REDLAND CITY COUNCIL

Wildlife Connections Plan

2018 - 2028

Redland
CITY COUNCIL

Provide habitat
for native species
Provide safe fauna passage
for species including, nomadic and migratory species, and dispersing individuals
Facilitate the continuity of ecological processes
through healthy and resilient animal and plant populations
Maintain or enhance genetic interchange
between otherwise isolated animal or plant populations
WHAT WE WANT TO ACHIEVE
HOW WE ARE GOING TO DO IT
Enhance and connect corridors
by acquiring priority land
Geographically identify core wildlife habitat
and terrestrial wildlife corridors
Manage and protect the wildlife habitat
we currently have
Manage impacts
of urban and/or peri-urban and/or rural areas
Manage impacts
from storm tide and sea level rise.
Provide input
into planning scheme

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Executive Summary

Fragmentation of wildlife habitat in the Redlands has resulted in smaller disconnected patches of wildlife habitat that has reduced wildlife movement and has led to a reduction in biodiversity. Wildlife habitat, networks and corridors are the areas of connected native vegetation that enable the maintenance of ecological processes, the movement of wildlife and support the continuation of viable populations. The Wildlife Connections Plan 2018-2028, aims to geographically identify, at a city wide scale, and provide priority actions for the management, protection and enhancement of a network of core wildlife habitat and connecting corridors in Redland City.

Development of this plan utilised spatial modelling (CircuitScape) to identify areas of key terrestrial wildlife corridor values that occur between core vegetation areas throughout Redland City. The modelling was based on the most up-to-date research, technology and available ecological and anthropogenic data. The modelling outputs and expert local knowledge were used to develop the high priority wildlife habitat networks and corridors detailed within this plan. The priority corridors have been assigned target widths and buffers, based on wildlife corridor ecology literature and principles.

The identified priority wildlife habitat corridors are assigned names and values, connectivity, threats and priority management actions have been recorded to increase the understanding of each corridor. The corridors link the critical areas of Core Habitat, based on interior areas of remnant vegetation.

Five categories of wildlife habitat corridors have been defined:

- Established Corridors - high ecological value and strong wildlife movement;
- Regional Riparian Corridors - high ecological value and identified as a state significance riparian corridors;
- Coastal Foreshore Corridors - coastal fringe corridor of mainland and islands;
- Enhancement Corridors - sufficient ecological values and linkages with scope for enhancement; and
- Stepping Stone Corridors - isolated patches of functional connected habitat.

Priority objectives and outcomes are listed for each individual corridor to:

- Improve Corridor Habitat
  - Rehabilitation of gaps and pinch points.
- Prevent Wildlife Deaths
  - Safe fauna passage across road (or rail) barriers.
- Reduce Impacts on Corridors
  - Management of urban and/or peri-urban and/or rural area impacts; and
  - Management of storm tide and sea level rise impacts
- Protect Corridor Habitat
  - Review City Plan to determine any necessary consequential amendments.

Strategic corridor locations identifying key values and associated priority outcomes are found in the associated document, Corridor Descriptions and Locations (Appendix 4-7). The implementation of the priority outcomes will be achieved through a variety of methods and will be the responsibility of several areas within Council.

It is important to recognise that the identified mapped core habitat and corridors represent only the high value habitat and corridors. Many of the areas not identified within this plan will still play a vital role in providing habitat and safe movement opportunities for many wildlife species.

Introduction

The Redland City Council local government area is made up of both mainland and island communities. It includes developed urban areas in the north of the City, rural and bushland habitat areas in the south as well as North Stradbroke Island, Coochiemudlo Island and the Southern Moreton Bay Islands (Macleay, Lamb, Karragarra and Russell Islands). The Redlands contains a diverse array of wildlife habitats, including dry and wet eucalypt forests, littoral and riparian rainforest, various wetland and heathland habitats, mangrove and saltmarsh. These habitats all accommodate wide-ranging populations of plants, animals and fungi. To ensure the healthy function of our natural environment, Council is focussed on ensuring habitat is properly mapped, connected, enhanced and protected using a mixture of scientifically rigorous methods and expert knowledge and skills.

Fragmentation of wildlife habitat in the Redlands is caused by the clearing of native vegetation for agricultural, industrial and urban development. Fragmentation results in smaller disconnected patches of wildlife habitat that reduces the ability of wildlife movement, and ultimately leads to a reduction in biodiversity. (Brearley 2011 & Ndubisi et al. 1995)

The Redland City Council area contains many existing wildlife habitat networks and corridors with various values. These corridors and networks are essential for viable flora and fauna populations as they enable migration, colonisation and breeding within a fragmented landscape.

Networks and corridors of wildlife habitat may consist of a combination of environmental (bushland habitat) areas, street tree plantings, recreational parks and reserves, residential backyards, non-urban private lands, foreshore areas, waterways and riparian areas. Effects from transport networks (road and rail), urban areas and other developments can have a detrimental impact on flora and fauna populations.

For the purposes of this plan, wildlife habitat networks and corridors are the areas of land or water (physical connections) that link and provide plant and animal habitats, therefore reducing the impacts of the fragmented landscape. The term network refers to the broad connectivity between patches of core wildlife habitat and the corridors that link them.

All native flora and fauna are protected by a suite of legislative and non-legislative tools in South East Queensland, including planning and non-planning instruments. In recent years, government responses at both the State and Federal level have strengthened and enhanced corridor connections. With development and population growth in Redland City continuing, Council is committed to ensuring wildlife habitat corridors and networks are protected and enhanced for the conservation of our valued wildlife and their natural habitats.

The challenge for this non-statutory plan is to re-evaluate, document and consolidate Council's approach to corridor conservation and management, by identifying and focusing effort on outcomes that are viable, and identify new and innovative actions.

Objectives of the Plan

The Wildlife Connections Plan 2018-2028 aims to, at a city wide scale, geographically identify and provide priority actions for the management, enhancement and protection of core wildlife habitat patches and to facilitate improved connection of wildlife corridors in Redland City.

It is important to recognise that as this plan is at the city wide scale, only the highest priority corridors are presented. Areas not identified as core habitat or corridors will continue to play a vital role in providing habitat and movement opportunities for wildlife.

This plan aims to include terrestrial (land), riparian (waterway) and coastal foreshore corridors to provide ecologically appropriate wildlife habitat networks and corridors for a range flora and fauna.

This non-statutory plan will form a guide to strengthen corridors by recognising opportunities for the management and enhancement of existing Council reserves and managed land. This plan will also be used to inform Council's extension and community education programs, conservation land acquisitions program and assist in identifying potential offset sites. A review of City Plan will also be undertaken to determine any necessary consequential amendments.

The wildlife habitat corridors are identified by local geographic location, aimed to engender local community recognition, acceptance and ownership.

The plan aims to facilitate a number of key outcomes to achieve these objectives through a targeted and prioritised action plan. The action plan addresses the key risks to the function, protection and management of corridors and networks.

Action Plan Objectives

- **Improving Corridor Habitat**

  Outcome 1: Rehabilitation of gaps and pinch points.

- **Preventing Wildlife Deaths**

  Outcome 2: Safe fauna passage across road (or rail) barriers.

- **Reduce Impacts on Corridors**

  Outcome 3: Management of urban and/or peri-urban and/or rural area impacts; and

  Outcome 4: Management of storm tide and sea level rise impacts.

- **Protecting Corridor Habitat**

  Outcome 5: Review City Plan to determine any necessary consequential amendments.

Legislation, Policy and Plans relevant to Strategic Corridors

National, State and Regional Corridor Strategic Planning

Successful strategic planning for wildlife habitat networks and corridors must involve participation from local, regional, state and national levels. Table 1 below outlines the relevant national, state and regional plans and strategies involving wildlife habitat networks and corridors planning. Appendix 1 provides a summary and review of these Federal, State and Regional documents.

Table 1: Summary of Corridor Planning

Scale	Program
National	National Wildlife Corridors Plan (Department of Sustainability, Environment, Water, Population and Communities, 2012)
State	Corridor identification through the Biodiversity Planning Assessments (Queensland Department of Environment and Heritage Protection, 2015)
Regional	Shaping SEQ - Draft South East Queensland Regional Plan (Department of Infrastructure, Local Government and Planning, 2016)
	Biodiversity Planning Assessment for the Southeast Queensland Bioregion – Version 4.1 (Department of Environment and Heritage Protection, 2016)

Redland City Council Corporate Plan 2015-2020

The Redland City Council Corporate Plan 2015-2020 establishes a commitment to promoting:

> "*A diverse and healthy natural environment, with an abundance of native flora and fauna and rich ecosystems, will thrive through awareness, commitment and action in caring for the environment.*
>
> 1. *Redland's natural assets including flora, fauna, habitats, biodiversity, ecosystems and waterways are managed, maintained and monitored.*
> 2. *Threatened species are maintained and protected, including the vulnerable koala species*."

Council understands that key to the delivery of this outcome is the maintenance of sufficient wildlife habitat across the City to support the ecological functions of the flora and fauna that live within or migrate through the Redlands.

Redland City Council - Natural Environment Policy

In June 2015, Council adopted the *POL-3128 Natural Environment Policy*, consolidating former environmental policies. Council resolved to prepare updated strategies and plans to progress the Natural Environment Policy, identifying a number of priorities; including corridors. This plan will relate to the following sections of the Natural Environment Policy:

"1*. Protect, enhance, restore the natural values of the City that include:*

a. Koalas and other native animal and plant populations and habitats;

b. core habitat areas as sanctuaries for wildlife;

c. safe wildlife movement corridors across the landscape;

d. maintaining no net loss of native vegetation as defined in the Vegetation Management Act 1999;

e. biological diversity and ecosystem services;

f. waterways, foreshores, wetlands, coasts, aquatic ecosystems and Moreton Bay;

2. Enhance and restore Council's protected areas and strengthen the connections between core habitats through public open space plantings, pest management and appropriate street tree planting programs in accordance with SEQ Natural Resource Management targets.

3. A conservation acquisition program that prioritises acquisition of land for rehabilitation, offsets, corridors and long term protection to achieve cost effective environmental outcomes that contribute to facilitating biodiversity conservation (eg koala survival) and has community benefits.

4. Manage protected areas to provide the best possible buffering of the City's natural and cultural heritage values from the impacts of a changing climate."

Local Corridor Strategic Planning

Although strategic corridor planning is undertaken at a federal, state and regional level it is at the local level that the implementation of corridor management usually occurs. Over the past twenty years Redland City Council has developed and implemented a number of plans, strategies and mapping tools relating to wildlife habitat networks and corridors, including:

- Redland City Council Plans and Strategies:
    - Bushland and Habitat Corridor Plan 2004; and
- Mapping Tools:
    - Environmental Inventory (Chenoweth) 1996 to 2007;
    - Green Infrastructure 2009;
    - Wildlife Corridor Mapping Using Species Indicator Model 2010;
    - Natural Environment Decision System (AECOM and BAAM) 2011;
    - Redlands Trunk Green Corridors 2013; and
    - Wildlife Corridor Mapping (BAAM) 2014.

The implementation and success of these plans has been varied. Appendix 2 provides a summary and review of these Redland City Council documents and mapping products.

The most recent review of the Bushland and Habitat Corridor Plan 2004 (the precursor to this plan) revealed that of the 41 recommendations made within the 2004 plan, 17 have been implemented (or are ongoing), 15 were partially implemented and 9 were not implemented. It is noted that several of the implemented recommendations involved the development of a plan, strategy, mapping tool, research or advocacy, and that the on-ground actions derived from these may not have been realised.

Successful implementation of recommendations from the 2004 plan included:

- Surveys, reports and installation of treatments for fauna crossing points of roads in Redland City;
- Incorporation of the Environmental Inventory mapping into Redland Planning Scheme; and
- Koala habitat mapping projects.

Ecology and Principles of Wildlife Habitat Networks and Corridors

The basic ecological principles of wildlife habitat networks and corridors involve linking and improving connectivity between patches of core habitat in a fragmented landscape. Wildlife habitat networks and corridors must provide functional connectivity for flora and fauna species to move through fragmented landscapes to larger core habitat patches that contain greater resources and are more suitable for survival (Hess & Fischer 2001). A lack of connectivity in a fragmented landscape results in the isolation of flora and fauna populations, which reduces the possibility of demographic or genetic rescue (Doerr & Davies 2010).

The ability of networks and corridors to increase connectivity and provide for dispersal depends primarily on the dispersal behaviour of the species involved, as well as the characteristics of the corridors, core habitat patches and the surrounding matrix (Heinz et al. 2007). Wildlife behaviours (including home range, diet and social structure) and habitat preferences of locally relevant species should be used to determine the design and management of corridors and networks (Lindenmayer & Nix, 1993). The requirements of species most threatened by habitat fragmentation and also species acting as vectors for ecological processes (e.g. seed dispersers, pollinators, predators) are critical for successful wildlife habitat networks and corridors (Scotts & Cotsell 2014).

Wildlife habitat networks and corridors have multiple benefits, they are important for:

- Providing residential habitat for some species;
- Providing movement habitat for wide-ranging species, nomadic and migratory species, and dispersing individuals;
- Maintaining or enhancing genetic interchange between otherwise isolated animal or plant populations; and
- Facilitating the continuity of ecological processes through healthy and resilient animal and plant populations (Bennett 1998; Beier & Noss 1998; Lindenmayer & Franklin 2002; Hilty et al. 2006; Chester & Hilty 2010; Doerr et al. 2010).

The ecology and principles of wildlife habitat networks and corridors is a relatively well-studied and researched area. Appendix 3 provides a literature review on the major components of this topic. To summarise this work Table 2 describes the guiding principles for a functional wildlife habitat corridor.

