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Technical Report

Mapping Littoral Rainforest & Coastal Vine Thickets of Eastern Australia in the Wet Tropics

Mission Beach Pilot Study

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Australian Government
Department of the Environment

Reef & Rainforest RESEARCH CENTRE

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Cover photograph: Tony O'Malley, Terrain NRM

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Acronyms Used In This Report

DAFF ..... Department of Agriculture, Forestry and Fisheries
DEHP..... Department of Environment and Heritage Protection
DOE..... Department of Environment
DSEWPaC..... Department of Sustainability, Environment, Water, Population and Communities
GBR..... Great Barrier Reef
CSIRO..... Commonwealth Scientific and Industrial Research Organisation
JCU..... James Cook University
GIS ..... Geographical Information System
LR&CVToEA.. Littoral Rainforest & Coastal Vine Thickets of Eastern Australia
MTSRF..... Marine and Tropical Sciences Research Facility
MHWS ..... Mean High Water Springs
NRM..... Natural Resource Management
RE..... Regional Ecosystems
WTWHA..... Wet Tropics World Heritage Area

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Summary

The extent of littoral rainforest in the Wet Tropics bioregion appears to be greater than the EPBC Listing Advice for *Littoral Rainforest & Coastal Vine Thickets of Eastern Australia* would suggest. This means that more of this critically endangered resource exists, but also means that those areas of it not yet formally identified are at risk of further loss. We discuss development of a GIS approach to better identify potential littoral rainforest sites, and extensively ground-truth our model in a pilot study area with the assistance of a range of regional experts. We provide recommendations for development of this method to revise our understanding of the distribution of littoral rainforest community types throughout the Wet Tropics bioregion, and suggestions for ways in which these data may best be used. A critical next step would be the application of this methodology across the entire Wet Tropics bioregion.

Introduction

Coastal processes such as salt spray, salt-laden on-shore winds, tidal inundation and storm tides, salt-water lens intrusion and interaction with groundwater and unstable and dynamic substrates (particularly deposition and erosion of coastal sands) have driven the development of distinct ecological communities composed of species with particular adaptations and tolerances. These communities are comprised of a mix of specialist coastal species and other species from neighbouring communities which have adaptations which enable them to survive such challenging environments or survive due to the shelter of more tolerant species on the seaward side. Pre-clearing, there was an almost continuous archipelago of patches of the community along the eastern coast of Australia (DSEWPaC 2009a). The coast of Australia is also attractive to people, with 85% of the population living within 50 km of the coast and coastal areas showing increasing population growth, often at the expense of inland areas (Australian Bureau of Statistics 2004, Smith & Doherty 2006). As a consequence of limited extent and significant threats, the ecological communities represented by littoral rainforest and coastal vine thicket from Princess Charlotte Bay in the Cape York Peninsula Bioregion, Queensland, to the Gippsland Lakes in the South East Corner Bioregion, Victoria, (excluding Brigalow Belt North etc) have been listed under the EPBC Act (1999) as a critically endangered ecological community under the name Littoral Rainforest & Coastal Vine Thickets of Eastern Australia (henceforth LR&CVToEA). These communities represent a complex of rainforests and coastal vine thickets developed on beach ridges derived from Quaternary sands, and on other coastally-derived or influenced substrates that include headlands, sea-cliffs and flats (DSEWPaC 2009a).

While the EPBC listing advice describes the broad characteristics of this community there is considerable variation in floristic composition and structure (which is understandable given its distribution across three east coast states), as well as in how far from the coast these communities remain recognisably distinct. (The listing advice allows up to two kilometres from the coast or an estuary.) To support protection and management, several attempts have been made to produce regionally-specific pre-listing approaches to mapping and classifying such vegetation types (e.g. DEH 2004, Woodcock 2008). In Queensland, vegetation communities are described using the Regional Ecosystem framework developed by the Queensland Herbarium (DEHP 2013a), and these Regional Ecosystems (REs) have been used in the listing advice (DSEWPaC 2009a) to derive lists of REs that equate wholly with the ecological community (Table 1). A series of issues have been identified with this approach (e.g. Metcalfe & Ford 2010, Metcalfe et al. 2011) that contribute to ongoing problems with appropriately demarcating LR&CVToEA in the Wet Tropics Bioregion, which in practice means that this community continues to be cleared or damaged largely unchallenged. Provisional research to map this resource in the Wet Tropics from a plant community perspective has identified a number of sites where on-ground assessment and implementation of the listing advice arrives at apparently contradictory interpretations of the presence or absence of LR&CVToEA, i.e. some obvious littoral rainforests that comply with the listing advice description and condition thresholds were not within REs that equate wholly and some REs that equate wholly did not comply with the listing advice description in the field . Consequently, we sought, with support from regional experts (Fig. 1) and acknowledgment from DSEWPaC, to use collated field, remote sensing and vegetation mapping data to identify the extent of LR&CVToEA in the Wet Tropics and its broad condition/key threats, to produce a simple and accurate procedure for identifying LR&CVT in a Wet Tropics context, and with the support and involvement of vegetation managers and experts of the Wet Tropics region to help build public understanding of the location, significance and appropriate management of this asset.

Table 1: Regional Ecosystems (REs) which equate wholly to LR&CVToEA in the Wet Tropics bioregion, their descriptions and figures for estimated remaining extent (DEHP 2013a).

RE	Description	Vegetation management status	Biodiversity conservation status	Estimated remaining in 2003 (Wet Tropics Bioregion)	Ecological value
7.2.1 a-i	Mesophyll vine forest. Beach ridges and sand plains of beach origin, mainly in small patches in the lee of coastal beach ridges in very high rainfall areas.	Of concern	Endangered	< 10,000 ha and 10-30% of the pre-clearing area remaining.	Important fruit source for birds, and very significant for many migratory species. Habitat for the endangered *Gardenia actinocarpa* and *Arenga australasica*. High scenic value.
7.2.2 a-h	Notophyll to microphyll vine forest. Species commonly include *Cupaniopsis anacardioides, Diospyros geminata, Canarium australianum, Alphitonia excelsa, Acacia crassicarpa, A. mangium, Hibiscus tiliaceus, Pleiogynium timorense, Chionanthus ramiflora, Blepharocarya involucrigera, Mimusops elengi, Polyalthia nitidissima, Millettia pinnata, Geijera salicifolia, Ficus opposita, Pouteria sericea, Terminalia muelleri, T. arenicola, Drypetes deplanchei,* and *Exocarpos latifolius*. Beach ridges and sand plains of beach origin.	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	Important fruit source for birds, and very significant for many migratory species. Habitat for the vulnerable *Livistona drudei*. High scenic value. 7.2.2e: A very rare and unusual landform.
7.2.5 a	Mesophyll to notophyll vine forest of *Syzygium forte* subsp. *forte* (white apple). Beach ridges and sand plains of beach origin.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	A very attractive vegetation community aesthetically. Important fruit source for birds, and very significant for many migratory species.

7.2.6 b	Evergreen notophyll vine thicket with *Acacia crassicarpa, Elaeodendron melanocarpum, Aglaia elaeagnoidea* and *Drypetes deplanchei*. Aeolian dunes.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	
7.11.3 b	Semi-deciduous mesophyll vine forest on metamorphics. Moist and dry metamorphic foothill slopes.	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	
7.12.11 d	Simple to complex notophyll vine forest and semi-evergreen notophyll vine forest. Rocky areas and talus on moist foothills and uplands on granite and rhyolite.	Not of concern	Of concern	> 10,000 ha and >30% of the pre-clearing area remaining.	

Bioregional context

The Wet Tropics bioregion (*sensu* DSEWPaC 2013) encompasses over half of Australia's rainforest, and supports 28% of the entire Australian vertebrate fauna and 17% of the Australian native flora (Williams et al. 1996, Metcalfe & Ford 2009). The Wet Tropics of Queensland WHA has been inscribed on the World Heritage list for its outstanding universal values (Wet Tropics Management Authority 2012). This extraordinary diversity is maintained by the proximity of the Great Dividing Range to the east coast of Australia, and the consequent high rainfall resulting from the predominantly south-easterly winds releasing rain as they rise over the mountains. Intense monsoonal rainfall and appreciable rainfall even during the 'dry' season support relicts of the Gondwanan forests that covered much of Australia 50-100 million years ago as well as other rainforest lineages that migrated from SE Asia more recently (Sniderman & Jordan 2011). Australian coastal rainforests were much more extensive during the last glaciations, but have retreated to their current positions since the end of the glacial period (c. 10,000 years ago).

Unlike littoral communities in southern Queensland, New South Wales and Victoria, the Great Barrier Reef along the north Queensland coast hugely reduces wave strength and height, with the consequence that salt spray reaches much less far inland (Young 1989). This means that salt deposition on leaf surfaces is limited to only a few tens of metres inland, rather than the hundreds of metres experienced in more exposed southern locations. High leaf area index and high rainfall also mean that salt deposition and residence time on leaves is reduced. This again narrows the potential extent of the littoral communities, as opposed to coastal lowland communities, and makes fragmentation of littoral communities more likely in theory and in practice.

Development in the Wet Tropics bioregion has been highly skewed, with 70% of the area still covered by some form of native vegetation, but complete removal of some lowland community types in those areas suitable for agricultural or coastal development and by ribbon development along transport arteries. Coastal vegetation types have been particularly hard hit, with some coastal grassland communities now extinct, and most of the REs included in LR&CVToEA endangered or of concern from both a vegetation management and biodiversity conservation perspective (see Table 1). Comparison of the extent of REs wholly compliant with LR&CVToEA listing advice today with their extent before European clearance activities shows a reduction in areal coverage of 44% (current extent 1782 ha compared with pre-European colonisation extent of 2686 ha).

The fate of the remaining LR&CVToEA will be determined largely by the degree and appropriateness of human intervention. Following national recognition, the first major challenge faced is recognition at a regional and local level of the value of the resource, and the need for proactive management. With many remnants fragmented, isolated or thin linear strips adjacent to roads or housing developments or on eroding shorelines, management agencies need better information on the potentially significant threats posed by apparently minor tree clearing, construction of foreshore infrastructure, or relaxed approaches to weed control. Similarly, revision and enforcement of existing planning and development controls is needed to prevent ongoing attrition of habitat margins by commercial, residential and infrastructure corridor development. Recent impacts on the remaining resource have resulted from confusion over habitat classification and spatial location, overzealous post-cyclone clean up works, employment of contractors with limited local contextual understanding, and modification of vegetation to accord with some residents' perceptions of what coastal vegetation 'should' look like in the tropics.

