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Towards an Australian Bioregionalisation Atlas: A provisional area taxonomy of Australia's biogeographical regions

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Abstract

The large number, definition, varied application and validity of named Australian biogeographical regions reflect their *ad hoc* development via disparate methods or case study idiosyncracies. They do not represent a coherent system. In order to resolve these uncertainties an *Australian Bioregionalisation Atlas* is proposed as a provisional hierarchical classification, accounting for all known named areas. This provisional area taxonomy includes a diagnosis, description, type locality and map for each named area within the Australian continent, as well as a first-ever area synonymy. Akin to biological classifications, this Atlas seeks to provision universality, objectivity and stability, such that biogeographers, macroecologists and geographers, can test existing areas as well as proposing novel areas. With such a formalised and comparative system in place, practitioners can analyse the definition and relationships of biotic areas, and putatively minimise *ad hoc* explanations.

Key words: area taxonomy, Australia, biogeography, bioregionalisation, regionalisation, regions

Introduction

Australian biogeographical regionalisation, or bioregionalisation, has a long and rich history spanning over 150 years (Ebach 2012). In that time, many phyto-, zoogeographical, freshwater and marine regions have been proposed for the Australian continent. Many of these regional names have fallen into disuse or have been absorbed into newer classifications. This has resulted in multiple bioregionalisations, and as a result is fragmentary and comprises considerable area synonymy. Our aim in this work is to rationalise these areas and propose a provisional area classification, which we name the *Australian Bioregionalisation Atlas*. The Atlas diagnoses, describes and accurately maps all known named areas based on an area naming system: the *International Code of Area Nomenclature* (ICAN, Ebach *et al.* 2008). With incorporation of ICAN criteria, the Atlas proposed in this work provides a classificatory framework for accommodating existing and newly named areas. This approach is akin to that of biological taxonomy, inclusive of the principles of priority and synonymy (e.g., see Parenti & Ebach 2010, López *et al.* 2008). Our provisional classification provides explicit area definitions and standardised nomenclature, so that users can avoid using different area definitions for the same name or the same areas with different names. It is envisaged that the Atlas will not only allow biogeographers to adopt a unified area classification but also to match hypotheses of area relationships, and existing definitions of regional and sub-regional biogeographic units.

The Atlas is restricted to biotic areas and is inclusive of previously defined areas and their names (e.g., Bassian, Eremaean etc.), which are based on taxic distributions rather than geo-political boundaries, grids, geographical features such as 'deserts' or other biotic classifications such as vegetation types (e.g., 'savannah', 'tropical rainforest'). Moreover abiotic distributions may not necessarily overlap with biotic distributions. This novel classification is explicitly distinct from other classifications that are based on abiotic and vegetative factors

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(e.g. Australian Natural Resources Atlas, World Wildlife Fund's ecoregions), and have been derived for alternate purposes (e.g., conservation). The *Interim Biogeographical Atlas for Australia* (IBRA, Environment Australia 2000) and the *Integrated Marine and Coastal Regionalisation of Australia* (IMCRA, Commonwealth of Australia, 2006), are both recent regionalisations based on mapping overlapping abiotic and floristic databases. Whereas both IBRA and IMCRA are ingenious approaches at Australian regionalisation, they contain no historical "baggage" of earlier attempts at identifying larger regions (e.g., Bassian, Peronian etc.). Rather, IMCRA and IBRA contain smaller and precise areas that have no documented relation to any earlier attempts at regionalisation, leaving it somewhat ahistorical. Rather than subsume IBRA and IMCRA into the existing repository of named Australian regions, we exclude these two regionalisations, and establish a classification that accounts for the 150-year history of documenting broad scale fluvial, terrestrial and marine regions.

The rationale of an area taxonomy of Australian regions

To avoid piecemeal outcomes, we propose a taxonomic convention for defining, equating and naming biogeographic areas of Australia. The Atlas is provisional and open to revision and testing just as taxa (e.g., species, genera) are within biological taxonomy. It is not conceived as a static classification, but nonetheless seeks to minimise the creation of unwarranted synonyms for existing named areas. We hope that the Atlas will promote greater consilience among animal and plant geographers.

The Atlas is compiled into four hierarchical classifications (Tab. 1), herein called area taxonomies, which divide the Australian Realm into phytogeographical, zoogeographical, freshwater and marine sub-realms. In order to minimise fragmentation of ranks into smaller units (e.g., sub-realms for birds versus provinces for carabid beetles), we recommend, that all zoological taxa be classed under a single zoogeographical classification, botanical taxa under a single botanical classification and so forth. The following provisional revision contains 19 regions and 36 sub-regions that cover the entire Australian continent and surrounding waters.

TABLE 1. A Provisional Area Taxonomy of the Phyto- Zoogeographical, Fluvial and Marine Regions within the Australian Sub-Realm.

Terrestrial Phytogeographical Regions		
Sub-Realm	Region	Sub-Region
Australia (de Candolle 1820)	Euronotian Tate 1889	New Guinea Doing 1970
		McPherson-Macleay Burbidge 1960
		Eastern Queensland Crisp *et al.* 1995
		Atherton Plateau Cracraft 1991
		Cape York Cracraft 1991
		Southeastern NSW Crisp *et al*. 1995
		Victoria Crisp *et al.* 1995
		Tasmania Cracraft 1991
		Kimberly Plateau Cracraft 1991
		Arnhem Land Cracraft 1991
	Eremaean Tate 1889	Northern Desert Cracraft 1991
		Eastern Desert Cracraft 1991
		Western Desert Cracraft 1991
		Pilbara Cracraft 1991
	South-west Australia Diels 1906	South-west Interzone (Nicholls 1933)
		Adelaide Cracraft 1991
		Eyre Cracraft 1991
		Hampton Ladiges *et al.* 2005

Terrestrial Zoogeographical Regions		
Sub-Realm	Region	Sub-Region
Australia Prichard 1826	Bassian (Hedley 1894)	Southeastern Forest Cracraft 1991
		McPherson-Macleay Burbidge 1960
		Adelaide Cracraft 1991
		Tasmania Cracraft 1991
	Torresian Bassian Spencer 1896	Atherton Plateau Cracraft 1991
		Cape York Peninsula Cracraft 1991
		Arnhem Land Cracraft 1991
		Kimberley Plateau Cracraft 1991
	Eyrean (Hedley 1894)	Northern Desert Cracraft 1991
		Eastern Desert Cracraft 1991
		Pilbara Cracraft 1991
		Western Desert Cracraft 1991
		Eyre Peninsula Cracraft 1991
		South-West Australia (Tate 1889)
		Riverina Sloane 1905

Freshwater zoogeographical regions or Fluvifaunulae		
Sub-Realm	Region	Sub-Region
Australia Swainson 1935	Sturtian Iredale & Whitley 1938	
	Greyian Iredale & Whitley 1938	
	Vlaminghian Iredale & Whitley 1938	
	Leichhardtian Iredale & Whitley 1938	
	Mitchellian Iredale & Whitley 1938	
	Lessonian Iredale & Whitley 1938	
	Tobinian Iredale & Whitley 1938	
	Krefftian Iredale & Whitley 1938	
	Jardinean Iredale & Whitley 1938	

Marine Regions		
Sub-Realm	Region	Sub-Region
Australia Forbes 1856	Great Barrier Reef Knox 1963	
	Solanderian Hedley 1904	
	Flindersian (Hedley 1904)	Maugean Iredale & May 1916
	Peronian Hedley 1904	Oxleyan Iredale 1937
	Damperian Hedley 1904	

The taxonomy and area nomenclature follows the recommended hierarchy set out in the ICAN (Ebach *et al.* 2008). In addition, following the notion of priority, existing names are used in favour of new names for regions. This will avoid unnecessary synonymy; for example Unmack (2001), although acknowledging the freshwater fluvifaunal areas of Iredale and Whitley (1938), nonetheless proposed new names for the same areas.

A note on abiotic, vegetative and geographical regions

The purpose of the study is to generate a biotic classification for extant taxa, so abiotic, palaeontological and vegetative classifications have been omitted. For example, abiotic classifications (including geographical and geo-political boundaries or grids) have no biotic elements. Similarly, vegetative classifications represent ecological types rather than taxic distributions. Given this, several existing classifications are not represented in this study, including IBRA and IMCRA, and vegetative regions like those of Beard (1981) and Barlow (1984) and recent attempts by the Australian Government Department of the Environment and Water Resources (2007). The exception is the fluvifaunal areas of Iredale and Whitley (1938), which are based on freshwater taxic distributions, are largely confined to river or drainage basins. In addition, biotic classifications which were only used once or are currently in disuse have also been omitted. These include Tenison-Woods (1882), Campbell (1963) and Pianka (1969).

Area taxonomy

Realm AUSTRAL Morrone 2002

Austral Morrone 2002: 150.

Diagnosis. "Comprises of the southern temperate areas in South America, South Africa, Australasia, and Antarctica" (Morrone 2002: 150).

Remarks. Herein we treat all regions to be part of the Austral Realm as proposed by Morrone (2002). Nested within it, we establish the following discrete classifications based on taxa and ecosystem; namely, the phytogeographical, zoogeographical, fluvial and marine sub-realms. These classifications overlap, which led early biologists to propose a single biogeographical regionalisation scheme (Nicholls 1933).

Terrestrial phytogeographical areas

Sub-Realm AUSTRALIA (de Candolle 1820)

(Fig. 1)

La Nouvelle-Hollande de Candolle 1820: 411.
Australia.—Good 1964: 32.
Australian Kingdom Doing 1970: 84–85, Map.
Australian Realm Udvardy 1975: 36.
Australian Kingdom (Australis) Takhtajan 1986: 268.

Diagnosis. The continent of Australia, including southeastern New Guinea.

Type locality. Lake Eyre, South Australia, Australia, 28°10'30.04"S 137°17'32.60"E.

Remarks. De Candolle (1820), while referring to the continent of Australia, used the term "La Nouvelle-Hollande", and we attribute this Sub-realm to him, translated herein as Australia. Doing (1970) classified the 'Australian Kingdom' based on floral regions and vegetation, which was divided into the Central Australian and the Eucalyptus sub-kingdoms. More broadly, Good (1964) placed Australia within Australasia.

