, 9)	5	546	0	0	0	0	5	1071	1	0.24	1	0.12
Tokelau (3, 0)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tonga (18, 71)	7	113	0	0	0	0	7	156	0	0	1	0.48
Tuvalu (9, 93)	1	0.12	0	0	0	0	1	1	0	0	0	0
Wallis and Futuna (3, 17)	3	11	0	0	0	0	4	23	0	0	1	0.12

5. Disclaimer

The islands and shoreline data are rigorously interpreted from satellite imagery but are not suitable for navigation. Some islands may exist but were not captured in the interpretation or are otherwise not represented in the data. Similarly, the existence of an island polygon in the data is not an assurance that island features exist at that location. Although for purposes of this analysis islands have been attributed as belonging to certain countries and territories following United Nations designations, in no case is actual sovereignty of any island represented in the data claimed or warranted. The authors apologize in advance if any island polygon has been incorrectly associated with a country, territory, or UN Sub-region. Any use of trade, product, or firm names does not imply endorsement by the US government.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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