Byron

Wildlife Corridor System 2022

A report to Byron Shire Council

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Landmark Ecological Services

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Summary

Byron LGA is an area of exceptionally high biodiversity, providing a refuge for species with Gondwanan lineages representative of the biota that covered the continent between 20 and 40 million years ago. It lies within a global biodiversity hotspot for rainforest flora species and in a bioregion with the highest number of marsupial and micro-bat species, the equal highest number of frog species and the second highest number of bird species in Australia.

Byron's biodiversity is under threat from a range of processes, particularly vegetation clearing, fragmentation, isolation and degradation and from anthropogenic climate change and its associated impacts. Urbanisation and infrastructure development and introduced (pest) plant and animal species are also impacting severely. There is an urgent need to protect and link remaining habitats to conserve and maintain the genetic viability of remnant populations of Byron's flora and fauna.

62 threatened vertebrate fauna species, 65 threatened flora species and 11 threatened ecological communities were selected as of the high conservation priority to provide a basis for mapping a corridor system that best catered for the most "at risk" species and plant communities in the LGA. Conservation of the habitats of these species and communities will also protect the habitats of many of the LGA's other plant and animal species.

Byron plant communities were combined into 11 habitat types and the preferred habitat types of the priority species were then identified. Rainforest and wet sclerophyll forest types were found to provide core habitat for the highest number of priority flora and vertebrate species.

The mapping process for the corridor system commenced with selection of the coastal and hinterland habitat blocks containing the largest contiguous stands of native vegetation (including the National Parks estate). The blocks were then buffered and connected across the landscape to select the highest value habitats (rainforest and wet sclerophyll types) where possible for the priority species. Minimum corridor widths were attained of 500 m for major connectors and 100m for minor connectors.

Connectors were selected to include native vegetation in the highest condition, the larger remnant patches, Koala habitat and Big Scrub remnants. Factors influencing corridor selection included accounting for plant populations on the LGA's different geologies, incorporating links over or under the M1 Motorway, avoiding flood-prone and prime agricultural land, including habitat attributes that would assist in mitigating the effects of climate change and aligning with habitat blocks or corridors in adjoining LGAs.

Riparian buffers were incorporated as an additional element in the design of the corridor system because in addition to providing important habitat for priority species and threatened communities they are considered likely to become increasingly important as climate change refugia.

The Byron Wildlife Corridor System 2022 comprises 11 hinterland and coastal habitat blocks linked by 27 major and 26 minor connectors, in combination with the network of riparian buffers. It substantially improves on previous corridor systems previously incorporating or prepared for the Byron LGA.

Recommendations are made for the revegetation and restoration of corridor components where gaps occur or vegetation is in a degraded condition.

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1. Background

In March 2020 Byron Shire Council (BSC) accepted Landmark Ecological Service's quote to undertake a "wildlife corridor mapping" project for the Byron Local Government Area (LGA). Due to the COVID-19 outbreak, the project was put on hold and a revised contract was received by Landmark in September 2020.

The project brief is attached as **Appendix 1**.

As stated in the contract, the project was to build on existing wildlife corridor mapping for the Byron LGA and for adjacent LGAs and to develop a methodology consistent with existing regional and local approaches to wildlife corridor identification and mapping.

The principal aims of the project, in summary, were to:

- derive lists of conservation-priority terrestrial vertebrate and plant species and threatened ecological communities listed on schedules of the *Biodiversity Conservation Act 2016 (BC Act 2016*) known from the Byron LGA, ranking conservation-priority terrestrial vertebrate and plant species on the basis of their habitat preferences, dispersal capabilities, perceived level of risk from threatening processes and in addition, vertebrate species according to their zoogeographical origins and plant species according to their reproductive strategies;
- identify and rank key habitats (renamed as habitat types) for vertebrate and plant assemblages;
- map records of conservation-priority terrestrial vertebrate and plant species and threatened ecological communities;
- identify a potential corridor system for the Byron LGA through an examination of existing connectivity across the landscape and existing protected areas on public and private land, to include appropriate buffers to National Parks (NP) and Nature Reserves (NR). Focus to be on the occurrence of the largest blocks of native vegetation containing the key habitats (habitat types) of highest significance for the most "at risk" terrestrial vertebrate and plant species groups;
- review existing key habitat and wildlife corridor systems for the Byron LGA in relation to their effectiveness for sustaining conservation-priority species;
- rank the selected corridors in accordance with their importance in the landscape, including facilitating links to key habitats (habitat types) and corridors in adjoining LGAs.

Special provisions were to be made for the Koala *Phascolarctos cinereus*, as requested by BSC, to ensure known and identified potential Koala habitat (Byron Shire Council 2016, Hosking 2020) was considered for inclusion in corridors where possible.

1.1 Previous biodiversity, mapping and corridor studies

Within and adjacent to the Byron LGA, recent relevant biodiversity studies that were available as background for the Byron Wildlife Corridor System 2022 included:

- BSC vegetation and HEV mapping (McKinley and Murray 2017a, b) and locations of restoration projects in the LGA (including Koala management properties; BSC database)
- Lismore City Council corridor system (adjoining Byron LGA to the west, Milledge 2012)
- Byron Biodiversity Conservation Strategy (Byron Shire Council 2020) and corridor mapping associated with the earlier strategy (Byron Shire Council 2004)
- Byron Flora and Fauna Study 1999. (Landmark Ecological Services, Ecograph and Terrafocus 1999)

The entire LGA had not been mapped consistently as the 2017 BSC vegetation mapping layer was confined to the area outside the National Parks estate. As a result, and to provide a whole-of-LGA coverage for the habitat block and connector selection, the vegetation maps for Arakwal NP, Tyagarah NR, historic State Forests forest-type mapping and draft State Vegetation Type Mapping – Eastern NSW v1.1 (covering the National Parks estate within the LGA) were combined with the 2017 BSC vegetation mapping layer in the early stages of the project, producing a composite vegetation map.

Regional corridor mapping also relevant to the LGA included:

- NSW National Parks and Wildlife Service (NPWS) key habitats and corridors system (Scotts 2003)
- NSW Office of Environment and Heritage (OEH) climate change corridors system (State Government of NSW and Department of Planning, Industry and Environment 2010)

2. Conservation priorities and regional biodiversity

2.1 Conservation priorities

Species of flora and fauna that have the highest priority in regional conservation planning are generally endemic species, or species with restricted and/or patchy distributions and species most at risk from processes that threaten their long-term viability (Scotts 2003). Byron LGA falls within one of five regional centres of endemism identified by Weber *et al.* (2014), based on the presence of high concentrations of range-restricted, endemic rainforest species. These centres have been estimated to have maintained relatively stable rainforest habitat over at least the last 120,000 years and the rainforest species often have ancestry going back to the ancient supercontinent of Gondwana (incorporating present-day South America, Africa, Arabia, Madagascar, India, Australia, and Antarctica). Other species with similar wet forest preferences evolved later once the Australian Plate was isolated, allowing a large variety of unique flora and fauna to develop independently from the rest of the world.

The processes that pose the greatest risk collectively to these species are habitat loss, fragmentation and isolation caused by vegetation clearing, and habitat degradation. These threatening processes are being exacerbated by anthropogenic climate change through extreme weather events and associated perturbations. Such processes result in the loss of local populations that can cumulatively cause species extinctions and in some cases (e.g. loss of keystone species)

could ultimately result in ecosystem collapse (Department of Environment and Conservation 2004, Fischer and Lindenmayer 2007).

2.2 Overall ecological significance of the South Eastern Queensland Bioregion

The Byron LGA is located in the southern section of one of the richest and most diverse bioregions for flora and fauna in Australia. This is the South Eastern Queensland Bioregion, extending from Coffs Harbour in north east NSW north to Gladstone in south east Queensland (IBRA v.7 2019). The bioregion is part of a global biodiversity hotspot for rainforest biota (Williams *et al*. 2011) and encompasses much of the area containing the Central Eastern Australian Rainforests (CEAR; Mitchell *et al.* 2021). It is located along the eastern fall of the Great Dividing Range from the Illawarra area in central east NSW north to Gympie in south east Queensland. The bioregion's rainforests have been noted by numerous authors as having high refugial importance for rainforest plant and vertebrate species with Gondwanan lineages, with many sedentary and with poor dispersal capability (e.g. Weber *et al.* 2014, Rossetto and Kooyman 2021, Schodde and Faith 1991, CSIRO 1996 and Mitchell *et al*. 2021). Gondwanan lineages include flora genera and species from the Cunoniaceae, Proteaceae, Monimiaceae, Elaeocarpaceae, Myrtaceae and Lauraceae families. Examples of species occurring in the LGA are the threatened Minyon Quandong *Elaeocarpus sedentarius*, Hairy Quandong *Elaeocarpus williamsianus*, Davidson's Plum *Davidsonia jerseyana* and Smooth Davidsonia *D. johnsonii*, all rainforest-dependent species listed on the schedules of the *BC Act 2016* and on the schedules of the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*).

Byron Shire Council (2020) has previously highlighted the particular importance of the LGA's rainforests, stating "Today, plants and animals descended from Gondwanan lineages still inhabit our high and mid-elevation rainforests, providing deep-time insights into the evolution and ecology of Australia's unique flora and fauna. They are of immense scientific significance and the Shire has a national responsibility to conserve its part of this evolutionary legacy".

From a faunal perspective, the area encompassed by the bioregion has been identified as supporting the highest species diversity of marsupials and non-*Ctenotus* skinks, the equal highest species diversity of frogs; and the second highest bird species diversity in Australia after the Wet Tropics of north Queensland (NSW National Parks and Wildlife Service 1994). On a palaeogeographic level, major elements of three of Australia's five historic land faunas, the Tumbunan, Torresian and Bassian, merge in the bioregion and minor elements of the remaining two, the Irian and Eyrean faunas are also present. (e.g. CSIRO Division of Wildlife and Ecology 1996).

Probably the most important in a biodiversity conservation context is the Tumbunan, the subtropical rainforest fauna with lineages extending back to the Gondwanan fauna that was formerly distributed extensively across the continent before it began to dry during the late Tertiary Period (CSIRO Division of Wildlife and Ecology 1996). The Tumbunan fauna is now essentially relictual, having contracted to two primary moist refugia, one of which encompasses the CEAR stands between the Illawarra and the Sunshine Coast (Mitchell *et al.* 2021). As a result, a relatively large number of rainforest-associated vertebrate species are endemic to the CEAR refugia with examples from the LGA including the threatened Pouched Frog *Assa darlingtoni*,

Loveridge's Frog *Philoria loveridgei*, Stephen's Banded Snake *Hoplocephalus stephensi* and Albert's Lyrebird *Menura alberti* (Scotts 2003). Other vertebrates endemic to the bioregion belong to the more recently-evolved fauna of the coastal Pleistocene sands or Wallum (Coaldrake 1961), such as the Wallum Sedge Frog *Litoria olongburensis* and Heath Shadeskink *Saproscincus oriarus*, both present in the LGA.

2.3 Traditional cultural values

Much of the Byron LGA lies in the Arakwal Jugun 'Country' within the Bundjalung Nation. It is home to the traditional owners and custodians of the land, the Arakwal People. Arakwal Jugun boundaries extend from Broken Head in the south to Newrybar, Bangalow and Mullumbimby in the west, and north to the Brunswick River (Byron Shire Council 2020).

The Byron wildlife corridor system project acknowledges and respects the Bundjalung of Byron Bay, the Arakwal People, as the traditional custodians of the land within the Byron LGA, that form part of the wider Aboriginal Nation known as Bundjalung. The project also acknowledges and respects the Widjabul and Mindjungbul People (as traditional custodians within the Byron LGA) and the Aboriginal and Torres Strait Islander People who now reside within the area.

2.4 Geology

The predominant features of the north-eastern NSW landscape are the two eroded shield volcano calderas of Wollumbin (Mt Warning) in the Tweed Valley andFocal Peak to the west including Mt Barney, both of which were formed about 20–30 million years ago (see textbox).

Geology influences factors such as soil structure, fertility, permeability, nutrient availability and moisture retention. In turn, those factors influence the distribution and abundance of species and the distribution of species assemblages (co-occurring species) that shape vegetation communities.

Figure 1 illustrates the broad geology of Byron LGA. The eroded edge of the Wollumbin shield basaltic flows extends west from Hayters Hill, northwards to Main Arm and west to Lismore. On the lowlands, the rich basalt-derived soils historically supported the Big Scrub subtropical rainforests. In the north west, the basalt is overlaid by quartz-rich acid volcanic flows that form the Nightcap and Koonyum ranges. These acid volcanics (rhyolite) produce less fertile soils and typically support warm temperate rainforests (dominated by Coachwood *Ceratopetalum apetalum*) and wet and dry sclerophyll forests with grassy or shrubby understories. Capping basalt is a feature of the Nightcap Range at higher altitude.

Basaltic and rhyolitic outcroppings also occur on some of the low coastal ridges (e.g. Mt Chincogan, Montecollum-Andersons Ridge, and Tyagarah) but most of the eroded eastern coastal hills are much older exposed bedrock. Some sedimentary rocks composed of sandstones, conglomerates and siltstones (mapped as sandstone in **Figure 1**) are part of the Clarence Moreton Basin deposits. These occur from Broken Head to Coorabell (below the basalt plateau), but most of the coastal ridges and headlands are Neranleigh-Fernvale deposits of predominantly greywackes and phyllites (mapped as metasediments in **Figure 1**) dating from around 350 mya. The low fertility and poor permeability of the soils derived from this bedrock generally favour sclerophyll forest, with local enrichment by colluvium from eroded volcanic material, providing opportunity for the development of subtropical rainforest, especially on the lower slopes and in riparian galleries.

The alluvial soils along the rivers and floodplains approaching the coast (mapped as alluvium in **Figure 1**) are similarly enriched, and characteristically support lowland subtropical rainforest and swamp and wet sclerophyll forest transitions (Morand 1994). The coastal zone brings the influence of marine-aeolian and estuarine sands interacting with the alluvial mud and clay, with distinctive estuarine, coastal alluvium and coastal sand soil regimes.

Excerpt from **Border Ranges Rainforest Biodiversity Management Plan:**
The Tweed, Nightcap, Darlington, Beechmont and eastern McPherson Ranges are the eroded remnants of the Wollumbin (Mt Warning) volcano. The Wollumbin volcano had a series of eruptions creating two significantly different types of lava flows. The most extensive flows were of Tertiary basalt that weathered to form the deep fertile red soils typical of the area around Lismore. These soils usually support subtropical rainforest in wetter areas and drier vine forests (e.g. with Hoop Pine emergents) in areas where the rainfall is lower.
In places these once-extensive basalt plateaus have eroded to expose the older underlying geologies. Alluvial and colluvial deposition has subsequently formed the coastal floodplain of the major river valleys. The other type of lava flow was of rhyolite, which weathers slowly to form low-nutrient, free-draining soils. A third lava type present in these volcanoes, trachyte, generally did not occur as a flow but formed volcanic plugs and dykes.
"Rhyolites and trachytes are particularly resistant to erosion and can be seen as prominent cliffs, mountains and outcrops such as Mt Warning, Mt Lindesay, Nimbin Rocks and the cliffs of the Tweed caldera. Soils derived from trachyte and rhyolite typically supports drier eucalypt forest, but at higher elevation where rainfall is greater, these soils can support tracts of warm temperate rainforest.
Underlying these volcanic rocks are older, Triassic sedimentary rocks of the Clarence–Moreton Basin (135–200 million years old), the Triassic volcanics (200 million years old) and Silurian metamorphosed sediments (meta-sediments) of the Neranleigh–Fernvale Series (250–500 million years old). The Clarence–Moreton Basin typically comprises sandstones, claystones, mudstones and conglomerate which erode to form low-nutrient, free-draining soils.
The Neranleigh–Fernvale meta-sediments include greywackes and phyllites that outcrop along coastal headlands, the Condong and Burringbar Ranges and the hills of the Gold Coast hinterland. Because of their elevation and proximity to the coast, these areas attract higher rainfall and often support subtropical rainforest in protected gullies.
The most recently laid down geological strata, the Quaternary sediments, occur in valleys, lowlands and floodplains. These sediments have been laid down in the last 2.6 million years". (DECCW 2010 p.14).

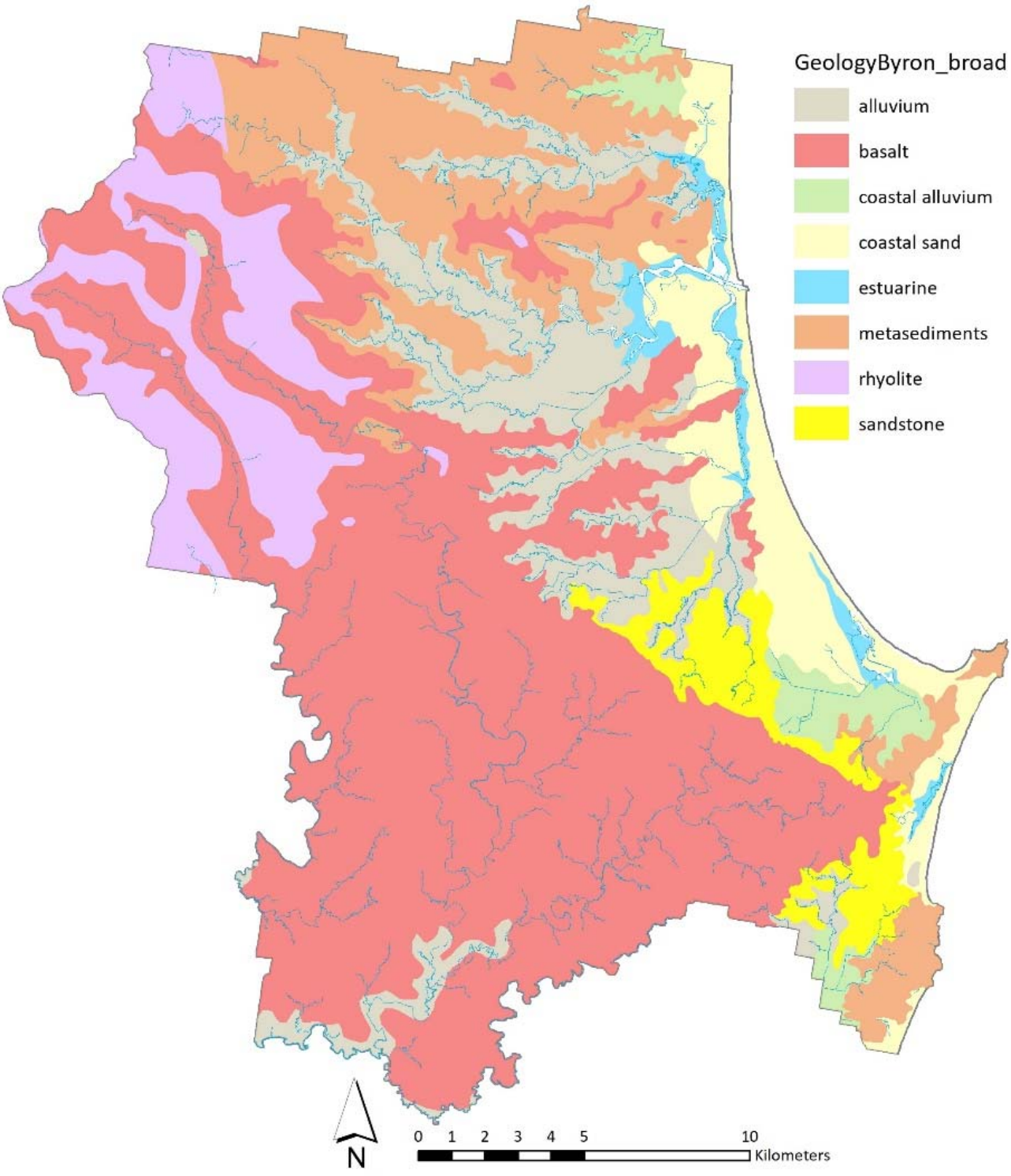

Figure 1 Broad Geology
(derived from SEED portal, OEH 2008)

2.5 Vegetation and flora species

The total area of Byron LGA is 56,717ha of which:

- 8,194ha (14%) comprises rainforest
- 4,690ha (8%) comprises wet sclerophyll forest
- 2,954ha (5%) comprises moist sclerophyll forest
- 2,402ha (4%) comprises swamp sclerophyll forest
- 1,516ha (3%) comprises dry sclerophyll forest
- 1,198ha (2%) comprises coastal complex vegetation

From these figures it can be seen that wet and moist forests cover 31% or almost one third of the area of the LGA.

2.5.1 Vegetation communities

A brief description of the native vegetation communities mapped in the LGA (McKinley and Murray 2017a and sources identified in s1.1) follows:

Rainforests

Warm temperate rainforest is found on rhyolite at higher elevation in the mountainous areas in the north-west of the LGA where fire is excluded or very infrequent. Crabapple *Schizomeria ovata* and Coachwood *Ceratopetalum apetalum* are usually dominant in the canopy and Brush Box *Lophostemon confertus* is often present. Bangalow Palm *Archontophoenix cunninghamiana* is a common understorey species.

With decrease in elevation, subtropical rainforest becomes the dominant rainforest type. Maiden's Blush *Sloanea australis*, White Booyong *Heritiera trifoliolatum*, Red Carabeen *Geissois benthamii* and Yellow Carabeen *Sloanea woollsii* and Bangalow Palm are typical canopy species.

On the coast subtropical rainforest is replaced with littoral rainforest typically dominated by Tuckeroo *Cupaniopsis anacardioides*, Three-veined Laurel *Cryptocarya triplinervis* and Brush Box.

Native vegetation on the basalt plateau that once supported the Big Scrub in the south of the LGA is now reduced to small but very significant rainforest remnants with high tree species richness and diversity. White Booyong is usually present. Black Bean *Castanospermum australe*, Red Bean *Dysoxylum mollisimum*, Pepperberry *Cryptocarya obovata* and Native Tamarind *Diploglottis australis* frequently occur. Black Bean is particularly common along creek lines. The understorey is mixed and vines are abundant.

Derived rainforest

Camphor Laurel is an exotic species. Camphor Laurel dominated forest is particularly prevalent on the basalt soils in the southern part of the LGA but also occurs on other substrates. The mid and understorey are variable with some areas containing a diverse established rainforest understorey whilst in others the understorey is sparse with few other species present. The term Derived rainforest is used to distinguish areas with Camphor Laurel dominant but with a significant component (20-50%) of the canopy and understorey comprised of rainforest species.

Wet sclerophyll forests

Wet sclerophyll forest typically occurs on rhyolite, basalts and metasediments in the mountainous areas to the north-west of the LGA.

Flooded Gum *Eucalyptus grandis* is usually found on the sheltered lower slopes, often in association with Tallowwood *E. microcorys* and frequently with a well-established rainforest understorey. The mid-slopes typically support Pink Bloodwood *Corymbia intermedia*, Tallowwood, Blackbutt *E. pilularis* and White Mahogany *E. acmenoides*.

Blackbutt forest is mainly found on the upper drier slopes and hill crests. Tallowwood, Grey Ironbark *E. sideroxylon*, White Mahogany, Pink Bloodwood and Brush Box *Lophostemon* confertus are common canopy associates. The understorey is variable but small trees such as Tree Heath *Trochocarpa laurina* and Sweet Pittosporum are usually present. The ground layer is often dominated by grasses.

Swamp sclerophyll forests

Swamp sclerophyll forests are found mainly on the floodplain on alluvium and on coastal sands. Paperbark *Melaleuca quinquenervia* is often the canopy dominant and in less waterlogged situations Forest Red Gum *Eucalyptus tereticornis*, Swamp Mahogany *E. robusta* and Swamp Box *Lophostemon suaveolens* are frequent co-dominants. Swamp Oak *Casuarina glauca* grades in with increase in salinity.

The swamp sclerophyll forest communities often intergrade with floodplain rainforest.

Dry sclerophyll forests

The drier hill slopes and crests in the hinterland block support dry sclerophyll forest communities such as Scribbly Gum *E. signata*, and Blackbutt grassy open woodland. Blackbutt and Scribbly Gum are also found on Pleistocene sands in the coastal block. Coast Cypress Pine *Cupressus columellaris*, also occurs on old sands in the coastal block.

Coastal complex

The coastal strip includes a mosaic of wet and dry heath and woodland communities with Coast Banksia *Banksia integrifolia* and Dwarf Banksia *Banksia oblongifolia* communities on sands and on metasediments. The drier sand areas are generally dominated by Wallum Banksia *Banksia aemula* shrubland. These communities intergrade with Themeda grassland communities on coastal headlands and with saltmarsh in the estuaries.

Additional planted and/or exotic vegetation is recognised and included in the 2017 mapping as follows:

- rainforest DERIVED
  (Camphor Laurel 51-80%)
- Camphor Laurel >80%
- planted exotic pine
- planted Hoop Pine
- planted landscaping, mixed
- planted orchard
- planted rainforest
- planted sclerophyll
- exotic

2.5.2 Threatened ecological communities

The Byron LGA is exceptional for the number of threatened ecological communities (TECs listed under the *BC Act 2016*) that occur proportional to its area. The high number present is a function of the geological and topographic diversity, mild coastal climate, high rainfall and the ongoing proliferation of threatening processes. The 11 TECs that occur in the LGA are:

- Byron Bay Dwarf Graminoid Clay Heath
- Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Coastal Cypress Pine Forest in the New South Wales North Coast Bioregion
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion
- Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions
- Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- *Themeda* grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions (known from Byron LGA on National Parks Estate)

Three of the 11 TECs occurring in the LGA are rainforest communities that have been cleared extensively in the past and are subject to ongoing threats, with the remainder mostly consisting of coastal plain and floodplain communities that have also been largely cleared and are suffering continuing degradation.

Four of the TECs listed under the *BC Act 2016* are also listed under the *EPBC Act 1999*, albeit under slightly different configurations and titles. These are:

- Littoral Rainforest and Coastal Vine Thickets of Eastern Australia
- Lowland Rainforest of Subtropical Australia
- Subtropical and Temperate Coastal Saltmarsh
- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland

The occurrences of the 11 TECs (*BC Act 2016*) known to be present in the LGA were derived from the High Ecological Value Vegetation (HEV) mapping of McKinley and Murray (2017b). The HEV mapping and hence the TEC mapping derived from it were confined to the parts of the LGA outside the National Parks.

2.5.3 Threatened flora species

An examination of BioNet flora records for the Byron LGA (accessed January 2022) indicates that 144 out of a total of 1907 native plant species are listed as threatened on the schedules of the *BC Act 2016* and/or the *EPBC Act 1999.* 65 of these threatened species were selected as priority

species for this project based on restricted distribution or habitat, dispersal characteristics and reproductive capabilities. These are listed in **Appendix 2**. Additional species recorded in BioNet but not included in **Appendix 2** are understood to represent planted specimens or a species reassigned to another species but still listed by its original identification. The 64 *BC Act*-listed species include two species listed as Critically Endangered, 38 species listed as Endangered and a further 24 species listed as Vulnerable. The 36 *EPBC Act*-listed species include 35 species also listed under the *BC Act* and one species not listed under the latter legislation, with 18 species listed as Endangered and 18 species as Vulnerable.

Again, many of these species are endemic to the area encompassed by the CEAR and South Eastern Queensland Bioregion (s.2.1).

2.6 Vertebrate species

2.6.1 Threatened vertebrate species

BioNet vertebrate records (accessed January 2022) indicate that 95 of 402 native terrestrial vertebrate species reported from the Byron LGA are listed as threatened under the *BC Act 2016*. This total comprises 20 species listed as Endangered and 75 listed as Vulnerable. Although both totals contain a few species included in error, the number of threatened species represents approximately 24% of the overall total vertebrates recorded for the LGA, a notably high proportion. As with threatened flora, many of these species are endemic to the area encompassed by the South East Queensland Bioregion and the CEAR.

A subset of 23 of the 95 *BC Act*-listed terrestrial vertebrate species is also listed under the Commonwealth *EPBC Act 1999*, together with an additional 3 terrestrial species occurring in the LGA that are not listed under the former Act. The 26 *EPBC Act*-listed species comprise 2 species listed as Critically Endangered, 11 species listed as Endangered and 13 species listed as Vulnerable.