Whereas the phytogeographical regions have a single origin (Tate 1889), the majority of sub-regions are derived from the vertebrate endemic areas of Cracraft (1991). The latter were mostly adopted by Crisp *et al.* (1995, 1999), with novel subdivision of the southeast of Australia, and inclusion of New Guinea. Only a few of these have been altered from their original diagnoses. Cracraft's sub-regions are discussed in detail in the zoogeographical section.

Region EURONOTIAN Tate 1889
(Fig. 1)

Euronotian Tate 1889: 315.
East Australia Diels 1906: 38–39.
Northeast Australia Takhtajan 1986: 270.

Diagnosis. The southern and eastern parts of the Great Dividing Range and watershed between the Grampians and Cape York.

Type locality. Mount Hay, Blue Mountains National Park, NSW, Australia, 33°37'16.43"S 150°24'38.89"E.

Remarks. Tate (1889) originally described the Euronotian (lit. south-east wind) as "dominant in the south and east parts of the Continent". This term has fallen out of use in favour of the Torresian and Bassian zoogeographical regions (see below). We recommend retaining both to distinguish between phyto- and zoogeographical regions. Crisp *et al.* (1995) adopted Cracraft's (1991) vertebrate regions as areas of endemism for plants. However, Crisp *et al.* (1995), like Cracraft (1991), attempted to define these areas as 'endemic' rather than 'biotic'.

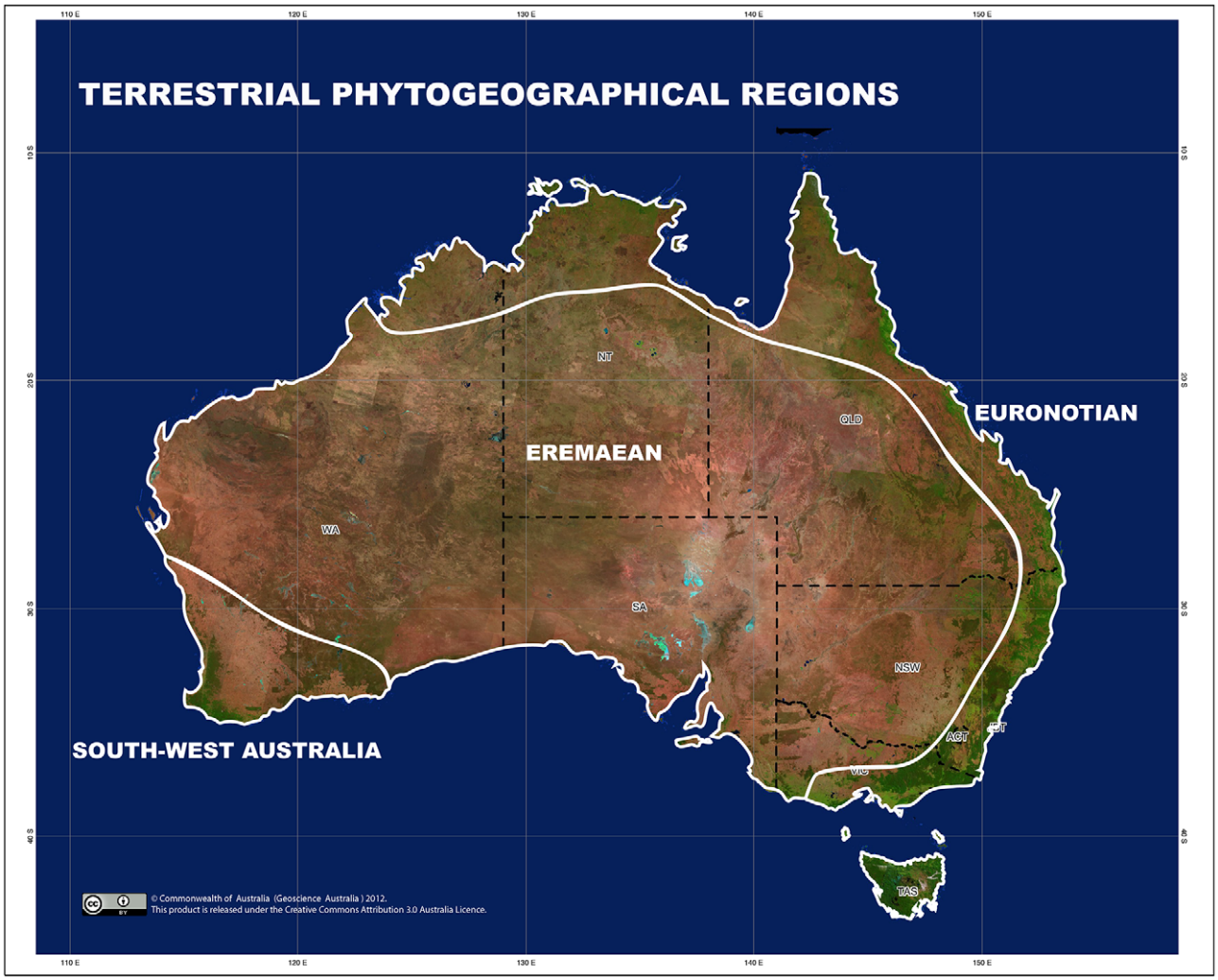

FIGURE 1. Phytogeographical regions of Australia (excluding New Guinea).

Sub-Region NEW GUINEA Doing 1970

New Guinea Doing 1970: 84–85, Map.
New Guinea.—Crisp *et al.* 1995: 459.

Diagnosis. The southeastern part of New Guinea.

Type locality. Owen Stanley Range, Papua New Guinea, 09°14'9.94"S 147°59'3.86"E.

Remarks. Doing (1970) included southeastern New Guinea in the Australian Kingdom. In contrast it was classified as a sub-region by Crisp *et al.* (1995). However, neither Doing's nor Crisp *et al.*'s term had been linked to a diagnosis. Herein we use Doing's brief description as a diagnosis for the term New Guinea.

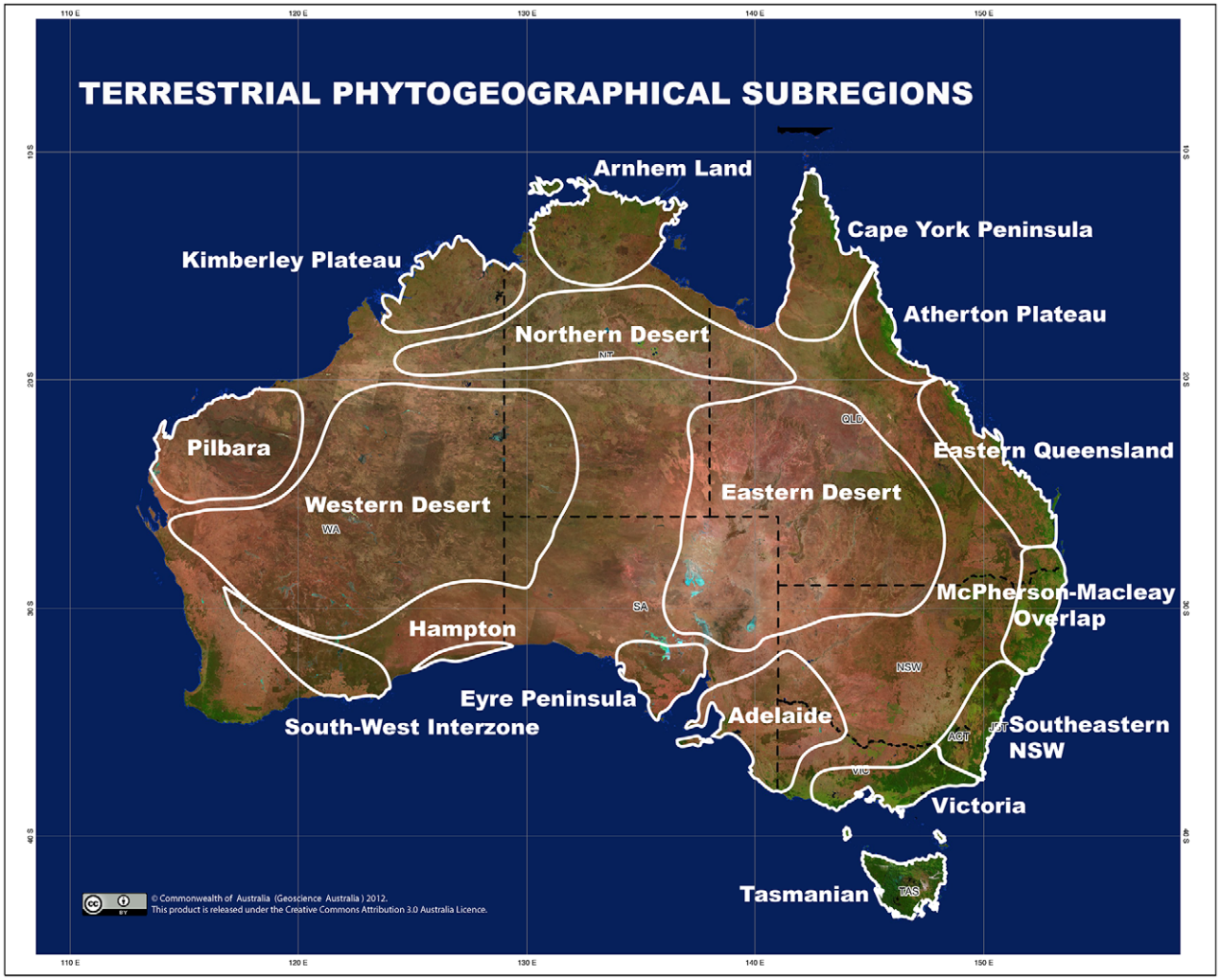

FIGURE 2. Phytogeographical sub-regions of Australia (excluding New Guinea).

Sub-Region MCPHERSON-MACLEAY Burbidge 1960

(Fig. 2)

McPherson-Macleay Burbidge 1960: 143–144.

Diagnosis. The eastern watershed of the Great Dividing Range between the Glass House Mountains and the upper Hunter Valley.

Type locality. Mount Warning, Mount Warning National Park, NSW, Australia, 28°23'54.00"S 153°16'18.00"E.

Remarks. Burbidge (1960) described the McPherson-Macleay overlap zone as the area of overlap between temperate and subtropical regions in eastern Australia, bounded in the north by the McPherson Ranges in Queensland and in the south by the Macleay River. The size of the overlap zone has increased to include the Glass House Mountains in the north and the upper Hunter Valley farther south (Crisp et al. 1995).