This report builds on a number of previous studies focussing on or pertaining to LR&CVToEA including, but not limited to, projects funded under the Australian Government's Marine and

Tropical Sciences Research Facility (MTSRF), by Queensland Department of Environment & Heritage, the Wet Tropics Management Authority and local councils. While we recognise the need for a bioregion-wide reconsideration of the remnant littoral rainforest resource, time, funding and available collaborator support make a case study more appropriate at this time, albeit with recommendations and implications for extension of our approach to the broader bioregion. The Mission Beach case study area has been selected because it builds on existing knowledge and work conducted under MTSRF and through the Mission Beach Habitat Network Action Plan with considerable community support, aligns with current priorities of Terrain NRM, and because the case study area provides an example of much of the bioregion in microcosm, incorporating LR&CVToEA on sand, basalt, granite and metamorphic geologies, on rocky headlands and prograding dune systems, and in an area with significant cultural, biological and geological significance. Due to resource constraints, we do not consider LR&CVToEA adjacent to large salt-water bodies within two kilometres of the coast or on offshore islands, despite these being eligible under the Listing Advice. Most of the islands of the Great Barrier Reef, particularly in the Wet Tropics, contain some forms of littoral rainforest and some of this is unmapped as LR&CVToEA including well known examples such as Green Island off Cairns.

Mission Beach Pilot Study

The Mission Beach area has very important Aboriginal cultural values associated with the living traditions and practices of the Djiru Traditional Owners. From a Djiru perspective, all remaining forests are important. Djiru people might want to apply for funding for management of littoral vine forest on Native Title land where relevant or where existing. However Djiru people have concerns that littoral rainforest mapping might restrict development opportunities on Native Title land.

The Mission Beach area has grown from a rural and small residential area for early tree/sea-changers into a renowned holiday destination, heavily marketed as where the rainforest meets the reef, and as a prime area in which to see iconic local wildlife, such as the endangered southern cassowary (Fig. 2). This means that the area has a combination of high biodiversity values, high tourism and development pressure, and a significant proportion of the local population who are strongly committed to, or at least aware of, environmental protection and conservation. As a coastal town in the heart of the Cooktown to Ingham cyclone zone (Turton 2008), it is also subject to significant natural disturbance by cyclones and storm tides.

The town of Mission Beach is a group of five coastal villages (Carmoo population 205, Bingil Bay 369, Mission Beach 765, Wongaling Beach 1064 and South Mission Beach 778, ABS 2012) 120 km south of Cairns in the central Wet Tropics. Development potentially threatens much of the biodiversity which is the key attraction to the area, with land clearance, fragmentation, road kill and weeds and pest animals all impacting on the area.

Much of the native vegetation of the region's coastal lowlands has been cleared over a century of development for agriculture, residential, industrial and communication uses (Metcalfe & Ford 2008). Mission Beach lies in the super-wet zone where the Walter Hill Range, which for the most part is still covered in rainforest, meets the coast. This makes the area a significant point in the Wet Tropics where there remains a continuous link between the Great Dividing Range uplands and the coast – a link only found at the foot of the Cardwell Range to the south of the Daintree River; the next significant upland-coastal link remaining is c. 200 km further north (see other attributes of the Mission Beach area in Chenoweth EPLA 2007). This link provides a critical point of access for fauna which move between lowland and upland areas depending on the seasons and/or resource availability, including the endangered southern cassowary. This link is possibly the longest and widest east-west rainforest corridor in Australia. One of the wettest

places in Australia (Tully receives c. 4100 mm rain per year, BoM 2013), the lowland forest around the Mission Beach area also supports substantial areas of fan- and feather-palm swamp forest, the highest concentration of the endangered southern cassowary in Australia, camps and feeding sites for the endangered spectacled flying fox, NCA and EPBC-listed plant species such as arenga palm (*Arenga australasica*) and large areas of coastal vegetation including LR&CVToEA.

Coastal vegetation in the Mission Beach area has experienced considerable pressure over recent decades as a result of residential and tourism development, hard infrastructure for roads, coastal infrastructure, drains and the like, and both the direct impact of severe tropical cyclones Larry (in March 2006) and Yasi (in February 2011) (winds broke trees, storm tides washed some areas away and surviving areas were exposed to subsequent weed invasion) and overzealous clean-up attempts after the event (Fig. 3). There are also differing public perceptions about what coastal vegetation should look like, with some local residents clearing for sea views and access, planting exotic vegetation such as coconut palms and lawns and actively removing council attempts to revegetate the coastal strip (Fig. 4). Exotic plantings and their maintenance carry the risk of spreading transformer weeds into these fragile systems such as Singapore daisy (Fig. 5) and may increase the spread of myrtle rust (*Uredo rangelii*) into the Wet Tropics (DAFF 2012 & Fig.5). Nevertheless due to optimal environmental conditions and generally low-key development, Mission Beach probably supports some of the most extensive, diverse and well-connected littoral rainforests in Australia today.

Figure 1. Djiru Traditional Owners in RE 7.2.3 on Native Title land, Wongaling Creek mouth (left); littoral rainforest expert panel members doing fieldwork

Figure 2. Endangered cassowaries (left) in RE 7.12.1 in the Wet Tropics of Queensland World Heritage Area crossing to the adjacent Great Barrier Reef World Heritage Area, Wee Beach (photo by Liz Gallie), and (right) crossing road between rainforest fragments in the Wet Tropics WHA, Moresby Range.

Figure 3. Overzealous bulldozing of cyclone debris (left) and cutting of 'unsightly' damaged trees resulted in significant fragmentation of surviving littoral rainforest after severe tropical cyclone Yasi.

Figure 4. Well developed littoral rainforest on basalt at Clump Point (left) and 'idealised' modified tropical coastal vegetation with coconut palms at northern Mission Beach.

Figure 5. Singapore daisy, coconut and arrowhead vine invading littoral rainforest edge (left); myrtle rust on beach cherry (right)

The aim of this pilot study is to produce a scientifically-rigorous approach to identifying LR&CVToEA in the Mission Beach area, compiled with input from environmental managers and policy makers, and experts on the floristics and community ecology of the region. This approach needs to be validated by the above groups, broadly applicable to the rest of the Wet Tropics, and couched in the criteria (particularly the description and condition thresholds) outlined in the EPBC Act listing advice. We anticipate that such an approach will provide proof of concept, enabling other subregions in the Wet Tropics to be assessed using a similar approach. Such a proof of concept should provide a basis for applications for resourcing to enable such mapping, but also provide a baseline from which management decisions regarding future clearing, restoration or maintenance might be assessed. Compilation of this approach, the report derived from it and appropriate community consultation is reportable by CSIRO against a NERP-funded project led by D. Metcalfe, and by Terrain NRM against Mission Beach Habitat Network Action Plan and a project funded through the Caring for Our Country program. We suggest that this type of assessment and analysis is also a deliverable against the Conservation Advice provided with the EPBC listing of LR&CVToEA, e.g. "Undertake survey work in suitable habitat or potential habitat to locate any additional remnants". The study aims to increase certainty for land use planning and management and facilitate targeted actions for conservation.

Methodology

Our first step was to collate all publicly-available survey data from areas identified as LR&CVToEA. This predominantly involved survey data compiled for various projects by CSIRO or by various branches of the Queensland State Government (Queensland Herbarium, Parks & Wildlife).

We then used an iterative scenario-development-and-testing approach applying GIS techniques complemented by field survey and ground truthing to produce and refine our mapping approach. This approach was used to generate rules that could be generally applied at a bioregional scale; rules applied were threshold based rather than absolute, to allow for local variation and accommodate recognised exceptions to rules.

Our initial scenarios are reported in Metcalfe, Ford & Lawson (2011) in a MTSRF report. Of these, the most conservative approach was a scenario which considered an elevation of up to 20 m (to take into account salt spray and sea surges on headlands and up fast-narrowing creeks where a marine influence could be anticipated at above 10 m elevation), a sand substrate and a maximum distance from the coast of 3 km. This approach scored the least false-positives (areas identified as LR&CVToEA in the scenario, but which proved not to be on assessment in the field) but with the substrate constrained to sand, it missed some important communities on other substrates.

We subsequently established a Littoral Rainforest Expert Panel and, through a series of expert panel workshops including fieldwork (described in Appendix 1), refined this approach to develop the following rules, which are explained below:

1. REs that equate wholly according to the listing advice
2. Rainforest <75 m from mean high water at spring tide (MHWS) on an open coast, excluding areas >10 m above sea level (asl) on basalt-derived soils.
3. Rainforest on coastal sand deposits <2 km from an open coast that have not been obviously reworked by fluvial processes
4. Rainforest in high or medium hazard storm tide inundation areas <200 m from open coast
5. Wetlands and waterways are excluded
6. Other identified littoral rainforest sites, based on ground-truthed expert advice.

In our rules and maps, "rainforest" means rainforest or vine thicket that complies with the listing advice description and condition thresholds and may include vegetation with non-rainforest emergent trees and/or regrowth. Regional Ecosystems which occurred in the study region which had the potential to equate with the listing advice are tabulated in Appendix 2.
We applied the rules to polygons of remnant and regrowth regional ecosystems.

REs that equate wholly according to the listing advice

The National Context section of the Listing Advice identifies a number of Regional Ecosystems (REs) in the Wet Tropics bioregion that 'equate wholly' to the ecological community (Fig. 6). Consequently we mapped the following REs as 'littoral rainforest': 7.2.1a-i, 7.2.2a-h, 7.2.5a and 7.2.6b, 7.11.3b and 7.12.11d.

Aspect and exposure

In our initial models we considered aspect to be important, to reflect the effects of the predominantly south-easterly winds on blowing salt spray over the forest canopy. The listing advice (DSEWPaC 2012a) indicates that LR&CVToEA may occur within two kilometres of the coast or adjacent to a large salt water body. In the Wet Tropics the fringing effects of the Great Barrier Reef mean that waves have considerably less power when they reach the shore than in unprotected southern regions, and consequently less salt spray is generated. Additionally, high rainfall supports dense vegetation and frequently washes salt from vegetation. We consistently found that characteristic littoral rainforest species were replaced by lowland forest species within 75 m of the coast on soils other than sand – 75 m represents approximately three canopy widths in this type of rainforest, which is just wide enough to build in some resilience to the ecological community and appears to be the limit of the littoral influence of exposure. We have therefore minimised the potential distance from the coast from 2 km to 75 m to reflect this minimal impact of aspect and exposure. On basalt soils, we have added further limitations (see below). Although the local predominant winds are south-easterly, the study area is not particularly windy and we found no significant difference in landward extent of littoral rainforest according to different aspects. This may differ on windier coasts in the bioregion, e.g. north of Cape Tribulation. We have used MHWS to represent the seaward extent of terrestrial vegetation. Due to resource constraints, we limited this rule to the open coast including bays and didn't develop a rule for estuaries and other saltwater bodies.

Basalt-derived soils

The rare (on Wet Tropics coast) but significant basalt-derived soils (rule 2) that are associated with Clump Point and Stephens Islands (Whitehead et al. 2010) provide a very high fertility substrate on which rainforest grows. Expert panel field surveys suggest that these fertility levels produce vegetation that provides additional buffering capacity against the saline influence of sea-spray, salt-laden winds and occasional sea-water incursions. To exclude rainforest on deep basalt soils, we adapted our exposure rule to exclude vegetation on basalt derived soils > 10 m asl.

