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Melioidosis in the Torres Strait Islands, Australia: Exquisite Interplay between Pathogen, Host, and Environment

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Abstract. *Burkholderia pseudomallei*, a bacterium that lives in the soil of the tropics, causes the disease melioidosis. This retrospective study investigated the temporospatial epidemiology of the 49 laboratory-confirmed melioidosis cases in the Torres Straits Islands of tropical Australia between 1997 and 2017. An identifiable risk factor for the disease was present in 43/49 (88%) cases and in 35/36 (97%) cases with complete clinical data. The mean incidence of melioidosis varied across the region, from 0/100,000 persons/year in the Eastern Island Cluster to 116.1/100,000 persons/year in the Near Western Island Cluster. An environmental suitability score for the growth of *B. pseudomallei*—constructed using the rainfall, vegetation, and soil type on each island—correlated with disease incidence (Spearman's rho 0.51; $P = 0.035$). Melioidosis is an opportunistic disease that occurs in patients with specific risk factors, but its incidence is also strongly influenced by environmental factors that favor the growth of *B. pseudomallei*.

Melioidosis is an opportunistic infection caused by the environmental Gram-negative bacterium *Burkholderia pseudomallei*. Infection is usually asymptomatic, but it can be rapidly fatal in individuals with specific comorbidities including diabetes mellitus, hazardous alcohol use, and chronic kidney disease (CKD).[1] Even where there is access to sophisticated intensive care support, the case-fatality rate can exceed 10%.[2,3] Meanwhile in resource-poor and remote locations, the case-fatality rate can approach 35%.[4] Melioidosis has no effective vaccine, so it is important to identify other strategies to prevent the disease.

Burkholderia pseudomallei lives in the soil and surface water of tropical and subtropical regions, with rainfall and the physicochemical properties of soil and vegetation all appearing to influence the organism's growth. The association with rainfall is strong and is emphasized by the clustering of cases after severe weather events and the observation that almost 90% of human cases in northern Australia present during the wet season.[5,6] The influence of soil and vegetation type on the growth of *B. pseudomallei* is less well defined, but both also appear to be important. Some investigators have noted that fine-textured soils with a higher proportion of silt and clay particles, and a lower pH and carbon: nitrogen ratio, provide conditions preferred by the bacteria.[7] However, other studies have found a positive association with the proportion of sand.[8] Conversely, increasing soil salinity limits the bacterium's growth.[8] There are fewer data that define the effect of vegetation; however, the organism appears to thrive in rice fields and in the presence of grasses of the *Aristida* species.[9,10]

The Torres Strait archipelago in tropical northern Australia covers an area of 48,000 km^2. There are 17 inhabited islands, grouped into five geographically and culturally distinct areas: an Eastern Cluster of volcanic islands; a Central Cluster of low sandy islands; a Top Western Cluster comprising predominantly alluvial muds overlying old coral platforms; a Near Western Cluster composed of volcanic and granitic rocks; and an Inner Cluster (Thursday Island Cluster) comprising basement igneous and volcanic rock (Figure 1).[11] The mean daily temperature ranges from 28.3°C to 32.1°C (82.9–89.7°F). The December–April wet season accounts for approximately 91% of the annual rainfall.[12]

Only 4,514 people inhabit the islands, with approximately 92% of the residents identifying as Indigenous Torres Strait Islanders, ethnically a Melanesian population.[13] There is a high prevalence of risk factors for melioidosis: approximately one-third have diabetes, while up to 49% consume excess alcohol.[14] The precise local prevalence of CKD is uncertain, although there is a significant local burden that necessitates a nine-chair hemodialysis unit and an outreach peritoneal dialysis service.[15] There are health clinics on all 17 inhabited islands; however, their remote location means that clinic staff frequently have to rely on telephone advice from medical staff based in the region's main hospital on Thursday Island.

Previous work suggest that the annual incidence of melioidosis in the Torres Straits Islands is 42.7/100,000, one of the highest in the world.[16] However, the distribution of cases is quite heterogeneous, with local clinicians observing that melioidosis is very rare in the Eastern Cluster of islands, despite a similar prevalence of risk factors for the disease.[17]

To determine whether differences in local environmental factors might account for this apparent disparity, all microbiologically confirmed cases of melioidosis diagnosed in the Torres Strait between 1997 and 2017 were evaluated. This period was chosen as it coincided with the establishment of a statewide electronic database, which ensured that all cases were captured. Additional patient data were collected from their medical records, where they were available. Disease incidence was determined using population data from the Australian Bureau of Statistics.[13] A variety of sources were used to collect environmental data: Australian Bureau of Meteorology data were used to determine the rainfall for each of the 17 islands, whereas vegetation and soil data for the one-kilometer radius around the primary community settlement on each island were collated from an environmental survey performed in 2009.[11,12] To determine the environmental suitability for *B. pseudomallei*, a score was calculated from these data (Supplemental Table 1). A score between 1 (least suitable for the growth of *B. pseudomallei*) and 5 (most suitable) for rainfall was determined (Supplemental Table 2). A blinded reviewer, with environmental microbiological expertise, based in mainland Australia, was provided with a list of the soil and