Sub-Region EASTERN QUEENSLAND Crisp *et al.* 1995
(Fig. 2)

Eastern Queensland Crisp *et al.* 1995: 459.
Coastal East Queensland Ladiges et al. 2011: 34.
Inland South East Queensland Ladiges *et al.* 2011: 33–34.
Inland Central Queensland Ladiges *et al.* 2011: 33.
Inland North Queensland Ladiges *et al.* 2011: 33.

Diagnosis. The western margin of the Great Dividing Range and eastern watershed between the Glass House Mountains and the Einasleigh Uplands.

Type locality. Mount Molangul, Gindoran Queensland, Australia, 24°40'3.00"S 151°31'39.00"E.

Remarks. Ladiges *et al.* (2011) defined Inland Central Queensland based on three endemic red bloodwoods (*Corymbia* sp.), which includes "Brigalow Belt North and Desert Uplands", Inland North Queensland as the "Einasleigh Uplands" and, Inland South Eastern Queensland as including the Brigalow Belt South bioregion (Ladiges *et al.* 2011: 33). Together, these regions could be regarded as a western extension to Eastern Queensland of Crisp *et al.* (1995). The diagnosis has been extended to include the western margin of the Great Divide, but excludes both Inland North and South Eastern Queensland, which is based on the abiotic IBRA Brigalow Belt South and Einasleigh Uplands bioregions.

Sub-Region ATHERTON PLATEAU Cracraft 1991
(Fig. 2)

Atherton Plateau Cracraft 1991: 213.
Atherton Crisp *et al.* 1995: 459.
Queensland Wet Tropics Ladiges *et al.* 2011: 33.

Diagnosis. See Cracraft (1991) and below.

Type locality. Mount Hypipamee, Mount Hypipamee National Park, Queensland, Australia, 17°25'28.84"S 145°28'59.40"E.

Sub-Region CAPE YORK PENINSULA Cracraft 1991
(Fig. 2)

Cape York Peninsula Cracraft 1991: 213.

Diagnosis. See Cracraft (1991) and below.

Type locality. Nourlangie Rock, Kakadu, Northern Territory, Australia, 12°52'1.10"S 132°48'40.14"E.

Sub-Region SOUTHEASTERN NSW Crisp *et al.* 1995
(Fig. 2)

Southeastern NSW Crisp *et al.* 1995: 459.
South East New South Wales Ladiges *et al.* 2011: 34.

Diagnosis. See Cracraft (1991) and below.

Type locality. Kurnell, Sydney, NSW, Australia, 34° 0'23.79"S 151°12'59.83"E.

Sub-Region VICTORIA Crisp *et al.* 1995
(Fig. 2)

Victoria Crisp *et al.* 1995: 460.

Diagnosis. See Crisp *et al.* (1995).

Type locality. Otway Ranges, Victoria, Australia, 38°40'0.00"S 143°34'60.00"E.

Sub-Region TASMANIA Cracraft 1991
(Fig. 2)

Tasmania Cracraft 1991: 214.
Tasmania.—Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Cradle Mountain, Tasmania, Australia, 41°41'6.48"S 145°57'9.55"E.

Sub-Region KIMBERLEY PLATEAU Cracraft 1991
(Fig. 2)

Kimberley Plateau Cracraft 1991: 213.
Kimberley.—Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Mitchell Plateau, Western Australia, Australia, 15°7'14.27"S 125°47'39.67"E.

Sub-Region ARNHEM LAND Cracraft 1991
(Fig. 2)

Arnhem Land Cracraft 1991: 213.
Arnhem Crisp *et al.* 1995: 460.
Top End (in part) Ladiges *et al.* 2011: 33.

Diagnosis. "Encompasses Arnhem Land, the Gulf Fall and Uplands and Gulf Plains" Ladiges *et al.* (2011: 33).

Type locality. Nourlangie Rock, Kakadu, Northern Territory, Australia, 12°52'1.10"S 132°48'40.14"E.

Remarks. Ladiges *et al.* (2011) use the term Top End to refer to Arnhem Land and the region immediately to the east including the Gulf Fall and Uplands and Gulf Plains. The region was proposed by Bowman *et al.* (2010) as part of the Australian Monsoon Tropics; however, Ladiges *et al.*'s sub-region extends further west, east and south. The Ladiges *et al.* diagnosis is far more concise than Cracraft's original and is used herein.

Region EREMAEAN Tate, 1889
(Fig. 1)

Eremian Tate 1889: 315.
Eremaean.—Diels 1906: 40.
Central or Eremaean.—Takhtajan 1986: 274.

Diagnosis. The dry desert region bounded by the Southwest region, the Euronotian region in the east and north and by the northwest and northern coastlines.

Type locality. Lake Eyre, South Australia, Australia, 28°10'30.04"S 137°17'32.60"E.

Remarks. The Eremaean was originally diagnosed as the "dominant in the dry [botanical] region, which has its centre in the Lake Eyre Basin [...] It is bounded on the north and north-east by the Indo-Australian vegetation;

on the east and south-east by the typical Euronotian Flora, and on the extreme south-west by the Autochthonian" (Tate 1889: 315 and see below). Without any justification, Diels (1906) changed the spelling to Eremaean, which over time has been adopted as the correct spelling.

Sub-Region NORTHERN DESERT Cracraft 1991
(Fig. 2)

Northern Desert Cracraft 1991: 214.
Northern Desert.—Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Riversleigh, Queensland, Australia, 26°46'12.86"S 146°28'12.55"E.

Sub-Region EASTERN DESERT Cracraft 1991
(Fig. 2)

Eastern Desert Cracraft 1991: 214.
Eastern Desert.—Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Nappa Merrie Breakaways, Queensland, Australia, 27°23'7.24"S 141° 9'51.81"E.

Sub-Region WESTERN DESERT Cracraft 1991
(Fig. 2)

Western Desert Cracraft 1991: 214.
Western Desert.—Crisp *et al.* 1995: 460.
Southern Desert Ladiges *et al.* 2011: 33.
Central Desert Ladiges *et al.* 2011: 32–33.

Diagnosis. See Cracraft (1991) and below.

Type locality. Veevers Crater, Western Australia, 22°58′12 S, 125°22′21″E.

Remarks. The desert sub-regions proposed by Ladiges *et al.* (2011) are more concise in their definition than any of Cracraft's desert areas. The Central Desert for instance is diagnosed as "the region south-east of the Pilbara: Little Sandy Desert, Gibson Desert, Central Ranges, MacDonnell Ranges, Finke and Burt Plain. The vegetation includes red sandplains dominated by spinifex and shrubland, tree and shrub steppe, open grassland with scattered trees and mulga woodlands" (Ladiges *et al.* 2011: 32–33). While the diagnosis is precise, it has not been widely adopted. Herein we retain Crisp *et al.*'s usage of Cracraft's sub-regions until a wider study confirms that these regions have a wider application.

Sub-Region PILBARA Cracraft 1991
(Fig. 2)

Pilbara Cracraft 1991: 214.
Pilbara.—Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Type locality. Mount McRae, Western Australia, Australia, 22°16'60.00"S 117°34'42.00"E.

Region SOUTHWEST AUSTRALIA Diels 1906
(Fig. 1)

Südwest-Provinz Diels: 1906: 40.
South-west Province.—Gardner 1944: xli.
Southwest Australia Takhtajan 1986: 273.
Southwest Crisp et al. 1995: 460.
Geraldton Sandplains Ladiges *et al.* 2005: 1913.
Jarrah Forest Ladiges *et al.* 2011: 32.
Wheatbelt Ladiges *et al.* 2011: 32.
Goldfields Ladiges *et al.* 2011: 32.

Diagnosis. Triangular crescent shaped area bounded by the Western Australian coastline between Hill and Murchison Rivers in the north to the Phillips River and Israelite Bay in the southwest.

Type locality. Mount Magog, Stirling Range National Park, WA, Australia, 34°23'39.00"S 117°56'48.00"E.

Remarks. Originally called the Autochthonian by Tate in 1889, Diels (1906: 375) dispensed with the term because it referred to a concept, namely, the oldest component of the Australian flora. Gardener (1944) continued Diels' use of the term, mainly to refer to vegetations, rather than biotic regions. However, Burbidge (1960) preferred the use of Gardener's definition, which is used above. Gardener's province is divided into four areas by Ladiges *et al.* (2005, 2011) based on the IBRA bioregions. These include Geraldton Sandplains (Ladiges *et al.* 2005), Jarrah Forest, Wheatbelt and Goldfields (Ladiges *et al.* 2011). These areas have been included as junior synonyms.

Sub-Region SOUTH-WEST INTERZONE Nicholls 1933
(Fig. 2)

Hesperonotian Nicholls 1933: 94.
Interzone 1 Burbidge 1960: 80.
South-west Interzone Ladiges *et al.* 2005: 1913.

Diagnosis. "The Interzone is intermediate between the tall wet forests and the arid, desert region to the east" (Ladiges *et al.* 2011: 32).

Type locality. Mount Geraldine, Mount Jackson WA, Australia, 29°58'0.00"S 119°24'0.00"E.

Remarks. The southwest interzone was first described by Nicholls (1933) as the Mesohesperian "a less well-defined borderland, overlapping the Eremian [and Southwest Australia] and agreeing fairly closely with Prescott's Sclerophyll Woodland and Scrub" (Nicholls 1933: 94). Unfortunately Nicholls never provided a map detailing the precise location of the Mesohesperian. Burbidge (1960: 80) independently described the same area, Interzone 1, as "a triangular area lying between the South-West Province and the Eremaea proper". Herein we use the term Southwest Interzone of Ladiges *et al.* (2011) as it refers to Burbidge's Interzone 1.

Sub-Region ADELAIDE Cracraft 1991
(Fig. 2)

Adelaide Cracraft 1991: 214.
Adelaide.—Crisp et al. 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Gluepot Reserve, South Australia, Australia, 33°45'42.52"S 140° 7'27.51"E.

Sub-Region EYRE PENINSULA Cracraft 1991
(Fig. 2)

Eyre Peninsula Cracraft 1991: 214.
Eyre Crisp *et al.* 1995: 460.

Diagnosis. See Cracraft (1991) and below.

