KU-RING-GAI BIODIVERSITY AND RIPARIAN LANDS STUDY

Ku-ring-gai Council
2013

Revision	Details	Date
	Biodiversity and Riparian Lands Study	March 2012
1	Maps updated in line with DLEP 218 and other minor modifications.	January 2013

Cover Page Pictures

1. Blue Gum High Forest	2. Rocky Creek, Gordon	3. Powerful Owl	4. Eriostemon sp

Disclaimer

This document may only be used for the purpose for which it was designed. Changes to available information, legislation and schedules are made on an ongoing basis and readers should obtain up to date information.

Ku-ring-gai Council accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report and its supporting material by any third party. Information provided is not intended to be a substitute for site specific assessment or legal advice in relation to any matter. Unauthorised use of this report in any form is prohibited.

Table of Contents

Appendices

List of Figures

List of Tables

List of Abbreviations

API	Aerial Photograph Interpretation
APZ	Asset Protection Zone
BGHF	Blue Gum High Forest ecological community
CEEC	Critically Endangered Ecological Community
CMA	Catchment Management Authority
CRZ	Core Riparian Zone
CSA	Conservation Significance Assessment
DA	Development Application
DCP	Development Control Plan
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change (formerly DEC)
DECCW	NSW Department of Environment, Climate Change and Water (formerly DECC)
DF	Duffys Forest ecological community
DIPNR	Department of Infrastructure Planning and Natural Resources
EEC	Endangered Ecological Community
EP&A Act	*NSW Environment Planning and Assessment Act 1979* (NSW)
EPI	Environmental Planning Instrument
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FM Act	*Fisheries Management Act 1994*
HNCMA	Hawkesbury-Nepean Catchment Management Authority
KC	Ku-ring-gai Council
KVC	Key Vegetation Communities
KLEP (Local Centres)	*Draft Ku-ring-gai Local Environmental Plan (Local Centres) 2012*
KPSO	*Ku-ring-gai Planning Scheme Ordinance 1971*
LEP	Local Environmental Plan
LEP 218	Draft Local Environmental Plan 218 (incorporates Biodiversity, Riparian and Heritage Conservation Areas into KPSO)
LGA	Local Government Area
LiDAR	Light Detection and Ranging
OEH	Office of Environment and Heritage (formerly DECCW)
PLEP	*Planning Proposal for the Ku-ring-gai Principal Local Environmental Plan*
RFS	NSW Rural Fire Service
SCA	Sydney Catchment Authority

SEPP	State Environmental Planning Policy
SMCMA	Sydney Metropolitan Catchment Management Authority
STIF	Sydney Turpentine Ironbark Forest ecological community
SCIVI	South-east NSW Native Vegetation Classification and Mapping
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
TEC	Threatened Ecological Community

Glossary

Asset Protection Zones (APZ)	An APZ is a buffer zone between a bush fire hazard and buildings, which is managed progressively to minimise fuel loads and reduce potential radiant heat levels, flame, ember and smoke attack. The appropriate APZ is based on vegetation type, slope and levels of construction. Planning for Bushfire Protection NSW Rural Fire Service 2006a.
Biobase	Ku-ring-gai Council's flora and fauna database (incorporating consultants' reports, NSW Wildlife Atlas, sightings by Council staff and the community).
Core Riparian Zone (CRZ)	The land contained within and adjacent to the waterway channel which should be retained, or revegetated with fully structured native vegetation (including groundcovers, shrubs and trees). The width of the CRZ is measured from the top of the bank and determined by assessing the importance and riparian functionality of the waterway, merits of the site and long-term land use.
Genetic Erosion	"The process in which a plant or animal species faces a gradual or drastic diminishing or complete loss of its unique gene pool" (Panse 2009).
Office of Environment and Heritage (OEH) protected areas	NSW Office of Environment and Heritage (OEH) has over 820 protected areas in NSW (including 4 reserves covering over 1700 ha within Ku-ring-gai). These are classified according to their use, location and fragility. Examples include national parks, marine parks, state conservation areas and aboriginal sites. For more information, visit: http://www.environment.nsw.gov.au/parktypes/TypesOfParks.htm
Formal reserves	Including: • Office of Environment and Heritage protected areas (eg. Nature Reserves and National Park listed under the *National Parks and Wildlife (NPW) Act 1974)* • Ku-ring-gai Natural Areas as categorised under the *NSW Local Government Act 1993* • Bushland with adjoining LGAs For available mapping see Figure 2.
Key Vegetation Community	Key vegetation communities within the Ku-ring-gai Local Government Area, including communities currently or considered likely to be listed under the *NSW Threatened Species Conservation (TSC) Act 1995, NSW Fisheries Management (FM) Act 1994* and / or the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999.* Vegetation condition is a key factor determining the inclusion of remnant vegetation as a threatened ecological community, under the TSC Act, FM Act and EPBC Act. In order to recognise that future variations in federal and state scientific committee determinations and their interpretation may occur, Key Vegetation Communities have been based upon vegetation community not condition. As such Key Vegetation Communities may include areas outside the scope of conditions required to meet the determination.
Ku-ring-gai Natural Areas	All Council managed lands classified as community land and categorised 'Natural Areas' under the *Local Government Act 1993 and* crown land under *Crown Lands Act 1989* (under care control and management of Ku-ring-gai Council and categorised as'Natural Area').

Nutrients	Nutrients in this context are substances that negatively affect bushland such as phosphates and nitrates from sources including garden fertilisers, detergents and organic materials such as sewage, garden clippings and dog faeces.
Patch and Patch size	*Patch*, a term fundamental to landscape ecology, is defined as a relatively homogeneous area that differs from its surroundings. Patch size is simply the size of the identified patch. Within this report patch size has been applied to land management areas (Formal Reserves) and vegetation communities (KCVs). e.g. Patch size of Key Vegetation Communities = Total area of connected Key Vegetation Communities. So 1ha of Blue Gum High Forest connected to 1ha of Sydney Turpentine Ironbark Forest, would result in a patch size of 2ha.
Provenance	Provenance (plant stock) is a term used to describe something's origin or source and in the case of seed as its "geographic place of origin or seed" (Loch and Whalley 1997). This term is broadened to describe the patterns of variation exhibited by a species over its range reflecting its evolutionary history (Coates and van Leeuwen 1996).
Regionally significant species, populations and habitat	Flora and fauna species, populations, ecological communities and habitat identified as regionally significant in Council's Biodiversity Strategy.
Remnant vegetation	Remnant vegetation describes native vegetation occurring within fragmented landscapes. Remnants are generally small to medium sized patches of vegetation surrounded by highly modified land used for urban residential and associated infrastructure.
Riparian Land	That (land or zone) adjoining (or at the interface of) a river or waterway, including the waterway. Within the context of this report, this consists of the: 'Riparian Category' - mapped waterway and Core Riparian Zone + the vegetated buffer (where required) *Please see Section 2.2 for further explanation of Riparian Category; Core Riparian Zone and Riparian Buffer.*
Threatened Ecological Communities	In NSW this includes ecological communities listed under the *Threatened Species Conservation Act (NSW) 1995 or Fisheries Management Act 1994*; in the categories of, Critically Endangered, Endangered or Vulnerable; depending on their risk of extinction. Ecological communities can also be listed as nationally threatened under the Commonwealth's *Environment Protection and Biodiversity Conservation Act, 1999.*

1 Introduction

This study aims to provide specific environmental baseline data, management overlays and recommendations to guide the community and Ku-ring-gai Council in the preparation of the Draft Local Environmental Plan 218 (LEP 218), (incorporating Biodiversity, Riparian and Heritage Conservation areas into the Ku-ring-gai Planning Scheme Ordinance (KPSO)), the Planning Proposal for the Ku-ring-gai Principal Local Environment Plan (PLEP) and the Draft Ku-ring-gai Local Environmental Plan (Local Centres) 2012 [draft KLEP (Local Centres)]. The Local Environmental Plans (LEPs) will be based on the NSW Standard LEP template, and between them, relate to all areas within the Ku-ring-gai Local Government Area (LGA). The draft LEP 218 relates to all land (outside the local centres) within the LGA, the draft KLEP will relate to the six centres of Turramurra, Pymble, St Ives, Gordon, Lindfield and Roseville. The PLEP will relate to all areas of the LGA outside these centres.

In relation to riparian and biodiversity management (including the protection and recovery of threatened communities, species and populations), Council is required to consider a range of legislation, plans, strategies, objectives and targets in planning for the LEPs. In order to fulfil its obligations in this regard, Council has undertaken an extensive data audit and mapping program to provide baseline data regarding natural resources within Ku-ring-gai.

This study provides information on the collection and analysis of this data and the conservation significance assessment process applied in the creation of the following planning/ management overlays:

- *Riparian lands mapping*
- *Greenweb mapping*
    - Key vegetation community mapping
    - Flora and fauna assessment
    - Regional and local fauna habitat mapping
    - Biodiversity corridor mapping
    - Conservation significance assessment

Both the base line data and overlays will be used for a variety of purposes, including the Ku-ring-gai Biodiversity Strategy. However, the focus of this study is to inform the Draft LEPs. The study is not a comprehensive environmental assessment, rather it focuses on the key factors that affect land use planning in Ku-ring-gai and recommends planning measures to manage the impacts.

1.1 Aims

The aims of this study are to:

a) Identify lands having strategic ecological value within the LGA.

b) Provide a transparent, consistent and robust method for the assessment and management of biodiversity and riparian lands in an urban landscape.

c) Integrate the data used in the preparation of the *draft Ku-ring-gai LEP (Local Centres) 2012.*

d) Inform the protection of important natural resources and ecosystem processes under draft LEP 218, the draft PLEP and associated DCPs.

e) Integrate biodiversity planning in LEPs, DCPs and future revisions of the Ku-ring-gai Biodiversity Strategy.

Objectives

The objectives of the study within the context of the above aims are to:

a) Protect, maintain and where possible increase extent of local native vegetation.

b) Improve condition of native vegetation.

c) Increase connectivity of terrestrial native vegetation, riverine systems and riparian areas.

d) Improve recovery of threatened species, populations and ecological communities.

e) Increase in number of sustainable populations of a range of native flora and fauna species.

f) Improve condition of riverine ecosystems, wetlands and coastal ecosystems.

g) Improve ability of groundwater systems to support groundwater dependent ecosystems and designated beneficial uses.

h) Ensure that natural resource decisions contribute to improving or maintaining economic sustainability and social wellbeing for the local government area (LGA).

i) Mitigate and provide for adaptations to climate change.

j) Avoid and minimise bushfire risks to life property and biodiversity.

k) Manage land according to its capability.

1.2 Legislative and planning framework

Council is required to consider a range of national, state and regional legislation, plans, strategies, objectives and targets in the planning for the Draft LEPs. A list of significant Acts and Planning Instruments is included below.

Legislation

- *Environmental Planning and Assessment Act (NSW) 1979 (including Section 117 directions);*
- *Environment Protection and Biodiversity Conservation Act (Commonwealth) 1999 (EPBC Act);*
- *Threatened Species Conservation Act (NSW) 1995 (TSC Act);*
- *Fisheries Management Act (NSW) 1994;*
- *Local Government Act (NSW) 1993;*
- *National Parks and Wildlife Act (NSW) 1974;*
- *Rural Fires Act (NSW) 1997;*
- *Water Management Act (NSW) 2000.*
- *Water Management General Regulation (NSW) 2011.*

State / Federal Plans and Environmental Planning Instruments

- Relevant Priority Action Statement, recovery plans and threat abatement plans;
- Metropolitan Strategy -Sydney Towards 2036 (Dec 2010);
- North Subregion: Draft Subregional Strategy (2007);
- Draft NSW Biodiversity Strategy 2010-2015;
- Australia's Biodiversity Conservation Strategy 2010-2030;
- National Biodiversity and Climate Change Action Plan 2004-2007;
- National Objectives and Targets for Biodiversity Conservation, 2001–2005;
- NSW Greenhouse Plan 2005;
- Hawkesbury Nepean Catchment Action Plan 2007-2016 (2008);

- Sydney Metropolitan Catchment Action Plan 2009;
- State Environment Planning Policies (SEPPs) and deemed SEPPs:
    - SEPP 19 Bushland in Urban Areas;
    - SEPP 44 Koala Habitat Protection;
    - Sydney Regional Environment Plan -Hawkesbury Nepean River;
    - Sydney Regional Environment Plan- Sydney Harbour Catchment 2005 (and associated DCP).

Council also has a range of policies, plans and strategies including:

- Ku-ring-gai Planning Scheme Ordinance 1971[1];
- Sustainability Vision Report 2008-2033 (KC 2008a);
- Ku-ring-gai Biodiversity Strategy 2006 (KC 2006)
- Plans of Management for parks, Natural Areas, the Ku-ring-gai Flying Fox Reserve
- Development controls plans, policies and strategies in relation to ecologically sensitive lands, open space, water, waste, fire, companion animals, weeds, riparian lands, urban residential and business development.

It is intended that the planning outcomes of this study will support the achievement of the targets and objectives identified in the key strategies, plans and policies. A summary of how the objectives of this study align to the key targets and objectives is provided in Table 1.

[1] The KPSO will be replaced in time by the Draft Ku-ring-gai Principal Local Environment Plan (PLEP) and the Draft Ku-ring-gai Local Environmental Plan (Local Centres) [Draft KLEP (Local Centres)]

Table 1: Summary of Relevant Targets and Objectives Contained within Key Plans

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Maintain/ increase extent of vegetation	• Protect unique diversity of plants & animals • Protect regional reserves (for biodiversity, recreation, scenic amenity) • E.3.1 Contain urban footprint • E6.2.1 Manage conservation areas while achieving growth targets	• Clearing controls in place that prevent clearance of ecological communities with an extant below 30% of that present pre-1750 • Review reserve acquisitions to allow species to adapt to climate change	• Maintain the extent and condition of terrestrial native vegetation in all landscapes (SM) • Maintain the extent of native terrestrial vegetation in all landscapes (HN)	• Re-establish native veg/habitat on private land (NP). • Enhance establishment of offsets such as trees; use of native vegetation for carbon sequestration (GP) • Reduce land-clearing (GP)	• Highly value & conserve natural environment/ bushland of Ku-ring-gai	• A national increase in the extent of native habitat across tenures • An increase in the extent of private land managed for biodiversity conservation • By 2015, a national increase of 600,000 km^2 of native habitat managed for biodiversity conservation across terrestrial, aquatic & marine environments	• Retain bushland in parcels of a size & configuration to enable long term survival of existing plant & animal communities • Protect habitats for native flora & fauna • Maintain bushland in locations readily accessible to community & for its scenic values & unique visual identity • Protect the remnants of plant communities once characteristic of land now in urban area
Improve condition of native vegetation	• Protect unique diversity of plants & animals	• Minimise impact of invasive organisms on biodiversity in	• Improve the extent and condition of terrestrial native vegetation in all	• Improve habitat (NP) • Provide for adaptation to	• Highly value & conserve natural environment	• A national increase in the condition of native habitat across	• Promote the management of bushland in a manner which

* The catchment targets are listed here; please refer to the relevant Catchment Action Plan for the specific management targets relating to each.

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Improve condition of native vegetation (continued...)	• Development to retain bushland in sustainable configurations • E2.1.5 Promote Water Sensitive Urban Design	future climates	landscapes (SM) • Improve native vegetation condition in priority fauna habitat, and/or areas that are part of the network of regional corridors (HN)	climate change (NP) • Reduce existing pressures from threatening processes(NP) • Integrate tools & guidelines for adaptation to climate change into the planning system (including consideration of invasive weeds) (GP)		tenures • By 2015, reduce by at least 10% the impact of invasive species on threatened species & ecological communities	protects & enhances the quality of the bushland & facilitates public enjoyment of the bushland compatible with its conservation
Increase connectivity of terrestrial native vegetation	• Protect unique diversity of plants & animals • Mapping & information advice from the Department of Environment, Climate Change and Water (DECCW) • Development to retain bushland in sustainable configurations	• Identify natural refuges (priority habitats) & habitat linkages with potential importance in maintaining species vulnerable to climate change	• Increase the connectivity of native vegetation (SM)	• Improve ecological linkages/ stepping stones (NP) • Integrate tools & guidelines for adaptation to climate change into the planning system(GP)	• Protect & increase tree cover	• An increase in the connectivity of fragmented landscapes & seascapes • By 2015, four collaborative continental-scale linkages established & managed By 2015, 1,000 km^2 of fragmented landscapes & aquatic systems being restored	• Protect wildlife corridors & vegetation links with other nearby bushland

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Improve recovery of threatened species, populations & ecological communities	• Protect unique diversity of plants & animals • Mapping & information advice from DECCW • Development to retain bushland in sustainable configurations	• Native vegetation restoration programs to recover ecological communities that are below 10% of that present pre-1750 or are nationally listed as critically endangered	• Better conserve aquatic and terrestrial threatened species, EECs and populations by implementing Priority Action Statement actions (SM)	• Provide for adaptation to climate change (NP) • Reduce existing pressures from Threatening Processes (NP)		• An improvement in the conservation status of listed threatened species & ecological communities • An increase in the number, extent & condition of ecosystems protected under secure conservation tenure	• Protect rare & endangered flora & fauna species
Increase in number of sustainable populations of a range of native fauna species	• Protect unique diversity of plants & animals • Development to retain bushland in sustainable configurations		• Reduce the impact of terrestrial and freshwater invasive species on biodiversity (SM, HN) • Undertake actions that assist in the conservation of threatened species(HN) • Reduce conditions that favour invasive species through improving ecosystems (HN)		• Value & protect natural environment .	• An improvement in conservation status of listed threatened species & ecological communities	• Protect habitats for native fauna

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Increase in number of sustainable populations of a range of native fauna species (continued....)			• Improve sustainability of key native fauna populations (HN, SM)				
Improve condition of riverine ecosystems / Wetlands / coastal ecosystems	• E2.1.2, EE2.1.4, E2.1.5 E2.1.7, E2.1.8 • Improve health of waterways, coasts & estuaries. Consider Catchment Action Plans & work with agencies & CMAs in planning & priorities for local areas • Map & protect regionally significant riparian zones • Promote Water Sensitive Urban Design (WSUD) • Refer to *Groundwater Management Handbook*		• Improve the health and conservation of modified waterways, riparian corridors and natural waterways(SM) • Improve the health of riparian lands (HN) • Maintain and improve the condition, function and extent of wetlands (SM, HN). • Progress towards achieving the Water Quality and River Flow Objectives (SM) • Improve the condition and function of coastal and marine ecosystems (SM, HN) • Improve the sustainability of key native aquatic populations and the recovery of threatened aquatic species (HN)	• Integrate tools & guidelines for adaptation to climate change into the planning system(GP)	• Improve water quality	• Improve the management of aquatic habitats including by reducing key threats to aquatic biodiversity • By 2015, 1,000 km^2 of fragmented landscapes & aquatic systems being restored	• Protect existing landforms, such as natural drainage lines, watercourses & foreshores

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Improve ability of ground-water systems to support ground-water-dependent ecosystems & designated beneficial uses	• E2.1.8 Refer to *Groundwater Management Handbook*		• Improve the quality and sustainable use of groundwater systems (SM) • Improve the ability of groundwater systems to support groundwater-dependent ecosystems and beneficial uses (HN)				• Protect existing landforms, such as natural drainage lines, watercourses & foreshores
Manage land according to its capability	• E3.5 Improve health of waterways • Manage impacts of tourism		• Increase the amount of land managed within its capability - & incorporate into EPI's (SM) • Implement actions under the Sydney Metropolitan Strategy that recognise, protect and improve key natural resources (SM) • Natural Resource elements of the statutory planning system are consistent with the SMCMA's CAP (SM)[#]				• Protect bushland as a natural stabiliser of the soil surface

[#] Management Target

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Natural resource decisions contribute to improving or maintaining economic sustain-ability & social wellbeing	• E3.5, 3.5.1, 3.5.2 Manage the environmental impacts of tourism & visitors. • Conserve & manage regionally significant open space to contribute to biodiversity, recreational opportunity & scenic amenity • Urban development should not compromise access & use		• Improve focus and collaboration between organisations that act in or influence natural resource management (SM) • Increasing the catchment community's capacity to contribute to managing its natural resources (HN) • Identify, acknowledge and incorporated Indigenous cultural landscape values into all natural resource management activities and land use planning (SM)	• Greenhouse policies to be targeted to achieve additional social & environ-mental benefits where possible (GP)	• Protect the rich natural, social, cultural & built heritage. • Value sense of space. • Natural environment contributes to sense of belonging.	• Develop & align, where appropriate, emerging markets for biodiversity with markets for other ecosystem services. • Develop innovative mechanisms to encourage private investment & interest in biodiversity conservation • By 2015, all jurisdictions review legislation, policies & plans to maximise alignment with the strategy	• Give priority to retaining bushland, unless its value outweighed by significant environment-al, economic or social benefits • Protect & preserve bushland within the urban areas for its value to the community as part of the natural heritage • Protect the aesthetic, recreational, educational & scientific value & potential of bushland & its geological features & archaeological relics
Mitigate climate change	• 60% cut in greenhouse gas emission by 2050		• Improve awareness and willingness to adopt mitigating strategies for climate change impacts on natural resource values (SM)	• NSW Return to 2000 emissions by 2025(GP) • 60% cut in greenhouse emission by 2050 (GP)	• Address climate change	• An increase in the use of strategic & early interventions to manage threats to biodiversity including climate change	• Promote the management of bushland in a manner which protects & enhances quality of the bushland

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Mitigate climate change (continued...)				Incorporate climate change consideration in land use planning & assessment (GP)			
Provide for adaptation to climate change	• E5.1.1, E5.3 Identify natural hazards & risk management measures related to climate change • Use latest information when planning for natural hazards including climate change; Consider *National Climate Change Adaptation Framework* & *NSW Greenhouse Plan*	• Factor potential impacts of Climate Change on biodiversity into land use planning, natural resource management, including EPIs, policies etc • Review reserve acquisitions & habitat connections to allow species to adapt to climate change	• Improve awareness and willingness to adopt adaptive strategies for climate change impacts on natural resource values (SM) • Identify regional/catchment biodiversity corridors to provide for species movement under climate change (HN)	• Use risk management approach to adaptation (NP) • Improve habitat/ linkages/ stepping stones (NP) • Re-establish native veg/habitat on private land (NP) • Integrate reserve planning with broader landscape networks(NP) • Likely need to increase protected areas. • Reduce pressures from threatening processes (NP) • Integrate tools &	• Minimise threats from climate change	• Identify & protect climate change refugia to strengthen opportunities for genetic & ecological adaptation • By 2015, 1,000 km^2 of fragmented landscapes & aquatic systems being restored	• Retain bushland in parcels of a size & configuration which will enable the existing plant & animal communities to survive in the long term • Protect wildlife corridors & vegetation links with other nearby bushland

Objectives of this study	*Targets and Objectives within Key Plans*						
	North Subregion: Draft Subregional Strategy (2007); (E2, E2.1, E2.2 also apply to all objectives)	**National Objectives & Targets for Biodiversity Conservation 2001-2005**	**Catchment Action Plan Targets [Hawkesbury Nepean H(N), Sydney Metropolitan (SM)]***	**National Biodiversity & Climate Change Action Plan 2004-07 (NP) & NSW Greenhouse Plan 2005 (GP)**	**Ku-ring-gai Sustainability Vision Report 2008-2033**	**Australia's Biodiversity Conservation Strategy 2010-2030**	***SEPP 19 (Bushland in Urban Areas)***
Provide for adaptation to climate change (continued.....)				guidelines for adaptation to climate change into the planning system (GP) • Reduce social economic & environmental costs of current & future climate variability & extremes (GP)			
Avoid / minimise bushfire risks to life property & biodiversity	• E5.3.3 Develop bushfire prone land maps & Bush Fire Risk Management Plans- through an understanding of climate change & in accordance with *Planning for Bushfire Protection (RFS 2006a)* • See also actions under E2 of this strategy			• Provide for adaptation to climate change (NP) • Reduce existing pressures from Threatening Processes, such as altered fire regimes(NP) • Integrate tools & guidelines for adaptation to climate change into the planning system (GP)	• Minimise threats	• Improvement in the use of ecological fire regimes to conserve biodiversity & protect the public	• Give priority to retaining bushland, unless value outweighed by significant environment, economic or social benefits

1.3 Ecological Values of Ku-ring-gai

Overview

The Ku-ring-gai Council area, though relatively small is an area of biological diversity as it contains a variety of plant associations and habitat types that support over 800 plant species, at least 170 fungi and over 690 fauna species including invertebrates and fish. Ku-ring-gai's significant biodiversity stems from its diverse habitats and geological landscapes ranging from estuarine mangrove mudflats to steep sided sandstone gullies and ridges swathed in heath, open forest and riparian scrub to shale capped ridge tops with tall open forest. The area gets one of the highest levels of rainfall in Sydney averaging around 1400mm per annum (Wilks, 2010), which helps support tall open forest dominated by blue gums, blackbutts, turpentines and ironbarks on the richer clay soils. Today Council reserves and the tree lined suburbs provide important bio-linkages or corridors between three national parks and smaller reserves within and around the lower north shore.

Ku-ring-gai LGA covers 84 km^2 with about 1,100 ha of Council bushland reserves many of which are contiguous with about 1,800 ha of National Parks including Ku-ring-gai Chase, Garigal, Lane Cove and Dalrymple-Hay Nature Reserve.

Habitats and diversity

The relatively high species diversity in the LGA is likely due to the diverse range of habitats, microhabitats and ecotones.

Table 2: Summary of biodiversity in Ku-ring-gai

Species and ecosystem diversity	Numbers of species or associations
Flora species	843
Fauna species	693 (including invertebrates)
Mammals	47
Reptiles	45
Amphibians	26
Birds	218
Fish	28
Invertebrates	329**
Fungi species	171
Vegetation associations	26
Threatened Species	
Flora species	15
Fauna species	28
Mammals	8
Reptiles	1
Amphibians	3
Birds	15
Fish	1
Invertebrates	1 - not confirmed
Threatened Ecological Communities	
Threatened Ecological Communities (NSW TSC Act / FM Act)	7 (2 of these also listed under EPBC Act)
** Mostly aquatic macro-invertebrates identified to family or morpho-species only. With approximately 195 identified to species or genus level. Source: *Biodiversity Strategy* (KC 2006) (Refer to strategy for full species list).	

Ecological communities and plant associations

A summary of vegetation communities (including Key Vegetation Communities) within the Local government area as mapped with *Mapping and assessment of key vegetation communities across the Ku-ring-gai local government area KC 2012a and 2012b),* is provided within in Table 3 below (See Section 3.1 for further information).

Table 3: Vegetation Communities within Ku-ring-gai LGA

Vegetation Community	Legal status ▲		Key & non-key vegetation
	TSC Act & FM Act	*EPBC Act*	
Blue Gum High Forest (BGHF)	CEEC	CEEC	Key vegetation community
Sydney Turpentine-Ironbark Forest (STIF)	EEC	CEEC	
Duffys Forest (DF)	EEC	-	
Coastal Shale Sandstone Forest (CSSF)	Legal status to be determined through consultation with OEH, upon completion of the Sydney Metropolitan CMA mapping (DECCW 2009a)		Key vegetation community identified and added during the course of the vegetation mapping project in response to increased knowledge gained. Considered regionally significant. Recognised through field work and consultation with OEH (as part of their Sydney metropolitan vegetation mapping, DECCW 2009a).
Sydney Sandstone Gully Forest (SSGF)	-	-	These non-key communities have defined using broad community descriptions.
Sydney Sandstone Ridgetop Woodland (SSRW)	-	-	
Gully Rainforest (GF)	-	-	This non-key community was defined using broad community descriptions.
Estuarine Fringe Forest - Swamp Oak Floodplain Forest	EEC	-	Key communities. Fine scale mapping of these communities has been undertaken by Allen *et al* (2007), Kelleway *et al* (2007), West and Williams (2008) and incorporated within DECCW (2009a). No field assessment was undertaken for these communities within Council's vegetation mapping project.
Estuarine Saltmarsh	EEC	-	
Seagrass	P, EP	-	

Vegetation Community	Legal status ▲		Key & non-key vegetation
	TSC Act & FM Act	*EPBC Act*	
Estuarine Mangrove	P	-	Non-key communities. Fine scale mapping of these communities has been undertaken by Allen *et al* (2007) and incorporated within DECCW (2009a). No field assessment was undertaken for these communities within Council's vegetation mapping project.
Coastal Flats Swamp Mahogany Forest	EEC Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	-	Key community No field assessment was undertaken for these communities within Council's vegetation mapping project. These communities were beyond the sandstone boundaries of Council's field validation process and are incorporated within DECCW (2009a).
Coastal Upland Swamp	EEC	-	Key community Field assessment for this community was undertaken as part of ongoing vegetation mapping refinement and bushland management

▲ *FM Act 1994*: P – Protected, EP – Endangered Population
TSC Act 1995 and *EPBC Act 1999:* CEEC - Critically Endangered Ecological Community
EEC - Endangered Ecological Community

- ***Source:*** *Ku-ring-gai Council 2013a and 2013b* (further consultation of as part of finalisation for the SM CMA mapping (DECCW,2009a) is yet to be undertaken, this may inform future vegetation community classifications).

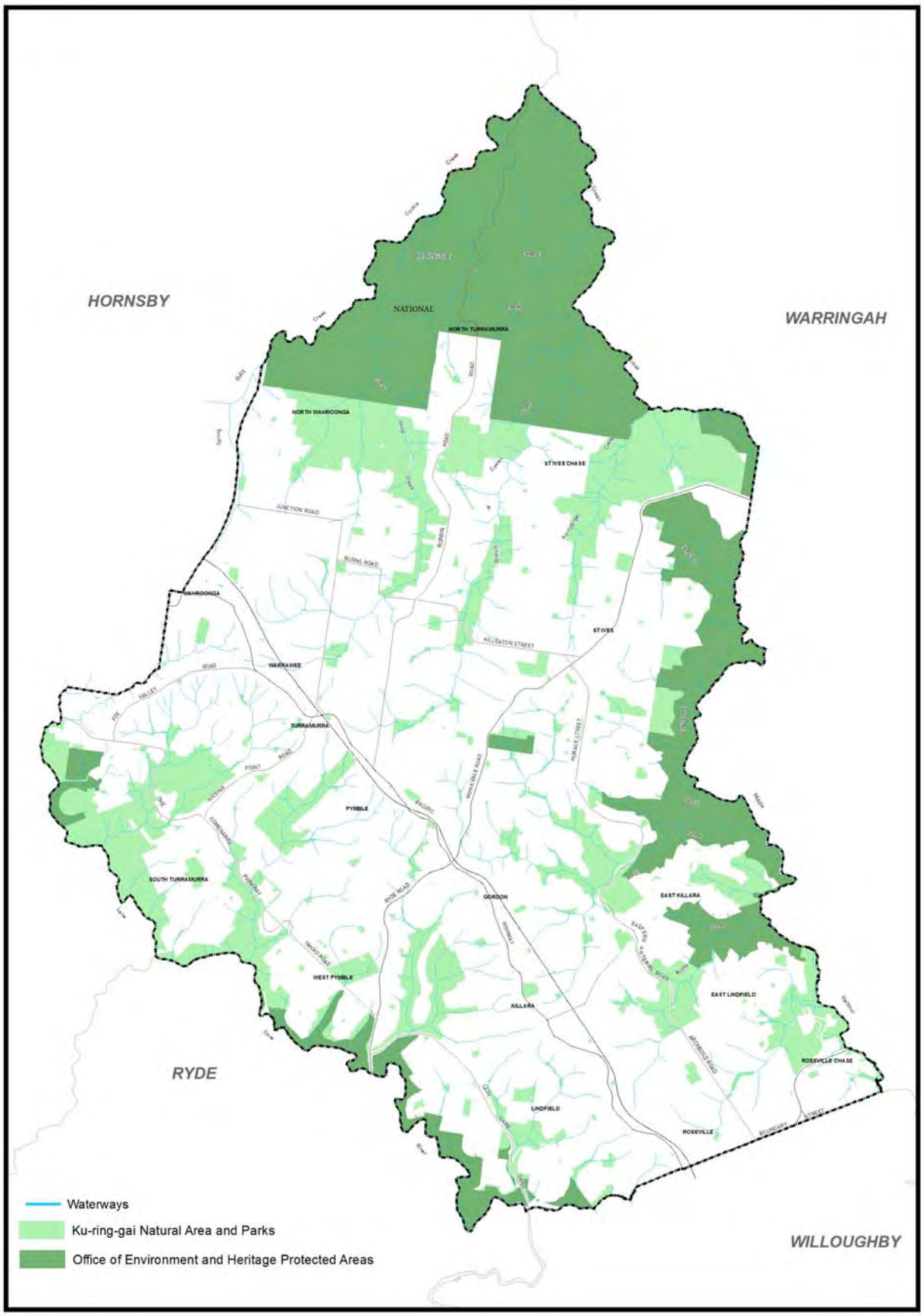
Habitats

Ku-ring-gai contains both terrestrial and aquatic habitats (see Table 4).These broad habitat types can merge into others forming ecotones between terrestrial and aquatic, urban and natural and between types within each group such as forest to woodland. Within terrestrial vegetation Ku-ring-gai contains various structural types of plant associations. Based on the Specht (1981) classification system there are structural types ranging from closed forest and tall open forest to low open woodland and low heath land.