We may need to also exclude similarly-rich metamorphosed basalts >10 m asl if fieldwork shows this to be necessary. The available 10 m contour mapping is fairly coarse and field validation may need to accommodate some error factor. The maps presented in the Results section (below) are based on the recently released 7.5 m LIDAR-derived contour which provides very high elevational accuracy.

Coastal sand deposits

Rainforest on coastal sand deposits <2 km from open coast typically supported species which are typical of littoral rainforest when those sands were of Holocene origin and had not been obviously reworked by fluvial processes – that is, sands which retain a marine characteristic (Fig. 7). Sands which are older, or which are of riverine origin, tend to support coastal lowland but not littoral species. Soils and geology mapping is imprecise and we were unable to access mapping that differentiated Holocene and Pleistocene sands, and in some places maps soils of metamorphic origin as sand. Land zone mapping provided better Holocene/Pleistocene resolution than geological mapping, presumably after expert interpretation of the available data. Consequently, for the sake of this analysis we use REs on Quaternary coastal sand deposits (land zone 2) and assume all dunes within 2 km of the coast at Mission Beach are Holocene not Pleistocene in origin. We note that Wet Tropics Pleistocene dunes support some unique and extremely rare rainforest associations floristically different from surrounding alluvial rainforest.

The Listing Advice Description allows for emergent Eucalyptus and other species. We identified the following Wet Tropics REs on sand in the study area that included rainforest or vine thicket components: 7.2.3, 7.2.6 (other than 7.2.6b), 7.2.7, 7.2.8. Those with a well-developed vine thicket understorey when mapped between 1994 and 2005 (indicated by a 'v' in the "Veg" field in the source coverage of the regional ecosystem mapping of the Wet Tropics), have an increased chance of meeting littoral rainforest listing criteria and this proved to be the case in the field. However we retained uninspected 'v' sites as 'potential rainforest', partly because eucalypt dominant littoral habitats with a native grassy layer are perhaps some of the rarest and unique of all habitats in the Wet Tropics lowlands and we do not wish to discourage appropriate fire management practices in littoral habitats.

In the super-wet zone the 'v-rule' does not work for RE 7.2.7 *Casuarina* woodland which fieldwork repeatedly suggests is an early successional stage in the development of littoral rainforest on recently disturbed coastal dunes. We did not pursue aerial photography interpretation due to a lack of recent useful imagery, but are aware that the Fitzroy Basin Association applied stereoscopic analysis of overlapping runs of aerial photographs and SPOT imagery to identify littoral rainforest on sand.

Storm-tide inundation

Storm-tide inundation mapping indicates areas which are likely to be subject to marine incursions. High hazard sites are most frequently subject to marine incursion but many are freshwater wetlands and waterways due to the high rainfall environment and saltwater impact is overridden by freshwater, therefore we excluded all wetlands and waterways; medium hazard sites are less frequently flooded by saltwater, but typically also experience less flushing with fresh water so experience longer saltwater-residence. Sites within 200 m of the coast appear to receive more air-borne salt impact and littoral rainforest plant propagules than more inland inundation sites. Our maps (see Results) show rainforest and potential rainforest in High and Medium hazard storm tide inundation areas <200 metres from MHWS on an open coast.

Other littoral rainforest sites

We found that irrespective of how we constructed GIS-based rules we consistently identified some sites which were exceptions to those rules and which displayed characteristics of LR&CVToEA due to historical factors, successional inertia or other factors. This underlined the critical nature of involving local experts in the mapping process, which involved workshops with expert panels, field visits and feedback from traditional owner groups, agency staff and research providers.

Regrowth

The Listing Advice allows for small patches (0.1 ha) in degraded condition to be included, though such areas are generally excluded from RE definitions. Our rules were limited to REs, so we have included an additional condition to capture vegetation that is not mapped as RE but complies with the Listing Advice. Regrowth mapping that captures such areas has been sourced from DEHP (2013b) using their regrowth rules, and overlaid on pre-clearance mapping to see what RE is presumed to have formerly existed there. The rule thus imposed was that if regrowth is located in an area where the pre-clear RE was a rainforest type (not a sclerophyll/rainforest type) and it is either within 75 m of the coast, on coastal sand deposits within 2 k of the coast, or in an inundation area within 200 m of coast, it is considered to be littoral rainforest. A similar rule applies to potential rainforest types.

Results, Discussion and Recommendations

We have conducted a pilot study within a relatively small geographic region with the aim of improving identification and mapping of littoral rainforest communities within a Wet Tropics context. Initial phases of the study concerned refining GIS approaches to improve identification accuracy; subsequently most effort has been directed at field visits to ground truth findings and highlight and address inconsistencies. Below we discuss the rules and recommendations around their use as they relate to the pilot study area. We recognise that, subject to Department of Environment (DoE) acceptance, some additional testing will be necessary as this methodology is moved outside this area into other parts of the Wet Tropics. Even within the current study area, additional refinement is necessary as, for example, we did not visit all sites.

Development of mapping protocols in conjunction with ground-truthing generates a robust first pass, and a significant improvement on the 'REs that equate wholly' approach taken in the Listing Advice, with many sites identified as 'potentially littoral rainforest' through our process being confirmed as such when visited (Figs. 7 and 8). Seeking local expert opinion and conducting field visits (subject to landowner approval) are highly recommended to investigate those sites which have been mapped broad scale only, heavily disturbed (e.g. regrowth), occur at or across soil boundaries, are experiencing changed fire regimes, or which may receive frequent freshwater inundation, etc.

Figure 6. RE 7.12.12, which potentially equates to LR&CVToEA, at Garners Beach (left) and Brookes Beach (right)

The following rules have proved to be the most appropriate in conducting the initial GIS approach to identifying littoral rainforest habitat within the study area:

1. RE's that equate wholly according to the listing advice (Fig. 6)
2. Rainforest <75 m from mean high water at spring tide (MHWS) on an open coast, excluding areas >10 m above sea level (asl) on basalt-derived soils (Figs. 8 and 9).
3. Rainforest on coastal sand deposits <2 km from open coast that have not been obviously reworked by fluvial processes(Figs. 10 and 11).
4. Rainforest in high or medium hazard storm tide inundation areas <200 m from open coast (Figs. 12 and 13).
5. Wetlands and waterways are excluded.
6. Other identified littoral rainforest sites, based on ground-truthed expert advice.

However, ground-truthing highlighted several potential modifications or problems which included finer resolution mapping for basalt-derived soils, the challenges of overburden, soil mapping issues, and succession.

Predictive mapping was based on available soil mapping, which considers surface soil types. However, in some cases, the surface soil may be a superficial overburden layer masking a different soil type into which the majority of trees are rooted. For example, at the James Road site (mapped as 7.2.8 *Melaleuca leucadendra* open forest to woodland on sands of beach origin) a thin overburden of marine sand covers underlying metamorphic rock, so the floristic composition is actually driven to a greater extent by the metamorphic soil than the sand layer. **We recommend that potential rainforest at or across soil boundaries be visited to verify vegetation associations.**

The largest RE polygon that 'equates wholly' with Littoral Rainforest in the Mission Beach study area is mapped as 7.2.1 (Mesophyll vine forest on beach ridges and sand plains of beach origin). The panel generally thought it was wrongly mapped, being instead 7.3.3 (Mesophyll vine forest with *Archontophoenix alexandrae* on poorly drained alluvial plains) on sand/mud alluvium deposited by river action rather than a marine deposit, or at the very least a marine sand overlain by a subsequent deposit of riverine mud. This individual polygon, should, therefore, be removed from the list of sites which 'equate wholly'. **We recommend that REs that 'equate wholly' in the Listing Advice be checked in the field to ensure they are actually that RE; that existing wetlands mapping (Queensland Wetlands mapping and Great Barrier Reef Wetlands mapping) be used to exclude freshwater wetlands from all rule maps, especially sand and inundation maps; and that the best available Holocene coastal sand deposits mapping be used to exclude vegetation on alluvial and Pleistocene sands.**

Fieldwork, especially in the aftermath of Severe Tropical Cyclone Yasi, underlined the distinctly successional nature of many communities identified as littoral rainforest. Casuarina recruits heavily into newly deposited sand dunes and plays a significant role in sand stabilisation, facilitating the recruitment of littoral rainforest species. Cyclonic winds had a particularly severe impact on established Casuarina trees, but their understorey of rainforest shrubs and seedlings survived or recovered much better, and in some cases resulted in RE polygons mapped as Casuarina-dominated communities no longer containing Casuarina. Similarly, cyclones might impact sclerophyll overstorey more severely than rainforest understorey. Consequently, **we recommend that Casuarina woodlands on fore-dunes in the super-wet zone of the Wet Tropics bioregion are listed as potential littoral rainforest**. Other grassland and woodland communities, particularly when fire has been or is suppressed, also often support a substantial rainforest/vine thicket seedling understorey or mid-storey, hence the 'v-rule' described above. **We recommend that all woodlands on coastal sand deposits in the super-wet zone known to contain a rainforest or vine thicket understorey or mid-storey, excluding freshwater swamps, be mapped as potential littoral rainforest**. This recommendation builds on advice from the Expert Panel that determination of what should be considered littoral rainforest should to a large extent be determined by assessing the suite of species regenerating and dominating under a vegetation type, taking into account both those species which are present and those which are conspicuously absent. We noted that the absence of fire was supporting the transition of littoral sclerophyll communities to littoral rainforests, particularly on coastal sand deposits. **We recommend that the impacts of changed fire regimes on coastal forest biodiversity be investigated and addressed.**

Other observations from the mapping process are as follows:

RE mapping

Our initial identification of littoral rainforest is based on interpretation of RE mapping. This mapping is, for the Wet Tropics Bioregion, based on amalgamation of 1:25,000 scale vegetation mapping carried out by David and Peter Stanton for the Wet Tropics Management Authority (Stanton & Stanton 2005). Their approach was based on stereoscopic interpretation of aerial photographs, backed by extensive fieldwork, although even their mapping is in some cases incorrect in the highly spatially variable coastal complexes of the Tully-Murray floodplains. The amalgamation of the Stanton & Stanton units into Regional Ecosystem polygons at a scale of 1:50,000 has meant that some small areas of littoral rainforest are subsumed into other vegetation types. Consequently in some areas RE mapping does not adequately reflect the vegetation on the ground, even though the Listing Advice recognises patches of littoral rainforest as small as 0.1 ha– effectively the RE mapping scale means that community boundaries are inappropriately applied. **We recommend that in future revisions of the Regional Ecosystem framework for the Wet Tropics Bioregion RE subtypes are identified that reflect mosaics containing littoral rainforest.**

Coastline

Different mapping products use different coastlines, sometimes with large discrepancies depending on, for example, where they are based in the tidal range, or how they smooth inlets, estuaries and other features. Our definitions require a line that represents the seaward boundary of terrestrial vegetation from which we can measure landward distances, e.g. 75 m for aspect rule, 200 m for inundation rule, and 2 k for sand rule. We found that best results for mapping the coastline were obtained using LIDAR with a 2.5 m contour, amended to bridge creek mouths rather than following creeks upstream.