Type locality. Darke Peak Range, South Australia, Australia, 33°28'26.85"S 136°10'29.68"E

Sub-Region HAMPTON Ladiges *et al.* 2005
(Fig. 2)

Hampton Ladiges *et al.* 2005: 1913

Diagnosis. "Coastal dry region south of the Nullabor" (Ladiges *et al.* 2005: 1913).

Type locality. Wurrengoodyea Hills, Madura, Western Australia, Australia, 32°12'0.00"S 126°22'0.00"E.

Terrestrial zoogeographical areas

Sub-Realm AUSTRALIA Prichard 1826
(Fig. 3)

Australia Prichard 1826: 533.
Australia.—Swainson 1835: 114.
Australia.—Schmarda 1853: 313.
Australia.—Agassiz 1854: lxxviii.
Australiana Sclater 1858: 141.
Australia.—Wallace 1876: 59.
Australia.—Tenison-Woods 1882: 48.
Austrogæan (Australian) Gill 1884: 22.

Diagnosis. The Australian continent and southern New Guinea.

Type locality. Uluru, Northern Territory, Australia, 25°21'9.34"S 131° 2'3.70"E.

Remarks. Prichard (1829) used a mixture of terms, including "Terra Australis", "New Holland" and "Australia" to describe the continent. However, Swainson (1835) redefined Australia as including "... the vast island of New Holland, and those immediately adjoining, as New Guinea, New Zealand, and Van Diemen's Lands, but likewise the whole of the oceanic clusters forming Polynesian division of some geographers" (Swainson, 1835: 114). Sclater (1858) classified his Regio Australiana in the same way. Schmarda (1853) and Tenison-Woods (1882), however, describe their "Australia" as the island continent, while Agassiz (1854) had a restricted Australian Realm which he divided into the Papuan and New Holland Fauna. We herein use a combination of both Prichard's and Swainson's diagnoses that is much closer to Agassiz's Australian Realm, namely the Australian continent and the southern areas of New Guinea.

It was Tenison-Woods, however, who first proposed a regionalisation of zoogeographical areas of Australia. He defined Australia as a continent "as more than a province in the animal and vegetable kingdom" (Tenison-Woods 1882: 48), which was divided into seven sub-provinces. Tenison-Woods' sub-provinces, however, were largely ignored by most zoogeographers. The next large scale regionalisation came from Hedley (1894), who borrowed floral regions from Tate (1889) to describe his three zoogeographical regions, separating the northern part of the Euronotian as the Papuan. Spencer (1896) however presented a new regionalisation, with new terms, essentially keeping Hedley's regions the same. The wide usage of Spencer's terms means that his 1896 names have preference, as the Papuan of Agassiz and the Euronotian of Tate may be confused with the earlier names of Hedley (1894).

The sub-regions of Sloane (1905, 1915) were the first to diagnose the Murray-Darling Basin (Riverina) as a

terrestrial faunal area within the Eyrean region. The last major regionalisation, by Cracraft (1991) divided Australia into “endemic areas” based in bird and vegetation distributions. While these areas proved popular with botanists and zoologists, they are poorly defined (by Cracraft’s own admission) and mainly follow the Atlas of Australian Resources Vegetation provinces. As the vegetative areas help define the geography of bird distributions, they are accepted as biotic herein.

Region BASSIAN (Hedley 1894)
(Fig. 3)

Euronotian Hedley 1894: 444.
Bassian Spencer 1896: 196–199.

Diagnosis. “The eastern and south- eastern coastal strip, lying between the coast line and the Dividing Range south of the Clarence River, and also Tasmania. On the mainland it naturally merges to a certain extent, where the dividing Ranges falls away at its western end” (Spencer 1896: 196–199).

Type locality. Barrington Tops New South Wales, Australia, 31°55'21.78"S 151°32'11.46"E.

Remarks. The precise divide between the Bassian and Torressian regions is never clearly defined by Spencer (as the diagnosis shows). Presently the area between the McPherson Ranges and Glass House Mountains is chosen as a general location of the biotic break between both regions.

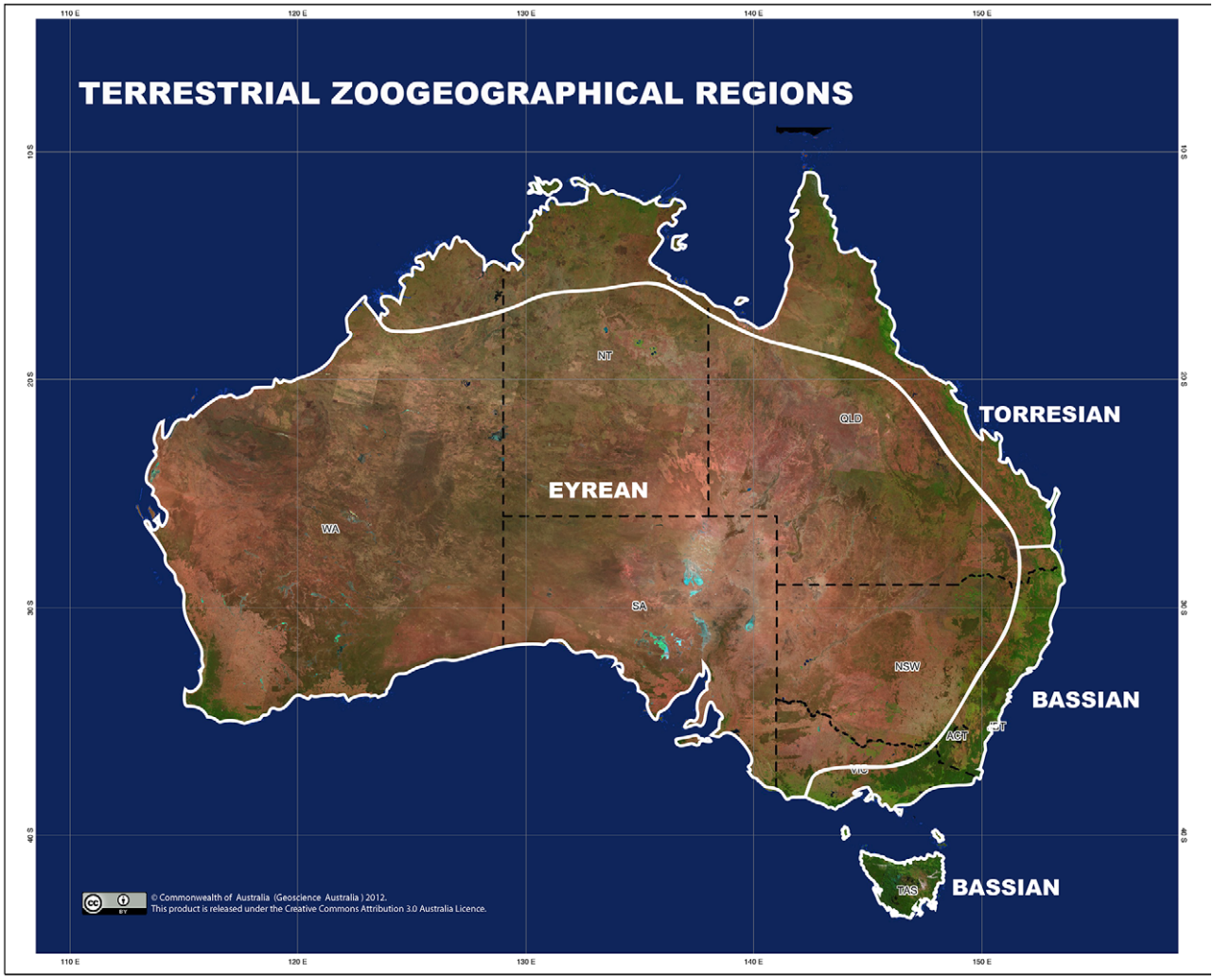

FIGURE 3. Zoogeographical regions of Australia (excluding New Guinea).

Sub-Region SOUTHEASTERN FOREST Cracraft 1991
(Fig. 4)

Southeastern Forest Cracraft 1991: 214.

Diagnosis. "The area is bounded to the north by the Hunter River valley, to the north-west (inland) by the Great Dividing Range or drier, more open habitats, and at its western boundary by lowlands vegetated by mallee" (Cracraft 1991: 214).

Type locality. Mount Imlay, Mount Imlay National Park, Narrabarba, New South Wales, Australia, 37°10'48.00"S 149°44'3.00"E.

Remarks. Cracraft's diagnosis includes the coastal, plateau and alpine regions of the southeast. While this may seem counter-intuitive, we leave this designation, which we feel will be revised in the near future.

Sub-Region MCPHERSON-MACLEAY Burbidge 1960
(Fig. 4)

McPherson-Macleay Burbidge 1960: 143–144.

Diagnosis. The eastern part of the Great Dividing Range and eastern watershed between the Glass House Mountains and the upper Hunter Valley.

Type locality. Mount Warning, Mount Warning National Park, NSW, Australia, 28°23'54.00"S 153°16'18.00"E.

Remarks. Cracraft's use of Eastern Queensland is unique as it does not distinguish between Bassian and Torresian elements. Herein Eastern Queensland is split into two areas divided by the biotic break of the Bassian and Torresian regions, which has the exact same dimensions as the McPherson-Macleay overlap zone proposed by Crisp *et al*. (1995) in their revision of Cracraft (1991). For the sake of clarity, we have followed Cracraft's (1991) diagnosis for Southeastern Forest to limit the western boundary of Eastern New South Wales to the Great Dividing Range.

Sub-Region ADELAIDE Cracraft 1991
(Fig. 4)

Adelaide Cracraft 1991: 214.

Diagnosis. The area occupied by "those species restricted to the mallee vegetation east of the Flinders and Mount Lofty Ranges, south of the Darling River valley, and west of the Great Dividing Range [...] Some species that extend their distributions westward through the Mount Lofty Ranges to the Yorke Peninsula but do not extend around Spencer Gulf to the Eyre Peninsula are also included" (Cracraft 1991: 214–215).

Type locality. Gluepot Reserve, South Australia, Australia, 33°45'42.52"S 140° 7'27.51"E.

Remarks. Cracraft's Adelaide region abuts Sloane's Riverina sub-region, making of one of few sub-regions that share a common boundary, namely south of the Darling River valley. Together with the Riverina, much of Australia's southeast is covered by a biotic/endemic area.