Table 4: Examples of broad habitat categories within Ku-ring-gai

Terrestrial habitats	Intermediate habitats	Aquatic Habitats
Forest	Riparian zones	Streams (freshwater)
Woodland	Mangroves	Streams tidal (brackish)
Heath	Wetlands / soaks	Estuarine (marine)
Caves, rock faces and soil	Intertidal zones	
Urban / artificial	Drains, culverts and channels	Dams, ponds, marinas

Figure 1 : Ku-ring-gai Local Government Area



1.4 Key ecological issues within Ku-ring-gai

The maintenance and enhancement of biodiversity and riparian values within the LGA is dependant on appropriate policy and on ground activities to manage of existing and future pressures.

1.4.1 Key pressures

Urbanisation represents the major single pressure on Ku-ring-gai's biodiversity. The *Metropolitan Strategy -Sydney Towards 2036* (NSW Government, 2010) requires a significant increase in the number of dwellings within the subregion and the LGA. Ku-ring-gai is committed to an increase of 10,000 dwellings by 2036, from a 2004 base, an increase of approximately 28%.

Clearing and fragmentation

Land clearing is a key threatening process under both the TSC Act and the EPBC Act. Clearing of remnant trees (live and dead), shrubs, groundcovers, rocks and litter results in the direct loss of habitat for vegetation communities, flora and fauna. It also results in a number of indirect impacts. For instance, where the clearing is within riparian zones, erosion and sedimentation reduce water quality downstream, in turn adversely impacting on downstream habitats.

Another significant indirect impact of clearing for urban development is the fragmentation and isolation of natural areas (Conacher Travers, 2000). Fragmentation results in:

- reduced interaction within plant and animal populations
- reduced opportunity for genetic flows and dispersal (Bridgman *et al*, 1995)
- Increased opportunity for exotic flora and fauna species to invade natural areas
- reduced potential for rare or threatened species to maintain their life cycles
- reduced size of populations (Saunders *et al*, 1987).

Stormwater runoff

Changes to stormwater runoff caused by urban development continue to be a long term pressure on waterways, vegetation communities, flora and fauna (Ecological Engineering 2007; Walsh et al. 2004 & Conacher Travers, 2000). This is due to an increase in the amount and connectivity of hard surfaces within catchments which:

- concentrate stormwater and runoff flows through pipes and channels to drains and gullies rather than seeping into the soil;
- increased quantity and rate of water flows, resulting in altered flow regimes, erosion and sedimentation;
- favouring weeds and non-local natives, that establish and thrive in the excess moisture (Lake and Leishman 2004);
- carrying seed, fruit and vegetative material into the bushland resulting in weed invasion;
- carrying environmentally damaging pollutants including herbicides, insecticides, detergents and grease into bushland and waterways;
- carrying nutrients into bushland and waterways.

Increased stormwater runoff, leads to increased erosion and sedimentation within drainage lines, which could potentially modify the foraging and breeding habitat of the Red-crowned Toadlet and other rare or threatened fauna species found in Ku-ring-gai and reduce the habitat quality of macro-invertebrates and native fish.

Increased nutrients

Native plants are adapted to low levels of nutrients such as nitrogen and phosphorus. Nutrient enrichment of our soils reduces the competitive advantage of local species, encouraging exotics over locally indigenous plants (Lake and Leishman 2004). High concentrations of nutrients can also be toxic to some native species (especially for naturally low nutrient environments such as sandstone areas). Sources of increased nutrient flows include stormwater, dumped rubbish and garden refuse and sewage overflows.

Blue Gum High Forest can be substantially altered by the introduction of elevated nutrients (Conacher Travers 2000). Exotic flora species may colonise areas of elevated nutrient flow thus compromising the values of this critically endangered vegetation community.

Accelerated erosion of drainage lines, together with increased nutrients have changed and will continue to change the undeveloped landscape within the adjoining reserves and river catchments (Benson and Howell, 1994).

Bushfire and bushfire management

Urban development near bushland often requires vegetation management to reduce the risk from bushfire. This includes creation of fire trails, controlled burning and manual fuel reduction works (such as clearing, underscrubbing, and litter removal).

As a result of historic fire patterns and evolution, the structure and composition of ecosystems in Ku-ring-gai are adapted to recurring fire intervals. Changing that recurrence interval may change the composition and structure of the vegetation (Bridgman *et al*, 1995). High frequency fire is a key threatening process under the TSC Act.

As Conacher Travers (2000) notes, control burns are usually conducted in seasons when the intensity of the burns can be controlled. Many species require a varied fire intensity to reproduce. For example only a hot fire will induce *acacia* species to crack seed coats and induce germination (Bridgman *et al*, 1995). Any prescribed strategy is likely to disadvantage some species as many species have growth, flowering and fruit patterns which are seasonally or fire controlled (Conacher Travers, 2000). Therefore the fire management strategy can influence species composition through elimination, favour and gradual drift in species abundance.

Fires can eliminate the understorey of a vegetation community leaving the earth exposed and susceptible to erosion. This in turn leads to erosion leading to nutrient increase in waterways in turn leading to a change in vegetation structure and composition.

Some threatened species and ecological communities found in Ku-ring-gai that may be threatened by altered fire regimes include *Eucalyptus camfieldii, Tetratheca glandulosa,* Red-crowned Toadlet (*Pseudophryne australis*), Powerful owl (*Ninox strenua*), Sydney Turpentine Ironbark Forest and Blue Gum High Forest.

Managing Bushfire Risk, Now and into the Future – Draft Background Study (Ku-ring-gai Council: 2011) discusses bushfire management issues in more detail.

Introduced species

Species that displace, or predate upon, native flora and fauna have been, and continue to be introduced into urban areas, both deliberately and accidentally (Conacher Travers, 2000). These include ornamental plants and domestic pets, including highly competitive species such as carp, rabbits, cats, blackberry and lantana (Bridgman *et al*, 1995). Feral animals such as foxes, cats, birds, introduced bees and wasps have a significant effect on native plants and animals. Urbanisation brings about a massive change in the species mix.

The natural fauna, often comprising mainly mammal, bird, reptile and insect species, is replaced with humans, their domestic pets and a variety of insect and vertebrate pests. The native flora is replaced with watered urban parks and gardens, or reduced as forests are replaced by lawns (Bridgman *et al*, 1995).

Weeds invade the natural areas and reduce the natural regeneration of native species, change the composition and structure of the vegetation, outcompete threatened species, reduce habitat and food plants for native fauna and alter fire regimes (Conacher Travers, 2000). Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants, is a key threatening process under the EPBC Act. A number of weed and pest species found in Ku-ring-gai are also listed as key threatening processes under the TSC Act. Introduced species have reduced the abundance and distribution of native species.

Weed growth results from increased moisture and nutrients, soil disturbance and erosion, garden rubbish, runoff containing weed seeds and vegetative material and from weeds growing in nearby gardens and stormwater paths.

Weed invasion into drainage lines is of significant concern in Council Reserves and National Parks adjacent to developed areas. For example, run-off into the drainage lines of Ku-ring-gai Chase National Park from stormwater runoff, garden fertilising, sewer overflows for instance, promotes weed invasion into the Park's riparian lands. Areas of major concern that are subject to these pressures include Lover's Jump Creek, Cockle Creek and Cowan Creek.

Exotic species growths into these areas have and will continue to change the natural environment for native species and potentially displace various threatened / locally significant flora and fauna assemblages that are restricted to these environments.

Recreational use

Natural areas are often suited to a range of recreational opportunities. However, remnant vegetation within urban bushland is subject to a greater number of disturbances than large intact areas of bushland. Disturbances include vehicles, people trampling plants, and the introduction of weeds and soil erosion.

Where the use exceeds the carrying capacity of the ecosystem, or it is not properly managed, these impacts may result in a decline of species diversity, distribution and abundance, as well as a degradation of the structure of vegetation communities and habitat quality.

Misuse of urban bushland

Bushland remnants are sometimes abused by neighbours or other residents. Dumping of rubbish and garden clippings, vehicular traffic, tree lopping, backyard encroachment into bushland as well as soil, litter, plant and bushrock removal for use in landscaping, all result in degradation of flora and fauna habitats (Conacher Travers, 2000). These problems are proportional in magnitude to the number of residents and the type of development in an area.

Air quality

Increased urbanisation generally results in an increase in vehicles and energy consumption resulting in increased air pollution. Air pollution significantly increases the stress on plants and animals in the urban area (Conacher Travers, 2000). Studies have shown seedlings and actively photosynthesising plants are most sensitive to increased levels of ozone and sulphur dioxide. Many acacias, banksias and eucalypts are sensitive to sulphur dioxide pollution (Bridgman *et al*, 1995). This may account for the loss of some species from bushland in polluted areas.

Climate change

Human induced climate change is a key threatening process under both the TSC Act and the EPBC Act. Temperature and rainfall play major roles in determining where individual species of plants and animals can live, grow and reproduce. The concentration of carbon dioxide in the atmosphere will add to the stresses. The identification by the Commonwealth of Australia *National Biodiversity and Climate Change Action Plan 2004-2007* of potential direct impacts of climate change on species and ecosystems includes the following:

- Reductions in the geographic range of species;
- Changes to the timing of species' lifecycles;
- Changes in population dynamics and survival;
- Changes in the location of species' habitats;
- Increases in the risk of extinction for species that are already vulnerable;
- Increased opportunity for range expansion of invasive species;
- Changes in the structure and composition of ecosystems and communities.

Climate change is also expected to exert an indirect effect by influencing the intensity and magnitude of existing stresses, such as invasive species and fire regimes, on terrestrial and aquatic biodiversity and ecosystem structures, functions and processes (*Draft NSW Biodiversity Strategy*, *2010-2015*: NSW Government, 2010).

1.4.2 Management and protection

Many of the pressures outlined above are recognised as threatening processes that require consideration / management, to protect existing and future ecological processes and improve the resilience of ecological communities, species and populations.

This may be achieved through a number of measures, including:

- Avoiding increases in urban density in sensitive locations;
- Avoiding building in locations that require clearing for human safety;
- Consolidation of remnants;
- Restoration of connectivity within the landscape;
- Regeneration/ rehabilitation of degraded habitats;
- Improving stormwater management;
- Restoration of waterways and riparian habitat;
- Careful design of recreational access to bushland;
- Consideration of fire regimes in controlled burning regimes;
- Reduced use of fossil fuel;
- Education and enforcement on misuse of bushland.

Improved protection and enhancement of native vegetation including trees, through measures such as those listed above, has a number of other benefits including:

- Direct mitigation of greenhouse emissions (likely to be even more so where the community structure is intact or restored),
- Providing shade for residents, workers and visitors in the higher summer temperatures predicted in the future;
- Regulating the temperature within structures, and reducing the need for air conditioning;
- Contribution to the unique character and aesthetics of Ku-ring-gai;
- Positive mental health of human population (presence of trees and natural areas contributes to good mental health).

This study focuses on the strategic assessment of riparian lands and biodiversity within Ku-ring-gai, and the measures that can be achieved through local land use planning.

However, these measures need to be considered, while providing at the same time for urban development. The complexity and intertwining of the natural and urban environments in Ku-ring-gai significantly add to this challenge. Vegetation communities and threatened species habitat protected under state and federal laws occur within both bushland and urbanised areas of the LGA (See Section 1.3), for example:

- The NSW Scientific Committee has recognised Blue Gum High Forest (BGHF) and Sydney Turpentine Ironbark Forest (STIF) as including both good condition ecologically functioning remnants as well as urban remnant trees lacking vegetation structure. Clause 9 of the final determination for BGHF *states "highly modified relics of the community also persist as small clumps of trees without a native understorey"* and clause 3 states, *"above ground individuals of some species may be absent, but the species may be represented below ground in the soil seed banks or as dormant structures"* (NSW Scientific Committee,2007). From this definition there is no minimum area or basic composition of understorey species required and it is not necessary to have representation of species across all the ecological spectra, a selection of key structural components is sufficient.

- Clause 2 of the final determination for STIF states, *"At any one time, seeds of some species may only be present in the soil seed bank with no above-ground individuals present",* and clause 3 states *"the structure of the community was originally forest, but may now exist as woodland or as remnant trees."* (NSW Scientific Committee, 1998).

In Ku-ring-gai such remnants (of BGHF and STIF) occur frequently in the urban / garden setting.

Similarly, the steep nature of Ku-ring-gai's topographic setting has resulted in waterways and riparian areas being well integrated into the local urban landscape. These range from smaller intermittent waterways which are intensively landscaped and used as a garden feature, to larger permanent waterways which flow through bushland reserves to the major receiving waterbodies. These areas help create microclimate benefits for residents and sustain important corridors, habitat and refuges to provide for ecological diversity.

This study has been designed to assist in considering and assessing the strategic significance of these remnants and riparian lands within the landscape.

1.4.3 Community concerns

A consultation process involving 264 residents from 9 to 99 years old was undertaken for Council's *Sustainability Vision Report* (KC 2008a). Participants from all age groups emphasised the conservation of natural areas as they give Ku-ring-gai character and make it a 'sanctuary' that people come home to.

Key environmental concerns raised include the following:

- That future generations will be able to experience this same environment and fearing future loss future due to increasing urban development and population growth
- Loss of bushland and wildlife
- Climate change: (including loss of resilience through isolation and loss of genetic diversity)
- Need for tree protection, and increase in tree cover.

Community participants also identified the following as needed in the protection and management of ecological processes in Ku-ring-gai:

- Education (illegal dumping, encroachment, weed control, flora and fauna protection, water management, sustainable land management)
- More proactive restoration of BGHF
- Need for tree protection, and increase in tree cover

- Reduction in greenhouse emissions, and increase in renewable energy
- Improved water management (including water conservation through water recycling, stormwater harvesting etc);
- Monitoring and reporting;
- Tighter controls and enforcement on development affecting trees and natural areas through the building approval and enforcement processes;
- The need to embed sustainability in zoning, development control plans (DCPs), orders and regulations.

It is evident that many of the concerns and management responses identified by the community mirror those identified within the literature. This study will provide more specific guidance on these responses.

2 Assessment of riparian lands

Riparian is a term that refers to land adjoining a river or waterway. Riparian lands were assessed for waterways where they were determined to fall within the definition of a 'river' under the *Water Management Act 2000* or where they are considered important for the provision of ecosystem services for the catchment and adjoining waterways.

For the purposes of this report the term 'Riparian Land' includes land adjoining and including a waterway.

2.1 NSW Water Management Act

The NSW *Water Management Act 2000* is the main piece of legislation to protect rivers (see definition below) in NSW. This Act controls a variety of development and water sharing activities that are undertaken in, on, under and adjacent to rivers. The objectives of this Act are to:

> *"provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular:*
> - *to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and*
> - *to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna"*

Under the *Water Management Act 2000* provision to control development around rivers is established through the requirement to obtain permission to undertake controlled activities within waterfront land.

Controlled activities consist of:

> *(a) 'the erection of a building or the carrying out of a work (within the meaning of the Environmental Planning and Assessment Act 1979), or*
> *(b) the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or*
> *(c) the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or*
> *(d) the carrying out of any other activity that affects the quantity or flow of water in a water source.'*

waterfront land means:

> *'the bed of any river, together with any land lying between the bed of the river [or lake or estuary] and ... the prescribed distance inland of, the highest bank of the river [or shore of the lake or mean high water mark of the estuary]'*
>
> The prescribed distance is 40 metres, except where the regulations prescribe a lesser distance.

Therefore to consider the location of waterfront land, it is important to define the term 'river'. NSW *Water Management Act 2000* defines 'river' as:

(a) 'any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and

(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and

(c) anything declared by the regulations to be a river, whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river.'

Essentially, any type of development works in or within 40m of a 'river' falls under the definition of a controlled activity unless exempted under Clauses 38, 39 and 40 of the *Water Management (General) Regulation*, *2011*.

It is clear from this definition of a 'river' that a variety of waterways (not just larger, permanent flowing rivers) are intended to be protected. In addition to the information provided above, evidence which is often used to define wether a waterway falls under the 'river' definition includes:

- Clearly defined bed and bank structure
- Fluvial erosion or depositional features
- Clearly definable flow regime (where traditional bed and bank structure is not present)
- Presence of aquatic/riparian flora and fauna species (native or exotic);
- Local geomorphology
- Catchment size, and
- Evidence from rainfall and climate patterns.

It is also important to note that the definition for 'river' includes natural channels that have been 'artificially improved'. This includes waterways that have previously been re-aligned or piped for the purposes of flood or disease control. The majority of waterways within urban areas fall within the definition of "artificially improved" channels as they have been incorporated into the local stormwater conveyance system. This is particularly relevant within Ku-ring-gai.

2.2 Riparian lands mapping

Establishment of riparian corridors around rivers and watercourses is a major control used by the NSW Office of Water when determining controlled activity approvals (see above) and this approach has been adopted by Ku-ring-gai Council.

In 2004 Ku-ring-gai Council's riparian policy was developed to help guide sustainable development around waterways, including those where a controlled activity approval is not required. The Policy aims to prevent further decline of waterway ecological condition through halting and reversing the negative impact of development on riparian systems.

Riparian mapping was originally completed for the Ku-ring-gai Council Riparian Policy in 2004 based on classifications developed by the Department of Infrastructure Planning and Natural Resources (DIPNR) (DIPNR, 2004). The main categories and objectives of the riparian policy have previously been incorporated into Council's DCP 47 – Water Management (KC 2005).

The mapping identifies the location and extent of the riparian lands, according to three determined categories:

1 - 'Environmental corridor',
2 - 'Terrestrial and aquatic habitat',
3 - 'Channel stability and water quality'.

These categories define the core functions as well as the current and predicted environmental significance (DIPNR 2004). A variation of Category 3 was formally included in the Ku-ring-gai LEP (Local Centres) 2012, to identify discontinuous, poorly defined and piped channels. This variation is carried through in this study and is identified on the map at *Appendix D Riparian Lands within the Ku-ring-gai LGA* as Category 3a.

Appendix D Riparian Lands within the Ku-ring-gai LGA, identifies the Riparian Lands within the LGA.

Each category establishes a 'Core Riparian Zone' (CRZ) with a set distance where appropriate structurally diverse vegetation of local provenance is encouraged. Core Riparian Zones are also required for works undertaken under the *Water Management Act 2000*. The NSW Office of Water (NOW) "Guidelines for Controlled Activities – Riparian Corridors" (NOW, 2011), provides the following definition:

> *"The core riparian zone (CRZ) is the land contained within and adjacent to the channel. The CRZ should be retained, or revegetated with fully structured native vegetation (including groundcovers, shrubs and trees). The width of the CRZ from the banks of the stream is determined by assessing the importance and riparian functionality of the watercourse, ...merits of the site and long-term land use. Infrastructure such as roads, drainage, stormwater structures, services, etc should not be located within a CRZ."*

The NOW guidelines provide recommended CRZ widths according to the stream order (Strahler 1952) of the waterway and also include provision for adjusting the recommended widths based on a merit assessment of site specific features (NOW, 2011).

The riparian width categories within Council's mapping are based on classifications developed in the DIPNR's *Riparian Corridor Management Study* (DIPNR, 2004). This approach recognises that a classification based on stream order is not always relevant in Ku-ring-gai's highly modified environment (see section 2.2.1) and that a strategic mapping approach reflecting the environmental significance of waterways from a catchment perspective is important.

The Core Riparian Zone is measured from the distance from the top of each bank or, in the case of category 3a, the centre line.

- Category 1 40 metres;
- Category 2, 20 metres;
- Category 3, 10 metres ; and
- Category 3a, 10 metres from the centreline.

Category 1 and 2 areas have an additional 10m vegetated buffer to protect the CRZ from development. This additional vegetated area is established to protect the integrity of the CRZ by providing a buffer to weed invasion, micro-climate changes, litter, trampling, pollution and bushfire management requirements.

2.2.1 Mapping and categorisation process

The mapping, categorisation and rationale for Riparian Lands has followed the investigations and approach developed by the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR, 2004). The mapping process has included a desktop study, data audit, expert workshop (including Council staff, Macquarie University and DIPNR), and site field validation.

Waterways and their riparian corridors were classified into the three categories based on:

- The width and continuity of vegetated riparian corridors;
- The connectivity between riparian vegetation and formal reserves (for example linking Council bushland reserves and adjoining National Parks);
- The continuity of open / natural stream channels;
- Relative length and location sequence of piped sections;
- Current and likely future housing and other development under current land use zoning;
- Potential for riparian corridor maintenance, re-instatement or restoration;
- Aquatic ecosystem condition;
- Native vegetation condition, as reflected by the presence and density of weeds;
- Habitat value; and
- Presence of threatened species, populations or plant communities.

When assigning categories, consideration was given to the potential for establishment of environmental corridors, particularly those that maintain or re-create biodiversity corridors between large bushland remnants such as Lane Cove River, Garigal and Ku-ring-gai Chase National Parks and other significant reserves within the urban area (such as Sheldon Forest and Dalrymple Hay Nature Reserve).

Validation of Riparian Lands within local centre areas was undertaken in 2008, including field assessment of relevant lots to refine the mapping of waterways and identify areas of piped and non piped waterways. This was completed using the best topographic information available at the time (being 2m and 10m contours). The integration of the local centres mapping with the wider mapping for the LGA to create a single map for the Draft Biodiversity, Riparian and Heritage Local Environmental Plan (BRHLEP) has provided a further opportunity to refine the riparian mapping within local centres. This was undertaken using LiDAR derived 0.5m contour information and updated aerial photos during October – November 2011.

Validation of mapping for areas of Ku-ring-gai outside local centres was undertaken from June 2010 – January 2011. This update included utilisation of LiDAR derived 0.5m contours, updated drainage information and more thorough field validation including GPS location at strategic points.

As outlined at the beginning of this Section, Riparian Lands were mapped for waterways, which were determined to fall within the definition of a 'river' under the *Water Management Act, 2000* or which are considered important for the provision of ecosystem services for the catchment and adjoining waterways. The latter is the case particularly for waterway reaches that have small contributing catchments.

In practical terms, mapping of waterways included areas that:

- Follow natural linear depressions as indicated by the contours (i.e. are in an appropriate geomorphic setting);
- Have sufficient catchment size to enable sufficient runoff to form an identifiable channel and/or channel features (tanking into account the area's high rainfall);
- Have a definable channel and/or known flow regime;

- Demonstrate fluvial features; or
- Have aquatic/riparian flora or fauna species present.

In Ku-ring-gai this includes a range of waterways. This represents a spectrum from fully functioning riparian corridors to those that are confined to easements, that may have been channelised, rip-rapped, concrete lined, previously piped, or have a number of stormwater pipes connected to them. Identified waterways were mapped and categorised with the most appropriate riparian category. However, the total restoration of fully functioning watercourses and riparian areas is not always practical and from a strategic approach, objectives may be more appropriately targeted to include rehabilitation or remediation to protect or enhance the ecological processes.

A number of important criteria were set up to ensure that identification and categorisation of waterways were consistent across the mapped area. Generally, categories have been allocated to achieve maximum environmental outcomes with due consideration given to the existing planning and development context. For example a number of category 2 Riparian Lands identified in the 2004 map have been revised to category 3 Riparian Lands to more accurately reflect the constraints of existing development. A list of working criteria and guidelines that were applied during the process of mapping and categorising waterways is listed below:

- Waterways are mapped as far upstream as they continue to show evidence of river features and function. If piped, category 3a waterways are mapped as commencing at a point in the catchment that would have sufficient runoff to form an identifiable channel and/or channel features;
- When assigning categories, priority is given to the degree to which a riparian corridor meets or has potential to meet the environmental objectives of that category, with the current core riparian zone (CRZ) width noted as a secondary consideration. In this way, a corridor in good ecological condition that provides significant terrestrial and aquatic habitat, yet is only 15 m wide, will be classed as category 2 not category 3;
- Categories are not changed for small pinch points, but are adjusted for larger areas of development (two or more consecutive lots);
- Piped waterways assigned to category 3a are mapped to follow pipes and easements as long as these features broadly follow the natural contour depressions on the landscape;
- Driveway crossings are not mapped as category 3a if they are piped: they are treated as a pinch point and the category remains unchanged;
- Where the buffer is uneven on opposite banks the category reflects the larger of the two buffers to conserve the more significant vegetation;
- Riparian corridors through open space reflect the primary purpose of the space (eg. a category 1 corridor is not placed through a golf course unless a fully structured riparian zone is already present).
- Environmental objectives are considered in an integrated manner with practical planning constraints, for example:
    - core riparian zone buffers are considered in regard to existing development
    - waterways within drainage easements are mapped where they are within close proximity to topographic drainage lines
    - piped (3a) tributaries are left unmapped where there is no possibility of reinstatement of a natural watercourse . Such circumstances include where:
        - the area is already highly developed;
        - roads have been established along the natural drainage line and it is now piped; and
        - the drainage trajectory has been significantly altered.

  However, where there is a section of open channel upstream from piped sections which are significantly altered, these sections are mapped as category 3a to maintain connectivity throughout the catchment.

This validation process has greatly improved the quality of Council's map of riparian lands and has improved the clarity of management objectives that apply to these areas.

Limitations of Riparian Lands mapping

There are a number of limitations in the riparian mapping that should be taken into account when the mapping is considered, including:

- Significant effort was made to groundtruth waterway centrelines wherever possible, however not all areas were accessible or prioritised for site inspection. Thus there is still reliance on desk-top evidence in many areas and all mapping should be groundtruthed when works are proposed.

- Riparian lands have been mapped through a desktop measurement from the approximate centreline of the waterway.
    - This is due to the difficulty in determining the top of bank without site based survey. The top of bank should be groundtruthed when works are proposed
    - Note: along much of Middle Harbour the Riparian land has been mapped from the edge of the Council boundary/high tide. This is to ensure a better indication of the buffer as measured from the top of bank.

- Ends of Riparian lands have been 'clipped' to reflect land use and drainage characteristics but the edges of Riparian lands have not.
    - This is because a change in category is often defined by certain land uses or drainage characteristics and is clearly distinct (e.g. piped reach to open bushland),
    - Where there is not enough information to determine the exact position of where a watercourse starts, the ends of mapped Riparian lands have been rounded to indicate this potential variability.
    - Riparian lands have not been clipped at changes in land use along their length to ensure consistency in mapping of the categories. Where there are significant changes in land use along the length of identified riparian land, such as a road or a change from bushland to residential areas, a merit assessment would be required to assess any proposal for these areas.
    - As outlined above, the riparian lands mapping applies a category to a waterway according to the largest available buffer from the top of either bank of the channel. Waterways were not given separate categories for each bank. Where there is an uneven corridor around a channel it is was treated as a pinch point. For example, where there is a waterway that has development 10m from the top of the bank on one side, but a full 20-30m vegetated corridor on the other side it is categorised as Category 2 with a 20m CRZ in order to protect the intact side of the corridor.

3 Assessment of biodiversity

This section outlines mapping and assessment relating to the identification, management and protection of biodiversity within Ku-ring-gai.

A data audit of relevant information has been undertaken, including:

- Ku-ring-gai Residential Development Strategy: Environmental Baseline Study, for Ku-ring-gai Municipal Council (Conacher Travers, 2000).
- Mapping, plans, reports, strategies and polices outlined within this section and Section 1.2.

3.1 Key Vegetation Community mapping

Mapping of Key Vegetation Communities within the Ku-ring-gai Local Government Area (LGA) has been undertaken by multiple agencies, over numerous years, extents and at varying resolutions. In the past, inaccuracies have been identified, especially in regard to a number of our threatened ecological communities, such as the Blue Gum High Forest and Sydney Turpentine-Ironbark Forest (NSW NPWS 2000). In an effort to amend these inaccuracies, in 2007, Ku-ring-gai Council embarked on a project to identify, map and assess Key Vegetation Communities (KVCs) in a manner that will enable us to better monitor and protect these areas.

The project titled *Mapping and assessment of key vegetation communities across the Ku-ring-gai local government area* (Ku-ring-gai Council 2012a and 2012b), included the following key aims:

- Identify and assess vegetation communities listed under the *NSW Threatened Species Conservation Act 1995*, or the *Environment Protection and Biodiversity Conservation Act 1999,* across the LGA.
- Map key vegetation communities at a scale of 1:2000, including field validation on public and private lands, with the exception of:
    - Lands owned by the Office of Environment and Heritage (OEH); and
    - Lands within alluvial and estuarine areas (Allen at al. 2007, West and Williams 2008, *Kelleway et al* 2007).

The method used for this project was adapted and refined as a result of input from key stakeholders. The project aimed to integrate computer generated canopy mapping, with field based rapid surveys of key vegetation communities and aerial photographic interpretation (API). A limited number of systematic field control plots were also incorporated (undertaken within this project and previous surveys). The methodology provides a transparent, LGA wide methodology for assessing key vegetation communities.

Mapping of the Sydney Metropolitan Catchment is currently being undertaken by OEH on behalf of the Sydney Metropolitan Catchment Management Authority (SMCMA) (DECCW 2009). On going consultation and data sharing with OEH has been undertaken. The DECCW (2009) mapping is currently draft with future consultation and data sharing planned (particularly relating to Duffys Forest and Coastal Shale Sandstone Forest). Further information on DECCW mapping is available at: http://www.sydney.cma.nsw.gov.au/our-projects/vegetation-mapping.html (accessed 10 November 2011)

The Ku-ring-gai key vegetation community mapping classifies individual trees down to community level, rather than the broad "urban vegetation" category used by DECCW (2009), and involves more intensive field validation than other publicly available products. A vegetation condition category was also applied (See Appendix B).

This level of detail enables Council to determine the location, condition and importance of key vegetation communities, and identify areas of regional and local connectivity value. Providing a mechanism assist in reducing development and management impacts on threatened ecological communities and other biodiversity values.

Alluvial and estuarine areas mapped by DECCW (2009) have also been integrated to the Ku-ring-gai vegetation mapping.

Limitations relating to the mapping are described within detailed vegetation mapping reports (Ku-ring-gai Council 2013a and 2013b).