2.7 Key Threatening Processes

There are a total of 39 Key Threatening Processes (KTPs) listed under the *BC Act 2016*, with 35 of those operating with varying levels of impact on biodiversity in the LGA. The majority of the latter KTPs are associated with or result from the loss or fragmentation, isolation and degradation of native vegetation. **Appendix 3** lists the 21 KTPs that constitute the main threats to biodiversity in the Byron LGA in 2022 and indicates which KTPs are also listed under the *EPBC Act 1999*.

As noted in s.2.1, the threatening processes that pose the greatest threat to species of conservation significance in the LGA are caused by clearing of vegetation causing habitat loss, fragmentation and isolation and habitat degradation. Protecting, expanding and buffering intact areas of vegetation, restoring degraded areas and reducing fragmentation by linking vegetation patches, as achieved by the implementation of a corridor system, are key mechanisms for reducing these threats. The primary KTPs that would be mitigated by a corridor system designed for the LGA are discussed below.

2.7.1 Habitat fragmentation

Fragmentation of native vegetation caused by clearing, as formally recognised by the KTP "Clearing of native vegetation" is one of the major threats to the conservation of biodiversity, resulting in local extinctions and increasing the vulnerability of populations and ecosystems to other threats. Larger, intact vegetation patches are less exposed to damaging edge effects such as wind-throw, drying winds, weed invasions and incursions by introduced predators. As vegetation patches are reduced in size and become increasingly isolated, the on-going viability of ecosystems and individual populations of species within them is severely affected (Department of Environment and Conservation 2004). Fragmentation of vegetation also reduces the likelihood of gene flow between populations, resulting in genetic isolation and "genetic bottlenecks" that reduce longer term viability of populations, eventually leading to local extinctions (Fischer and Lindenmayer 2007).

Examples of threatened plant species in the LGA particularly at risk from fragmentation are large-fruited species that lack effective dispersal mechanisms such as Crystal Creek Walnut *Endiandra floydii*, Ball Nut *Floydia praelta*, Rusty Plum *Niemeyera whitei*, Southern Ochrosia *Ochrosia moorei*, and Red Bopple Nut *Hicksbeachia pinnatifolia* and species that no longer produce viable seed and rely on suckering such as the Hairy Quandong and Smooth Davidsonia. Vertebrate species in the LGA also at risk from the effects of fragmentation include Stephen's Banded Snake, Albert's Lyrebird, Paradise Riflebird *Ptiloris paradisea* and the Long-nosed Potoroo *Potorous tridactylus*, all species that require large areas of intact habitat and appear reluctant to cross wide (non-forested) gaps between forest habitat areas.

KTPs strongly associated with and exacerbated by clearing of native vegetation and presently having the most serious impacts in the LGA, specifically involving invasions of introduced plant species or weeds, include:

- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by exotic perennial grasses
- Invasion of native plant communities by Bitou Bush and Boneseed *Chrysanthemoides monilifera*
- Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens lat.*)
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants

The threat of weed invasion is increased when vegetation becomes fragmented by clearing and edge habitat is increased. Most weed species in the LGA are favoured by the disturbance created by clearing and tend to favour edges for establishment, with subsequent invasion of less degraded habitats.

KTPs involving pest animal species that are exacerbated by clearing of native vegetation and having the most significant effects in the LGA include:

- Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*
- Competition from feral honeybees *Apis mellifera* L.
- Invasion and establishment of the Cane Toad *Bufo marinus*
- Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)
- Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)

- Predation by *Gambusia holbrooki* (Plague Minnow)

Other KTPs operating in the LGA that may be increased by clearing of native vegetation and subsequent habitat degradation involve pathogens causing diseases, particularly:

- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (Myrtle Rust)
- Infection of frogs by amphibian chytrid causing the disease chytridiomycosis

2.7.2 Anthropogenic climate change

The KTP "Anthropogenic climate change" is currently posing the greatest threat to biodiversity in the Byron LGA with the predicted increases in the frequency, duration and severity of droughts, excessively high temperatures and extreme fire weather, extreme flood events, and extreme cyclonic impacts already having severe impacts. Together with an increase in the severity of storms, cyclones and other catastrophic events, these occurrences have all been previously demonstrated by modelling for eastern Australia (State of the Climate 2020, CSIRO website accessed December 2021; AdaptNSW, accessed December 2021). Climate change is resulting in major perturbations and disturbances to ecological systems and is intensifying the effects of most of the KTPs listed in s.2.6 above.

Although many species survived previous climatic shifts by evolving, moving or modifying their behaviour, this was over a substantially longer time period than is occurring with the current more rapid changes. In addition, movement was facilitated through largely continuous forest prior to clearing. As a result, there is the likelihood of species already at their altitudinal, temperature or moisture limits or for species unable to move across unsuitable habitat to suffer local extinctions and for those with restricted ranges, to eventually become extinct across their range.

Mitigating the impacts of anthropogenic climate change will be one of the primary benefits of implementing a corridor system within the Byron LGA, through the protection and buffering of refugia and facilitating the movement of plant and animal species with poor dispersal capabilities. North east NSW is predicted to have a decrease in rainfall in summer and winter and increased rainfall during autumn and spring by 2030, but increased rainfall in summer, autumn and spring by 2070. Overall, there is likely to be an increase in fire severity in summer, although little change in winter and some decrease in fire severity during autumn due to increase in rainfall. However, increases in fire severity will occur during the peak prescribed burning season (spring) and peak fire risk season (summer). Higher temperatures and increased fire risk mean that corridor systems should maximise the inclusion of riparian, gully and south-facing slope terrain that can provide vegetation able to withstand or offer protection from these threats, creating a series of fire refugia within the system.

Corridors should be large (wide) enough to absorb the potential impacts from major flooding events.

Another issue associated with anthropogenic climate change is the projected rise in sea level over time, creating a major concern for management of the coastal zone and particularly for Wallum communities in the Byron LGA.

The potential implications of sea level rise for Wallum communities (AdaptNSW, accessed December 2021) include:

- higher projected storm surge and inundation levels
- landward recession of sandy shorelines
- salt water intrusion and landward advance of tidal limits within estuaries and the tidal reaches of major rivers

3. Development of the Byron corridor system

The value of wildlife corridors for biodiversity conservation is well established (Bennett 1990, Saunders and Hobbs 1991, Scotts 2003, Scotts and Drielsma 2003, Mackey *et al.* 2010, National Wildlife Corridors Plan Advisory Group 2012) and their provision and maintenance are particularly important in the Byron LGA. This is due to the area's significance for biodiversity conservation at a National level (s.2.1), and the isolated nature of many vegetation remnants, especially in the central and southern sections of the LGA.

3.1 Basis for development

The process for developing the Byron corridor system was initiated by:

- identifying the most "at risk" or priority vertebrate species
- grouping priority vertebrate species according to biogeographical origin, primary habitat preference, dispersal capability and conservation status
- identifying the most "at risk" or priority flora species
- assigning priority flora species to preferred habitat type, geology, propagule characteristics and dispersal mechanisms
- identifying the major habitat blocks and applying buffers
- identifying connectors
- identifying riparian corridors

3.1.1 Data sources

NSW Government and BSC databases and GIS layers were used to inform the selection of priority flora and vertebrate species and provide information on their habitat preferences, attributes and responses to threats. These sources included PlantNet, BioNet, OEH threatened species' profiles, Harden *et al.* 2016, AdaptNSW (including NicheFinder, accessed December 2021) and threatened flora and vertebrate records compiled by BSC (additional to BioNet records). Published and unpublished papers and reports relating to the Byron LGA were also sourced for this purpose, with additional information being obtained from relevant experts and local ecologists.

BSC vegetation and HEV mapping (McKinley and Murray 2017a, b) provided the basis for design of the corridor system, and locations of restoration projects incorporated into the system (including Koala management properties) were sourced from BSC.

3.2 Habitat types

For the purpose of assigning flora and vertebrate habitats, the derived composite vegetation map (s.1.1) was reclassified into 11 broad habitat types (**Table 1**, **Figure 2**) to provide a basis for assigning the habitat preferences of the species of conservation significance (priority species, s.3.3 and s.3.4 below) selected to guide the corridor design.

Table 1 Habitat types for corridor design

Vegetation habitat type	Description
high elevation rainforest >300 m	warm temperate rainforest + high elevation subtropical rainforest
low elevation rainforest <300 m	low elevation subtropical rainforest (including Big Scrub remnants) + riparian rainforest + floodplain rainforest
coastal rainforest	littoral rainforest on sand + headland rainforest
wet sclerophyll forest	wet eucalypt communities variously dominated by, e.g. Flooded Gum, Brush Box, Tallowwood, Pink Bloodwood usually with well-developed rainforest understorey
moist sclerophyll forest	Blackbutt with shrubby understorey
floodplain swamp sclerophyll forest	on alluvium, includes Swamp Mahogany, Swamp Box, Forest Red Gum
coastal swamp sclerophyll forest	on coastal sandy alluvium, typically dominated by Paperbark and/or Swamp Oak
high elevation dry sclerophyll forest >300 m	dry eucalypt communities typically dominated by Scribbly Gum and/or Blackbutt, usually with a grassy or dry shrubby understorey
low elevation dry sclerophyll forest <300m	dry eucalypt communities, usually dominated by Scribbly Gum, Blackbutt and sometimes Forest Red Gum with a grassy or dry shrubby understorey
dry coastal complex	shrubland, heathland and mallee woodland on Wallum sand and clay
wet coastal complex	shrubland, heathland and sedgeland on Wallum sand

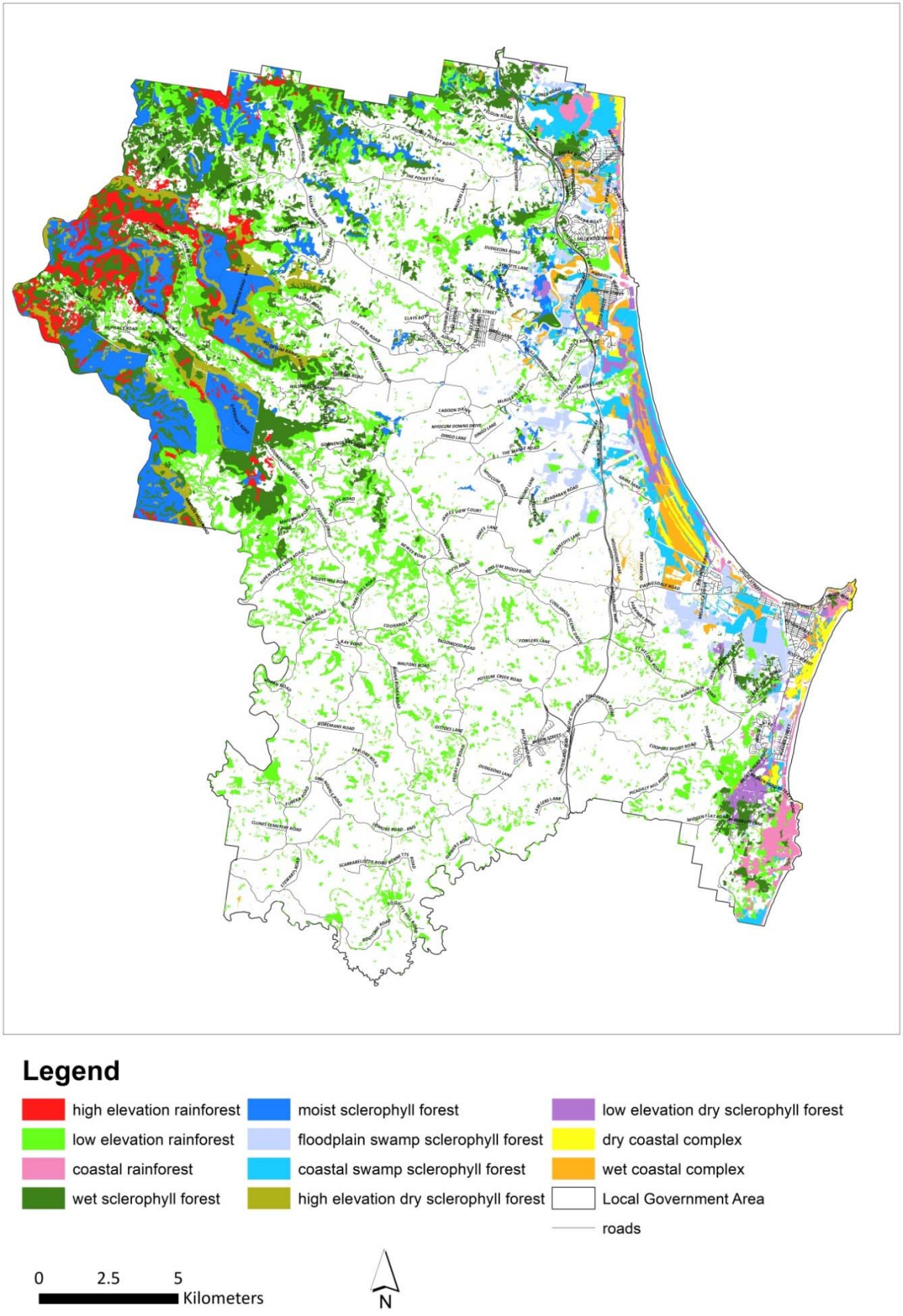

Figure 2 Habitat types
(derived from McKinley and Murray 2017a and sources identified in s.3.1.1)

3.3 Priority vertebrate species

3.3.1 Identification of priority vertebrate species

A total of 62 vertebrate species were identified as priority species to guide the design of the corridor system, being considered to have core habitat in the Byron LGA and most at risk from habitat fragmentation, isolation and degradation (**Appendix 4**). The total comprised 26 species listed under the *BC Act 2016* and an additional 36 species regarded as of regional conservation significance in previous assessments of significant fauna species of north-east NSW (NSW National Parks and Wildlife Service 1995, Scotts 1996, 2003). Species were regarded as having core habitat in the LGA if:

- they had their strongholds in north east NSW, and
- were listed as threatened under the *BC Act 2016* or had been considered of conservation significance by previous regional conservation assessments, and
- the LGA supported viable populations or provided important seasonal habitat

The numbers of records of terrestrial vertebrate species from the Byron LGA contained in BioNet (**Appendix 4**) were used as a guide to gauge whether viable populations were present, although BioNet records are subject to numerous biases (for example the number of records of the Koala opposed to records of some cryptic reptile species, **Appendix 4**). Records were also obtained from the BSC threatened fauna database and local ecologists to confirm the status of a number of species.

Zoogeographical origins of Byron vertebrates

The Tumbunan fauna has lineages dating back to the Gondwanan rainforests that covered the continent from ca.40 to 20 million years ago and typically comprise wet forest-dependent, forest-interior species with small home ranges and low dispersal capability. A large component (61%) of the 62 priority vertebrate species is representative of the Tumbunan fauna (**Appendix 4**), with minor components representative of the Irian fauna (18%, consisting of more recent colonists from the New Guinea region); the Wallum fauna (6%, comprising relatively recently evolved species largely confined to vegetation of the coastal dunes and swales developed during the Pleistocene period); the Torresian fauna (8%, species typical of the drier savannah woodlands of northern Australia); and the Bassian fauna (6%, species typical of the tall, cool forests of southern Australia). Apart from Wallum species, species representative of the other faunas were considered as less at risk than Tumbunan species to habitat fragmentation, isolation and degradation and also climate change impacts, as they have greater dispersal capability and some are adapted to drier, more open habitats.

3.3.2 Threatened vertebrate species not included as priority species

A total of 69 terrestrial vertebrate species listed as threatened under the *BC Act 2016* and with verified BioNet records from the Byron LGA were omitted from inclusion as priority species. The reasons for omission included species apparently extinct in the LGA or recorded in error and species that are vagrants or not considered to have core habitat in the LGA. The latter included a number of species that prefer drier habitats, poorly represented in the LGA, such as the Little Lorikeet *Glossopsitta pusilla*, Barking Owl *Ninox connivens*, Varied Sittella *Daphoenositta chrysoptera*, Dusky Woodswallow *Artamus cyanopterus*, Squirrel Glider *Petaurus norfolcensis*, Hoary Wattled Bat *Chalinolobus nigrogriseus* and Eastern Cave Bat *Vespadelus troughtoni*. They also included a number of species with large home ranges occurring at low densities and distributed widely outside the LGA, with high dispersal capability and mostly without large areas of preferred habitat in the LGA. These included the White-bellied Sea-eagle *Haliaeetus leucogaster*, Square-tailed Kite *Lopholaimus isura*, Little Eagle *Hieraeetus morphnoides*, Glossy Black-cockatoo *Calyptorhynchus lathami*, Powerful Owl *Ninox strenua*, Masked Owl *Tyto novaehollandiae*, Spotted-tailed Quoll *Dasyurus maculatus* and Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris*.

3.3.3 Grouping of priority vertebrate species according to zoogeographical origins, habitat preferences, dispersal capability and threatened status

The priority vertebrate species were arranged into 10 priority vertebrate groups ranked on their risk status (**Appendix 5**), derived from an analysis of zoogeographical origins, general habitat preferences, dispersal capability and threatened status (as listed under *BC Act 2016*). The zoogeographical origin of species was considered particularly important in assessing risk from lack of habitat connectivity due to the Byron LGA's high component of Tumbunan species. Tumbunan species were regarded as particularly vulnerable to habitat fragmentation and isolation and to climate change impacts due to their relictual characteristics (s.3.3.1, Zoogeographical origins of Byron vertebrates).

he general habitat preferences and dispersal capabilities of priority vertebrate species were sourced from the standard literature (e.g. Tyler and Knight 2009, Swan *et al.* 2017, Menkhorst *et al.* 2019, Van Dyck *et al.* 2013) and from consultation with local experts. The 11 broad habitat categories recognised in the LGA (**Table 1**) ranged from wet to dry types, with rainforests and wet sclerophyll forest at one end of the gradient and dry sclerophyll forest and dry coastal complex at the other. Priority vertebrate groups with wet habitat preferences were ranked at highest risk and those with dry habitat preferences at lowest risk from lack of habitat connectivity and climate change impacts. Priority vertebrate groups containing species with the lowest dispersal capabilities were ranked at greater risk from these effects than groups comprised of species with the highest dispersal capabilities. Five categories of dispersal capability were recognised consisting of low, low-moderate, moderate, moderate-high and high. The conservation status ranking of priority species followed the *BC Act 2016* listings, with Endangered species ranked at higher risk than Vulnerable species and non-listed species ranked lowest.

Species included in each of the 10 priority groups were then scored according to their habitat preferences against the 11 broad habitat types (Appendix 6) to guide corridor design on the basis of selecting the highest rated habitat types wherever possible. The results from this analysis demonstrated that low elevation rainforest and wet sclerophyll forest were the highest rated

habitats for vertebrates in the LGA, followed by high elevation rainforest, swamp sclerophyll forest on alluvium and coastal rainforest, with wet coastal complex, dry coastal complex, low elevation dry sclerophyll forest, swamp sclerophyll forest on sand, moist sclerophyll forest and high elevation dry sclerophyll forest rated lowest (**Appendix 6**).

3.4 Priority flora species

3.4.1 Identification of priority flora species

The 65 threatened flora species (*BC Act 2016 and/or EPBC Act 1999)* recorded from the LGA identified in s.2.5.3 were adopted as priority flora species for the purposes of corridor system design. These species were considered to be of high conservation significance in the Byron LGA because of their "at risk" or threatened listing

3.4.2 Assignment of species to habitat type, geology, propagule characteristics and dispersal mechanisms

The preferred habitats of priority flora species were identified through sources such as Floyd (2008) and Harden *et al.* (2016) and from consultation with local experts. The distribution of priority species within the 11 broad habitat types (**Table 1**, **Figure 2**) and on the different substrates (**Figure 1**) was checked against the recent Byron LGA vegetation mapping (McKinley and Murray 2017a) using BioNet records, geology mapping (**Figure 1**) and local knowledge for the purpose of allocation of habitat preferences (**Appendix 2**).

Rainforest was the broad habitat type of highest significance for most of the priority flora species in the LGA, as shown in **Table 1.** Low elevation rainforest (<300 m asl) was found to be the preferred habitat for the highest number of species and high elevation rainforest (>300 m asl) was also important preferred habitat.

An important consideration in corridor system development was selecting habitat blocks and connectors to incorporate the full range of different substrates within the LGA preferred by particular priority species (**Table 2**). For example, a suite of rainforest species occurs primarily on soils derived from metasediments in the north of the LGA including Marblewood *Acacia bakeri*, Davidson's Plum, Hairy Quandong and Crystal Creek Walnut. Other species such as Isoglossa *Isoglossa eranthemoides* and Sweet Myrtle *Gossia fragrantissima* are largely restricted to soils derived from basalt whereas Minyon Quandong and Peach Myrtle are found on soils of the acid volcanics in the Nightcap and Koonyum Ranges.

Table 2 Numbers of priority flora species in habitat types on different geologies in the LGA

habitat type	geology	no. of priority species	example priority species with preferred habitat
high elevation rainforest (>300m)	acid volcanics (Nimbin rhyolite)	18	*Corokia whiteana* *Elaeocarpus sedentarius* *Hibbertia hexandra* *Niemeyera whitei* *Uromyrtus australis*
-low elevation rainforest (<300m)	metasediments	17	*Acacia bakeri* *Cryptocarya foetida* *Davidsonia jerseyana* *Elaeocarpus williamsianus* *Endiandra floydii* *Floydia praealta*
	Lismore basalt	13	*Choricarpa subargentea* *Diploglottis campbellii* *Gossia fragrantissima* *Owenia cepiodora*
	alluvium	10	*Diospyros mabacea* *Floydia praealta*
coastal rainforest (on sand or headland)	metasediments	10	*Cryptocarya foetida* *Niemeyera whitei* *Senna acclinis* *Xylosma terra-reginae*
	coastal sands	5	*Acronychia littoralis* *Cryptocarya foetida*
wet sclerophyll forest	metasediments	2	*Cyperus semifertilis* *Drynaria rigidula*
moist sclerophyll forest	all geologies	0	
floodplain swamp sclerophyll forest	alluvium	2	*Corokia whiteana* *Phaius australis*
coastal swamp sclerophyll forest	coastal sands	0	
high elevation dry sclerophyll forest (>300m)	acid volcanics (Nimbin rhyolite)	0	
low elevation dry sclerophyll forest (<300m)	metasediments	0	
	coastal sands	0	
dry coastal complex	coastal sands	2	*Allocasuarina thalassoscopica* *Pterostylis nigricans*
	clay derived from metasediments	2	*Allocasuarina thalassoscopica* *Diuris byronensis*
wet coastal complex	coastal sands	0	

The preferred habitat types of priority flora species are given in **Appendix 2**.

Priority flora species with the least effective seed dispersal mechanisms were regarded as being at greater risk from these threatening processes than those with more successful mechanisms. An

examination of the dispersal strategies of the priority flora species showed that they were dependent on a wide range of dispersal mechanisms (**Appendix 2**) with differing implications for corridor design. However, consistent with the dominance of rainforest-associated species among the priority flora species, many species have small to medium-sized fleshy fruits attractive to frugivorous bird species, making them dependent for seed dispersal on species such as the rainforest-associated fruit-doves, other fruit pigeons and bowerbirds. Priority rainforest species with small to medium-sized fleshy fruits that are bird-dispersed include Stinking Cryptocarya *Cryptocarya foetida*, Minyon Quandong, Green-leaved Rose Walnut *Endiandra muelleri* ssp. *bracteata*, Small-leaved Tamarind *Diploglottis campbellii* and Spiny Gardenia *Randia moorei*.

Other important vertebrate dispersers of seeds of rainforest flora species with attractive fleshy fruits are the fruit-bats. The Grey-headed Flying-fox is an important dispersal agent of rainforest tree and vine species (Eby and Law 2008), being highly mobile and flying as far as 40 km to and from feeding areas in one night (Eby and Law 2008). The fleshy-fruited rainforest flora species dispersed by birds and fruit-bats are among the priority species with the most effective seed dispersal mechanisms but their dependence on these vertebrates makes the conservation of the vertebrate species themselves of major significance. Hence, the protection of flying-fox camps is an important factor in maintaining the dispersal mechanisms of many of the priority flora species with vertebrate-attractive fleshy fruit. Priority flora species with poor dispersal mechanisms include rainforest species with large fruits and seeds such as Ball Nut, Rough-shelled Bush Nut *Macadamia tetraphylla*, Crystal Creek Walnut, Southern Ochrosia, Red Bopple Nut and Rusty Plum.

Although large-fruited species with large seeds such as Red Bopple Nut, Rusty Plum and Rough-shelled Bush Nut are dispersed by mammals such as possums or rodents, including the Bush Rat *Rattus fuscipes* and Fawn-footed Melomys *Melomys cervinipes* (Rossetto *et al.* 2015), dispersal distances are probably short and are unlikely to be across large gaps between remnant patches. Consequently, linking and expanding small rainforest remnants will facilitate the dispersal of large-fruited species that rely on rainforest mammal species.

Two rainforest tree species, the Hairy Quandong and Smooth Davidson's Plum currently reproduce exclusively through vegetative suckering, although genetic evidence suggests these species once reproduced by seeds (Weber *et al.* 2014). Both species are endemic to the lowland rainforests of the Border Ranges (Rossetto *et al* 2004) with wild populations entirely confined to far north east NSW. These populations are widely spaced and clonal and could be thousands of years old and, although likely to be able to tolerate small disturbances, may presently be restricted to refugia where catastrophic disturbances occur infrequently (Weber *et al.* 2014). As a consequence, they are likely to be particularly vulnerable to the predicted increasing frequency of major disturbances associated with climate change. Expansion and restoration of known habitats and reconnection of isolated remnants where they occur will assist protection and expansion of clonal populations. Species such as Ball Nut, Red-fruited Ebony *Diospyros mabacea* and Durobby *Syzygium moorei* may now be primarily water-dispersed, as indicated by their current distribution patterns primarily along watercourses. Expansion and connection of riparian vegetation would assist the establishment of these species that are water-dispersed.

3.5 Habitat blocks and buffers

The Byron LGA retains significant large areas or blocks of relatively intact habitat in the hinterland and along the coast, the majority of which are reserved as National Parks or Nature

Reserves. Large intact natural areas across the world are declining and are increasingly threatened by extreme events. Such areas usually comprise or include refugia (Rossetto and Kooyman 2021, Watson *et al.* 2016 and see Kooyman *et al.* 2013). Refugia may be defined as "sites to which biota retreat, persist in and potentially expand from under changing environmental conditions" (Keppel *et al.* 2012). Groves *et al*. (2012) suggested protecting climatic refugia as one approach to climate change adaptation that could be integrated into conservation planning.

Rossetto and Kooyman (2021) identified three types of refugia:

- persistent refugia
- future refugia
- temporary refugia

Persistent refugia are defined as areas that have survived under stable environmental conditions across evolutionary time scales, resulting in continuous occupation by a species or a vegetation community in a specific location.

Future refugia are defined as areas predicted to be buffered from anthropogenic climate change, allowing for relative (dynamic) stability into the future and with secure land tenure.

Temporary refugia are defined as habitats of varying size that have survived within larger areas subject to stochastic extreme events due to specific localized conditions, such as fire-proof pockets buffered by streams, cliffs, or scree slopes.; In a larger landscape context, localized conditions can also protect spatially larger areas within 'wilderness areas' that in some scenarios may represent entire national parks or nature reserves.

In contrast to persistent refugia, which typically operate over evolutionary timescales, transient and future refugia may function for the benefit of species affected by changes to habitat and climatic conditions over quite short timeframes.

Linking the hinterland habitat blocks in the Byron LGA that fall within the Border Ranges refugium of Weber et al. (2014; s.2.1) with the coastal habitat blocks is considered to be the highest priority for the Byron corridor system project. This is because they include both persistent and future refugia as defined by Rossetto and Kooyman (2021) and they provide crucial refugia for threatened (*BC Act 2016*, *EPBC Act 1999*) flora and vertebrate species. Such species include Corokia *Corokia whiteana*, Minyon Quandong, Hairy Quandong, Small-leaved Hazelwood *Symplocos baeuerlenii* and Peach Myrtle *Uromyrtus australis* and threatened vertebrate species including the threatened Pouched Frog, Loveridge's Frog, Stephen's Banded Snake, Marbled Frogmouth, Albert's Lyrebird, Common Planigale *Planigale maculata*, Greater Glider *Petauroides volans*, Red-legged Pademelon, Eastern Tube-nosed Bat, Eastern Blossom-bat *Syconycteris australis* and Eastern Long-eared Bat *Nyctophilus bifax*.