Sub-Region TASMANIA Cracraft 1991
(Fig. 4)

Tasmania Cracraft 1991: 214.

Diagnosis. The island of Tasmania including surrounding islands, such as Flinders and King Islands.

Type locality. Cradle Mountain, Tasmania, Australia, 41°41'6.48"S 145°57'9.55"E.

Remarks. Cracraft (1991: 214) characterises 'Tasmania' as the area occupied by species that "inhabit the tall open, closed, and open forests of Tasmania", while designating the whole island (including the smaller offshore islands) as a single area. Herein we follow Cracraft's map.

Region TORRESIAN (Hedley 1894)

(Fig. 3)

Papuan Hedley 1894: 445.
Torresian Spencer 1896: 197.

Diagnosis. "Includes Papua and north and north-eastern Australia as far south as the Clarence River. On its north-western side it merges as might be expected to a certain extent into the western area" (Spencer 1896: 197).

Type locality. Mount Tibrogargan, Glasshouse Mountains National Park, Queensland, Australia, 26°55'37.31"S 152°56'50.44"E.

Remarks. Hedley's Papuan region, an older term, defines the same region as Spencer's Torresian. The term Papuan has fallen out of usage in favour of Spencer's more popular Torresian, which was widely used in the mid to late 20th century. We use Spencer's junior term herein. Spencer's diagnosis is vague about the western extent of the Torresian region. The southern limit (discussed above) is far narrower than the western margin in the northwest. This leads us to conclude that it follows the western edge of the Great Dividing Range, making the western margin of both the Bassian and Torresian consistent.

Sub-Region ATHERTON PLATEAU Cracraft 1991

(Fig. 4)

Atherton Plateau Cracraft 1991: 213.

Diagnosis. "(M)oist closed-forest (rainforest) habitats" ..."circumscribed by the lowlands to the north, by drier, more open habitats to the west, and by open woodland in the region of the Burdekin River valley" (Cracraft 1991: 213).

Type locality. Mount Hypipamee, Mount Hypipamee National Park, Queensland, Australia, 17°25'28.84"S 145°28'59.40"E.

Remarks. The Atherton Tableland overlaps exactly with that of Crisp *et al.* (1995).

Sub-Region CAPE YORK PENINSULA Cracraft 1991

(Fig. 4)

Cape York Peninsula Cracraft 1991: 213.

Diagnosis. "The area is bounded to the south-east by the uplands of the Atherton Plateau and to the south and south-west by drier, more open habitats" (Cracraft 1991: 213).

Remarks. Species endemic to this area inhabit medium closed forest (rainforest), open forest, and woodland habitats (Cracraft 1991: 213).

Sub-Region ATHERTON PLATEAU Cracraft 1991

(Fig. 4)

Arnhem Plateau Cracraft 1991.

Diagnosis. "(W)oodland and low woodland habitats of Arnhem Land ... isolated from the Kimberley Plateau to the

west by the Victoria and Daly River valleys [...] to the south by the lowlands of the northern interior desert, and to the south-east by drier, more open habitats around the Gulf of Carpentaria" (Cracraft 1991: 213).

Type locality. Nourlangie Rock, Kakadu, Northern Territory, Australia, 12°52'1.10"S 132°48'40.14"E.

Remarks. Both the Cape York Peninsula and Arnhem Land diagnoses refer to "drier lands, more open habitats". These may be defined geographically, referring to the boundaries of deserts or savannahs. While these diagnoses are vague (i.e. not specifying which interior desert), they do communicate where one would expect to find a biotic break.

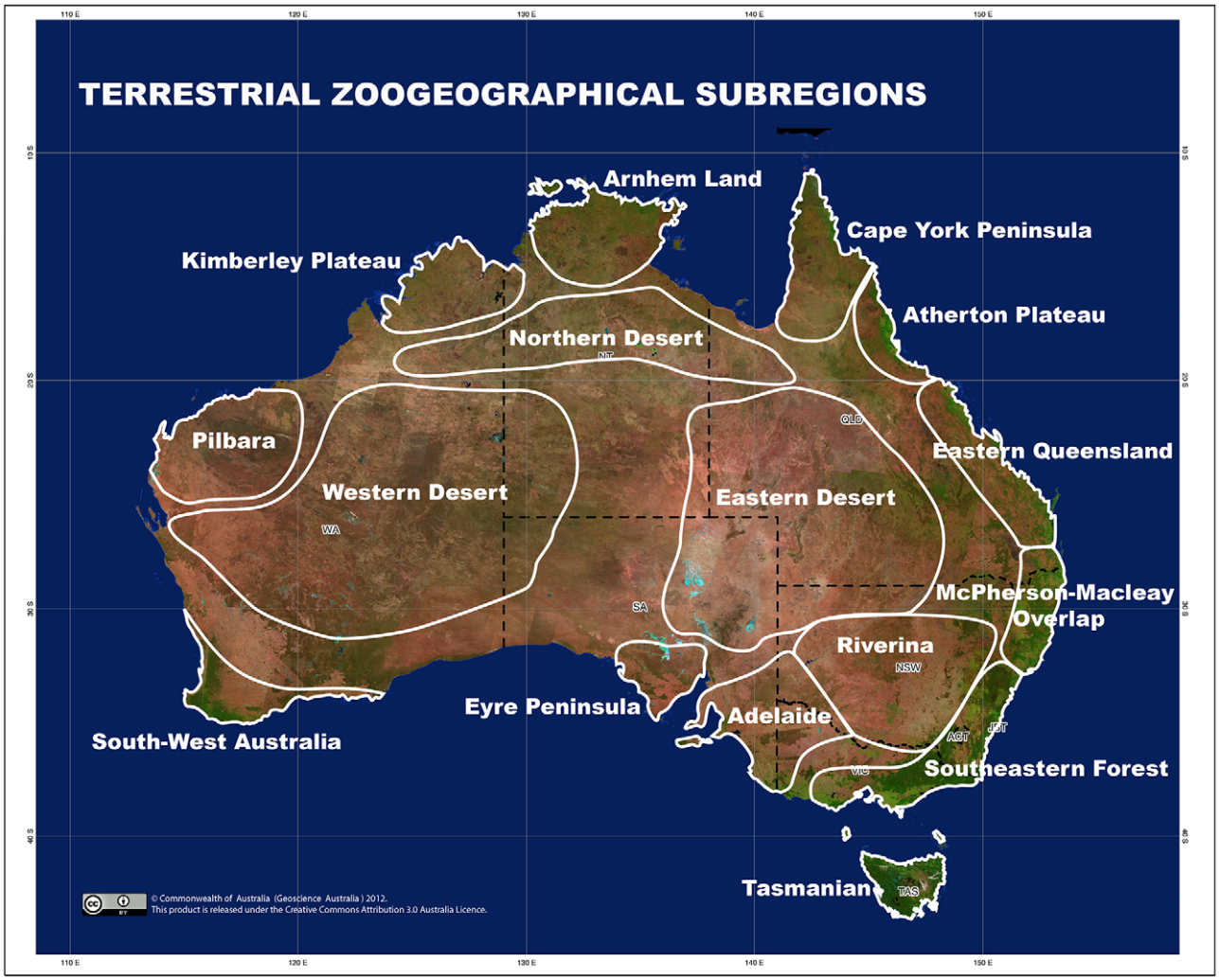

FIGURE 4. Zoogeographical sub-regions of Australia (excluding New Guinea).

Sub-Region KIMBERLEY PLATEAU Cracraft 1991

(Fig. 4)

Kimberley Plateau Cracraft 1991: 213.

Diagnosis. Bounded by the Fitzroy River drainage (Western Australia) and the "Great Sandy Desert in the south-west, to the south by the northern interior desert, and to the east from Arnhem Land by the lowlands of the Victoria and Daly River valleys" (Cracraft 1991: 213).

Type locality. Mitchell Plateau, Western Australia, Australia, 15°7'14.27"S 125°47'39.67"E.

Region EYREAN (Hedley 1894)
(Fig. 3)

Eremian Hedley 1894: 444.
Eyrean Spencer 1896: 196–199.

Diagnosis. "Includes the whole of the interior, southern and western part of the continent, the coastal region on the east and south-east separating it from the Torresian subregion in the north-east and the Bassian sub-region in the south-east" (Spencer 1896: 196–199).

Type locality. Uluru, Northern Territory, Australia, 25°21'9.34"S 131°2'3.70"E.

Remarks. Originally termed the Eremian (from Tate's regionalisation), Spencer's term Eyrean has been widely used with the zoological literature (Sloane 1915; Main *et al*. 1958). Since Spencer (1896), only one attempt has been made to rename these regions. Smith (1984) termed much of the Eyrean "Centralian" to regionalise land mollusc fauna. Smith (1984) ignores Spencer's regionalisation completely, renaming all regions based on marine distributions that were extrapolated inland. This rather baffling regionalisation has, to our knowledge, not been followed within the malacological community, remaining as an historical curiosity. Other sub-regionalisations of the Eyrean Subregion include Pianka (1969), who based his lizard regions on abiotic factors and vegetation. While these are helpful for determining ecological zones, they largely follow geographical and vegetation regions as well as being termed as such (e.g., Mulga Scrub, Mulga Scrub Country, Nullabor Plain, Great Victoria Desert). These areas have been omitted from this classification.

Sub-Region NORTHERN DESERT Cracraft 1991
(Fig. 4)

Northern Desert Cracraft 1991: 214.

Diagnosis. Area found between the "southern edges of the Kimberley Plateau and Arnhem Land areas of endemism and the northern boundaries of the Eastern and Western Desert areas. The area extends eastward to the base of the Gulf of Carpentaria" (Cracraft 1991: 214).

Type locality. Riversleigh Queensland, Australia, 26°46'12.86"S 146°28'12.55"E.

Remarks. Cracraft (1991) considered the Northern Desert to be the "most poorly defined of all the areas" possibly because this single sub-region consists of varying landforms each part of a different desert (i.e., Tanami and Great Sandy Deserts).

Sub-Region EASTERN DESERT Cracraft 1991
(Fig. 4)

Eastern Desert Cracraft 1991: 214.