Table 2 - Summary of Wildlife Habitat Networks and Corridors attributes functions and guiding principles.

Core Habitat Patches	
Large as Practical	To provide necessary resources and environmental conditions required for survivorship, reproduction and movement of a species core habitat patches should be as large as practical.
Circular Shape	The perimeter of core habitat patches should be minimised to reduce the impacts of edge effects (such as weed infestation, human-generated damage, microclimatic variables, and predation).
> 60m Buffer	A minimum 60m buffer of native vegetation should be provided for core habitat patches to reduce the risk of edge effects.
< 1100m Gaps	Core habitat patches should be no more than 1100m apart (even where structurally intact corridors are linking the core habitat patches).
Wildlife Habitat Corridors	
< 106m Gaps	To facilitate wildlife movement gaps (open areas) in habitat along wildlife habitat corridors should be no more than 106m.
> 100m Width	Wildlife habitat corridors should have a minimum width of 100m (preferably 250m to retain variety of bird species and complete suite of arboreal mammals).
> 50m Buffer	A minimum 50m buffer of native vegetation should be provided for wildlife habitat corridors to reduce the risk of edge effects.
Feathered Edge	To minimise exposure to edge effects and keep species movements within the corridor, wildlife habitat corridors should have an edge with a feathered shape.
Diverse Structure	A diversity of native flora (for example layers including grasses, small shrubs, and variety of trees) will benefit a greater number of species moving through wildlife habitat corridors.
Minimise Barriers	Minimising the number and impact of barriers (for example highways, railway lines and impermeable fences) will increase the success of wildlife habitat corridors.
Stepping Stones	Identification of critical stepping stone corridors (for example scattered street or paddock trees) will increase the success of wildlife habitat networks.

Wildlife habitat networks and corridors can operate at a variety of scales:

- National corridors operate at the continental scale, aiming to create or enhance major landscape links. The 'National Wildlife Corridors Plan: A framework for landscape-scale conservation 2012' provides the framework for Australia's national corridor network.
- Regional corridors are connections between larger areas of generally protected habitat. They provide a range of ecosystem processes and are capable of supporting viable wildlife populations within the corridors. Regional corridors are generally greater than 500m in width and typically connect along altitudinal or migratory ecological gradients such as coast to hinterland (DECC 2004). The South East Queensland Regional Plan and the South East Queensland Biodiversity Planning Assessment (State Significance Corridors) provide the framework for regional corridors in Queensland.
- Sub-regional corridors facilitate species movement and dispersal opportunities for a wide range of species, but are not wide enough to support an extensive range of viable populations. Sub-regional corridors are generally greater than 300m wide and typically link larger vegetated landscape features (DECC 2004). The South East Queensland Biodiversity Planning Assessment 2016 (Regional Significance Corridors) provides the framework for regional corridors in Queensland. The Gold Coast Bioregional Corridor Plans are an example of implementation of a sub-regional corridor planning (Conics 2009).
- Local scale corridors function as conduits for wildlife movement between patches of core habitat by providing adequate cover and refuge for the duration of the wildlife movement, but generally do not provide habitat which is able to sustain viable populations within the corridor (Bennett 2003). The wildlife habitat corridors is presented within this plan are local scale.

Modelling of Redlands Wildlife Habitat Networks and Corridors

Biodiversity Assessment and Management (BAAM) ecological consultants were commissioned by Redland City Council to geographically identify a well-defined wildlife habitat network of core habitat patches and connecting corridors in Redland City. The resulting 'Wildlife Habitat Networks and Corridor Mapping – Redland City' report (BAAM 2016), used spatial modelling to generate a heat map of key terrestrial wildlife corridor values that occur between core vegetation areas throughout Redland City.

The work was based on the refinement of a previous study (BAAM 2014), which provided a contemporary approach to modelling and mapping wildlife networks and corridors in Redland City using a network modelling tool called CircuitScape. CircuitScape is a connectivity analysis software package which uses algorithms from electronic circuit theory to predict patterns of movement among plant and animal populations. Circuit theory considers the effects of all possible pathways across a landscape simultaneously. (BAAM 2016) This modelling tool was again used to develop wildlife habitat network and corridor value maps for Redland City, based upon the attribution of several key anthropogenic and ecological parameters. These parameters included:

- Remnant vegetation mapping, with edges treated separately;
- Regrowth vegetation mapping, with edges treated separately;
- Urban trees - small patches of trees or isolated clumps of vegetation;
- Open areas - very sparse canopy, infrequent artificial obstacles;
- Urban land - lots equal to, or less than 2000m2 were classified as urban land; and
- Transport infrastructure - major, secondary and local roads, and the rail network.

Separate spatial layers were created for each parameter and the parameters were given a ranked score, based upon key assumptions about their relative conductivity contributions to wildlife movement. These layers were all used to inform the creation of a single raster suitable for input into the modelling software.

A separate raster of core habitat was created to identify the connectivity source points, which form a critical component of the model. The core habitat raster is based on interior areas of the remnant vegetation mapping (with a 60m edge-affected rim removed).

Each of the Redland City land areas (mainland, Coochiemudlo Island, the inhabited Southern Moreton Bay Islands and North Stradbroke Island) were modelled independently.

The model revealed a series of wildlife networks across Redland City, as shown in Figure 1. These are particularly well-defined on the mainland, but also evident on the Southern Moreton Bay Islands and, to a lesser extent, on North Stradbroke Island, which is comprehensively dominated by remnant vegetation (core habitat).

The output rasters were relativised and transformed into a single vector. The vector was then simplified into two levels of attribution (based on their medium–high “heat” scores outside of core areas) to represent two different types of wildlife corridor (as shown in Figure 2):

- **Established Corridor Values:** these are areas of particularly high ecological value that hold strong, pre-existing values in providing movement opportunities for wildlife in general; and
- **Enhancement Corridor Values**: these are areas that exhibit sufficient ecological value and linkages that would be appropriate targets for strategic enhancement to strengthen Established Corridors.

The output of networks and wildlife corridors were then critiqued using a series of overlays. These included local waterways, corridor dependent species database records, the Queensland Government Biodiversity Planning Assessment (BPA) regional and state corridors layer and a public land layer. This interrogation of the model outputs indicated that these corridors, despite being simplified versions of the model output, correspond closely with vegetated waterways, corridor dependent species records, and the independently derived BPA corridors.

This automated modelling system provided an objective connectivity map that can be used in conjunction with complimentary studies, land tenure data, key habitats, corridor-dependent species data and expert knowledge of the area to identify potential terrestrial wildlife corridors.

The mapping outputs from the CircuitScape modelling (core habitat patches, raster heat mapping outputs and Established and Enhancement Corridor layers) are used to help the visual identification of priority wildlife corridors throughout Redland City. These mapping outputs will be useful to inform planning and management of:

- Existing Council reserves
- Waterway, wetland and riparian programs
- Individual property planning
- Potential offset sites
- Conservation land acquisitions, and
- City wide land use planning

The mapping report recommends an analysis is undertaken to identify corridors for strategic protection and enhancement in future planning instruments. This recommendation has been implemented by the delineation of the priority wildlife habitat corridors, outlined in the following sections of this plan.

Limitations of Modelling Redlands Wildlife Habitat Networks and Corridors

Issue: Defining Established and Enhancement Corridor layers from heat mapping vector.

- **Reason**: Allows areas with higher connectivity value to stand out, which assist in prioritising decision making.
- **Limitation**: Areas of habitat that did not meet the cut-off for Established and Enhancement Corridors may still be important for the linkage of key core habitat areas.
- **Options to address:** Secondary rehabilitation of areas between enhancement corridors may result in additional areas being included in Established and/or Enhancement Corridor layers in the future.

Issue: Focus on terrestrial corridors.

- **Reason:** The BAAM report and modelling exercise is limited to the recognition of terrestrial wildlife corridors.
- **Limitation:** The modelling does not address non-terrestrial fauna movement, such as the movement of migratory shorebirds between intertidal areas.
- **Options to address:** The scope of the Wildlife Connections Plan is terrestrial fauna movement, in line with the current priority of Council. A change in scope, or separate plan would be required to address non-terrestrial fauna movement.

Issue: The formation of the model's core habitat layer did not include areas of regrowth vegetation.

- **Reason:** All areas of regrowth vegetation were excluded from the core habitat layer, as regrowth vegetation was not deemed to have sufficient habitat values to be considered as core habitat**.**
- **Limitation:** Some areas of high-quality regrowth vegetation with important habitat features were excluded from the core habitat layer. These areas of habitat may still include features of core habitat and they may still support a diversity of wildlife.
- **Options to address:** Include regrowth vegetation in core habitat layer in future runs of the model.

Issue: Removal of 60m edge-affected rim from core habitat.

- **Reason:** A minimum 60m buffer of native vegetation should be provided for core habitat patches to reduce the risk of edge effects. The core habitat is based on interior areas of the remnant vegetation mapping (with a 60m edge-affected rim).
- **Limitation:** Certain areas of recognised habitat value were excluded from the core layer in the model by applying and removing the 60m wide edge-affected rim. This does not necessarily suggest these areas are not ecologically important, and it should be recognised they may still support a diversity of wildlife.
- **Options to address:** Width of buffer could be adjusted in future runs of the model, in accordance with changes to contemporary knowledge and practice.

Issue: Habitat features beyond the Redland City boundary were excluded in the modelling. This could potentially influence wildlife network and corridor values within Redland City.

- **Reason:** The western edge of the city is largely bounded by remnant bushland areas with contiguous core habitat areas extending within and along the boundary itself (such as Tingalpa Creek Conservation Park, Daisy Hill Conservation Park, Venman Bushland National Park, Cornubia Nature Refuge and the Bayview, Days Road, Kidd Street and Serpentine Creek Conservation Areas).
- **Outcome:** The inclusion of areas outside of Redland City in the modelling process was considered likely to have little influence on the identification of wildlife network and corridor values within Redland City.
- **Options to address:** The scope of the Wildlife Connections Plan is terrestrial fauna movement throughout Redland City, in line with the current priority of Council. A change in scope, or separate plan would be required to address fauna movement across local government boundaries with neighbouring local governments.

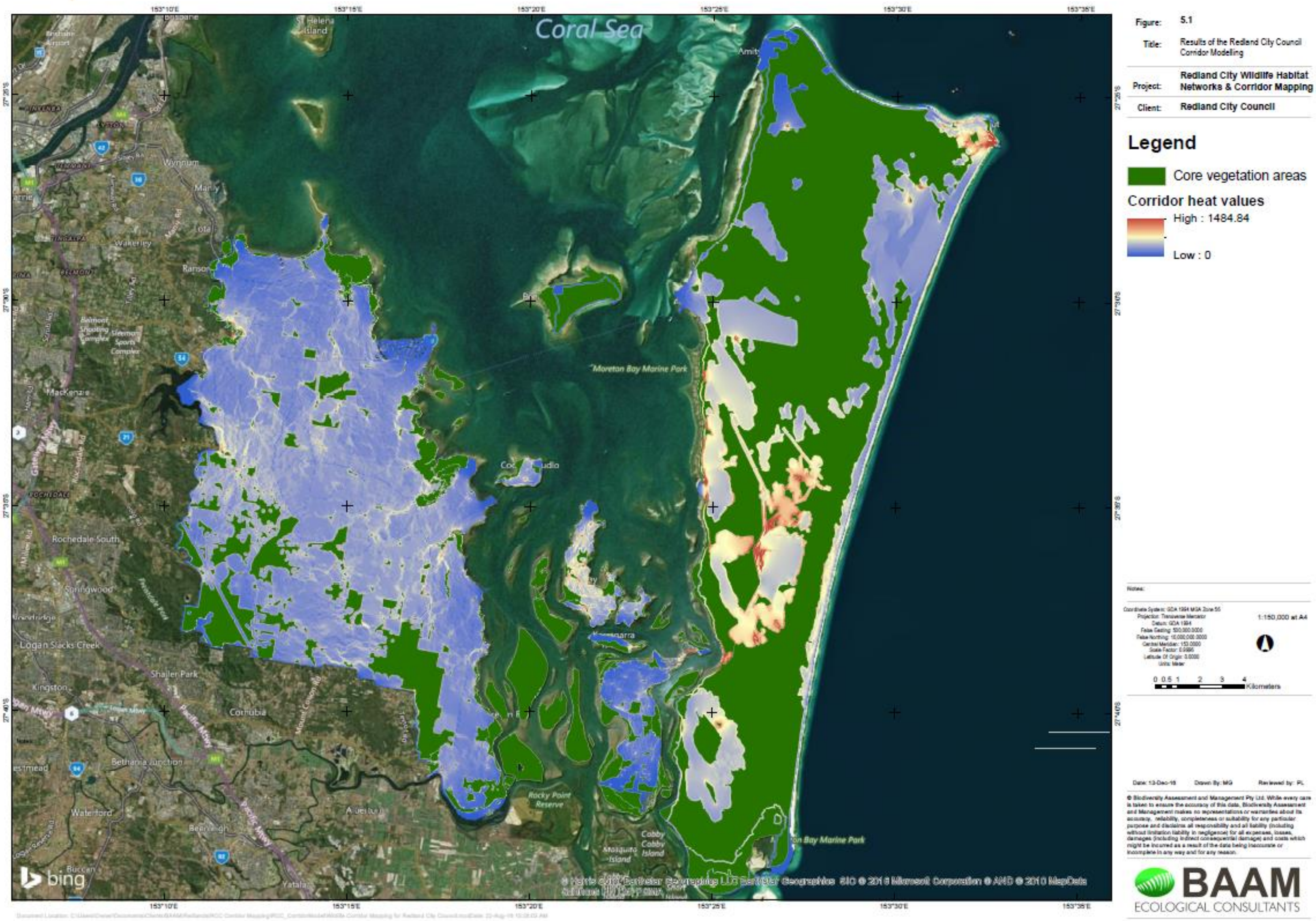

Figure 1 - Raster heat map output from CircuitScape modelling.