The process for developing the Byron corridor system was initiated by first identifying the hinterland and coastal habitat blocks, which contained the main local refugia provided by National Parks and Nature Reserves. They also contained the major areas of preferred habitats for the most "at risk" flora and vertebrate species and of the TECs. Buffers were then applied to the blocks, which in most cases provided protection to the boundaries of the National Parks estate.

3.6 Connectors

Major connectors were then selected to link the habitat blocks, either directly or via additional connectors and to incorporate the Big Scrub remnants, most of which fell outside the identified

habitat blocks. Minor connectors were selected to link major connectors or to link with other minor connectors.

In selecting and defining major and minor connectors linking the identified habitat blocks, the principles followed were:

- selection of the shortest vegetated links incorporating the least fragmented vegetation in the best condition (1A-1B, 2A-2B vegetation condition classes; McKinley and Murray 2017b)
- preferentially incorporating the habitat types with the highest preferred habitat ratings for priority vertebrate species (**Appendix 6**) and habitat types catering for the highest number of priority flora species (**Appendix 2**)
- attempting to attain a minimum width of 500 m for major connectors and a minimum width of 100 m for minor connectors
- catering for known populations of priority flora species, particularly species with restricted occurrences in the LGA (**Appendix 2)** and known populations and habitat for the highest priority vertebrate species (priority group 1 species, **Appendix 5**)
- incorporating HEV mapping polygons (McKinley and Murray 2017b) associated with TECs
- incorporating lands covered by the Coastal State Environmental Planning Policy (SEPP)
- application of minimum width buffers to NPWS estate, BSC reserves and watercourses as specified in **Table 3**
- incorporating a substantial area of south-facing slopes (in addition to north-facing slopes) and gullies within major connectors to assist in mitigating the impacts of anthropogenic climate change
- incorporating sections of elevated land adjoining floodplain areas within blocks and connectors to cater for flooding events and relocation of flora and fauna with sea level rise

Other factors taken into consideration in development of the corridor system were:

- including areas where regeneration of native vegetation was known to have taken place
- including areas where plantings of Koala food trees were known to have occurred and areas of known Koala habitat
- aligning connectors intersecting with the M1 Motorway with fauna under- or over-passes and bridges and culverts to maximise faunal movements across this major barrier
- avoiding designated Prime Agricultural Land and future development areas identified by BSC
- providing linkages with designated corridor systems or identified major habitat blocks in adjoining LGAs

To ensure that native vegetation in highest condition classes was included to maximum effect within connectors, the maps of native vegetation were filtered to highlight only those polygons where the vegetation was in high condition, defined as condition classes 1 - 2 and cover classes A – B (McKinley and Murray 2017a,b; **Figure 3**).

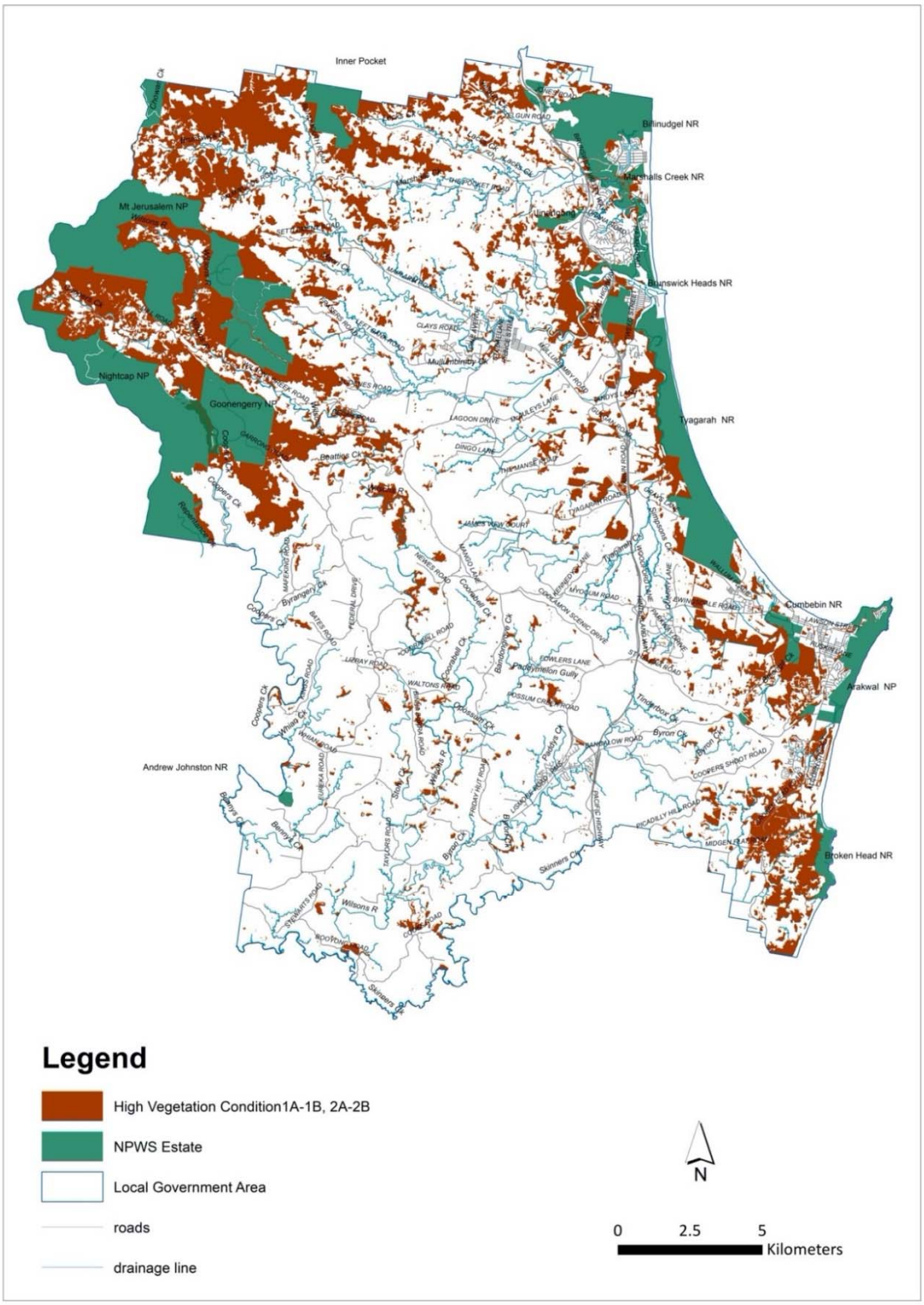

Figure 3 Native vegetation in highest condition classes

3.7 Riparian buffers (corridors)

The local riparian network was also incorporated as a primary element of the corridor design, providing linear connectivity across the landscape and supporting diverse aquatic habitats together with the preferred habitats of many of the priority species and communities.

Riparian vegetation, at the interface between terrestrial and aquatic ecosystems and consequently somewhat linear, plays a crucial role in supporting and connecting biota and therefore conserving biodiversity. Riparian buffers or corridors serve a vital function in allowing the movement of flora and fauna between remnant vegetation as well as functioning as habitat in their own right (Jansen and Robertson 2001, MacNally *et al.* 2000). Riparian vegetation, together with large woody debris and aquatic vegetation within the watercourse, provides shelter, feeding and breeding habitat for many native invertebrate and invertebrate species, shading the water, reducing evaporation and providing refuge for additional fauna species during drought (Waters and Rivers Commission 2005) and fire (Pettit and Naiman 2007).

Riparian areas will become increasingly important as refugia with the escalating extended drying periods and more frequent severe fires caused by anthropogenic climate change and provide a logical framework for the design of any corridor system. An increase in frequency and severity of flood events such as those experienced in March 2022 will have serious impacts on riparian systems and this can, to an extent, be countered by ensuring riparian corridors are as wide as possible. The NSW Government (Department of Primary Industries 2012) recommends maintaining a variable width vegetated riparian zone (measured from the top of the highest bank on both sides of a watercourse) based on the watercourse order (**Table 3**, Strahler 1952).

Table 3 Minimum buffer widths applied either side of watercourses to create riparian buffers and also to NPWS estate and Big Scrub remnants

	buffer width, m	notes
1st, 2nd order watercourse#	30*	applied only where watercourse intersects with a habitat block or connector
3rd to 7th order watercourse#	50*	
NPWS estate, BSC reserve, Big Scrub remnant	50	
habitat block outside NPWS estate	nil	buffer incorporated in habitat block

#stream order following Strahler system (Strahler 1952)

**buffer width greater than that recommended by NSW Office of Water 2012, to provide increased habitat and movement benefits to fauna and increased watercourse health benefits.*

4. Corridor system outcomes, refinement and assessment

4.1 Corridor system components

The corridor system development process and application of the principles outlined in s.3.1 above to the Byron LGA produced a corridor system, termed the Byron Wildlife Corridor System 2022, consisting of 11 habitat blocks, 26 major connectors, 26 minor connectors and a network of riparian buffers. A total of 28 Big Scrub remnants were included in the system, primarily embedded in major connectors (**Figure 4, Appendix 7**).

4.1.1 Data fields accessible within the corridor system components

The mapping layer of habitat blocks, major and minor connectors and Big Scrub remnants provided as a GIS allows interrogation of each of the blocks, connectors and remnants to provide information on a range of data fields including the habitat types and geologies present, overall vegetation condition, TECs present, known records of threatened flora and vertebrate species (*BC Act 2016*) and other priority vertebrate species, presence of Koala habitat and recommended restoration actions. An example of the data fields is provided in **Appendix 8**. Codes were used in the GIS to denote the attributes present in each of the data fields for each habitat block or connector (**Appendices 8** and **9**).

In addition to the data extracted from GIS layers and databases, a refugial status field was added to each habitat block based on Rossetto and Kooyman's (2021) definitions of temporary, persistent or future refugia. The assignment of refugium was not necessarily applied to a whole polygon but depended on, for instance, land form, tenure and vulnerability to fire, flood, erosion, drought.

Calculation of the areas of the 11 broad habitat types encompassed by the Byron corridor system shows that the system contains very high percentages (mean 93.4%) of the total areas of the types present in the LGA (**Table 4**). These range from 99.6% of the total area of high elevation dry sclerophyll forest to 79.7% of the total area of low elevation rainforest. **Table 4** also provides a breakdown of the areas of other mapped units from the 2017 Byron mapping (McKinley and Murray 2017a).

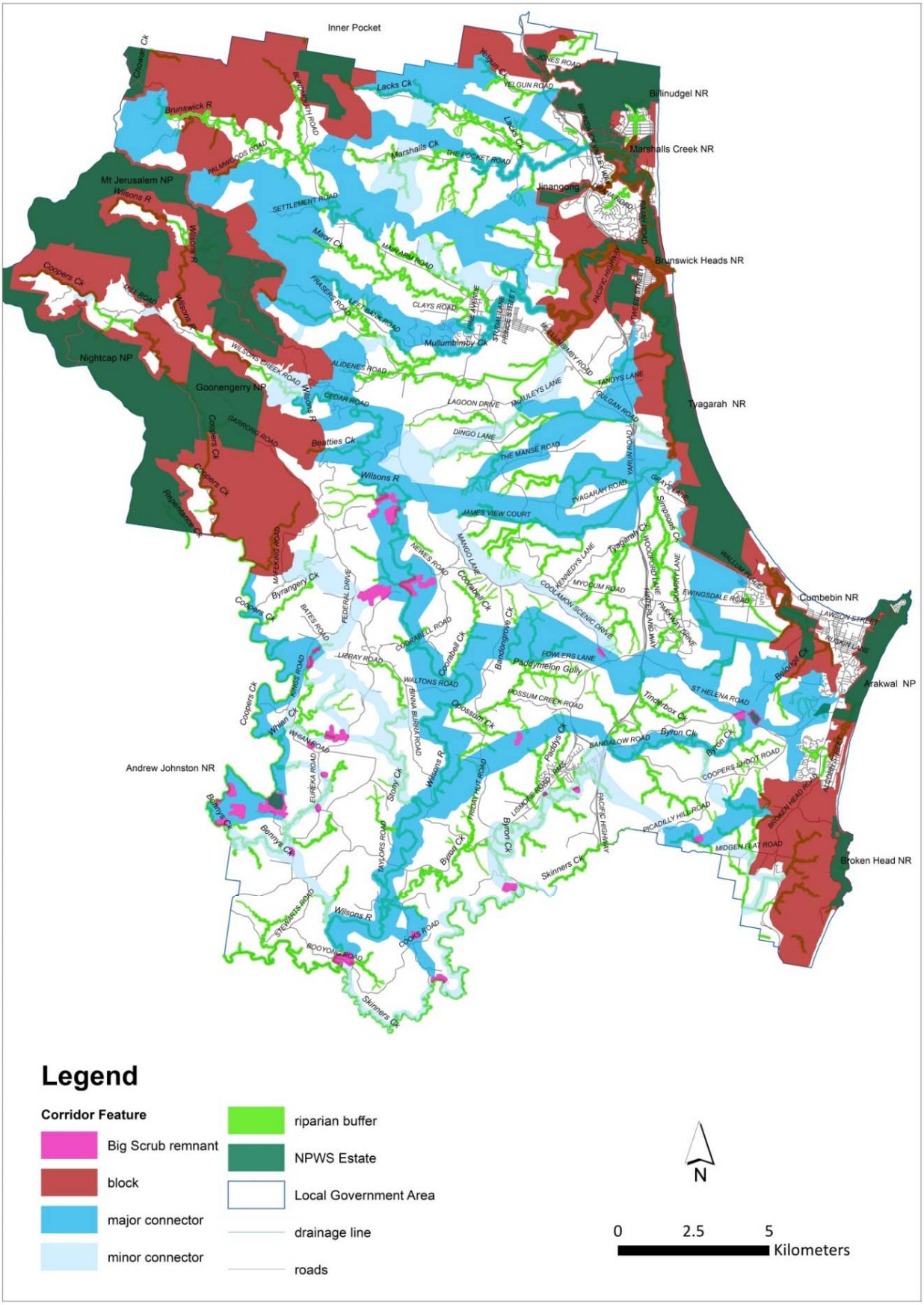

Figure 4 Byron Wildlife Corridor System 2022

Table 4 Percentages of the 11 habitat types and other mapped units within the LGA compared with areas of the 11 habitat types and other units included in the corridor system

(The areas are derived from the combined habitat type map as described in s 3.2)

	total area within LGA, ha	total area within habitat blocks and connectors, ha	total area within riparian buffers outside habitat blocks and connectors, ha	combined total area within blocks and connectors and riparian buffers, ha	% of total area within LGA
habitat types					
dry coastal complex	372.69	369.05		369.05	99.0
wet coastal complex	825.56	778.56	16.41	794.97	96.3
low elevation dry sclerophyll forest	524.64	488.10	2.10	490.20	93.4
high elevation dry sclerophyll forest	991.15	986.95		986.95	99.6
moist sclerophyll forest	2953.98	2886.49	0.36	2886.85	97.7
coastal rainforest	544.30	515.52	0.70	516.22	94.8
high elevation rainforest	1141.48	1066.51		1066.51	93.4
low elevation rainforest	6507.74	4977.16	209.66	5186.83	79.7
coastal swamp sclerophyll forest	1319.58	1263.35	6.43	1269.78	96.2
floodplain swamp sclerophyll forest	1082.63	909.44	20.93	930.37	85.9
wet sclerophyll forest	4690.29	4261.16	19.95	4281.11	91.3
other mapping units					
rainforest DERIVED (Camphor Laurel 51-80%)	3159.81	1871.87	134.75	2006.62	63.5
Camphor Laurel >80%	2017.89	891.59	115.06	1006.65	49.9
open water	266.48	157.75	34.65	192.40	72.2
planted exotic pine	96.63	49.69	3.92	53.61	55.5
planted Hoop Pine	19.47	10.56	0.28	10.85	55.7
planted landscaping, mixed	785.26	291.59	37.12	328.71	41.9
planted orchard	1971.13	379.36	32.78	412.14	20.9
planted rainforest	434.77	264.82	22.40	287.22	66.1
planted sclerophyll	953.64	353.20	21.48	374.67	39.3
exotic	260.92	163.80	7.02	170.82	65.5
Total	**30920**	**22936**	**686**	**23622**	

Table 4 demonstrates that the corridor system incorporates a high proportion of each of the 11 habitat types recognised in the LGA and with adequate revegetation and restoration to close existing gaps and restore vegetation condition, provides a realistic solution for maintaining populations of priority species, plant communities and overall biodiversity values in the LGA.

4.2 Priority species distribution patterns

The examination of records of priority flora and vertebrate species from BioNet and other sources (s.3.3 and s.3.4 above) revealed varying distribution patterns within the LGA. Some flora species exhibited LGA-wide distributions whereas others had restricted distributions, in some cases occurring mainly on soils derived from particular geologies, as discussed in s.3.4 above. Vertebrate species exhibited a similar variation in patterns of distribution, although this was partly influenced by their dispersal capabilities. Some species with high dispersal capabilities had LGA-wide distributions whereas other species with low dispersal capabilities were restricted to hinterland or coastal habitats. Some rainforest species with low dispersal capabilities displayed patterns indicating relict distributions in the hinterland and coast, whereas other primarily hinterland species with moderate dispersal capabilities exhibited distributions suggesting recent colonisation of coastal habitats.

Examples of the varying distributions of a selection of flora and vertebrate species are described and mapped in **Appendix 10**.

4.3 Inclusion and connectivity provided for priority vertebrate and flora species and TECs

The Byron Wildlife Corridor System 2022 was checked for its effectiveness in catering for the priority flora and vertebrate species and their preferred habitats in the LGA by overlaying maps of the species' occurrences derived from BioNet and other validated records. Priority vertebrate species occurrences were first overlaid on the mapped corridor system and good correlations were observed, as expected since priority vertebrate species and their habitats had been the initial drivers of corridor design. As a generalisation, flora species records were found to be less well correlated with the corridor system configuration and consequently relevant adjustments were then made to the system, primarily to major connectors, to include additional locations of priority flora species and to consolidate connectivity that was expected to improve gene flow.

Overlaying of the HEV mapping (McKinley and Murray 2017b) as indicative of the presence of TECs showed that most were included in the corridor system.

Examination of records of the group of threatened vertebrate species known to occur in the LGA but excluded as priority species (s3.3.2) showed that these were well catered for by the selected corridor system, with most of their occurrences and substantial areas of their preferred habitats included in the extensive hinterland and coastal habitat blocks.

4.4 Comparison with existing corridor systems

The corridor system was then overlaid on the three existing wildlife corridor systems incorporating or prepared for the LGA (s.1.1) to demonstrate how the system compared with and addressed the limitations that had been identified in these systems. The overlays are shown in **Appendix 11** and indicate that the Byron Wildlife Corridor System 2022 incorporates all the components of these systems and also addresses their various deficiencies. Specific improvements include the application of riparian buffers to waterways that are currently not vegetated, extending

and connecting truncated corridors and by including more comprehensive connections with Big Scrub remnants.

4.4.1 NPWS key habitats and corridors system

The NPWS key habitats and corridors system (Scotts 2003; **Appendix 11**) is designed primarily to link NPWS estate at the regional and sub-regional levels. It incorporates the main refugia or large unfragmented habitat blocks within the Byron LGA including Nightcap, Goonengerry and Mt Jerusalem National Parks and Whian Whian State Conservation Area in the hinterland, and Billinudgel, Brunswick Heads, Tyagarah, Cumbebin and Broken Head Nature Reserves and Arakwal National Park along the coast. Both the hinterland and coastal blocks comprise sections of regional corridors that link through the adjoining Tweed, Lismore and Ballina LGAs with regional corridors connecting refugia throughout north east NSW.

Within the Byron LGA, this system provides continuous north-south habitat connections through the hinterland and coastal areas, and four vegetated linkages between the hinterland and coast. However, there are several truncated corridors in the south of the LGA and connectivity is lacking in this area. Most of the Big Scrub remnants that occur in the south of the LGA are also not linked by the NPWS system. The NPWS system excludes many riparian buffers or corridors within the LGA, reflecting the absence of substantial areas of vegetation along many watercourses at lower altitudes, particularly in the centre and south of the area.

4.4.2 OEH climate change corridors system

The OEH climate change corridors system (State Government of NSW and Department of Planning, Industry and Environment 2010; **Appendix 11**) provides wide links across the LGA that cater for broad groupings of the NPWS key habitats and corridors vertebrate assemblages. Two assemblage groups, moist and coastal complex are recognised as present in the LGA, comprised of species from these habitats grouped on the basis of their perceived risk from climate change impacts. The three major habitat blocks in the hinterland, encompassing sections of the Nightcap, Koonyum and Burringbar Ranges and mostly falling within Nightcap, Goonengerry and Mt Jerusalem National Parks, are linked via a wide moist corridor in the north and a narrower moist corridor in the south to a continuous north-south coastal complex corridor. There is also a coastal complex corridor providing a further coast to hinterland link through the Brunswick River floodplain. The wide hinterland moist corridor links to moist corridors in adjoining Tweed and Lismore LGAs and there is a narrower moist link to a moist corridor to the south in the Ballina LGA.

The OEH corridor system provides improved spatial connectivity within the LGA compared with the NPWS system but includes major vegetation gaps that reduce its functionality. It also omits any connection through the centre of the LGA and incorporates few Big Scrub remnants.

4.4.3 BSC wildlife corridors system 2004

The BSC wildlife corridors system (Byron Shire Council 2004; **Appendix 12**), which excludes NPWS estate, provides links to the major habitat blocks encompassed by NPWS estate in the

hinterland and along the coast. This system provides four primary links from the coast to the hinterland that follow the links in the NPWS system and although expanding and improving these links, contains some truncated corridors. It appears to follow the vegetation cover extant at the time of its configuration, but the system is not supported by a development rationale. As with the other systems, it provides minimal connectivity in the south of the LGA and does not link many Big Scrub remnants.

4.5 Inclusion of relevant attributes and values

Additional overlays on relevant attribute and values layers available for the LGA showed that the 2022 system also provided for:

- connection with established corridor systems and major habitat blocks in adjoining LGAs
- incorporation of lands covered by the Coastal Management SEPP
- incorporation of areas of higher elevation land adjoining the coastal plain to accommodate sea level rise
- incorporation of areas of southern-facing slopes and gullies to mitigate anthropogenic climate change
- inclusion of known areas of native vegetation regeneration including Koala food tree plantings and areas of designated Koala habitat
- inclusion of northern slopes with existing or potential for regeneration of moist and dry sclerophyll forest communities
- aligning coast to hinterland (east-west) connectors with designated fauna crossings, bridges and culverts allowing vertebrate movements across the M1 Motorway

5. Limitations

The database layers used to inform the mapping for the Byron Wildlife Corridor System 2022 (vegetation, soil landscapes, streams and rivers, flora and vertebrate records) all have inherent limitations to their use. Accuracy of point data for species records (especially historic records) is highly variable. As an example, a significant percentage, (12.9%), of the priority flora species records were located outside mapped vegetation polygons. However, most of these were able to be accommodated within the corridor system boundaries.

The 2015 air photo series provided by Council *(Byron_22Apr2015_MGA94z56.ecw)* as the basis for corridor mapping is now seven years old. Many land-use changes since that time (native vegetation clearing, Camphor Laurel removal, native regrowth, restoration projects) are not represented in the corridor system and with access to more recent photography, it is likely that mapping of connectors could be modified or expanded in some areas to incorporate these changes and allow the 2022 system to more accurately prioritise revegetation for effective connectivity. Although effort was made to achieve maximum connectivity of native vegetation within connectors by including existing restoration plantings, and in some instances large areas currently dominated by Camphor Laurel, many un-vegetated gaps occur within the system. These are likely to inhibit movements of priority flora and vertebrates, particularly those with poor dispersal capabilities, and should be viewed as priorities for revegetation.

The project brief required

> *"Identify and rank key habitats for vertebrate and plant assemblages using mapped PCTs in current Byron vegetation mapping, with particular attention to threatened ecological communities."*

It was not possible to comply with this requirement of the brief as suitable PCT mapping was not available. Vegetation classification in the 2017 BSC vegetation mapping (McKinley and Murray 2017a) used Keith classes (Keith 2004) in addition to candidate or draft Plant Community Types (PCTs). The draft PCTs were supplied by OEH prior to finalisation of a description of these vegetation units for northern NSW and many did not fit the communities occurring in the Byron LGA. Consequently, not all mapped vegetation polygons could be assigned to PCTs and in addition, the BSC vegetation mapping did not cover the whole of the LGA, omitting the National Parks estate.

6. Recommendations

6.1 Priorities for restoration of corridor system components

The habitat blocks and connectors comprising the Byron Wildlife Corridor System 2022 were selected to protect and improve the habitat of significant flora and vertebrate species and ecological communities in the Byron LGA for the long-term, with an emphasis on providing opportunities for survival and adaptation to climate change.

Priorities for revegetation should include the numerous unvegetated gaps and vegetation in poor condition that were identified within the major and minor connectors and riparian buffers (s.5). The habitat blocks, providing the largest and most important refugia, are considered of highest priority for protection through revegetating any gaps and consolidating buffers. The major connectors, Big Scrub remnants and riparian buffers are also regarded as of high priority for both protection and restoration. The corridor system components that should receive the major focus in the planning and implementation of regeneration planting and restoration are:

- the major coast to hinterland connectors
- connectors directly linking blocks
- the north-south Koonyum-Goonengerry-Wilson's River-Booyong major connector
- riparian buffers along major rivers and streams including the Brunswick River, Lacks Creek, Marshalls Creek and Byron Creek.

6.2 Plantings to be informed by site attributes

The diversity of physical landscape attributes (terrain, aspect, soils) occurring across the LGA is reflected in the number of different vegetation communities present and in the varying distributions of individual flora species. For example, the preferred habitats of a number of the priority flora species were found to occur on soils derived from particular geologies (**Table 2**). The inclusion of these habitats in the corridor system highlights the importance of selecting species for corridor restoration plantings appropriate for the soils and other attributes of respective sites. Communities on ridge lines for instance are likely to have a different floristic composition compared with communities on north-facing slopes and those on south-facing slopes are likely to be different again.

Plantings at sites within the corridor system should aim to use locally-sourced species representative of the local vegetation communities present in that section of the corridor system. The result should be a mosaic of vegetation communities suited to the different environmental attributes of the site. Plantings should attempt to reconstitute the floristic composition of vegetation communities likely to have been present prior to European settlement based on advice from BSC and local Landcare groups. The TreesNearMe app (State of NSW and Department of Planning and Environment 2021) provides an informative guide to the likely vegetation communities that existed on a site pre-clearing.

Plantings on the LGA's basalt soils which previously supported stands of the Critically Endangered lowland subtropical rainforest that was part of the Big Scrub Rainforest should be limited to rainforest species representative of the communities that comprise this ecosystem.

These forests provide refugia for many species with ancient Gondwanan and Indo-Malesian lineages and comprising a significant proportion of the priority flora species.

Soils derived from metasediments provide core habitat in the LGA for several Endangered priority flora species such as Hairy Quandong and Davidson's Plum. Restoration on metasediments should, again, focus on those species which naturally occur in the various communities that occur on this substrate.

Riparian vegetation in the Byron LGA provides an important refuge during drought and fire and riparian plantings should be generally restricted to the rainforest species that usually occur on alluvium or the different soil types in steeper catchments. The refugia provided by riparian vegetation together with that on south-facing slopes are likely to become increasingly important as high temperatures, drought and increased severe fire frequency increase due to anthropogenic climate change.

Plantings with eucalypts on north-facing slopes may require regular cool burns to maintain these communities and to reduce fire hazard.