Because we narrowed the rules for distance from the coast (except for sand substrates) from 2000 m to 75 m and also because we wanted to exclude rainforest on deep basalts within that zone, we needed a method to accurately map MHWS and the 10m contour. High resolution LIDAR-derived mapping enabled us to get a good reading of the seaward extent of terrestrial veg/MHWS (which we then called 0 m asl) and then an accurate reading of the 10 m contour and 75m on the horizontal plane. **We recommend that the use of high level topographic mapping become standard where it is available**.

Listing Advice Wet Tropics flora species list

The Listing Advice provides an indicative list of species which, when found together, are a good indication of littoral rainforest. Acknowledging constraints on the length of this list, we still feel that several omissions are critical, including *Barringtonia asiatica, Cerbera manghas, Erythrina variegata, Hernandia nymphaeifolia, Pandanus tectorius, Pisonia umbellifera* and *Terminalia catappa*. In part this may result from a focus on species of sandy substrates, but as this pilot study demonstrates a significant proportion of wholly compliant littoral rainforest exists on substrates other than sand. **We recommend that the Attachment A to the Listing Advice (Flora Species of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia by Bioregion: Wet Tropics) be updated with key species that reflect the range of communities found in the Wet Tropics bioregion**.

We also raise concern that the Listing Advice *Condition Thresholds* refer to patches needing to have at least 25% of Attachment A species present, while the *Policy Statement* says that of the species present in a patch, 25% need to be from Attachment A. The *Condition Thresholds* sit within a legal document, but the more recently released *Policy Statement* provides a more

realistic measure. **We recommend that the wording of the Listing Advice Condition Thresholds is revised to indicate that 25% of native species present in an assessed patch need to be from Attachment A.**

Weeds

Weedy species are generally advantaged by disturbance, and the combination of natural disturbance from storms and tidal surges together with the extensive human disturbance means that many areas of littoral rainforest are highly impacted by invasion by non-native species, whether exotic or introduced from other Australian habitats. Wet Tropics littoral rainforests are additionally disturbed by cyclones and subsequent "clean-ups". A separate study has considered transformer weeds in littoral rainforest (unpublished internal report, Terrain NRM, 2013, *Littoral rainforest transformer weed management on Council land: Mission Beach pilot*) which affect habitat viability in a number of ways (smothering, fire propagation, resource competition, etc.). These include herbaceous species such as Singapore daisy (*Sphagneticola trilobata*), shrubs such as bamboos (*Bambusa* spp.), climbers such as arrowhead vine (*Syngonium podophyllum*) and pothos (exotic *Epipremnum* species) and trees such as coconut (*Cocos nucifera*), Pond apple (*Annona glabra*) and potentially mango (*Mangifera indica*), . While many of these species are recognised as high threat species across landscapes, others are seldom seen as environmental threats as they are perceived by many as native and/or attractive (e.g. coconut). Many of the littoral rainforest transformer weed species identified during expert panel fieldwork are absent from Attachment A to the Listing Advice (Flora Species of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia by Bioregion: Wet Tropics: Transformer Weeds). Many of the transformer weeds listed in Attachment A were not observed to be transformer weeds in the super-wet zone of the Wet Tropics bioregion. Consequently, **we recommend that the list of transformer species specific to littoral rainforests in the Wet Tropics be reviewed and amended, and given appropriate weight by government in considering funding applications for control.**

Other coastal (not littoral) lowland rainforest

The topography of the Wet Tropics bioregion, with coastal ranges rising several hundreds of metres to extensive uplands or tablelands from close to the coast, means that the coastal lowland communities are typically highly constrained and limited in extent, and are highly fragmented through development of agriculture, urban infrastructure, coastal settlements (including tourism) and transport and communication corridors. Our focus on the littoral rainforest components of these systems has also allowed us to collate data on these coastal lowland systems in parallel, and indeed non-littoral lowland rainforests approach to within less than 100 m of the coastline in places, particularly on high fertility soils and where there is a substantial freshwater influence. Given the highly fragmented nature of many of the communities in these systems, we are producing a companion report to this one considering coastal lowland rainforests of the Wet Tropics bioregion; many of the themes and recommendations outlined above apply equally to other coastal lowland systems that do not have a distinct marine influence.

Next Steps

Above we detail the steps taken to build a comprehensive understanding of a small part of the littoral rainforest resource in the Wet Tropics bioregion (Fig. 14). We have clearly demonstrated a number of deficiencies in the existing mapping of LR&CVToEA, and have proposed alternative regionally-specific approaches that more comprehensively identify areas of littoral rainforest which should be recognised as compliant with the intentions of the listing advice. The intent of the maps is to flag general areas that are likely to be LR&CVToEA. In the event of a proposed significant impact, expert field work would determine the exact boundaries. Some mapped areas may not be LR&CVToEA and some unmapped areas may be LR&CVToEA.

Our approach has been necessarily limited in scope due to resourcing and time constraints. However, we suggest that a number of further steps may build on the existing Listing Advice, Conservation Advice and Policy Statement and enhance existing protection measures for this endangered community.

At the Federal level we suggest that incorporation of our approach or elements of it in a bioregional assessment of the LR&CVToEA resource would better identify the current condition, distribution of and threats to LR&CVToEA within the Wet Tropics bioregion. We look forward to participating in the preparation of a recovery plan. We hope that (DoE) considers our method and map as information for resource allocation, development assessment and compliance and extension of work in the study area (particularly of "potential" sites and granite sites) to enable refinement and application to the broader Wet Tropics bioregion. We also suggest that wet tropical lowland rainforest be considered as a future threatened ecological community.

At the State level we suggest that future revision of Regional Ecosystem definitions and boundaries recognise the mosaic, narrow and successional nature of many littoral rainforest communities, and ensure alignment between RE types and LR&CVToEA threshold conditions.
At the local government level we note that much littoral rainforest in the study area is located in Council-managed esplanades, some developed as roads and some in natural condition. We suggest that our data layers be integrated into Council biodiversity strategies and land use planning, that knowledge of transformer weeds and fragmentation results in improved management on Council-managed land, that the threatened status and successional nature of littoral rainforest communities is recognised in Council works including cyclone response, and that a management plan is prepared and implemented for littoral rainforest on Council-managed land.

At the community level we aim to promote awareness of the distribution and significance of littoral rainforest and provide guidelines to reducing threats and managing and protecting littoral rainforest, support community groups with presentations and training, work with tourism in presenting "rainforest meets reef" experiences, and grow understanding of the value of these vegetation types for protecting and maintaining high quality natural habitat. From a scientific perspective we need to ensure dissemination of data to support the above activities, peer-reviewed publication of our methods and findings, and communication with all of the above stakeholders from the community to the Federal level. We recommended further studies of Wet Tropics littoral rainforest communities per substrate, littoral rainforest on the unique basalt/sand ecotone at Mission Beach, and significant littoral rainforest flora and fauna species e.g. peppermint stick insect.

Littoral rainforest and coastal vine thickets in the Wet Tropics bioregion are probably Australia's most species-diverse, extensive and tall littoral rainforests, the best connected to other rainforests, and the most cyclone-affected. Some patches are within the Wet Tropics World Heritage Area and most are adjacent to the Great Barrier Reef World Heritage Area. They epitomise "where the rainforest meets the reef". They provide habitat for endangered and/or iconic fauna such as the southern cassowary and peppermint stick insect. Littoral rainforest and coastal vine thickets protect areas from erosion, filter sediments, nutrients and pollutants, mitigate the effects of flooding and wind during storm events, and provide supporting habitat for biodiversity. Littoral vegetation and natural dune structures also provide protection to coastal communities, beaches, infrastructure and agriculture and aquaculture industries as vegetation attenuates waves and reduces the strength of storm surge. Other ecosystem services include the provision of shade, nesting sites and food resources for fauna, migration capacity for endemic and iconic species, and cultural and aesthetic services. Wet Tropics littoral rainforests represent a rare opportunity for proactive conservation of a relatively healthy ecological community that elsewhere is critically endangered.

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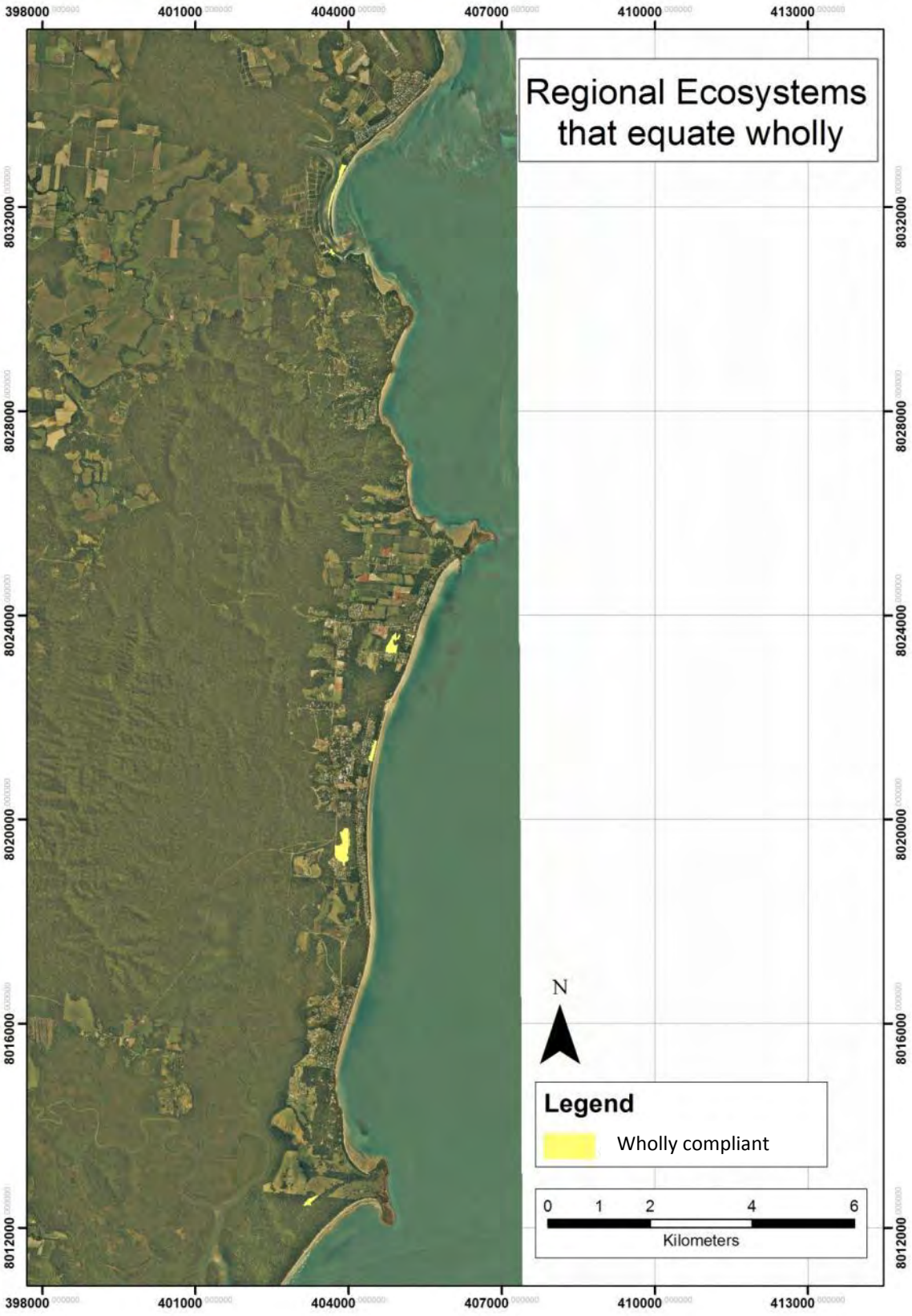


Figure 7. Regional Ecosystems (REs) in the Wet Tropics bioregion that 'equate wholly' to the Littoral Rainforest & Coastal Vine Thickets of Eastern Australia ecological community listing advice.