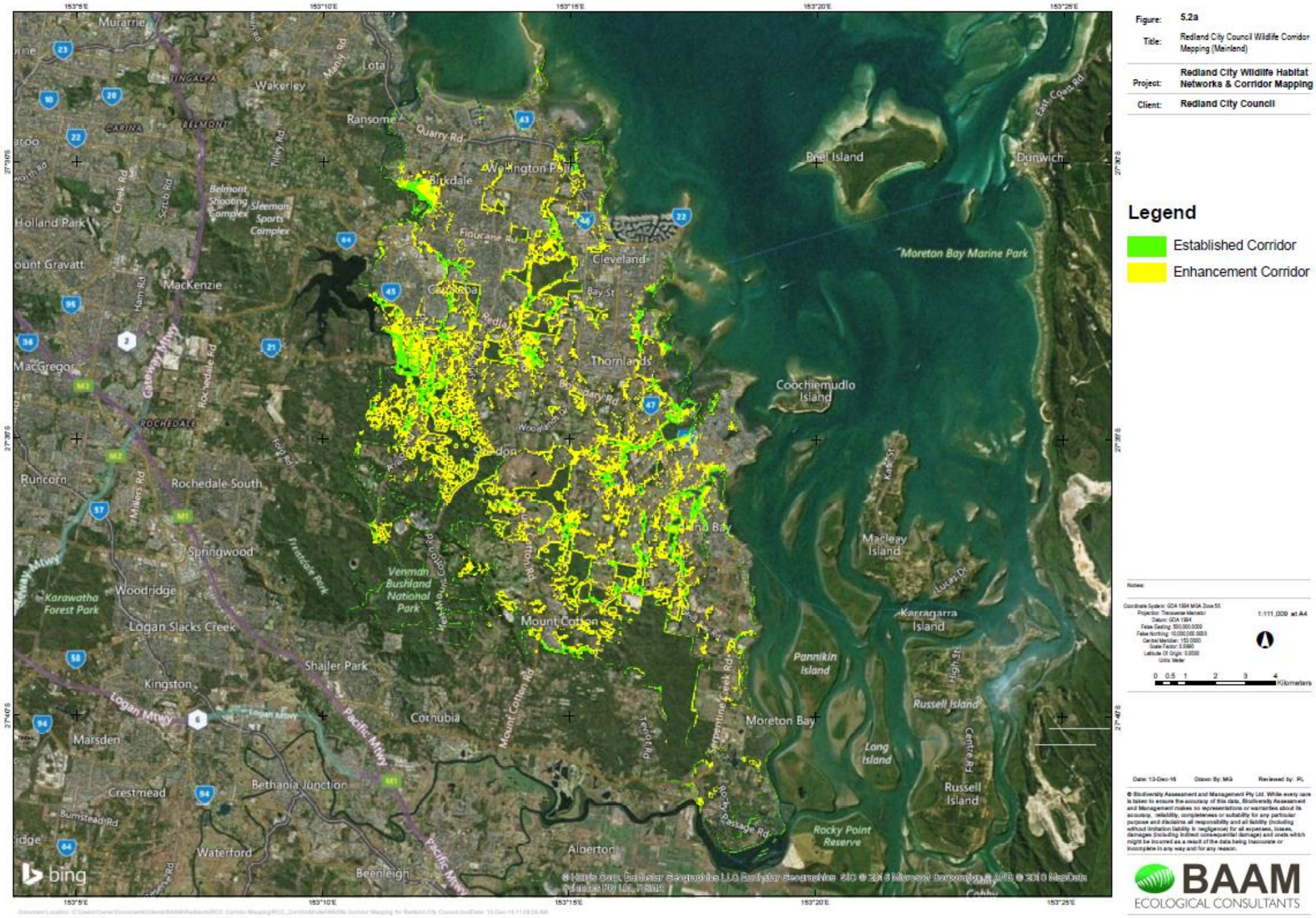

Figure 2 - Core Habitat, Established and Enhancement Corridors from CircuitScape Modelling

Developing the Redlands Wildlife Habitat Networks and Corridors

The CircuitScape modelling outputs have been used to develop the high priority corridors outlined in the proceeding sections of this plan. A series of workshops and working groups utilised expert local knowledge of habitat, wildlife, land use, connectivity and the CircuitScape modelling outputs to develop the wildlife habitat networks and corridors. The principles and data sets used to develop these priority networks and corridors were:

- The Core Habitat identified by the wildlife habitat networks and corridors modelling formed the 'core hubs' that the corridors aim to connect;
- The modelling was the primary source used to delineate the Established Corridors and the Enhancement Corridors;
- Where possible, multiple corridors were provided as alternative links between Core Habitat patches to account for potential disturbance events (such as fire, storms, flooding, disease and impacts from development); and
- Council owned and managed land was favoured to form the trunk centre line of corridors.

Whilst this plan only represents the corridors identified as containing a high level of corridor value, it is imperative to understand that many of the areas not identified will still play a vital role in providing habitat and movement opportunities for many species of wildlife.

The corridors have been assigned target widths and buffers, based on wildlife corridor ecology literature and principles (refer to Appendix 3). Based on these targets, the corridors have been presented as defined 'strips' through the landscape. However, it must be recognised that corridors should not always be viewed as clear pathways. For many wildlife species, movement is diffused through the landscape, and they may not adhere to bushland corridors.

Wildlife Habitat Networks and Corridors

Five categories of wildlife habitat corridors have been defined in this plan (Table 3).

The corridors are assigned names to engender local community recognition, acceptance and ownership. The naming reflects the corridor's local geographic location (Figure 3 and 4).

Core Habitat: The patches of Core Habitat (based on interior areas of remnant vegetation) form the 'core hubs' that the corridors aim to connect. The areas of Core Habitat are all of very high ecological value and a very high priority for protection and rehabilitation.

Table 3 - Definition of Wildlife Habitat Corridor Types

Corridor Type	Definition	Ecological Value	Priority for Rehabilitation
Established	Corridors of particularly high ecological value that hold strong, pre-existing values in providing movement opportunities for wildlife in general.	Highest Ecological Value	Highest Priority for Rehabilitation
Regional Riparian	Particularly significant riparian corridors for biodiversity that form a major element of habitat continuity, as identified in the Biodiversity Planning Assessment (BPA) for the Southeast Queensland Bioregion (EHP 2016).	Highest Ecological Value	Highest Priority for Rehabilitation
Coastal Foreshore	Coastal fringe corridor of the Redland City mainland, Southern Moreton Bay Islands, Coochiemudlo Island and the township areas of North Stradbroke Island. May contain Established, Enhancement or Stepping Stone values.	High Ecological Value	High Priority for Rehabilitation
Enhancement	Corridors that exhibit sufficient ecological value and linkages that would be appropriate targets for strategic enhancement to strengthen Established Corridors.	Medium Ecological Value	Medium Priority for Rehabilitation
Stepping Stone	Corridors of isolated patches of habitat that, while not physically connected, are functionally connected, allowing movement between larger patches.	Less Ecological Value	Lower Priority for Rehabilitation

For each of the wildlife habitat corridors, the values, connectivity, threats and priority management outcomes have been identified to increase the understanding of these priority corridors.

The following specific attributes are assigned to each of the priority corridors:

- Description
  - Location, orientation and linkages to Core Habitat patches.
- Environmental Values
  - Dominant vegetation types and keystone wildlife values.
- Core Habitat Linkages
  - Number of Core Habitat patches linked by corridor; and
  - Maximum distances between Core Habitat patches
- Land Uses
  - Tenure and planning scheme zonings.
- Community Uses
  - Values and potential uses.
- Threats and Barriers
  - Edge effects from urban, peri-urban and rural land use;
  - Road and rail infrastructure; and
  - Development potential within the planning scheme.
- Gaps and Pinch Points
  - Significant gaps (greater than 106m) of open or developed areas along the corridor; and
  - Narrow points of corridor (where width is less than 100m).
- Priority Outcomes
  - Mitigation of current threats and barriers; and
  - Rehabilitation of gaps and pinch points (focusing on where maximum distances between Core Habitat patches is more than 1100m apart)

The above attributes for each corridor are presented in the associated document 'Corridor Descriptions and Locations' (Appendix 4-8). Within this document all corridors display the mapped vegetation within the corridor as a solid colour (with the colour dependent on the corridor type). The areas within the corridor that do not contain mapped vegetation are presented with a transparent colouring. This presentation allows clear distinction between the higher ecological function sections of a corridor (i.e. mapped vegetation represented as solid colours) and other buffer areas of human uses (residential areas, roads etc.) or potential gaps or pinch points for rehabilitation. Please note that while every effort has been made to use the most up to date aerial imagery in the maps presented, not all images may be current.