6.3 Plantings to enhance genetic diversity

Plantings should attempt to increase the genetic diversity of isolated populations through the use of stock obtained from within a species' local range. Rossetto *et al.* (2019) provide a "replicable framework for gathering and interpreting evolutionary, ecological, and genomic data" to support restoration practices. At a time of rapid climatic change and continuing widespread native vegetation clearing, restoration projects need to focus on producing resilient and long-term, self-sustaining populations. Rossetto *et al.* (2019) have expanded current knowledge of genetic provenance via genome-scan data, environmental niche modelling and site-specific climate information to provide more precise guidance for restoration projects using analysis of leaf tissue representative of the distributions of over 100 species commonly used in restoration on the NSW North Coast. This guidance includes advice on the selection of genetic material that may be adapted to future climatic conditions, for example where the range of a northern NSW species extends to coastal north Queensland. Here, the introduction of genetic material of northern provenance to a subtropical population may improve the capacity of the species locally to withstand the impacts of increasing climatic warming.

6.4 Plantings to cater for vertebrate species

In plantings involving the restoration of rainforest, particularly replacement of the introduced Camphor Laurel, the emphasis should be on selecting winter-fruiting laurel species and other winter-fruiting, fleshy-fruited native species favoured by vertebrate frugivores such as the fruit-doves and flying-foxes. This is because of the present dependence by these frugivores on the extensive winter food resource provided by Camphor Laurel (Date *et al.* 1996). Priority in rainforest restoration planting in fragmented landscapes should focus on establishing a predominance of fleshy-fruited tree species attractive to vertebrate seed dispersers at other times of the year, particularly large-gaped bird species (Green 1993).

With increasing pressure on orchardists from the Grey-headed Flying-fox due to continuing clearing of their preferred natural food resources (Eby and Law 2008), benefits to both flying-foxes and orchardists could be achieved by replanting winter and spring-flowering tree species

that are appropriate to the locality. Winter and spring-flowering species suitable for the Byron LGA include Coast Banksia, Black Bean, Forest Red Gum, Blackbutt, Pink Bloodwood, Swamp Mahogany and Paperbark (Law *et al.* 2002).

Where plantings of eucalypt food trees favoured by the Koala are being undertaken, particularly in areas that formerly supported rainforest, these should be interspersed and buffered by rainforest species to reduce their potential for destruction by wildfire.

The inclusion of small stands of Black She-oak *Allocasuarina littoralis* and Forest Oak *Allocasuarina torulosa*, favoured food trees of the Glossy Black-cockatoo in sclerophyll plantings, particularly in hinterland locations would benefit this Vulnerable species and assist in replacing the important food resource destroyed during the 2019 wildfires in these areas.

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APPENDIX 1 Project brief

1. Prepare GIS project containing baseline data supplied by Byron Council along with previous habitats and corridors mapping developed for North Coast region and adjacent LGAs. The GIS platform will be ESRI ArcGIS.

2. Derive a list of conservation-priority terrestrial vertebrate and plant species (including threatened species listed under the BC Act 2016) and threatened ecological communities known from Byron Shire using BioNet ATLAS records, Adapt NSW biodiversity tools and source additional records from the published and unpublished literature and local observers). Derivation of the list of conservation-priority species will consider:

- *Threatened species and their conservation status*
- *Other conservation-priority species identified by previous regional biodiversity conservation assessments*
- *Species with limited dispersal capability*
- *Species and communities most vulnerable to climate change, including altitudinally restricted species*
- *Potential future impacts of climate change on existing vegetation communities and their constituent plant and vertebrate species*

3. Identify potential corridor systems in Byron Shire through an examination of

- *Existing connectivity across the landscape*
- *Existing protected areas on public and private land and recently restored land and land under restoration*

4. Review existing identified key habitats and wildlife corridor systems for the Byron Shire in relation to their effectiveness for achieving conservation of conservation-priority species, e.g. Scotts 2003, DECC 2007.

5. Map conservation-priority terrestrial vertebrate and plant species and threatened ecological communities from available datasets and identify clusters indicating the locations of refuges for these species and communities in the Byron Shire.

6. Rank conservation priority terrestrial vertebrate and plant species on the basis of dispersal capability including plant species relative to reproductive strategies.

7. Rank conservation-priority terrestrial vertebrate and plant species on the basis of perceived level of risk from threats, particularly those associated with climate change, wildfires, droughts, elevated temperatures and other impacts resulting in habitat, modification, isolation and fragmentation. The buffers to National Parks and Nature Reserves in the Nightcap and Koonyum Ranges will be critical for future management to reduce fire threats to rainforest.

8. Identify and rank key habitats for vertebrate and plant assemblages using mapped PCTs in current Byron vegetation mapping, with particular attention to threatened ecological communities.

9. Select and map corridors focusing on the occurrence of the largest blocks of native vegetation containing the key habitats of highest significance for the highest ranked assemblages in establishing hubs for connection in a corridor matrix. Rank corridors in accordance with their importance in the landscape, include consideration of links to key habitats and corridors in adjacent shires.

APPENDIX 2 Conservation status, preferred habitats and dispersal mechanisms of priority flora species

arranged alphabetically by family and by genus

family	scientific name	*BCA 2016*	*EPBC 1999*	common name	dispersal mechanism	habitat type (mostly occurs)	vegetation classes (also occurs)	geology - (mostly occurs on)	notes
Acanthaceae	*Harnieria hygrophiloides*	E			seed	low elevation rainforest		metasediments, coastal sands	
Acanthaceae	*Isoglossa eranthemoides*	E	E	Isoglossa	capsules	low elevation rainforest	high elevation rainforest	alluvium, Nimbin rhyolite	
Apocynaceae	*Ochrosia moorei*	E	E	Southern Ochrosia	seeds in stone, within red fleshy fruit	low elevation rainforest		basalt	
Argophyllaceae	*Corokia whiteana*	V	V	Corokia	drupe, fleshy, stone usually solitary, 1 seeded	high elevation rainforest	coastal swamp sclerophyll forest	Nimbin rhyolite, alluvium	
Asclepiadaceae	*Cynanchum elegans*	E	E	White-flowered Wax Plant	seed, a stone within a red fleshy fruit	coastal rainforest		metasediments	1 record in Brunswick NR
Asclepiadaceae	*Marsdenia longiloba*	E	V	Slender Marsdenia	seeds	low elevation rainforest		metasediments	
Casuarinaceae	*Allocasuarina thalassoscopica*		E		fruit, a samara	dry coastal complex		coastal sands, metasediments	
Cunoniaceae	*Davidsonia jerseyana*	E	E	Davidson's Plum	seed, a pyrene within a purple fleshy drupe	low elevation rainforest		metasediments	in north of LGA
Cunoniaceae	*Davidsonia johnsonii*	E	E	Smooth Davidson's Plum	not viable	low elevation rainforest	high elevation rainforest	metasediments, basalt, Nimbin rhyolite	
Cyperaceae	*Cyperus rupicola*	V		Cliff Sedge	nut	high elevation rainforest		Nimbin rhyolite	cliffs in Wollumbin and Nightcap NPs
Cyperaceae	*Cyperus semifertilis*	E	V	Missionary Nutgrass	nsut	wet sclerophyll forest		metasediments	
Dilleniaceae	*Hibbertia hexandra*	E		Tree Guinea Flower	dry fruit, 1 or 2 follicles	high elevation rainforest		Nimbin rhyolite	1 record in Goonengerry NP

family	scientific name	*BCA 2016*	*EPBC 1999*	common name	dispersal mechanism	habitat type (mostly occurs)	vegetation classes (also occurs)	geology - (mostly occurs on)	notes
Doryanthaceae	*Doryanthes palmeri*	V		Giant Spear Lily	seed, winged, in capsule	high elevation rainforest		Nimbin rhyolite	cliffs about Nightcap and Koonyum Ranges
Ebenaceae	*Diospyros mabacea*	E	E	Red-fruited Ebony	seed, within a red fleshy berry	low elevation rainforest		alluvium	1 record on Brunswick R
Elaeocarpaceae	*Elaeocarpus sedentarius*	E	E	Minyon Quandong	seeds within a blue flesh-covered stone	high elevation rainforest		Nimbin rhyolite	
Elaeocarpaceae	*Elaeocarpus williamsianus*	E	E	Hairy Quandong	seeds within a blue flesh-covered stone	low elevation rainforest		metasediments	
Euphorbiaceae	*Acalypha eremorum*	E	E	Acalypha	dry fruit, schizocarpic capsule	low elevation rainforest		alluvium	
Euphorbiaceae	*Fontainea australis*	V	V	Southern Fontainea	stone within a red fleshy fruit	low elevation rainforest		basalt	
Fabaceae (Caesalpinioideae)	*Caesalpinia bonduc*	E		Knicker Nut	seed, enclosed in follicle	coastal rainforest		coastal sands	
Fabaceae (Caesalpinioideae)	*Senna acclinis*	E		Rainforest Cassia	seeds, within a dry flat pod	coastal rainforest		metasediments	
Fabaceae (Faboideae)	*Desmodium acanthocladum*	V	V	Thorny Pea	seed in velcro pod	low elevation rainforest		alluvium	
Fabaceae (Mimosoideae)	*Archidendron hendersonii*	V		White Lace Flower	seeds, within orange pod	coastal rainforest		metasediments, alluvium	
Flacourtiaceae	*Xylosma terrae-reginae*	E		Xylosma	seeds, within a red-purple fleshy berry	coastal rainforest		metasediments	
Grammitaceae	*Grammitis stenophylla*	E		Narrow-leaf Finger Fern	spores	high elevation rainforest	low elevation rainforest	Nimbin rhyolite, basalt	all records in NPWS estate
Lamiaceae	*Plectranthus nitidus*	E	E	Nightcap Plectranthus	seeds	high elevation rainforest		Nimbin rhyolite	
Lauraceae	*Cryptocarya foetida*	V	V	Stinking Cryptocarya	seed, within fleshy fruit	coastal rainforest		coastal sands, metasediments	
Lauraceae	*Endiandra floydii*	E	E	Crystal Creek Walnut	seed within a black fleshy berry	low elevation rainforest		metasediments, alluvium	
Lauraceae	*Endiandra hayesii*	V	V	Rusty Rose Walnut	seed within a black fleshy berry	high elevation rainforest		Nimbin rhyolite	

family	scientific name	*BCA 2016*	*EPBC 1999*	common name	dispersal mechanism	habitat type (mostly occurs)	vegetation classes (also occurs)	geology - (mostly occurs on)	notes
Lauraceae	*Endiandra muelleri subsp. bracteata*	E		Green-leaved Rose Walnut	seed within a black fleshy berry	low elevation rainforest		metasediments	
Lindseaceae	*Lindsaea brachypoda*	E		Short-footed Screw Fern	spores	low elevation rainforest	high elevation rainforest	Nimbin rhyolite	
Meliaceae	*Owenia cepiodora*	V	V	Onion Cedar	seeds within red fleshy drupe	low elevation rainforest		basalt	
Menispermaceae	*Tinospora tinosporoides*	V		Arrow-head vine	seed, within a red fleshy drupe	low elevation rainforest		basalt	
Mimosaceae	*Acacia bakeri*	V		Marblewood	seeds within pod	low elevation rainforest		metasediments	
Myrtaceae	*Choricarpia subargentea*	E		Giant Ironwood	seed, enclosed in dry nut	low elevation rainforest		basalt	
Myrtaceae	*Gossia fragrantissima*	E	E	Sweet Myrtle	seeds within an orange berry	low elevation rainforest		basalt, alluvium	
Myrtaceae	*Rhodamnia rubescens*	CE		Scrub Turpentine	seeds, within red-black fleshy berry	low elevation rainforest	high elevation rainforest	metasediments, basalt, Nimbin rhyolite	
Myrtaceae	*Rhodomyrtus psidioides*	CE		Native Guava	fleshy, berry, many seeded	coastal rainforest		metasediments	
Myrtaceae	*Syzygium hodgkinsoniae*	V	V	Red Lilly Pilly	seed, within a red fleshy berry	low elevation rainforest		alluvium	
Myrtaceae	*Syzygium moorei*	V	V	Durobby	seed, within a white fleshy berry	low elevation rainforest		alluvium	
Myrtaceae	*Uromyrtus australis*	E	E	Peach Myrtle	seeds, within a black fleshy berry	high elevation rainforest		Nimbin rhyolite	
Orchidaceae	*Diuris byronensis*	E		Byron Bay Diuris	seed	dry coastal complex		metasediments	
Orchidaceae	*Geodorum densiflorum*	E		Pink Nodding Orchid	seeds	coastal rainforest		metasediments	
Orchidaceae	*Oberonia titania*	E		Red-flowered King of the Fairies	seeds	low elevation rainforest		metasediments	records in Inner Pocket NR
Orchidaceae	*Peristeranthus hillii*	V		Brown Fairy-chain Orchid	seeds	coastal rainforest		metasediments	
Orchidaceae	*Phaius australis*	E	E	Southern Swamp Orchid	seeds	coastal swamp sclerophyll forest		alluvium	
Orchidaceae	*Pterostylis nigricans*	V		Dark Greenhood	seeds	wet coastal complex		coastal sands	
Orchidaceae	*Sarcochilus fitzgeraldii*	V	V	Ravine Orchid	seeds	high elevation rainforest		Nimbin rhyolite	

family	scientific name	*BCA 2016*	*EPBC 1999*	common name	dispersal mechanism	habitat type (mostly occurs)	vegetation classes (also occurs)	geology - (mostly occurs on)	notes
Orchidaceae	*Sarcochilus hartmannii*	V	V	Hartman's Sarcochilus	seeds	high elevation rainforest		Nimbin rhyolite	
Phyllanthaceae	*Phyllanthus microcladus*	E		Brush Sauropus	seeds, within a dry capsule	low elevation rainforest		alluvium	
Poaceae	*Arthraxon hispidus*	V	V	Hairy Jointgrass	seed	low elevation rainforest		basalt	often in grazing land, sometimes on rainforest edges
Polypodiaceae	*Belvisia mucronata*	E		Needle-leaf Fern	spore	low elevation rainforest		metasediments	in Brunswick NR near high tide level
Polypodiaceae	*Drynaria rigidula*	E		Basket Fern	spores	wet sclerophyll forest		metasediments	
Proteaceae	*Floydia praealta*	V	V	Ball Nut	seed within a dry drupe-like fruit	low elevation rainforest		alluvium, basalt	
Proteaceae	*Grevillea hilliana*	E		White Yiel Yiel	seeds, winged, within a dry follicle	low elevation rainforest		metasediments, basalt	
Proteaceae	*Hicksbeachia pinnatifolia*	V	V	Red Bopple Nut	stone, within red fleshy drupe	low elevation rainforest		Nimbin rhyolite, metasediments	
Proteaceae	*Macadamia tetraphylla*	V	V	Rough-shelled Bush Nut	seed, within dry follicle	low elevation rainforest		basalt, metasediments	
Psilotaceae	*Psilotum complanatum*	E		Flat Fork Fern	spore	high elevation rainforest		Nimbin rhyolite	
Rubiaceae	*Randia moorei*	E	E	Spiny Gardenia	seeds, within orange fleshy berry	low elevation rainforest		metasediments	
Rutaceae	*Acronychia littoralis*	E	E	Scented Acronychia	seed in a mesocarp within a fleshy fruit, seeds not viable	coastal rainforest		coastal sands, metasediments	
Rutaceae	*Bosistoa transversa*	V	V	Yellow Satinheart	seed	low elevation rainforest		metasediments	
Rutaceae	*Melicope vitiflora*	E		Coast Euodia	seeds, covered by black aril and enclosed in follicle	coastal rainforest	high elevation rainforest	metasediments, Nimbin rhyolite	

family	scientific name	*BCA 2016*	*EPBC 1999*	common name	dispersal mechanism	habitat type (mostly occurs)	vegetation classes (also occurs)	geology - (mostly occurs on)	notes
Sapindaceae	*Diploglottis campbellii*	E	E	Small-leaved Tamarind	seed within a dry capsule, orange fleshy aril attached	low elevation rainforest		basalt	
Sapotaceae	*Niemeyera whitei*	V		Rusty Plum	seed, within purple black fleshy fruit	high elevation rainforest	low elevation rainforest	Nimbin rhyolite and metasediments	on Nimbin rhyolite in Nightcap-Goonengery block and metasediments at Broken Head
Symplocaceae	*Symplocos baeuerlenii*	V	V	Small-leaved Hazelwood	seed, within red fleshy drupe	high elevation rainforest		Nimbin rhyolite	
Urticaceae	*Dendrocnide moroides*	E		Gympie Stinger	seed, within a dry achene, seated on a fleshy purplish petiole	low elevation rainforest		metasediments	

V – Vulnerable
CE – Critically Endangered
E - Endangered

APPENDIX 3 Key Threatening Processes

Table 1 Key Threatening Processes

Key Threatening Process	*BC Act*	*EPBC Act*
Climate change		
Anthropogenic climate change	x	x
Terrestrial habitat loss or change		
Clearing of native vegetation	x	x
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	x	
Loss and/or degradation of sites used for hill-topping by butterflies	x	
Loss of hollow-bearing trees	x	
Removal of dead wood and dead trees	x	
Weeds		
Invasion and establishment of exotic vines and scramblers	x	
Invasion of native plant communities by Bitou Bush and Boneseed *Chrysanthemoides monilifera*	x	
Invasion of native plant communities by exotic perennial grasses	x	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	x	
Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens lat.*)	x	
Pest species		
Competition from feral honeybees *Apis mellifera* L	x	x
Invasion and establishment of the Cane Toad *Bufo marinus*	x	x
Predation by *Gambusia holbrooki* (Plague Minnow)	x	x
Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)	x	
Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)	x	
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	x	
Diseases		
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	x	
Infection of native plants by *Phytophthora cinnamomi*	x	
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	x	x
Aquatic habitat change		
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	x	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ***BC Act*** = *Biodiversity Conservation Act 2016*;

APPENDIX 4 The 62 priority vertebrate species used to derive priority vertebrate groups

common name	scientific name	Tumbunan	Irian	Wallum	Bassian	Torresian	no. BioNet records in LGA (Jan. 2020
amphibians - 10 species							
Pouched Frog	***Assa darlingtoni***	x					67
Wallum Froglet	***Crinia tinnula***			x			226
Fletcher's Frog	*Lechriodus fletcheri*	x					6
Giant Barred Frog	***Mixophyes iteratus***	x					120
Loveridge's Frog	***Philoria loveridgei***	x					5
Red-eyed Tree Frog	*Litoria chloris*	x					31
Wallum Rocket Frog	*Litoria freycineti*			x			3
Wallum Sedge Frog	***Litoria olongburensis***			x			42
Pearson's Tree Frog	*Litoria pearsoniana*	x					28
Revealed Frog	*Litoria revelata*	x					22
reptiles - 14 species							
Southern Leaf-tailed Gecko	*Saltuarius swaini*	x					0
Major Skink	*Bellatorius frerei*					x	26
Land Mullet	*Bellatorius major*	x					41
Pink-tongued Lizard	*Cyclodomorphus gerrardii*	x					23
Blue-speckled Forest-skink	*Eulamprus murrayi*	x					6
McPhee's Skink	*Liolophis mcpheei*	x					1
Short-limbed Snake-skink	*Ophioscincus truncatus*	x					7
Orange-tailed Shadeskink	*Saproscincus challengeri*	x					9
Heath Shadeskink	*Saproscincus oriarus*			x			0
Gully Skink	*Saproscincus spectabilis*	x					4
Southern Forest Dragon	*Lophosaurus spinipes*	x					6
Southern Dwarf Crowned Snake	*Cacophis krefftii*	x					27
Stephen's Banded Snake	***Hoplocephalus stephensii***	x					7
Rough-scaled Snake	*Tropidechis carinatus*	x					34
birds - 19 species							

common name	scientific name	Tumbunan	Irian	Wallum	Bassian	Torresian	no. BioNet records in LGA (Jan. 2020
Wompoo Fruit-dove	***Ptilinopus magnificus***		x				118
Superb Fruit-dove	***Ptilinopus superbus***		x				19
Rose-crowned Fruit-dove	***Ptilinopus regina***		x				356
Topknot Pigeon	*Lopholaimus antarcticus*	x					332
Marbled Frogmouth	***Podargus ocellatus***		x				38
Black Bittern	***Ixobrychus flavicollis***		x				81
Pale-vented Bush-hen	***Amaurornis moluccana***		x				220
Sooty Owl	***Tyto tenebricosa***	x					97
Eastern Grass Owl	***Tyto longimembris***			(x)		x	27
Albert's Lyrebird	***Menura alberti***	x					398
Green Catbird	*Ailuroedus crassirostris*	x					103
Regent Bowerbird	*Sericulus chrysocephalus*	x					156
Australian Logrunner	*Orthonyx temminckii*	x					274
Barred Cuckoo-shrike	***Coracina lineata***	x					28
Little Shrike-thrush	*Colluricincla megarhyncha*		x				592
White-eared Monarch	***Carterornis leucotis***		x				236
Paradise Riflebird	*Ptiloris paradiseus*	x					30
Pale-yellow Robin	*Tregellasia capito*	x					211
Russet-tailed Thrush	*Zoothera heinei*	x					27
mammals - 19 species							
Common Planigale	***Planigale maculata***					x	49
Brown Antechinus	*Antechinus stuartii*	x					99
Koala	***Phascolarctos cinereus***				x		3464
Greater Glider	*Petauroides volans*				x		6
Long-nosed Potoroo	***Potorous tridactylus***			(x)	x		203
Red-legged Pademelon	***Thylogale stigmatica***	x					383
Red-necked Pademelon	*Thylogale thetis*	x					89
Eastern Blossom-bat	***Syconycteris australis***		x				41
Eastern Tube-nosed Bat	***Nyctimene robinsoni***		x				6
Grey-headed Flying-fox	***Pteropus poliocephalus***		x				382
Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	x					47
Golden-tipped Bat	***Kerivoula papuensis***	x					0

common name	scientific name	Tumbunan	Irian	Wallum	Bassian	Torresian	no. BioNet records in LGA (Jan. 2020
Little Bent-winged Bat	***Miniopterus australis***					**x**	231
Eastern Long-eared Bat	***Nyctophilus bifax***	**x**					161
Southern Myotis	***Myotis macropus***				**x**		238
Greater Broad-nosed Bat	***Scoteanax rueppelli***	**x**					8
Eastern Forest Bat	*Vespadelus pumilus*	**x**					61
Grassland Melomys	*Melomys burtoni*					**x**	81
Fawn-footed Melomys	*Melomys cervinipes*	**x**					41

bolded species listed as threatened under the *BSC Act 2016*
zoogeographical origin:
Tumbunan 38 species
Irian 11 species
Wallum 4 species
Torresian 4 species
Bassian 5 species

APPENDIX 5 The 10 priority vertebrate groups derived from analysis of attributes of the 62 priority vertebrate species

Groups are ranked from most at risk (1.1) to least at risk (3.4) according to zoogeographic origin, primary habitat preference, dispersal capability and conservation status and showing zoogeographical origin and *BC Act 2016* status

vertebrate group (with zoogeographic origin, primary habitat preference, dispersal capability and conservation status)	**common name**	**scientific name**	**zoogeographic origin**	***BC Act* status**
priority 1 group				
1.1 Tumbunan_rainforest/wet sclerophyll forest-associated_very low/low dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Pouched Frog	*Assa darlingtoni*	**Tu**	**V**
	Fletcher's Frog	*Lechriodus fletcheri*	**Tu**	
	Giant Barred Frog	*Mixophyes iteratus*	**Tu**	**E**
	Loveridge's Frog	*Philoria loveridgei*	**Tu**	**V**
	Southern Leaf-tailed Gecko	*Saltuarius swaini*	**Tu**	
	Southern Forest Dragon	*Lophosaurus spinipes*	**Tu**	
1.2 Tumbunan_rainforest/wet sclerophyll forest-associated_very low/low dispersal capability_non-*BC Act*-listed	Red-eyed Tree Frog	*Litoria chloris*	**Tu**	
	Pearson's Tree Frog	*Litoria pearsoniana*	**Tu**	
	Land Mullet	*Bellatorius major*	**Tu**	
	Blue-speckled Forest-skink	*Eulamprus murrayi*	**Tu**	
	Short-limbed Snake-skink	*Ophioscincus truncatus*	**Tu**	
	Orange-tailed Shadeskink	*Saproscincus challengeri*	**Tu**	
	Gully Skink	*Saproscincus spectabilis*	**Tu**	
1.3 Tumbunan/Irian_rainforest/wet sclerophyll forest-associated_low dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Marbled Frogmouth	*Podargus ocellatus*	**Ir**	**V**
	Albert's Lyrebird	*Menura alberti*	**Tu**	**V**
	Paradise Riflebird	*Ptiloris paradiseus*	**Tu**	
	Red-legged Pademelon	*Thylogale stigmatica*	**Tu**	**V**
	Eastern Tube-nosed Bat	*Nyctimene robinsoni*	**Ir**	**V**
	Golden-tipped Bat	*Kerivoula papuensis*	**Tu**	**V**
1.4 Wallum_swamp sclerophyll forest_coastal complex-associated_low dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Wallum Froglet	*Crinia tinnula*	**Wa**	**V**
	Wallum Rocket Frog	*Litoria freycineti*	**Wa**	
	Wallum Sedge Frog	*Litoria olongburensis*	**Wa**	**V**
	Heath Shadeskink	*Saproscincus oriarus*	**Wa**	
	Northern Long-nosed Potoroo	*Potorous tridactylus tridactylus*	**Ba(Wa)**	**V**

vertebrate group (with zoogeographic origin, primary habitat preference, dispersal capability and conservation status)	**common name**	**scientific name**	**zoogeographic origin**	***BC Act* status**
	Grassland Melomys	*Melomys burtoni*	**To(Wa)**	
priority 2 group				
2.1 Tumbunan/Bassian_rainforest/wet sclerophyll forest/moist sclerophyll forest/dry sclerophyll forest-associated_low-moderate dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Revealed Tree Frog	*Litoria revelata*	**Tu**	
	Pink-tongued Lizard	*Cyclodomorphus gerrardii*	**Tu**	
	Stephen's Banded Snake	*Hoplocephalus stephensii*	**Tu**	**V**
	Sooty Owl	*Tyto tenebricosa*	**Tu**	**V**
	Australian Logrunner	*Orthonyx temminckii*	**Tu**	
	Pale-yellow Robin	*Tregellasia capito*	**Tu**	
	Russet-tailed Thrush	*Zoothera heinei*	**Tu**	
	Greater Glider	*Petauroides volans*	**Ba**	
	Red-necked Pademelon	*Thylogale thetis*	**Tu**	
2.2 Tumbunan/Torresian_rainforest/wet sclerophyll/swamp sclerophyll forest/moist sclerophyll forest/coastal complex/dry sclerophyll forest-associated_low-moderate dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Major Skink	*Bellatorius frerei*	**To**	
	McPhee's Skink	*Liolophis mcpheei*	**Tu**	
	Southern Dwarf Crowned Snake	*Cacophis krefftii*	**Tu**	
	Rough-scaled Snake	*Tropidechis carinatus*	**Tu**	
	Brown Antechinus	*Antechinus stuartii*	**Tu**	
	Common Planigale	*Planigale maculata*	**To**	**V**
	Fawn-footed Melomys	*Melomys cervinipes*	**Tu**	
priority 3 group				
3.1 Tumbunan/Irian/Bassian_rainforest/wet sclerophyll forest/moist sclerophyll forest/swamp sclerophyll forest-associated_moderate dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Green Catbird	*Ailuroedus crassirostris*	**Tu**	
	Little Shrike-thrush	*Colluricincla megarhyncha*	**Ir**	
	Long-nosed Potoroo	*Potorous tridactylus*	**Ba**	**V**
	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	**Tu**	
	Eastern Long-eared Bat	*Nyctophilus bifax*	**Tu**	**V**
	Eastern Forest Bat	*Vespadelus pumilus*	**Tu**	
3.2 Irian/Torresian/Bassian_coastal complex/swamp sclerophyll forest/rainforest-associated_high dispersal capability_*BC Act*-listed	Black Bittern	*Ixobrychus flavicollis*	**Ir**	**V**
	Pale-vented Bush-hen	*Amaurornis moluccana*	**Ir**	**V**
	Eastern Grass Owl	*Tyto longimembris*	**To(Wa)**	**V**

vertebrate group (with zoogeographic origin, primary habitat preference, dispersal capability and conservation status)	**common name**	**scientific name**	**zoogeographic origin**	***BC Act* status**
	Southern Myotis	*Myotis macropus*	**Ba**	**V**
3.3 Irian/Tumbunan_rainforest/wet sclerophyll forest/swamp sclerophyll forest-associated_high dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Wompoo Fruit-dove	*Ptilinopus magnificus*	**Ir**	**V**
	Superb Fruit-dove	*Ptilinopus superbus*	**Ir**	**V**
	Rose-crowned Fruit-dove	*Ptilinopus regina*	**Ir**	**V**
	Topknot Pigeon	*Lopholaimus antarcticus*	**Tu**	
	Regent Bowerbird	*Sericulus chrysocephalus*	**Tu**	
	Barred Cuckoo-shrike	*Coracina lineata*	**Tu**	**V**
	White-eared Monarch	*Carterornis leucotis*	**Ir**	**V**
3.4 Bassian/Irian/Tumbunan/Torresian_rainforest/wet sclerophyll forest/swamp sclerophyll forest/dry sclerophyll forest/coastal complex/moist sclerophyll forest-associated_high dispersal capability_*BC Act*-listed/non-*BC Act*-listed	Koala	*Phascolarctos cinereus*	**Ba**	**V**
	Eastern Blossom-bat	*Syconycteris australis*	**Ir**	**V**
	Grey-headed Flying-fox	*Pteropus poliocephalus*	**Ir**	**V**
	Little Bent-winged Bat	*Miniopterus australis*	**To**	**V**
	Greater Broad-nosed Bat	*Scoteanax rueppelli*	**Tu**	**V**