3.2 Flora and fauna assessment

3.2.1 Regional Fauna Habitat assessment by CMAs

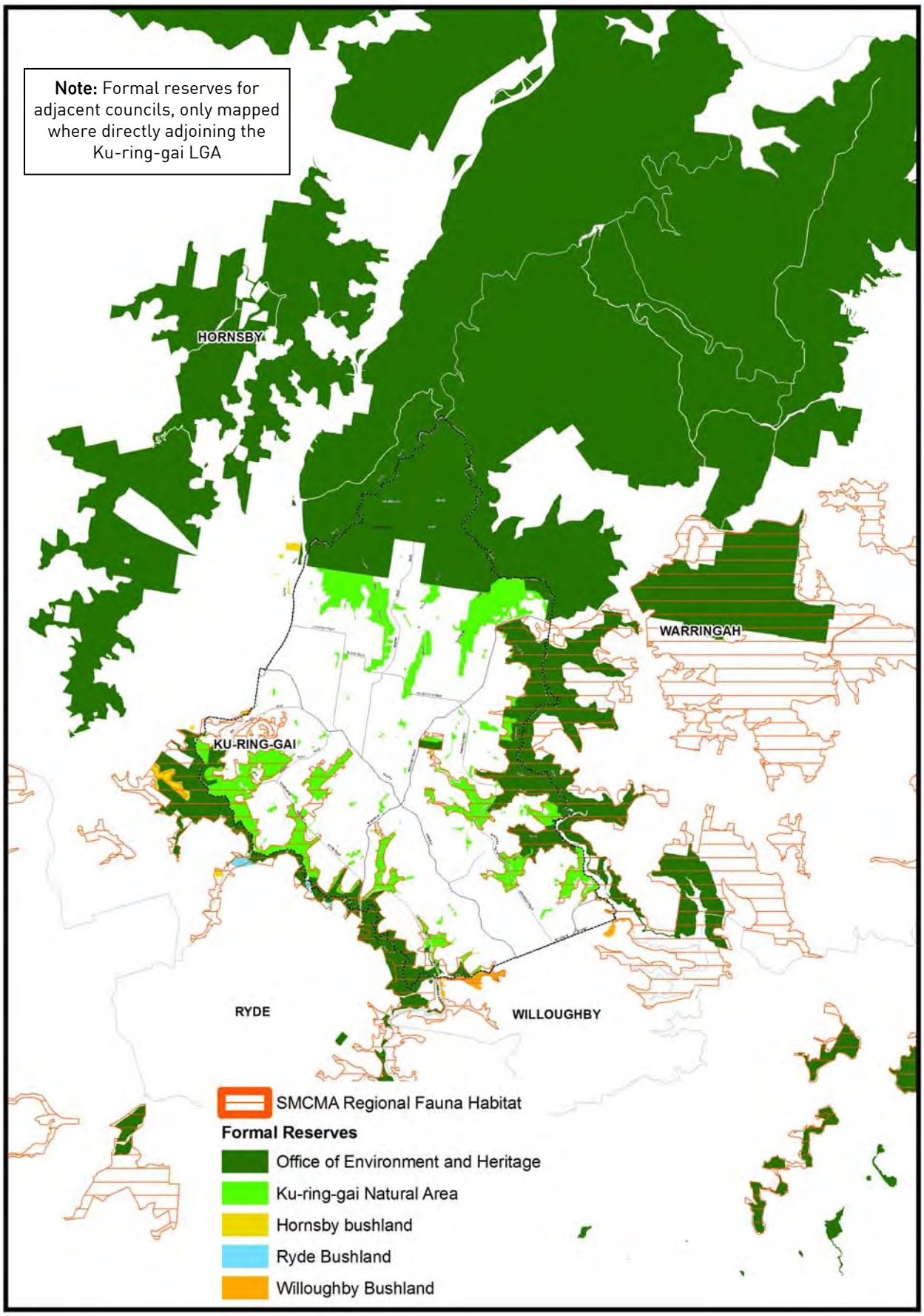
Southern Sydney Region and Sydney Metropolitan Catchment Management Authority Area
A rapid fauna habitat assessment has been undertaken for the Sydney Metropolitan Catchment Management Authority (SMCMA) Area (DECC 2008c) (See Figure 2). Providing a catchment wide assessment of remnant vegetation value for native fauna conservation and a priority ranking for larger sites; the study enables identification of fauna habitats of significant regional value (including 'Regional Fauna Habitat and corridors') and 'core habitat' stepping stones located within the urban matrix.

A study of the habitat and distribution of native and introduced animals in the Greater Southern Sydney Region was also undertaken between 2002 and 2007 by the Sydney Catchment Authority (SCA) and DEC (DECC, 2007b). This study partially covered the SMCMA and HNCMA area (south and west of Ku-ring-gai LGA) and looked specifically at the habitat and distribution of animals of conservation priority and pest animals.

Hawkesbury-Nepean Catchment Management Authority Area
Rapid assessment of biodiversity within the Hawkesbury-Nepean Catchment was also undertaken by the Hawkesbury-Nepean Catchment Management Authority (HNCMA) (HNCMA, 2008). This involved identifying a network of regional corridors to connect areas of priority habitat and reserved lands in the catchment. No regional corridors or priority habitats were identified within or adjacent to the Ku-ring-gai LGA. Reserved lands in the Ku-ring-gai LGA were recognised by the HNCMA (2008) as habitat areas. This includes parts of Ku-ring-gai Chase National Park and is supported by Ku-ring-gai Council mapping (See Figure 3).

The HNCMA (2008) recognise that more fauna corridors and priority habitats may exist but due to a paucity of information the corridors and priority habitat have been mapped from a more regional perspective. These broader scale corridors follow contiguous native vegetation and form links between habitats currently managed for conservation.

Figure 2: Formal Reserves and Fauna Habitat – Regional Perspective



Source: SMCMA Regional Fauna Habitat (DECC 2008c), Office of Environment and Heritage 2011, Ku-ring-gai Council 2011, Hornsby Council 2010, Willoughby Council 2010, UBD 2010

3.2.2 Ku-ring-gai flora and fauna assessment

An assessment of available flora and fauna data has been undertaken to identify local flora and fauna habitat patterns and core habitat areas within Ku-ring-gai. This assessment provides base line information to inform future flora and fauna research and facilitates effective management and protection of key habitat areas. The assessment included biodiversity hotspot mapping, fauna data analysis and a review of Biobase (Council's flora and fauna data base - incorporating consultants' reports, NSW Wildlife Atlas, sightings by Council staff and the community), and information contained within Council's vegetation mapping (see Section 3.1 and KC 2009), .

Field validation of known flora records within Council managed lands was undertaken in 2007 to validate plant location and condition.

Biodiversity hotspots

Biodiversity hotspots are defined for the purposes of this study as locations where multiple threatened species are recorded. Multiple threatened species are considered to be two or more flora species or three or more fauna species within a 300m (approximate) radius.

Within the LGA biodiversity hotspots were identified by analysing threatened species records, limited to observations:

- recorded after 1980;
- with a 1km accuracy;
- where the source is a government agency or ecological consultant (to ensure reliability).

It is important that areas supporting multiple threatened species, termed biodiversity hotspots, are protected. It was found that most biodiversity hotspots in Ku-ring-gai are located in National Parks or Ku-ring-gai Natural Areas and are therefore offered higher levels of protection.

Fauna data analysis

As part of Council's ongoing fauna management program, Council has commissioned (since 1998) a number of fauna surveys and analysis on land within Council's control (Refer to Appendix A for survey and analysis details). The 2001 fauna surveys and assessment identified that the Cowan Creek and Middle Harbour catchments support a greater number of native fauna species than the Lane Cove River catchment (Smith and Smith, 2001). This is supported by further fauna surveys in 2003-2005 (Smith and Smith, 2005; Smith and Smith, 2004; Smith and Smith, 2003).

Fauna studies also conclude that there is a lower abundance of fauna sensitive to disturbance in the Lane Cove Valley. This is thought to be due to the lack of bushland connectivity and the impediments to fauna movement in the Lane Cove River Catchment (Connell Wagner, 2002). The occurrence of species sensitive to disturbance within bushland in the east of the LGA, demonstrates better habitat connectivity.

While most flora and fauna in Ku-ring-gai, especially threatened species, are found in bushland, urban trees and exotic vegetation also provide significant habitat for fauna. For example the Ku-ring-gai 2002 fauna assessment (Connell Wagner, 2002) acknowledges the use of urban vegetation by Grey-headed flying foxes (*Pteropus poliocephalus*). Several species will utilise vegetation remnants in urban areas to travel between larger areas of bushland habitat.

Visual analysis of Biobase records

A visual analysis of Biobase records (Council's flora and fauna database), for threatened species and populations was undertaken to determine known distribution patterns, evidence of urban habitat use and existing population fragmentation within the LGA. Records were limited as per biodiversity hotspot analysis (above).

3.3 Regional and Local Fauna Habitat

3.3.1 Background

Healthy native fauna are required for functioning ecosystems, providing vital ecosystem services influencing biodiversity, including pollination and nutrient cycling (HNCMA, 2008). As previously described in Section 1.4.1, habitat loss, predation and competition by introduced species are leading to declining population and distribution of threatened and non-threatened fauna (HNCMA, 2008). Adequate conservation of ecosystem services and biodiversity over long time-frames requires protection of ecological processes as well as high quality habitats.

The NSW Department of Environment and Climate Change considers that 'areas supporting high vertebrate fauna species diversity are also likely to be complex, diverse, functioning environments that have, at least in part, escaped the myriad of threatening processes acting on natural ecosystems' (DECC 2008c). Vertebrate fauna species are particularly sensitive to habitat disturbance and local extinction is often the result.

Large connected areas of bushland (core areas) are required to support threatened and non-threatened fauna populations (including national, state and regionally significant species). For the purposes of this study regionally important areas are considered to be Regional Fauna Habitats (See Figure 3). These include both native and non native vegetation with structure. The presence of weeds and non natives still provide an ecological service through the creation of habitat, food resources, soil stability and connectivity.

Fauna habitat is also provided by core isolated remnants located more centrally in the LGA, for example areas adjoining Wombin Reserve. Within this study these areas of local significance are included within either Ku-ring-gai Natural Areas or private / public lands not reserved for conservation (See Figure 3).

By recognising and seeking to protect areas of Regional and Local Fauna Habitat, Ku-ring-gai Council intends to support the role of native fauna in the ecosystem, facilitating their continued survival, as well as preserving their social and cultural importance for the community.

Ecological principles underlying the identification of land as regional and local fauna habitats include the recognition of habitats:

- with the highest relative biodiversity values;
- that are likely to support the highest population densities of fauna;
- that strengthen population viability through important landscape or habitat connectivity features (as supported through biodiversity corridors, Section 4.2);
- with consideration of the effect of reserve size on fauna conservation and biodiversity;
- occurring along environmental gradients (for instance rainfall, temperature, altitude and soil type);
- located across land tenures. Although fauna habitat is primarily located within formal reserves, other private and public lands may have an equally important role in sustaining the regional viability of biodiversity by enhancing habitat characteristics and total size.

  Regional and local fauna habitat within Ku-ring-gai and the broader Sydney Metropolitan Catchment Management Area (DECC 2008c), includes formal reserves and lands owned by local Councils, the Crown, OEH, as well as other public authorities and private landholders.

  Publicly owned Regional and Local Fauna Habitat is not necessarily designated for conservation purposes. Land in Ku-ring-gai owned by public agencies such as the Roads and Traffic Authority and the Department of Planning is considered to be Regional Fauna Habitat if it contains native vegetation communities with structural complexity and meets the criteria listed above.

3.3.2 Context of Regional Fauna Habitat in Ku-ring-gai

The Ku-ring-gai LGA is bordered by bushland in formal reserves (including National Parks and Council Natural Areas) in the northern, eastern and south-western directions (See Figure 2 and Figure 2). This bushland is continuous with adjoining bushland owned by OEH, Hornsby, Willoughby and Ryde Councils. Strips of remnant vegetation extend from these Formal Reserves into urbanised areas of the LGA (See Figure 3). The National Parks, Natural Areas and connected remnants provide the core habitat for Ku-ring-gai's fauna.

Three key areas of regional fauna habitat have been identified:

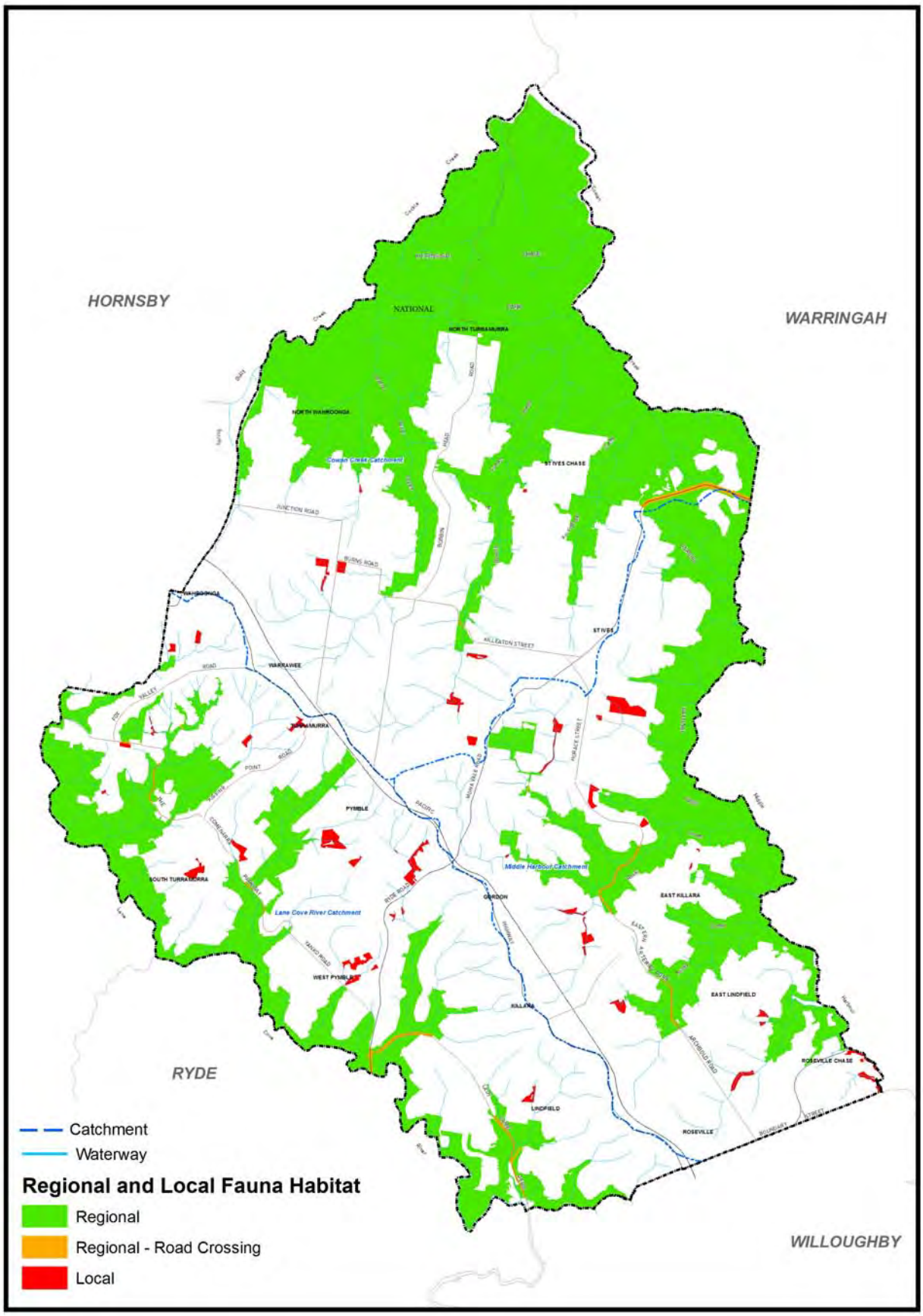
1. Regional Fauna Habitat within the Cowan Creek catchment is located at the north of the LGA and adjoins Ku-ring-gai Chase National Park. There are 23 threatened fauna species found in this area including the Red-crowned toadlet, powerful owl, grey-headed flying fox, glossy black cockatoo (*Calyptorhynchus lathami)* and the Southern brown bandicoot (*Isoodon obesulus*)(BIObase, October 2010). Fauna studies commissioned by Ku-ring-gai Council between 2001 and 2005 have found that this area has the highest native species diversity recorded out of the three catchments (Smith and Smith, 2005).

2. Habitat within the Middle Harbour Valley (including sections of Garigal National Park and areas beyond the Middle Harbour Catchment within Ku-ring-gai LGA), is categorised by DECC (2008c) as having 'Highest Fauna Values'. This habitat is comprised of sections of Garigal National Park as well as connected lands that have good vegetation structure, for example Dalrymple Hay Nature Reserve. DECC (2008c) recognise that Middle Harbour supports moderate amounts of priority fauna habitat (covering 5-50% of Middle Harbour Valley). Three endangered and 14 vulnerable species have been recorded in Middle Harbour Valley, including the Rosenberg's goanna (*Varanus rosenbergi)* and the Grey-headed flying fox colony (located at Ku-ring-gai Flying Fox Forest Reserve, Gordon) (DECC, 2008c). DECC advocated protecting colony sites as these are vital to the conservation of flying foxes (DECC, 2007a).

3. The Lane Cove Valley is considered to have very high fauna values' (DECC, 2008c). This regional fauna habitat is made up of parts of the Lane Cove National Park and connected lands that have good vegetation structure including Sheldon Forest and Troon Creek Natural Areas. It also includes areas beyond the Lane Cove River Catchment in Ku-ring-gai LGA. DECC (2008c) recognise that Lane Cove valley supports moderate amounts of priority fauna habitat (covering 5-50% of Lane Cove valley). The Lane Cove valley regional Fauna Habitat is know to provided habitat for 231 vertebrate fauna species (DECC, 2008c). Of these one endangered and nine vulnerable species and part of one endangered population are found in this area, including the threatened Powerful owl, Barking owl (*Ninox connivens*), Red-crowned Toadlet and Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis)* (DECC, 2008c).

For further information on fauna within these catchments refer to Appendix A.

Figure 3: Ku-ring-gai Regional and Local Fauna Habitat



2.5.3 Factors considered in Identifying Regional and Local Fauna Habitat

Habitat diversity

Regional and local fauna habitats identified within the LGA are designed to cross a number of environmental gradients including rainfall, temperature, altitude and soil type. This contributes to diversity in vegetation communities which range from mangroves and salt marsh to sandstone and clay influenced environments (see Section 1.3). Each of these communities provides a range of habitat types influencing flora and fauna assemblages. Many species require specific habitat requirements and their persistence is dependant on habitat characteristics being maintained. For example:

- The vulnerable Red-crowned Toadlet inhabits ridgetops in open woodland and heath communities typical of Hawkesbury sandstone geology (characterised by of sandstone ridge and hillside habitats), usually at altitudes less than 200m (DECCW 2001, Smith and Smith 2001). Other habitat attributes required for this vulnerable species include proximity to an ephemeral watersource, typically at the headwaters, and sandstone outcrops (Thumm, 1997).
- The Powerful owl is predominantly recorded in forested gullies with large watercourses (Kavanagh, 2004). Hollow bearing trees are required by Powerful owls for nesting and roosting and are also used by arboreal marsupials which are the owl's main prey (DEC, 2006). A tall, dense shrub layer is preferred at Powerful owl roosting sites as it provides protection for fledglings (DEC, 2006). The species is known to inhabit suburban riparian areas, especially where they adjoin National Parks or reserves with extensive bushland (Kavanagh, 2004, Supported through BIObase records as searched in October 2010).

Regional and local fauna habitat should also link areas of similar habitat to allow fauna to migrate to areas of acceptable habitat when required, for example in times of bushfire (HNCMA, 2008).

Habitat size, fragmentation and effects

In addition to habitat diversity, the size and shape of fauna habitat is also important (See Figure 4 for Ku-ring-gai Formal Reserve patch size analysis). Drinnan (2005) identifies remnant size as being the most significant predictor of species richness. His studies suggest that thresholds exist for remnant size, for example under 4ha the diversity of frogs and birds in a reserve severely declines and at less than 2ha plant and fungal species diversity rapidly declines (Drinnan, 2005). The same study investigated the size of bushland reserves in southern Sydney and found that forest birds only became dominant over urban birds once reserve size exceeded 50ha Drinnan (2005). Suggesting that connecting habitat areas that exceed 40ha (and in many cases 100ha) ensures that regional fauna habitat accommodates shy species that prefer forest habitats free from edge effects as well as urban adapted species (Drinnan, 2005).

The purpose of Local Fauna Habitat areas are to provide stepping stones connections between larger protected areas (including regional fauna habitats and Ku-ring-gai Natural Areas). This connection may be direct or through Biodiversity Corridors (see Section 4.1). Local Fauna Habitats also contribute to the total habitat area available to fauna species.

Many local fauna habitat areas are comprised of native vegetation communities with structural complexity, including threatened ecological communities.

The *Australian Biodiversity Conservation Strategy (2010-2030)* (NRMMC, 2010) acknowledges that fragmentation, associated habitat loss and population isolation, impede the ability of plants and animals to tolerate external pressures. In urban environment such as Ku-ring-gai there has been extensive habitat removal and fragmentation, reducing habitat size and heavily impacting biodiversity. For example, Blue Gum High Forest remnants are highly fragmented, with less than 5% of the original area remaining (NSW Scientific Committee, 2008; Smith and Smith, 2001). Ku-ring-gai fauna surveys in Blue Gum High Forest demonstrate that fauna in these remnants is

depauperate and there are much lower proportions of species which are intolerant to urban environments compared to less fragmented habitats (Smith and Smith, 2001; Smith and Smith, 2005). Even species commonly found in other bushland in Ku-ring-gai were not recorded in these disconnected sites - most of the species recorded in Blue Gum High Forest are those typically found in urban habitats (Smith and Smith, 2001).

Habitat removal and fragmentation in Ku-ring-gai results in reduced habitat size and heavily impacts biodiversity. Ku-ring-gai contains fauna with a range of responses to habitat fragmentation (as broadly defined by Drinnan 2005):

- 'Urban' adapted species, such as the Eastern Water Skink and the Grey-headed Flying Fox, and birds (See Appendix A for urban bird list), are those which will use habitat in urban environments;
- 'Edge' species which will inhabit the bushland/urban interface, such as the Sugar glider (*Petaurus breviceps*) and Satin bowerbird (*Ptilonorhynchus violaceus);*
- 'Forest interior' species which are shy and unlikely to travel through, or inhabit, disturbed areas. This last group, which includes the Southern brown bandicoot and Heath monitor (*Varanus rosenbergi*), are most affected by habitat fragmentation.

In determining Regional Fauna Habitat, provision of habitat for forest interior species is particularly important. Drinnan (2005) reports that once reserve size exceeds 50ha, species less tolerant of fragmentation increase in number. The regional fauna habitat mapping provides for forest interior species, especially in the large bushland reserves adjoining the Ku-ring-gai Chase, Garigal and Lane Cove River National Parks, for example connectivity between Lovers Jump Creek Reserve and Ku-ring-gai Chase National Park is maintained. Urban and edge fauna may be more abundant in the narrower sections of Regional Fauna Habitat such as that between Ku-ring-gai Flying Fox Reserve and Richmond Park.

While some species are recorded as inhabiting, foraging and reproducing in urban and edge environments, evidence exists that these may not be optimal habitats. Hoye and Spence (2004) recognise that even though the Large Bent-wing Bat (*Miniopterus schreibersii*) roosts in urban environments in Ku-ring-gai (including caves and stormwater channels, disused buildings etc), the urban populations suffer more injury and signs of stress compared to roosts unaffected by urban environments (Hoye and Spence, 2004). It is important to ensure that remaining vegetation is protected so that high value habitat does not diminish.

Through appropriate planning and management of urban areas, habitat quality and viability may be improved. One example of this is the potential for improved habitat through the provision of a connected area of non illuminated habitat (as provided by Riparian Lands and some Biodiversity Corridors). Leaving unlit paths for nocturnal bats to commute and roost within can protect them from isolation, reducing foraging pressures and increasing both animal and population fitness (Jones 2000, Stone et al 2009, Boldogh et al 2007). This is particularly important for slower-flying bat species[2] that (unlike faster flying species) do not utilise artificial light areas for foraging, due to a reduced ability to avoid predators (Longcore & Rich 2004). Pressure upon these species is further increased by competitive pressures from faster flying species that do use these resources (Blake et al 1994, cited in Longcore & Rich 2004).

It is also important that the value of smaller habitat patches be recognised. Although large reserves provide the necessary backbone of successful conservation, small patches form part of the greater habitat mosaic and add important complementary value to large patches. Dispersal through the landscape is facilitated by small patches which act as stepping stones for mobile species. Species differ in their response to habitat fragmentation and not all species are reliant

[2] Within Ku-ring-gai this includes species such as the Lesser Long-eared Bat (*Nyctophilus geoffroyi)*, Eastern Horsehoe Bat *(Rhinolophus megaphyllus).*

on large patches. Small, isolated patches may be particularly important for native invertebrates. Mobile organisms may actively choose to occupy small patches rather than large ones, particularly when small patches of remnant vegetation provide important resources that may be rare or absent from larger patches. For example, parrots may nest in patches as small as single trees providing that a suitable hollow is available.

Protection across tenure

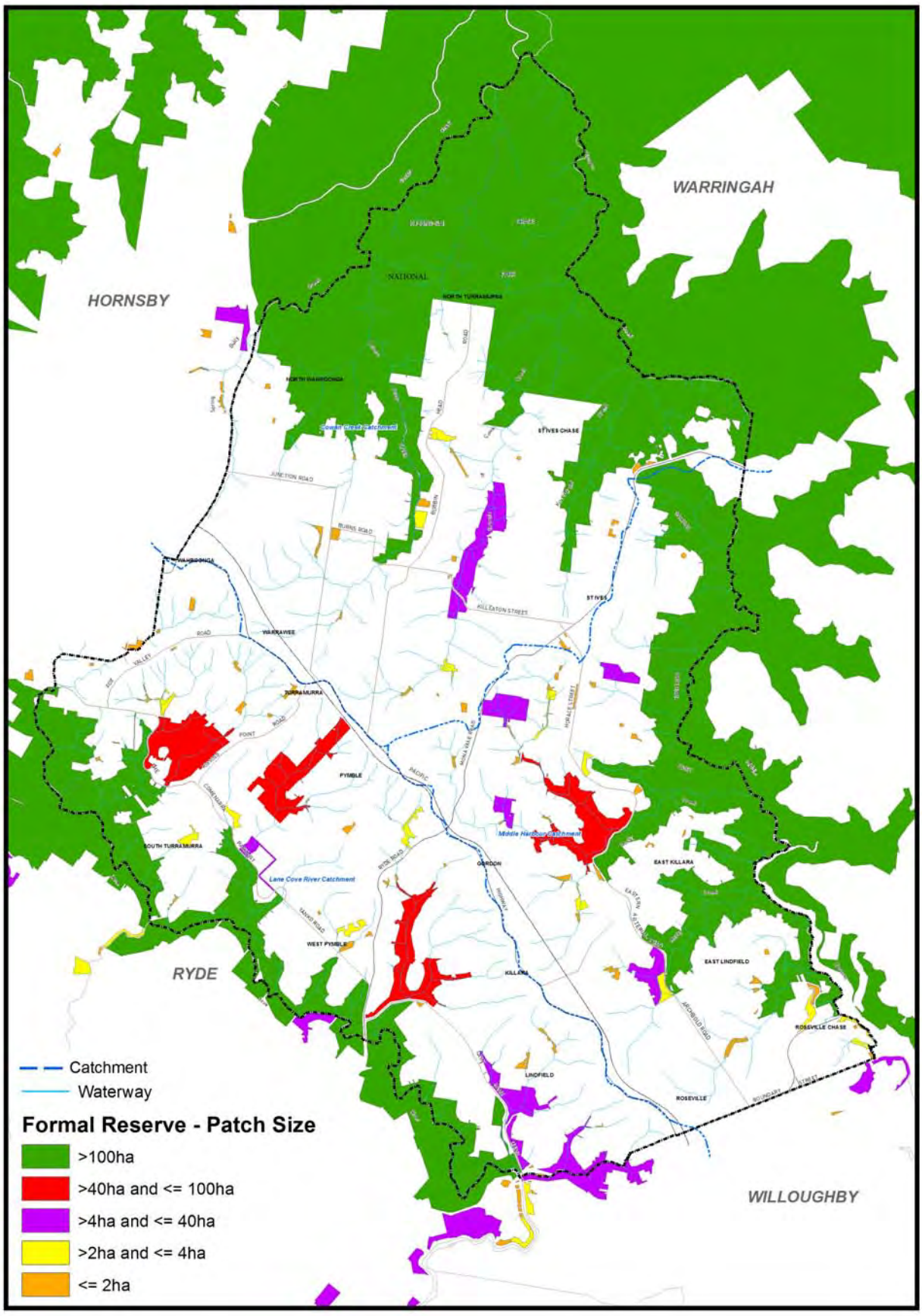
Private land that abuts bushland can also provide habitat for native fauna, even for 'forest interior' species (Catterall, 2004). Small bodied native birds, such as the Golden whistler (*Pachycephala pectoralis*) and Grey fantail (*Rhipidura fuliginosa)*, have been recorded in private gardens in properties adjacent to reserves in Ku-ring-gai. Maintaining the structural complexity (i.e. varying levels of vegetation height) of gardens adjoining bushland is fundamental to these species continuing to use it as habitat.

Removing fauna habitat on private lands may reduce the cumulative area available to these species and can also increase the perimeter to area ratio of fauna habitat (Catterall, 2004). Species with large home ranges or those particularly vulnerable to edge effects may be negatively impacted. For example, Kavanagh (2004) identified the ''northern leafy suburbs of Sydney' as providing habitat for the Powerful owl, which has a large home range of up to 300-1500ha (DEC, 2006). Property in close proximity to bushland was found to be particularly important in this study. Fauna surveys in Ku-ring-gai support the importance of private land for fauna with records the Long-nosed bandicoot (*Perameles nasuta*) foraging in private gardens (Smith and Smith, 2005).

While Ku-ring-gai Council acknowledges the importance of fauna habitat on private property, requirements for bushfire management through the creation of Asset Protection Zones (APZ) must also be considered. Where bushfire prone land is mapped to include areas close to private dwellings, regional and local fauna habitat mapping has been modified to facilitate the creation of an APZ between residential structures and areas to be protected as fauna habitat. It should be noted that detailed assessment of residential requirements against *Planning for Bushfire Protection* (RFS, 2006a) was not undertaken and it is acknowledged that the creation of fire mitigation measures within regional and local fauna habitat areas may still be required.

OEH and Council managed land outside the Ku-ring-gai LGA, but contiguous with Ku-ring-gai bushland, was also used to inform Regional Fauna Habitat. Where bushland is contiguous across the LGA boundary, the entire area was considered important for fauna habitat since the statutory boundaries are of no relevance to fauna migration.

Figure 4: Patch size of Formal Reserves within and surrounding Ku-ring-gai



2.5.4 Mapping methodology

Mapping of Regional and Local Fauna Habitat was based upon Bushfire Vegetation, as contained within the *Ku-ring-gai Bushfire Prone Lands Map* (created in 2008 through desktop and field analysis). Developed according to the *Guideline for Bushfire Prone Land Mapping* (RFS, 2006), Bushfire Vegetation is structured vegetation (containing canopy, shrub and understorey) within patches of the following sizes:

Bushfire Vegetation Category 1

- >1ha in size

Bushfire Vegetation Category 2

- < 1 ha, within 100m from Bush Fire Vegetation Category 1
- < 1 ha, within 30m from Bush Fire Vegetation Category 2

Bushfire Vegetation Categories 1 and 2, exclude vegetation considered to be mown or highly managed (i.e. lacking structure) or purely garden (ornamentals, exotics etc), but including both native and non-native vegetation. It is recognised that the presence of weeds and non natives still provide an ecological service through the creation of habitat, food resources, soil stability and connectivity.