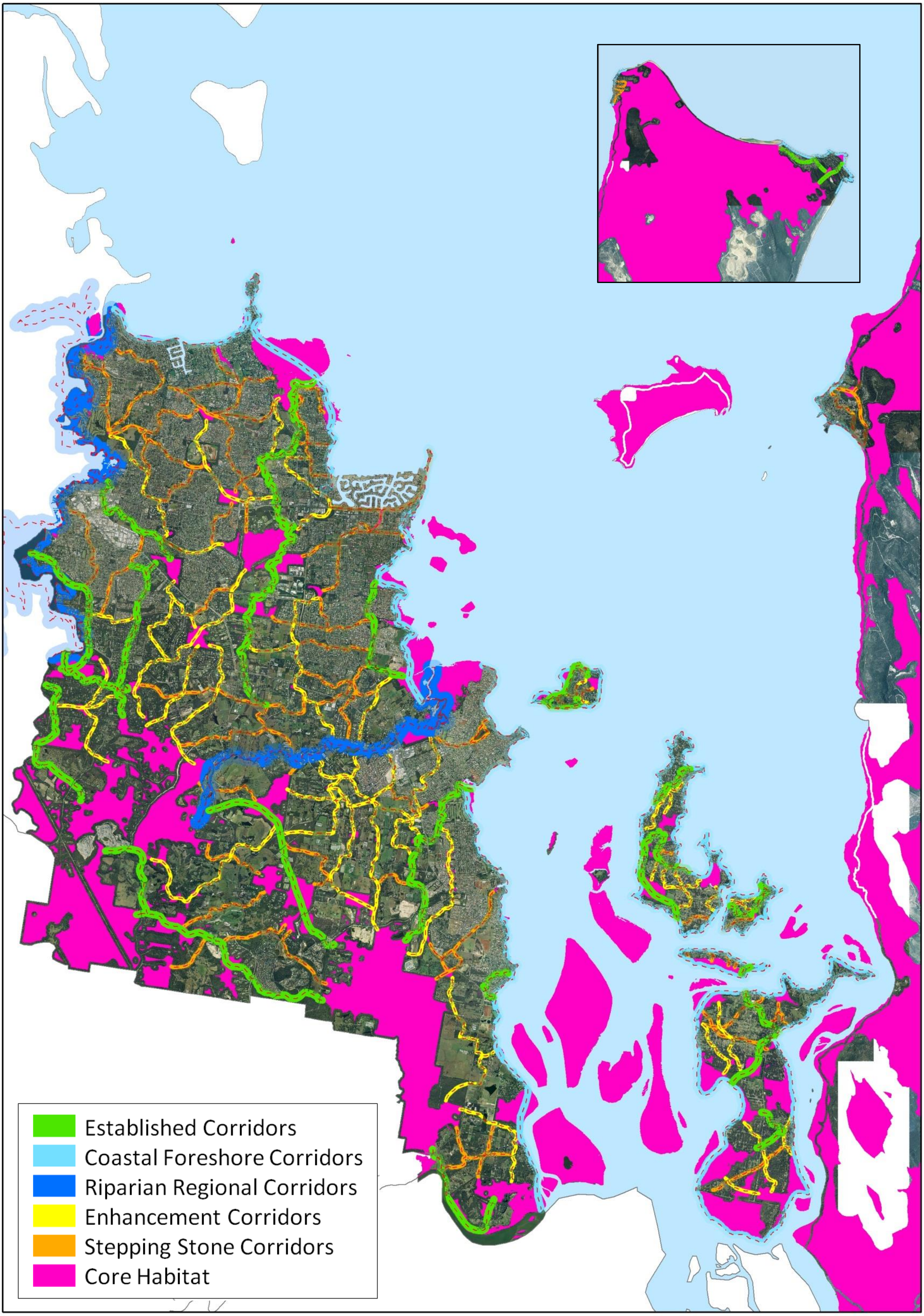

Figure 3 - Wildlife Habitat Network and Corridors in Redland City

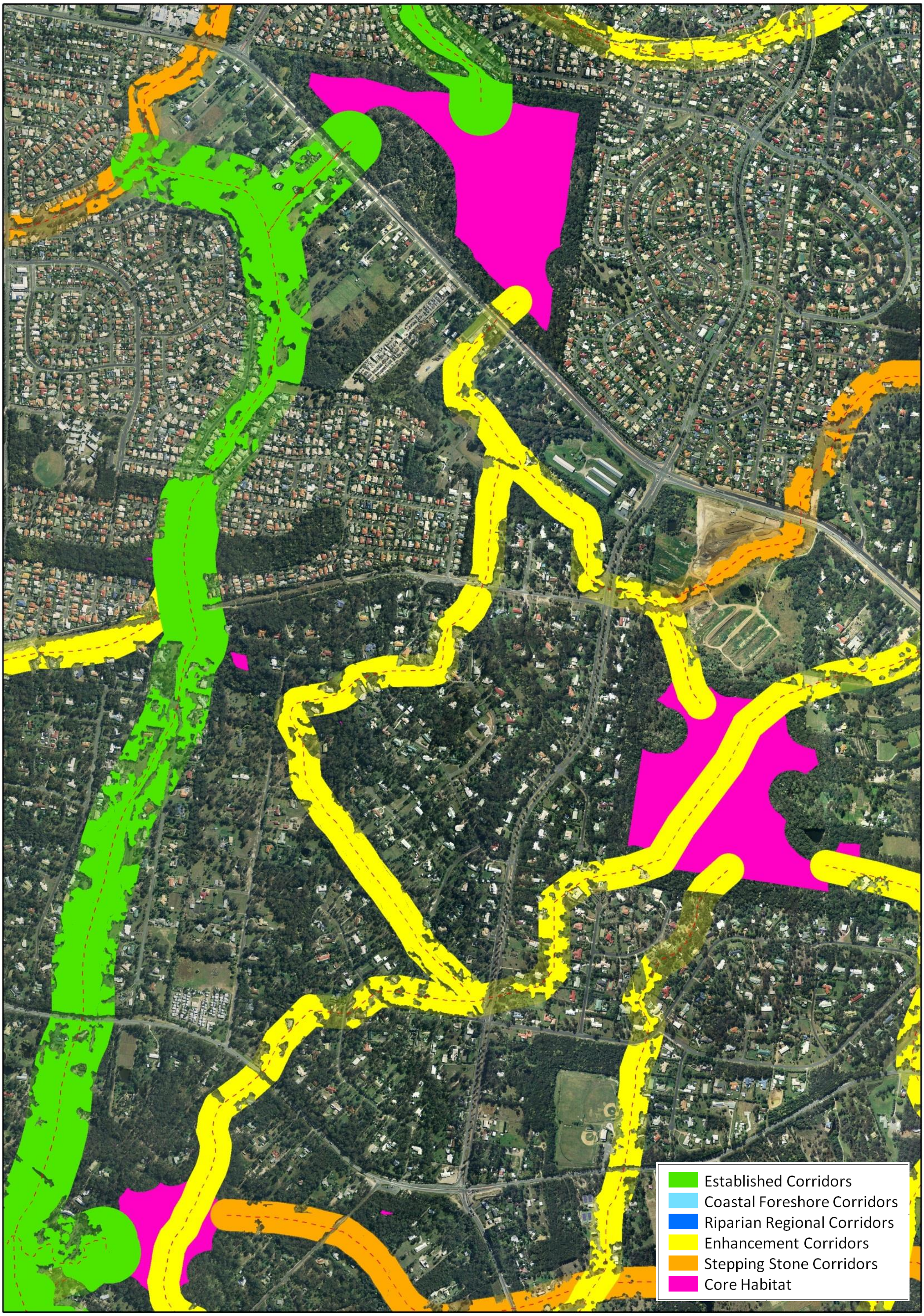

Figure 4 - Wildlife Habitat Network and Corridors – Detailed Example

Established Corridors

The Established Corridors are local scale corridors, and have been defined and mapped within the Redland City local government area. The Established Corridors are areas of particularly high ecological value that hold strong, pre-existing values in providing movement opportunities for wildlife.

To retain a variety of bird species and complete suite of arboreal mammals, the Established Corridors are defined as having a width of 100m, with a minimum 50m buffer of native vegetation (on each side) to reduce the risk of edge effects, resulting in a 200m wide corridor.

The Established Corridors are the highest priority for protection and rehabilitation, as they represent the best value in terms of financial and ecological benefits. The priority outcomes outlined in Appendix 4 should be implemented in the Established Corridors first.

A total of 24 Established Corridors have been identified in Redland City (Figure 5). Appendix 4 provides the full details (name; map; description; environmental values; core habitat linkages; land uses; community uses; threats and barriers; gaps and pinch points; and priority outcomes) for each of these corridors.

Table 4 provides a summary of the attributes of the Established Corridors.

Table 4 - Summary of the values and threats for the Established Corridors

Attributes	Amount	Percentage of Total Corridor
Total number of Established Corridors	24	
Total area of all Established Corridors (200m wide)	1775 ha	
Total area of mapped vegetation (Regional Ecosystem) within all Established Corridors	1320 ha	74%
Total area of open area, urban area, road and rail within all Established Corridors	455 ha	26%
Total area of Council owned land within all Established Corridors	589 ha	33%

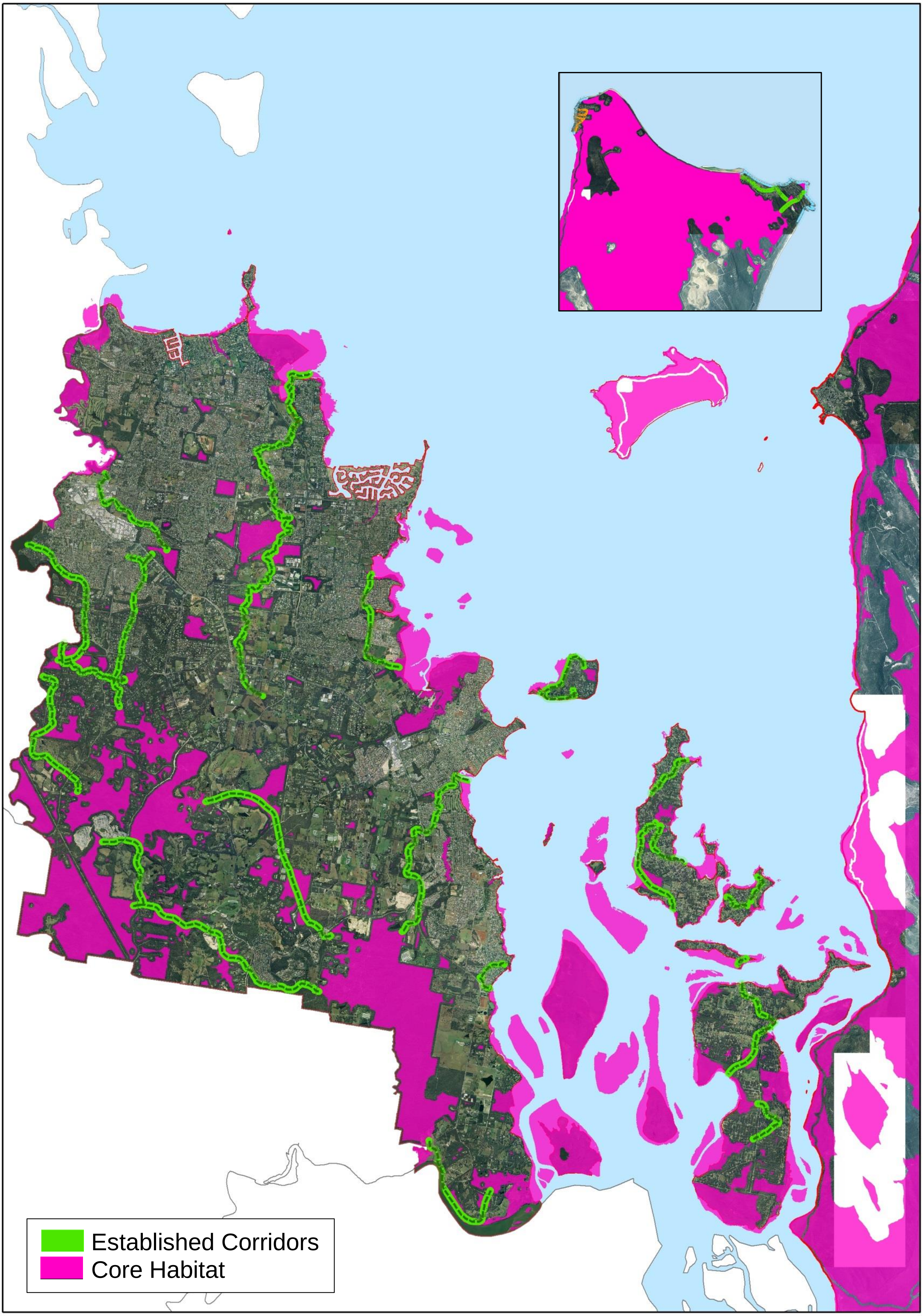

Figure 5 - Established Corridors

Regional Riparian Corridors

The Regional Corridors are identified in the Biodiversity Planning Assessment (BPA) for the Southeast Queensland Bioregion (EHP 2016). The riparian corridors from the BPA are included within this plan as they represent local scale corridors. The terrestrial BPA corridors are not included as they represent state and regional scale planning, beyond the scope of this plan.

The Regional Riparian Corridors are equal priority to the Established Corridors for protection and rehabilitation, as they represent the best value in terms of financial and ecological benefits. The BPA has assigned the regional riparian corridors a target width of 400m. The priority outcomes outlined in Appendix 5 should be implemented in the Established and Regional Riparian Corridors first.

A total of two Regional Riparian Corridors are located in Redland City (as shown in Figure 6). Appendix 5 provides the full details (name; map; description; environmental values; core habitat linkages; land uses; community uses; threats and barriers; gaps and pinch points; and priority outcomes) for each of these corridors.

Table 5 provides a summary of the attributes of the Regional Riparian Corridors.

Table 5 - Summary of the values and threats for the Regional Riparian Corridors.

Attributes	Amount	Percentage of Total Corridor
Total number of Regional Riparian Corridors	2	
Total area of all Regional Riparian Corridors (400m wide – within Redland City)	1065 ha	
Total area of mapped vegetation (Regional Ecosystem) within all Regional Riparian Corridors (in Redland City)	600 ha	56%
Total area of water reservoir, open area, urban area, road and rail within all Regional Riparian Corridors	465 ha	44%
Total area of Council owned land within all Regional Riparian Corridors	167 ha	16%

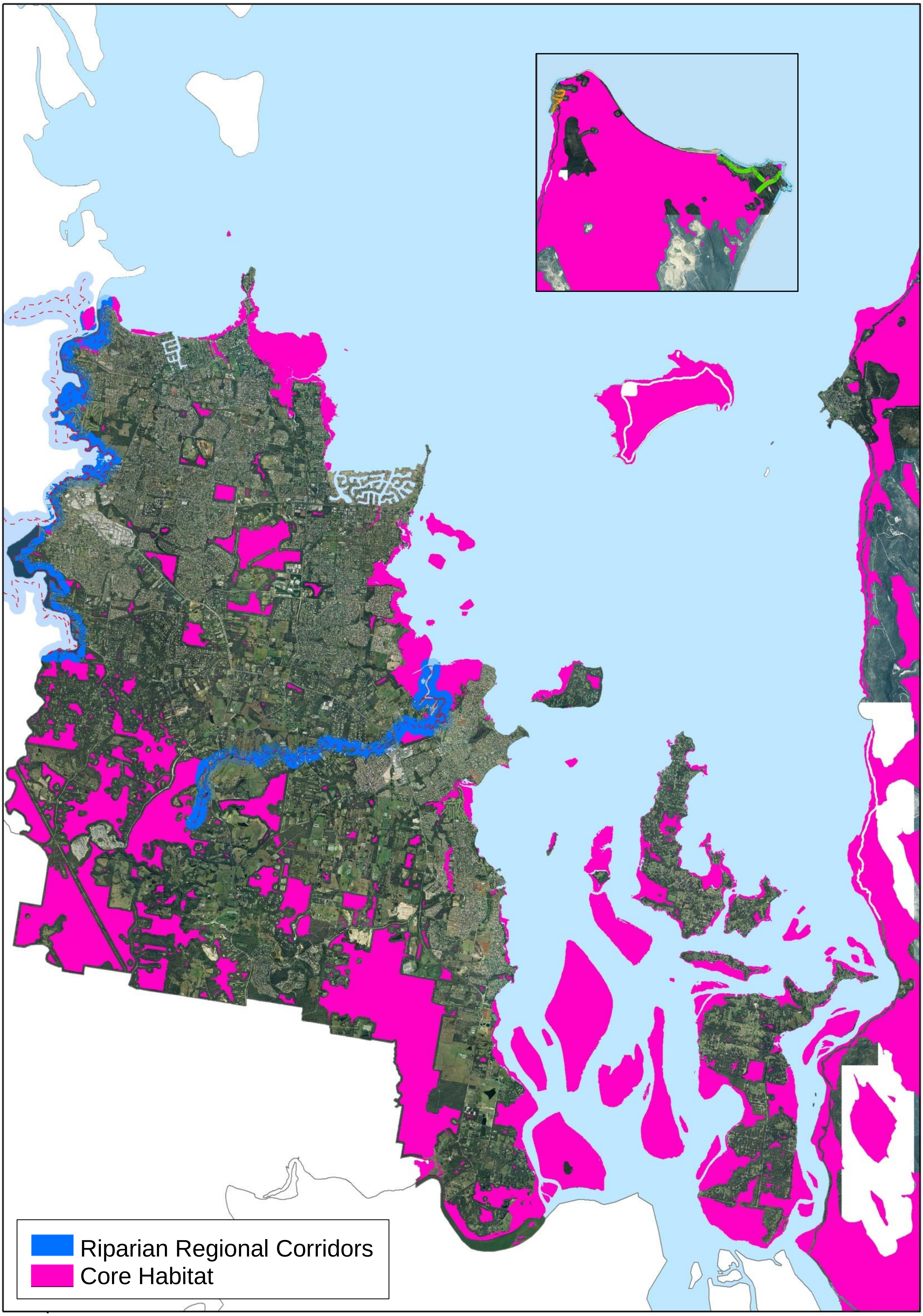

Figure 6 - Regional Riparian Wildlife Habitat Corridors

Coastal Foreshore Corridors

The Redlands Coastal Foreshore Corridors are local scale corridors, and have been defined and mapped within the Redland City local government area. The coastal foreshore corridors make up the coastal fringe of the Redland City mainland, Southern Moreton Bay Islands, Coochiemudlo Island and the township areas of North Stradbroke Island. Although these corridors may exhibit characteristics of Established, Enhancement or Stepping Stone Corridors, they have been grouped together as they have similar values, threats and management actions.