BC Act 2016 status:
V - Vulnerable,
E - Endangered

zoogeographical origin:

Tu	Tumbunan	38 species
Ir	Irian	11 species
Wa	Wallum	4 species
To	Torresian	4 species
Ba	Bassian	5 species

APPENDIX 6 Preferred habitat ratings for species comprising the priority vertebrate groups

habitat type	rainforest			wet sclerophyll forest	moist sclerophyll forest	swamp sclerophyll forest		dry sclerophyll forest		coastal complex	
	high elevation (>300m)	low elevation (<300m)	coastal (on sand or headland)			on alluvium (floodplain)	on sand (coastal)	high elevation (>300m)	low elevation (<300m)	dry (on sand or clay)	wet (on sand)
priority vertebrate group / common name / scientific name	rating for habitat type										
priority 1 group											
group 1.1 Pouched Frog	*Assa darlingtoni*	**3**	2		**3**						
Fletcher's Frog	*Lechriodus fletcheri*	2	**3**		**3**						
Giant Barred Frog	*Mixophyes iteratus*	1	**3**		2						
Loveridge's Frog	*Philoria loveridgei*	**3**	2		2						
Southern Leaf-tailed Gecko	*Saltuarius swaini*	2	**3**		**3**						
Southern Forest Dragon	*Lophosaurus spinipes*	1	**3**		**3**						
group 1.2 Red-eyed Tree Frog	*Litoria chloris*	2	**3**		**3**	1					
Pearson's Tree Frog	*Litoria pearsoniana*	2	**3**		**3**	1					
Land Mullet	*Bellatorius major*	1	**3**	1	**3**	1	2				
Blue-speckled Forest-skink	*Eulamprus murrayi*	**3**	**3**		**3**		1				
Short-limbed Snake-skink	*Ophioscincus truncatus*	2	**3**		2						
Orange-tailed Shadeskink	*Saproscincus challengeri*	2	**3**	2	**3**		2				
Gully Skink	*Saproscincus spectabilis*	1	**3**		**3**						
group 1.3 Marbled Frogmouth	*Podargus ocellatus*	2	**3**		2	1					
Albert's Lyrebird	*Menura alberti*	**3**	2		**3**	2		1			
Paradise Riflebird	*Ptiloris paradiseus*	**3**	**3**		**3**	1					
Red-legged Pademelon	*Thylogale stigmatica*	2	**3**		**3**						
Eastern Tube-nosed Bat	*Nyctimene robinsoni*	1	**3**		2	1					
Golden-tipped Bat	*Kerivoula papuensis*	1	2		2						
group 1.4 Wallum Froglet	*Crinia tinnula*						1	2			1	**3**

		habitat type	rainforest			wet sclerophyll forest	moist sclerophyll forest	swamp sclerophyll forest		dry sclerophyll forest		coastal complex	
			high elevation (>300m)	low elevation (<300m)	coastal (on sand or headland)			on alluvium (floodplain)	on sand (coastal)	high elevation (>300m)	low elevation (<300m)	dry (on sand or clay)	wet (on sand)
(1.4 cont.)	Wallum Rocket Frog	*Litoria freycineti*							1			2	**3**
	Wallum Sedge Frog	*Litoria olongburensis*						1	**3**			1	**3**
	Heath Shadeskink	*Saproscincus oriarus*						1	2		1	2	2
	Northern Long-nosed Potoroo	*Potorous tridactylus tridactylus*						1	2		**3**	2	1
	Grassland Melomys	*Melomys burtoni*						1	1		2	**3**	**3**
	priority 2 group												
group 2.1	Revealed Tree Frog	*Litoria revelata*	2	2		**3**		1	1				1
	Pink-tongued Lizard	*Cyclodomorphus gerrardii*	1	**3**	2	**3**	1	1	1				
	Stephen's Banded Snake	*Hoplocephalus stephensii*	**3**	**3**		**3**	2			2			
	Sooty Owl	*Tyto tenebricosa*	**3**	**3**		**3**	2						
	Australian Logrunner	*Orthonyx temminckii*	**3**	**3**		**3**	1	1					
	Pale-yellow Robin	*Tregellasia capito*	2	**3**	1	**3**		1					
	Russet-tailed Thrush	*Zoothera heinei*	2	**3**		**3**							
	Greater Glider	*Petauroides volans*	1			**3**	2			2			
	Red-necked Pademelon	*Thylogale thetis*	**3**	2		**3**	1						
group 2.2	Major Skink	*Bellatorius frerei*	1	1	1	2	2			1	2	2	
	McPhee's Skink	*Liolophis mcpheei*					1			2			
	Southern Dwarf Crowned Snake	*Cacophis krefftii*	1	**3**	2	**3**	1	1					
	Rough-scaled Snake	*Tropidechis carinatus*	2	**3**	2	**3**	1	2	2				1
	Brown Antechinus	*Antechinus stuartii*	**3**	**3**	**3**	**3**	2	2	1	1	1		
	Common Planigale	*Planigale maculata*		1	2	1	1	**3**	2		2	**3**	2
	Fawn-footed Melomys	*Melomys cervinipes*	**3**	**3**	**3**	**3**	1	1					
	priority 3 group												
group 3.1	Green Catbird	*Ailuroedus crassirostris*	**3**	**3**	2	2							

		habitat type	rainforest			wet sclerophyll forest	moist sclerophyll forest	swamp sclerophyll forest		dry sclerophyll forest		coastal complex	
			high elevation (>300m)	low elevation (<300m)	coastal (on sand or headland)			on alluvium (floodplain)	on sand (coastal)	high elevation (>300m)	low elevation (<300m)	dry (on sand or clay)	wet (on sand)
(3.1 cont.)	Little Shrike-thrush	*Colluricincla megarhyncha*	2	**3**	**3**	2		**3**	1				
	Long-nosed Potoroo	*Potorous tridactylus*	**3**	2		**3**	1			1			
	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	2	**3**	2	**3**	1	1	1				
	Eastern Long-eared Bat	*Nyctophilus bifax*	2	**3**	**3**	**3**	1	**3**	2		1		1
	Eastern Forest Bat	*Vespadelus pumilus*	2	2	2	**3**	2	2	1		1		
group 3.2	Black Bittern	*Ixobrychus flavicollis*		2		1		**3**	2				
	Pale-vented Bush-hen	*Amaurornis moluccana*		2		2		**3**	2				2
	Eastern Grass Owl	*Tyto longimembris*										**3**	**3**
	Southern Myotis	*Myotis macropus*	1	**3**		2		**3**	1				1
group 3.3	Wompoo Fruit-dove	*Ptilinopus magnificus*	**3**	**3**	2	2		2					
	Superb Fruit-dove	*Ptilinopus superbus*	2	**3**	2	1		1					
	Rose-crowned Fruit-dove	*Ptilinopus regina*	2	**3**	**3**	2	1	**3**					
	Topknot Pigeon	*Lopholaimus antarcticus*	**3**	**3**	**3**	**3**	1	2	1				
	Regent Bowerbird	*Sericulus chrysocephalus*	**3**	**3**	**3**	2	1	2					
	Barred Cuckoo-shrike	*Coracina lineata*	2	**3**	1	2	1	1					
	White-eared Monarch	*Carterornis leucotis*	1	**3**	**3**	2		**3**	1				
group 3.4	Koala	*Phascolarctos cinereus*	1	1		**3**	**3**	**3**	1	1	**3**		
	Eastern Blossom-bat	*Syconycteris australis*		1	**3**	2		**3**	2		2	**3**	**3**
	Grey-headed Flying-fox	*Pteropus poliocephalus*	**3**	**3**	**3**	2	2	**3**	**3**	1	**3**	**3**	1
	Little Bent-winged Bat	*Miniopterus australis*	2	**3**	**3**	**3**	1	**3**	2		2	2	2
	Greater Broad-nosed Bat	*Scoteanax rueppelli*	1	2	1	2	1	**3**	2		1		

habitat scores:
3 – high
2 - medium
1 – low

number of species with high to low preferred habitat scores for habitat types:

high	**17**	**39**	**11**	**33**	**1**	**13**	**2**	**0**	**3**	**5**	**6**
medium	20	11	10	19	8	8	11	3	5	5	4
low	14	4	5	3	23	15	12	6	5	2	5

APPENDIX 7 Habitat blocks, connectors and Big Scrub remnants

habitat blocks

Belongil Creek-Cumbebin block
Billinudgel block
Broken Head block
Brunswick block
Cape Byron-Tallow Creek block
Mt Jerusalem-Upper Wilsons Creek-Koonyum Range block
Nightcap-Goonengerry block
Palmwoods block
Tyagarah block
Upper Main Arm-Inner Pocket block
Yelgun block

major connectors

Broken Head-Hogans Bluff connector
Chincogan Mountains-Brunswick River connector
Cumbebin-Tallow-Ck-Hayters-Broken Hd connector
Durrumbul-Main Arm connector
Federal-Coopers Ck connector
Hayters Hill-Bangalow-Wilsons River connector
Hayters Hill-Cumbebin connector
Inner Pocket to Yelgun connector
Koonyum--Goonengerry-Wilsons River-Booyong connector
Maori Ck-Durrumbul-Chincogan-Jinangong connector
Maori Creek Koala connector
Middle Pocket connector
Mullumbimby Ck-Brunswick River connector
Myocum- Andersons Ridge Koala connector
Myocum-Andersons Ridge connector
Nashua-Skinners Creek connector
Nightcap-Goonengerry-Coopers Creek connector
Palmwoods connector
Palmwoods Koala connector
Seapeace wetlands project
St Helena-Hayters Hill connector
The Pocket-Marshalls Ck connector
Tyagarah-Belongil Creek connector
Upper Main Arm connector
Wilsons River - St Helena connector
Wilsons River-Tyagarah connector

minor connectors

Andrew Johnson NR to Booyong BSR minor connector
Andrew Johnston-Nobles Scrub minor connector
Armstrong Lane-Midgen Ck minor connector
Bangalow -Byron Creek-Piccadilly Hill minor connector
Brunswick-Mt Chincogan mInor connector
Coolamon Scenic Drive minor connector

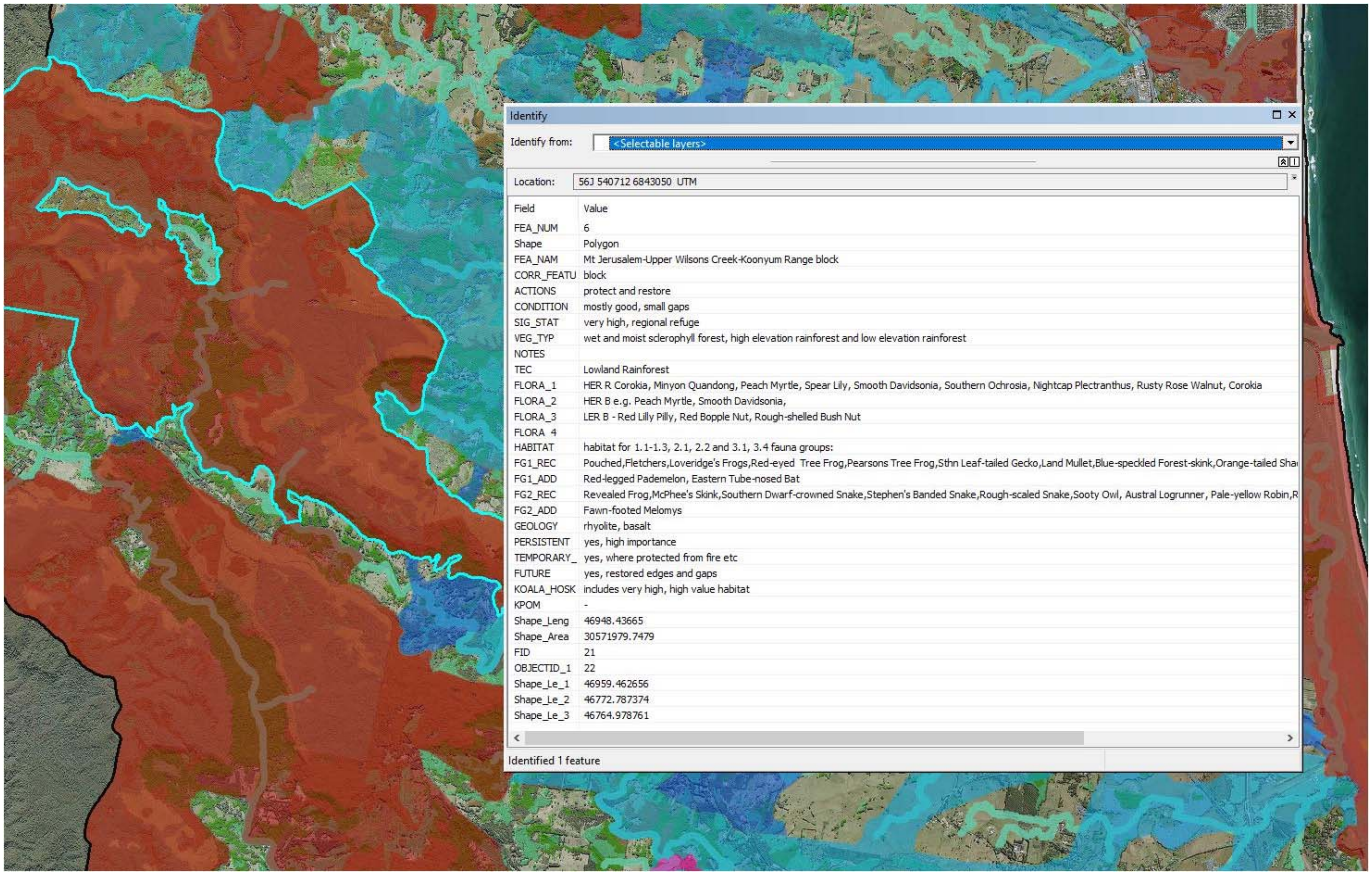
Coopers Creek-Allensby BSR minor connector
Dingo Lane minor connector
Federal mInor connector
Goonengerry-Koonyum minor connector
Great Granny Waterhouse minor connector
Koonyum Range-Goonengerry minor connector
Lune de Sang - Federal remnants minor connector
Maori Ck-Durrumbul-Chincogan-Jinangong minor connector
Marshalls Ck to the Pocket minor connector
McAuleys Lane connector
Mt Chincogan to Brunswick R minor connector
Mt Jerusalem-Mullum Ck-Brunswick River minor connector
Nightcap-Mt Jerusalem minor connector
Pipeclay Creek riparian
Risleys Hill minor connector
Simpsons Creek tributary connector
Skinners Creek minor connector
The Pocket minor connector
The Pocket to Inner Pocket minor connector
Yankee Creek mInor connector

Big Scrub remnants
Allensby BSR
Andrew Johnston NR
Beacom BSR
Bennys Scrub BSR
Booyong BSR
Cedarvale BSR
Collins Bridge BSR
De Heer BSR
Derrygonelly BSR
Emerald Valley BSR
Emerys BSR
Eureka Church BSR
Federal BSR
Haynes BSR
Hayters Hill BSR
Hayters Hill NR
Hermans BSR
Hogans Bluff BSR
Little Bennys BSR
Lune de Sang BSR
McLeods Shoot BSR
Midland BSR
Mortons Scrub BSR
Nobles Scrub BSR
Sommerville BSR
Tarra BSR
Tarraweera BSR
Wiltons BSR

APPENDIX 8 Data fields included in the GIS map layer

field name	explanation
FEA_NAME	name of feature
CORR_FEATU	corridor feature - block, major connector, minor connector, Big Scrub remnant
ACTIONS	recommended actions for corridor feature
CONDITION	notes on overall condition of vegetation within the corridor feature
SIG_STAT	significance of the corridor feature
VEG_TYP	broad vegetation communities (including habitat types) present in corridor feature
NOTES	general notes
TEC	Endangered Ecological Communities recorded in feature
FLORA_1	habitat (broad vegetation community and substrate) and threatened flora species (*BC Act 2016*) occurring in that habitat in the corridor feature (see Appendix 6 with vegetation and geology codes)
FLORA_2	additional habitat and associated threatened flora species occurring in the corridor feature (see Appendix 6 with veg and geology codes)
FLORA_3	additional habitat and associated threatened flora species occurring in the corridor feature (see Appendix 6 with veg and geology codes)
FLORA_4	additional habitat and associated threatened flora species occurring in the corridor feature (see Appendix 6 with veg and geology codes)
HABITAT	list of fauna groups with suitable habitat occurring in the feature
FG1_REC	priority group 1 fauna species (including *BC Act 2016*-listed species) recorded in the feature
FG1_ADD	additional priority group 1 fauna species (including *BC Act 2016*-listed species) recorded in the feature
FG2_REC	priority group 2 fauna species s (including *BC Act 2016*-listed species) recorded in the feature
FG2_ADD	additional priority group 3 fauna species s (including *BC Act 2016*-listed species) recorded in the feature
GEOLOGY	geological origin of landscape within feature
PERSISTENT	includes persistent refugia (Rossetto and Kooyman 2021)
TEMPORARY	includes temporary refugia (Rossetto and Kooyman 2021)
FUTURE	includes future refugia (Rossetto and Kooyman 2021)
KOALA_HOSK	high quality (HQ) and very high quality (VHQ) Koala habitat mapping (Hosking 2020)
KPOM	vegetation identified in the KPoM as preferred Koala habitat

Example showing data for Mt Jerusalem-Upper Wilsons Creek-Koonyum Range block



APPENDIX 9 Codes used to denote attributes of habitat blocks and connectors in corridor system GIS data fields including mapped polygons within blocks and connectors

Landscape condition [LANDS_CO]
(from McKinley and Murray 2017a)

1	old-growth / excellent condition	Mature forest or other vegetation with common age-related features (fallen logs, senescent trees, stags, tree hollows, epiphytes, lithophytes, buttresses, large trees, emergents etc). API indicators include large crowns, senescent emergents, longevity of mature vegetation in historical aerial photographs, known remnants.
2	mature Forest	Mature vegetation – well developed vegetation, e.g. >5 years old for non-woody vegetation; >8 years for shrublands; >40 years for forests. API indicators include mature crowns dominant, longevity of mature vegetation in aerial photographs.
3	advanced regrowth	Intermediate successional development, e.g. 1-5 years old for non-woody vegetation; 3-8 years for shrublands, 10-40 yrs for forests
4	regrowth	Early successional development, e.g. <1 year old for non-woody vegetation; <3 yrs for shrublands; <10 years for forests. API indicators include comparison of aerial photographs from past 10 years.

Canopy cover [CANOPY]

A 81-100%
B 51-80%
C 31-50%
D 10-30%

Broad geology

code	geology
A	alluvium
B	basalt
CA	coastal alluvium
CS	coastal sands
E	estuarine
M	metasediments
R	rhyolite
S	sandstone

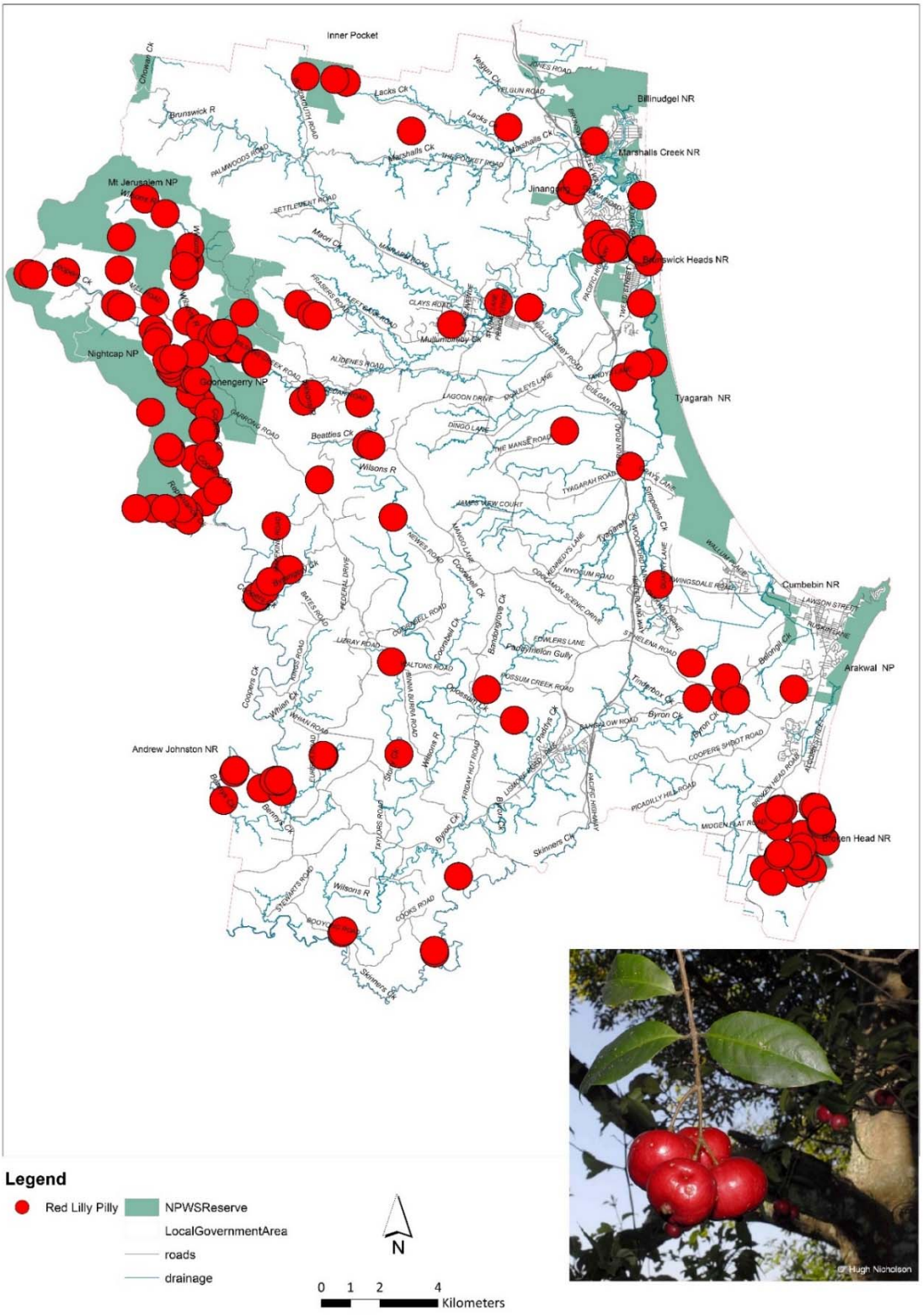
Broad geology and habitat type codes are used in the **[FLORA_x]** data fields.