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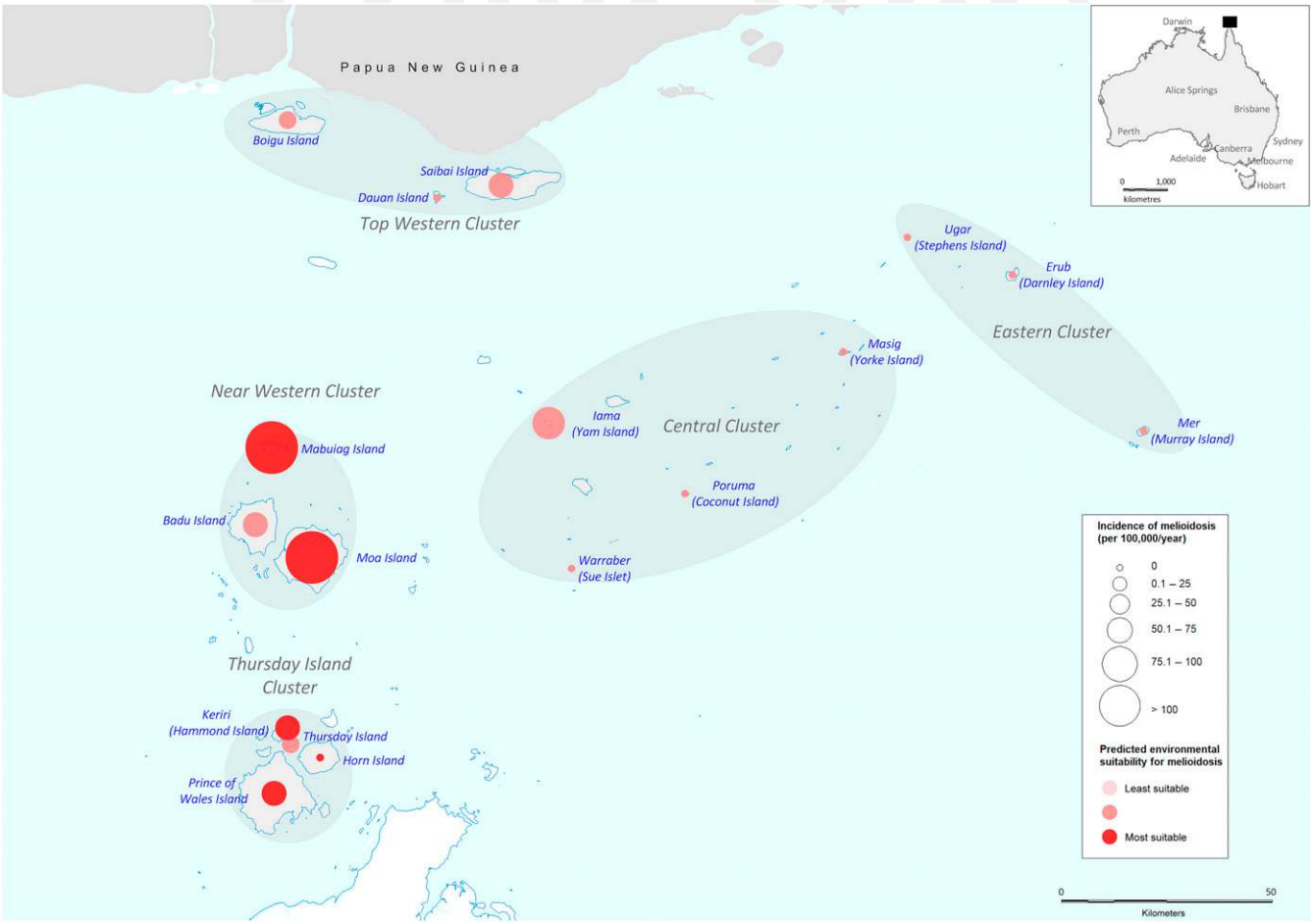

FIGURE 1. Map of the Torres Strait region showing the annual incidence (cases/100,000) of melioidosis during the study period on each of the inhabited islands and the environmental suitability of each of the islands for the growth of *Burkholderia pseudomallei.* This figure appears in color at www.ajtmh.org.

vegetation types found in the region, although he was unaware of their distribution. Each soil and vegetation type was also assigned a score between 1 and 5 (Supplemental Tables 3–5). The three 5-point scores were added together, and a percentage was generated. Data were entered into an electronic database (Microsoft Excel) and analyzed using statistical software (Stata 14.0). Associations between continuous variables were examined using Spearman's rho. The Far North Queensland Human Research and Ethics Committee provided ethical approval for the study (HREC/15/QCH/46–977).

There were 49 cases of laboratory-confirmed melioidosis that occurred relatively evenly across the study period (Figure 2). The patients' median age was 44.9 years, and 69% were male. In nine cases, limited clinical data were available (five charts had been destroyed and four of the charts were inaccessible or contained minimal detail). Despite this, there were only 6/49 (12%) patients who had no identifiable or documented risk factor for melioidosis. In the 36 patients for whom complete risk factor data were available, only two (6%) patients did not have diabetes mellitus, CKD, or recent hazardous alcohol consumption, and one of these two had another recognized predisposing factor (chronic lung disease). In the patients in whom the presence of specific risk factors could be confidently determined, 35/46 (76%) were diabetic, 25/37 (68%) reported hazardous alcohol consumption, and 7/46 (15%) had CKD. Of the 49 cases, 41 (84%) occurred during the December–April wet season; four (8%) patients died.

The mean annual incidence of melioidosis varied across the region, ranging from 0/100,000 in the Eastern Cluster (there were no cases during the entire study period) to 116.1/100,000 in the Near Western Cluster (Supplemental Table 1). On one of the islands in the Near Western Cluster, there were nine separate individuals of a mean population of 234 affected during the study period, with a cumulative risk in the general population of 3.9% (95% CI: 2.0–7.2%). The suitability score varied across the region from 50 to 72 and correlated with the incidence on each island (Spearman's rho 0.51; $P = 0.035$) (Figure 3). The association between incidence and mean annual rainfall (Spearman's rho 0.61; $P = 0.01$) was stronger than the association between incidence and vegetation (Spearman's rho 0.42; $P = 0.09$), and soil (Spearman's rho –0.13; $P = 0.61$) (Figures 2 and 3).