Mapping also included alluvial and estuarine vegetation (foreshore areas) adjacent to Formal Reserves. Containing Mangrove Forests, Salt Marsh and other protected vegetation communities, these areas:

- Are important habitat for bats, mammals, crustaceans, fish and birds (including species of migratory birds protected under federal legislation and international treaties); providing protection, feeding and breeding habitat (Sydenham & Thomas 2003, Gonsalves et al 2009, DECC 2008).

- Provide important ecological services such as nutrient cycling, improving water quality by detention and slow release of flood water, filtering pollutants, trapping of sediments, stabilising and improving the soil and protecting shorelines from erosion (Sydenham & Thomas 2003, DECC 2010).

Regional and Local Fauna Habitat was created by incorporating alluvial and estuarine areas (as identified within Section 3.1) and Ku-ring-gai Bushfire Prone Lands Mapping (KC 2008), this was then refined in order to better reflect areas that provide regionally and locally important fauna habitat. This was undertaken through a desktop assessment at 1:2000 scale, including aerial photography interpretation [API] of 2011 and / or 2005 aerial photography and Ku-ring-gai vegetation mapping (KC, 2009).

A number of factors were considered in the identification of Regional Fauna Habitat, including whether the:

- Land contains Bushfire Vegetation Category 1
- Land contains alluvial or estuarine vegetation adjacent to Formal Reserves (connectivity of these areas was assessed from a land based perspective)
- Land contains vegetation, within, connected or adjacent to Formal Reserves (Figure 2)
- Vegetation primarily consists of native vegetation communities, with vegetation structure (canopy, shrub and understorey) as determined through API and / or vegetation mapping condition information (DECCW 2009, KC 2009).
- Vegetation is known to support threatened species and/or populations; or was assessed as providing important habitat for threatened and non-threatened fauna species. This was primarily determined through an analysis of patch size and connectivity of formal reserves

(Figure 4) and remnant vegetation; as well as results from flora and fauna analysis (see Section 3.2).
- Land is included within CMA regional habitat mapping (as addressed within Section 3.2.1, and below).

The Sydney Metropolitan Catchment Management Authority's rapid fauna habitat assessment (DECC 2008c) was also considered when delineating Regional and Local Fauna Habitat in Ku-ring-gai. Variation between Ku-ring-gai fauna habitat mapping and that identified by the SMCMA (DECC 2008c) reflect a regional-v-local mapping perspective, specifically:

- Rapid fauna habitat assessment site boundaries created at 1:25,000 scale. Within this study an audit of available fauna data was undertaken, with Ku-ring-gai being categorised as well surveyed. As such additional systematic field surveys were not undertaken within this area (DECC 2008c).

- Ku-ring-gai regional fauna habitat mapping was created at 1:2000 scale, using field validated base data (Bushfire Prone lands mapping and Ku-ring-gai vegetation mapping). As a result many small areas were excluded.

Regional Fauna Habitat within the HNCMA, was guided by Hawkesbury Nepean Catchment Action Plan (HNCMA, 2008), which identified reserved areas in the Ku-ring-gai LGA as important for fauna habitat.

The Ku-ring-gai Bushfire Prone Lands Mapping (KC 2008) was pulled back where it was in close proximity to structures on private or public land. Regional and Local Fauna Habitat mapping thus includes consideration for APZs and APZs can also be created within this land where necessary.

Whilst Ku-ring-gai Regional Fauna Habitat mapping considered habitat within adjoining LGAs, waterways of Middle Harbour and Lane Cove River were excluded (it is noted that DECC (2008c) mapping included waterways adjacent to terrestrial regional fauna habitat). Reflecting this, Regional Fauna Habitat within Ku-ring-gai's mapping excludes areas south of Roseville Bridge due to a lack of local connectivity.

Vegetation linking Dalrymple Hay Nature Reserve to Governor Phillip Reserve was included as regional fauna habitat in Ku-ring-gai [as supported by DECC (2008c), even though vegetation condition mapping revealed a narrow disturbed vegetation link.

Regional Fauna Habitat -'Road Crossings' have been incorporated (See Figure 3) to link regional fauna habitat across major, regional and collector roadways. The road crossing identifies areas that form potential barriers to fauna movement within Regional Fauna Habitat (for example Mona Vale Road St. Ives, the Regional Fauna Habitat - Road Crossing is used to identify this 1.5km road barrier).

Smaller and more isolated sites that contain continuous native vegetation, especially endangered ecological communities, were considered to be Local Fauna Habitat areas. These are areas of bushland isolated from Regional Fauna Habitat. Several of these sites are linked to Regional Fauna Habitat and/ or Formal Reserves through Riparian Lands or Biodiversity Corridors.

Sites considered to be Local Fauna Habitat include areas smaller (no minimum size was used) and more isolated sites that contain important good condition native vegetation and which:
- Contain Category 1 or Category 2 Bushfire Vegetation.
- Contain alluvial or estuarine vegetation adjacent to Formal Reserves (connectivity of these areas was assessed from a land based perspective)

- Are comprised primarily of native vegetation communities, with vegetation structure (canopy, shrub and understorey) as determined through API and / or vegetation mapping condition information (DECCW 2009, KC 2009).
- Where the vegetation is known to support threatened species and/or populations; or was assessed as providing important habitat for threatened and non-threatened fauna species. This was primarily determined through and analysis of patch size and connectivity of formal reserves (Figure 4) and remnant vegetation; as well as results from flora and fauna analysis (see Section 3.2).
- Consideration of CMA regional habitat mapping (as addressed within Section 3.2.1, and below). Areas considered too isolated as mapped at 1: 2,000 were mapped as local rather than regional habitat (eg. lands to the south of Roseville Bridge).

3.4 Biodiversity corridor mapping

3.4.1 Background

Areas providing regional connectivity are considered to be incorporated within Regional Fauna Habitat mapping (See Sections 3.2.1 & 3.3; Figure 2 and Figure 3).

A review of Regional and Local Fauna Mapping, fauna analysis, vegetation mapping and Formal Reserves within Ku-ring-gai has identified the following biodiversity connectivity shortcomings (see information with Section 3 for further details):

- Middle Harbour valley is considered to be poorly connected to surrounding bushland (DECC, 2008c). This is due to sites being linked through narrow habitat connections of modified vegetation. It is also as a result of road barriers preventing easy connection. DECC (2008c) advocate a continuous link between Middle Harbour and Cowan Creek Regional Fauna Habitat in St Ives.

- Within the LGA connections between Middle Harbour and Cowan Creek Regional Fauna Habitat is provided by Regional Fauna Habitat 'road crossings' over Mona Vale Road. These are areas that form connections between Regional Fauna Habitat over regional, main and some collector roads. Required management techniques for these areas are specific to each corridor as briefly addressed within Appendix C.

- The Lane Cove Valley bushland is not connected to adjacent protected areas or reserves (DECC 2008c). DECC (2008c) supports connecting the Lane Cove Valley with bushland in the Berowra Valley in the Hornsby LGA; however this is outside the scope of this report. The connectivity of Lane Cove Valley bushland within the Ku-ring-gai LGA is compromised by main roads, specifically Ryde Road and The Comenarra Parkway, intersecting the natural areas. Connections between habitat within Lane Cove Valley National Park and Ku-ring-gai Natural Areas and Regional Fauna Habitat is provided by Regional Fauna Habitat 'road crossings', for example across where the Comenarra Parkway divides Lower Dam Creek Reserve and Comenarra Reserve at West Pymble.

- That there is no continuous, good condition vegetation / habitat crossing the urban area of Ku-ring-gai in either a north-south or east-west direction (as supported by Cunningham, 2002). The importance of re-establishing this link was recognised by Conacher Travers (2000), by their recommendation for a broad biolinkage through the urban areas of Ku-ring-gai.

Threatened and Pest Animals of Greater Southern Sydney report (DECC, 2007b) identifies that vegetated fauna corridors are influential in the survival of many fauna species in the Greater Southern Sydney Region. Several of these species are also found in the Ku-ring-gai LGA, for example Rosenberg's goanna and the Southern brown bandicoot DECC, 2007b).

Adam (2004) argues that maximum connectivity of urban bushland in Sydney is fundamental for the survival of urban bushland. Connectivity is also important to maintain diversity and functionality in urban bushland and avoid becoming what Adam terms 'living museums' (2004).

In response to the issues raised above Biodiversity Corridors within the LGA, have been identified through desktop assessment (using field validated vegetation and riparian mapping). These biodiversity corridors link remnants, regenerated or planted vegetation between Regional and local fauna habitat, Ku-ring-gai Natural Areas and remnant patches. These areas are not necessarily comprised of continuous vegetation nor do they necessarily form a direct physical connection between fauna habitat, due to the existence of roads and other urban infrastructure.

Biodiversity Corridors facilitate wildlife (vertebrate and invertebrate) migration between areas of habitat and are particularly important in urban areas, such as Ku-ring-gai, where urban development obstructs migration between formal reserves and local habitat.

Biodiversity Corridors also support the continued survival of flora populations in the landscape primarily by promoting pollination and seed dispersal. *Western Sydney Urban Bushland Biodiversity Survey* (James, 1997) recognises that road reserves, creek corridors and larger patches of habitat on both public and private property play an important role in maintaining biodiversity outside reserves.

Biodiversity Corridors define areas that will be managed for biodiversity connectivity (for example through weed removal and bush regeneration, or appropriate native landscape planting). A brief outline of biodiversity management objectives, advantages and disadvantages, as well as potential management strategies for Biodiversity Corridors within Ku-ring-gai is provided in Appendix C.

It is recognised that flora and fauna will utilise a range of resources both within and outside identified biodiversity corridors, and these areas form one part of a broader approach to biodiversity management within the more urbanised areas of the LGA. This is supported through:

- Council Biodiversity Strategy (KC 2006) and Tree Management Policy (KC 1999)
- Wildthings, Council's care programs (streetcare, parkcare, bushcare) (http://www.kmc.nsw.gov.au/www/html/280-bushcare.asp?intSiteID=1)
- Tree Preservation Order
- *Threatened Species Conservation Act 1995*, *Environmental Protection and Biodiversity Conservation Act 1999*
- Ku-ring-gai Council's Development Control Plans

Ecological principles underlying biodiversity corridors and supporting regional connectivity include:

- Avoiding local extinction
    - Biodiversity Corridors are valuable for protecting isolated flora and fauna populations in Ku-ring-gai and may assist in avoiding local extinction. Fahrig (2003) identified a decline in species richness, population abundance and distribution as being some of the effects of habitat loss and fragmentation on biodiversity.

- Reproduction and genetic mixing
    - Low genetic variation has been identified as one of the effects of habitat fragmentation on fauna (Aares and Ims, 1999: Fahrig, 2003). Facilitating fauna movement between habitats particularly benefits the genetic diversity of isolated, extinction-prone flora (Tewkesbury *et al.*, 2002) and fauna (Aares and Ims, 1999) populations.
    - Biodiversity Corridors provide fauna with an opportunity to connect with breeding partners and offer a greater selection of breeding partners (Aares and Imes, 1997).

  - Biodiversity Corridors enhance native vegetation reproduction and genetic diversity (Tewkesbury *et al.*, 2002). This is particularly important for endangered ecological communities.

- Pollination and seed dispersal
  - Vegetation that relies on animals for seed dispersal or pollination is able to colonise new habitat (Tewkesbury *et al.*, 2002). This results in increased flora diversity and increased foraging prospects for fauna in the newly colonised patch. Grey-headed Flying-foxes disperse pollen and seeds over a wide range during foraging, often up to 60-100 km per night (DECC, 2007a; Royal Botanical Gardens and Domains Trust, 2010). In this way they contribute to the movement of plant genetic material and thus influence evolutionary processes of forest ecosystems (DECC, 2007a).
  - A study undertaken in South Carolina found that habitat patches connected by corridors contained a higher proportion of flowers which produced fruit than isolated patches (Tewkesbury *et al.,* 2002). This was attributed to pollen movement by invertebrates in this study. The same study by Tewkesbury *et al.* (2002) also found that seeds are more likely to be found in connected than unconnected habitat patches. This was attributed to a preference for birds to use the corridor to travel between patches.

- Response to change
  - Habitat disturbance, or a change in habitat condition, has the potential to result in local extinction if fauna populations have no migration pathway. Bushfire, drought, food scarcity and increased predation can all potentially result in a decline in fauna numbers. Biodiversity Corridors provide an opportunity to temporarily seek refuge in a more favourable habitat (HNCMA, 2008). Smith and Smith (2005) acknowledge that National Parks experience more frequent fires than the adjacent bushland in Ku-ring-gai. Corridors provide the ability for fauna to migrate to unburnt areas during these times.
  - Biodiversity Corridors also facilitate the re-colonisation of sites following a disturbance (HNCMA, 2008). There is greater potential for successional flora and fauna species to enter the disturbed site while it is directly connected to undisturbed habitat.
  - Flora and fauna that have particular habitat, foraging or prey requirements can use the corridors for seasonal migration (HNCMA, 2008) or in response to changing climate factors.

- Regeneration
  - Connectivity between fragmented habitats can also allow for some restoration of naturally occurring landscape variations, patchiness and diversity, which has been lost from smaller isolated fragments (James, 1997).

- Increasing habitat
  - Corridors facilitate increased biodiversity by enabling flora and fauna migration to new habitat that may have been previously unavailable. Linking natural areas may also result in locally extinct species being reintroduced (Tewksbury *et al.*, 2002).
  - Habitat opportunities may also provide fauna with protection from predators in the corridor.
  - Biodiversity Corridors offer a larger total habitat to wildlife species. This provides greater habitat diversity and foraging area. It also assists in preventing over-crowding of existing habitats (Jordan, 2000). More extensive habitat areas also benefits species with large home ranges.

- Corridors may provide additional habitat for flora and fauna species, termed diffusion dispersal (Krebs, 2001 as cited in Horn, 2003) or may provide a migration pathway as animals disperse in search of food, habitat or a mate, termed jump dispersal (Krebs, 2001).

Biodiversity Corridors are considered to be particularly important for species (HNCMA, 2008):

- with large home ranges
- which are sensitive to habitat fragmentation
- which are nomadic or migratory
- which are not able to disperse easily.

3.4.2 Factors considered in identifying Biodiversity Corridors

A landscape approach has been used to identify Biodiversity Corridors within the LGA. In mapping Biodiversity Corridors the following design principles were considered:

Condition

The highest value Biodiversity Corridors are those in good condition which provide connectivity between high value habitats.

A wide corridor of continuous vegetation with native species in all structural layers and providing diverse habitats is likely to supply a migration pathway to a greater number of species (HNCMA, 2008). However even patches of disturbed vegetation provide an important ecological function. Connecting good condition habitat through corridors of partially disturbed communities, for example where the upper stratum is retained but the lower strata are weed infested, can also assist the viability of the ecological community.

The highly urbanised nature of Ku-ring-gai means that garden and street trees are also vital attributes for allowing connectivity and often form integral parts of urban corridors, providing both an ecological and community character function. There is evidence of both bird and bat species that will not travel through open space but will use urban trees. Large-bodied native birds, such as the Grey Butcherbird and Noisy Friarbird, are prevalent in vegetated suburban environments but are less frequently found in suburbs lacking vegetation (Catterall, 2004). These large native birds, which Catterall (2004) terms 'Aussi Icon' species, can be important for public appreciation of wildlife and community support for habitat protection measures. Basham (2005), reports that only the most common bat species forage in the open with the rarer species preferring canopy or shrub cover. Catterall (2004) also emphasises the importance of urban vegetation for small-sized native birds. Small native birds can use gardens with complex strata as habitat, especially those that adjoin bushland. Catterall (2004) further highlights the importance of vegetation in urban areas, especially when compared to unvegetated urban areas. Even though small-bodied native birds will not typically inhabit urban areas, large-bodied native birds are often found here with appropriate vegetation. The designation of biodiversity corridors will encourage increasing vegetation complexity and connectivity to support these species.

Fauna, flora and vegetation community distribution

The flora and fauna assessment (Section 3.2) and Regional Fauna Habitat (Section 3.3) was used to assist in the identification of biodiversity corridors.

A review of threatened ecological community distribution was undertaken to facilitate linking of key remnants. In accordance with NSW recovery strategies for *Acacia bynoeana, Melaleuca deanei, Tetratheca glandulosa,* a review of species location and population connectivity was undertaken in order to ensure that vegetation linkages between sites were retain or re-established. It was determined that connectivity and protection of these species was addressed within the Ku-ring-gai Regional Fauna Habitat.

Fauna assessment surveys in 2001 identified that the Cowan Creek and Middle Harbour catchments support a greater number of native fauna species than the Lane Cove River catchment (Smith and Smith , 2001). This is supported by further fauna surveys in 2003-2005 (Smith and Smith, 2005; Smith and Smith, 2004; Smith and Smith, 2003). In particular the Bush rat, Long-nosed Bandicoot and Swamp wallaby *(Wallabia bicolour)* were absent from Hawkesbury Sandstone vegetation in Lane Cove River catchment but recorded in similar vegetation in the other two catchments during these surveys (Smith and Smith, 2001). In fact the species that show the strongest patterns of differentiation between the three catchments are those that spend all or most of their time on the ground (Smith and Smith, 2005).This may reflect the lack of migration pathways available to terrestrial fauna in Ku-ring-gai. The Brushtail possum (*Trichosurus vulpecular*) and Sugar glider were also recorded only in the eastern bushland of the LGA. This provides evidence of the need for Biodiversity Corridors for arboreal fauna.

Throughout the LGA vegetation remnants on Hawkesbury Sandstone support more, native species of a greater diversity than those on Ashfield Shale. This disparity is likely due to the highly fragmented nature of Blue Gum High Forest on Ashfield Shale. Higher fauna diversity is recorded in sandstone vegetation in gullies when compared to sandstone vegetation on ridges and hillsides. In the Lane Cove River catchment the number of native fauna species was much higher in Hawkesbury Sandstone vegetation near watercourses than either sandstone vegetation on ridges and hillsides away from watercourses or isolated plots of BGHF on shale.
There are fauna in Ku-ring-gai that use all of these habitats and it is essential to maintain linkages between them.

Fauna assessment also demonstrates lower abundance of fauna in the Lane Cove Valley which are sensitive to disturbance. This is thought to be due to the lack of connectivity of bushland in the south to Lane Cove National Park. The eastern bushland, where species sensitive to disturbance were recorded, does not display this trend. This reflects the importance of maintaining habitat connectivity in the LGA, through the re-establishment of corridors where necessary.

Urban trees and exotic vegetation provide further significant habitat and migratory pathways for fauna in Ku-ring-gai. Fauna assessment in 2002 (Connell Wagner, 2002) identified Sugar glider bite marks on street trees at several locations in St. Ives. In the Cowan Creek catchment the Long-nosed bandicoot has been observed foraging in lawns and gardens adjacent to bushland (Connell Wagner, 2002). Several species, including some threatened species, will utilise vegetation remnants in urban areas to travel between larger bushland habitat.

Following drought and fire the ratio of urban birds to bush birds increases (Smith and Smith, 2001). This may reflect the lack of refuge habitats available to forest interior species, whereas urban adapted species can find habitat in the urban environment. The Biodiversity Corridor network aims to increase habitat opportunities and access for species which cannot survive in the urban environment.

Corridor design

a) Biodiversity Corridors should link core areas of habitat to support local and regional biodiversity (Section 3.4.1 for ecological principles of biodiversity corridors). These core areas include regional and local fauna habitat (Section 3.3), DECCW protected areas and Ku-ring-gai Natural Areas.

   The area of core habitat to which a corridor joins, is a primary consideration of corridor importance (Drinnan, 2005; Lindenmeyer, 1993).

   A review of Formal Reserve patch size within and adjacent to Ku-ring-gai was undertaken to assist in identification of core areas to be connected (See Figure 4 and glossary for patch size definition). This included mapping areas into 5 classes based on patch size (ha):

- > 100ha
- > 40ha to ≤ 100ha
- > 4ha to ≤ 40ha
- >2ha to ≤ 4ha
- ≤ 2ha

b) Biodiversity Corridors should link key vegetation communities and incorporate existing remnant vegetation.

Corridor pathways were designed to include areas containing Threatened Ecological Communities and/or good condition remnant vegetation to support the recovery of these communities.

c) Shorter Biodiversity Corridors minimise the exposure of flora and fauna to edge effects (Wilson and Lindenmeyer, 1995 as cited in Macdonald, 2003).

Where possible, biodiversity corridors have been designed to connect core habitat through the shortest possible distance. However, they have also been designed to incorporate remnant native vegetation within the urban environment; recognising its role for foraging and habitat stepping stones, facilitating fauna and flora movements. Due to the urban nature of the environment, this does not always result in the shortest distance between the linked habitats.

d) Minimise barriers

Road crossings have been minimised where possible, however, crossing of main, regional and local roads is required in order to link regional and local fauna habitat and address identified connectivity requirement of the LGA. For example, there are two corridors that cross Campbell Drive, Wahroonga. One links regional fauna habitat in Lower Campbell Reserve to the Middle Campbell Reserve Natural Area. The other links Middle Campbell Reserve to regional fauna habitat in South Campbell Reserve. These areas have been identified within biodiversity corridor mapping in order to recognise constraints and to facilitate future management (See Appendix C).

e) Include a diversity of habitats and topographies

Where possible corridors connected and incorporated a diverse range of vegetation communities and habitat types in order to provide opportunity for a greater range of species to access the corridor. For example, corridors connecting gullies to ridges have been found to support greater species diversity and abundance than corridors over a single topographic position (Lindenmayer *et al.,* 1993).

f) Areas identified for corridors should be practical and long term

Where design principles (stated in this section) allow, biodiversity corridors sought to align with riparian mapping (See Section 2.2). These areas will be required to be managed to protect the watercourses and the adjoining lands. Development is already required to be setback from watercourses, providing practical opportunities to restore well connected areas.

It is understood that duplication of the north shore rail line is planned. This would prevent opportunities over the long term to retain or re-establish suitable vegetation and habitat along these areas and therefore biodiversity corridors along these areas have not been identified. It should be noted that mapped threatened ecological communities will be incorporated into other Conservation Significance Assessment Categories (see Section 3.5).

g) 'Loop' design, where habitats are linked in a circular pattern and multiple corridors that link each habitat, are more robust than 'necklace' pattern corridors (Jordan, 2000) or corridors that end in 'dead-ends' (Tewkesbury *et al*, 2002).

Loop corridors were created, where possible, to form multiple connections between habitats. For example Regional Fauna Habitat to the west of Campbell Drive, Wahroonga is linked to Lower Campbell Reserve and adjoining bushland across Lucinda Avenue South in the north and Campbell Drive in the south. The connectivity of habitat is more robust with multiple linkages since if one corridor becomes degraded the others maintain the connection (Jordan, 2000).

Necklace corridor design has been adopted where an isolated Natural Area has been linked to Regional Fauna Habitat. Dead end corridors have only been incorporated where they correspond with a riparian corridor that contains threatened ecological communities and provides a closer link between north and south Regional Fauna Habitat across the LGA.

Corridor width

Though there is evidence that narrow corridors (<40 meters) of remnant vegetation are still beneficial for fauna dispersal (Bennett, 1990), it is generally agreed that wider corridors provide better protection from predators, more foraging opportunities, reduce edge effects and increase the likelihood of fauna migration (Lindenmeyer, 1994; Drinnan, 2005; Tischendorf and Wissel, 1997; Horn, 2003). A study of bird species diversity in road reserves in Western Australia (Arnold and Weeldenberg, 1990) found that the number of bird species significantly increased as road reserve width increased. Wider corridors also facilitate the migration of forest interior species as well as urban and edge species, especially where the corridor is in good condition (Drinnan, 2005).

Wider corridors have less edge for a given amount of area (Fahrig, 2003). Edge effects include:

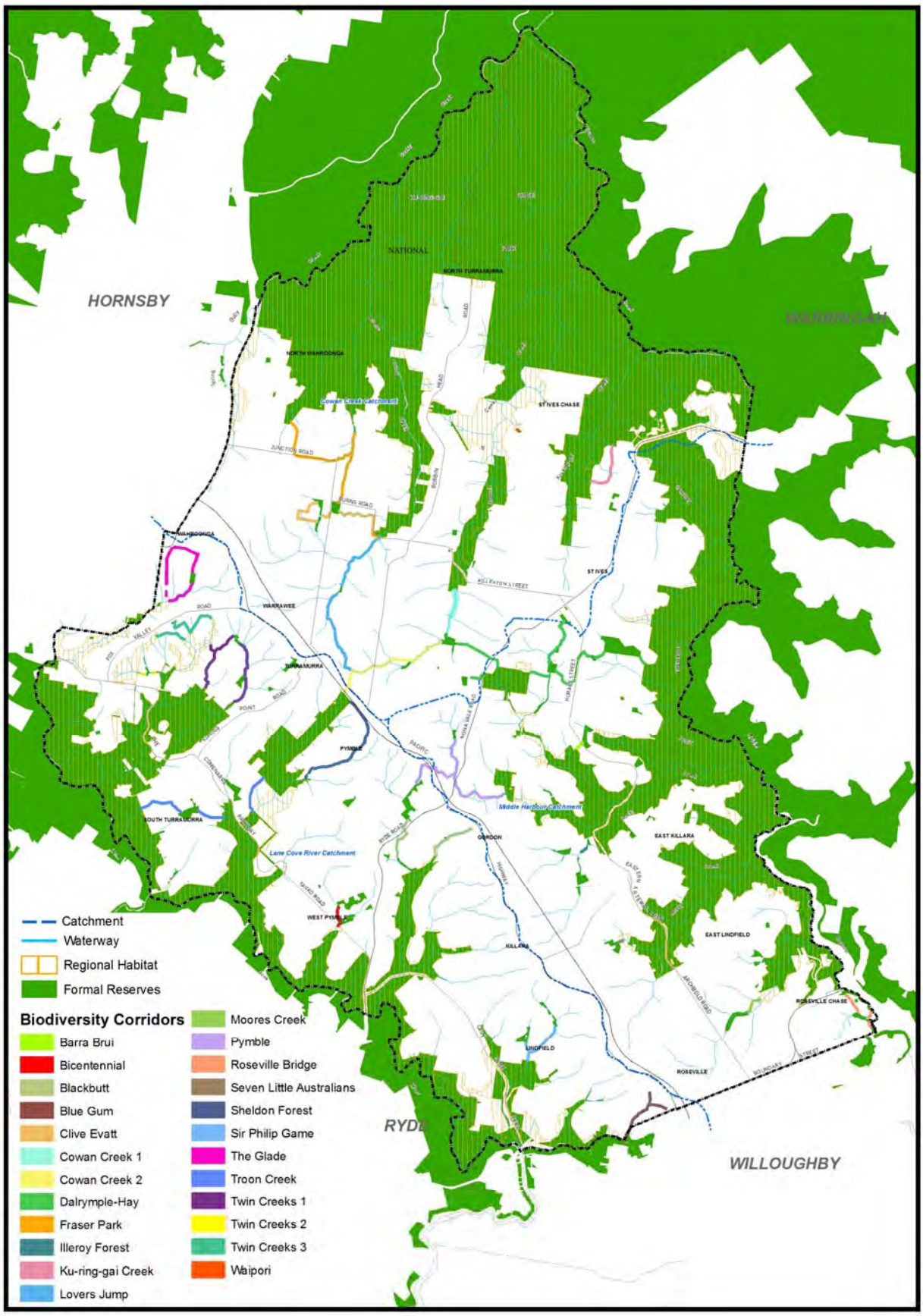
- Changes to the microclimate
- Weed invasion
- Increased predation
- Nutrient enrichment of the soil (Smith and Smith, 1997)

It is advised that corridors be greater that 25 m wide to prevent the increase of edge effects (LCC Biodiversity Strategy, 2003. Queensland Fisheries Service recommend minimum buffer widths for provision of wildlife habitat (15 – 45m), protection of remnant vegetation (5 – 100m) and sediment filter / control and stormwater run-off filter / control (30 – 90m) (Bavins *et al* 2000).

A 40m wide corridor is considered to be adequate for many species to use as a dispersal mechanism between core habitat areas (Horn, 2003). However species that do not tolerate urban or bushland edge environments may not travel through such a narrow corridor. Wider biodiversity corridors may be necessary to facilitate the migration of the shyer forest interior species (Drinnan, 2005). These species are more likely to move through Regional Fauna Habitat.

Given the limitations of the Ku-ring-gai urban environment a 40m wide Biodiversity Corridor has been adopted for all corridors with the exception of corridors that align with Riparian Lands mapping Category 1 'Environmental corridor'. Here a width of 80m was applied, matching riparian mapping Core Riparian Zones (See Section 2.2).

Figure 5: Biodiversity Corridors



3.5 Conservation significance assessment (CSA)

An LGA wide assessment of biodiversity conversation significance was undertaken using baseline data and overlay information outlined within Section 2 and 3.

The Conversation Significance Assessment (CSA) (***also referred to as 'Greenweb'***) identifies five (5) categories and will be used to inform Council's management and its LEPs and DCP (see Section 4.2.1).

An explanation of CSA categories and supporting information is provided below, along with important data preparation and limitation information. Maps showing CSA results are provided within Appendices F and G.

Data preparation

Riparian lands, Regional and Local Fauna Habitat and Biodiversity Corridor mapping
Additional information relating to preparation of data used in this analysis (including riparian lands, regional and local fauna habitat and corridor mapping) is provided in Sections 2 and 3.

Vegetation mapping, connectivity and patch size
Refer to Section 3.1 for additional information relating to preparation of vegetation data used in this analysis.

In addition to recognising protected and core habitat lands, the CSA mapping prioritises the protection of Key Vegetation Communities (KVCs).

Key Vegetation Communities include communities currently listed, or considered likely to be listed, under the *NSW Threatened Species Conservation (TSC) Act 1995, NSW Fisheries Management (FM) Act 1994* and / or the *EPBC Act 1999*.

Vegetation condition is a key factor determining the inclusion of remnant vegetation as a threatened ecological community, under the *TSC Act, FM Act* and *EPBC Act.* In order to accommodate future variations in federal and state scientific committee determinations and their interpretation, KVCs have been based upon vegetation community not condition. As such Key Vegetation Communities (KVC) are vegetation communities that align with Threatened Ecological Communities (listed under the *TSC Act, FM Act* and /or the *EPBC Act*) but may include areas outside the scope of conditions required to meet the determination.

A new vegetation community, Coastal Shale Sandstone Forest has been recognised within Ku-ring-gai's recent vegetation mapping and mapping by DECCW (DECCW 2009). The future legal status of this community is unclear at present and further consultation with OEH as part of the SMCMA mapping project (DECCW 2009) is being undertaken. From a precautionary standpoint, within the LGA this community should be treated as regionally significant and has been included within the CSA as a Key Vegetation Community.

The CSA used condition classes applied to Ku-ring-gai key vegetation community mapping (KC 2011a and 2011b) (See Appendix B and Section 3.1). Condition mapping within alluvial and estuarine areas mapped by DECCW (2009) was not easily translatable to KC vegetation condition classes. However all areas containing these communities are included under Greenweb categories that did not require the consideration of condition)) (See Table 5).

For all areas within Ku-ring-gai key vegetation community mapping (KC 2011a and 2011b), lacking condition class information, a category of low condition (TXU / TXUD) was applied.

An assessment of vegetation connectivity and patch size was undertaken as part of the CSA process to enable protection / consideration of more connected and larger patches of vegetation.

The assessment of connectivity was based upon direct connectivity of vegetation mapping, refined to canopy areas of ≥10m in height (with areas <10m in height included on an opportunistic basis) (See Section 3.1). It is acknowledged that vegetation below these heights may be part of a KVC or provide connectivity to larger remnants.

Key Vegetation Community (KVC) patch size was derived by grouping all directly adjoining areas of KVCs. When reviewing the final CSA mapping it is important to note that part of a patch may be included within an area identified as a higher category.