Habitat type

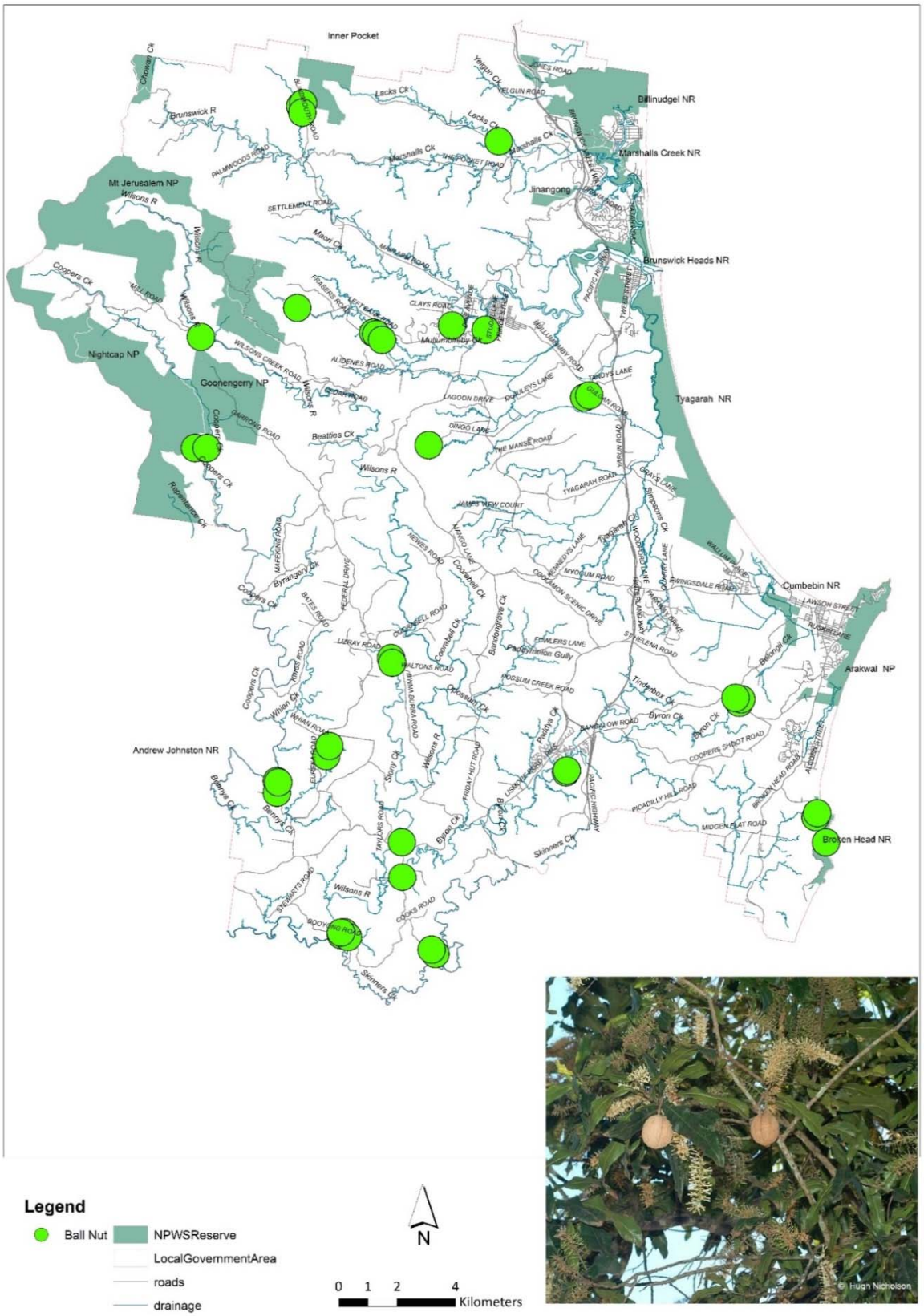
code	habitat type
DCC	dry coastal complex
WCC	wet coastal complex
CSSF	coastal swamp sclerophyll forest
FSSF	floodplain swamp sclerophyll forest
HEDSF, DSH	high elevation dry sclerophyll forest
MSF	moist sclerophyll forest
WSF	wet sclerophyll forest
HER	high elevation rainforest
LER	low elevation rainforest
CR	coastal rainforest
Rd	rainforest (derived, Camphor Laurel)

APPENDIX 10 Distribution patterns of selected priority flora and vertebrate species in the Byron LGA

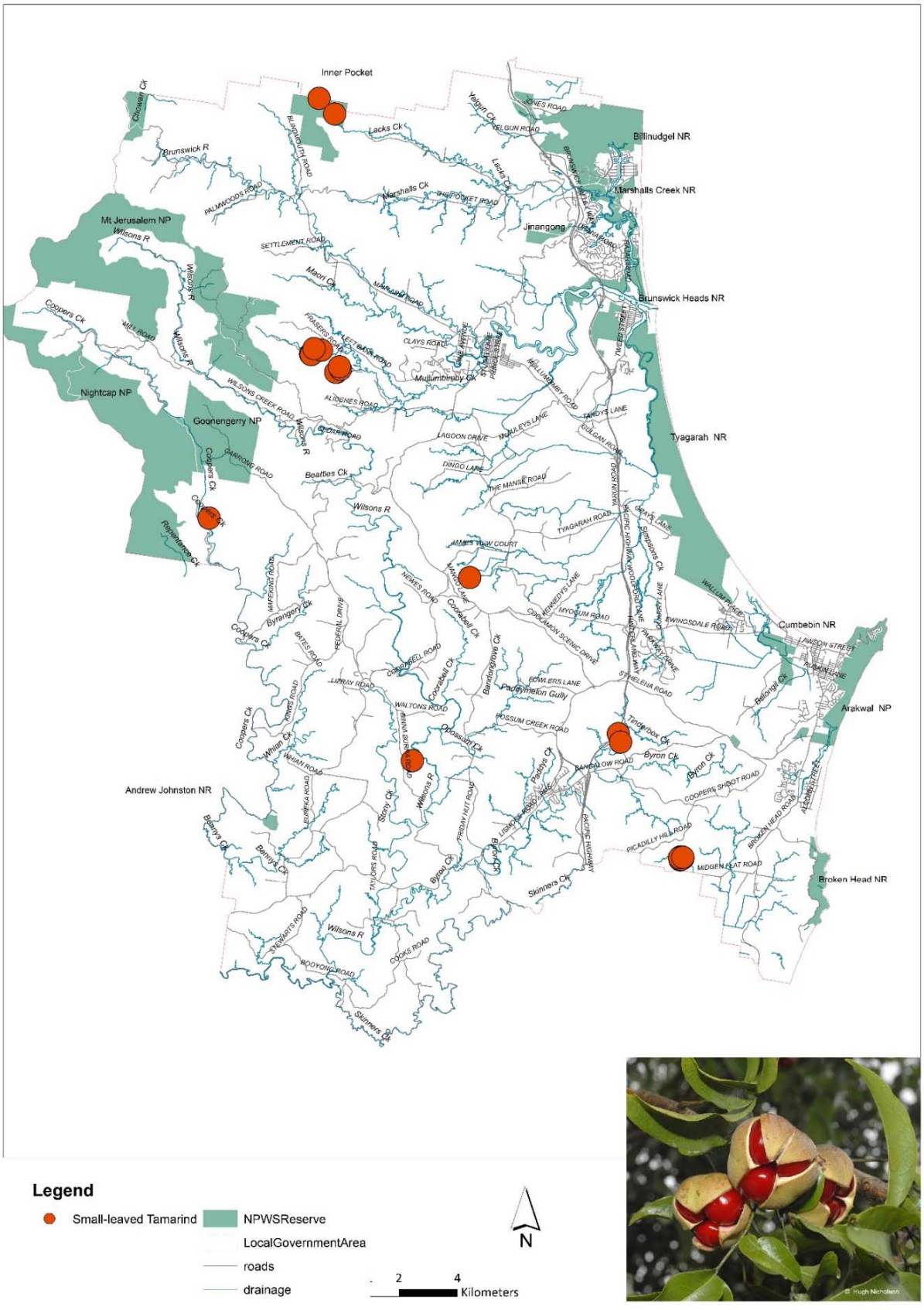
Red Lilly Pilly *Syzygium hodgkinsoniae* – occurs throughout the LGA in low elevation rainforest mainly on a range of soils derived from basalt, acid volcanics and metasediments



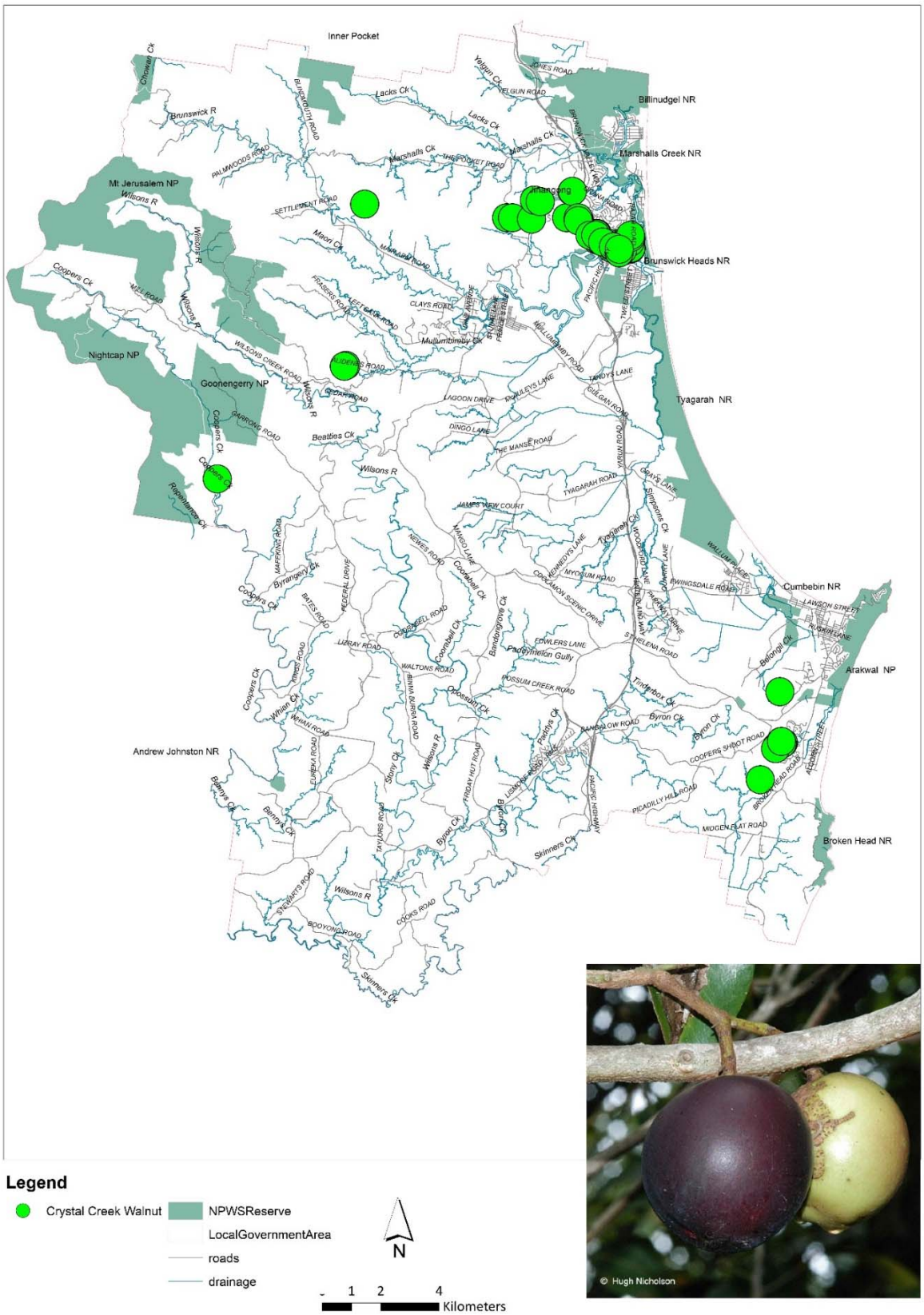
Ball Nut *Floydia praealta* – occurs in restricted locations throughout the LGA in low elevation rainforest mainly on alluvium



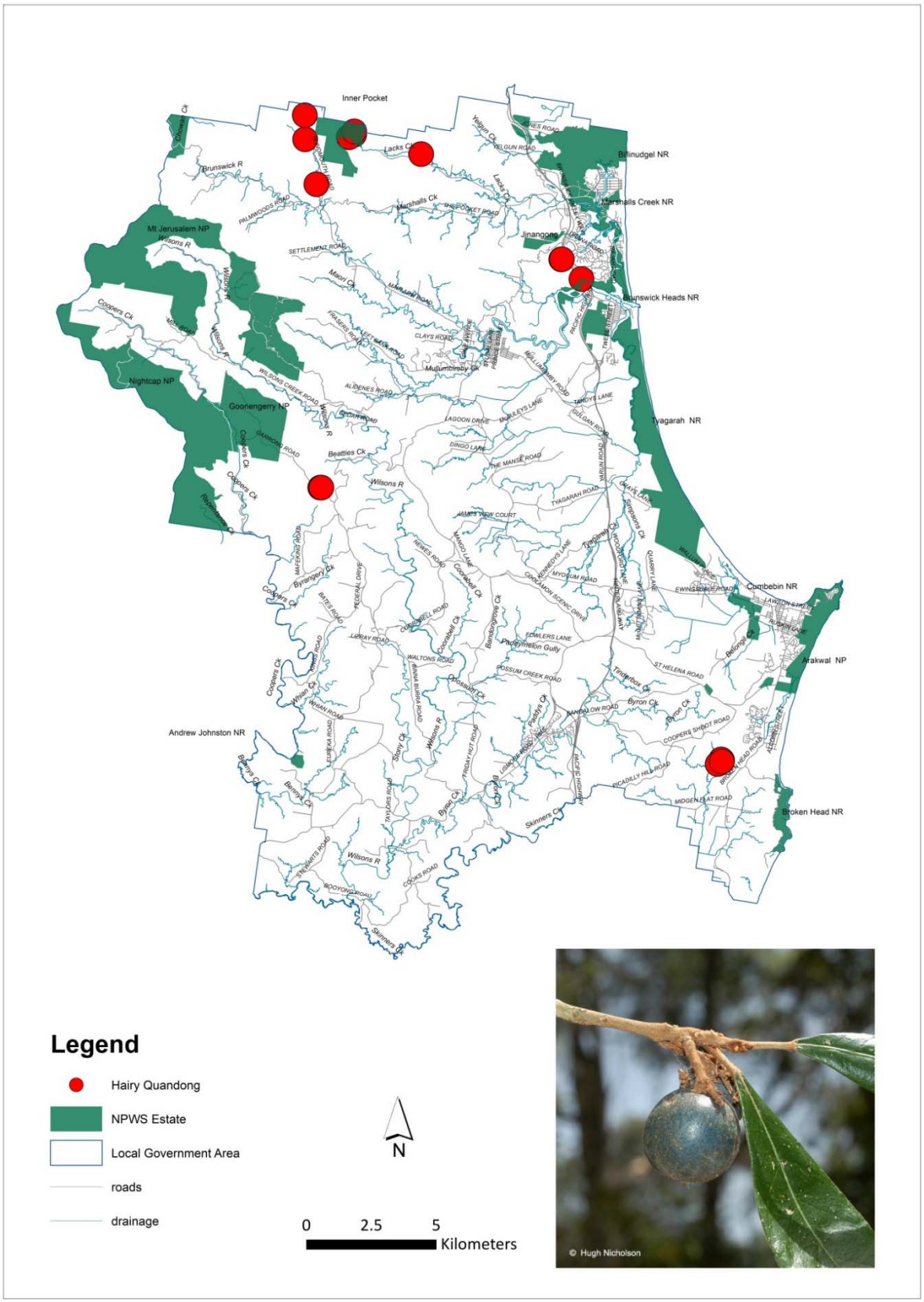
Small-leaved Tamarind *Diploglottis campbellii* – occurs at very restricted locations throughout the LGA in low elevation rainforest mainly on soils derived from basalt



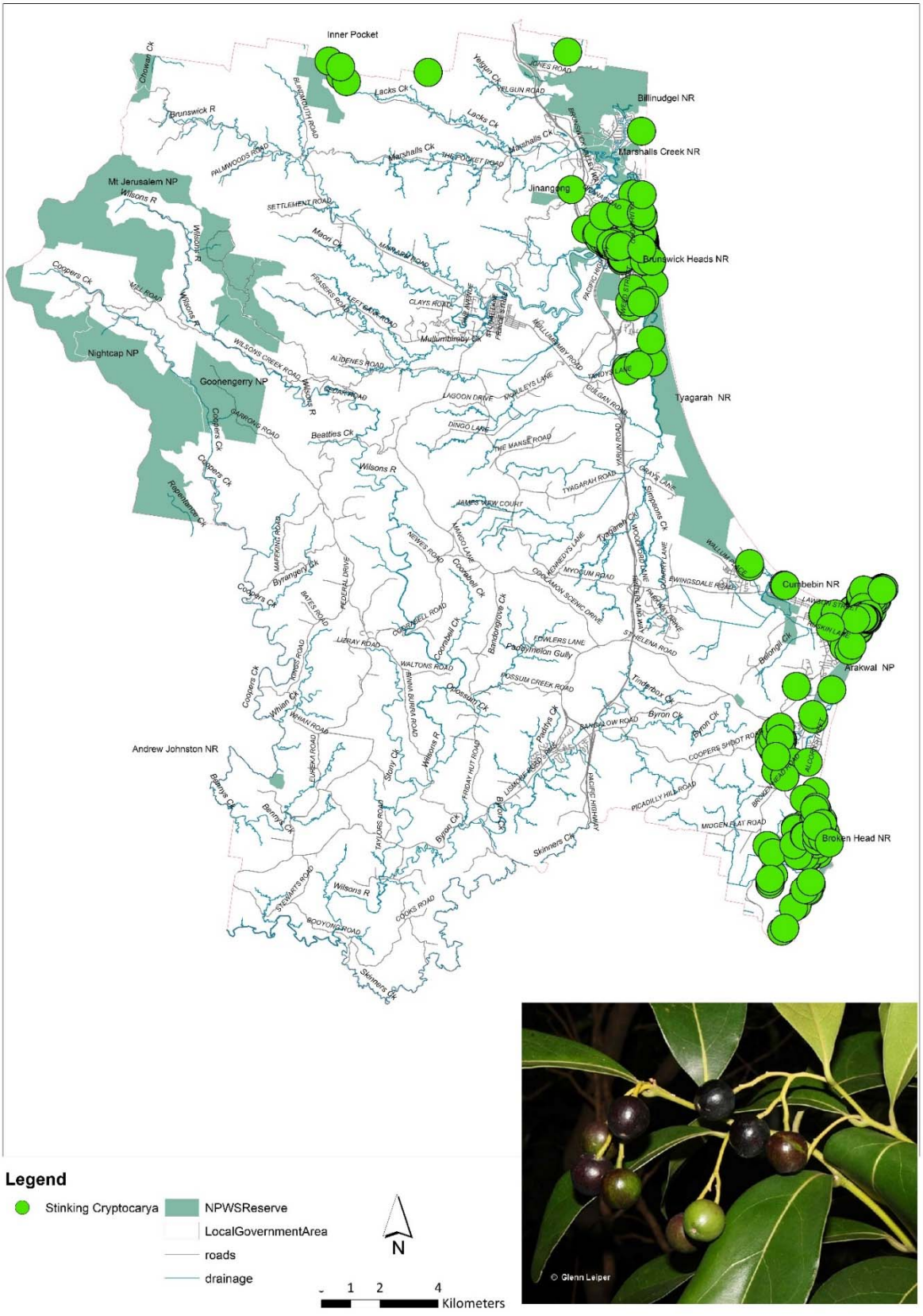
Crystal Creek Walnut *Endiandra floydii* – occurs in restricted locations throughout the LGA in low elevation rainforest mainly on soils derived from metasediments



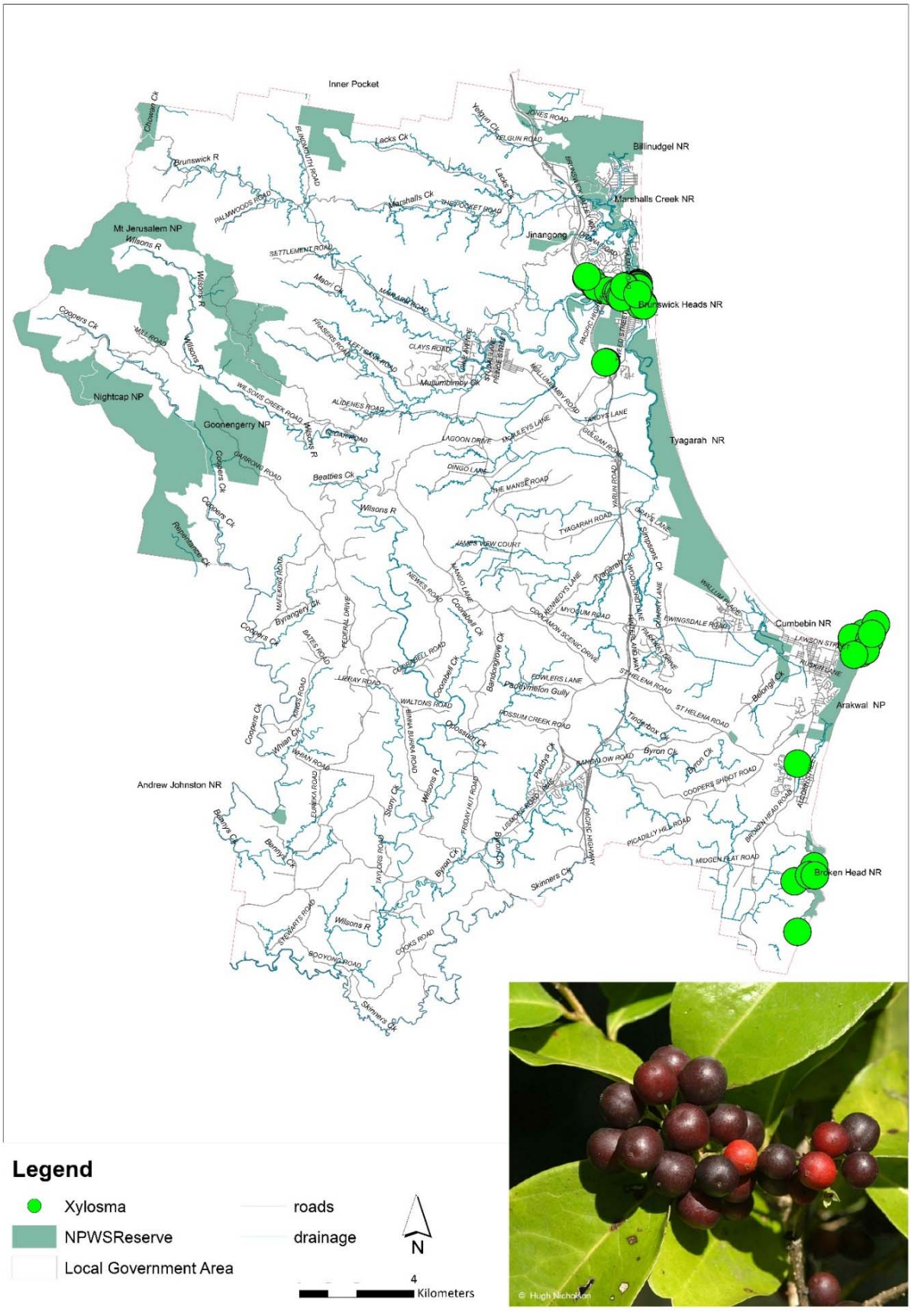
Hairy Quandong *Elaeocarpus williamsianus* – occurs at very restricted locations in low elevation rainforest mainly on soils derived from metasediments



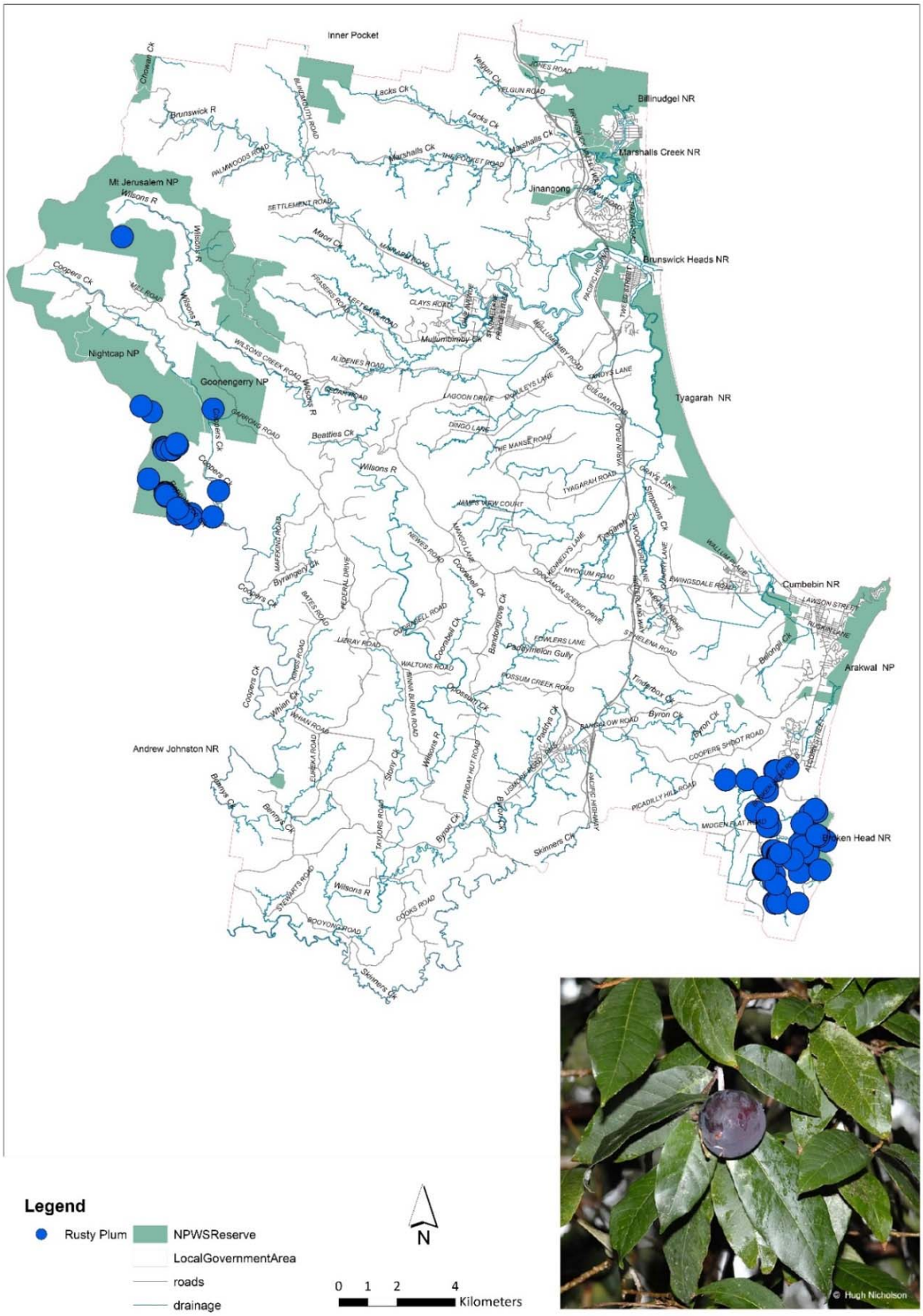
Stinking Cryptocarya *Cryptocarya foetida* – occurs in coastal rainforest mainly on soils derived from metasediments and at very restricted locations in the northern hinterland in low elevation rainforest mainly on soils derived from metasediments



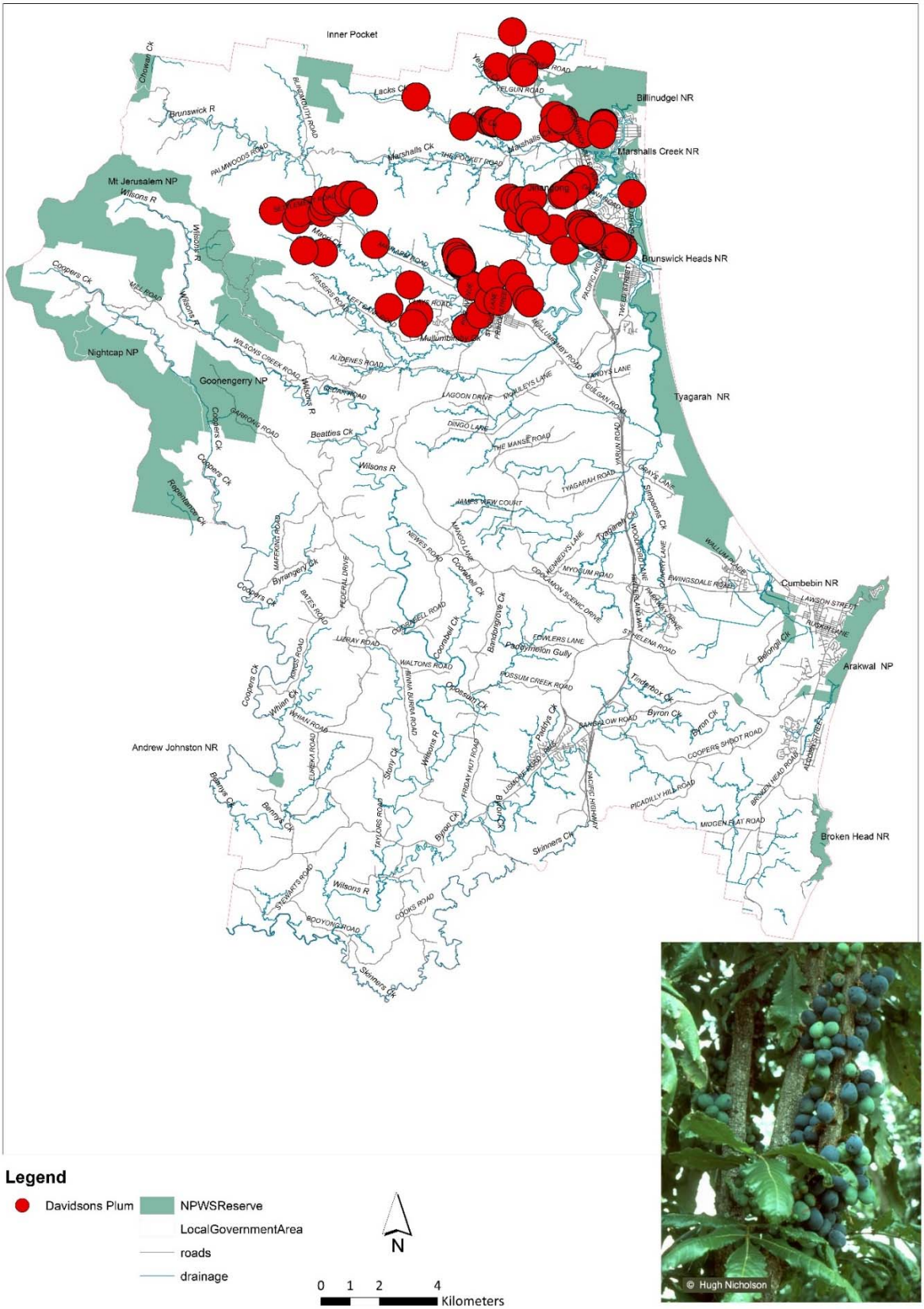
Xylosma *Xylosma terra-reginae* – occurs at restricted locations in coastal rainforest mainly on soils derived from metasediments