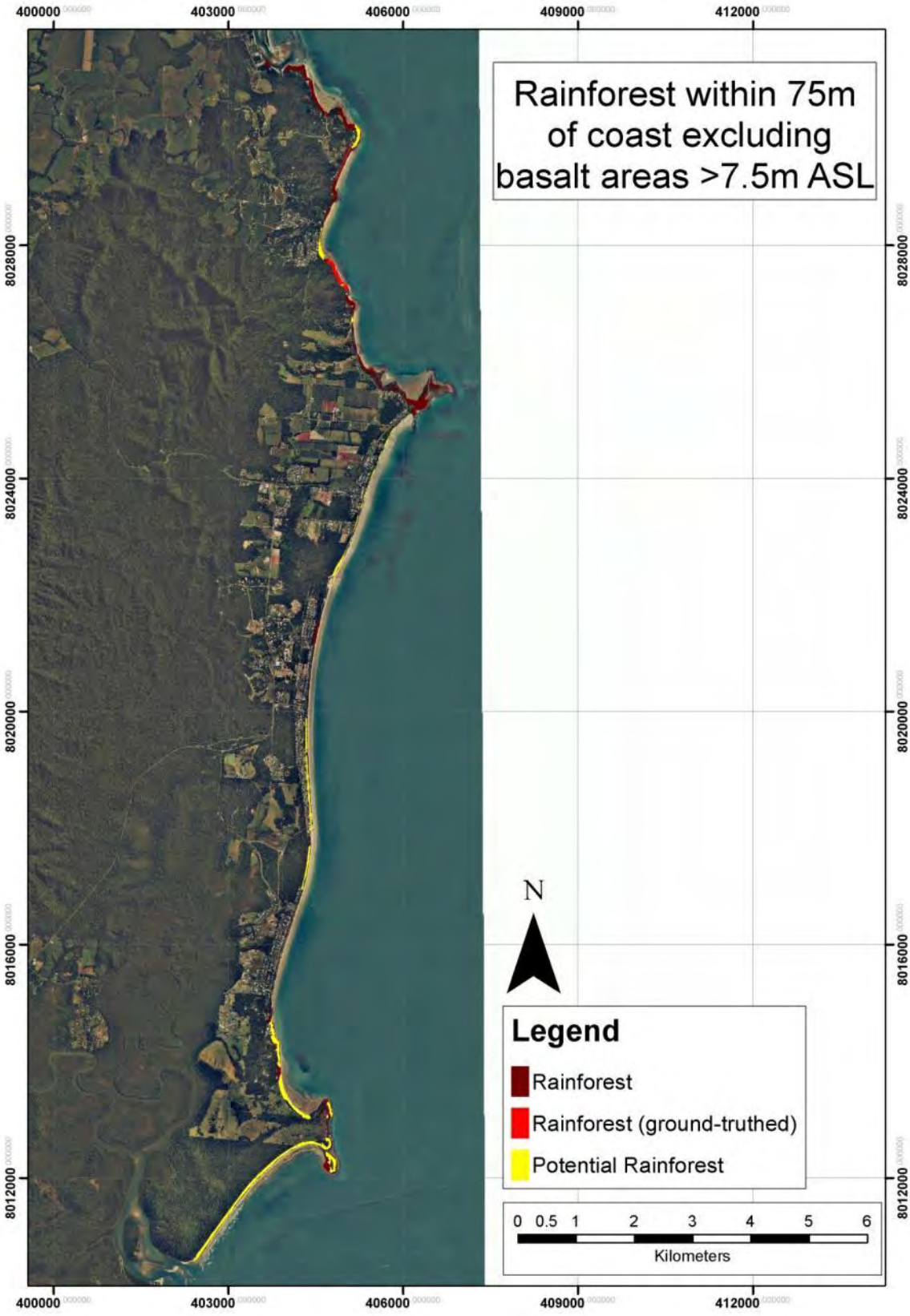


Figure 8. Littoral rainforest (wholly compliant and potential) within 75 m of MHWS excluding forest on basalt-derived soils>7.5 m above sea level

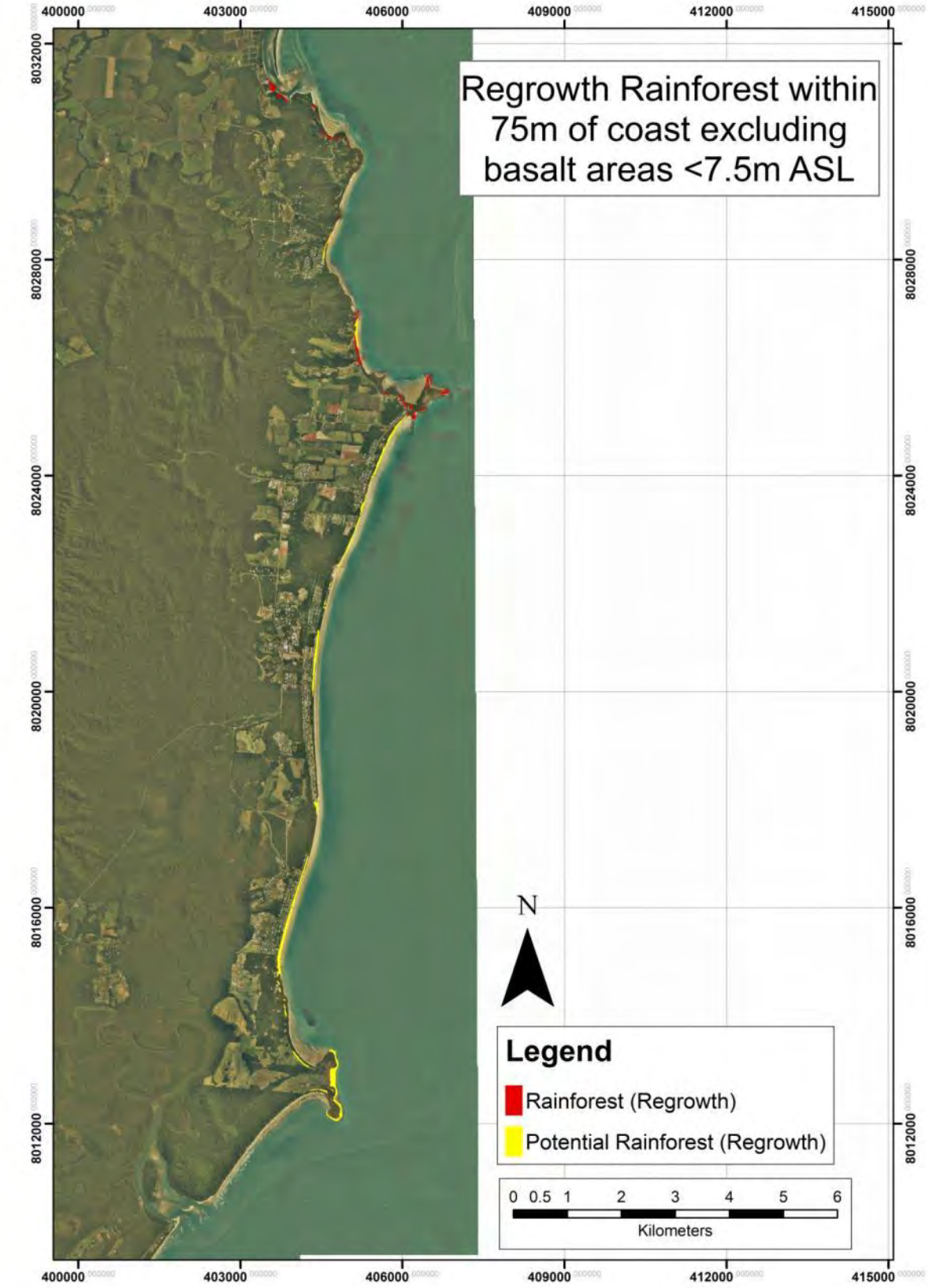


Figure 9. Regrowth rainforest (wholly compliant and potential) within 75 m of MHWS excluding forest on basalt-derived soils >7.5 m above sea level