This study highlights the important interplay between the pathogen, the host, and the environment in the local incidence of melioidosis. A recognized risk factor was present in 97% of patients with complete data, and 84% of cases occurred during the region's wet season, emphasizing the status of *B. pseudomallei* as a seasonal, opportunistic pathogen. In this context, the marked heterogeneity of cases across the region is striking. There is very little variation in the prevalence of the

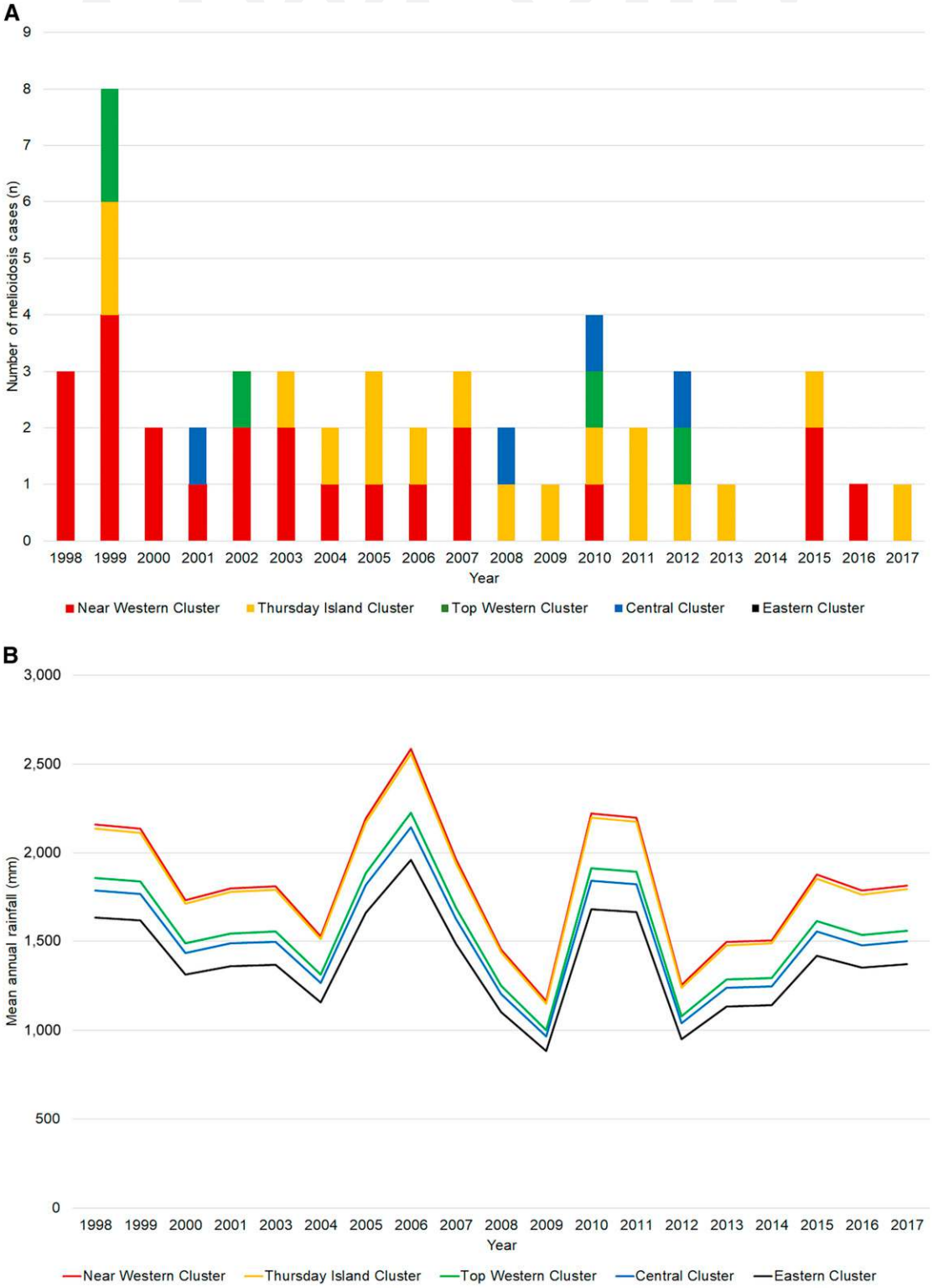

FIGURE 2. (**A**) Distribution of the cases by year. (**B**) Mean annual rainfall by island cluster during the study period. This figure appears in color at www.ajtmh.org.

comorbidities that predispose to the disease, and yet on several islands there were no cases during the study period at all, whereas on others the disease incidence is among the highest ever reported.[1,17] The association between the environmental suitability score and disease incidence is, therefore, notable.

Public health campaigns to prevent melioidosis have had mixed success but may be more effective if they can be targeted more precisely to populations at higher risk of the disease. The case-fatality rate of 8% underscores the organism's virulence and emphasizes the importance of including agents with activity against *B. pseudomallei* in the empirical regimen