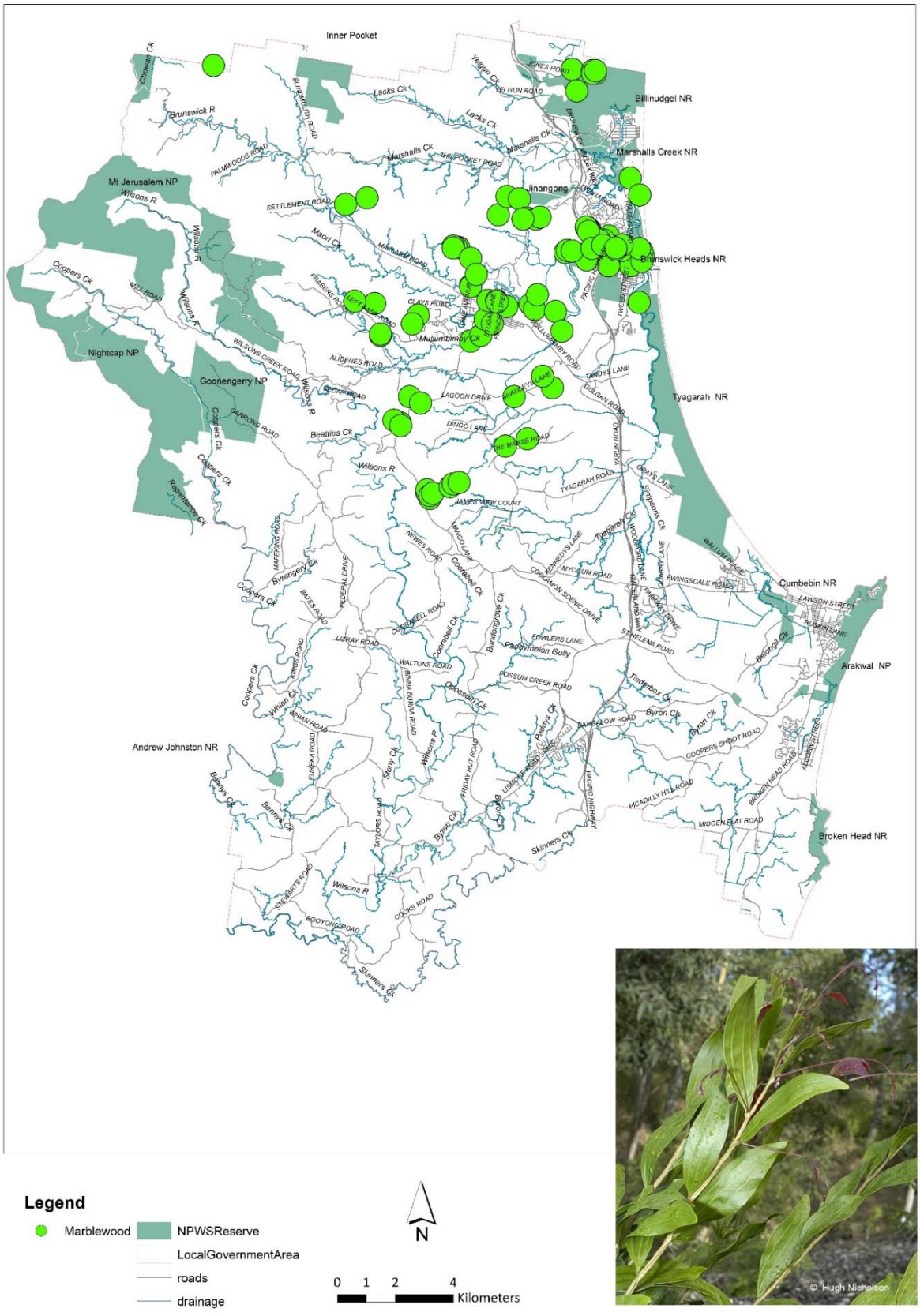
Rusty Plum *Niemeyera whitei* – occurs at restricted locations in the hinterland in high elevation rainforest mainly on soils derived from acid volcanics and in the south of the LGA in coastal rainforest mainly on soils derived from metasediments



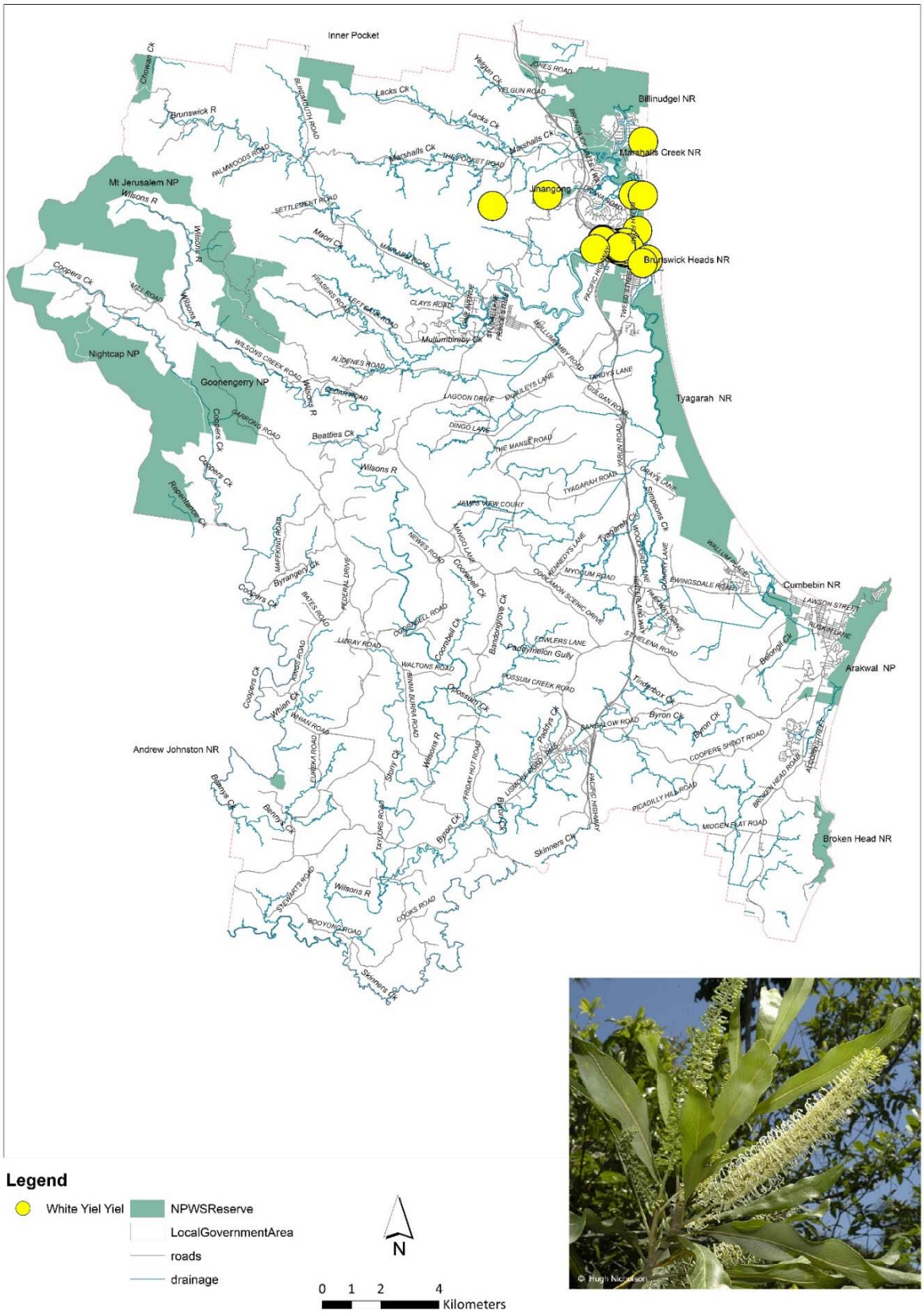
Davidson's Plum *Davidsonia jerseyana* – occurs at locations in the north of the LGA in low elevation rainforest mainly on soils derived from metasediments



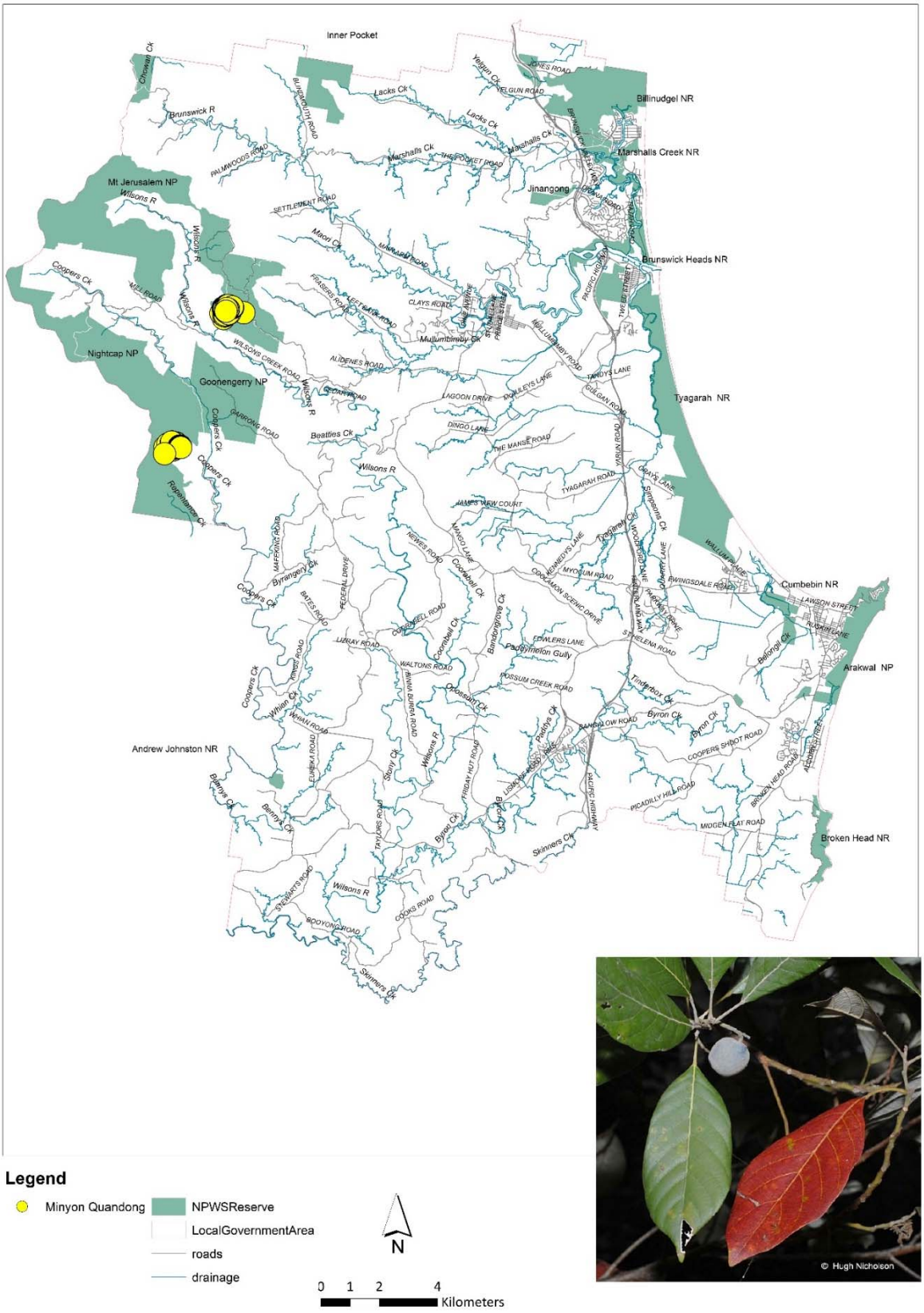
Marblewood *Acacia bakeri* – occurs in the north of the LGA in low elevation rainforest mainly on soils derived from metasediments



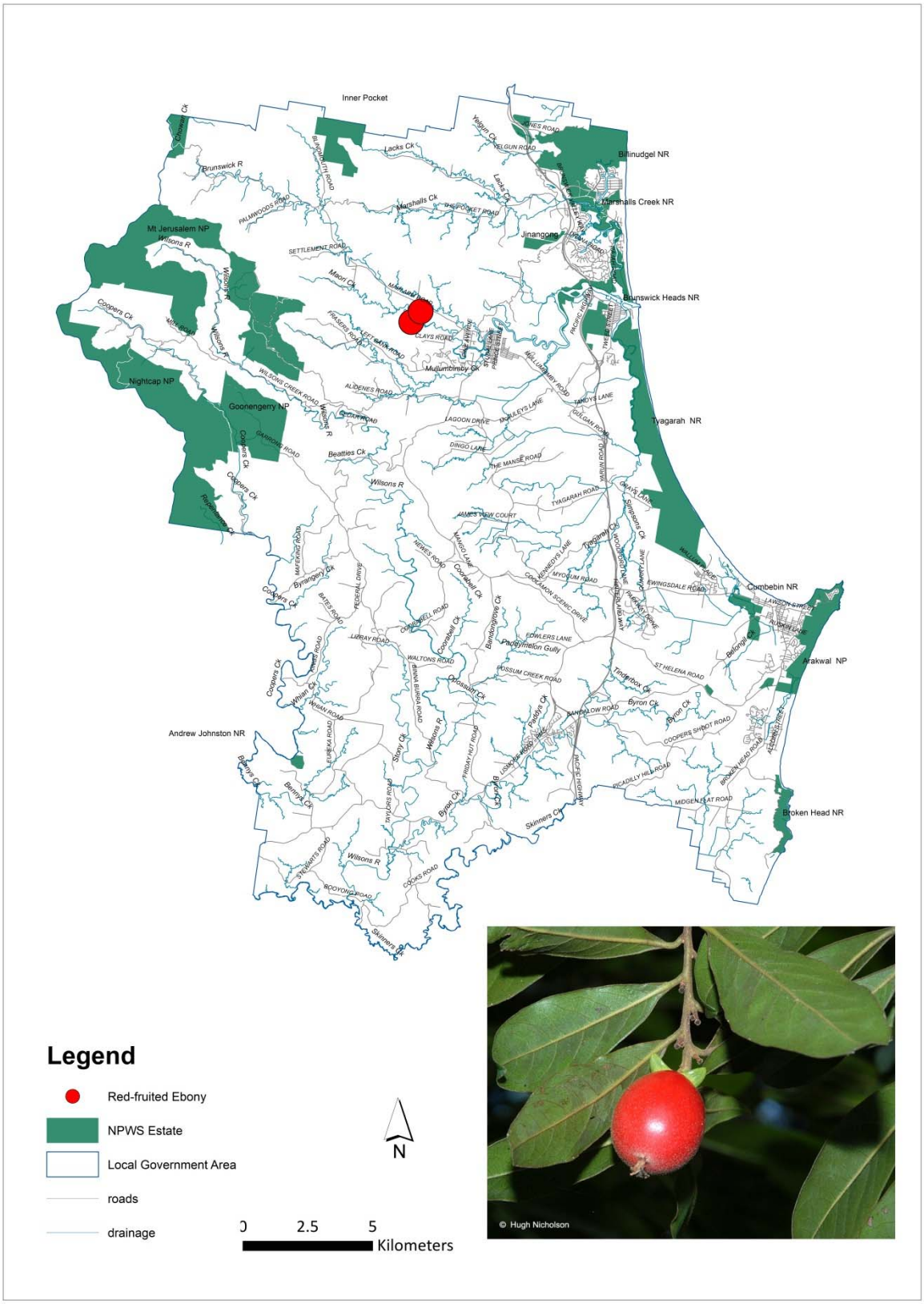
White Yiel Yiel *Grevillea hilliana* – occurs at restricted locations in the north of the LGA in coastal and low elevation rainforest mainly on soils derived from metasediments



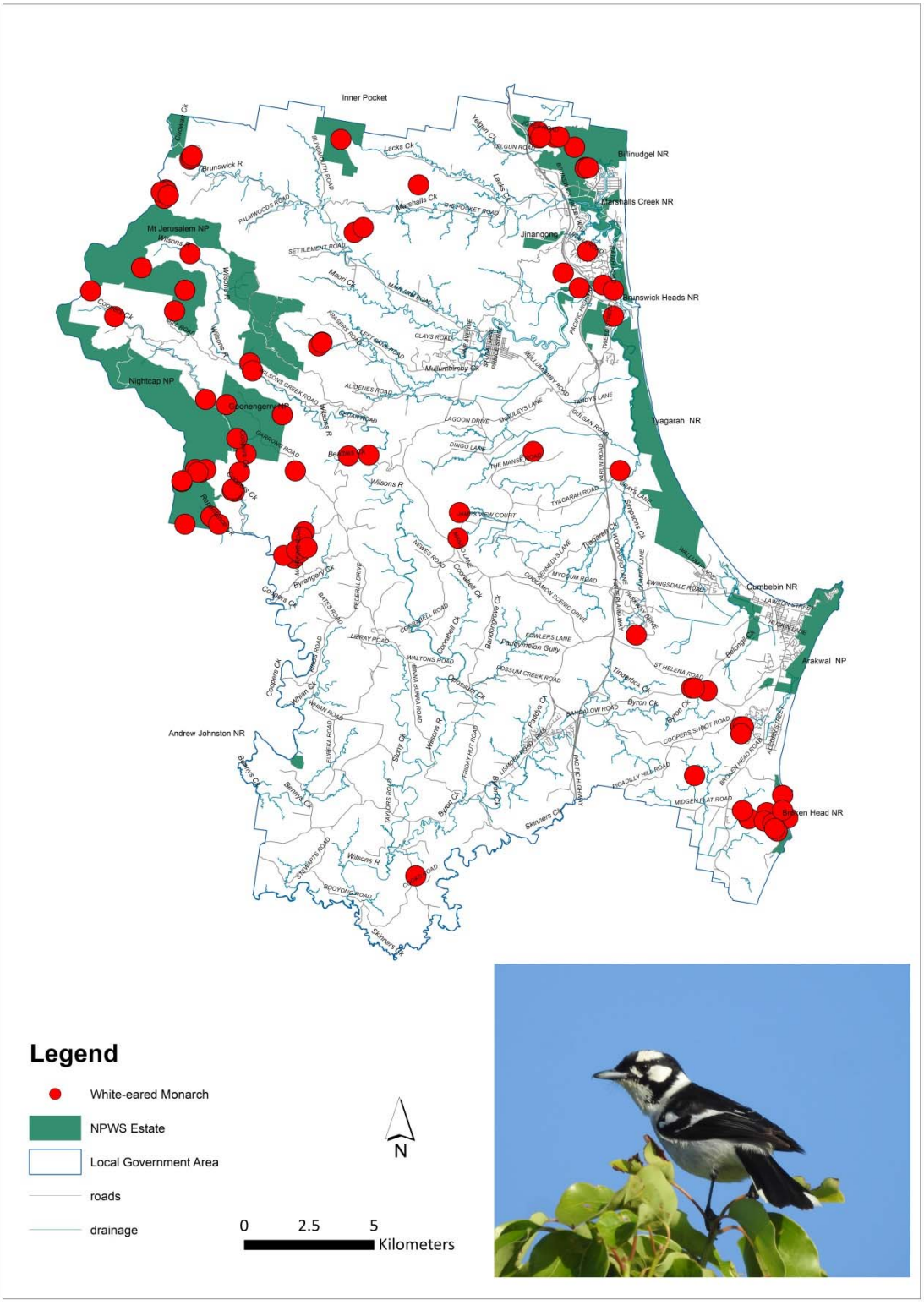
Minyon Quandong *Elaeocarpus sedentarius* – occurs at very restricted locations in the hinterland in low to high elevation rainforest mainly on soils derived from acid volcanics



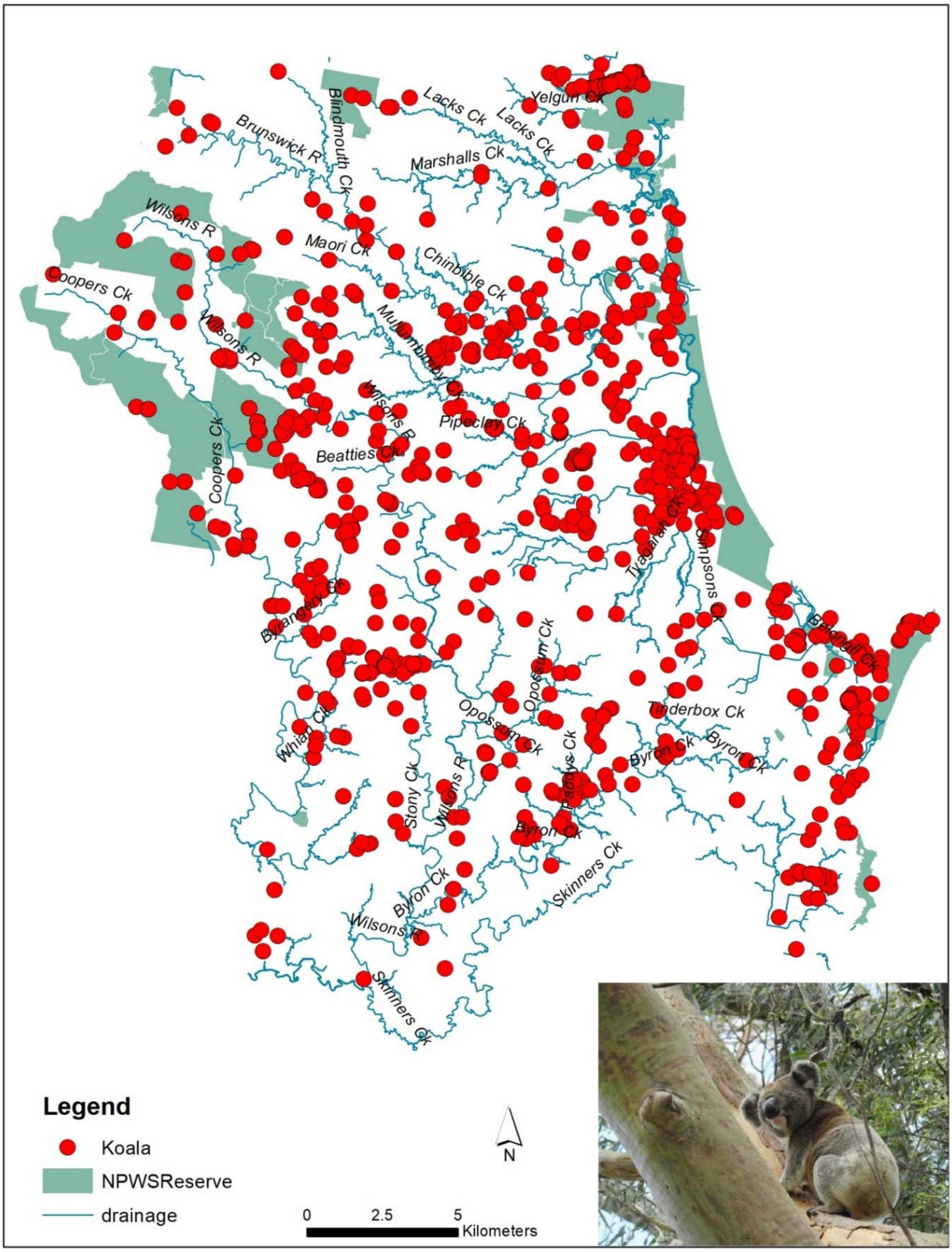
Red-fruited Ebony *Diospyros mabacea* – occurs at one location in the north of the LGA in low elevation rainforest on alluvium



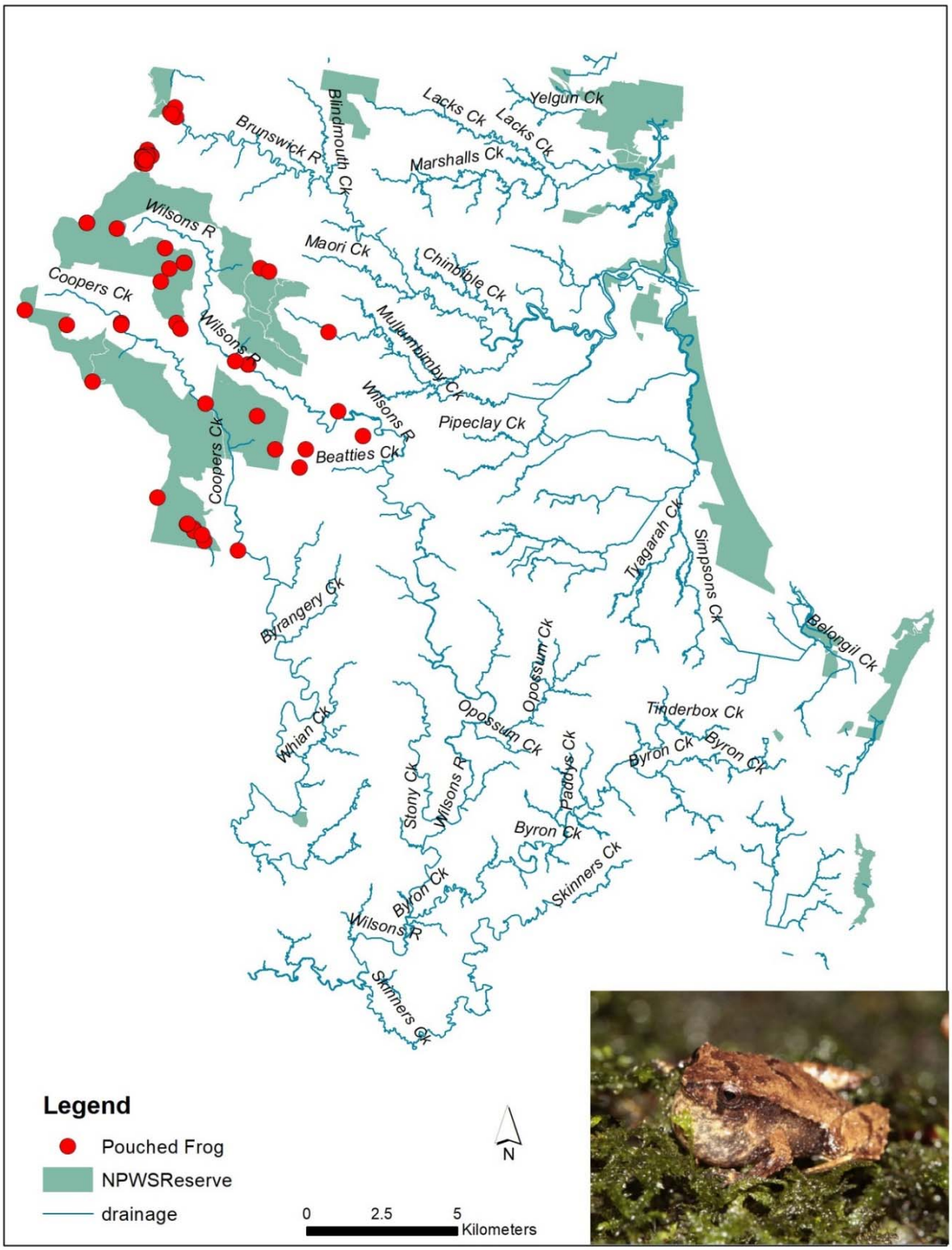
White-eared Monarch *Monarcha leucotis* – priority group 3.3, high dispersal capability, occurs throughout the LGA mainly in lowland rainforest, coastal rainforest and floodplain swamp sclerophyll forest