In order to allow for small scale regeneration and disturbances as well as mapping accuracy, a 2m buffer was applied to vegetation mapping data used within CSA. However, due to the fine scale mapping, the unbuffered vegetation mapping was used to determine patch size and connectivity (eg. vegetation adjoining Regional Fauna Habitat and adjoining vegetation in core riparian zones). For vegetation within Core Riparian Zones and Biodiversity Corridors the 2m buffer applied was restricted to the areas within the CRZ or Biodiversity Corridor.

Ku-ring-gai Natural Areas and Office of Environment and Heritage protected areas

For the purpose of CSA mapping, a review of drainage easements and access handles was undertaken for Ku-ring-gai Natural Areas and Office of Environment and Heritage protected areas (formal reserves). This review sought to exclude formal reserve areas extending into adjacent land uses, and that do not provide ecological functionality; thereby consolidating mapping of core biodiversity lands.

These drainage easements and access handles were included within the CSA mapping only where the land contained vegetation or riparian value, where the access handle or easement is relatively wide.

Limitations of the Conservation Significance Assessment (CSA)

- Limitations of the *Mapping and assessment of key vegetation communities across the Ku-ring-gai local government area* (KC 2012a and 2012b) apply to this Conservation Significance Assessment (See Section 3.1).

- The CSA utilises the identified Core Riparian Zone (CRZ) from riparian mapping as outlined within Section 2. Limitations relating to this mapping apply (See Section 2.2.1.).

- Mapping of Significant trees within KVCs was undertaken with reference to surrounding vegetation. As such where a tree is located within a larger remant KVC patch, the entire patch was mapped. As such mapping of Significant trees within KVCs includes the mapped area in which they are located. Where sufficient information was not available to refine location to a reasonable level the tree was excluded from this mapping.

- The purpose of this CSA is to foster a consistent and strategic approach to biodiversity management. Although there are considerable benefits to natural resource planning at this scale there are also limitations. Investigations at a site scale for DA and activity proposals may identify inaccuracies.

Conservation Significance Assessment methodology

The methodology for the Conversation Significance Assessment (CSA) (Greenweb) is outlined within Table 5, with further descriptions provided below.

The following category descriptions are provided in an alternate table based format within Appendix E. Maps of each category are provided at Appendices F and G.

Table 5: Ku-ring-gai Conservation Significance Assessment methodology

Category	*Description*
Category 1	Office of Environment and Heritage protected areas
	Ku-ring-gai Natural Areas
	Regional Fauna Habitat
Category 2	Key Vegetation Communities (KVCs), adjoining Category 1
	Local Fauna Habitat
	Vegetation within Core Riparian Zones: • Riparian categories 1, 2 and 3 – all vegetation • Riparian category 3a - limited to KVCs and KVCs adjoining vegetation within Core Riparian Zones as mapped above.
	All vegetation within Biodiversity Corridors
Category 3	KVC Patches that are ≥ 0.1ha in size or contain KVC vegetation in good, moderate condition
	Significant trees within KVCs and the mapped area in which they are located
Category 4	Areas of consolidation for Category 1 & Category 2
	Areas lacking vegetation within Biodiversity Corridors
Category 5	KVC Patches that are <0.1ha in size and do not contain KCV vegetation in good, moderate condition

Category 1

OEH protected areas

Formal reserves consisting of Office of Environment and Heritage estate managed for the purpose of biodiversity protection.

Ku-ring-gai Natural Areas

Formal reserves consisting of areas managed by Ku-ring-gai Council as Natural Areas under the *Local Government Act* 1993 for the purpose of biodiversity protection.

Regional Fauna Habitat

Regional Fauna Habitat includes regionally important connected areas of habitat providing resources for threatened and non threatened fauna species and populations (including national, state and regionally significant species).

Areas of Regional Fauna Habitat which cross major, regional and collector roadways have been included within this category, but have been identified in order to assist in the management of key barriers / breaks within the regional fauna habitat (See Figure 3).

See Section 3.3 for further background.

Category 2

Key Vegetation Communities (KVC) adjoining Category 1

These areas provide support for Category 1, through the protection and improvement of vegetation quality and quantity, providing a buffer, reducing the contrast between core lands and the urban environment.

This concept is supported by the recommendations for a 60m retained buffer zone of native vegetation around significant vegetation; in response to identifying impacts from human disturbance up to 60m from road edges within the Blue Mountains (Smith and Smith (1997). Similarly, NSW DECC (2007c) recommends an absolute minimum buffer of 50m to Duffys Forest.

Whilst lands adjoining core areas within Ku-ring-gai consist primarily of developed lands, there is still capacity to retain / enhance some form of vegetation assemblage and structure as a buffer supporting adjoining core areas.

These buffer areas have the ability to provide resources that encourage urban-sensitive species to utilise forest edges and adjoining areas, as well as reducing edge effects to consolidated vegetation. Enabling for example a higher level of bird diversity to be maintained (Hodgson 2005, Hodgson et al 2006). This benefit is enhanced by native vegetation but is also aided by exotic plantings.

Research has identified significant bird diversity and abundance within the LGA (See Appendix A). In addition, the proportion of housing and associated factors including habitat and predation have been recognised as influencing the movement of birds between native vegetation and the urban matrix (Hodgson et al 2006). Medium sized nectarivores have been observed to increase at the edges of high-density housing, encouraged by inappropriate planting (multitudes of large flowering cultivars) (Birds Australia et al 2005), and an increased predation ability (added by a reduction in the complexity of vegetation structure). In turn these birds have been observed to induce an inhibitory response among the small insectivores at the edges of high-density housing reducing bird diversity.

Local Fauna Habitat

Local Fauna Habitat is provided by isolated remnants located more centrally in the LGA. Mapping included areas within both private and public land ownership, including Ku-ring-gai Natural Areas.

See Section 3.3 for further background.

Vegetation within Core Riparian Zones:

- *Riparian categories 1, 2 and 3 – all vegetation*
- *Riparian category 3a - limited to KVCs*

and KVCs adjoining vegetation within Core Riparian Zones as mapped above.

Vegetation within CRZs provide support for riparian lands through the protection and improvement of vegetation quality and quantity.

All vegetation within these Core Riparian Zones (as identified in Section 2) has been targeted, including native and non-native species, with the exception of Riparian category 3a (consisting of piped creeks). For Riparian category 3a the areas identified in Greenweb category 2 is limited to mapped KVCs only, recognising the significance of these areas within any future restored landscape.

KVCs adjacent to CRZ areas described above have also been included within Greenweb category 2. These areas provide an increased buffer to CRZ within areas of ecological importance. Additionally connectivity provided by the CRZ helps to support the KVC area.

Vegetation within riparian areas provides a number of ecological services, including habitat, food resources, bank stability and sediment / nutrient filtration. They also act as microclimates, changing conditions in small remnant areas to support a variety of organisms as well as providing resources to nomadic, migratory and nearby resident species (Price et al 2007). Whilst occupying only a small proportion of the landscape, they support a greater variety and abundance of animal life than surrounding areas (Catterall et al 2007).

Riparian areas are known to be directly associated with many species. Apart from a wide array of invertebrates, in Ku-ring-gai, the Eastern Water Skink (*Eulamprus quoyii)*, the Eastern Water Dragon (*Physignathus lesueurii*) and a number of frog species are entirely dependant on riparian areas for dispersal and survival. A number of microbat species, ground dwelling marsupials and the endangered Powerful Owl (*Ninox strenua*)[3] depend on riparian zones regularly on a daily and seasonal basis.

The potential for moister environments to withstand temperature rises as associated with climate change may also play an important conservation role in the future. These areas provide for the protection of vegetation across the topographical range within the LGA. From 1st order streams, originating at shale bearing ridges though to 3rd order streams within sandstone gullies and estuarine environments.

[3] Ku-ring-gai has the highest recorded distribution throughout the Greater Sydney Region (Kavanagh 2004).

All vegetation within Biodiversity Corridors

This includes all vegetation, including non local / non native species, within Biodiversity Corridors.

See Section 3.4 for further background on biodiversity corridors.

Note that areas of within Biodiversity Corridors lacking vegetation are mapped within Category 4.

Category 3

KVC Patches that are ≥ 0.1ha in size or contain KVC vegetation in good, moderate condition

This includes all vegetation of patch size ≥ 0.1ha in size or vegetation areas of good or moderate condition within the urban matrix.

The patch size of ≥ 0.1ha, is estimated to include an area of approximately 6 large established trees. This patch size aligns to the 0.1ha layout of nested 20 × 50 m and 20 × 20 m plots used for the assessment of vegetation condition, as used within Biobanking (DECC 2008b) and the Biometrics methodology for assessing clearing and ecological thinning proposals on terrestrial biodiversity under the *Native Vegetation Act 2003* (DECCW 2011).

This patch size is considerably larger than the 'standard' plot size (0.04ha) recommended by *Native Vegetation Interim Type Standard* for vegetation mapping and identification (Sivertsen 2009[4]). It is also larger than the minimum area of forest (0.05 hectares with tree crown cover >10%) used for emissions reporting and accounting purposes under the Kyoto Protocol (Cadman, 2008).

Note: A 5ha size threshold is adopted within the Biobanking methodology (DECC 2008a) and the BGHF listing advice under the EPBC Act (DEWHA 2005). A patch size analysis of Key Vegetation Communities ≥ 0.1ha as included within Category 3, identified that all patches ≥ 5ha are already mapped within Category 1 or 2.

These areas assist in the maintenance of TECs across a range of topographies. They also play an important role as biodiversity reservoirs, providing stepping stone links for fauna and seedbank / pollination resources to support the resilience of remnant vegetation patches.

Small patches can be valuable for native inverterbrates and for some birds (Fischer and Lindenmayer, 2002). Urban street trees for example, provide bird habitat for resting, nesting, feeding and hollow use (Young *et al* 2007, Tzilkowski *et al* 1986, Weleh 1994, Cannon 1999, Chamberlain *et al* 2004). They also provide habitat for pollinators, such as bats, that may be less constrained by landscape features (Aldrich & Hamrick 1998, cited in Sork and Smoise 2006).

Areas included within this category (as well as those identified within biodiversity and riparian corridors) provide genetic resources from remnant vegetation to support the ecological functions of both KVCs and non KVCs, and facilitate gene flow (reducing genetic erosion / isolation and the effects of fragmentation).

In urban areas where fragmentation has occurred, the main strategy to fight genetic erosion is the maintenance of a good quality and quantity of gene flow among fragments. "Fragmentation

[4] The *Native Vegetation Interim Type Standard* (Sivertsen 2009) addresses the quality and nature of the scientific processes for native vegetation type activities; and applies to all relevant vegetation activities to which the NSW Government is a signatory or to which the NSW Government makes a financial or in-kind contribution.

does not necessarily equate to genetic isolation", Krauss *et al* states (2007 p396). As long as there is sufficient gene flow between fragments, species should be able to survive and grow at a distant site. In other words, even though habitat may be separated, if the quality and frequency of gene flow can be maintained, genetic erosion should not occur. Sork and Smoise (2006) summarized that two elements measuring the degree of isolation of a fragmented landscape are the quantity of incoming pollen and the diversity of incoming gene sources.

As such the more connectivity and protection of sufficient / relevant remnant areas within the urban area, the higher the resilience the core areas will have.

Significant trees within KVCs and the mapped area in which they are located

This category includes trees within KVCs identified as significant during Ku-ring-gai Key Vegetation Community mapping (KC 2011a and 2011b).

This included the identification of local native trees; identified as significant due to the presence of habitat (e.g. a hollow), provision of food for wildlife, and / or exceptional form or size. This mapping provides an opportunistic selection of significant native trees and is not considered to capture every significant tree within the urban landscape.

Category 4

Areas of consolidation for Category 1 and Category 2

This consists of an 8m buffer applied to areas of Category 1 and 2, in order to highlight areas where improved connectivity/consolidation is sought. This may include both vegetated and non vegetated areas not already included within categories above.

These buffers will help to reduce edge effects on the ecological community (Smith and Smith, 1997; NSWDECC, 2007c). Edge effects include, for instance, the impacts of stormwater runoff, disturbance, dumping, weed encroachment, microclimate variations and nutrient changes. The buffer width is limited to 8m due to the practical constraints of the urban environment of Ku-ring-gai.

Areas lacking vegetation within Biodiversity Corridors

This category addresses areas lacking vegetation within identified Biodiversity Corridors. These areas are identified for enhancement to reconnect patches of remnant vegetation, facilitating the improvement of connectivity between core habitats. These areas may provide additional functions such as protection of water quality.

Considered within the context of surrounding vegetation and habitat, these areas will help to maintain and restore the health, diversity and connectivity of native species population and communities and improve their resilience under future climate change.

Note that vegetation within Biodiversity corridors' is addressed within in Category 2.

Category 5

KVC Patches that are <0.1ha in size and do not contain vegetation in good, moderate condition

Whilst smaller than patches identified within Category 3, these areas also provide habitat stepping stones, assist in the maintenance of TECs across a range of topographies, facilitate genetic flow and provide fauna habitat for more mobile / urbanised species.

4 Recommended land use planning measures

Under the state government's standard LEP instrument, a number of measures can be used to protect riparian lands and biodiversity. It is recommended that a combination of these be used for the relevant LEPs.

The proposed location, type and design of future development under the proposed LEPs need to consider the results of the strategic assessment of riparian lands and biodiversity outlined above. Further detail will need to be provided in the associated DCP/s. However, it is also recognised that a number of other factors must also be integrated with these considerations.

The results of the mapping and assessment process are recommended for incorporation within the Draft LEPs through a number of mechanisms:

- inclusion of environmental zones;
- incorporation of a map overlay, identifying areas of biodiversity significance (the *Biodiversity Map*);
- incorporation of a map overlay, identifying riparian lands (the *Riparian Lands Map)*, broken down into the categories described in Section 2.2.1;
- inclusion of local provisions relating to the areas identified in the map overlays;
- inclusion of a local stormwater provision;
- increase in the minimum lot size, and a reduction in the maximum floor space ratio for larger sites in environmental zones;
- inclusion of the tree preservation provision.

More detailed controls would need to be provided in the DCP/s. It is recommended that controls be prepared specific to each category of the Greenweb.

4.1 LEP Zoning

The *Ku-ring-gai Planning Scheme Ordinance (1971)* (KPSO) is a deemed environmental planning instrument, that dates back prior to the EP&A Act. There are no environmental zones within the KPSO. It is recommended that four environmental zones be incorporated within the LEPs:

E1 – National Parks and Nature Reserves:

- This zone is intended to enable management and appropriate use of lands that are identified by OEH as 'protected areas'. These include National Parks and Nature Reserves. It is also intended to apply to sites proposed to be reserved under this Act to protect their environmental significance. The permissible land uses are set through the standard LEP instrument, as those governed by the *NSW National Parks and Wildlife Act 1974*
- This zone will apply to Ku-ring-gai Chase National Park, Lane Cove National Park, Dalrymple Hay and Garigal National Park and to land zoned E1 for the Ku-ring-gai Campus of the University of Technology, Sydney under *SEPP (Major Development) 2005*.

E2 -Environmental Conservation:

- This zone is intended to protect land that has high conservation value. The objectives for this zone are primarily related to the protection and restoration of areas of ecological, scenic, cultural or aesthetic values.
- A number of land uses considered to be inappropriate for this zone have been mandated as prohibited uses in the standard LEP instrument. Dwelling houses can be prohibited by councils within this zone. It is therefore most appropriate for reserves, or as a split zone on larger private sites. While split zoning is generally discouraged, there are instances where it may be justified.[5]
- It is recommended that the following lands be considered for inclusion within this zone:
  - Council owned lands categorised as Natural Areas under the *Local Government Act 1993*
  - Lands zoned for acquisition for conservation under the KPSO, namely lands zoned *County Open Space* and containing bushland that have not yet been acquired by the relevant authority. These sites are generally larger than standard residential sites. It is noted that this will result in split zones for some sites, as occurred in the KPSO, however, as many of the sites zoned in this way under the KPSO have now been acquired, the number of sites affected is far more limited. Where these lands are owned by state agencies the concurrence of the state agencies will be required for any proposed acquisition and consent for the proposed zoning.
  - Lands identified as E2 under *SEPP (Major Development) 2005* for Wahroonga Estate
  - Roads (including unformed roads), through, or in some cases, adjacent to, E2 lands.
  - Lands owned by state agencies or the Crown, that are identified as Regional or Local Fauna Habitat (eg in the abandoned B2 corridor in Wahroonga and Carcoola Rd St Ives). Consent from the state agencies and the Crown will be required.
  - Areas of high conservation value/Regional Fauna Habitat that are currently within split zones – e.g. currently open space and residential.

E3 -Environmental Management:

- According to the NSW Department of Planning (2009) this zone is for land *'where there are special ecological, scientific, cultural or aesthetic attributes or environmental hazards/ processes that require careful consideration/ management and for uses compatible with these values'.*
- The objectives of this zone under the Standard LEP Instrument, relate to the provision of development that will allow the protection, management and restoration of areas with special ecological, scientific, cultural or aesthetic values.

[5] For instance, drainage easements and access handles to formal reserves extending into adjacent land uses that do not provide ecological functionality were split from E2 zones. These drainage easements and access handles are only to be included as E2 only where the land contains vegetation, has riparian value, or where the access handle or easement is relatively wide.

- Mandatory permissible land uses to be included in the zone are restricted to dwelling houses, home occupations roads and environmental protection works. Uses such as seniors housing, service stations and multi-dwelling housing and retail premises are prohibited.
- The *Draft Background Paper on Managing Bushfire Risks Now and into the Future* (Ku-ring-gai Council 2011) recommends the use of this zone in certain extreme risk bushfire prone lands[6]. It is recommended that the zone be extended to protect Regional Fauna Habitat in these areas, forming a transition between high conservation value land, e.g. land zoned E1 or E2 and other land as recommended by the Department of Planning (2009).
- Isolated lots that meet these criteria may not be appropriate for the E3 zoning. The zone would be applied to lots in groups.
- The lands identified as E3 under *SEPP (Major Development) 2005* for the Ku-ring-gai Campus of the University of Technology, Sydney must also be retained as E3 in the PLEP.

E4 – Environmental Living:

- The objectives within the Standard LEP Instrument relate to the provision of low-impact residential development in areas with special ecological, scientific or aesthetic values.
- Mandatory land uses to be included in the zone are restricted to dwelling houses, home occupations, roads and environmental protection works. There are also a few mandatory prohibited uses.
- It is recommended that:
  - Additional permitted uses in the E4 zone include bed and breakfast accommodation, group homes and secondary dwellings. These uses can be compatible with the protection of environmental values, while allowing some additional residential development to occur on these sites.
  - The E4 zone be applied where a combination of ecological values and risks support greater restrictions on land uses and development.
  - Isolated lots that meet these criteria would not be zoned E4. The zone would be applied to lots in groups.
- This zoning would fit well with the urban nature of Ku-ring-gai.
- The *Draft Background Paper on Managing Bushfire Risks Now and into the Future* (Ku-ring-gai Council 2011) also recommends the use of the e4 zone to minimise bushfire risk. [7] Areas visible from Middle Harbour would also be included for the purposes of scenic protection. The E4 zone in these locations will also provide valuable ecological protection to vegetation and habitat within these sites.

[6] The application of the E3 – Environmental Management zone where land is constrained by hazards is recognised by the Department of Planning (2009). The land use table would prohibit uses that would increase the evacuation risk in these areas, (such as secondary dwellings, seniors housing, dual occupancy and bed and breakfast), uses that may result in combustible materials being stored or used on the site, as well as development types that are mostly used by the more vulnerable members of the community.

[7] The *Draft Background Paper on Managing Bushfire Risks Now and into the Future* (Ku-ring-gai Council 2011) recommends the use of this zone for lands identified as Category 1 or 2 bushfire prone lands in areas of lower risk than those identified for E3 zones.

Selection of E3 or E4:

There will be a number of areas in Ku-ring-gai, particularly residential areas, where a combination of ecological values and risks support an environmentally focussed set of zoning objectives and land uses. In determining whether an E3 or E4 zone should be applied to a particular site, at least the following aspects should be considered in combination:

- the biodiversity significance and extent of the lands within the site identified in the Greenweb map;
- the location and category of riparian land on the site;
- the steepness of the site;
- the bushfire risk;
- the scenic value (from Middle Harbour);
- proximity to and connectivity with formal reserves;
- high potential for site erosion;
- existing lot size/development configuration on the site.

Where a number of these factors combine in such a way as to make it preferable to apply the restrictions of an environmental zone, the most suitable zone would then be considered. Where bushfire evacuation risk plays a major role in the combination of factors, the E3 zone may be the most suitable. Where bushfire risk is not as high, and other factors point towards an environmental zoning, the E4 zone is likely to be applied.

4.2 Environmental map/ overlays

The standard LEP template allows for the incorporation of maps or overlays and associated local provisions in the Instrument. The advantage of a map overlay is that it is possible to co-ordinate and implement multiple natural resource management provisions and objectives, while allowing for development permissible within the zoning. The map overlay identifies areas that require consideration of specific objectives and provisions in order to ensure that important attributes within these areas are considered during the development assessment process.

It is recommended that this measure be used to support environmental outcomes in the draft LEPs currently under preparation. Similarly to the KLEP (Local Centres), two maps are proposed:

- *Biodiversity Map* and
- *Riparian Lands Map.*

4.2.1 Natural Resource – Biodiversity

An LEP is a strategic land use planning document. Accordingly, it is not appropriate to include every remnant patch or tree, even if potentially part of a threatened ecological community (TEC) within the LEP maps.

It is recommended that biodiversity *Categories 1 to 4* (within Section 3.5 of this report) be combined as a single overlay for the purposes of the LEPs. Maps may be found in Appendix F.

The LEP maps need to relate to a local provision within the LEP Instruments. The comprehensive DCP would then break down this layer into its component categories.

Lands mapped as *Category 5* (within Section 3.5) will also be included as part of the Greenweb in the associated DCP. Maps may be found at Appendix F.

It is important to note that the exclusion of small areas of TECs from the Greenweb does not preclude legal protection under relevant legislation.

Future updates of Biodiversity Map / Greenweb

The purpose of Greenweb is to foster a consistent and strategic approach to biodiversity management. Although there are considerable benefits to natural resource planning at this scale there are also limitations. Investigations at a site scale for Development Application (DA) or activity proposals may identify inaccuracies. Council will need to consider on merit, arguments relating to any inaccuracies within Greenweb.

It is recommended that a mechanism be provided to allow public and private landholders to comment on any inaccuracies in the mapping. If it is determined that an area is incorrectly identified within Greenweb, any development application or activity proposal would then be assessed on the basis of the corrected Greenweb category, however, the change would be limited to the site. If a change in category results in flow-on effects to other lands, the changes would be noted by Council, and any flow on effects would be addressed at the next review of the LEP and DCP.

4.2.2 Waterways and riparian lands

Similarly a riparian land map/overlay, *Riparian Lands Map*, is recommended for inclusion in the Draft LEPs. The maps should be based on the riparian mapping and assessment outlined in Section 2.2.1, incorporating categories 1, 2, 3 and 3a, as well as the buffer to categories 1 and 2, as described in Section 2.3. Again, the map should relate to a local provision within the LEP Instruments, with more detailed provisions within the DCP.

4.3 LEP provisions

The Standard LEP instrument provides the opportunity for the inclusion of local provisions, either as stand alone clauses, and/or as additions to the main clauses in the Standard LEP. In addition, some clauses are optional.

It is recommended that the clauses for Floor Space Ratio, Minimum Subdivision Lot Size and Preservation of Trees and Vegetation be adopted.

It is also recommended that local provisions be incorporated for following:

- Part 4 of the Instrument
    - Reduced floor space ratio in E3 – Environmental Management and E4 - Environmental Living Zones.

- Part 6 of the Instrument
    - Matters of consideration for lands identified within the natural resource maps;
    - A provision relating to stormwater management.

Part 4 provisions

A minimum lot size of 1500m^2 is recommended for E3 and E4 zones. This size would reduce the potential for further subdivision, reducing potential significant losses of ecological values. Further consideration of lot size should be undertaken as part of the planning for the LEPs.

It is also recommended that a standard for floor space ratios, similar to that applied for the E4 zone in the KLEP (Local Centres), be applied to the E3 and E4 zones. The floor space ratio should be reduced for large sites, such that substantial dwellings on large lots would still be allowed, but protecting the ecological values of the locality.

Part 5 provision

The standard LEP instrument includes an optional clause for tree and vegetation preservation. It is recommended that this clause be adopted and supported by the DCP.

Part 6 provisions

Provisions linked to the natural resource maps should be included. The Department of Planning and Infrastructure has released draft model provisions for Natural Resource Management.

It is recommended that the provisions include matters of consideration for the consent authority which relate to the objectives. These should relate to both the protection of existing ecosystems and the consideration of opportunities for enhancement.

While not part of the draft model provisions, it is recommended that the clause include a provision requiring the consent authority to be satisfied that measures to achieve no net loss of significant vegetation or habitat have been considered:

- While every effort has been made to avoid setting up conflicts between natural environmental values and future development in the LEPs, the achievement of viable, residential areas, supported by services and infrastructure, and lively centres of various sizes may require some compromise of small but potentially significant patches of vegetation or habitat within a site.

- 'No net loss' recognises this need for flexibility. This flexibility may be achieved by the application of off-sets. Offsets are designed to make up for the loss of the natural values of a site, through improvements or protection. Offsets should only be used, where all other practical measures have been taken to prevent or mitigate environmental impacts. Any remaining adverse impacts are then offset by a range of management actions undertaken in such a manner that the actions maintain or improve biodiversity outcomes for the region.

- A policy to guide the implementation of 'no net loss' across the LGA is currently in preparation and would supplement the Biobanking Scheme, a state-wide offsetting program. The map overlays would provide a basis for decision making on the appropriateness of proposed donor offset sites and the selection of receiving sites. Provisions relating to 'no net loss' should be incorporated within Council's DCP.

A stormwater provision in relation to stormwater management is also recommended. The Department of Planning and Infrastructure has drafted a sample clause that requires urban development to:

- maximise water permeable surfaces to allow infiltration of water where soil allows;
- provide on site stormwater retention for re-use where practical; and
- minimise and mitigate downstream impacts on adjoining sites, bushland and watercourses.

It is recommended that a stormwater provision be included in the LEPs.

4.4 Development Control Plans

The incorporation of natural resource provisions and environment protection zones within the KLEP (Local Centres) and the PLEP will need to be supplemented by detailed provisions in the associated development control plans. These would most likely cover:

- the design, construction and management of uses in these zones, particularly with respect to dwellings (NSW Department of Planning: 2009),
- the encouragement of appropriate vegetation retention, regeneration and planting;
- measures to assist flora pollination and fauna food resources;
- measures to protect habitat;
- tree and vegetation preservation controls (outside the DA process); and
- opportunities for enhancement of ecological values as part of a development.

It is recommended that objectives and controls be provided for each Greenweb category, namely categories 1 to 5. Similarly, objectives and controls for the riparian lands should be provided for each category of riparian land.

It is recommended that the DCPs make it clear that certain general land management works are acceptable within Category 1 biodiversity lands. These works include the creation, upgrade and maintenance of fire trails, access roads, car parks and picnic areas on public lands, as well as the maintenance of asset protection zones.

It is also recommended that provision for a merit assessment of appropriate riparian setbacks be allowed in the DCP. Any merit assessment for a site that seeks to reduce a target distance, would need to demonstrate both the necessity for the reduced setback and how the proposal still meets the objectives for the identified category.

5 References

Aares, J. and Imes, R. A., 1997, The effect of habitat corridors in rates of transfer and interbreeding between vole demes. *Ecology* Vol. 80, pp. 1648-1655.

Adam, P. 2004, 'Urban bushland – stepping stones, living museums or cemeteries' in Lunney, D. and Burgin, S. (eds.), *Urban Wildlife: More than Meets the Eye*, Royal Zoological Society of NSW, Mosman, pp. 21–31.

Allen, CB, Benson, DH, James, T, & Kelleway, J (2007), *Vegetation map of the Sydney Harbour foreshore, December 2006*. Prepared for NSW Maritime and the Sydney Metropolitan CMA by the Royal Botanic Gardens Sydney.

Arnold, G. W. and Weeldenberg, J. R. 1990. 'Factors determining the number and species of birds in road verges in the Wheatbelt of Western Australia'. *Biological Conservation* vol. 53, pp. 295–315.

Australian Museum. 2005, *Birds Australia and Australian Museum Bird Friendly Spaces,* viewed September 2008, http://www.birdsinbackyards.net/spaces/bird-attracting-plants.cfm.

Bankstown City Council, 2002, *Bankstown Biodiversity Strategy – Draft for Public Exhibition June 2002,* Bankstown City Council.

Basham, R., 2005, *Microbats in Sydney's urban landscape: are they persisting and what factors influence their presence?* Honours Thesis. School of Biological, Earth and Environmental Sciences, University of New South Wales.

Bavins M, Couchman D, Beumer J, 2000, *Fisheries Guidelines for Fish Habitat Buffer Zones.* Queensland Fisheries Service & DPI.

Bennett, A. F. 1990, 'Habitat corridors and the conservation of small mammals in a fragmented forest environment', *Landscape Ecology,* vol. 4, pp. 109-122.

Benson, D. & Howell, J., 1994, *The Natural Vegetation of the Sydney 1:100 000 Map Sheet.*, Cunninghamia, vol. 3, no. 4.

BIObase, October 2010. Ku-ring-gai Council flora and fauna database.

Boldogh S, Dobrosi D and Samu P 2007. The effects of the Illumination of Buildings on House-dwelling Bats and its Conservation Consequences *Acta Chiropterologica* 9(2):527-534.

Bridgman, H., Warner, R. & Dodson, J., 1995, *Urban Biophysical Environments*, Oxford University Press, Melbourne.

Burton, A. & Hancock, N., 2007, *Bird surveys of selected Bushcare sites for Ku-ring-gai Municipal Council – June*, Unpublished.

Burton, A. & Hancock, N. 2007a, *Bird surveys of selected Bushcare sites for Ku-ring-gai Municipal Council – December*, Unpublished.

Burton, A. & Hancock, N. 2008, *Bird surveys of selected Bushcare sites for Ku-ring-gai Municipal Council – March*, Unpublished.

Burton, A. & Hancock, N. 2008a, *Bird surveys of selected Bushcare sites for Ku-ring-gai Municipal Council – June*, Unpublished.

Cadman, S. 2008, *Defining forests under the Kyoto Protocol: a way forward,* http://unfccc.int/files/methods_science/redd/application/pdf/seancadman1_12nov08.pdf.

Camden Council, 2003, *Camden Council Natural Assets Policy*, Available online at: http://www.camden.nsw.gov.au/page/natural_assets_policy.html.

Cannon A. 1999. 'Opinion the Significance of private gardens for bird conservation.' *Bird Conservation International* 9(4):287-297.

Catteral, C. P. 2004, 'Birds, gardens plants and suburban bushlots: where good intentions meet unexpected outcomes', in Lunney, D. and Burgin, S. (eds.), *Urban Wildlife: More than Meets the Eye*, Royal Zoological Society of NSW, Mosman, pp. 21–31.

Chamberlain D. E, Cannon A. R. and Toms M. P. 2004. *Associations of garden birds with gradients in garden habitat and local habitat*. *Ecography* 27(5):589-600.

Coates D.J and van Leeuwen S.J. 1996. "Delineating seed provenance areas for revegetation from patterns of genetic variation". *In: Proceedings of the second Australian workshop on Native Seed Biology for Revegetation.* Eds. S.M.Bellairs and J.M. Osborne, 11-12 October, 1996, Newcastle. Australian Centre for Minesite Rehabilitation Research. pp 3-14.