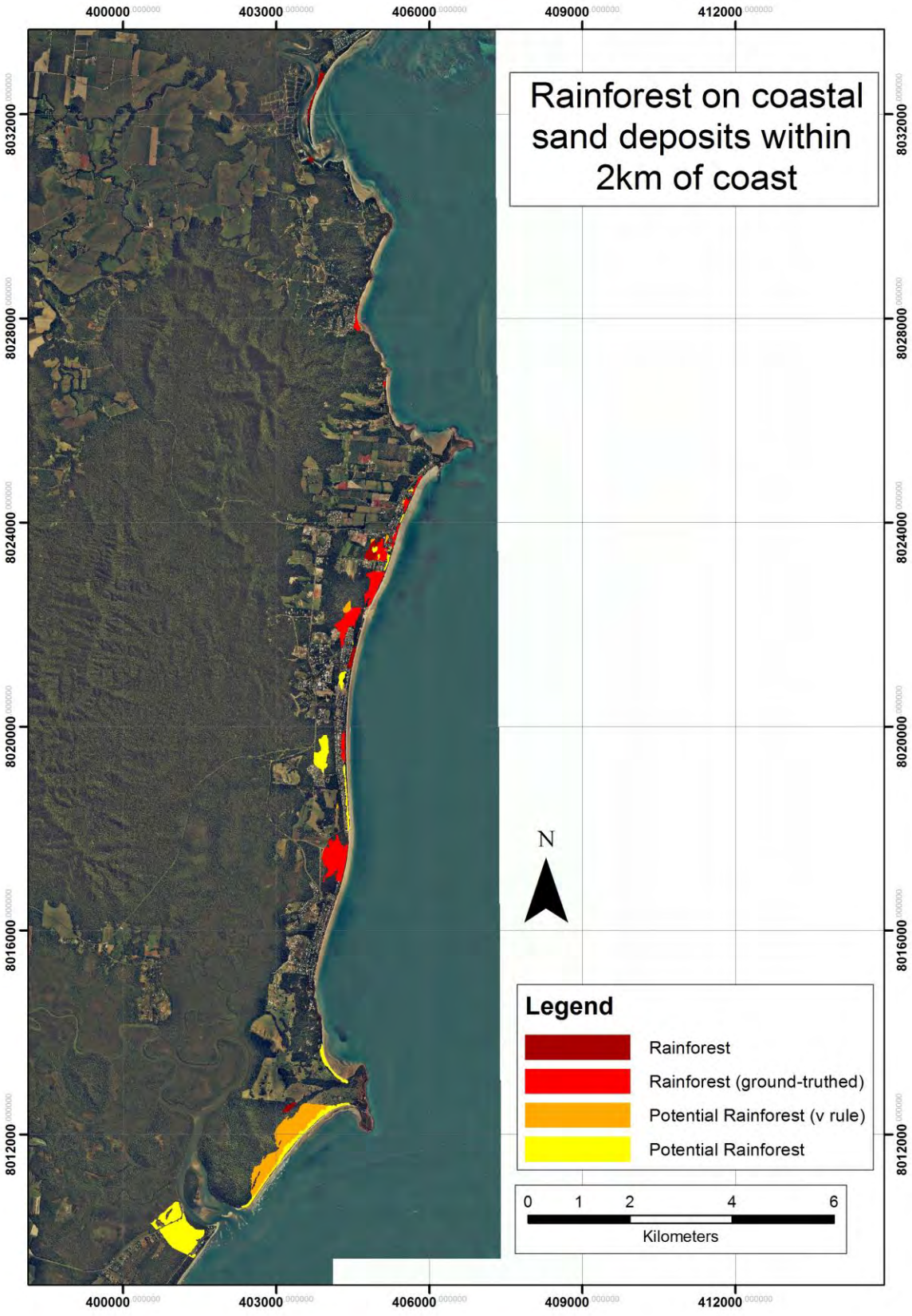


Figure 10. Littoral rainforest (wholly compliant and potential) on coastal sand deposits within 2 km of MHWS.

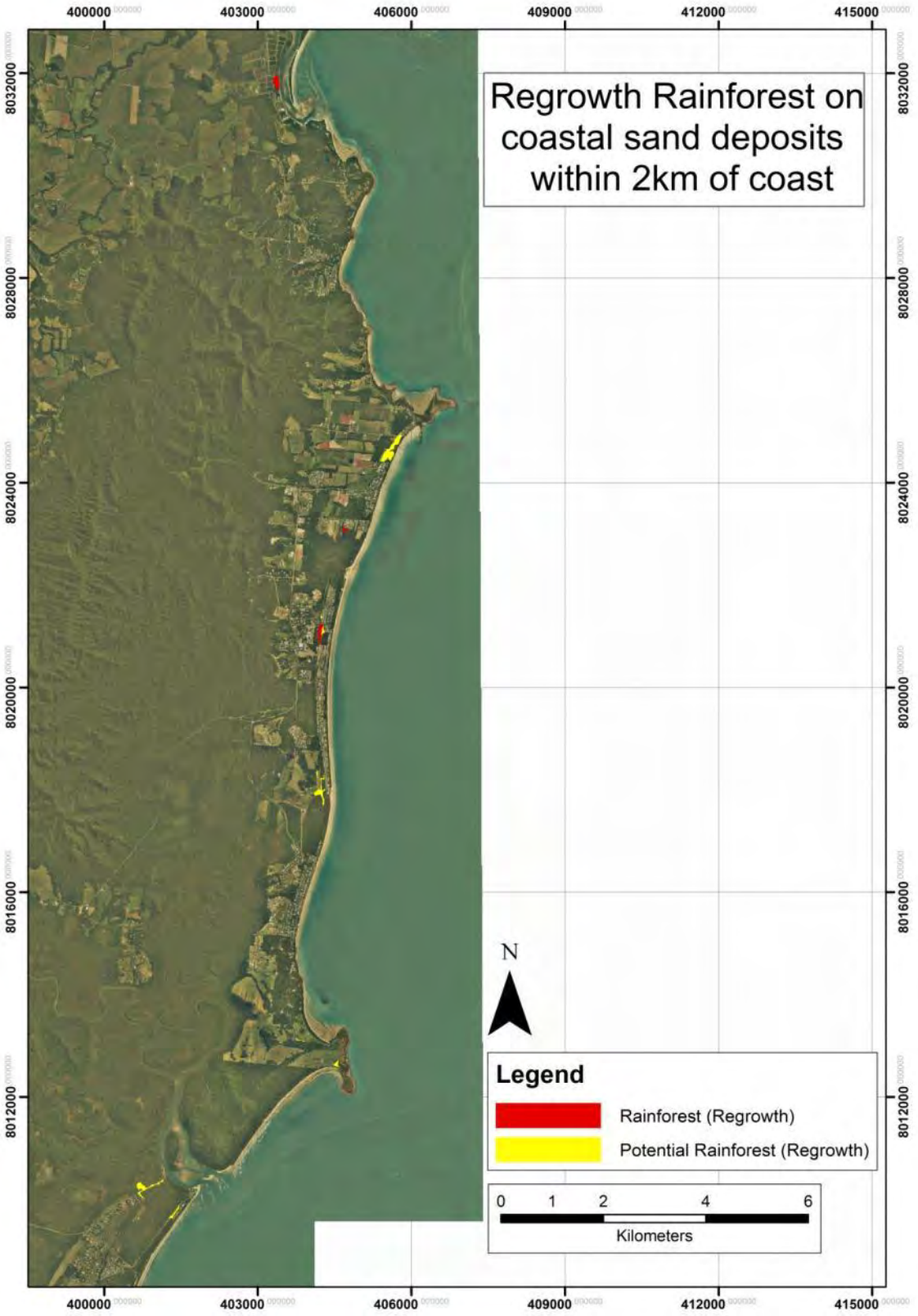


Figure 11. Regrowth rainforest (wholly compliant and potential) on coastal sand deposits within 2 km of MHWS.

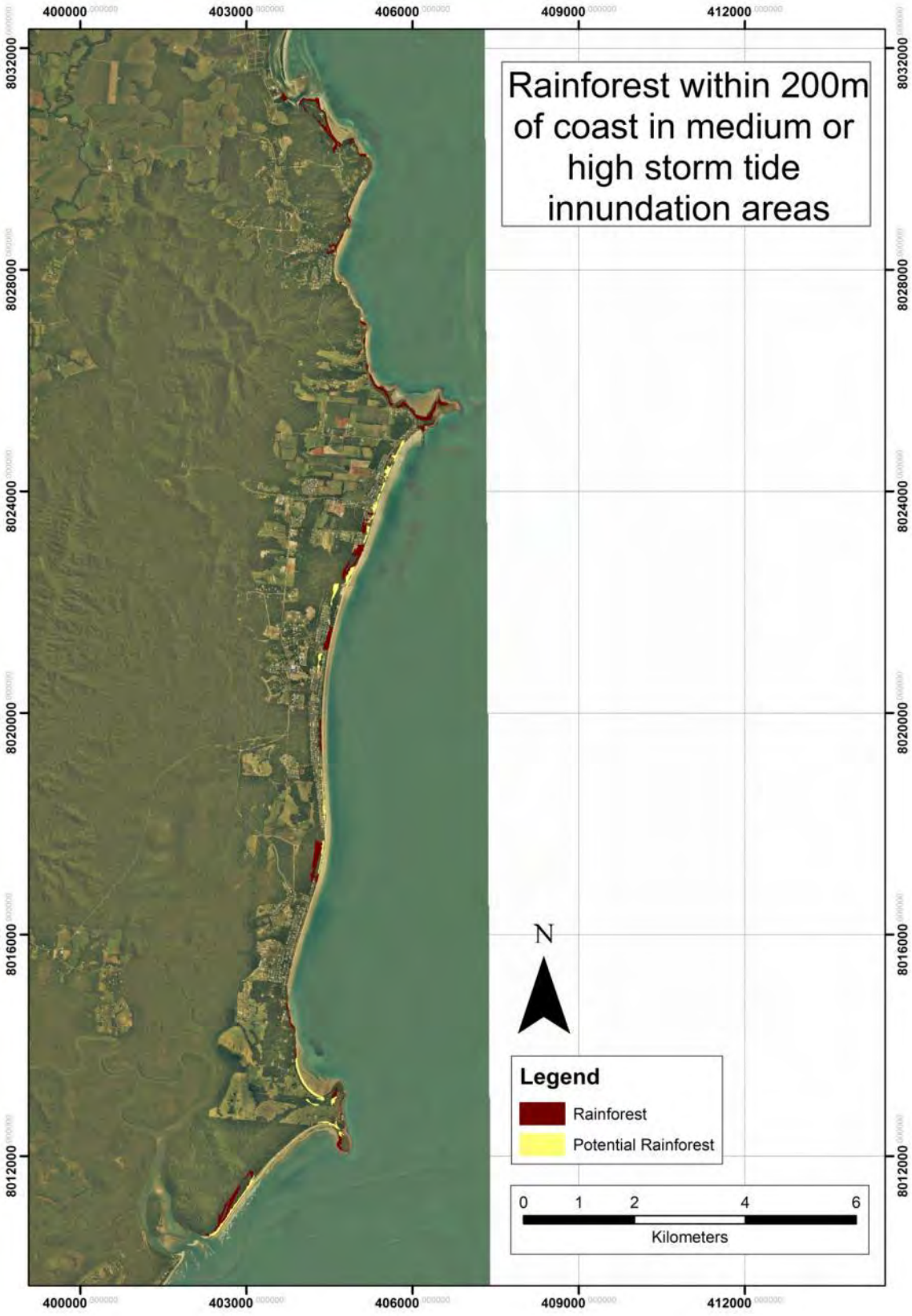


Figure 12. Littoral rainforest (wholly compliant and potential) in medium or high risk of storm tide inundation within 200 m of MHWS.