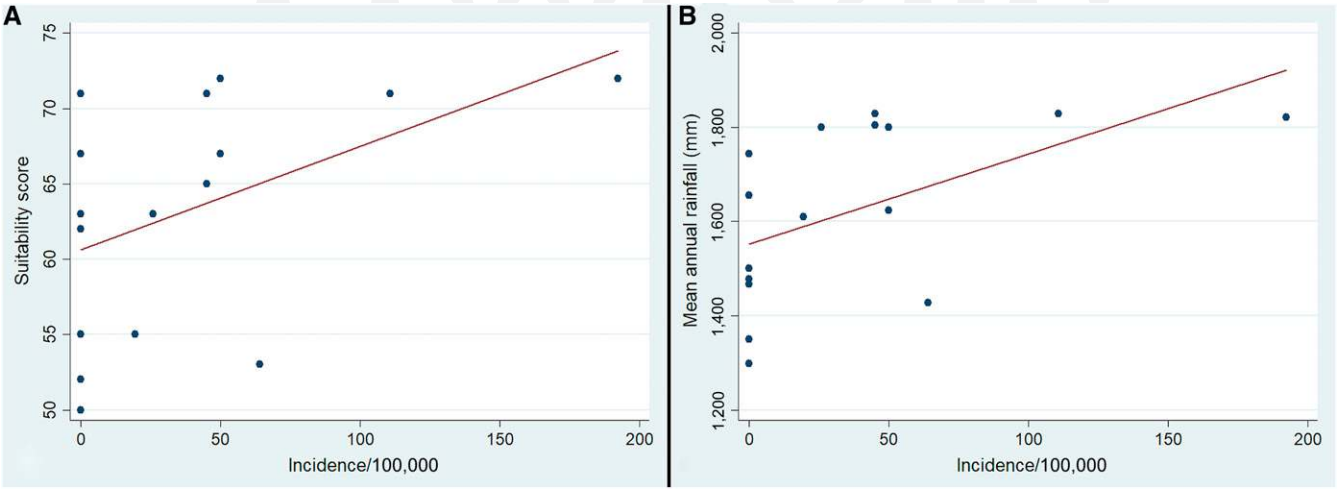

FIGURE 3. (**A**) Relationship between calculated suitability score and annual disease incidence on each island. (**B**) Relationship between mean annual rainfall and annual disease incidence on each island. This figure appears in color at www.ajtmh.org.

of local cases of sepsis and severe community-acquired pneumonia. On islands where the incidence is greatest, it is essential to have reliable access to meropenem or ceftazidime. However, these data support the impression of local clinicians that melioidosis is much less common in other parts of the region. This may encourage them to seek alternative diagnoses, and in an era when antibiotic stewardship is increasingly important, it might also permit earlier de-escalation.

The study has several limitations. The study's suitability score is crude; the relationship between rainfall and melioidosis cases is not linear, the rainfall's timing is critical, and other factors including fluctuations in dewpoint and groundwater levels are also important.[9,18] The impact that soil and vegetation have on *B. pseudomallei* persistence—in addition to rainfall—remains poorly understood, and the suitability score assumes an equal weighting for these variables, which may not be appropriate. Indeed, of the three factors, only rainfall had an independently statistical association with disease incidence in this small dataset. There are other potential weaknesses: the small population on each of the islands affects the reliability of the reported disease incidence, and although most infections are suspected to be the result of percutaneous inoculation, our score did not take patient behavior into account. Furthermore, even if an environment is notionally suitable for *B. pseudomallei*, this does not necessarily mean that the organism will be found there.[19,20] Previously, genetic characterization of *B. pseudomallei* from soil and cases of melioidosis in the Torres Strait Islands has identified sequence types common to both Papua New Guinea and mainland Australia, suggesting a nonrandom distribution of the microbe.[21] It is postulated that historical trade and migration between Papua New Guinea and mainland Australia have influenced the distribution of *B. pseudomallei*.[16] However, notwithstanding these caveats, the score was determined in a blinded manner, by a microbiologist with extensive experience in the environmental determinants of *B. pseudomallei* growth. The correlation between the score and disease incidence is at least hypothesis-generating, and there are plans to prospectively sample soil from the Torres Straits Islands to confirm the findings and to inform disease prevention strategies.

In summary, this study illustrates the exquisite interaction between the pathogen, host, and environment in the local incidence of melioidosis. On a broader level, it emphasizes the importance of understanding the temporospatial epidemiology of infectious diseases, particularly in remote and poorly resourced locations, to facilitate prevention, expedite detection, and optimize management.

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Note: Supplemental tables appear at www.ajtmh.org.

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Supplementary file 1. Table showing the derivation of the suitability score for each of the islands.

Cluster	Island	Mean population	Number of cases 1997-2017	Mean incidence (per 100000 population)	Rainfall score (out of 5)	Soil score (out of 5)	Vegetation score (out of 5)	Total score (out of 15)	Total score (%)
Top Western Cluster	Boigu	257	1	19.5	5	1.5	1.8	8.3	55
	Dauan	149	0	0.0	4	2.3	3	9.3	62
	Saibai	400	4	50.0	5	2.2	2.8	10.0	67
Near Western Cluster	Badu	775	7	45.2	5	2.3	2.4	9.7	65
	Mabuiag	234	9	192.5	5	2.3	3.5	10.8	72
	Moa (Kubin & St Pauls)	316	7	110.8	5	2.5	3.1	10.6	71
Central Cluster	Iama (Yam)	312	4	64.2	4	2	2	8.0	53
	Warraber (Sue)	236	0	0.0	5	2	1.3	8.3	55
	Poruma (Coconut)	156	0	0.0	4	2	1.5	7.5	50
	Masig (Yorke)	275	0	0.0	4	2	1.8	7.8	52
Eastern Cluster	Mer (Murray)	427	0	0.0	4	3	2.5	9.5	63
	Erub (Darnley)	328	0	0.0	4	3	3	10.0	67
	Ugar (Stephens)	66	0	0.0	4	3	2.5	9.5	63
Thursday Island Cluster	Thursday	2694	14	26.0	5	2	2.5	9.5	63
	Horn	520	0	0.0	5	2.6	3.1	10.7	71
	Hammond	221	2	45.2	5	2.2	3.4	10.6	71
	POW	100	1	50.2	5	2.8	3	10.8	72

Supplementary file 2. Derivation of the rainfall score

Annual rainfall volume (milliliters)	Suitability score (1 = very unsuitable; 5 = very suitable)
< 300	1
300-600	2
600-1000	3
1000-1500	4
> 1500	5