Commonwealth of Australia, 1999, *Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia, 2004, *National Biodiversity and Climate Change Action Plan 2004-2007.*

Commonwealth of Australia, 2001, *National Objectives and Targets for Biodiversity Conservation 2001–2005.*

Commonwealth of Australia, 1998, *The National Local Government Biodiversity Strategy 1998.*

Commonwealth of Australia, 1996, *The National Strategy for the Conservation of Australian Biodiversity 1996.*

Conacher Travers Pty. Ltd., 2000, *Ku-ring-gai Residential Development Strategy: Environmental Baseline Study, for Ku-ring-gai Municipal Council*, Sydney.

Connell Wagner Pty. Ltd., 2002, *Identification of Environmentally Sensitive Areas – Fauna Assessment.*

Drinnan, I.N. 2005, The Search for Fragmentation Thresholds in a Southern Sydney Suburb, *Biological Conservation*, vol.124, pp. 339–349.

Ecological Engineering. 2007. Lofberg Quarry Creek Sustainable Water Management Options Report. Report for Ku-ring-gai Council.

Fahrig, L. 2003. 'Effects of habitat fragmentation on biodiversity'. *Annual Review of Ecology, Evolution and Systematics* vol. 34, pp. 487-515.

Federal Government, 1999, *Environment Protection and Biodiversity Conservation Act (Commonwealth)* 1999.

Federal Government, *Department of Sustainability, Environment, Water Population and Communities Department of Environment and Heritage Annual Report*, 2005.

Federal Government, 2006, *Australia State of the Environment*, Australian Waterways Report to Australian Government for the Environment and Heritage, Australian Government.

Federal Government, Catterall, C.P., Lynch, R.J. & Jansen, A., 2007, Chapter 8, *Riparian Wildlife and Habitats in Principles for Riparian Lands Management*, Land and Water Australia, Australian Government.

Federal Government, Department of Sustainability, Environment, Water, Population and Communities, 2010, *Australia's Biodiversity Conservation Strategy 2010-2030,* Australian Government.

Hawkesbury-Nepean Catchment Management Authority, 2008, *Hawkesbury-Nepean Catchment Action Plan 2007-2016,* Hawkesbury-Nepean Catchment Management Authority, Goulburn.

Fischer, J and Lindenmayer, D. B. (2002), *Small patches can be valuable for biodiversity conservation: two case studies on birds in southeastern Australia*. *Biological Conservation* 106: 129-136

Fox C., Giutronich S., Pieris H., Rowling R., 2001, *Habitat Corridors for Wildlife Conservation in Manly Local Government Area: Solution or Inexpedient in Vogue Practice?,* Wildlife Unlimited.

Gonsalves L, Lamb S, Monamy V, Law B and Webb C, 2009. *An investigation of the importance of declining coastal saltmarsh communities to insectivorous bat species.* Poster presentation given at the 10th International Congress of Ecology (INTECOL), 17-21 August 2009, Brisbane, Queensland, Australia. Available online: http://www.dpi.nsw.gov.au/research/areas/fre/scientific-outputs/2009/1572, 13/12/2011

Hodgson, P.R. 2005, *Characteristics of Urbanisation that Influence Bird Communities in Suburban Remnant vegetation*, University of Wollongong.

Hodgson, P.R., French, K. & Major, R. E. 2006, 'Avian Movement Across Abrupt Ecological Edges: Differential Responses to Housing Density in an Urban Matrix'. *Landscape and Urban Planning*, vol. 79, issue no. 3-4, pp. 266-272.

Horn, T. 2003, *South East Biodiversity Corridor Strategy*. Foresty South Australia.

Hoye, G. and Spence, J.2004, 'The Large Bent-wing Bat *Miniopterus schreibersii* in urban environments: a survivor?', in Lunney, D. and Burgin, S. (eds.), *Urban Wildlife: More than Meets the Eye*, Royal Zoological Society of NSW, Mosman, pp. 138–147.

James, T. 1997, *Native Flora in Western Sydney: Urban Bushland Biodiversity Survey*, New South Wales National Parks & Wildlife Service.

Jones J. (2000). *Impact of Lighting On Bats.* Available online: http://www.lbp.org.uk/downloads/Publications/Management/lighting_and_bats.pdf. 13/12/11

Jordán, F. 2000, 'A Reliability-Theory Approach to Corridor Design', *Ecological Modelling*, vol. 128, pp. 211-220.

Kavanagh, R.P. 2004, 'Conserving Owls in Sydney's Urban Bushland: Current Status and Requirements', in Lunney, D. and Burgin, S. (eds.), *Urban Wildlife: More than Meets the Eye*, Royal Zoological Society of NSW, Mosman, pp. 93–108.

Kelleway J, Williams RJ, and Allen CB (2007). *An assessment of the saltmarsh of the Parramatta River and Sydney Harbour*. NSW Department of Primary Industries.

Ku-ring-gai Council (KC), 1971 as amended 31 October 2008, *Ku-ring-gai Planning Scheme Ordinance,* Ku-ring-gai Council.

Ku-ring-gai Council (KC),1996, *Flying Fox Reserve Management Plan* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 1998, *Fauna Management Policy,* Ku-ring-gai Council.

Ku-ring-gai Council (KC),1999, *Bushland Fauna Assessment Guidelines*, Ku-ring-gai Council.

Ku-ring-gai Council (KC) 1999, *Tree Management Policy*, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2001, *Natural Area and Non-natural Area vegetation mapping in Ku-ring-gai LGA*. Digital data files held within Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2003, *Generic Parks Plan of Management*, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2004, *Riparian Policy – December 2004 Managing Watercourses and Riparian Zones in the Ku-ring-gai Local Government Area*, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2005, *Development Control Plan 47 – Water Management,* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2005a, *Community Environmental Research Project 2005*, Unpublished, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2005b, *Council Open Space Strategy,* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2005c, *Generic Plan of Management for Parks in Ku-ring-gai,* Ku-ring-gai Council.

Ku-ring-gai Council, 2005d, *Plan of Management*, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2006. *Biodiversity Strategy May 2006,* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2006a, *The Ku-ring-gai Residential Design Manual-Development Control Plan 38,* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2006b, *Bushland Reserves Plan of Management,* Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2006c, *Development Control Plan 55, Railway / Pacific Highway Corridor and St Ives Centre.* Ku-ring-gai Council.

Ku-ring-gai Council (KC) 2007, *Weed Management Policy*, Ku-ring-gai Council.

Ku-ring-gai Council (KC). 2008, *Bush Fire Prone Lands Mapping – Certified 2nd January 2008 by the Commissioner, NSW Rural Fire Service*.

Ku-ring-gai Council (KC). 2008a, *Sustainability Vision Report 2008-2033.*

Ku-ring-gai Council (KC), 2011, *Managing Bushfire Risk, Now and into the Future, Draft Background Study*, Ku-ring-gai Council.

Ku-ring-gai Council (KC), 2012a, *Mapping and assessment of key vegetation communities across the Ku-ring-gai local government area, Volume 1 – Technical Report,* Ku-ring-gai Council Report.

Ku-ring-gai Council (KC), 2012b, *Mapping and assessment of key vegetation communities across the Ku-ring-gai local government area, Volume 2 – Vegetation communities.* Ku-ring-gai Council Report.

Lake, J. C and Leishman, M.R. 2004, Invasion success of exotic plants in natural ecosystems: the role of disturbance, plant attributes and freedom from herbivores, *Biological Conservation* 117, pp. 215–226

Lindenmayer, D.B. and Nix, H.A., 1993, *Ecological principles for the design of wildlife corridors*, Conservation Biology, Volume 7, pp. 627-630.

Lindenmeyer, D. B. 1997, 'Wildlife Corridors and the Mitigation of Logging Impacts on Fauna in Wood-Production Forests in South-Eastern Australia: a Review'. *Wildlife Research*, vol, 21, no. 3, pp. 323-340.

Liverpool City Council (LCC), 2003, *Biodiversity Strategy*, Liverpool City Council Report.

Loch D. and Whalley R.D.B., 1997. Native Grassland Rehabilitation: The Place of Provenance Seed. *In: Proceedings of the First workshop of the Australian Native Grass and Legume Seed Industry Association Inc.*, 22 Oct 1997. Brisbane. pp 59-69.

Longcore T and Rich C 2004 Ecological light pollution *Frontiers in Ecology and Environment* 2(4):191-198.

NSW Department of Environment and Climate Change, *NSW Greenhouse Plan - NSW Greenhouse Office 2005*, Department of Environment and Climate Change, Hurstville.

NSW Department of Environment and Conservation, 2005, *Recovering Bushland on the Cumberland Plain, Best Practice Guidelines for the Management and Restoration of Bushland*, Department of Environment and Climate Change, Hurstville.

NSW Department of Environment and Conservation, 2006, NSW Recovery plan for the large forest owls: Powerful Owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*). Department of Environment and Conservation, Sydney.

NSW Department of Environment and Climate Change, 2007a, *Flying-fox camp management policy.* Department of Environment and Climate Change NSW, Sydney.

NSW Department of Environment and Climate Change, 2007b, *Threatened and Pest Animals of Greater Southern Sydney*, NSW Department of Environment and Climate Change, Sydney.

NSW Department of Environment and Climate Change, 2007c, *Guidelines for the management of Duffys Forest ecological community remnants: buffers and adjoining Vegetation.* NSW Department of Environment and Climate Change, Sydney.

NSW Department of Environment and Climate Change (DECC), 2008. *Protecting and restoring Coastal saltmarsh*. Department of Environment and Climate Change NSW 59–61 Goulburn Street, Sydney. Available on line: *http://www.environment.nsw.gov.au/resources/threatenedspecies/08609coastalsaltmarshbro.pdf* 13/12/2011

NSW Department of Environment and Climate Change (DECC), 2008a. *BioBanking Assessment Methodology*, NSW Department of Environment and Climate Change, Sydney.

NSW Department of Environment and Climate Change (DECC) 2008b. *BioBanking Assessment Methodology and Credit Calculator Operational Manual*. NSW Department of Environment and Climate Change, Sydney.

NSW Department of Environment and Climate Change, 2008c, *Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area*, Department of Environment and Climate Change, Hurstville.

NSW Department of Environment, Climate Change and Water (DECCW), 2009, *The Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area*. Department of Environment and Climate Change NSW, Hurstville.

NSW Department of Environment and Climate Change (DECC), 2010, *NSW Wetlands Policy*. Department of Environment, Climate Change and Water NSW 59–61 Goulburn Street, Sydney. Available on line: http://www.environment.nsw.gov.au/resources/water/10039wetlandspolicy.pdf, 13/12/11

NSW Department of Environment, Climate Change and Water (DECCW) 2011, *Operational Manual for BioMetric 3.1*. Department of Environment, Climate Change and Water, NSW Sydney.

NSW Department of Environmental Heritage, 2005, *Biodiversity Toolbox for Local Government*, October 2005, Available online: http://www.environment.gov.au/biodiversity/toolbox/index.html.

NSW Department of Infrastructure Planning and Natural Resources, 2004, *Riparian Corridor Management Study: Covering all of the Wollongong Local Government Area and Calderwood Valley in the Shellharbour Local Government Area*. Prepared for Wollongong City Council by Department of Infrastructure Planning and Natural Resources.

NSW Department of Climate Change and Water, 2005, *NSW Greenhouse Plan,* 2005.

NSW Department of Environment and Climate Change 2010, *Draft NSW Biodiversity Strategy 2010-2015.*

NSW Department of Environment and Conservation, and NSW Department of Natural Resources 2006, *Southeast New South Wales Native Vegetation Classification and Mapping – SCIVI*, 2006.

NSW Department of Planning, 2007 *North Subregion: Draft Subregional Strategy*.

NSW Department of Planning, 2005, *Sydney Harbour Foreshores and Waterways Area Development Control Plan 2005*.

NSW Department of Planning, 2009, *Practice Note: PN 09-002 Environmental protection zones*

NSW Department of Planning, 2010, *Metropolitan Strategy -Sydney Towards 2036.*

NSW Office of Water (NOW), 2011, *Controlled activities - Guidelines for riparian corridors*. Available online: http://www.water.nsw.gov.au/Water-licensing/Approvals/Controlled-activities/Controlled-activities/default.aspx 09/12/2011

NSW Scientific Committee (NSW SC) 2007, Blue *Gum High Forest in the Sydney Basin Bioregion - critically endangered ecological community listing, NSW Scientific Committee - final determination*, Available online: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/blue_gum_high_forest_endangered 30/01/2008.

NSW Scientific Committee (NSW SC) 1998, Sydney *turpentine-ironbark forest - endangered ecological community listing, NSW Scientific Committee - final determination,* Available online: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Sydney+turpentine+ironbark+forest+endangered+ecological+community+listing, 30/01/2008.

NSW Scientific Committee (NSW SC) 1998a, *Duffys Forest ecological community in the Sydney Basin Bioregion - endangered ecological community listing, NSW Scientific Committee - final determination*, Available online: http://www.environment.nsw.gov.au/determinations/DuffysForestEcologicalCommunitySydneyEndComListing.html, 23/10/2008.

NSW Rural Fire Service (RFS) 2006, *Guideline for Bushfire Prone Land Mapping*, Available online: http://www.rfs.nsw.gov.au/file_system/attachments/State08/Attachment_20070228_06EF9BB7.pdf, 16/12/2010.

NSW Rural Fire Service (RFS) 2006a, *Planning for Bushfire Protection*, NSW Government.

NSW State Government, 1974, *National Parks and Wildlife Act, 1974 (NSW).*

NSW State Government 1979, *Environmental Planning and Assessment Act 1979 (NSW) (and associated Section 117 directions)*.

NSW State Government 1974, *National Parks and Wildlife Act1974 (NSW).*

NSW State Government, 1986, *State Environmental Planning Policy Number 19-Bushland in Urban Areas.*

NSW State Government, 1993, *Local Government Act 1993 (NSW).*

NSW State Government, 1994, *Fisheries Management Act 1994 (NSW).*

NSW State Government 1995, *Threatened Species Conservation Act 1995 (NSW) (TSC Act).*

NSW State Government, 1997, *Rural Fires Act, 1997 (NSW).*

NSW State Government 1997, *Sydney Regional Environmental Plan No 20—Hawkesbury-Nepean River (No 2—1997)*.

NSW State Government, 2000, *State Environmental Planning Policy Number 44-Koala Habitat Protection,* 2000.

NSW State Government, 2000, *Water Management Act*, 2000.

NSW State Government, 2002, *Green Offsets for Sustainable Development*, 2002.

NSW State Government, *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*.

NSW State Government, 2009, *Sydney Metropolitan Catchment Action Plan (CAP)*, 2009.

NSW State Government, 2010 *State Plan – Investing in a Better Future 2010*.

NSW State Government, 2011, *Water Management (General) Regulation*, 2011

Panse S. 2009 *Genetic Erosion* .Bright Hub. Available on line: http://www.brighthub.com/science/ genetics/articles/43678.aspx#ixzz1bE5Jr79S

Price, P. & Tubman, W. 2007, *Structure and Characteristics of riparian lands in Principles for Riparian Lands Management*, Land and Water Australia, Canberra, Chapter 1.

Queensland Government, 2010, *Fauna Sensitive Road Design Manual: Volume 2*, Department of Transport and Main Roads.

Rowley L., Edwards R., Kelly P., Land for Wildlife, 1999, *Edges – Their Effect on Vegetation and Wildlife*, Bushcare – Natural Heritage Trust.

Royal Botanical Gardens and Domains Trust, 2010, *Flying Foxes*, Article Online, Available:http://www.rbgsyd.nsw.gov.au/welcome_to_bgt/royal_botanic_garden/gardens_and_domain/wildlife/flying-foxes 14/2/2011.

Saunders D.A, Arnold GW, Burbidge AA, 1987, *Nature Conservation: The Role of Remnants of Native Vegetation*, Surrey Beatty and Sons, Sydney.

Saunders D.A., Hobbs, R.J, 1991, *Nature Conservation 2: The Role of Corridors*, Surrey Beatty and Sons, Sydney.

Sivertsen, D 2009 *Native Vegetation Interim Type Standard*, Department of Environment, Climate Change and Water NSW, Sydney.

Smith, J. and Smith, P. 1997, *Buffer Zones for the Protection of Sensitive Vegetation Units in the City of Blue Mountains.* Report to Blue Mountains City Council.

Smith, P. and Smith, J. 2001, *Ku-ring-gai Bushland Fauna Assessment*. Report to Ku-ring-gai Municipal Council.

Smith, P. and Smith, J. 2003, *Ku-ring-gai Bushland Fauna Assessment*. Report to Ku-ring-gai Municipal Council.

Smith, P. and Smith, J. 2004, *Ku-ring-gai Bushland Fauna Assessment*. Report to Ku-ring-gai Municipal Council.

Smith, P. and Smith, J. 2005, *Ku-ring-gai Bushland Fauna Assessment*. Report to Ku-ring-gai Municipal Council.

Specht, R. 1981, in Gillison. A.N. and Anderson, D. J. (eds) *Vegetation classification in Australia.* CSIRO/Australian National University Press, Canberra.

Stone E, Jones G. and Harris S. 2009, Street Lighting Disturbs Commuting Bats *Current Biology* 19:1123-1127.

Strahler, A. N. 1952, Hypsometric (area-altitude) analysis of erosional topography. *Bulletin of the Geological Society of America* 63:1117-1142.

Sydenham, S & Thomas, R. 2003, Mangroves in Australia. *Available Online:*]www.kidcyber.com.au, 13/12/11.

Sydney Metropolitan Catchment Management Authority (SM CMA) 2008, *Sydney Harbour Foreshore & Estuarine Vegetation Mapping*.

Sydney Metropolitan Catchment Management Authority. 2009, *Sydney Metropolitan Catchment Action Plan, Available Online: http://www.sydney.cma.nsw.gov.au/about-us/sydney-metropolitan-catchment-action-plan-cap.html,* 03/02/2011.

Tewkesbury, J. J., Douglas, J. L., Haddad, N. M., Sargent, S., Orrock, J. L., Weldon, A., Danielson, B. J., Brinkerhoff, J., Damschen, E. I. and Townsend, P. 2002. *'Corridors affects plants, animals, and their interactions infragmented landscapes'.* Proceedings of the National Academy of Sciences vol. 99, no. 20, pp. 12923-12926.

Thumm, K. 1997, *The Red-crowned Toadlet, Pseudophryne australis.* National Parks and Wildlife Service report.

Tischendorf, L. and Wissel, C. 1997, 'Corridors as Conduits for Small Animals: Attainable Distances Depending on MovementPattern, Boundary Reaction and Corridor Width'. *OIKOS* vol. 79, pp. 603-611.

Tozer, M. 2003, The Native Vegetation of the Cumberland Plain, 'Western Sydney: Systematic Classification and Field Identification of Communities', *Cunninghamia,* vol. 8, no.1, pp. 1-75.

Tzilkowski W. M, Wakeley J. S. and Morris L. J. 1986. *Relative Use Of Municipal Street Trees By Birds During Summer In State College*, Pennsylvania *Urban Ecology* 9:387-398.

Walsh, C. J., Leonard, A. W., Ladson, A. R., Fletcher, T. D. 2004. *Urban stormwater and the ecology of streams.* Cooperative Research Centre for Freshwater Ecology and Cooperative Research Centre for Catchment Hydrology, Canberra.

Welch J M. 1994. *Street and park trees of Boston: a comparison of urban forest structure*. *Landscape and Urban Planning* 29:13-43.

West G and Williams R (2008) *A preliminary assessment of the historical, current and future cover of seagrass in the estuary of the Parramatta River.* NSW Department of Primary Industries, Cronulla.

Whelan, R. J., Roberts, D. G., England, P. R and Ayre, D. J. 2006, "The potential for genetic contamination vs. augmentation by native plants in urban gardens." In *Biological Conservation* 128: 493-500

Wilks, D. 2010, *A hotbed of biodiversity? A natural history of the Ku-ring-gai Council* area. in Lunney, D. Hutchings, P and Hochuli, D (eds.) *The Natural History of Sydney*. Royal Zoological Society of NSW, Mosman pp. 282-300.

Young K. M, Daniels C. B .and Johnston G. 2007, *Species of street tree is important for southern hemisphere bird trophic guilds.* Austral Ecology 32(5):541–550.

Appendix A Fauna Data Analysis

Since 1998, Council has commissioned a number of fauna surveys within Councils care control and management as part of its ongoing fauna management program (as summarised in Table A1).

Analysis of fauna data was undertaken, including:
- Invasive Predation Index
- Bush/Urban Bird Index
- Introduced/Native Species Proportions
- Species Diversity Analysis

Analysis guidelines for Bush/Urban Bird Index and Species Diversity Analysis described by Smith and Smith (2005) were used. Guidelines for Invasive Predation Index and Introduced: Native Species Proportions were adopted from Ku-ring-gai Municipal Council (1999).

Invasive Predation Index :

Ku-ring-gai contains four main invasive predators considered in these studies. These include the Black rat (*Rattus rattus*), the Red fox (*Vulpes vulpes*), feral/domestic cat *(Felis catus) and feral/domestic dog* (*Canis lupis)*. The number of invasive predator species identified in each plot is recorded.

	Level of Predation	Definition
Predation Index	Very High	All introduced predators recorded
	Moderate	2 to 3 introduced species
	Low	1 introduced species recorded
	Absent	No introduced species

Bush/Urban Bird Index:

The Bush/Urban Bird Index is a comparative measure of the proportion of bird species denoted as 'Urban birds' to those denoted as 'Bush birds'. Urban birds are ones which prefer urban environments, for example gardens, lawns, parks and buildings, where as Bush birds prefer bushland environments.

Refer to Table A2 for urban bird species list.

	Bush/Urban Bird Index	Definition
Bush / Urban Bird Index	Very High	>80% to 100% Bush birds
	High	>60% to 80% Bush birds
	Moderate	>40% to 60% Bush birds
	Low	>20% to 40% Bush birds
	Very Low	0% to 20% Bush birds

Introduced/Native Species Proportions:

The Introduced/Native Species Proportions Index is a comparative measure of the overall proportion of introduced species to those denoted as native species.

Introduced / Native Species Proportions (number of introduced species x100) / number of native species	Level of Introduced /Native Species	Definition
	Very High High Moderate Low Very Low	> 60% Introduced species >35 to 60% Introduced species >20 to 35% Introduced species >5 to 20% Introduced species 0 to 5% Introduced species

Species Diversity Analysis:

The following indexes are relative guides regarding the number of different Mammal, Reptile and Bird species throughout Ku-ring-gai (adopted from Smith and Smith, 2005).

This analysis excluded introduced species, but urban native species were included.

Fauna Class	Diversity Index	Definition
Mammals	Very High High Moderate Low Very Low	15 or more native species recorded in plot 10-14 native species recorded in plot 6-9 native species recorded in plot 3-5 native species recorded in plot 0-2 native species recorded in plot
Reptiles	Very High High Moderate Low Very Low	10 or more native species recorded in plot 7-9 native species recorded in plot 4-6 native species recorded in plot 2-3 native species recorded in plot 0-2 native species recorded in plot
Birds	Very High High Moderate Low Very Low	40 or more native species recorded in plot 30-39 native species recorded in plot 23-29 native species recorded in plot 16-22 native species recorded in plot 0-15 native species recorded in plot

Table A1: Fauna Assessment Summary Table

Study	*Types*	*Season*	*Catchment/s*	*Geology▲*	*Sites*	*Limitations*
P & J Smith (2001)	Frog Reptile Bird Mammal	Summer / Autumn (December – March)	Cowan Creek	Hawkesbury Sandstone	1. Golden Jubilee Oval	Catchments surveyed sequentially: • LCR surveyed in Dec. 2000 • CC surveyed in Jan-Feb 2001 • MH surveyed in Feb-Mar 2001 Timing of reptile surveys not ideal in regard to reptile activity patterns.
					2. Barton Crescent	
					3. Lovers Jump Creek	
					5. Clissold Road	
					6. Branch of Cowan Creek	
					10. Ku-ring-gai Creek	
				Hawkesbury Sandstone and Mittagong Formation	9. Edgecombe Reserve	
					11. St. Ives Showground	
				Ashfield Shale	4. Clive Evatt Reserve	
					7. Maddison Reserve	
			Middle Harbour	Hawkesbury Sandstone	12. Dingley Dell	
					13. Lawson Parade	
					14. Richmond Park	
					15. Gordon Park	
					17. Koola Avenue	
					18. Seven Little Australians	
					19. Soldiers Memorial Park	
					20. Carlyle Road	
					21. Roseville Chase	
				Ashfield Shale	8. Browns Forest	
			Lane Cove River	Hawkesbury Sandstone	16. Little Blue Gum Creek	
					22. Lady Game Drive	
					23. The Comenarra	
					24. Bradley Reserve	
					25. Rofe Park	
					27. Browns Road	
					28. Twin Creeks Reserve	
				Ashfield Shale	26. Sheldon Forest	
					29. Duff Street Reserve	
					30. The Glade	

Study	Types	Season	Catchment/s	Geology▲	Sites	Limitations
P & J Smith (2003)	Frog Reptile Bird Mammal	Summer (January)	Lane Cove River	Hawkesbury Sandstone	16. Little Blue Gum Creek	Previously surveyed in December 2000. Bushfire (affecting 3 plots) and drought since the 2000 survey. Reptile survey method altered (more frequent surveying and later starting time).
					22. Lady Game Drive	
					23. The Comenarra	
					24. Bradley Reserve	
					25. Rofe Park	
					27. Browns Road	
					28. Twin Creeks Reserve	
				Ashfield Shale	26. Sheldon Forest	
					29. Duff Street Reserve	
					30. The Glade	
P & J Smith (2004)	Frog Reptile Bird Mammal	Summer (January)	Middle Harbour	Hawkesbury Sandstone	12. Dingley Dell	Previously surveyed in February and March 2001. This has implications for: - frog and bird breeding seasons and call patterns - bird counts which may be affected by plant flowering (especially *C. gummifera*) Reptile survey method altered.
					13. Lawson Parade	
					14. Richmond Park	
					15. Gordon Park	
					17. Koola Avenue	
					18. Seven Little Australians	
					19. Soldiers Memorial Park	
					20. Carlyle Road	
					21. Roseville Chase	
				Ashfield Shale	8. Browns Forest	
P & J Smith (2005)	Frog Reptile Bird Mammal	Summer (January)	Cowan Creek	Hawkesbury Sandstone	1. Golden Jubilee Oval	Below average rainfall since 2001 survey. Increase in mammal records due to increase in microbats which may be from weather changes. Reptile survey method altered.
					2. Barton Crescent	
					3. Lovers Jump Creek	
					5. Clissold Road	
					6. Branch of Cowan Creek	
					10. Ku-ring-gai Creek	
				Hawkesbury Sandstone and Mittagong Formation	9. Edgecombe Reserve	
					11. St. Ives Showground	
				Ashfield Shale	4. Clive Evatt Reserve	
					7. Maddison Reserve	

Study	Types	Season	Catchment/s	Geology▲	Sites	Limitations
Burton and Hancock (1. 2007a, 2. 2007b, 3. 2008a, 4. 2008b, 5. 2008c)	Bird	1. Autumn / Winter (Apr-Jun) 2. Spring (Sep-Dec) 3. Summer (Dec-Feb) 4. Autumn (Apr-May) 5. Winter (July-Aug)	Cowan Creek	Hawkesbury Sandstone / Lateritic	1. Ku-ring-gai Wildflower Garden	Different methods to Smith & Smith, including: - time of day - duration of survey Controlled burn at Kokoda and Kingsford sites . Weed removal at Redfield Road site Re-colonisation of weeds at Redfield Road site.
				Hawkesbury Sandstone	2. Palm Street	
				Shale	3. Karuah Road	
				Clay on shale	4. Kokoda Trail	
			Middle Harbour	Hawkesbury Sandstone	1. High Ridge Creek	
					2. Darnley Oval	
					3. Sandpaper Creek	
					4. Redfield Road	
					5. Flying-fox Reserve	
					6. Terrum-bine Reserve	
			Lane Cove River	Hawkesbury Sandstone / Volcanic	1. Browns Field	
				Shale	2. Sheldon Forest	
				Hawkesbury Sandstone	3. Twin Creeks	
					4. Kingsford Avenue	
					5. Blackbutt Creek	
				Hawkesbury Sandstone / Shale	6. Princes Park	
					7. Little Blue Gum Creek	
Connell Wagner (2002)	Reptile Bird Mammal		Lane Cove River	Hawkesbury Sandstone	8. Lady Game Drive	
					9. Avondale Golf Club	
					10. Twin Creeks Reserve	
			Middle Harbour	Hawkesbury Sandstone	4. Moores Creek	
					6. Carcoola Road	
					7. Stoney Creek	
			Cowan Creek	Hawkesbury Sandstone	1. Lovers Jump Creek	
					2. Branch of Cowan Creek (lower)	
					3. Branch of Cowan Creek (upper)	

Study	***Types***	***Season***	***Catchment/s***	***Geology▲***	***Sites***	***Limitations***
					5. Ku-ring-gai Creek	

Table A2: Urban Bird Species List**

Urban Bird List (adopted from Smith and Smith, 2005) Urban birds are those which are able to inhabitat urban areas, such as parks, sporting ovals and buildings (Smith and Smith, 2005). Urban birds may be introduced or native species.	
Australian King Parrot	Australian Magpie
Australian Raven	Australian Wood Duck
Channel-billed Cuckoo	Common Blackbird
Common Koel	Common Myna
Crested Pigeon	Crimson Rosella
Eastern Rosella	Galah
Grey Butcherbird	Laughing Kookaburra
Little Corella	Long-billed Corella
Magpie-lark	Masked Lapwing
Noisy Miner	Pied Currawong
Rainbow Lorikeet	Red Wattlebird
Red-whiskered Bulbul	Rock Dove
Silver Gull	Silvereye
Spotted Turtle-dove	Sulphur-crested Cockatoo
Superb Fairy-wren	Welcome Swallow
Willy Wagtail	

Ku-ring-gai Municipal Council

Fauna Data Analysis: Species Richness

Legend

- Very Low
- Low
- Moderate
- High
- Very High

Faunal Group: Mammals, Reptiles, Birds

Other Information: Natural Area; Catchment Boundary; IN Introduced/Native Species Index; PI Predation Index; UBI Bush/Urban Bird Index

- Fauna Assessment - 2002 - Connell Wagner
- Bird Surveys - Burton & Hancock 2007
- Fauna Assessment - P & J Smith (2003,2004,2005)

References

Ku-ring-gai Municipal Council (2008) *Fauna Data Analysis Report* Sydney NSW.
Smith, P. & J. (2003) *Ku-ring-gai Bushland Fauna Assessment*
Smith, P. & J. (2004) *Ku-ring-gai Bushland Fauna Assessment*
Smith, P. & J. (2005) *Ku-ring-gai Bushland Fauna Assessment*
Connell Wagner Pty Ltd (2002) *Ku-ring-gai Council Identification of Environmentally Sensitive Areas: Fauna Assessment*
Burton, A. & Hancock, N. (2007) *Bird Surveys of selected Bushcare Sites for Ku-ring-gai Municipal Council*

COWAN CREEK CATCHMENT

MIDDLE HARBOUR CATCHMENT

LANE COVE RIVER CATCHMENT

KU-RING-GAI CHASE NATIONAL PARK

WAHROONGA · TURRAMURRA · PYMBLE · ST.IVES · GORDON · KILLARA · LINDFIELD · ROSEVILLE · GARIGAL

Site 1: Golden Jubilee Oval
Site 5: Clissold Street
Site 2: Grosvenor Street
Site 10: Ku-ring-gai Creek
Site 2: Branch of Cowan Creek (lower)
Site 6: Branch of Cowan Creek
Site 1: Lovers Jump Creek
Site 3: Branch of Cowan Creek (upper)
Site 4: Clive Evatt Reserve
Site 5: Ku-ring-gai Creek
Site 11: St Ives Showground
Site 30: The Glade
Site 9: Edgecombe Road
Site 29: Duff Street
Site 3: Lovers Jump Creek
Site 6: Carcoola Road
Site 27: Browns Road
Site 13: Lawson Parade
Site 7: Maddison Reserve
Site 12: Dingley Dell
Site 26: Sheldon Forest
Site 10: Twin Creeks Reserve
Site 15: Gordon Park
Site 7: Stoney Creek
Site 28: Twin Creeks
Site 8: Browns Forest
Site 17: Koola Avenue
Site 19: Soldiers Memorial Park
Site 25: Rofe Park
Site 14: Richmond Park
Site 18 Seven Little Australians
Site 20: Carlyle Road
Site 24: Bradley Reserve
Site 23: The Comenarra
Site 22: Lady Game Drive
Site 9: Avondale Golf Course
Site 16: Little Blue Gum Creek
Site 21: Moores Creek
Site 8: Lady Game Drive
Site 4: Moores Creek

Ku-ring-gai Wildflower Garden · St Ives Showground · Browns Field · Twin Creeks Reserve · Sheldon Forest · Step Track · Kokoda Trail · Karua Road · Palm Street · Sandpaper Creek · Darnley Oval · Flying Fox Reserve Site 2 · Flying Fox Reserve Site 1 · Redfield Road · Terrumbine Reserve · Blackbutt Creek · High Ridge Creek · Princes Park · Little Blue Gum Creek

Wahroonga Stn · Warawee Stn · Turramurra Stn · Pymble Stn · Gordon Stn · Lindfield Stn · Roseville Stn

500 0 500 1000 2000

Appendix B Vegetation Condition Class

Source: KC 2011a

Condition Class	Condition Name	Condition ID	Canopy Density	Description
Good	Dense bushland	A	>10%	Canopy, midstorey and understorey in good condition. Regeneration occurring within all layers. Native dominated within all layers.
	Scattered bushland	B	<10%	Canopy, midstorey and understorey in good condition. Regeneration occurring within all layers. Native dominated within all layers.
Moderate	Dense native	TXND	>10%	Native medium to dense tree overstorey, with native shrub and ground layers, and Native dominated within 2 layers.
	Scattered native	TXN	<10%	Native scattered tree overstorey, with native shrub and ground layers, and Native dominated within 2 layers.
Low	Dense urban vegetation	TXUD	>10%	Native medium to dense tree overstorey, with no or limited native shrub and ground layers, and / or < 2 layers native dominated.
	Scattered urban vegetation	TXU	<10%	Native scattered tree overstorey, with no or limited native shrub and ground layers, and / or < 2 layers native dominated.