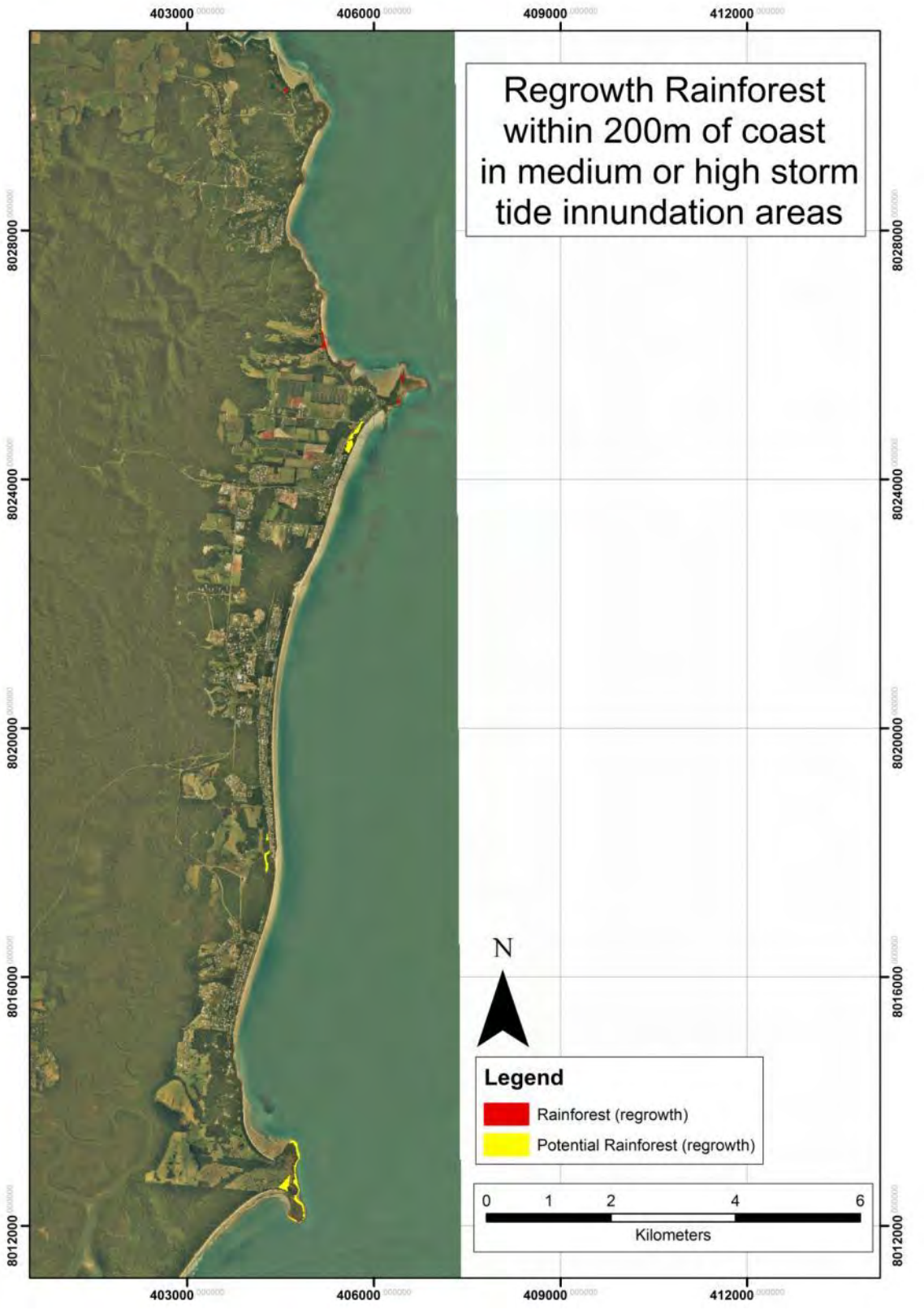


Figure 13. Regrowth rainforest (wholly compliant and potential) in medium or high risk of storm tide inundation within 200 m of MHWS.

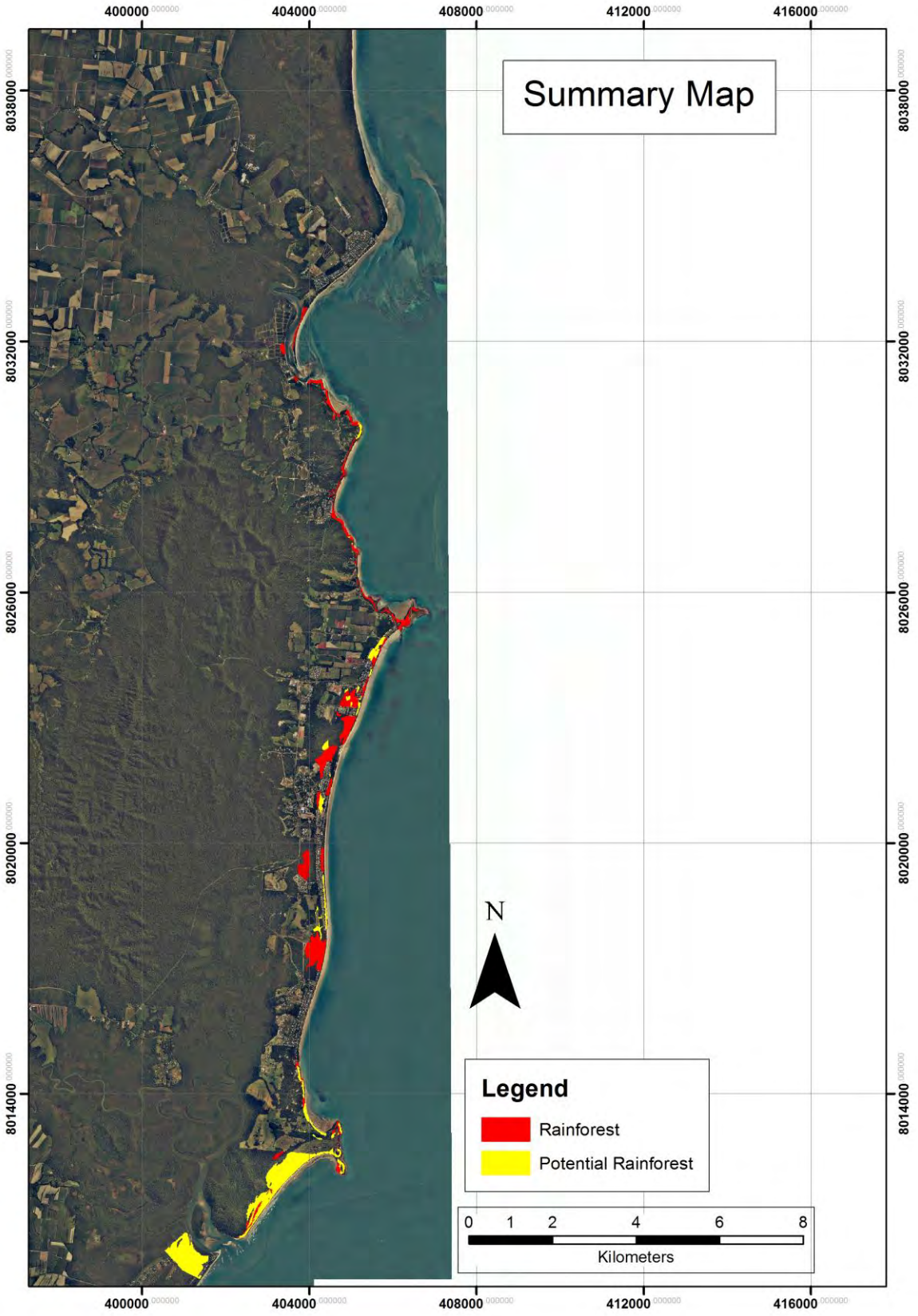


Figure 14. Littoral rainforest (wholly compliant and potential) in the Mission Beach study area.

Appendix 1: Field sites visited and subsequent interpretations

Field visits took place with members of the expert panel on 1 February 2012 (mapping workshop), 13 June 2012 (revised mapping workshop), 12 March 2013 (transformer weeds) and 7 May 2013 (T. O'M. in field with Djiru traditional owners).

Field site number	Site name	Regional Ecosystem	Considered LRF?	Comments
Feb Site 1	Porter Promenade	7.2.7	yes	C4 beachfront sand site.
Feb Site 1a	Porter Promenade	7.8.1	no	National Park basalt site. Important to research history of vegetation and disturbance.
Feb Site 2	Clump Point	7.8.1	yes	SE corner site. Classic exposed example.
Feb Site 2a	Clump Point	7.8.1	yes/no	Clump Pt Rd site. Problem of broadscale of RE mapping
Feb Site 2b	Clump Point	7.8.1	yes	Cutten Bros track site.
Feb Site 2c	Clump Point	7.8.1	no	Perrier Walk site. Deep basalt soil.
Feb Site 3	Narragon	regrowth	yes	Foreshore site. Importance of regrowth mapping.
Feb Site 3a	Narragon	7.12.1	yes/no	Landward site. transition zone
Feb Site 4	Pacific Parade/Oasis	7.2.1 & 7.2.7	no/yes	Pacific Parade site. 7.2.1 is not remnant veg. 7.2.7 is LRF
Feb Site 4a	Pacific Parade/Oasis	7.2.7	yes	Oasis beachfront site.
Feb Site 4b	Pacific Parade/Oasis	7.2.3	yes	Oasis 7.2.3 site Transition form sclerophyll to rainforest due to fire absence
Feb Site 4c	Pacific Parade/Oasis	7.2.1	yes	Oasis 7.2.1 site. Syzygium forte canopy
Feb Site 5	Conch St		no	Nivosa Court site. RE mapping error
Feb Site 5a	Conch St		no	Nonda St site. Freshwater overrides saltwater inundation.
Feb Site 6	Banfield Parade	7.2.5	yes	Protected from fire by swale
Feb Site 7	South of police station	7.2.1	no	RE mapping error. Meant to be the biggest patch of LRF at Mission Beach.
June Site 1	Clump Point		yes	Accords with the 75m rule, and broadly with the basalt > 10m ASL[1]. With LIDAR contour mapping possible that >7m would be more accurate than >10m

June Site 2	James Rd	7.2.8 with v[2]	yes	Actually this site represents a sand veneer over metamorphic substrate; i.e. possible RE mapping error, but either way it's LRF
June Site 3	Wee Beach		yes	Storm tide inundation[3] area.
JuneSites 3a	between Wee Beach and Bingil Bay boat ramp		Yes, with small included patches of non-LRF	LRF on rocky substrate
June Site 4	Bingil Bay boat ramp	7.2.3 (without v)	yes	Historically the site was sclerophyll with grassy understorey; now increasingly LRF in absence of fire
June Site 5	Bingil Creeks		yes	Storm tide Inundation area
June Site 6	Dunlop St	7.2.3 with v	yes	Historically the site was sclerophyll with grassy understorey; now increasingly LRF in absence of fire
June Site 7	Pacific View Drive	7.2.9 grading to 7.3.3	In part (see extended discussion)	Exclude all 7.2.9 irrespective of "v" rule because they are wetlands, not LRF
June Site 8	Reid Rd southern	7.2.7 (without v)	Potentially	was historically LRF; degraded by cyclones, shoreline recession, clearing, thinning and weeds; potential to recover to LRF
JuneSite 8a	Reid Rd southern	7.2.8 (without v)	no	
June Site 9	Wheatley Rd	7.2.3 with v	mosaic, with some LRF parts	Complies with listing advice and has many of listing advice spp, but large amount of sclerophyll with only patches of distinct LRF scattered through it; listing advice not clear in such an instance of what proportion of mosaic in polygon needs to be LRF to comply
June Site 9a	Wheatley Rd	7.2.7 (without v)	yes; though less convincingly so towards the southern end	Consider supplementary rule that would be LRF if it is a frontal dune mapped as *Casuarina* or RE other than sclerophyll. Pond apple was noted as a potential transformer weed
	Downtown Mission Beach i.e. Day Park		yes	[assessed during LRF transformer weed management on CCRC land: Mission Beach pilot visit]