Diagnosis. Bounded in the east by "the Central Highlands and the drier regions of the Simpson Desert [and the western margin of the Great Dividing Range]. The southern distributions of species are limited by the Darling River or areas of mallee vegetation" (Cracraft 1991: 214).

Type locality. Nappa Merrie Breakaways, Queensland, Australia, 27°23'7.24"S 141° 9'51.81"E.

Remarks. Cracraft's original diagnosis overlaps the Eastern Desert with the western margin of Eastern Queensland as it extends into "the uplands of the Great Dividing Range". While this is not clear in his original map, it does conflict in his diagnosis, which is herein amended.

Sub-Region PILBARA Cracraft 1991
(Fig. 4)

Pilbara Cracraft 1991: 214.

Diagnosis. "The uplands of the Pilbara (Hammersley Plateau), which are vegetated primarily with tall shrubland and tall open shrubland [is limited] to the north by the lowlands of the Great Sandy Desert, to the west by the Gibson Desert, and to the south by lowlands" (Cracraft 1991: 214).

Type locality. Mount McRae, Western Australia, Australia, 22°16'60.00"S 117°34'42.00"E.

Sub-Region WESTERN DESERT Cracraft 1991
(Fig. 4)

Western Desert Cracraft 1991: 214.

Diagnosis. "This is an ill-defined area of endemism that extends from south and west of the Pilbara east to the Simpson Desert (although some species are limited by the Central Highlands). It roughly conforms to the distribution of mulga vegetation [...], but some of the species are distributed to the north in tall open shrubland where the boundary of the area of endemism is ambiguous" (Cracraft 1991: 214).

Type locality. Veevers Crater, Western Australia, 22°58′12 S, 125°22′21″E.

Sub-Region EYRE PENINSULA Cracraft 1991
(Fig. 4)

Eyre Peninsula Cracraft 1991: 214.

Diagnosis. The area "limited to the north and east by the more arid Eyrean barrier and the Flinders Ranges and to the west by the drier area of the Nullarbor Plain (although some species may well have distributions extending to the South-western Forest area of endemism)" (Cracraft 1991: 214).

Type locality. Darke Peak Range, South Australia, Australia, 33°28'26.85"S 136°10'29.68"E

Remarks. The Pilbara, Western Desert and Eyre Peninsula sub-regions are clearly defined along vegetational and geographical lines. The addition of endemic bird distributions validates these as biotic regions. It is interesting to note however that Cracraft (1991) uses the term Eyrean Barrier, with which he is no doubt referring to Spencer's Eyrean region. Spencer's and Tate's regions are otherwise missing from Cracraft's treatment.

Sub-Region SOUTH-WEST AUSTRALIA (Tate 1889)
(Fig. 4)

Autochthonian Tate 1889: 315.
South-west Australia Sloane 1905: 3; Sloane 1915: 146.
South-western Forest Cracraft 1991: 214.

Diagnosis. Southwest region in Western Australia that is delineated by the coastline and by a rainfall line of 500 mm (20 inches) in the east.

Type locality. Mount Geraldine, Mount Jackson WA, Australia, 29°58'0.00"S 119°24'0.00"E.

Remarks. Originally the botanical Autochthonian Province Tate 1889, which was bounded in the east by a rainfall line of twenty inches, the term was rejected by Diels and others in the phytogeographical literature and the term Southwest was used instead. In zoogeographical treatments, the term "Autochthonian" still appears, but Spencer does not refer to it, rather placing the western part of Australia into the Eyrean Region. Spencer characterises the Eyrean region based on a range of mammals, reptiles, fish and molluscs. Only later authors such as Sloane (1905, 1915), Main *et al.* (1958) and Cracraft (1991) accept the southwest as a separate sub-region.

Sub-Region RIVERINA Sloane 1905
(Fig. 4)

Riverina Sloane 1905: 3.
Riverina.—Sloane 1915: 146.

Diagnosis. The Murray Darling Basin and the western watershed between the Darling and Barcoo Rivers.

Type locality. Hay Plain, New South Wales, Australia, 34°18'28.77"S 144°54'16.03"E.

Remarks. The Riverina or Murray Darling Basin was defined by Sloane (1905) who used it to regionalise carabid beetle distributions: "The Riverina district is probably merely part of the eastern marches of the Eyrean sub-region. It may be considered to take in the whole of the basin of the River Darling, its western boundary being the watershed between the Darling and Barcoo Rivers. Its chief distinctive character is the prevalence of immigrant forms from the Bassian and Torresian sub-regions" (Sloane, 1915: 146). For the most part it fills in a large region not covered by most zoogeographers including Cracraft (1991).

Freshwater zoogeographical regions or Fluvifauna

Sub-Realm AUSTRALIA Swainson 1835
(Fig. 5)

Australia Swainson 1835: 114.
Australia.—Wallace 1876: 59.
Australia.—Schmarda 1853: 313.
Australia.—Agassiz 1854: lxxviii.
Australiana Sclater 1858: 141.
Australia.—Tenison-Woods 1882: 48.
Austrogæan (Australian) Gill 1884: 22.

Diagnosis. The Australian continent and southern New Guinea.

Type locality. Cooper Creek at mouth (Lake Eyre), South Australia, Australia, 28°24'52"S 137°42'38"E.

Remarks. Unmack (2001) created a series of 10 new names (10 provinces divided into 31 regions), nine of which fall under existing names used by Iredale and Whitley (1938). All nine names are synonymised herein. Unmack (2001) gives no reason for his inverted classification of grouping biogeographic regions into provinces (i.e., subregions). Furthermore, Unmack's "regions", based on Australian Water Resources Council (AWC 1976) river basins and therefore not biotic, are omitted from this revision. Similarly, we have not included classifications used, for example, by Lake (1971, 1978), Allen (1989) or Allen *et al*. (2001), which are essentially abiotic drainage classifications from Bauer (1955) and AWC (1976). Unmack's tenth province (Paleo Pronvince) is also based on abiotic factors, lacking endemic taxa and corresponding largely to the Western Plateau Drainage of AWC (1976).

Region STURTIAN Iredale & Whitley 1938
(Fig. 5)

Sturtian Iredale & Whitley 1938: 64–68 and map.
Central Australian Province Unmack 2001: 1081.
Palaeo Province Unmack 2001: 1082.

Diagnosis. Inland drainages west of the Mitchellian Region.

Type locality. Cooper Creek at mouth (Lake Eyre), South Australia, Australia, 28°24'52"S 137°42'38"E.

Remarks. As noted above, Iredale and Whitley's (1938) map included the Gulf of Carpentaria portion of their Leichhardtian Fluvifaunula within their Sturtian Fluvifaunula contradicting their text definition of the former. No definition of the Sturtian Fluvifaunula is provided in their text. It includes the following: Lake Eyre, the Bulloo-Bancannian Basin, Lake Torrens and the drainages in the Barkly Tablelands, as well as various isolated inland catchments in Unmack's (2001) Palaeo Province (though excluding the Palaeo-southwestern Drainage).

Region LEICHHARDTIAN Iredale & Whitley 1938
(Fig. 5)

Leichhardtian Iredale & Whitley 1938: 64–68 and map.
Kimberley Province Unmack 2001: 1076.
Northern Province (in part) Unmack 2001: 1077.

Diagnosis. Northwestern and Gulf of Carpentaria coastal drainagesextending from the Fitzroy River (Western Australia) to the Torres Straits.

Type locality. Adelaide River at Arnhem Highway crossing, Northern Territory, Australia, 12°39’39”S 131°20’16”E.

Remarks. Iredale and Whitley’s (1938) description and depiction of this region are contradictory. In the text (p. 65) Iredale and Whitley state: “The LEICHHARDTIAN FLUVIFAUNULA is that inhabiting the rivers of the Northern Territory, from Port Essington eastwards, and Queensland, west of Torres Straits. This extends northwards to take in the river faunulae of Southern New Guinea.” In contrast, their map shows only northwestern Australia in the Australian portion of the Region, including only the Kimberleys to the western portion of the Gulf of Carpentaria. The remainder of the Gulf of Carpentaria is assigned to their Sturtian Fluvifauna, and the whole of the Cape York Peninsula is grouped with the eastern coastal drainages of Queensland under their Jardinean Fluvifaunulae. The definition here essentially matches that of Whitley (1959), but as modified by McMichael and Hiscock (1958) to exclude New Guinea portion (which they newly named the Riechian Fluvifaunula). As such, the Leichhardtian Region extends Iredale and Whitley’s (1938) text description southward to include the Kimberleys, and their map depiction eastward to include the Gulf of Carpentaria drainages on the Cape York Peninsula. In contrast to this definition, Iredale (1943) noted the discrepancies in Iredale and Whitley (1938) but corrected the Greyian Fluvifaunula to include the Kimberleys.

Region GREYIAN Iredale & Whitley 1938
(Fig. 5)

Greyian Iredale & Whitley 1938: 64–68 and map.
Pilbara Province Unmack 2001: 1076.

Diagnosis. Western Australian coastal drainages extending from the Greenough to the De Grey Rivers.

Type locality. Murchison River at Four Mile Pool, Western Australia, Australia, 27°45’39”S 114°41’18”E.

Remarks. Although Iredale and Whitley’s (1938) map mostly delimits the region as diagnosed above, the description is misleading in noting that the “Nannatherinidae” (based on *Nannatherina balstoni* Regan 1906, and currently classified in the Austral family Percichthyidae) is a remarkable component of the fauna, when the taxon is actually endemic to their Vlaminghian Fluvifaunula. The southern boundary with the Vlaminghian Region was not clearly depicted or described by Iredale and Whitley, though Whitley (1959) gave it as “south of Shark Bay.” Our choice of the Greenrough River as the southern limit follows Morgan and Gill (2004), who recognised three sub-areas within the Pilbara. As noted above, Iredale (1943) included the Kimberleys within the Greyian Fluvifaunula.

Region VLAMINGHIAN Iredale & Whitley 1938
(Fig. 5)

Vlaminghian Iredale & Whitley 1938: 64–68 and map.
Southwestern Province Unmack 2001: 1076.

Diagnosis. South-western coastal drainages from the Irwin River to the vicinity of Esperance, Western Australia.

Type locality. Frankland River at Nornalup, Western Australia, Australia, 34°59’26” 116°49’00”E.