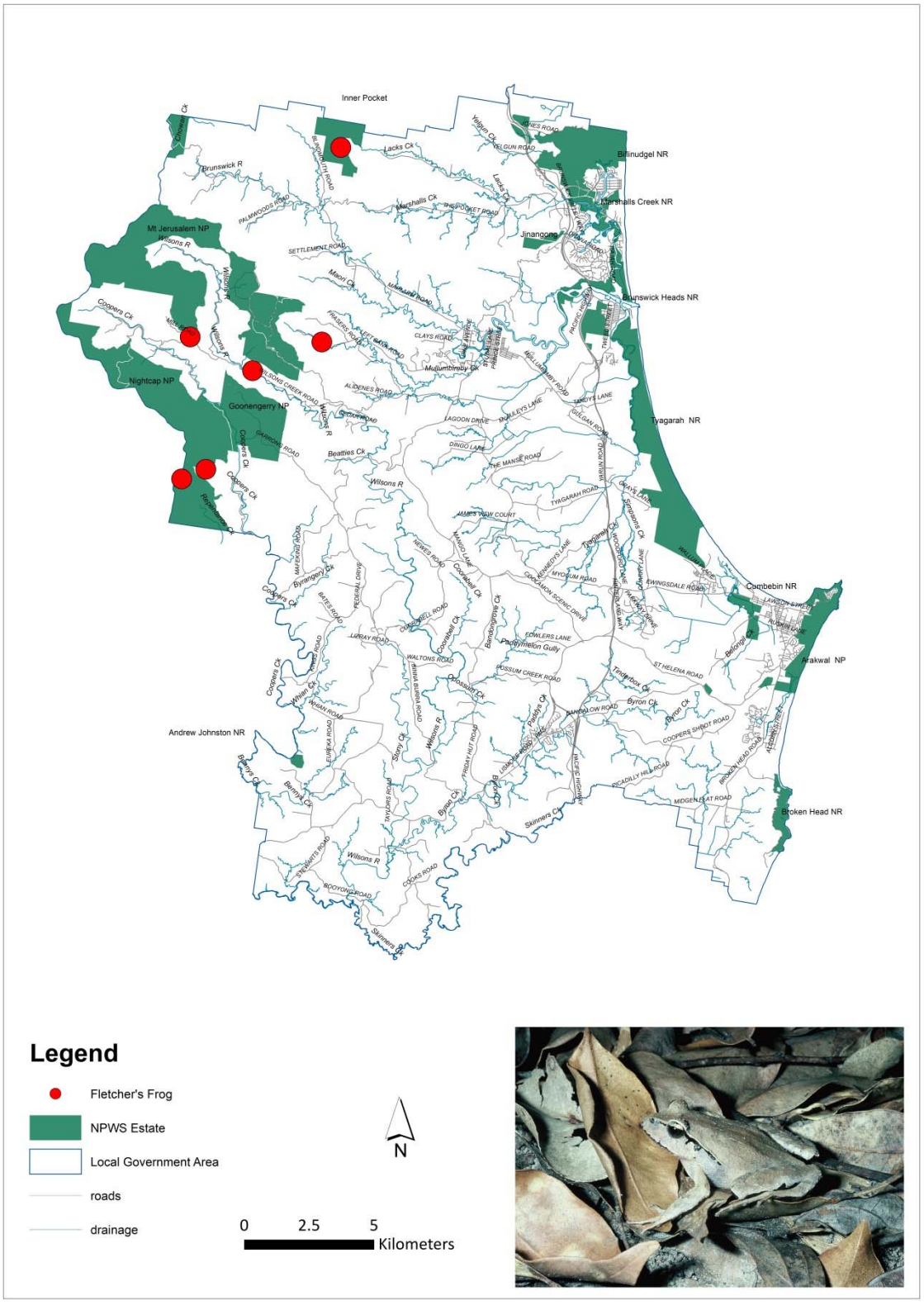
Koala *Phascolarctos cinereus* - priority group 3.4, high dispersal capability, occurs throughout the LGA mainly in wet sclerophyll forest, moist sclerophyll forest, floodplain swamp sclerophyll forest and low elevation dry sclerophyll forest



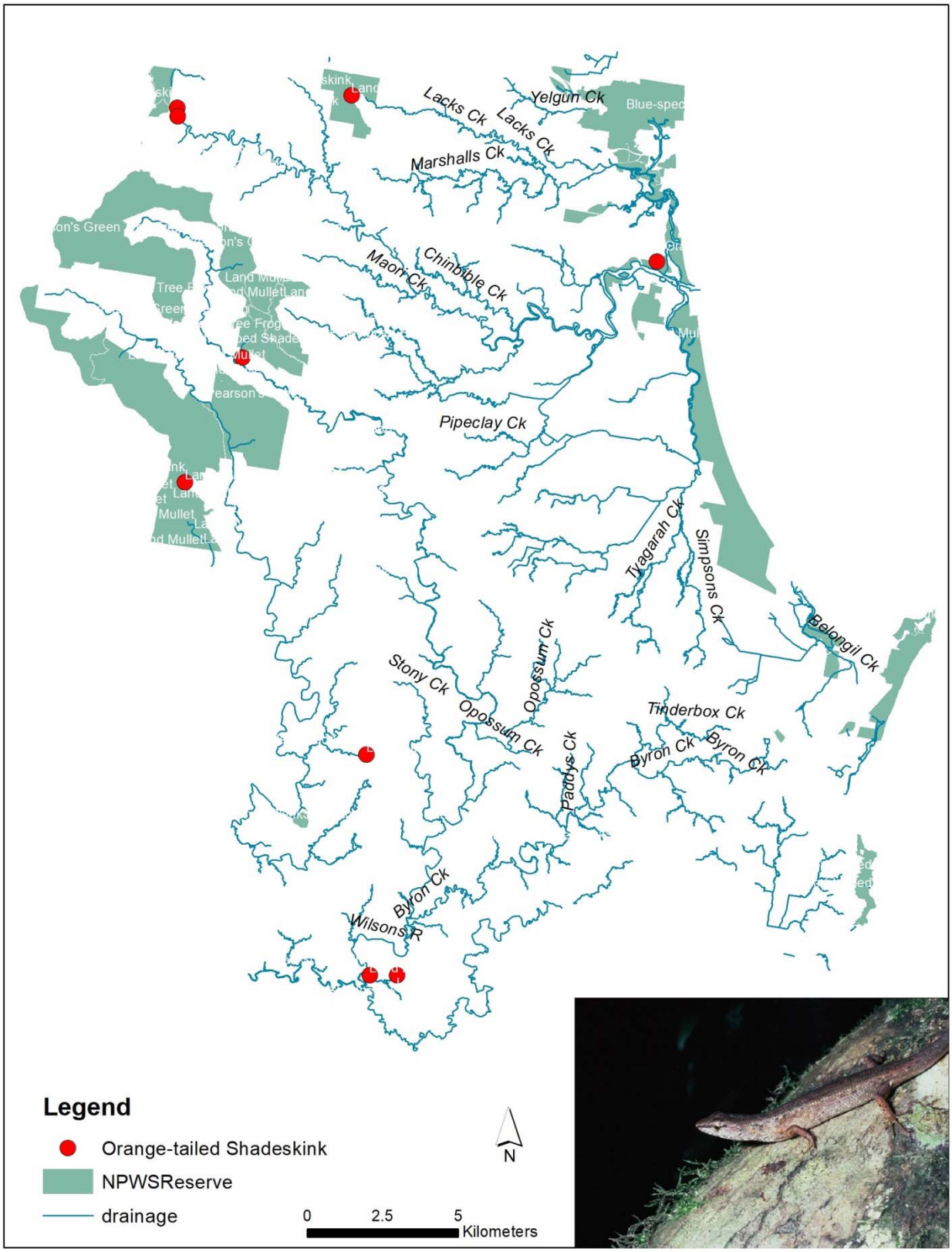
Pouched Frog *Assa darlingtonia* - priority group 1.1, very low/low dispersal capability, occurs in the hinterland mainly in wet sclerophyll forest and low to high elevation rainforests



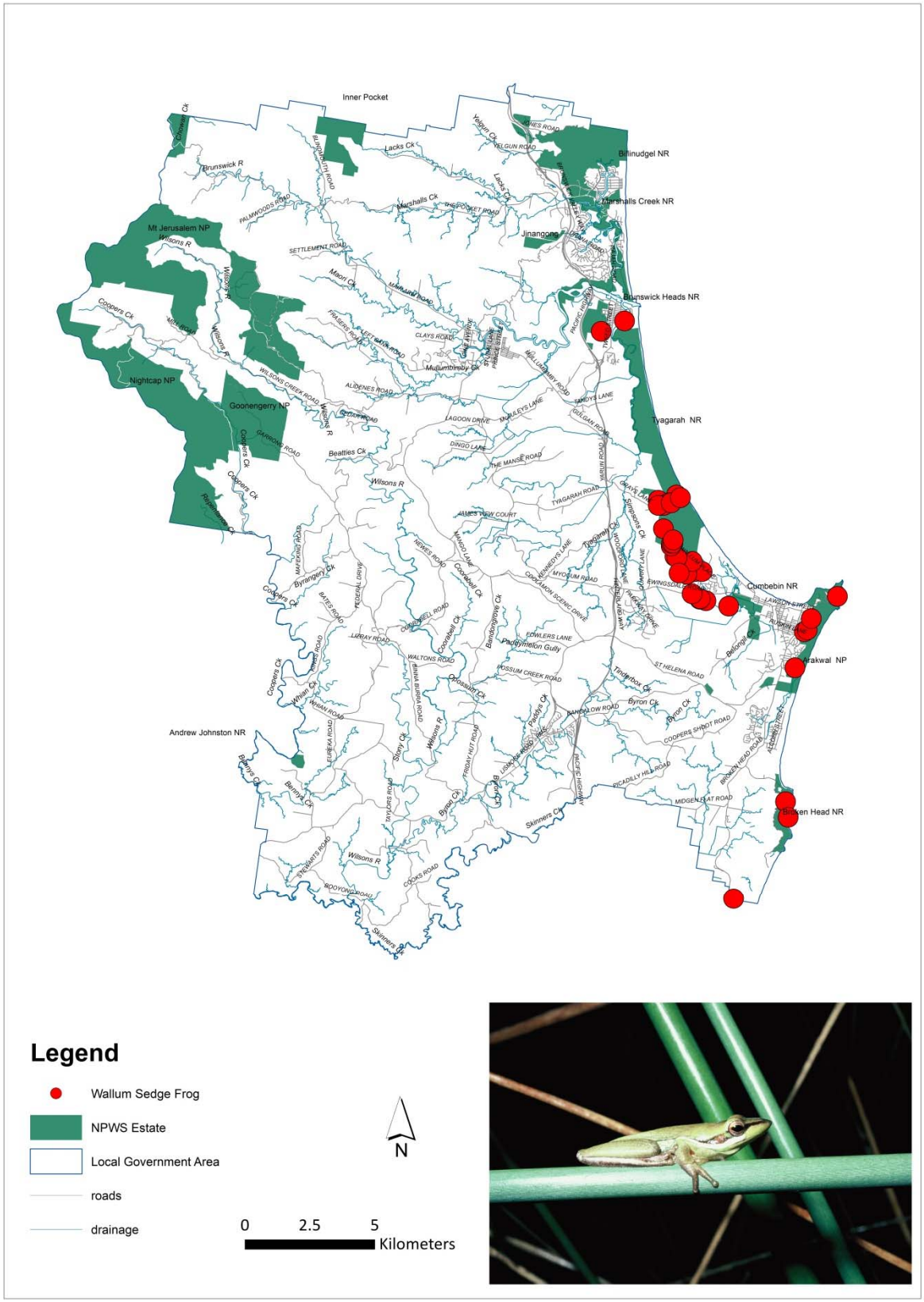
Fletcher's Frog *Lechriodus fletcheri* – priority group 1.1, very low/low dispersal capability, occurs in the hinterland mainly in low to high elevation rainforests and wet sclerophyll forest



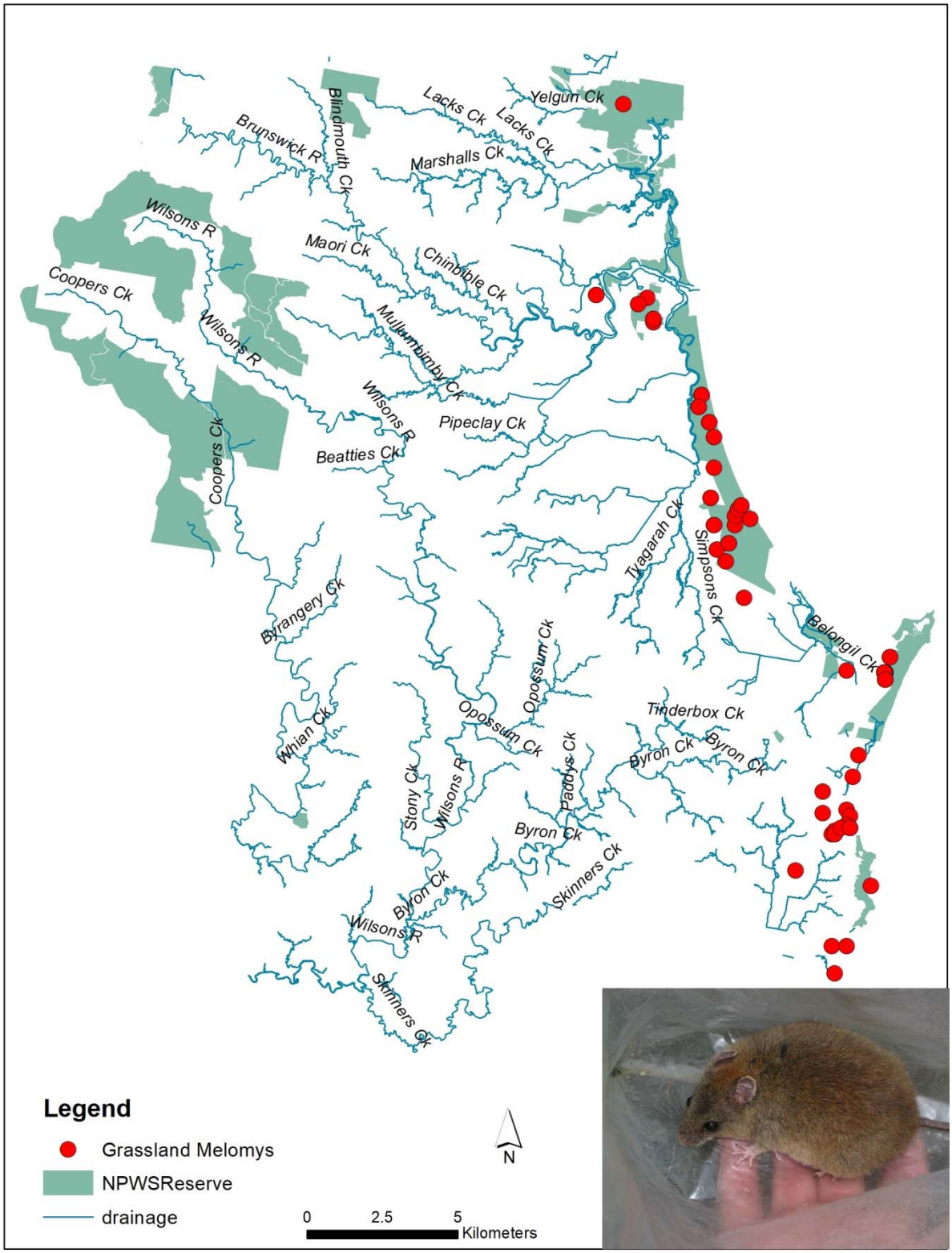
Orange-tailed Shadeskink *Saproscincus challengeri* - priority group 1.2, very low to low dispersal capability, occurs in the hinterland and at restricted locations on the coast mainly in low elevation rainforest, wet sclerophyll forest and floodplain swamp sclerophyll forest



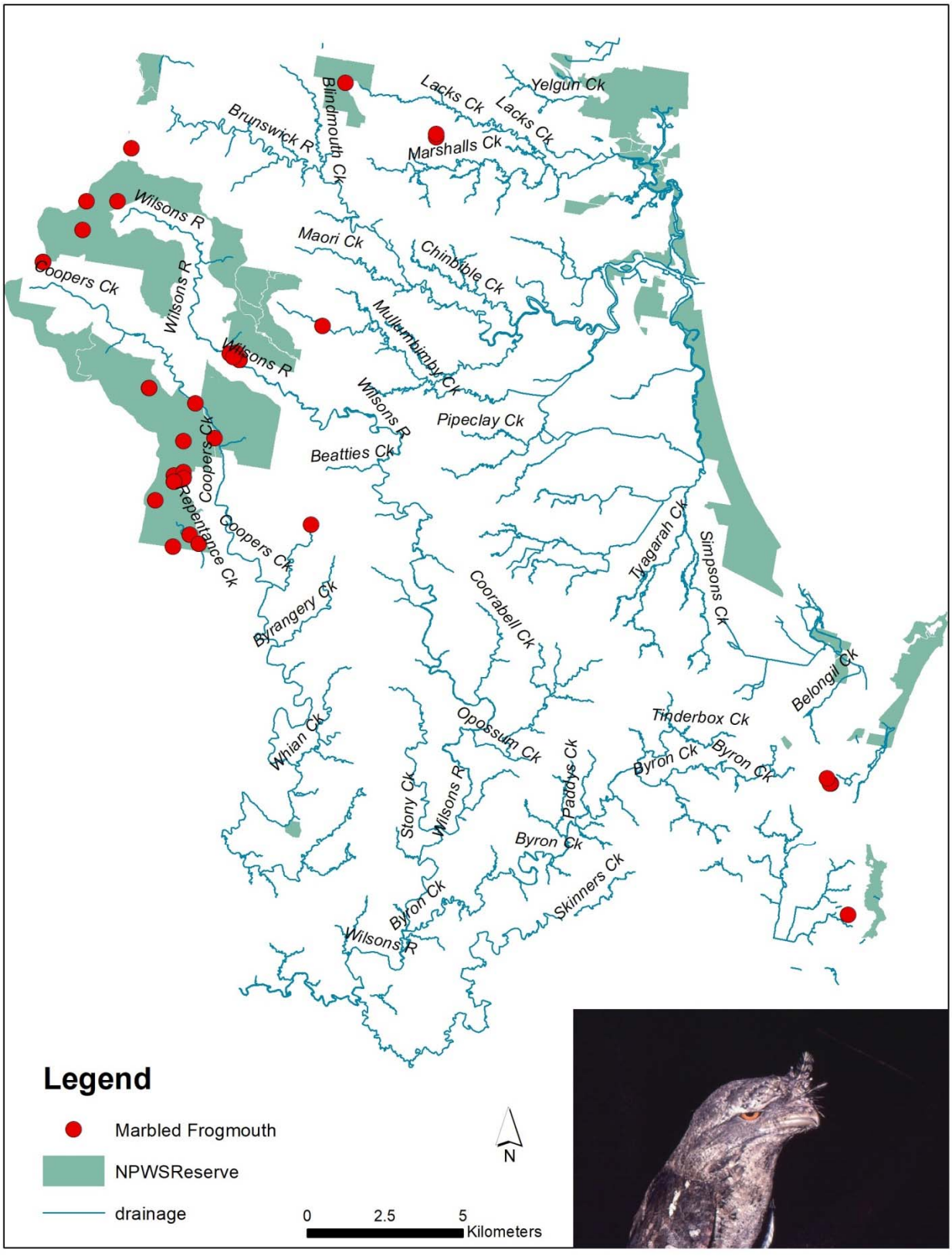
Wallum Sedge Frog *Litoria olongburensis* – priority group 1.4, low dispersal capability, occurs on the coast mainly in coastal swamp sclerophyll forest and wet coastal complex



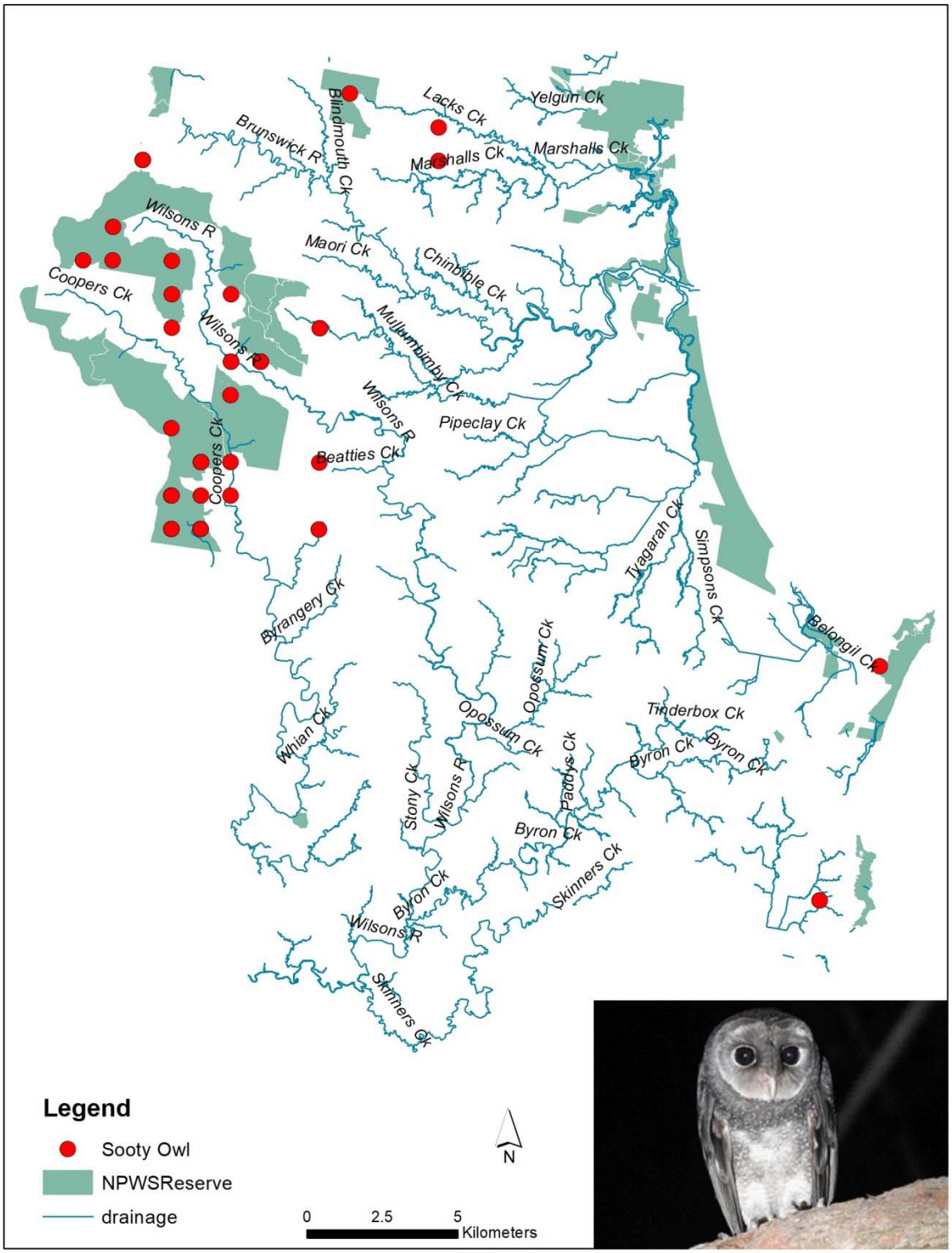
Grassland Melomys *Melomys burtoni* - priority group 1.4, low dispersal capability, occurs coastal swamp sclerophyll forest, low elevation dry sclerophyll forest and dry and wet coastal complex



Marbled Frogmouth *Podargus ocellatus* - priority group 1.3, low dispersal capability although some evidence of movements, occurs mainly in low elevation rainforest, coastal rainforest and wet sclerophyll forest

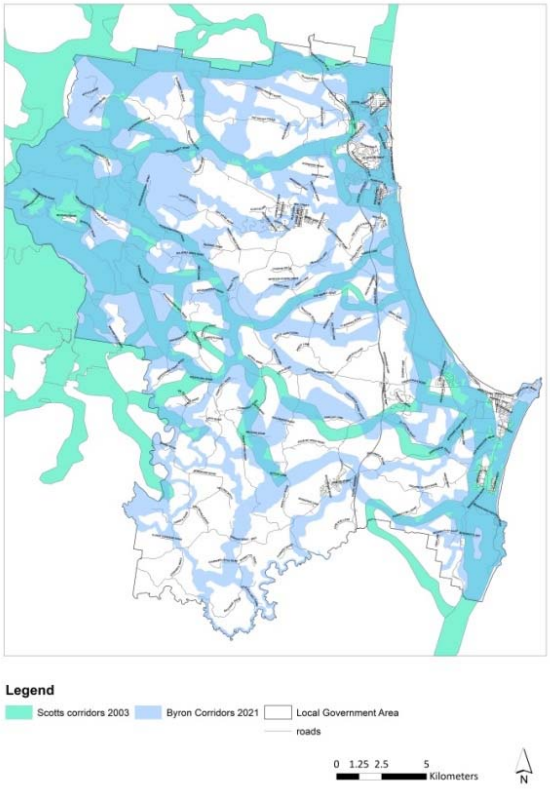


Sooty Owl *Tyto tenebicosa* - priority group 2.1, low-moderate dispersal capability and some evidence of movements, occurs mainly in low elevation rainforest, coastal rainforest and wet sclerophyll forest

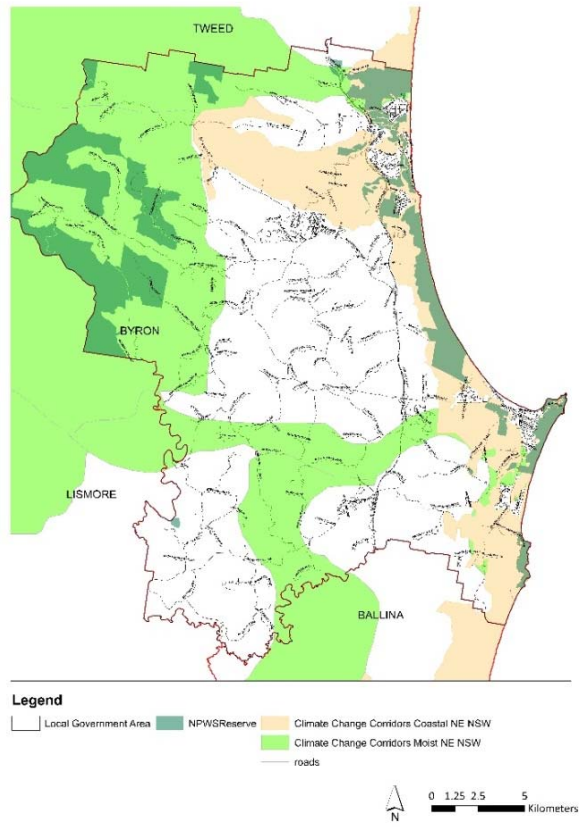


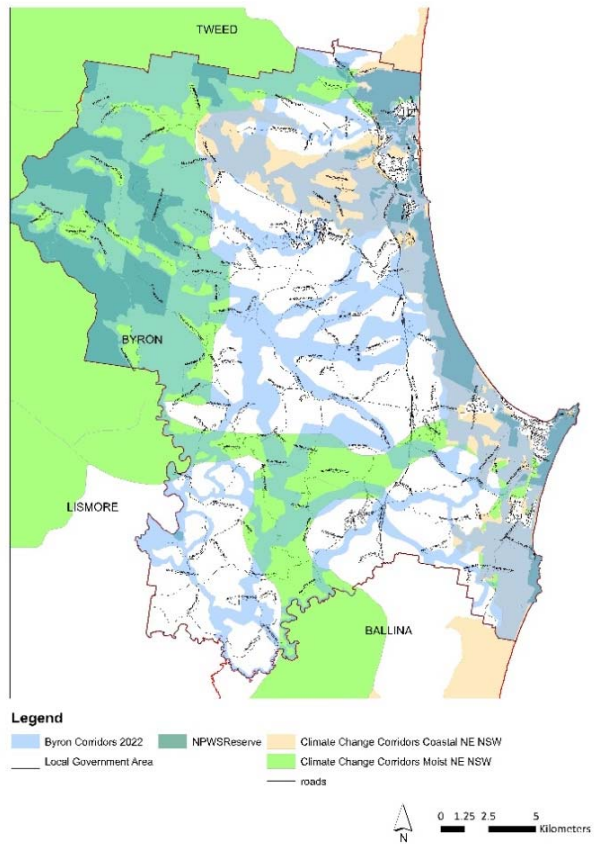
APPENDIX 11 Previous Corridor systems mapping

NSW National Parks and Wildlife Service Key Habitats and Corridors system – (Scotts 2003) and Byron Wildlife Corridor System 2022 overlaid



Climate Change Corridors system – State Government of NSW and Department of Planning, Industry and Environment 2010





Byron Shire Council wildlife corridors system – BSC 2004