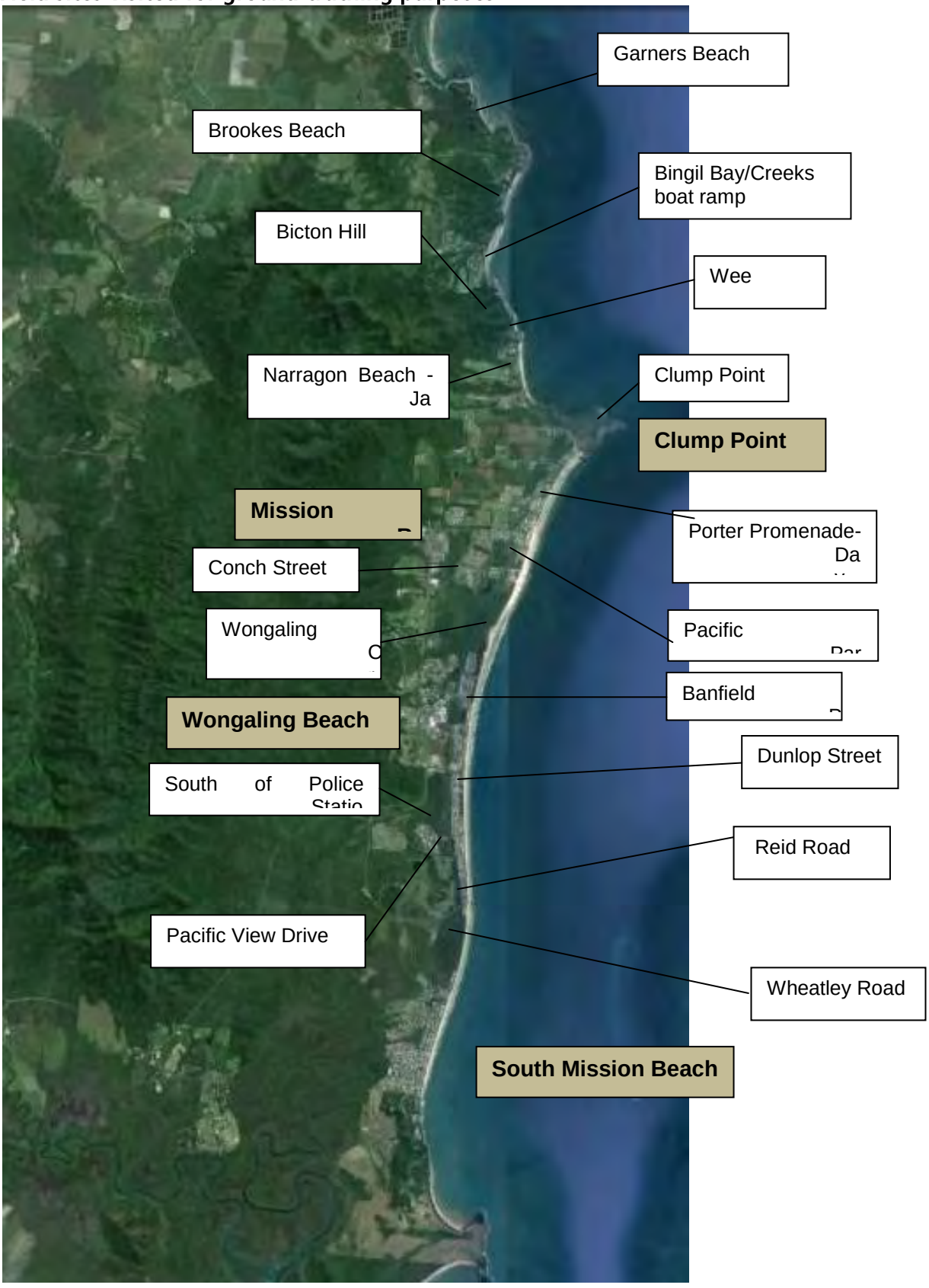
	Wongaling Creek mouth	3 sites	yes	LRF on coastal sand deposits – site 1 much eroded (Cyclone Yasi), site 3 developing LRF due to fire absence [assessment by T O'M during Djiru Native Title Determination property visit]
	Garners Beach	2 sites	Yes,	[assessed during LRF transformer weed management on CCRC land: Mission Beach pilot visit]
	Brookes Beach	3 sites	yes	[assessed during LRF transformer weed management on CCRC land: Mission Beach pilot visit]
	Bingil Bay	3 sites	yes	[assessed during LRF transformer weed management on CCRC land: Mission Beach pilot visit]
	Bicton Hill to Clump Point		yes	[assessed during LRF transformer weed management on CCRC land: Mission Beach pilot visit]

[1]7-10m ASL exclusion was introduced for basalt because deep rich soils can nullify the effects of salt spray more than other substrates. Elevations above a certain height may be beyond salt spray exposure but generally any areas within 75m of coastline on open coast are somewhat exposed no matter what elevation. Steep SE facing coasts like northern Brooks Beach might intensify exposure including > 10m ASL.

[2]"V" in RE code is based on Stanton & Stanton (2005) Wet Tropics mapping. Stanton's "v" indicated likely invasion of rainforest species into the understorey; it wasn't always ground-truthed. Our report infers that REs with "v" have a high probability that they are moving to rainforest; i.e. mapped area is LRF unless expert fieldwork/ground-truthing determines otherwise.

[3]200m storm tide inundation distance, excluding identified freshwater wetlands. Use LIDAR (2.5m contour) to exclude mangroves. *Heritiera,* etc. are included in Listing Advice Wet Tropics species list so there's no need to exclude areas with a few terrestrial "mangroves". This rule will help pick up LRF in areas of low elevation exposed to some storm tide inundation and/or groundwater salt intrusion and/or salt spray when not a freshwater wetland or waterway.

Field sites visited for ground-truthing purposes



Appendix 2: Regional Ecosystems (REs) in the study area which potentially equate to LR&CVToEA in the Wet Tropics bioregion when within 75 m of coast, in an inundation area within 200 m of coast, or on coastal sands within 2 k of coast. Figures for estimated remaining extent are taken from assessments made in 2003 (DEHP 2012).

N.B. This table does not include REs that wholly equate (see Table 1).

RE	**Description**	Vegetation management status	Biodiversity conservation status	Estimated remaining (Wet Tropics Bioregion)	Ecological value
7.2.3	*Corymbia tessellaris* (Moreton Bay ash) and/or *Acacia crassicarpa* (beach wattle) and/or *C. intermedia* (pink bloodwood) and/or *C. clarksoniana* (Clarkson's bloodwood) woodland to closed forest Beach ridges, predominantly of Holocene age	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	Habitat for the vulnerable *Livistona drudei*. 7.2.3a: Habitat for the vulnerable *Livistona drudei*. 7.2.3b: Habitat for the vulnerable *Livistona drudei*. 7.2.3j: A very rare and unusual landform.

7.2.6 (other than 7.2.6b)	Mosaic of clumps of notophyll vine forest, sclerophyll spp. shrublands and open woodlands, and bare sand blows. Aeolian dunes.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	
7.2.7	*Casuarina equisetifolia* (coast sheoak) +/- *Corymbia tessellaris* (Moreton Bay ash) open forest +/- groved vine forest shrublands. Beach strand and foredune.	Of concern	Endangered	< 10,000 ha and >30% of the pre-clearing area remaining.	A very unusual landform.
7.2.8	*Melaleuca leucadendra* (weeping tea tree) open forest to woodland. Sands of beach origin.	Of concern	Endangered	< 10,000 ha and >30% of the pre-clearing area remaining.	
7.3.7	*Eucalyptus pellita* (red stringybark) and *Corymbia intermedia* (pink bloodwood) open forest to woodland (or vine forest with emergent *E. pellita* and *C. intermedia*). Poorly drained alluvial plains.	Endangered	Endangered	< 10,000 ha and 10-30% of the pre-clearing area remaining.	
7.3.10	Simple to complex mesophyll to notophyll vine forest on moderate to poorly drained alluvial plains of moderate fertility	Of concern	Endangered		
7.3.19	*Corymbia intermedia* (pink bloodwood) or *C. tessellaris* (Moreton Bay ash) +/- *Eucalyptus tereticornis* (forest red gum) open forest (or vine forest with these species as emergents). Well-drained alluvium.	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	

7.3.25	*Melaleuca leucadendra* (weeping tea tree) +/- vine forest species, open to closed forest. Stream levees and prior streams on well-drained sandy clay loam alluvial soils.	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	Important wildlife corridors in cleared landscapes.
7.8.1	Complex mesophyll vine forest on well drained basalt lowlands and foothills	Least concern	Endangered		
7.11.1	Simple to complex mesophyll to notophyll vine forest on moderately to poorly drained metamorphics (excluding amphibolites) of moderate fertility of the moist and wet lowlands, foothills and uplands	Least concern	No concern at present		
7.11.18	Corymbia intermedia (pink bloodwood) and/or *C. tessellaris* (Moreton Bay ash) +/- *Eucalyptus tereticornis* (forest red gum), open forest, tall open forest to woodland (or vine forest with these species as emergents). Coastal metamorphic headlands and near-coastal foothills.	Of concern	Of concern	< 10,000 ha and >30% of the pre-clearing area remaining.	
7.11.34	Complex of shrublands, low heathy or shrubby woodlands and low forests, with *Corymbia tessellaris* (Moreton Bay ash) and *C. intermedia* (pink bloodwood) or *Melaleuca viridiflora* (broad leaf tea tree), *Allocasuarina* spp. (sheoaks) and *Acacia* spp. (wattles). Metamorphic coastal headlands and islands.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	
7.12.1	Simple to complex mesophyll to notophyll vine forest on moderately to poorly drained granites and rhyolites of moderate fertility of the moist and wet lowlands, foothills and uplands	Least concern	No concern at present		
7.12.12	*Acacia mangium* (black wattle) and *A. celsa* (brown salwood) open to closed forest or *A. polystachya* woodland to closed forest. Moist granite and rhyolite foothills.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	

7.12.23	*Corymbia intermedia* (pink bloodwood) and/or *C. tessellaris* (Moreton Bay ash) +/- *Eucalyptus tereticornis* (forest red gum), open forest to tall open forest to woodland (or vine forest with these species as emergents). Coastal granite and rhyolite headlands and near-coastal foothills.	Of concern	Endangered	< 10,000 ha and >30% of the pre-clearing area remaining.	
7.12.40	Closed vineland of wind disturbed vine forest, on granites and rhyolites	Of concern	Of concern		
7.12.54	Complex of shrublands and low open forests. Wind-exposed granite and rhyolite coastal headlands and islands, on skeletal soils.	Of concern	Of concern	< 1,000 ha and >30% of the pre-clearing area remaining.	