Cluster	**Island**	**Mean annual rainfall (mm)**	**Rainfall score (out of 5)**
Top Western Cluster	Boigu	1609.5	5
	Dauan	1477.1	4
	Saibai	1623.9	5
Near Western Cluster	Badu	1828.7	5
	Mabuiag	1820.5	5
	Moa (Kubin & St Pauls)	1828.7	5
Central Cluster	Iama (Yam)	1427.4	4
	Warraber (Sue)	1655.0	5
	Poruma (Coconut)	1499.8	4
	Masig (Yorke)	1466.7	4
Eastern Cluster	Mer (Murray)	1298.1	4
	Erub (Darnley)	1349.8	4
	Ugar (Stephens)	1499.8	4
Thursday Island Cluster	Thursday	1800.0	5
	Horn	1743.0	5
	Hammond	1805.0	5
	Prince of Wales	1800.0	5

Supplementary file 3. Derivation of the soil score (see supplementary file 5 for the calculation of each island's individual score)

Soil types	Suitability score (1 = very unsuitable; 5 = very suitable)
Intertidal Hydrosol	1
No soil development	1
Saline clay and silt	1
Aquic podosol	2
Rudosol	2
Tenosol	2
Dermosol	3
Podosol	3
Red clay loam (derived from basalt)	3
Red kandosol	3

Supplementary file 4. Derivation of the vegetation score (see supplementary file 5 for the calculation of each island's individual score)

Vegetation type	Suitability score
Acacia crassicarpa on coastal dunes and beach ridges, woodland to open forest	2
Avicennia marina low open forest	1
Casuarina equisetifolia woodland to open forest on foredunes on mainland and islands	2
Corymbia clarksoniana +/- *C. tessellaris* open forest on coastal granite ranges and lowlands	3
Corymbia clarksoniana or *C. novoguinensis* woodland on alluvial plains	3
Corymbia nesophila +/- *Eucalyptus tetrodonta* +/- *E. brassiana* woodland on alluvial sediments	3
Corymbia nesophila +/- *Eucalyptus tetrodonta* woodlands on igneous hills and rises	3
Corymbia nesophila open forest on sand rises	2
Corymbia stockeri +/- *Welchiodendron longivalve* +/- *C. tessellaris* +/- *Eucalyptus cullenii* woodland on steep to rolling granite hills	3
Corymbia tessellaris +/- *Welchiodendron longivalve* +/- *Eucalyptus cullenii* open forest on footslopes of granite hills	3
Deciduous to semi-deciduous vine thicket to forest on igneous slopes	3
Evergreen notophyll vine forest dominated by *Welchiodendron longivalve* on headlands	2
Evergreen notophyll vine forest with Melaleuca leucadendra on swamps	1
Grassland and/or sedgeland with *Pandanus* spp.	4
Grasslands, fresh swampy areas, rice patties	5
Herbland, sandy areas, hills, trees that like salty water	1
Heteropogon triticeus +/- *Sarga plumosum* closed tussock grassland on continental islands	4
Heteropogon triticeus or *Themeda triandra* or *Schizachyrium* fragile tussock grassland on rocky igneous coastal headlands and islands	4
Imperata cylindrica +/- *Heteropogon contortus* +/- *Mnesithea rottboellioides* closed tussock grassland on steep slopes of igneous hills	4
Imperata cylindrica +/- *Mnesithea rottboellioides* closed tussock grassland on coastal plains	4
Imperata cylindrica or *Mnesithea rottboellioides* tussock grasslands on basalt cones and rises	3
Lophostemon suaveolens +/- *Melaleuca cajuputi subsp. platyphylla* +/- *Pandanus* sp. +/- *Livistona muelleri* woodland and open forest on alluvial plains	3
Melaleuca, plants that live near fresh water, alluvial plains	5
Mangroves	1
Melaleuca argentea and/or *M. fluviatilis* +/- *M. leucadendra* open forest or *Melaleuca saligna* open forest fringing streams and creeks	3
Melaleuca dealbata +/- *Corymbia clarksoniana* tall open forest on alluvial plains	3
Melaleuca leucadendra +/- *M. dealbata* open forest in dune swales and swampy areas	3
Melaleuca saligna +/- *Hakea pedunculata* open forest on edges of salt pans	1
Melaleuca saligna +/- *M. viridiflora* low open woodland on drainage depressions and outwash plains	4
Melaleuca saligna +/- *M. viridiflora*, *Lophostemon suaveolens* woodland on drainage swamps	4
Melaleuca viridiflora low woodland in drainage areas	4
Notophyll vine forest of *Welchiodendron longivalve* and *Acacia polystachya* on low hills and rises on igneous hills	4
Open forest of *Melaleuca dealbata* or open forest of *Lophostemon suaveolens* on dunefields	2
Open herbland of mixed graminoids and forbs on exposed foredunes	2
Rice patties	5
Salty water	1
Salty/ Mangroves	1
Semi-deciduous and deciduous notophyll vine forest on the basaltic islands	2
Semi-deciduous notophyll vine forest on beach ridges, coral atolls, shingle cays and sand cays	1
Semi-deciduous vine thicket to vine forest on beach dunes and ridges	1
Sparse herbland and/or shrubland and bare sand areas predominantly on sand blows	1
Sparse herbland of mixed herbaceous species on foredunes and beach ridges	1
Sparse herbland or bare saltpans on salt plains and saline flats	1
Sporobolus virginicus closed tussock grassland on coastal plains	2
Vegetation in dry areas/ uncertain vegetation	3
Welchiodendron longivalve, *Acacia brassi* low woodland on igneous hills	3

Supplementary File 5: Derivation of the soil and vegetation suitability score by individual island