Remarks. Iredale and Whitley (1938) did not specify northern or eastern limits to their Vlaminghian Fulvifauna. We clarify the northern limit based on the above clarification of the southern limit of the Greyian Region. The eastern limit reflects the distribution of endemic freshwater fishes in the region.

Region MITCHELLIAN Iredale & Whitley 1938
(Fig. 5)

Mitchellian Iredale & Whitley 1938: 64–68 and map.
Murray-Darling Province Unmack 2001: 1080.

Diagnosis. The Murray-Darling river system, including coastal drainages of the Gulf of St. Vincent and Spencer Gulf.

Type locality. Junction of Murray and Darling Rivers, New South Wales, Australia, 34°06’48”S 141°54’43”E.

Remarks. Iredale and Whitley (1938) included Gulf of St. Vincent and Spencer Gulf drainages in their depiction of the Mitchellian Fluvifaunula, but did not justify this in their text. However, such justification was provided by Unmack (2001).

FIGURE 5. Fluvial Zoogeographical regions of Australia (excluding New Guinea).

Region LESSONIAN Iredale & Whitley 1938
(Fig. 5)

Lessonian Iredale and Whitley 1938: 67 and map.
Eastern Province (in part) Unmack 2001: 1078.
Bass Province Unmack 2001: 1079.

Diagnosis. "Rivers of eastern New South Wales, Victoria and North Tasmania" (Iredale & Whitley 1938: 67).

Type locality. Macleay River at Bellbrook, New South Wales, Australia, 30°49'11"S 152°30'21"E.

Region TOBINIAN Iredale & Whitley 1938

(Fig. 5)

Tobinian Iredale & Whitley 1938: 64–68 and map.
Southern Tasmanian Province Unmack 2001: 1080.

Diagnosis. The rivers of southern Tasmania.

Type locality. Huon River at Huonville, Tasmania, Australia, 43°02'00"S 147°02'48"E.

Region KREFFTIAN Iredale & Whitley 1938

(Fig. 5)

Krefftian Iredale & Whitley 1938: 64–68 and map.
Krefftian McMichael & Hiscock, 1958: 488.
Eastern Province (in part) Unmack 2001: 1078.

Diagnosis. "The coastal streams of the east coast of Queensland from about Brisbane north to the Tropic of Capricorn" (McMichael & Hiscock 1958: 488).

Type locality. Mary River at Tiaro, Queensland, Australia, 25°43'20"S 152°34'34"E.

Remarks. The diagnosis used here essentially follows Iredale and Whitley's (1938) figure. Whitley (1959) subsequently refined it to only include the Mary and Burnett Rivers, though his map depicted an area more in keeping with the definition used here.

Region JARDINEAN Iredale & Whitley 1938

(Fig. 5)

Jardinean Iredale & Whitley 1938: 64–68 and map.
Jardinean.—McMichael & Hiscock, 1958: 488.
Eastern Province (in part) Unmack, 2001: 1078.
Northern Province (in part) Unmack, 2001 1077.

Diagnosis. "Occupying the rivers of the east coast of Queensland north of the Fitzroy River [Queensland] to Cape York" (McMichael & Hiscock, 1958: 488).

Type locality. Mulgrave River at Gordonvale, Queensland, Australia, 17°06'06"S 145°47'20"E.

Remarks. As noted above, Iredale and Whitley's (1938) text and figure are contradictory, with the latter indicating eastern Gulf of Carpentaria drainages (Leichhardtian Region) within the Jardinean. Subsequently, Whitley (1959) included only the eastern drainages in the Jardinean.

Marine regions

Realm INDO-PACIFIC Perrier 1878

(Fig. 6)

Indo-Pacific Perrier 1878: 108.
Indo-Pacific.—Ortmann 1896: 60.

Diagnosis. Littoral and pelagic water marine regions between the Mozambique channel in the west to the Chilean and Peruvian coast in the east, bounded by the Australian Circumpolar Current in the south and, by the Indian subcontinent, and, by the Indian subcontinent, Mainland Asia, Japan and by the North Pacific in the north.

Remarks. Ortmann (1896) divided the Circumtropical Zone into the Atlantic and Indo-Pacific regions. Both these regions include littoral and pelagic life zones ("Lebensbezirk"). Ortmann (1896) never cites Perrier (1878) although the latter used the term first within the context of marine regions. The definition used by Ortmann places Australia within the Indo-Pacific (rather than as a separate region).

Sub-Realm AUSTRALIA Forbes 1856

(Fig. 6)

Australia Forbes 1856: pl. 31.
Australienne Perrier 1878: 108.
Australia.—Ortmann 1896: 60.

Diagnosis. The marine shallow water, reef, estuarine and shorelines of continental Australia (including Tasmania).

Type locality. Port Jackson, New South Wales, Australia, 33°51.51'S, 151°14.33'E.

Remarks. Forbes (1856) produced an impressive map in which is described (in the legend) the Australian Province within the Southern Circumcentral Homoiozoic Belt as including the "... seas around the greater part of New Zealand islands ..." (Forbes 1856: pl. 31). What we know of the Australian Province comes directly from the map itself namely a vague region that includes the area north of Shark Bay and Rockhampton. The extent of these areas longitudinally is opaque. However, Perrier (1878) classified Australia, the Indo-Pacific, Indian and Sino-Japanese regions as four regions (along with the Austral and Antarctic) based on starfish distributions. Neither of regions are mapped or described in any greater detail. Similarly, Ortmann (1896) recognised Australia to exist within the Indo-Pacific region, a region he designated to be "very homogeneous" (Ebach 2012).

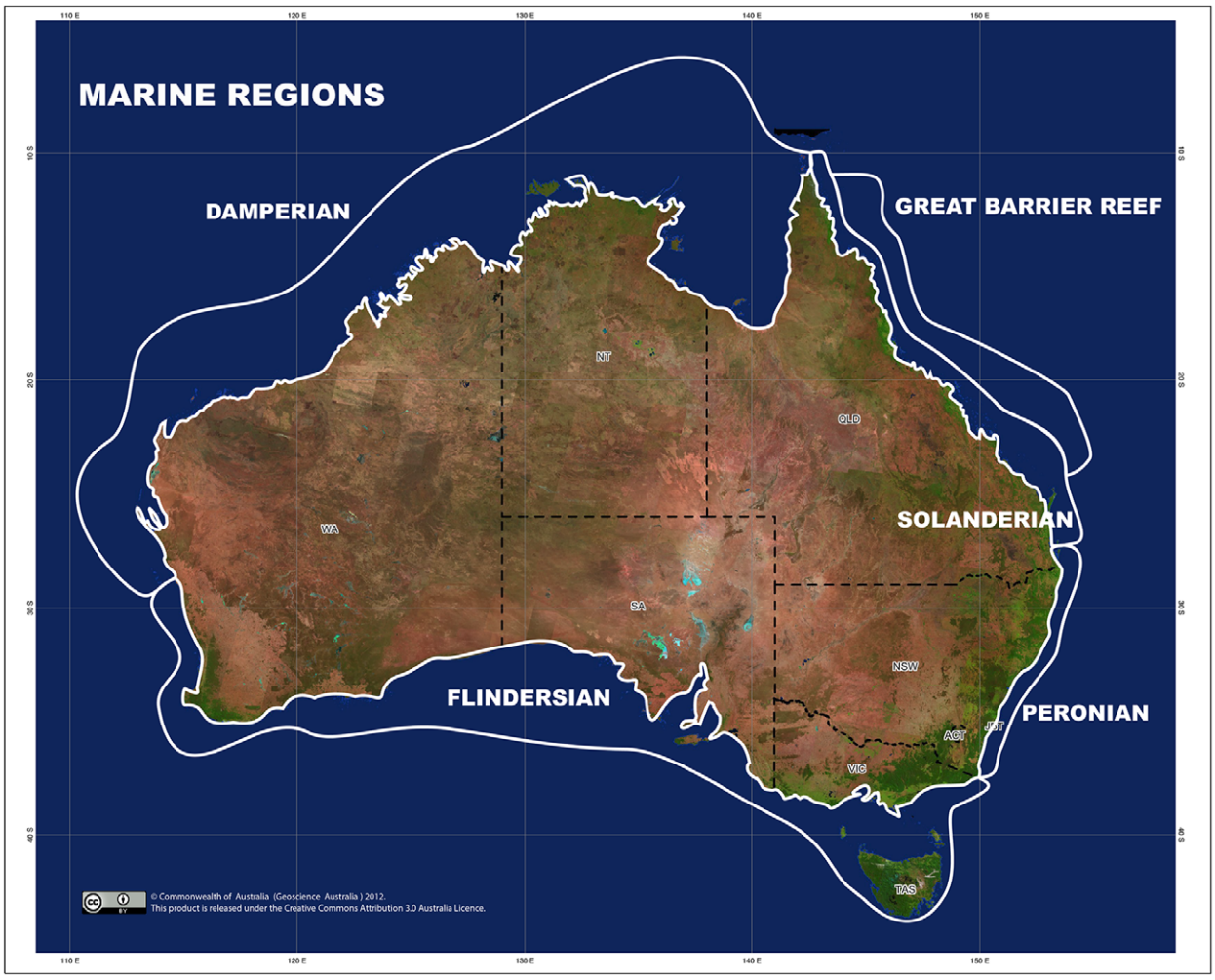

FIGURE 6. Marine regions of Australia.

Region GREAT BARRIER REEF Knox 1963
(Fig. 6)

Great Barrier Reef Knox 1963: 341.

Diagnosis. Marine region comprising the Great Barrier Reef and associated islands.

Type locality. Lizard Island, Great Barrier Reef, 14°39.98’S, 145°27.82’E.

Region SOLANDERIAN Hedley 1904
(Fig. 6)

Solanderian Hedley 1904: 880.
Banksian Whitley 1932: 166.
Queensland Schilder & Schilder 1939: 213.

Diagnosis. Coastal marine region extending from the Torres Strait (10°S latitude) to southern Queensland (possibly Moreton Bay or 25°S) or near the border of New South Wales.

Type locality. Magnetic Island, Queensland, 19°07.96’S, 146°50.53’E.