The Coastal Foreshore Corridors are a high priority for protection and rehabilitation, as they represent the value in terms of financial and ecological benefits. The priority outcomes for the Coastal Foreshore Corridors outlined in Appendix 6 should occur, following the implementation of actions in the Established and Regional Riparian Corridors.

The Coastal Foreshore Corridors predominately comprise of tidal flats, mangrove, saltpan, saltmarsh and casuarina habitats and may incorporate other fringing woodland vegetation (on coast dunes or alluvial land). These coastal foreshore corridors are crucial habitat for wader birds, intertidal marine vertebrates and invertebrates, and specialist species such as the Water Mouse.

To retain a variety of species the Coastal Foreshore Corridors are defined as having a width of 100m, with minimum 50m buffer (on each side) to reduce the risk of edge effects, resulting in a 200m wide corridor.

A total of 14 Coastal Foreshore Corridors have been identified in Redland City (as shown in Figure 7). Appendix 6 provides the full details (name; map; description; environmental values; core habitat linkages; land uses; community uses; threats and barriers; gaps and pinch points; and priority outcomes) for each of these corridors.

Table 6 provides a summary of the attributes of the Coastal Habitat Corridors.

Table 6 - Summary of the values and threats for the Coastal Foreshore Corridors

Attributes	Amount	Percentage of Total Corridor
Total number of Coastal Foreshore Corridors	14	
Total area of all Coastal Foreshore Corridors (200m wide)	2407 ha	
Total area of mapped vegetation (Regional Ecosystem) within all Coastal Foreshore Corridors (Please Note: does not include inter-tidal open areas)	908 ha	38%
Total area of marine zone, open area, urban area, road and rail within all Coastal Foreshore Corridors	1499 ha	62%
Total area of Council owned land within all Coastal Foreshore Corridors	295 ha	12%

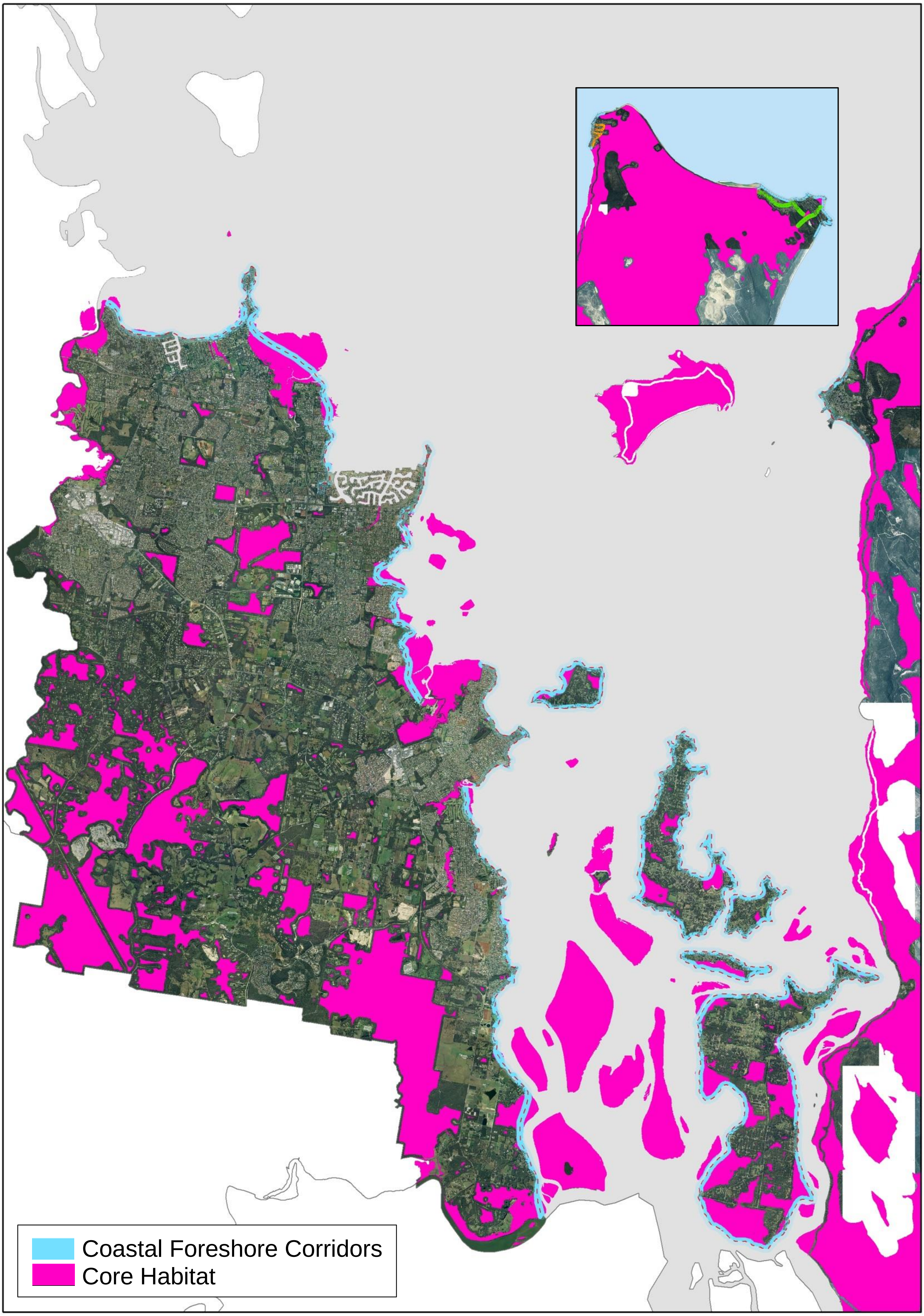

Figure 7 - Coastal Foreshore Wildlife Habitat Corridors

Enhancement Corridors

The Enhancement Corridors are local scale corridors, and have been defined and mapped within the Redland City local government area. The Enhancement Corridors are areas that exhibit sufficient ecological value and linkages that would be appropriate targets for strategic enhancement to strengthen Established Corridors.

The Enhancement Corridors are the second highest priority for protection and rehabilitation. The priority outcomes outlined in Appendix 7 should occur, following the implementation of actions in the Established, Regional Riparian Corridors and Coastal foreshore.

To retain a variety of bird species and complete suite of arboreal mammals, the Enhancement Corridors are defined as having a width of 100m.

Enhancement Corridors in Known Development Areas Corridors is a subgroup of Enhancement Corridors that are recognised as part of an identified development area under a planning instrument or existing approval (refer to Appendix 7a – Enhancement Corridors in Known Development Areas Corridors). These areas include Kinross Road Thornlands, South East Thornlands, Shoreline Redland Bay and the Bunker Road Victoria Point emerging community area. Additional 'property scale' corridors may be identified in these (and future) identified development areas, and established as different parts of the City are developed or as land uses change. It should be noted that it is not the role of the Wildlife Connection Plan to identify 'property scale' corridors.

A total of 44 Enhancement Corridors have been identified in Redland City (Figure 8). Appendix 7 and 7a provide the full details (name; map; description; environmental values; core habitat linkages; land uses; community uses; threats and barriers; gaps and pinch points; and priority outcomes) for each of these corridors.

Table 7 provides a summary of the attributes of the Enhancement Corridors.

Table 7 - Summary of the values and threats for the Enhancement Corridors

Attributes	**Amount**	**Percentage of Total Corridor**
Total number of Enhancement Corridors	44	
Total area of all Enhancement Corridors (100m wide)	1207 ha	
Total area of mapped vegetation (Regional Ecosystem) within all Enhancement Corridors	830 ha	69%
Total area of open area, urban area, road and rail within all Enhancement Corridors	377 ha	31%
Total area of Council owned land within all Enhancement Corridors	280 ha	23%

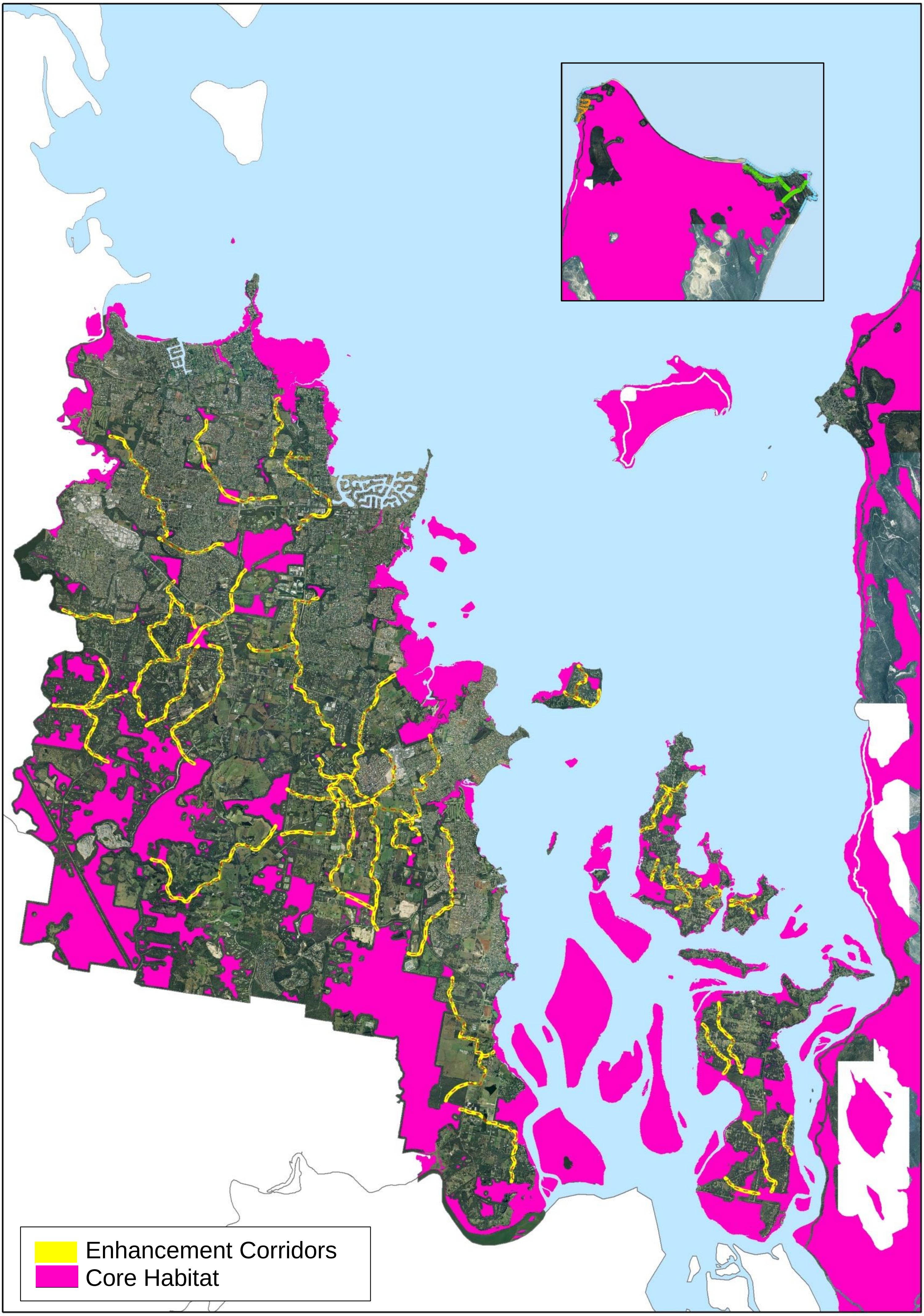

Figure 8 - Enhancement Corridors

Stepping Stone Corridors

The Stepping Stone Corridors are local scale corridors, and have been defined and mapped within the Redland City local government area. The Established and Enhancement Corridors represent predominately continuous and diversely structured habitat, and are generally the most appropriate for facilitating wildlife movement. However it is recognised that Stepping Stone Corridors (such as scattered trees) can be equally effective for certain species while dispersing or migrating. (Forman 1995 & Bennett 2003)

Stepping stones can be defined as isolated patches of habitat that, while not physically connected, are functionally connected, allowing movement between larger patches (National Wildlife Corridors Plan 2012). Stepping Stones of suitable habitat enhance connectivity in developed landscapes for species able to make short movements through disturbed environments. Stepping Stones may be natural patches, such as wetlands or patches of rainforest within drier forests or they may be small remnant patches of vegetation in a developed landscape. Scattered trees or patches of habitat are the most recognised form of Stepping Stones and are important to native fauna for movement, shelter, foraging habitat and nesting resources, especially in urban areas.

The Stepping Stone Corridors are a lower priority for protection and rehabilitation. The priority outcomes outlined in Appendix 8 should occur, following the implementation of actions in the Established, Regional Riparian, Coastal Foreshore and Enhancement Corridors.

To retain a variety of bird species and arboreal mammals, the outline of Stepping Stone Corridors are defined as having a width of 100m. However, by their nature, the Stepping Stone Corridors consist of patches of vegetation and not a continuous vegetated corridor.

A total of 62 Stepping Stone Corridors have been identified in Redland City (Figure 9). Appendix 8 provides the full details (name; map; description; environmental values; core habitat linkages; land uses; community uses; threats and barriers; gaps and pinch points; and priority outcomes) for each of these corridors.