Cluster: Top Western. Island: Boigu

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.1.2a	*Avicennia marina* low open forest	Estuarine flat	Saline clay and silt	Imperfectly Drained	Intertidal Hydrosol	Mangrove Habitats	1	1
3.1.5	*Sporobolus virginicus* closed tussock grassland on coastal plains	Estuarine flat	Saline clay and silt	Imperfectly Drained	Intertidal Hydrosol	Mangrove Habitats	1	1
3.1.6	Sparse herbland or bare saltpans on salt plains and saline flats	Estuarine flat	Saline clay and silt	Imperfectly Drained	Intertidal Hydrosol	Mangrove Habitats	1	1
3.3.62	Grassland and/or sedgeland with *Pandanus spp.*	Low alluvial rise	Clay loam	Imperfectly Drained	Dermosol	Grassland on alluvium	3	4
						Final scores:	**1.5**	**1.8**

Cluster: Top Western. Island: Dauan

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.2.2b	Semi-deciduous vine thicket to vine forest on beach dunes and ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	2
3.3.70	*Lophostemon suaveolens +/- Melaleuca cajuputi subsp. platyphylla +/- Pandanus sp. +/- Livistona muelleri* woodland and open forest on alluvial	Drainage swamp	Organic clay loam	Imperfectly Drained / Swamp	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	3
3.12.29	*Heteropogon triticeus +/- Sarga plumosum* closed tussock grassland on continental islands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained over basement rock	Tenosol	Grassland on Granite Hills	2	4
						Final scores:	**2.3**	**3**

Cluster: Top Western. Island: Saibai

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.1.5	*Sporobolus virginicus* closed tussock grassland on coastal plains	Estuarine flat	Saline clay and silt	Imperfectly Drained	Intertidal Hydrosol	Estuarine grassland	1	2
3.1.6	Sparse herbland or bare saltpans on salt plains and saline flats	Estuarine flat	Saline clay and silt	Imperfectly Drained	Intertidal Hydrosol	Estuarine forbland	1	1
3.3.42c	*Melaleuca viridiflora* low woodland in drainage areas	Alluvial depression / swamp	Organic clay loam	Imperfectly Drained	Dermosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.3.62	Grassland and/or sedgeland with Pandanus spp.	Low alluvial rise	Clay loam	Imperfectly Drained	Dermosol	Grassland on alluvial plains	3	4
3.3.70	*Lophostemon suaveolens +/- Melaleuca cajuputi subsp. platyphylla +/- Pandanus sp. +/- Livistona muelleri* woodland and open forest on alluvial plains	Low alluvial rise	Clay loam	Imperfectly Drained	Dermosol	Woodland on alluvial plains	3	3
						Final scores:	**2.2**	**2.8**

Cluster: Near Western. Island: Badu

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.2.15	*Melaleuca viridiflora* and *Neofabricia myrtifolia* woodland on beach ridges	Coastal dune	Sand	Rapidly drained	Rudosol	Woodland on beach ridges	2	4
3.2.3b	Open forest of *Melaleuca dealbata* or open forest of *Lophostemon suaveolens* on dunefields	Dune swale / Swamp	Organic rich sand	Imperfectly drain	Aquic podosol	Open forest on dune swamps	2	2
3.2.5c	*Acacia crassicarpa* on coastal dunes and beach ridges, woodland to open forest	Coastal dune	Sand	Rapidly drained	Rudosol	Closed forest on coastal dunes	2	2
3.3.10d	*Melaleuca argentea* and/or *M. fluviatilis +/- M. leucadendra* open forest or *Melaleuca saligna* open forest fringing streams and creeks	Watercoarse / Drainage Swamp	Organic rich sandy clay loam	Imperfectly Drained	Podosol	Melaleuca open forest on drainage lines	3	3
3.2.26	Sparse herbland and/or shrubland and bare sand areas predominantly on sand blows	Coastal dune	Sand	Rapidly drained	Rudosol	Forbland on coastal dunes	2	1
3.12.20	Evergreen notophyll vine forest dominated by *Welchiodendron longivalve* on headlands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	2
3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Alluvial Flat	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.2.2b	Semi-deciduous vine thicket to vine forest on beach dunes and ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	1
3.3.22a	*Corymbia clarksoniana or C. novoguinensis* woodland on alluvial plains	Alluvial Flat	Sandy clay loam	Moderately drained	Tenosol	Woodland on alluvial plains	2	3
3.2.3a	Open forest of *Melaleuca dealbata* or open forest of *Lophostemon suaveolens* on dunefields	Dune swale / Swamp	Organic rich sand	Imperfectly drained	Podosol	Open forest on dune swamps	3	2
						Final scores:	**2.3**	**2.4**

Cluster: Near Western. Island: Mabuiag

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.12.43a	*Welchiodendron longivalve, Acacia brassi* low woodland on igneous hills	Hillslope	Bare rock	Rapidly drained - watershed	No soil development	Shrubland on rock pavement	1	3
3.12.4a/4b	Notophyll vine forest of Welchiodendron longivalve and Acacia polystachya on low hills and rises on igneous hill	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	4
3.2.4d	*Melaleuca leucadendra +/- M. dealbata* open forest in dune swales and swampy areas	Dune swale / Swamp	Organic rich sand	Imperfectly Drained	Podosol	Melaleuca open forest on dune swamps	3	3
3.3.42	*Melaleuca viridiflora* low woodland in drainage areas	Alluvial Flat	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
						Final scores:	**2.3**	**3.5**