Remarks. Hedley (1904) described the Solanderian as being “the Queensland coast from Moreton Bay to Torres Strait” (Hedley 1904: 880), an area that was later termed Queensland by Schilder and Schilder (1939) based on Cypraeidae (cowries) distributions. Hedley’s term Solanderian is senior to the term Queensland, but the subregions proposed by the Schilder’s are significant: sub-region “Queensland S” extending from Hervey Bay down to the Macleay River in New South Wales is roughly equivalent to the McPherson-Macleay overlap zone. A revision by Phillips (2007) gives a latitudinal limit to the Solanderian, which is incorporated into the diagnosis.

Originally proposed by Whitley as “the coastal districts of Queensland, which possess a marine fauna quite distinct from that of the Great Barrier Reef” (Whitley 1932: 166), the Banksian sub-region was later revised by Straughan as “a province [...] which may be continuous with the Damperian, embracing the mainland coast and islands between 10°S and 25°S” (Straughan 1967: 254). Iredale (1937) used the Banksian in his ‘Faunal areas and regions of Australia’ map, but did not describe it in the text, while Kott (1952: 325) ignored it entirely finding “no distinction from the known ascidian distribution between Banksian and Solanderian faunas” (see Ebach 2012).

Region FLINDERSIAN (Hedley 1904)
(Fig. 6)

Adelaidean Hedley 1904: 879.
Flindersian Cotton 1930: 219.
South Australian Schilder & Schilder 1939: 213.
Baudianian Kott 1952: 323–324.
West Australian Province Womersley 1981: 300.

Diagnosis. From Geraldton, Western Australia, to the New South Wales-Victorian border including Tasmania.

Type locality. Gulf St. Vincent, off Adelaide, South Australia, Australia, 34°55.72’S, 138°23.36’E.

Remarks. Hedley’s original term Adelaidean included “marine fauna which extends from Melbourne along the south coast of Australia”, which was later modified by Cotton (1930) to Flindersian. Defined in this way, the Adelaidean does not include the western portion of Tasmania. While the Peronian extends from Gippsland to Moreton Bay, it does not include Tasmania (the eastern part of which is in the Maugean sub-region). Hedley’s (1904) “Map to illustrate the barrier opposed by the Bassian Isthmus to migration of the marine fauna” resolves several of these problems. The map shows the Adelaidean to extend to the southern point of Tasmania (west of South Cape Bay) to the western part of the Great Australian Bight (Esperance). The marine region between Esperance and Geraldton was undefined by Hedley, but others have referred to this as the West Australian Province (Womersley 1981). The West Australian Province takes in Kott’s (1952) Baudinian Province, but neither term has been adopted (see Womersley 1981).

Iredale and May (1916) do not specify where on the geographically diverse east coast the Maugean area starts or ends, but more recent workers constrain it to the Victorian and Tasmanian coasts (Womersley 1981). However, a quantitative biogeographical analysis using macroalgal assemblages has shown support for the traditional Peronian, Flindersian and Maugean regions (Waters *et al.* 2010: fig. 1). We herein consider the Maugean to be a subregion of the Flindersian.

Sub-Region MAUGEAN Iredale & May 1916
(Fig. 7)

Maugean Iredale & May 1916: 117.
Maugean.—Kott 1952: 324.
Maugean.—Wormersley 1981: 239.

Diagnosis. The coasts of Victoria (from Malacoota) to Tasmania and eastern South Australia to the vicinity of Victor Harbour.

Type locality. Derwent River, Hobart, 42°53.33’S, 147°21.21’E.

Remarks. Kott (1952) extends the Maugean sub-region of Iredale and May (1916) further north into the Peronian based on the distribution of ascidians. However, Womersley (1981) restricts the Maugean to the coasts of Victoria, Tasmania and eastern South Australia.

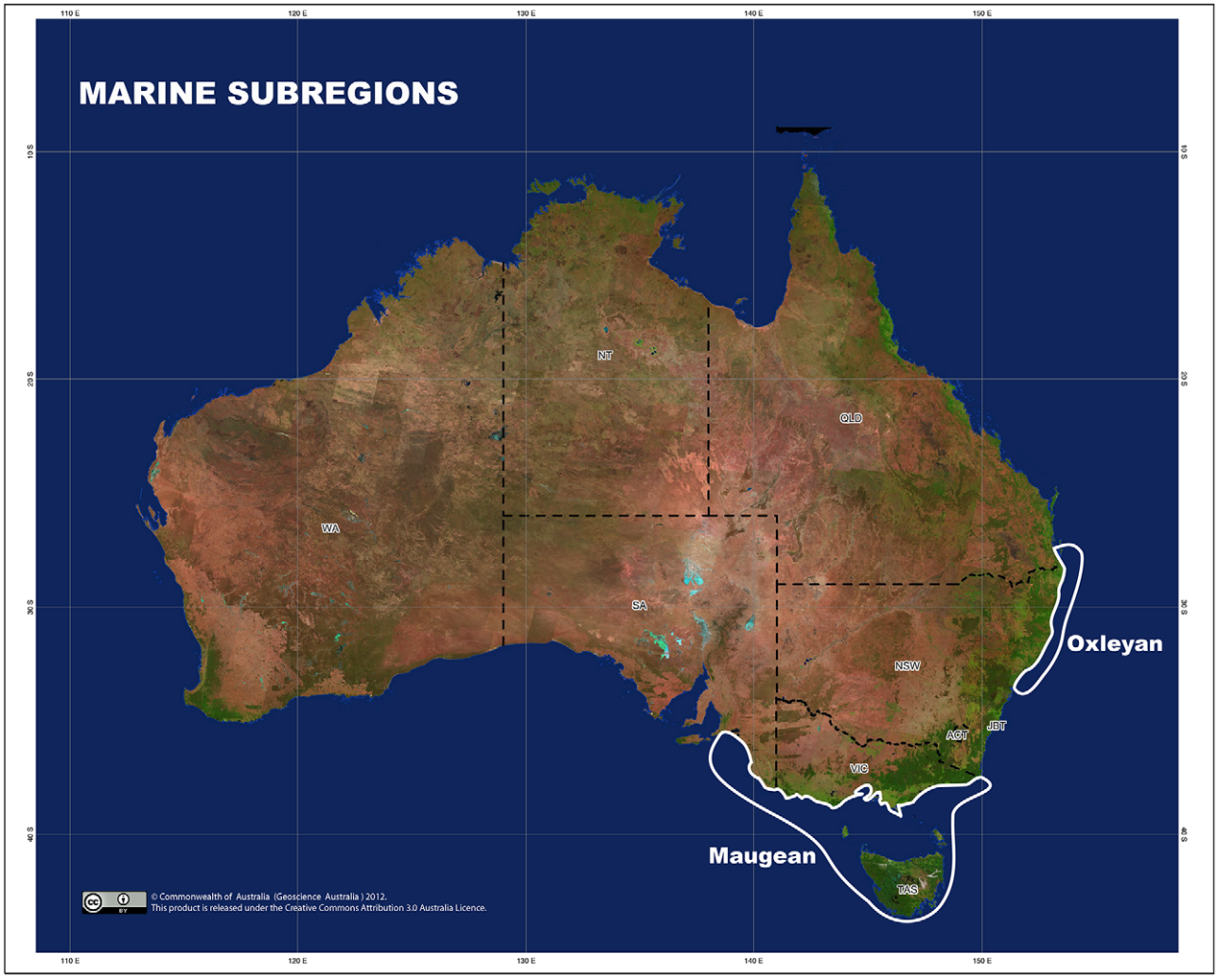

FIGURE 7. Marine sub-regions of Australia.

Region PERONIAN Hedley 1904
(Fig. 6)

Peronian Hedley 1904: 880.
Queensland Schilder & Schilder 1939: 213.
South Australian Schilder & Schilder 1939: 213.

Diagnosis. Marine region extending from Gippsland, Victoria, to Moreton Bay, Queensland.

Type locality. Salamander Bay, Port Stephens, New South Wales, Australia, 32°43.30’S, 152°05.52’E.

Remarks. In the original description by Hedley (1904), the Peronian region extends along “the east coast of Tasmania, Gippsland, and New South Wales” (Hedley 1904: 880). It is unclear from this description what lies between the New South Wales-Queensland border and Moreton Bay. Womersley (1981) recognises Moreton Bay as the northern limit of the Peronian, as we do here. Millar (2007: 554) places the Peronian “closely to the coastline of New South Wales and has an almost north-south orientation, spanning 9 degrees of latitude but only 3 degrees of longitude”. Although the Oxleyan subregion is recognised here, Millar (2007: 555) regards the Peronian as “essentially a transitional zone between the subtropical waters of Queensland and the cool-temperate waters of Southern Australia” and thus not meaningfully divisible.

Sub-Region OXLEYAN Iredale 1937
(Fig. 7)

Oxleyan Iredale 1937: 188.
Oxleyan.—Kott 1952: 324.

Diagnosis. Sub-region extending from Port Jackson to Moreton Bay.

Type locality. Salamander Bay, Port Stephens, New South Wales, Australia, 32°43.30’S, 152°05.52’E.

Remarks. The Oxleyan area was originally described by Iredale (1937) as a terrestrial sub-area part of the Euronotian. Kott (1952) creates the Oxlyean sub-region that extends from “Port Jackson to Moreton Bay, in an area corresponding to Iredale's Oxleyan sub-area” (Kott 1952: 324).

Region DAMPERIAN Hedley 1904
(Fig. 6)

Damperian Hedley 1904: 880.
Damperian.—Schilder & Schilder 1939: 212.

Diagnosis. Marine region extending from the Torres Strait west to the Houtman Abrolhos Islands (28°50’S, off the coast from Geraldton), Western Australia.

Type locality. Dampier, Western Australia, Australia, 20°39.50’S, 116°42.18’E.

Remarks. Schilder and Schilder (1939) used the same name to designate a smaller area extending from Geraldton to Port Essington in the Northern Territory. Although the Schilder’s cite Hedley, they never refer to his regions. Huismann’s (2007) revision of the Damperian region considered the boundaries to be vague, with a portion of the southern part of the region overlapping with the Flindersian.

Author contribution

All authors have contributed to this work and the authorship order reflects their relative contributions. MCE prepared the area classification, diagnoses, remarks (except for fluvial areas) and edited the final draft for submission; ACG prepared the area classification, diagnoses, remarks and fact checked the fluvial areas; STA fact checked marine areas and edited first draft; AK drew all maps based on final draft diagnoses; DJM fact checked phytogeographical areas and edited first draft and; GC fact checked zoogeographical areas.

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