Table 8 provides a summary of the attributes of the Stepping Stone Corridors.

Table 8 - Summary of the values and threats for the Stepping Stone Corridors

Attributes	**Amount**	**Percentage of Total Corridor**
Total number of Stepping Stone Corridors	62	
Total area of all Stepping Stone Corridors (100m wide)	1332 ha	
Total area of mapped vegetation (Regional Ecosystem) within all Stepping Stone Corridors	622 ha	47%
Total area of open area, urban area, road and rail within all Stepping Stone Corridors	710 ha	53%
Total area of Council owned land within all Stepping Stone Corridors	377 ha	28%

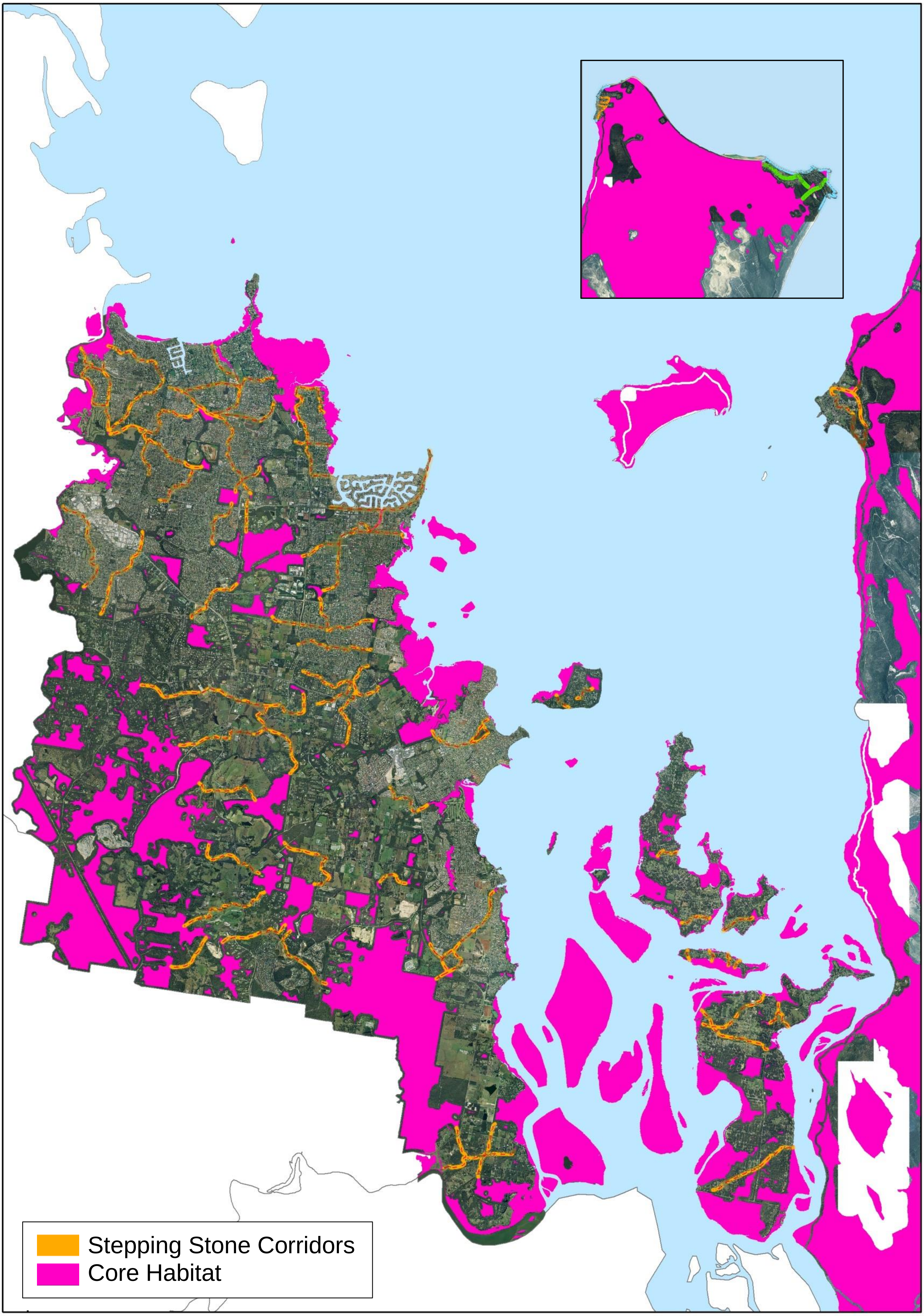

Figure 9 - Stepping Stone Corridors

Priority Outcomes for Wildlife Habitat Network and Corridors

Within associated document 'Corridor Descriptions and Locations (Appendices 4, 5, 6, 7 and 8), the priority outcomes are listed for each individual Established, Enhancement, Regional Riparian, Coastal Foreshore, and Stepping Stone Corridors. These priority outcomes aim to address the threats, barriers, gaps and pinch points for each, which are also listed for each corridor within Appendices 4, 5, 6, 7 and 8. Location descriptions are provided for each of the priority outcomes that recommend rehabilitation of gaps and pinch points. A summary of the types and number of priority outcomes for each corridor classification is provided in Table 9.

Table 9 - Summary of priority outcomes by corridor type

Priority for Rehabilitation	Corridor Type	Number of Corridors	Priority Outcomes	Number of Priority Sites
1	**Established**	24	Improve Corridor Habitat • Rehabilitation of gaps and pinch points	28
			Prevent Wildlife Deaths • Safe fauna passage across road (or rail) barriers	34
			Protect Corridor Habitat • Provide input into planning scheme	0
			Reduce Impacts on Corridors • Manage impacts of urban and/or peri-urban and/or rural areas	24
1	**Regional Riparian**	2	Improve Corridor Habitat • Rehabilitation of gaps and pinch points	3
			Prevent Wildlife Deaths • Safe fauna passage across road (or rail) barriers	6
			Protect Corridor Habitat • Provide input into planning scheme	0
			Reduce Impacts on Corridors • Manage impacts of urban and/or peri-urban and/or rural areas	2
2	**Coastal Foreshore**	14	Improve Corridor Habitat • Rehabilitation of gaps and pinch points	31
			Prevent Wildlife Deaths • Safe fauna passage across road (or rail) barriers	0
			Protect Corridor Habitat • Provide input into planning scheme	1
			Reduce Impacts on Corridors • Manage impacts of urban and/or peri-urban and/or rural areas	14
			• Management of impacts from storm tide and sea level rise impacts	14
3	**Enhancement**	44	Improve Corridor Habitat • Rehabilitation of gaps and pinch points	95
			Prevent Wildlife Deaths • Safe fauna passage across road (or rail) barriers	59
			Protect Corridor Habitat • Provide input into planning scheme	12
			Reduce Impacts on Corridors • Manage impacts of urban and/or peri-urban and/or rural areas	44
4	**Stepping Stone**	62	Improve Corridor Habitat • Rehabilitation of gaps and pinch points	118
			Prevent Wildlife Deaths • Safe fauna passage across road (or rail) barriers	55
			Protect Corridor Habitat • Provide input into planning scheme	2

Protecting and rehabilitating the highest value corridors will result in the best cost efficiency and often provides the greatest ecological benefit.

The Established Corridors and the Regional Riparian Corridors are equally the highest priority corridors, as they represent the most intact, connected and high ecological value corridors. The cost to protect and rehabilitate will provide the most ecological benefits for any investment.

The Coastal Foreshore are the second highest value ecological corridors, however may require significant investment for protection and rehabilitation, and consequently are lower priority for rehabilitation than the Established and Regional Riparian Corridors. The Enhancement Corridors are the third highest priority for protection and rehabilitation, as they will require a greater level of investment in protection and rehabilitation to achieve a high level of ecological benefit.

The Stepping Stone Corridors would require the greatest level of investment in protection and rehabilitation, and are therefore a lower priority.

It is important to note that the recommended priority actions for each corridor are developed based on a desktop assessment, utilising all available mapping resources, such as aerial imagery, vegetation mapping and the model outputs. The first step of implementation of any action is verifying the suitability of the recommendations on ground.

The priority outcomes listed for the management of impacts from urban, peri-urban and rural areas are somewhat general descriptions, and further work (including ground-truthing) is required to allow effective implementation of these actions.

Action Plan

The Wildlife Connections Action Plan lists the work areas within Council with responsibility for each action; implementation methods; implementation partners; performance measures; timeframe; and indication of cost of implementation.

The implementation of the priority outcomes within associated document 'Corridor Descriptions and Locations (Appendices 4, 5, 6, 7 and 8) can be achieved through a variety of methods based on tenure and location; and will be the responsibility of several areas within Council.

Implementation of the Action Plan will be undertaken with the following prioritisation considerations:

1. All areas of Core Habitat are a high priority for protection and rehabilitation. All actions within the Action Plan can be implemented in the identified Core Habitat areas;

2. The Established, Regional Riparian Corridors and Coastal Foreshore are the highest priority for protection and rehabilitation;

3. The Enhancement Corridors are the second highest priority for protection and rehabilitation;

4. The Stepping Stone Corridors are a lower priority for protection and rehabilitation;

5. All corridor rehabilitation and enhancement of buffer areas should follow South East Queensland (SEQ) Ecological Restoration Framework (SEQ Catchments, 2012); and

6. All corridor rehabilitation and enhancement of buffer areas must take into account fire management planning

Monitoring of Action Plan Implementation

The implementation of the actions in the plan will be reviewed annually. The review will assess the success of each action based on the 'Performance Measures' listed in the Wildlife Connections Action Plan. Information from each of the Council areas and external partners will be collated for the annual review.

If available, updated mapping (such as new Regional Ecosystem mapping or planning scheme zones) and other environmental data sets will be used to monitor changes to the values, attributes and threats of the wildlife habitat network and corridors.

Funding of the priority actions is critical to the success and performance of this plan. Delivery of the action plan will be funded through a combination of business as usual, general revenue, environment separate charge, reserve funds and resources obtained through external funding sources.

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Appendix 1 - Summary and review of Federal, State and Regional Corridor Plans and Strategies

National Wildlife Corridors Plan 2012

The *National Wildlife Corridors Plan* is an Australian Government document that highlights the need for habitat connectivity throughout the country (Department of Sustainability, Environment, Water, Population and Communities, 2012). The purpose of the national plan is to enable and coordinate efforts of landscape connectivity from all parties throughout Australia (Department of Sustainability, Environment, Water, Population and Communities, 2012). It is important that Australia's cities, rural areas, reserves, and national parks are connected to ensure movement through the landscape. The document consists of a five-point plan of action to be implemented gradually, and includes:

1. "Developing and supporting corridor initiatives
2. Establishing and ensuring institutional arrangements
3. Promoting strategic investment in corridors
4. Working with key stakeholders and supporting regional natural resource management planning
5. Monitoring, evaluating, and reporting"

(Department of Sustainability, Environment, Water, Population and Communities, 2012)

In order to be successful, the plan must incorporate a collaborative approach in the planning, management, and reporting of wildlife corridors. The government can plan corridors at a national, regional, or local scale, but they will not be successful without the cooperation of the community (Landcare Australia, 2011). The plan highlights that private land holders, community groups, NRM groups, Landcare, state agencies, and local government all have a role to play in managing and maintaining wildlife corridors.

The document examines why wildlife corridors need to be implemented, and provides limited information on how or what to implement. A number of existing national and state corridor initiatives are referenced including "the Gondwana Link, the Great Eastern Ranges Initiative, Habitat 141, NatureLinks, Trans-Australia Eco-Link, and the Tasmanian Midlandscapes" (Department of Sustainability, Environment, Water, Population and Communities, 2012). The Plan also promises to support and encourage regional and local corridor initiatives, which has had little success in implementation.

Corridor identification through the Biodiversity Planning Assessments 2015

This document was released by the Queensland Government in 2015, and highlights the key riparian and terrestrial corridors throughout the state. A number of specific state, and regional corridors are cited, accompanied with maps on different bioregions. The south east Queensland region consists of 48 state and regional terrestrial corridors that connect land to other regional areas (EHP 2015). Corridors were selected based on a number of factors, including the quality of existing habitat, location of existing regional corridors, altitudinal/geological/climatic gradients, ability to connect large tracts of habitat, and location of watershed, catchment, and coastal boundaries (EHP 2015). A map showing Queensland's State terrestrial corridors is seen in Figure 10 below.