Condition Class	Condition Name	Condition ID	Canopy Density	Description
	Regeneration	R	Any	Regeneration occurring but canopy not evident.
	Non native canopy potential regeneration	Cmi	Any	Non native canopy cover. May contain natives within shrub and /or understorey layers. Area connected to other remnant vegetation, soil seed bank may contain natives. Eg. Privet patch within reserve, or drainage line with scattered native ground cover but weed dominated canopy.
Other	Garden	G	Any	Garden / landscaping associated with commercial and residential buildings etc. Consisting of planted vegetation including exotic, non-local native species or native local plantings.
	Planting	P	Any	Planting native (local and non local) or exotics, associated with parklands, street verges and other public owned lands.

Assessment of Density for Condition:

1. < 3 trees TXU
2. ≥ 3 trees:
   a) Assess density over a 20x20m area
   b) Assess % canopy: ≥ 10% TXUD, <10% TXU

Appendix C Management of Biodiversity Connectivity within Regional Fauna Habitat and Biodiversity Corridors within Ku-ring-gai

MANAGEMENT OF BIODIVERSITY CONNECTIVITY WITHIN REGIONAL FAUNA HABITAT AND BIODIVERSITY CORRIDORS WITHIN KU-RING-GAI






Ku-ring-gai Council
November 2011

Cover Page Pictures

1	2	3
4	5	6

Photo Sources:

1. Common Eastern Froglet
2. *Boronia ledifolia*
3. Yellowtail Black Cockatoo
4. Middle Harbour
5. Replanting Native Flora in Seven Little Australians Park, Lindfield
6. Middle Harbour

Revision	Details	Date
Public exhibition draft	*Management of Biodiversity Connectivity Within Regional Fauna Habitat and Biodiversity Corridors Within Ku-ring-gai*	February 2011
Agency Consultation Draft	*Management of Biodiversity Connectivity Within Regional Fauna Habitat and Biodiversity Corridors Within Ku-ring-gai v.2*	November 2011

Table of contents

1 Purpose

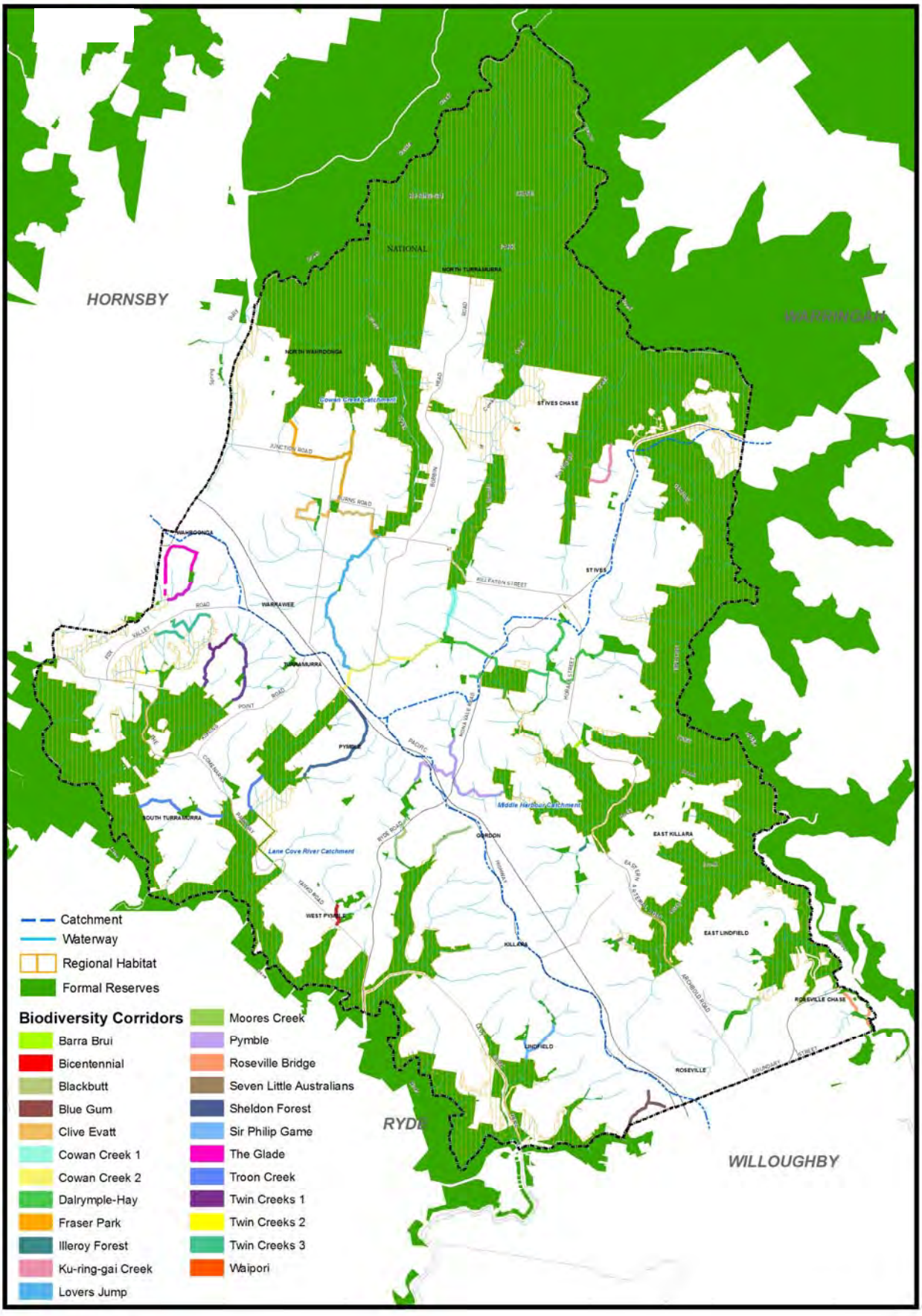
This document describes the limitations and opportunities supporting the continuation and creation of Biodiversity Corridors. The actions contained are relevant to both public and private land.

2 Objectives for Management of Biodiversity Connectivity within Regional Fauna Habitat and Biodiversity Corridors in Ku-ring-gai

The management objectives of biodiversity corridors within Ku-ring-gai include:

- Conserve the existing native flora and fauna in Ku-ring-gai
- Protect and increase abundance and dispersal of threatened flora and fauna species and populations
- Minimise obstructions to fauna migration through the consideration of design and construction
- Provide opportunities for habitat and foraging, such as the provision of winter flowering plants for migratory species
- Maximise the area and structural diversity of native vegetation, especially in areas adjacent to reserves and natural areas
- Provide vegetation and structure to encourage native fauna (such as small flowered Grevillea to attract butterflies) (Australian Museum 2005)
- Maximise the width of biodiversity corridors and retained vegetation
- Maintain islands of structured vegetation
- Encourage co-operative research projects to improve understanding and management of corridors within Ku-ring-gai
- Facilitate community awareness of flora and fauna conservation and encourage partnership with landowners

Figure C1:


HORNSBY
WILLOUGHBY
Catchment
Waterway
Regional Habitat
Formal Reserves
Biodiversity Corridors
Barra Brui
Bicentennial
Blackbutt
Blue Gum
Clive Evatt
Cowan Creek 1
Cowan Creek 2
Dalrymple-Hay
Fraser Park
Illeroy Forest
Ku-ring-gai Creek
Lovers Jump
Moores Creek
Pymble
Roseville Bridge
Seven Little Australians
Sheldon Forest
Sir Philip Game
The Glade
Troon Creek
Twin Creeks 1
Twin Creeks 2
Twin Creeks 3
Waipori

3 Management of biodiversity corridors

This section addresses short and long term strategies relevant to the future management of biodiversity corridors within Ku-ring-gai. In its design and treatment of bushland and urban matrix areas within biodiversity corridors, Council is highly aware of the need to balance the needs of users and the environmental qualities of the corridor. These areas include private lands used for recreation, gardening and other private residential uses. The detailed management responses of biodiversity corridors vary depending on each site and those options will differ for each corridor. For example, it is impractical to re-establish tree canopy coverage over Ryde Road to allow for sugar glider transport. However, the possible addition of poles at appropriate locations along the median strip may provide 'stop over' points for gliders without impeding traffic volume. Similarly it would be inefficient and inappropriate to install an overbridge connecting Dennis and Ada Avenue South within Wahroonga in an effort to reduce road kill in Wahroonga. However, installing warning signage, liaising with local residents, and improving traffic control measures (eg. through chicanes) may decrease the vulnerability of animals moving through the area.

Management strategies for biodiversity corridors must consider the advantages and disadvantages of the corridor (table C1) and the land both within the corridor as well as adjacent areas.

Table C1: Advantages and Disadvantages of Biodiversity Corridors

Advantages
Increased immigration rates
Increased genetic diversity – which prevents inbreeding depression
Reduced demographic and genetic stochasticity (unpredictability)
Movement route for a variety of species
Potentially increased population size
Increased foraging area
Increased cover between patches when escaping predators
Disadvantages
May facilitate the transmission of disease, pest, weeds
Potential to assist the spread of fire
Increased exposure to predators.
May only benefit a few species – has to be species specific to be effective.
Possibility of 'Edge effects' including increased opportunity for exotic species

In Ku-ring-gai, biodiversity corridors are generally located in close proximity to suburban, commercial and industrial areas. As such, the impacts of feral animal species, urban run off and pollution, bushfires, and corridor barriers must be considered as key influences on corridor productivity and health.

There are management strategies that can be implemented to increase the success of biodiversity corridors, as summarised in Table C2. It is important that prior to implementation consideration be given to the viability and efficacy of such strategies within reference to Ku-ring-gai's urban environment, topography and level of development.

Table C2: Issues and Management Strategies of Biodiversity Corridors

Issues	Management Strategy
Predation from introduced species and companion animals such as feral cats, foxes and dogs	• Baiting programs • Sound barriers • Providing education programs • Wildlife Protection Areas (these include council natural areas where cats and dogs are prohibited)
Nutrient loads and weed invasion Note: Weeds may very well be useful in providing protection for wildlife. Weeding a corridor might make it useless	• Weed management • Establishing bush care groups • Designing corridors through sites managed for regeneration • Managing stormwater outlets and improving drainage
Corridor vegetation and habitat condition, and bushfire risk	• Creating and maintaining habitats (including consideration of vegetation structure and habitat features - logs etc) • Appropriate landscaping • Maintaining separate clumps of vegetation and habitat within a bushfire asset protection zones (including horizontal and vertical separation) • Maintaining public safety • Creating buffer zones surrounding the corridor, by replanting native vegetation in areas adjacent to the corridor
Human disturbance on public and private land	• Providing rubbish bins and walking tracks • Creating mowing exclusion zones • Educating private landholders
Managing barriers	• Facilitating crossing • Installing structural modifications
Community awareness	• Liaising with the community • Providing education programs

3.1 *Predation*

Predation by introduced and companion animals, including foxes and cats, continues to negatively influence the viability of biodiversity corridors. These animals remain in close proximity to roads and tracks in or near bushland. This is particularly evident in areas close to residential properties home to domestic pets. Predation in these areas can significantly reduce native animal populations and prevent the migration of native species throughout the corridors.

Possible management strategies to reduce the risk of predation include:

- Feral animal eradication programs – includes baiting programs within council bushland.
- Education programs – in conjunction with other community groups and local vets, the council can provide education programs to pet owners on the management of domestic pets and feral animals.

- Sound barriers – often birds are unable to hear predators if there is a significant level of noise. As such, the installation of artificial sound barriers along busy, multi lane roads can help to minimise noise and predation within adjacent biodiversity corridors.

Examples of existing strategies by Ku-ring-gai Council:

i) Voluntary Conservation Agreements and Wildlife Protection Areas - including Ku-ring-gai Flying Fox Reserves and Browns Forest (council natural areas where cats and dogs are prohibited).
ii) Ku-ring-gai Council's feral animal control baiting program [in conjunction with the Urban Feral Animal Group (UFAG)].

3.2 *Nutrient loads and weed invasion*

High nutrient loads and weed invasion influence the success of biodiversity corridors. High levels of nutrients and fertilisers are transported via stormwater systems and overland flow throughout urban areas after rain. This impacts soil quality and encourages the growth of introduced weed species. Additionally, disturbances along the edges of corridors provide opportunities for weeds and pest species to establish themselves.

In order to minimise the effects of nutrient loads and weed invasion, the following practices may be implemented:

- Weed management and awareness – includes identifying and removing invasive species with minimal disturbance to surrounding areas.
- Establishing bush care groups – encourages community spirit, sense of ownership and pride in the maintenance of corridor regions.
- Managing storm water outlets and improving drainage – reduces and prevents urban and road run-off from entering corridor areas.
- Requiring development to meet water quality targets in managing stormwater runoff.

3.3 *Corridor vegetation and habitat condition*

Management to protect and enhance vegetation structure and condition within biodiversity corridors will provide habitat for a greater range of flora and fauna species. These may include locally indigenous shrubs, and groundcovers that are not found within nearby gardens, and a greater diversity of fauna, such as insect, lizard, frog and bird species.

The maintenance of good structure and condition of native vegetation can occur through:

- Weed and rubbish removal – in areas that have experienced minimal disturbance, this may be all that is necessary to manage corridors already in good condition.
- Increasing habitat opportunities – this may occur through preservation of natural features or creation of artificial structures to enhance or create new habitats. For example:
    - Natural preservation includes retaining hollow bearing trees.
    - Artificial nest boxes can be installed to provide habitats for species that use tree hollows. Bird, bat and some arboreal mammal species may also benefit from this, especially in corridors linking Lane Cove Valley to Cowan Creek or Middle Harbour.
    - Building artificial frog ponds can provide locations for frog breeding
    - Providing artificial ground cover can provide shelter from predators or be used as habitat.
- Creation of buffer zones – this will minimise edge effects on the corridor

- Replanting native vegetation on land adjacent to the corridor – this may benefit corridors comprised of more disturbed vegetation and can help to attract fauna into the corridor if appropriate plant species and vegetation structures are used.
- Appropriate landscaping – in order to restrict access to sensitive corridor areas, spiky foliaged plants or dense plantings of native grasses such as *Lomandra longifolia and Dianella caerulea* may be used.

While it is important to maintain vegetation and habitat condition, it is also necessary to consider bushfire management and risk. It is recognised that due to the topography and urbanisation of Ku-ring-gai, bushfires remain a significant threat. Therefore, bushfire risk mitigation strategies are required to be undertaken on both private and public land. This involves the creation of asset protection zones and fire trails as well as conducting hazard reduction burns. In addition, the structure and layout of gardens and biodiversity corridors through suburban areas must ensure that they do not contribute to the spread of bushfires. One way of attaining this within a bushfire asset protection zone is to maintain separate clumps of vegetation and / or habitat. Although these actions may reduce the effectiveness of biodiversity corridors, they are integral aspects of bushfire prevention.

Within some locations safety may be an additional consideration within biodiversity corridors. In order to maintain public safety, particularly the provision of visibility (for example within a park near a public walk way), it is important to be mindful of the type and species of plants used in revegetation. Therefore, in particular areas, only trees without low branches, low lying shrubs and grasses may be appropriate for use.

3.4 *Human disturbance*

Human disturbance and noise has been known to cause the displacement of native animals which may rely on the quiet seclusion of undisturbed habitat for survival. These impacts are more likely in parks and reserves and are heightened in narrow strips of habitat.

The natural areas and reserves are also popular recreational sites. Some recreational pursuits, where inappropriately used, pose a risk to biodiversity corridors through the trampling of vegetation and pollution of natural areas.

To overcome these issues, the following management practices may be implemented:

- Provision of walking tracks – this ensures that vegetation is not trampled and human access is concentrated to a defined managed area.
- Provision of rubbish bins – this will help to manage rubbish entering sites and will facilitate the appropriate disposal of waste products.
- Mowing exclusion zones – areas surrounding the biodiversity corridors will benefit from mowing exclusion zones as it will prevent disturbance to native flora and fauna.
- Educating private landholders – this will help to encourage and inform about the presence and importance of biodiversity corridors which exist on private land.

3.5 *Managing barriers*

In Ku-ring-gai, roadways are usually the main barriers to fauna migration. Therefore, fauna sensitive road design should be considered as roads are developed, modified and repaired.

Other management strategies to overcome barriers in biodiversity corridors include:

i. Facilitating crossings
   a. Encouraging tree canopy connectivity to enable arboreal mammals to cross roads and facilitate bird and bat migration.

   b. Reducing traffic speed and volume
      - Chicanes
      - Signage
      - Rumble strips

   c. Minimising noise to enable fauna mating and assist in the escape from predators
      - Planting next to roads
      - Artificial noise barrier

   Where road crossing is not possible, barriers to prevent fauna from crossing may need to be increased to reduce mortality rates. This may include:

   d. Fencing
      - To direct fauna crossing points and avoid road kill
      - Appropriate fauna design to facilitate fauna movement.

ii. Structural modification
   - Overpasses
   - Land bridges
   - Canopy bridges
   - Poles
   - Culvert and bridge underpasses
      - For example; retrofitting box culverts with ledges to allow for dry fauna crossing
   - Tunnels.

3.6 *Community awareness*

The support of the local community is essential when implementing biodiversity corridors, especially for those that exist on private land. Community involvement is necessary in order to increase awareness of the importance of local fauna protection.

This may be encouraged through:

- Signage denoting corridor placement, the ecology of the area and the importance of the corridor. This can raise awareness in locations where biodiversity corridors and areas of public use overlap.
- Liaising with the community
  - Encouragement of bush regeneration activities
  - Support for community flora and fauna programs run by council (such as Bushcare, Wildthings, Greenstyle, Parkcare and Streetcare, see http://www.kmc.nsw.gov.au/www/html/3605-bushcare.asp)
  - Establishment of 'no mow' areas and planting of native street trees
  - Partnering with private landholders to encourage proactive management of remnant bush habitats in order to conserve fauna and flora (where asset protection and bushfire prone land has already been considered).

4 References

Australian Museum. 2005, *Birds Australia and Australian Museum Bird Friendly Spaces,* viewed September 2008, http://www.birdsinbackyards.net/spaces/bird-attracting-plants.cfm.

Bankstown City Council, 2002, *Bankstown Biodiversity Strategy – Draft for Public Exhibition June 2002,* Bankstown City Council.

Fahrig, L. 2003. 'Effects of habitat fragmentation on biodiversity'. *Annual Review of Ecology, Evolution and Systematics* vol. 34, pp. 487-515.

Fox C., Giutronich S., Pieris H., Rowling R., 2001, *Habitat Corridors for Wildlife Conservation in Manly Local Government Area: Solution or Inexpedient in Vogue Practice?,* Wildlife Unlimited.

Lindenmayer, D.B. and Nix, H.A., 1993, *Ecological principles for the design of wildlife corridors*, Conservation Biology, Volume 7, pp. 627-630.

Queensland Government, 2010, *Fauna Sensitive Road Design Manual: Volume 2,* Department of Transport and Main Roads.

Rowley L., Edwards R., Kelly P., Land for Wildlife, 1999, *Edges – Their Effect on Vegetation and Wildlife,* Bushcare – Natural Heritage Trust.

Saunders D.A., Hobbs, R.J, 1991, *Nature Conservation 2: The Role of Corridors,* Surrey Beatty and Sons, Sydney.

Appendix D Riparian Lands within the Ku-ring-gai LGA

Riparian Lands Mapping

Components

Riparian Category

On the Draft Map of Riparian Lands, the Legend shows both:

'Riparian Category'

&

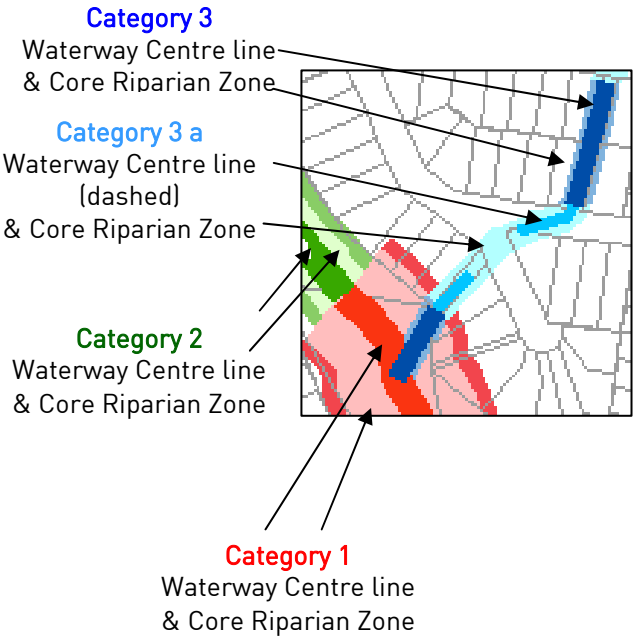
'Riparian Buffer'

These areas together make up Riparian Lands.

Riparian Category

'Riparian Category' displays both the mapped waterway centreline (line) and the Core Riparian Zone distance (shaded area around the line).

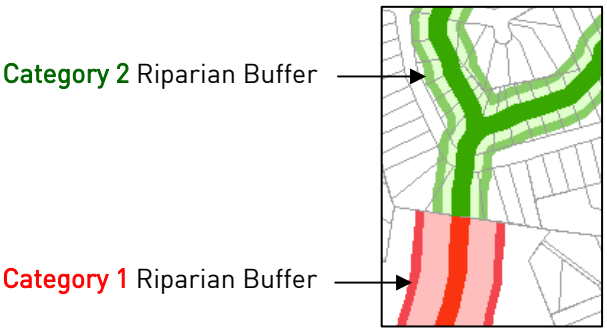
Category 1:		(40m)
Category 2:		(20m)
Category 3:		(10m)
Category 3a:		(10m)



Riparian Buffer

'Riparian Buffer' indicates the buffer to the Core Riparian Zone for Riparian Categories 1 and 2.

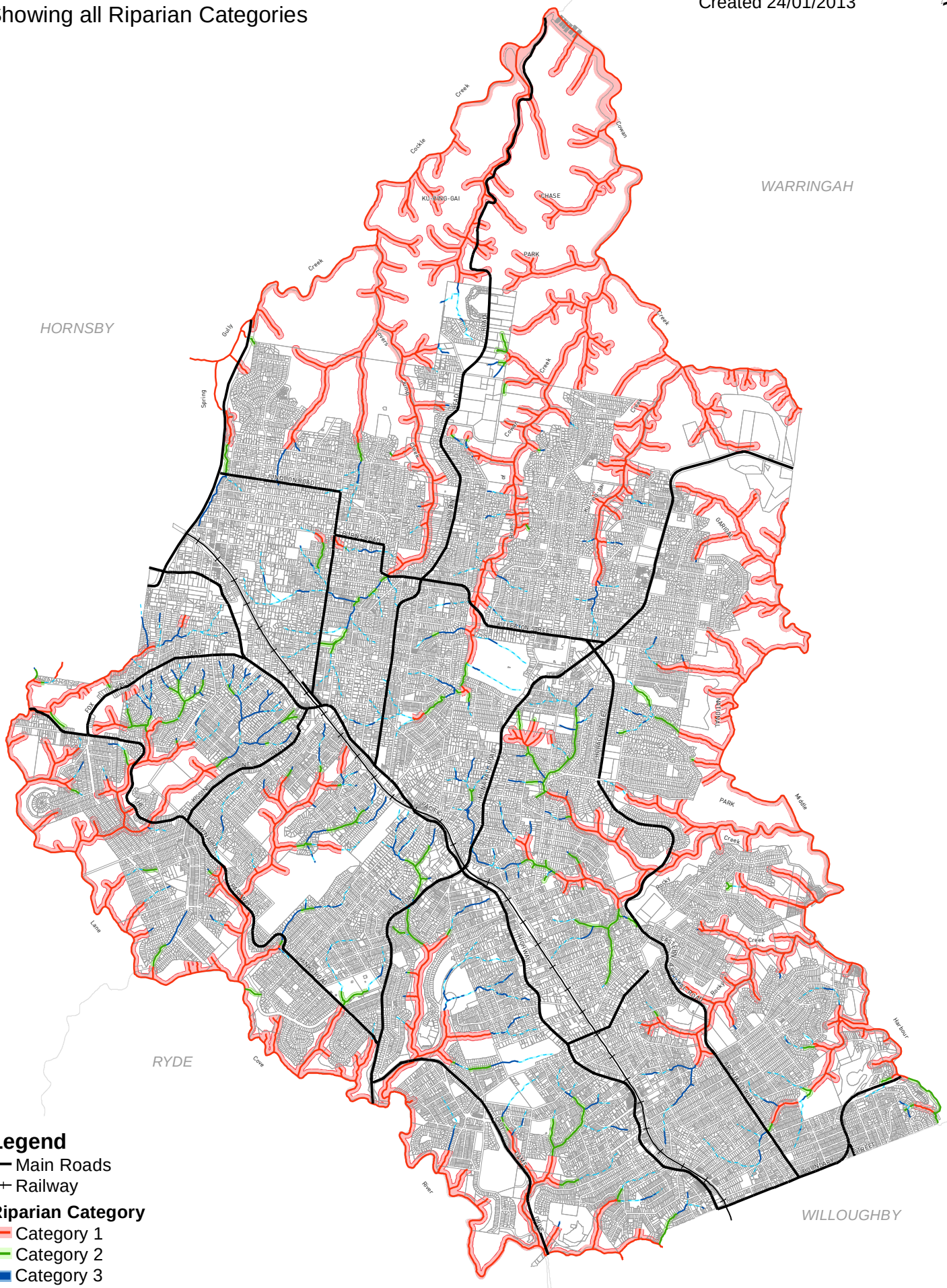
Category 1:		(10m)
Category 2:		(10m)



Draft Map of Riparian Lands:

Showing all Riparian Categories

Created 24/01/2013



Appendix E Conversation Significance Assessment (CSA) (Greenweb) - Category Description Table

Category	*Description*	*Background*
Category 1	OEH protected areas	Formal reserves consisting of Office of Environment and Heritage estate managed for the purpose of biodiversity protection.
	Ku-ring-gai Natural Areas	Formal reserves consisting of areas managed by Ku-ring-gai Council as Natural Areas under the *Local Government Act* 1993 for the purpose of biodiversity protection.
	Regional Fauna Habitat	Regional Fauna Habitat includes regionally important connected areas of habitat providing resources for threatened and non threatened fauna species and populations (including national, state and regionally significant species). Areas of Regional Fauna Habitat which cross major, regional and collector roadways have been included within this category, but have been identified in order to assist in the management of key barriers / breaks within the regional fauna habitat (See Figure 3). See Section 3.3 for further background.
Category 2	Key Vegetation Communities (KVC), adjoining Category 1	These areas provide support for Category 1, through the protection and improvement of vegetation quality and quantity, providing a buffer, reducing the contrast between core lands and the urban environment. This concept is supported by the recommendations for a 60m retained buffer zone of native vegetation around significant vegetation; in response to identifying impacts from human disturbance up to 60m from road edges within the Blue Mountains (Smith and Smith (1997). Similarly, NSW DECC (2007c) recommends an absolute minimum buffer of 50m to Duffys Forest. Whilst lands adjoining core areas within Ku-ring-gai consist primarily of developed lands, there is still capacity to retain / enhance some form of vegetation assemblage and structure as a buffer supporting adjoining core areas. These buffer areas have the ability to provide resources that encourage urban-sensitive species to utilise forest edges and adjoining areas, as well as reducing edge effects to consolidated vegetation. Enabling for example a higher level of bird diversity to be maintained (Hodgson 2005, Hodgson et al 2006). This benefit is enhanced by native vegetation but is also aided by exotic plantings.

Category	*Description*	*Background*
		Research has identified significant bird diversity and abundance within the LGA (See Appendix A). In addition, the proportion of housing and associated factors including habitat and predation have been recognised as influencing the movement of birds between native vegetation and the urban matrix (Hodgson et al 2006). Medium sized nectarivores have been observed to increase at the edges of high-density housing, encouraged by inappropriate planting (multitudes of large flowering cultivars) (Birds Australia et al 2005), and an increased predation ability (added by a reduction in the complexity of vegetation structure). In turn these birds have been observed to induce an inhibitory response among the small insectivores at the edges of high-density housing reducing bird diversity.
	Local Fauna Habitat	Local Fauna Habitat is provided by isolated remnants located more centrally in the LGA. Mapping included areas within both private and public land ownership, including Ku-ring-gai Natural Areas. See Section 3.3 for further background.
	Vegetation within Core Riparian Zones: • Riparian categories 1, 2 and 3 – all vegetation • Riparian category 3a - limited to KVCs and KVCs adjoining vegetation within Core Riparian Zones as mapped above.	Vegetation within CRZs provide support for riparian lands through the protection and improvement of vegetation quality and quantity. All vegetation within these Core Riparian Zones (as identified in Section 2) has been targeted, including native and non-native species, with the exception of Riparian category 3a (consisting of piped creeks). For Riparian category 3a the areas identified in Greenweb category 2 is limited to mapped KVCs only, recognising the significance of these areas within any future restored landscape. KVCs adjacent to CRZ areas described above have also been included within Greenweb category 2. These areas provide an increased buffer to CRZ within areas of ecological importance. Additionally connectivity provided by the CRZ helps to support the KVC area. Vegetation within riparian areas provides a number of ecological services, including habitat, food resources, bank stability and sediment / nutrient filtration. They also act as microclimates, changing conditions in small remnant areas to support a variety of organisms as well as providing resources to nomadic, migratory and nearby resident species (Price et al 2007). Whilst occupying only a small proportion of the landscape, they support a greater variety and abundance of animal life than surrounding areas (Catterall et al 2007).