Cluster: Near Western. Island: Moa (Kubin and St Paul's)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Alluvial Flat	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.2.5a	*Acacia crassicarpa* on coastal dunes and beach ridges, woodland to open forest	Coastal dune	Sand	Rapidly drained	Podosol	Closed forest on coastal dunes	3	2
3.2.24	Open herbland of mixed graminoids and forbs on exposed foredunes	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on beach dunes	2	2
3.2.6a	*Casuarina equisetifolia* woodland to open forest on foredunes on mainland and islands	Coastal dune	Sand	Rapidly Drained	Rudosol	Open forest on frontal dunes	2	2
3.2.2a	Semi-deciduous vine thicket to vine forest on beach dunes and ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	2
3.12.20	Evergreen notophyll vine forest dominated by *Welchiodendron longivalve* on headlands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	2
3.12.21	Deciduous to semi-deciduous vine thicket to forest on igneous slopes	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	3
3.3.48b	*Melaleuca saligna +/- M. viridiflora* low open woodland on drainage depressions and outwash plains	Alluvial Flat	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.3.42c	*Melaleuca viridiflora* low woodland in drainage areas	Alluvial Flat	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.5.15a	*Melaleuca viridiflora* and *Asteromyrtus symphyocarpa* low woodland on colluvial plains	Footslopes and colluvial aprons	Sandy clay loam	Imperfectly Drained	Podosol	Low woodland on footslopes	3	4

3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Drainage swamp	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.3.14	*Melaleuca saligna +/- M. viridiflora, Lophostemon suaveolens* woodland on drainage swamps	Drainage swamp	Organic rich sandy clay loam	Imperfectly Drained	Podosol	Melaleuca open forest on alluvial swamps	3	4
3.12.4a	Notophyll vine forest of *Welchiodendron longivalve* and *Acacia polystachya* on low hills and rises on igneous hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	4
3.3.57	*Imperata cylindrica +/- Mnesithea rottboellioides* closed tussock grassland on coastal plains	Alluvial Flat	Sandy loam	Well Drained	Rudosol	Grassland on alluvial soils	2	4
3.12.30	*Imperata cylindrica +/- Heteropogon contortus +/- Mnesithea rottboellioides* closed tussock grassland on steep slopes of igneous hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Grassland on granite hills	2	4
3.2.5a	*Acacia crassicarpa* on coastal dunes and beach ridges, woodland to open forest	Coastal dune	Sand	Rapidly drained	Podosol	Closed forest on coastal dunes	3	2
3.12.48	*Heteropogon triticeus or Themeda triandra* or *Schizachyrium* fragile tussock grassland on rocky igneous coastal headlands and islands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Grassland on granite hills	2	4
3.3.6	Evergreen notophyll vine forest with *Melaleuca leucadendra* on swamps	Swamp	Organic rich sandy clay loam	Imperfectly Drained	Podosol	Melaleuca open forest on alluvial swamps	3	2
3.3.69	*Melaleuca dealbata +/- Corymbia clarksoniana* tall open forest on alluvial plains	Alluvial Flat	Sandy loam	Well Drained	Tenosol	Melaleuca open forest on alluvial soils	2	4
3.2.24	Open herbland of mixed graminoids and forbs on exposed foredunes	Coastal dune	Sand	Well Drained	Rudosol	Forbland on beach dunes	2	2
3.2.4a	*Melaleuca leucadendra +/- M. dealbata* open forest in dune swales and swampy areas	Dune swale / Swamp	Organic rich sand	Imperfectly Drained	Podosol	Melaleuca open forest on alluvial swamps	3	3
						Final scores:	**2.5**	**3.1**

Cluster: Central. Island: Iama (Yam)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.12.35f	Semi-deciduous mesophyll and/or notophyll vine forest on igneous slopes	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite	2	2

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Cluster: Central. Island: Warraber (Sue)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3,2.6b	*Casuarina equisetifolia* woodland to open forest on foredunes on mainland and islands	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Woodland on coastal dunes	2	2
3.2.28	Semi-deciduous notophyll vine forest on beach ridges, coral atolls, shingle cays and sand cays	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	1
3.2.24	Open herbland of mixed graminoids and forbs on exposed foredunes	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	1
3.2.25	Sparse herbland of mixed herbaceous species on foredunes and beach ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	1
						Final scores:	**2**	**1.3**

Cluster: Central. Island: Poruma (Coconut)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3,2.6b	*Casuarina equisetifolia* woodland to open forest on foredunes on mainland and islands	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Woodland on coastal dunes	2	2
3.2.28	Semi-deciduous notophyll vine forest on beach ridges, coral atolls, shingle cays and sand cays	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	1
3.2.24	Open herbland of mixed graminoids and forbs on exposed foredunes	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	2
3.2.25	Sparse herbland of mixed herbaceous species on foredunes and beach ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	1
						Final scores:	**2**	**1.5**

Cluster: Central. Island: Masig (Yorke)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3,2.6b	*Casuarina equisetifolia* woodland to open forest on foredunes on mainland and islands	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Woodland on coastal dunes	2	2
3.2.28	Semi-deciduous notophyll vine forest on beach ridges, coral atolls, shingle cays and sand cays	Coral Cay	Calcareous sand	Rapidly Drained	Rudosol	Closed forest on coastal dunes	2	2
3.2.24	Open herbland of mixed graminoids and forbs on exposed foredunes	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	2
3.2.25	Sparse herbland of mixed herbaceous species on foredunes and beach ridges	Coastal dune	Sand	Rapidly Drained	Rudosol	Forbland on coastal dunes	2	1
						Final scores:	**2**	**1.8**

Cluster: Eastern. Island: Mer (Murray)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.8.4b	*Imperata cylindrica* or *Mnesithea rottboellioides* tussock grasslands on basalt cones and rises	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Grassland on basalt hill	3	3
3.8.5b	Semi-deciduous and deciduous notophyll vine forest on the basaltic islands	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Closed forest on basalt hills	3	2
						Final scores:	**3**	**2.5**

Cluster: Eastern. Island: Erub (Darnley)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.8.4b	*Imperata cylindrica* or *Mnesithea rottboellioides* tussock grasslands on basalt cones and rises	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Grassland on basalt hills	3	4
3.8.5b	Semi-deciduous and deciduous notophyll vine forest on the basaltic islands	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Grassland on basalt hills	3	2
						Final scores:	3	3