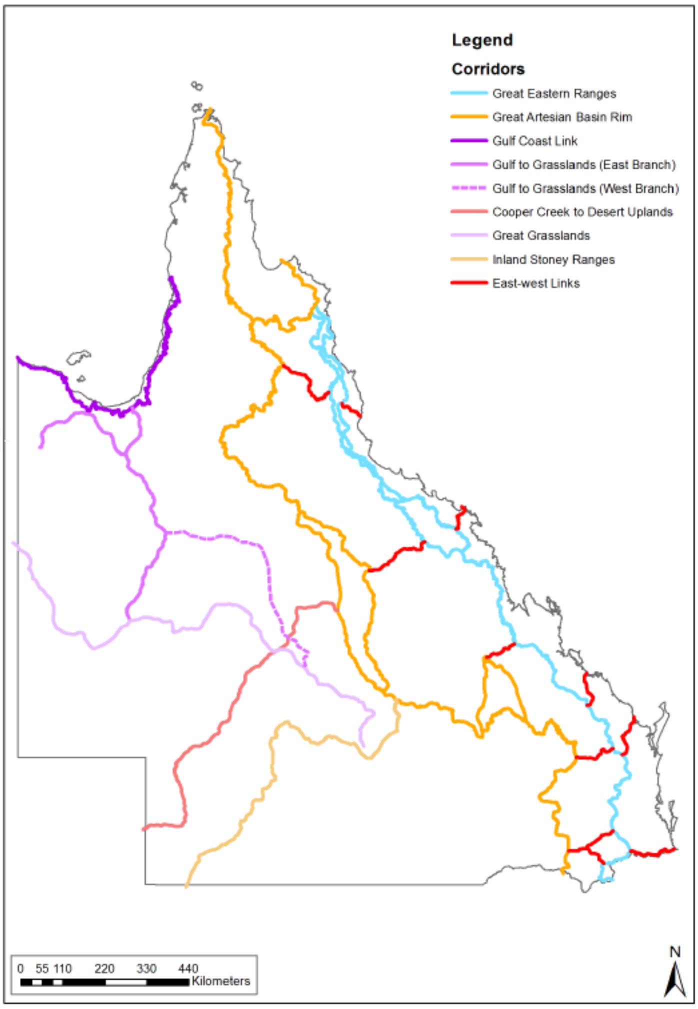

Figure 10 - Map of Queensland showing state-wide conservation corridors (Howell, et al., 2015)

Shaping SEQ - South East Queensland Regional Plan (Department of Infrastructure, Local Government and Planning, 2016)

ShapingSEQ is the Queensland Government's plan to guide the future of the South East Queensland (SEQ) region, prepared in collaboration with the region's 12 local governments. It aims to accommodate future growth sustainably and in a way that responds to change positively, and enhances the social, economic and environmental systems that support the region's liveability. For the purposes of the *Sustainable Planning Act 2009*, ShapingSEQ is the statutory regional plan for the SEQ region.

ShapingSEQ differs from previous regional plans in several new headline initiatives and key new functions including "Identifying and mapping regional biodiversity corridors and values to support the protection of these values."

Community consultation for ShapingSEQ revealed residents want to protect SEQ's natural environment, including: establishing wildlife corridors to allow safe passage and protection for the region's fauna. ShapingSEQ recognises fragmentation and degradation of natural corridors and habitats, has resulted in significant species decline.

Within ShapingSEQ, Goal 4: Sustain, Element 2: Biodiversity states “The regional biodiversity network is protected and enhanced to support the natural environment and contribute to a sustainable region.” The strategies proposed to achieve this are:

1. Protect regional biodiversity values (including koala habitat), and ecological processes that support them, from inappropriate development;
2. Focus coordinated planning, management and investment, including offset delivery, in regional biodiversity corridors;
3. Avoid fragmentation of regional biodiversity corridors; and
4. Maintain and enhance the value of biodiversity corridors to optimise biodiversity conservation outcomes.

The regional biodiversity corridors aim to connect or improve connectivity through targeted rehabilitation of natural assets, including between existing areas of Matters of State Environmental Significance (MSES) or regional biodiversity values. These corridors are to be investigated and refined by local government for consideration as Matters of Local Environmental Significance (MLES) where MSES do not already exist.

Biodiversity Planning Assessment - Southeast Queensland Bioregion, Queensland Environmental Protection Agency, 2007

A Biodiversity Planning Assessment (BPA) identifies the terrestrial ecological values in a region, or bioregion, according to their conservation significance. BPAs are used by governments, members of the community and landholders to make planning decisions about appropriate land use.

The SEQ Bioregion shares its western boundary with the Brigalow Belt Bioregion, and extends from the New South Wales border, north to the dry coastal corridor between Gladstone and Rockhampton that forms part of the Brigalow Belt Bioregion.

The SEQ BPA relied on a Biodiversity Assessment and Mapping Methodology (BAMM, Version 2.2) to provide a consistent approach for assessing biodiversity values at the landscape scale in Queensland using vegetation mapping data generated or approved by the Queensland Herbarium as a fundamental basis. The SEQ BPA also identifies and maps landscape scale corridors at a state-wide level for most of the state. The network is being expanded as BPAs are completed for each bioregion. Their broad purpose is to provide for ecological and evolutionary processes at a landscape scale by:

- maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations over long periods of time;
- maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;
- maintaining seasonal migrations and movement of fauna;
- maximising connectivity between large tracts/patches of remnant vegetation; and
- identifying key areas for rehabilitation and offsets.

The corridors have been selected to reflect:

- major watershed and catchment boundaries;
- intact river systems;
- major altitudinal/geological/climatic gradients;
- connectivity between remnant vegetation in good condition;
- linkages between bioregions; and
- linkages between permanent waterholes.

The methods used to identify bioregional terrestrial and riparian corridors, and gaps and critical weaknesses in terrestrial corridors, are outlined in Corridor Identification through Biodiversity Planning Assessments (EHP 2015). Corridors that form part of the state-wide network are assigned State significance. Other corridors providing connectivity at a sub-regional scale are assigned Regional significance.

The landscape expert panel workshops reviewed the existing network of corridors from version 3.5 of the BPA, making amendments and adding new corridors. The panel also discussed whether the definitions of corridors need to be modified in a highly fragmented bioregion like SEQ.

Appendix 2 – Summary and review of Existing Corridor Strategies and Actions for Redland City Council

A review and summary of the status of the strategies, plans, actions and mapping for corridors planning produced for Redland City Council is provided below.

Bushland and Habitat Corridor Plan - 2004

This document was adopted by Council in August 2004 and sets out a series of principles for protecting, managing and enhancing wildlife habitat and corridors in Redland City. This plan also outlines existing 'tools' for conserving habitat and makes recommendations for future directions. The Environmental Inventory Mapping (Stage 4) forms the basis of this plan.

The first part of the Plan describes objectives and principles. The objectives of the plan are to:

- identify and protect all core habitat areas in the Shire;
- manage and enhance corridors for wildlife movement;
- identify, protect, manage and enhance species and areas of special interest; and
- manage and enhance all core habitat areas and the balance habitat areas of the Shire.

The second part of the Plan describes the threats to habitat, seven primary and ten secondary tools and recommended actions. The threats include: development allowed under the planning scheme; existing and future roads; indiscriminate clearing; bushfires; and pest plants and pest animals.

The Primary Tools listed are: The Redland Environmental Inventory; State Planning Policy 1 / 97 – Conservation of koalas in the Koala Coast (subsequently superseded by SPP 1/05); Redland Shire Planning Scheme and the draft Redland Planning Scheme; Local Law No.6 – Protection of Vegetation; Environment Charge; Voluntary Conservation Agreement program; and Research.

The Secondary Tools are: Land for Wildlife Program; Transferable development rights; Conservation tax incentives; Rural Support program; Statutory Covenants on property title; Easements for management purposes; Voluntary land exchange; Councillor advocacy; Bushcare program; and Alternative forms of residential development.

41 specific recommendations are provided to meet the principles and concepts of the Plan and the associated 7 primary and 10 Secondary Tools. A recent review of the 41 recommendations found that 17 were implemented (or ongoing), 15 were partially implemented and 9 were not implemented. Successful implementation of recommendations from the plan included:

- Surveys, reports and installation of treatments for fauna crossing points of roads in Redland City;
- The incorporation of the Environmental Inventory mapping in the Redland Planning Scheme; and
- Koala habitat mapping projects.

It is noted that several of the implemented recommendations involved the development of a plan, strategy, mapping tool, research or advocacy, and the on-ground actions derived from these may not have been realised.

Environmental Inventory - 1996 to 2007

The Redland Shire Environmental Inventory is a spatial tool used to understand environmental priorities. The Environmental Inventory uses a Geographic Information System (GIS) database of mapped Conservation Management Areas (CMAs) and additional polygons selected as potential corridor links and environmental enhancement areas. The CMAs are prioritised according to four categories (Priority, Major, General and Enhancement) and are also assigned functional roles (Habitat, Corridor, Tidal, Patch etc) as part of a city-wide conservation network for retaining biodiversity, based on the principles of conservation biology.

This method was developed in 1996 by Chenoweth, prior to the availability of State Government mapping of Regional Ecosystems. The 2007 project review updated the boundaries of mapped CMAs and incorporated the State Government Regional Ecosystem and biodiversity mapping data (EPA) to review categories. The CMA system has proven to be an adaptable basis for land use planning and management. In 2011, version 4.3 of the Environmental Inventory was created by updating ground-truthed data and inputting additional survey data. The Environmental Inventory V4.3 was used as one of the primary inputs to NEDS.

Green Infrastructure - 2009

The Green Infrastructure Mapping (GIM) project was a geographic information system (GIS) based initiative that;

1. developed understanding of the relationship between remaining habitat across the city;
2. facilitated analysis of emerging issues and their impacts on the biodiversity of the Redlands; and
3. directed and prioritises the resources of the community, Redland City Council, the State and other stakeholders.

The GIM project aimed to improve Council officers understanding of the connectivity between remaining habitats, streamline service delivery and generate cost savings. The GIM project was a requirement of the Biodiversity Strategy 2008-2012 and the Redlands Koala Policy & Implementation Strategy 2008.

The GIM project was based on GIS layers for: Redland City Council Land; Environmental Inventory 4 (EI4); Road treatments; Interim State Koala areas; Extension Program participants; Urban Tree project and the Culvert Study.

The end product of the GIM was the identification of principal patches of habitat and priority corridors.

Wildlife Corridor Mapping Using Species Indicator Model - 2010

This internal Council report outlines the use of an Indicator Species Model (ISM) to identify critical wildlife corridors for seven indicator species throughout Redland City's mainland. The ISM utilises Geographic Information Systems (GIS) to determine the optimal locations for new corridors to link currently unconnected patches of vegetation.

The report uses Habitat Suitability Models, Patch Habitat Model, Corridor Modelling and Critical Corridor Analysis. The corridor maps produced illustrate the movement preferences of different species between patches of habitat. These maps improve the ability of managers to identify the most favourable locations for corridor restoration or impact mitigation. By comparing corridors with the overlays of other planning intentions such as proposed development, managers can foresee and proactively contend with possible conflicts.

The seven key indicator species being utilized to assess the viability of the City's green infrastructure were:

- Koala *Phascolarctos cinereus*;
- Squirrel Glider *Petaurus norfolcensis;*
- Swamp Wallaby *Wallabia bicolour;*
- Northern Brown Bandicoot *Isoodon macrourus;*
- Large Footed Myotis *Myotis macropus;*
- Striated Pardalote *Pardalotus striatus*; and
- Tusked Frog *Adelotus brevis.*

The report recommends implementation of the modelling by:

1. Applying Indicator Species Model to property/area in question to identify 'critical corridor' or 'species corridor' locations;
2. Performing field survey to ground-truth GIS analysis of area;
3. Determining extent of restoration and other enhancement actions required on site; and
4. Select the relevant program or plans most suitable to implement on site (including acquisitions, offsets, environmental education, Habitat Protection Programs and Bushcare).

Natural Environment Decision System - 2011

Natural Environment Decision System (NEDS) is a spatial model developed by AECOM and Biodiversity and Assessment Management (BAAM) designed to provide an expression of conservation value within Redland City. NEDS aims to supersede the Environmental Inventory mapping. In Phase 1 of NEDS, the system was developed and implemented. Phase 2 involved a number of changes to the spatial layers. This innovative tool delivers a highly sophisticated mapping and data management system that provides strong evidence to assist with environmental policy planning.

NEDS accepts all common digital data and integrates with all Councils existing systems. It primarily utilises updated information layers from the Regional Ecosystems, Wetlands, Conservation Significant Fauna and Flora records, Biodiversity Planning Assessment (BPA) Version 3.5 and Koala Habitat data sets. The supplementary data layers include LiDAR, Protected Areas, Nature Refuges, Essential Habitat and the Environmental Inventory v4. 3. The final output of NEDS is the mapped expression of "Conservation Values" for Redland City.

Redlands Trunk Green Corridors - 2013

The Redlands Trunk Green Corridors was a GIS mapping exercise used to inform large-scale corridor, or connectivity conservation projects. The exercise primarily utilised the Environmental Inventory mapping as the basis for identification of corridors. The mapping was also used to review the list of Council conservation acquisitions and the investigation of potential Council conservation land surplus to requirement.

Wildlife Corridor Mapping - 2014

A report on Wildlife Corridor Mapping for the Redland City Council Mainland was prepared by Biodiversity Assessment and Management Pty Ltd (BAAM). The report generated a heat map of key wildlife corridors that occur between core vegetation areas throughout Redland City's mainland areas.

The wildlife corridor mapping exercise involved:

- Literature review on current wildlife corridor mapping, positioning and ecological function;
- Analysis, weighting and scoring of key factors that impact wildlife corridor formulation and function;
- Identification of a core vegetation areas to find wildlife corridor linkages; and
- Using spatial datasets and the scoring system to create a map rating the level of connectivity between the core vegetation areas.

This completely automated system provided an indicative wildlife corridor map that can be modified and enhanced by expert knowledge and other key habitats and conservation significant species data. It was anticipated that the maps would inform the 2015 Redlands Planning Scheme and set the scene for future detailed work. Ultimately, the development of this mapping is intended to facilitate scientifically robust decision making of wildlife corridors within Redland City.

Redlands Planning Scheme Version 7

The Redlands Planning Scheme 2006 v7 is the primary tool through which land use and development decisions are made across the city.

The policy intent of the Redlands Planning Scheme is underpinned by six 'Desired Environmental Outcomes' which relate to:

"Natural Environment, Character and Identity, Community Health and Well Being, Access and Mobility, Essential Services, Economic Development"

These outcomes are supported by maps that indicate different zoning and attributes of the city. A 'Rural and Habitat Corridor Network' is identified, along with existing 'Urban Habitat Corridors'. The 'Habitat Protection' overlay also provides 'enhancement corridors' which trigger a table of assessment for any development applications. To achieve the 'Natural Environment' desired outcomes, the plan aims to enhance existing natural environment, and support significant ecosystems by providing corridor linkages that support wildlife throughout the city.