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Cluster: Eastern. Island: Ugar (Stephens)

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.8.4b	*Imperata cylindrica* or *Mnesithea rottboellioides* tussock grasslands on basalt cones and rises	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Grassland on basalt hills	3	3
3.8.5b	Semi-deciduous and deciduous notophyll vine forest on the basaltic islands	Hillslope	Red clay loam (derived from basalt)	Well drained	Red kandosol	Closed forest on basalt hills	3	2
						Final scores:	**3**	**2.5**

Cluster: Thursday Island Cluster. Island: Thursday

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.12.35e	Semi-deciduous mesophyll and/or notophyll vine forest on igneous slopes	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	1
3.12.21	Deciduous to semi-deciduous vine thicket to forest on igneous slopes	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	3
3.12.40	*Corymbia nesophila +/- Eucalyptus tetrodonta* woodlands on igneous hills and rises	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.12.20	Evergreen notophyll vine forest dominated by *Welchiodendron longivalve* on headlands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	2
3.12.9	*Corymbia tessellaris +/- Welchiodendron longivalve +/- Eucalyptus cullenii* open forest on footslopes of granite hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.12.8	*Corymbia clarksoniana +/- C. tessellaris* open forest on coastal granite ranges and lowlands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
						Final scores:	**2**	**2.5**

Cluster: Thursday Island Cluster. Island: Horn

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.12.35e	Semi-deciduous mesophyll and/or notophyll vine forest on igneous slopes	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	2
3.5.35	*Eucalyptus tetrodonta* and *Corymbia nesophila* woodland with heathy understory on sand plains	Coastal plain	Sandy loams and clay loams	Moderately drained	Podosol	Woodland on granite hills	3	3
3.2.5a	*Acacia crassicarpa* on coastal dunes and beach ridges, woodland to open forest	Coastal dune	Sand	Rapidly drained	Rudosol	Closed forest on granite hills	2	2
3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Drainage swamp	Sandy clay loam	Imperfectly Drained	Podosol	Closed forest on granite hills	3	4
3.5.34	*Corymbia nesophila* open forest on sand rises in the Torres Strait islands	Coastal plain	Sandy loams and clay loams	Moderately drained	Podosol	Closed forest on granite hills	3	3
3.12.40	*Corymbia nesophila +/- Eucalyptus tetrodonta* woodlands on igneous hills and rises	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.3.14	*Melaleuca saligna +/- M. viridiflora, Lophostemon suaveolens* woodland on drainage swamps	Drainage swamp	Organic rich sandy loam	Imperfectly Drained	Aquic podosol	Woodland on alluvial soils with impeded drainage	2	4
3.3.27a	*Corymbia nesophila +/- Eucalyptus tetrodonta +/- E. brassiana* woodland on alluvial sediments	Coastal plain	Sandy loams and clay loams	Moderately drained	Podosol	Woodland on alluvial soils	3	3
3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Drainage swamp	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4

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						Final scores:	**2.6**	**3.1**

Cluster: Thursday Island Cluster. Island: Hammond

Regional Ecosystem	**Vegetation Type**	**Landform Situation**	**General Soil Type/Texture**	**Drainage class**	**Soil Classification**	**General Habitat Description**	**Soil Suitability**	**Vegetation Suitability**
3.12.9	*Corymbia tessellaris* +/- *Welchiodendron longivalve* +/- *Eucalyptus cullenii* open forest on footslopes of granite hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.12.8	*Corymbia clarksoniana* +/- *C. tessellaris* open forest on coastal granite ranges and lowlands	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.3.42a	*Melaleuca viridiflora* low woodland in drainage areas	Drainage swamp	Sandy clay loam	Imperfectly Drained	Podosol	Low melaleuca woodland on alluvial soils with impeded drainage	3	4
3.12.11	*Corymbia stockeri* +/- *Welchiodendron longivalve* +/- *C. tessellaris* +/- *Eucalyptus cullenii* woodland on steep to rolling granite hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Woodland on granite hills	2	3
3.12.4a	Notophyll vine forest of *Welchiodendron longivalve* and *Acacia polystachya* on low hills and rises on igneous hills	Hillslope	Shallow skeletal sands and gravels over basement rock	Rapidly drained above basement rock	Tenosol	Closed forest on granite hills	2	4
						Final scores:	**2.2**	**3.4**

Cluster: Thursday Island Cluster. Island: Prince of Wales

Regional Ecosystem	Vegetation Type	Landform Situation	General Soil Type / Texture	Drainage class	Soil Classification	General Habitat Description	Soil Suitability	Vegetation Suitability
3.3.13	*Melaleuca saligna* +/- *Hakea pedunculata* open forest on edges of salt pans	Alluvial flat	Sandy loams and clay loams	Moderately drained	Podosol	Shrubland on poorly drained alluvium	3	4
3.2.5a	*Acacia crassicarpa* on coastal dunes and beach ridges, woodland to open forest	Coastal dune	Sand	Rapidly drained	Rudosol	Closed forest on granite hills	2	2
3.5.34	*Corymbia nesophila* open forest on sand rises	Coastal plain	Sandy loams and clay loams	Moderately drained	Podosol	Closed forest on granite hills	3	3
3.3.27a	*Corymbia nesophila* +/- *Eucalyptus tetrodonta* +/- *E. brassiana* woodland on alluvial sediments	Coastal plain	Sandy loams and clay loams	Moderately drained	Podosol	Woodland on alluvial soils	3	3
3.3.27	*Corymbia nesophila* +/- *Eucalyptus tetrodonta* +/- *E. brassiana* woodland on alluvial sediments	Alluvial flat	Sandy loams and clay loams	Moderately drained	Podosol	Woodland on alluvial soils with impeded drainage	3	3
						Final scores:	**2.8**	**3**