Draft City Plan

Council is preparing a new planning scheme. Draft City Plan was released for public notification in late in 2015 and in February 2017 Council resolved to forward the draft planning scheme to the Planning Minister for approval to adopt. The draft City Plan will commence following the Minister's approval and Council adoption.

The draft City Plan incorporated updated mapping of regional ecosystems, koala habitat and waterways, and integrated matters of national, State and local biodiversity significance.

The draft City Plan includes in its strategic framework a strategic outcome for the natural environment specifically addressing corridors that states:

> "*Viable and resilient wildlife corridors link habitat areas and facilitate the movement and migration of native fauna throughout the Redlands and beyond. Corridors connect terrestrial and aquatic environments (including waterways, wetlands and along the foreshore) and significant habitat. Ecological corridors are primarily protected by the environmental significance and waterway corridors and wetlands overlays as well as the conservation, environmental management and recreation and open space zones. However, other land may also perform corridor functions that are to be protected."*

This is then implemented primarily through the Environmental Significance overlay and the Waterway corridors and wetlands overlay, which together with the Environmental Management, Conservation, and Recreation and Open Space zones identify the city's areas of environmental value, and include specific provisions within the relevant codes that require development to provide for viable and resilient wildlife corridors.

Appendix 3 – Literature Review of Ecology and Principles of Wildlife Habitat Networks and Corridors

Core Habitat Patches

Core habitat patches are discrete areas of habitat surrounded by areas that are unsuitable as habitat for specific species. A core habitat patch must provide the necessary resources environmental conditions required for survivorship, reproduction, and movement of a species (Hess & Fischer 2001). Smaller habitat patches generally result in smaller flora and fauna populations and this can increase levels of inbreeding, reduce genetic variability, and increase sensitivity to environmental events (Doerr & Davies 2010). To ensure species populations have the required resources for survival, the patch size should be as large as possible to reduce mortality due to movement into unsuitable habitats.

The size and shape of a patch is important in determining suitable habitat for species in the area. For example, an irregular shaped patch will incur maximized edge effects as the area of perimeter is increased, and the area of high quality 'inner' habitat in decreased. This theory therefore favours a circular patch, as the area of perimeter is minimised, along with the presence of edge effects (Forman & Godron, 1986). A buffer of native vegetation also reduces the risk of edge effects, resulting from weed infestation, human-generated damage, microclimatic variables, and predation. A study conducted in New South Wales concluded that a buffer width of 60m was suitable to minimise adverse edge effects from a neighbouring urban environment (Smith & Smith, 2010).

Core habitat patches can be connected by corridors and networks (Milne, 1996). To maximise the use of habitat patches, the patch should be located adjacent to a corridor, and be as large as the environment can accommodate (Fleury & Brown, 1996). The home range of fauna species is also an important factor to consider, as species tend to increase their home range in a more fragmented landscape (Mabry & Barrett, 2002).

Gaps

Doerr & Davies 2010 used literature on bird and mammal species inhabiting wooded habitats to calculate a mean gap-crossing threshold of 106m, indicating that many species are unable to cross open areas that exceed this distance. It was also calculated an interpatch-crossing threshold of 1100m, indicating that many species are unable to disperse between patches of habitat separated by >1100m, even where structural connectivity exists between the patches (Doerr & Davies 2010). Although these calculations were based on limited data, and it is important to remember that different species will have different gap-crossing thresholds, they can provide a useful starting point for modelling and planning.

Length

The length of a successful wildlife corridor is species specific and will alter depending on the fauna being examined. Speed and movement behaviours vary the amount of time a species occupies a corridor, and therefore the required resources for survival. For example, burrowing animals may only move 1m a day, while some birds can travel 100km or more in the same time (Fleury & Brown, 1996). Shorter lengths are ideal to minimise the time spent in corridors, and to maximise usage of habitat patches (Fleury & Brown, 1996). This also ensures habitat patches are linked closely within a network, and are easy to travel between for a variety of species.

Width

The width of a corridor is vital to its success, influencing edge effects and mortality of the inhabiting species. The wider the corridor, the more successful it tends to be in reducing mortality (Fleury & Brown, 1996). The area of high value habitat is increased in a wider corridor, and edge effects such as predation, solar radiation, wind, humidity, temperature, and pollution are reduced (Sunshine Coast Council, 2011).

Assuming land is available, the width of the corridor should be based on the requirements of a species found in the area that is 'high on the food chain' (Fleury & Brown, 1996). This ensures that the structure of the corridor is suitable for a variety of species, and is specific to the area.

It is important that an appropriate buffer width is provided for wildlife habitat networks and corridors to minimise edge effects and increase efficiency. For riparian corridors, studies have shown that a buffer width of 40m is appropriate to maintain ecological functionality and to minimise impacts from human activities (Seng Mah, et al., 2015). For terrestrial corridors, studies have determined that 50m is an appropriate buffer to minimise edge effects (Cardo Chenoweth, 2012; Smith & Smith, 2010). These width recommendations were determined by the distance human-generated damage, weed invasion, microclimatic variation, predation, and parasitism has been recorded by previous studies conducted in Australia, New Zealand, and the United States (Smith & Smith, 2010).

A study of wildlife presence within corridors in Eden, New South Wales, determined that the optimum corridor width is 250m (Cardo Chenoweth, 2012). A corridor of this width was able to retain a variety of local bird species, along with a complete suite of arboreal mammals from the area. A corridor of 100m or less was able to retain most of the same arboreal mammals, although lacked diversity in other species (Cardo Chenoweth, 2012). Based on this study, a highly successful corridor should be 350m wide, including the 50m buffers to reduce edge effects.

Corridors of varying width can perform different ecological functions. The 'Landscape Corridors of the Coffs Harbour Local Government Area' (Scotts & Cotsell 2014) adopted the following corridor with classifications:

- Regional Corridors: 650 metres wide;
- Subregional Corridors: 350 metres wide;
- River Corridor: 100 metres wide;
- Local Corridors: 80 metres wide;
- Riparian Corridors: 80 metres wide (on 3rd & 4th order streams); and
- Urban Links: variable width but typically less than 80 metres.

Shape

The shape of a corridor affects what species can successfully enter and move through the corridor to reach suitable core habitat patches. It is important that the corridor is easily accessible, with as much linearity as possible (Fleury & Brown, 1996). This ensures that species don't reside in the edge of the corridor where there is a higher risk of mortality. Generally corridors are rectangular in shape, although this is sometimes restricted due to land use. When conflicting land use is a factor, alternative areas of vegetation might become vital in the connectivity of the corridor network. This can include stepping stones such as street trees and residential gardens that aid in providing a linear corridor to a habitat patch (Hess & Fischer, 2001). Studies have shown that a constant width with ‘feathered edges’ is the preferred corridor shape, as it minimises exposure to any edge effects, and keeps species movements within the corridor (Fleury & Brown, 1996).

Edge Effects

Edge effects are commonly known as the negative effects on wildlife and natural environments caused by urbanisation (Villasenor, et al., 2014). The effects are due to edge contrast, which is defined as being the compositional or structural difference between adjacent ecosystems at either side of the boundary (Villasenor, et al., 2014). Edges with a high contrast often present greater risks for wildlife, with more elements entering the corridor or habitat patch, and stronger barriers to movement. These hard edges are often formed with urban development such as roads, residential areas, and commercial or industrial developments (Brearley, 2011). Soft edges are preferred, and provide easier permeability to species. These types of edges are formed by wildfires, and vegetation with different ages that eventually blend together (Brearley, 2011).

Abiotic and biotic changes in vegetation can be a result of edge effects in urban environments. A primary response is a direct result of edge creation, which results in abiotic changes such as increased light pollution, fluctuations in temperature, and increased wind speed (Brearley, 2011). As a result of these ecological changes, secondary responses are observed including alterations in vegetation structure and composition (Brearley, 2011). This can include decreased canopy cover, sparse vegetation, and increased debris due to the exposure to the bordering environment.

Other negative edge effects created from an encroaching urban environment include increased competition, predation, changes in microclimate, and human-generated damage (Smith & Smith, 2010). Flora and fauna both experience competition, with invasive weeds becoming a major cause of environmental degradation (Smith & Smith, 2010). Predation by domestic cats on small mammals and birds has been widely researched, and is a common cause of mortality in urban-edge forests (Brearley, 2011). Microclimatic changes are often found up to 50m from the habitat edge, which can affect the native species diversity of the area (Smith & Smith, 2010). Human-generated damage is due to a variety of causes including the dumping of waste and green waste, firewood gathering, destruction of trees, and destruction of understory due to usage as a recreational area. These effects usually occur within the first 30m of the habitat edge, although can often be experienced up to 100m away from the edge (Smith & Smith, 2010).

As edge effects have such a detrimental effect on occupying wildlife, it is importance that an appropriate buffer is maintained around significant habitats. Research indicates that a minimum buffer width of 60m should be applied around all edges of habitat patches to minimise the negative effects of a neighbouring urban environment (Smith & Smith, 2010). The buffer should be comprised of native vegetation, and appropriate measures such as fencing and weed control may be necessary to reduce impacts on the interior habitat (Smith & Smith, 2010). A buffer of 50m should be applied on each side of corridors to reduce edge effects (Cardo Chenoweth, 2012). The purpose of a buffer is to provide protection to the interior habitat without requiring constant active management.

Structure

The structure and composition of wildlife habitat networks and corridors is generally related to the flora species present (Hess & Fischer, 2001). Species requirements of food source trees, vegetation density, and canopy cover will vary. A corridor with diverse flora will generally benefit a greater number of species, and any discontinuity in the composition of the corridor should be avoided (Fleury & Brown, 1996). To increase the structural diversity of a corridor, layers should be incorporated, including grasses, small shrubs, and a variety of native trees (Fleury & Brown, 1996). This increases the habitat available within the corridor by providing a number of horizontal and vertical nesting and foraging sites. Regional Ecosystems can be used to determine the appropriate composition of vegetation communities for a specific area. Other elements such as rock piles, hollows and brush piles can also add to corridor diversity by providing nesting sites and protection.

While wildlife habitat corridors containing continuous and diversely structured habitat are generally the most appropriate for facilitating movement, stepping stone corridors (such as scattered paddock trees) can be equally effective (Doerr & Davies 2010). These stepping stone corridors are not continuous, and may be broken by currently degraded or cleared areas. Stepping stone patches provide connectivity and can function as corridors for mobile species, particularly those willing to cross expanses of cleared land (Scotts & Cotsell 2014).

Barriers

Barriers to species movement along wildlife habitat corridors can come in many forms. Barriers such as highways, railway lines and impermeable fences can increase the mortality rate of some wildlife attempting to cross the barrier (Selles, O'Hare & Veage, 2008). Roads can be particularly significant barrier to wildlife movement, causing deaths and enabling behavioural avoidance due to traffic density, noise, and lighting (Clevenger & Kociolek, 2013). To encourage safe movement across roads, crossing infrastructure can be implemented in hot spots (areas with a high wildlife presence) (Garrah, et al., 2015). Crossing infrastructure includes underpasses such as culverts, passages, and tunnels, and overpasses such as bridges (Lister, et al., 2015). Barrier fencing can be a useful strategy to filter wildlife and ensure crossing is made at these underpasses or overpasses, which are often known as ‘fauna guiding fences’ or drift fences’ (Gleeson & Gleeson, 2012). However not all barriers present a complete impasse for all wildlife movement, some barriers may be a hindrance for certain species and not others. For example, barbed wire fences allow passage for many species however fruit bats and gliders are susceptible to being caught on these structures.

Stepping Stones

Stepping Stones can be defined as patches of habitat that, while not physically connected, are functionally connected, allowing movement between larger patches (National Wildlife Corridors Plan 2012). Stepping stones of suitable habitat enhance connectivity in developed landscapes for species able to make short movements through disturbed environments. Connectivity is achieved by a sequence of short movements or ‘hops’ from stepping stone to stepping stone along the length of the linkage, or by the combined dispersal movements of numerous individuals moving between populations resident within a chain of stepping stone habitats (Bennett 2003).

Stepping stones may be natural patches, such as wetlands or patches of rainforest within drier forests or they may be small remnant patches of vegetation in a developed landscape. They can also be anthropogenic in form of forestry plantations, artificial water bodies or urban. Scattered trees are the most recognised form of stepping stones and are important to native fauna for movement, foraging habitat and nesting resources (Gleeson & Gleeson 2012). Vegetated stepping stones are used by various mobiles species, and are important sources of seed for regeneration of adjacent vegetation.

Stepping stones are likely to be an effective approach to maintaining landscape connectivity:

- for species that regularly move between different resource patches in the landscape (such as temporally varying food sources, or spatially separated nesting and foraging habitat);
- for species that are relatively mobile and able to move substantial distances in relation to the intervening distance between fragments;
- for species that are tolerant of disturbed landscapes, although not necessarily able to live within the modified zone; and
- where the objective is to maintain continuity of ecological processes that depend on animal movements and the animal vectors are capable of movement across gaps (Bennett 2003).

For Appendices 4 to 8 refer to associated document ‘Corridor Descriptions and Locations 2018-2028’

Appendix 4 – Established Corridors

Appendix 5 – Regional Riparian Corridors (BPA)

Appendix 6 – Coastal Foreshore Corridors

Appendix 7 – Enhancement Corridors

Appendix 7a – Enhancement Corridors in Known Development Areas Corridors

Appendix 8 – Stepping Stone Corridors

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