Category	*Description*	*Background*
		Riparian areas are known to be directly associated with many species. Apart from a wide array of invertebrates, in Ku-ring-gai, the Eastern Water Skink (*Eulamprus quoyii*), the Eastern Water Dragon (*Physignathus lesueurii*) and a number of frog species are entirely dependant on riparian areas for dispersal and survival. A number of microbat species, ground dwelling marsupials and the endangered Powerful Owl (*Ninox strenua*)[8] depend on riparian zones regularly on a daily and seasonal basis. The potential for moister environments to withstand temperature rises as associated with climate change may also play an important conservation role in the future. These areas provide for the protection of vegetation across the topographical range within the LGA. From 1st order streams, originating at shale bearing ridges though to 3rd order streams within sandstone gullies and estuarine environments. Riparian areas are known to be directly associated with many species. Apart from a wide array of invertebrates, in Ku-ring-gai, the Eastern Water Skink (*Eulamprus quoyii),* the Eastern Water Dragon (*Physignathus lesueurii*) and a number of frog species are entirely dependant on riparian areas for dispersal and survival. A number of microbat species, ground dwelling marsupials and the endangered Powerful Owl (*Ninox strenua*) depend on riparian zones regularly on a daily and seasonal basis. The potential for moister environments to withstand temperature rises as associated with climate change may also play an important conservation role in the future. These areas provide for the protection of vegetation across the topographical range within the LGA. From 1st order streams, originating at shale bearing ridges though to 3rd order streams within sandstone gullies and estuarine environments.
	All vegetation within Biodiversity Corridors	This includes all vegetation, including non local / non native species, within Biodiversity Corridors. See Section 3.4 for further background on biodiversity corridors. Note that areas of within biodiversity corridors lacking vegetation are mapped within Category 4.

[8] [8] Ku-ring-gai has the highest recorded distribution throughout the Greater Sydney Region (Kavanagh 2004).

Category	*Description*	*Background*
Category 3	KVC Patches that are ≥ 0.1ha in size or contain KVC vegetation in good, moderate condition	This includes all vegetation of patch size ≥ 0.1ha in size or vegetation areas of good or moderate condition within the urban matrix. The patch size of ≥ 0.1ha, is estimated to include an area of approximately 6 large established trees. This patch size aligns to the 0.1ha layout of nested 20 × 50 m and 20 × 20 m plots used for the assessment of vegetation condition, as used within Biobanking (DECC 2008b) and the Biometrics methodology for assessing clearing and ecological thinning proposals on terrestrial biodiversity under the *Native Vegetation Act 2003* (DECCW 2011). This patch size is considerably larger than the 'standard' plot size (0.04ha) recommended by *Native Vegetation Interim Type Standard* for vegetation mapping and identification (Sivertsen 2009[9]). Note: A 5ha size threshold is adopted within the Biobanking methodology (DECC 2008a) and the BGHF listing advice under the EPBC Act (DEWHA 2005). A patch size analysis of Key Vegetation Communities ≥ 0.1ha as included within Category 3, identified that all patches ≥ 5ha are already mapped within Category 1 or 2. These areas assist in the maintenance of TECs across a range of topographies. They also play an important role as biodiversity reservoirs, providing stepping stone links for fauna and seedbank / pollination resources to support the survival of remnant vegetation patches. Small patches can be valuable for native inverterbrates and for some birds (Fischer and Lindenmayer, 2002).Urban street trees for example, provide bird habitat for resting, nesting, feeding and hollow use (Young *et al* 2007, Tzilkowski *et al* 1986, Weleh 1994, Cannon 1999, Chamberlain *et al* 2004). They also provide habitat for pollinators, such as bats, that may be less constrained by landscape features (Aldrich & Hamrick 1998, cited in Sork and Smoise 2006). Areas included within this category (as well as those identified within biodiversity and riparian corridors) provide genetic resources from remnant vegetation to support the ecological functions of both KVCs and non KVCs, and facilitate gene flow (reducing genetic erosion / isolation and the effects of fragmentation).

[9] The *Native Vegetation Interim Type Standard* (Sivertsen 2009) addresses the quality and nature of the scientific processes for native vegetation type activities; and applies to all relevant vegetation activities to which the NSW Government is a signatory or to which the NSW Government makes a financial or in-kind contribution.

		In urban areas where fragmentation has occurred, the main strategy to fight genetic erosion is the maintenance of a good quality and quantity of gene flow among fragments. "Fragmentation does not necessarily equate to genetic isolation", Krauss *et al* states (2007 p396). As long as there is sufficient gene flow between fragments, species should be able to survive and grow at a distant site. In other words, even though habitat may be separated, if the quality and frequency of gene flow can be maintained, genetic erosion should not occur. Sork and Smoise (2006) summarized that two elements measuring the degree of isolation of a fragmented landscape are the quantity of incoming pollen and the diversity of incoming gene sources. As such the more connectivity and protection of sufficient / relevant remnant areas within the urban area, the higher level resilience or core areas will have.
	Significant trees within KVCs and the mapped area in which they are located	This category includes trees within KVCs identified as significant during Ku-ring-gai Key Vegetation Community mapping (KC 2011a and 2011b). This included the identification of local native trees; identified as significant due to the presence of habitat (e.g. a hollow), provision of food for wildlife, and / or exceptional form or size. This mapping provides an opportunistic selection of significant native trees and is not considered to capture every significant tree within the urban landscape.
Category 4	Areas of consolidation for Category 1 & Category 2	This consists of an 8m buffer applied to areas of Category 1 and 2, in order to highlight areas where improved connectivity/consolidation is sought. This may include both vegetated and non vegetated areas not already included within categories above. These buffers will help to reduce edge effects on the ecological community (Smith and Smith, 1997; NSWDECC, 2007c). Edge effects include, for instance, the impacts of stormwater runoff, disturbance, dumping, weed encroachment, microclimate variations and nutrient changes. The buffer width is limited to 8m due to the practical constraints of the urban environment of Ku-ring-gai.
	Areas lacking vegetation within Biodiversity Corridors	This category addresses areas lacking vegetation within identified Biodiversity Corridors. These areas are identified for enhancement to reconnect patches of remnant vegetation, facilitating the improvement of connectivity between core habitats. These areas may provide additional functions such as protection of water quality. Considered within the context of surrounding vegetation and habitat, these areas will help to maintain and restore the health, diversity and connectivity of native species population and communities and improve their resilience under future climate change.

		Note that vegetation within Biodiversity corridors' is addressed within in Category 2.
Category 5	KVC Patches that are <0.1ha in size and do not contain KCV vegetation in good, moderate condition	Whilst smaller than patches identified within Category 3, these areas also provide habitat stepping stones, assist in the maintenance of TECs across a range of topographies, facilitate genetic flow and provide fauna habitat for more mobile / urbanised species.

Appendix F Greenweb lands: Category 1 – 4 (Categories included within the LEP Biodiversity Map)

Draft Greenweb:

Showing Categories 1- 4

Created 8/02/2013

Greenweb Category

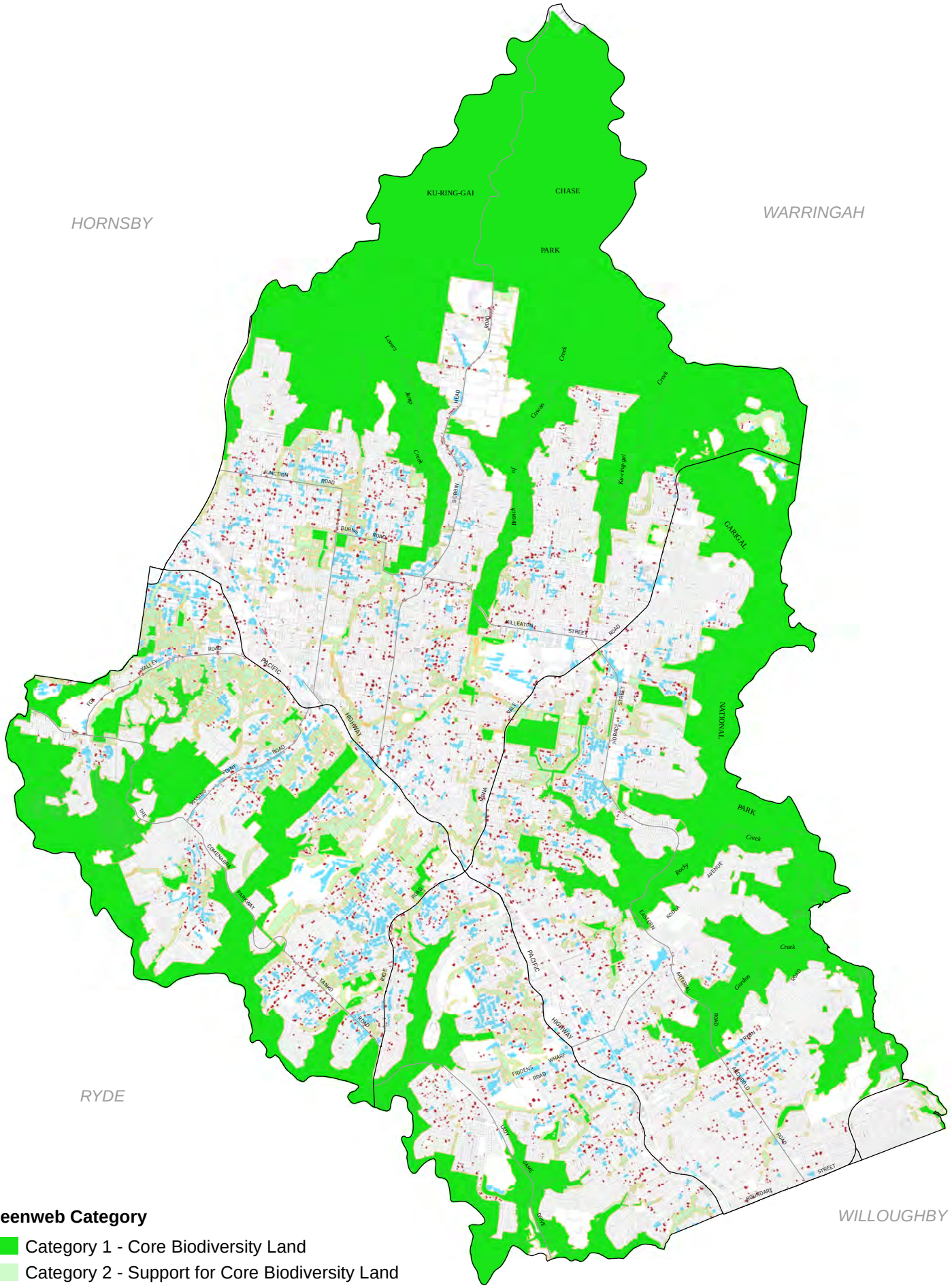
- Category 1 - Core Biodiversity Land
- Category 2 - Support for Core Biodiversity Land
- Category 3 - Landscape Remnant
- Category 4 - Biodiversity Corridor and Consolidation

Appendix G Greenweb lands: Categories 1 - 5

(All Greenweb categories – for incorporation within the DCP)

Draft Greenweb:
Showing All Greenweb Categories

Created 8/02/2013

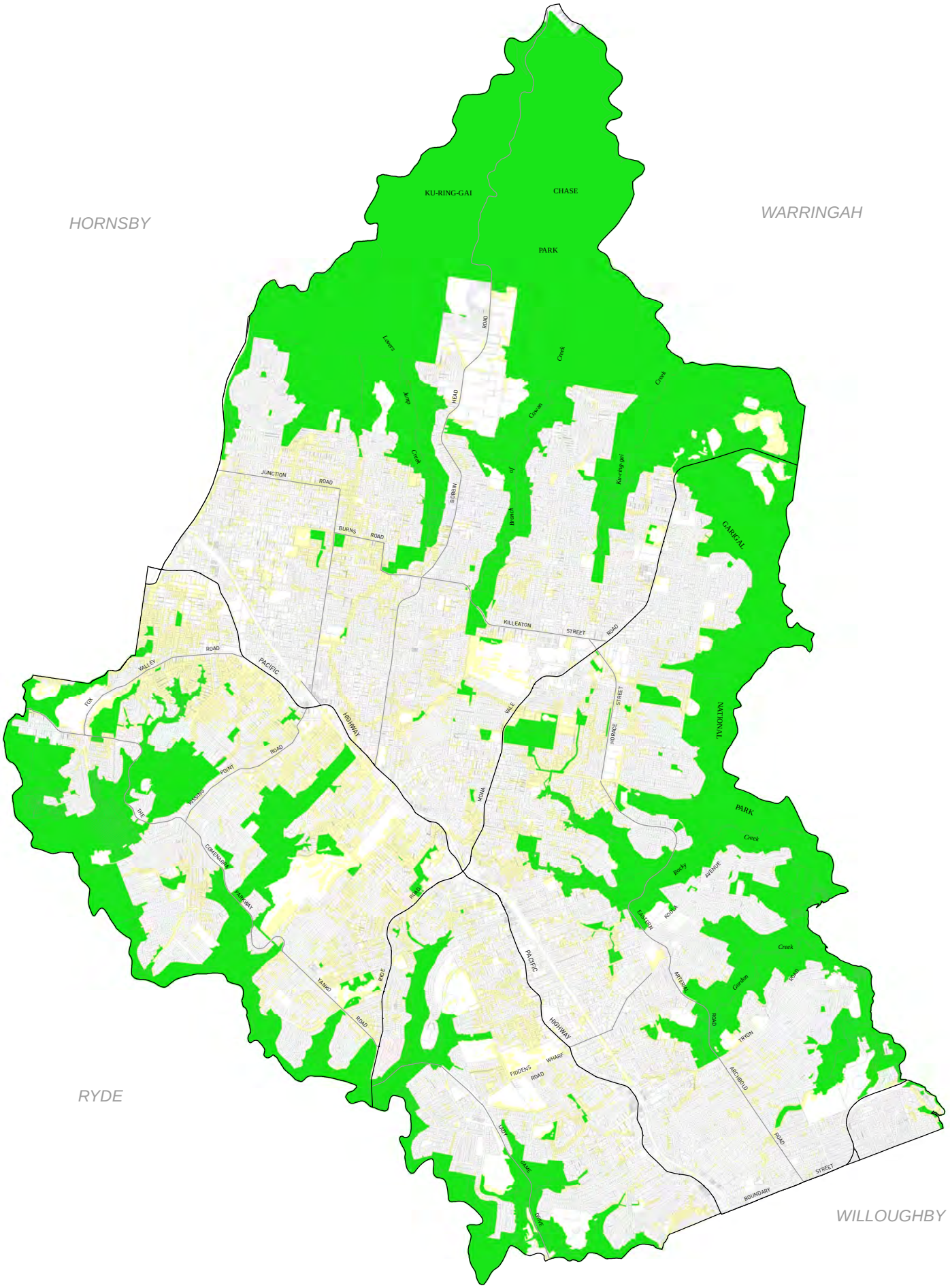


Greenweb Category

- Category 1 - Core Biodiversity Land
- Category 2 - Support for Core Biodiversity Land
- Category 3 - Landscape Remnant
- Category 4 - Biodiversity Corridor and Consolidation
- Category 5 - Canopy Remnant

Draft Greenweb:
Showing Category 1

Created 8/02/2013



Greenweb Category

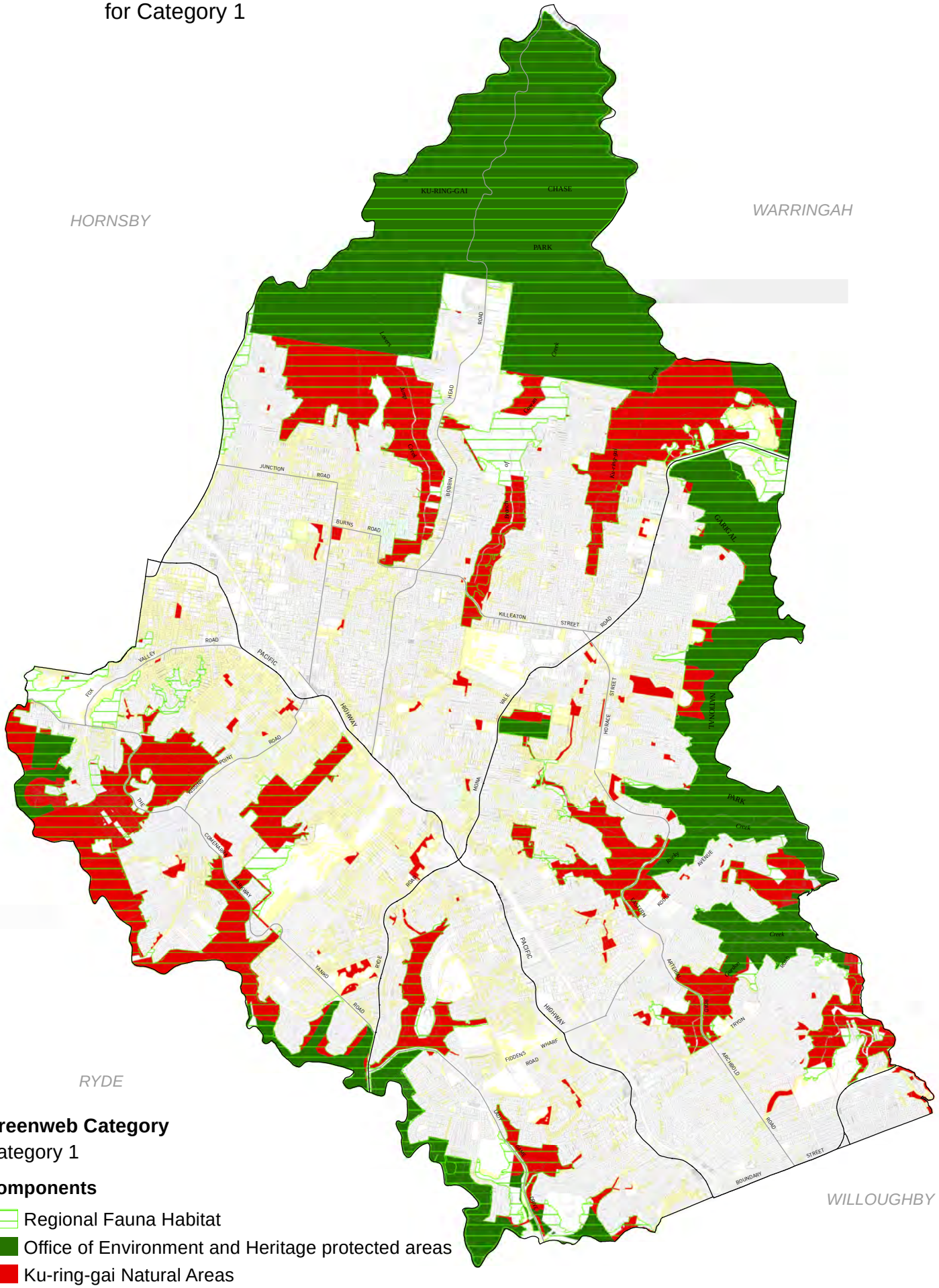
- Category 2, 3, 4, 5
- Category 1

0 0.5 1 2 Kilometres

Draft Greenweb:

Showing Detailed Category Information for Category 1

Created 8/02/2013



Greenweb Category

Category 1

Components

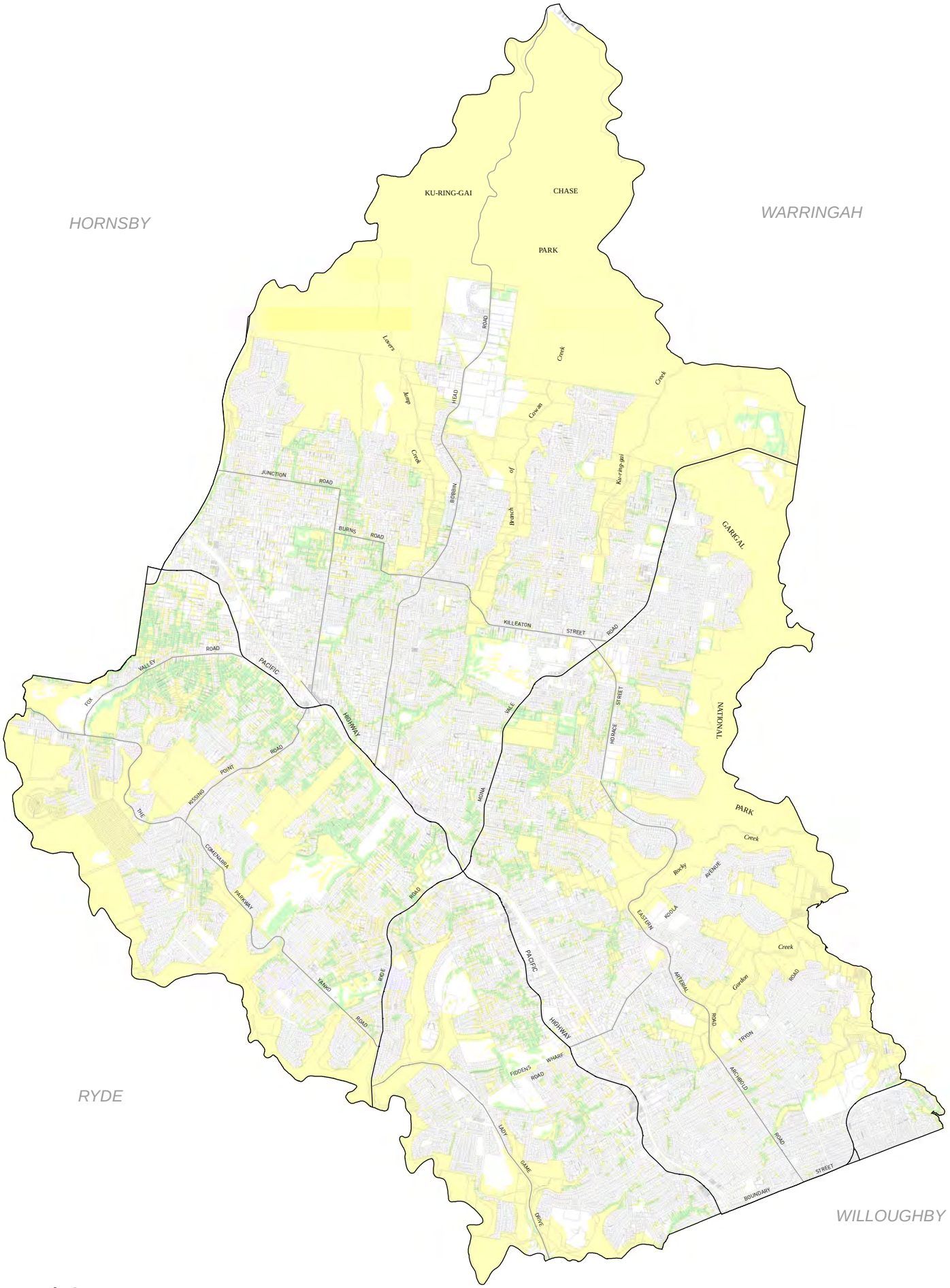
- Regional Fauna Habitat
- Office of Environment and Heritage protected areas
- Ku-ring-gai Natural Areas

Other

- Category 2, 3, 4, 5

Draft Greenweb:
Showing Category 2

Created 8/02/2013



Greenweb Category

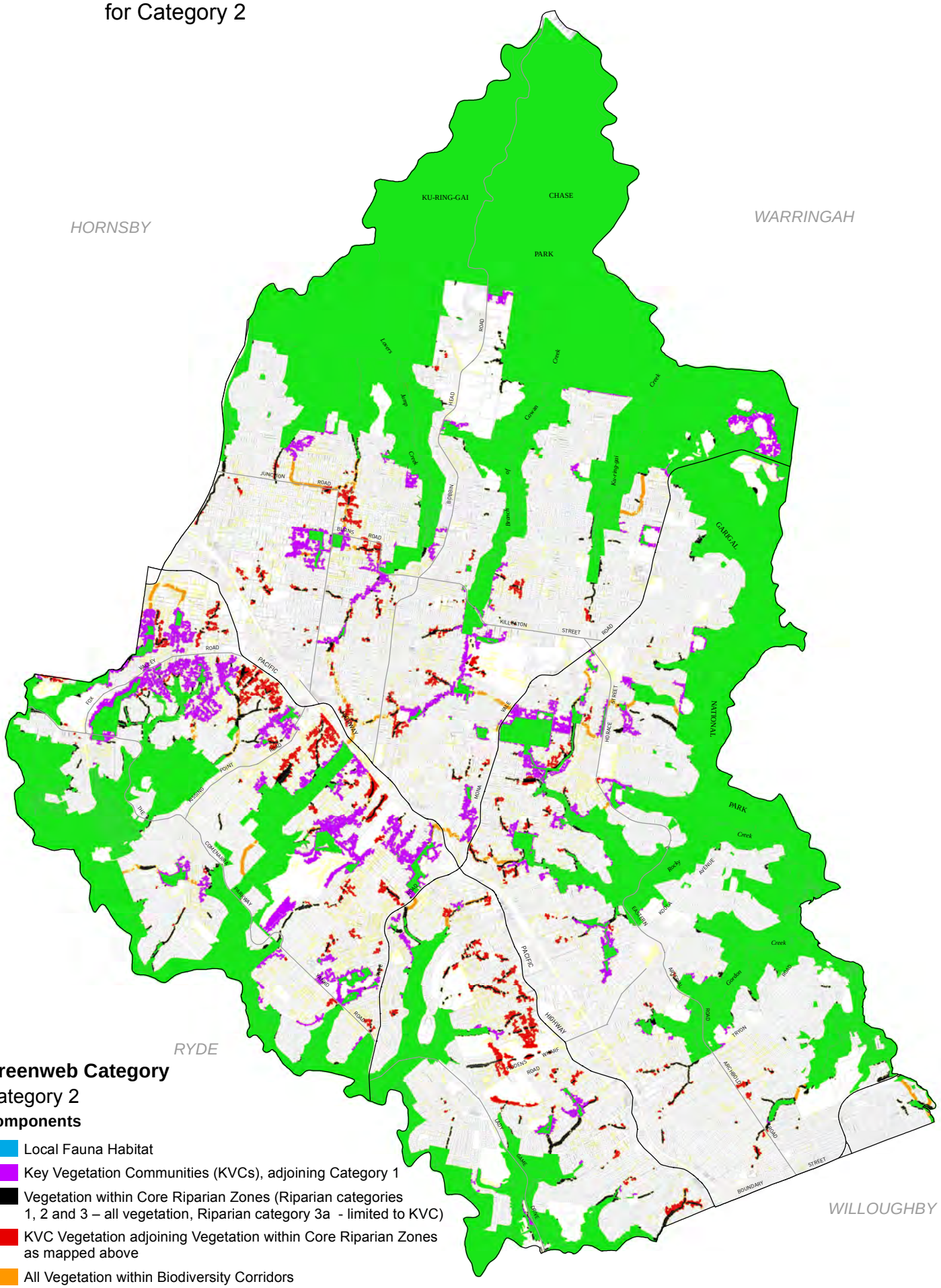
- Category 1, 3, 4, 5
- Category 2

0 0.5 1 2 Kilometres

Draft Greenweb:

Showing Detailed Category Information for Category 2

Created 8/02/2013



Greenweb Category

Category 2

Components

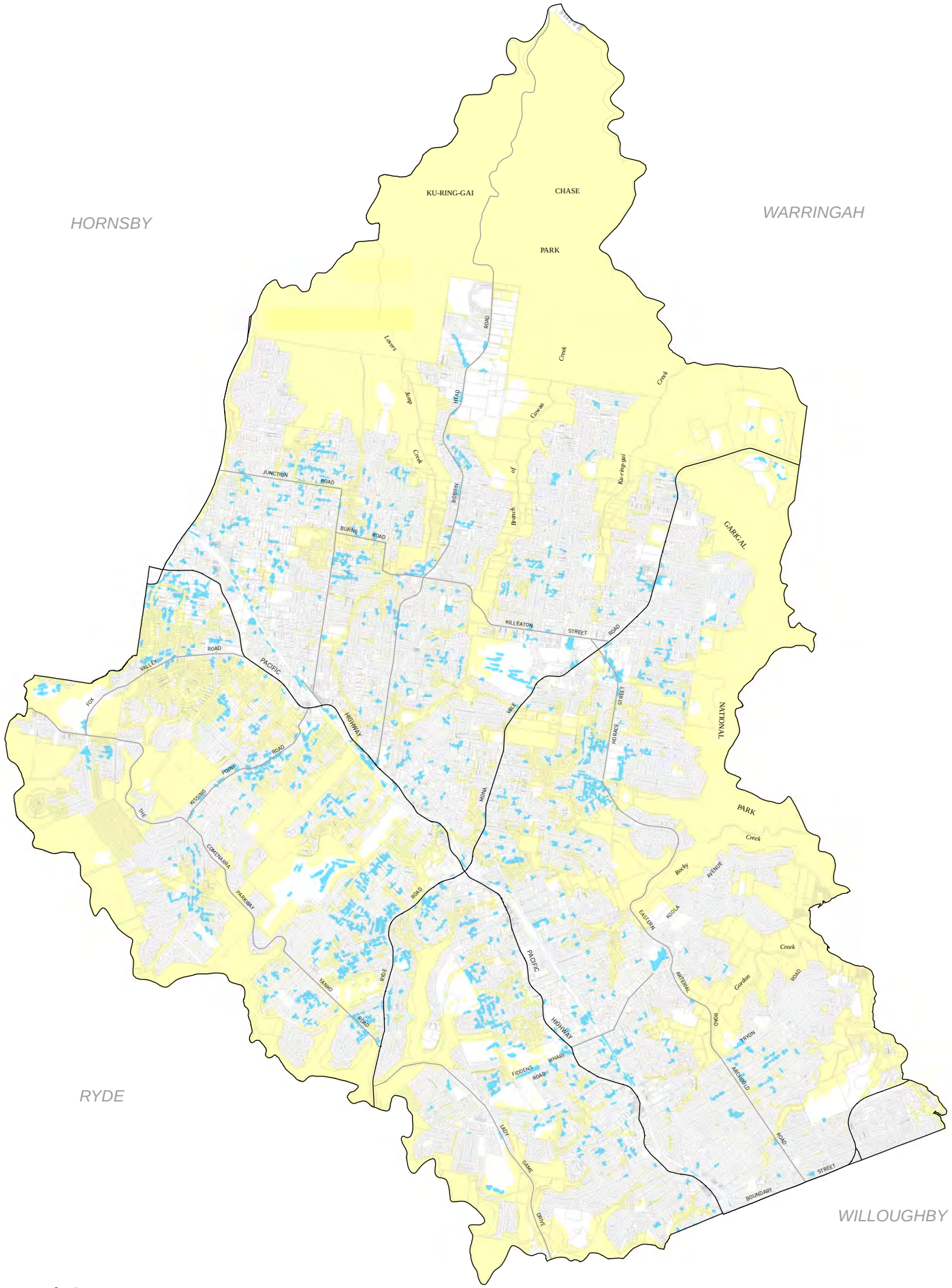
- Local Fauna Habitat
- Key Vegetation Communities (KVCs), adjoining Category 1
- Vegetation within Core Riparian Zones (Riparian categories 1, 2 and 3 – all vegetation, Riparian category 3a - limited to KVC)
- KVC Vegetation adjoining Vegetation within Core Riparian Zones as mapped above
- All Vegetation within Biodiversity Corridors

Other

- Category 3, 4, 5
- Category 1

Draft Greenweb:
Showing Category 3

Created 8/02/2013



Greenweb Category

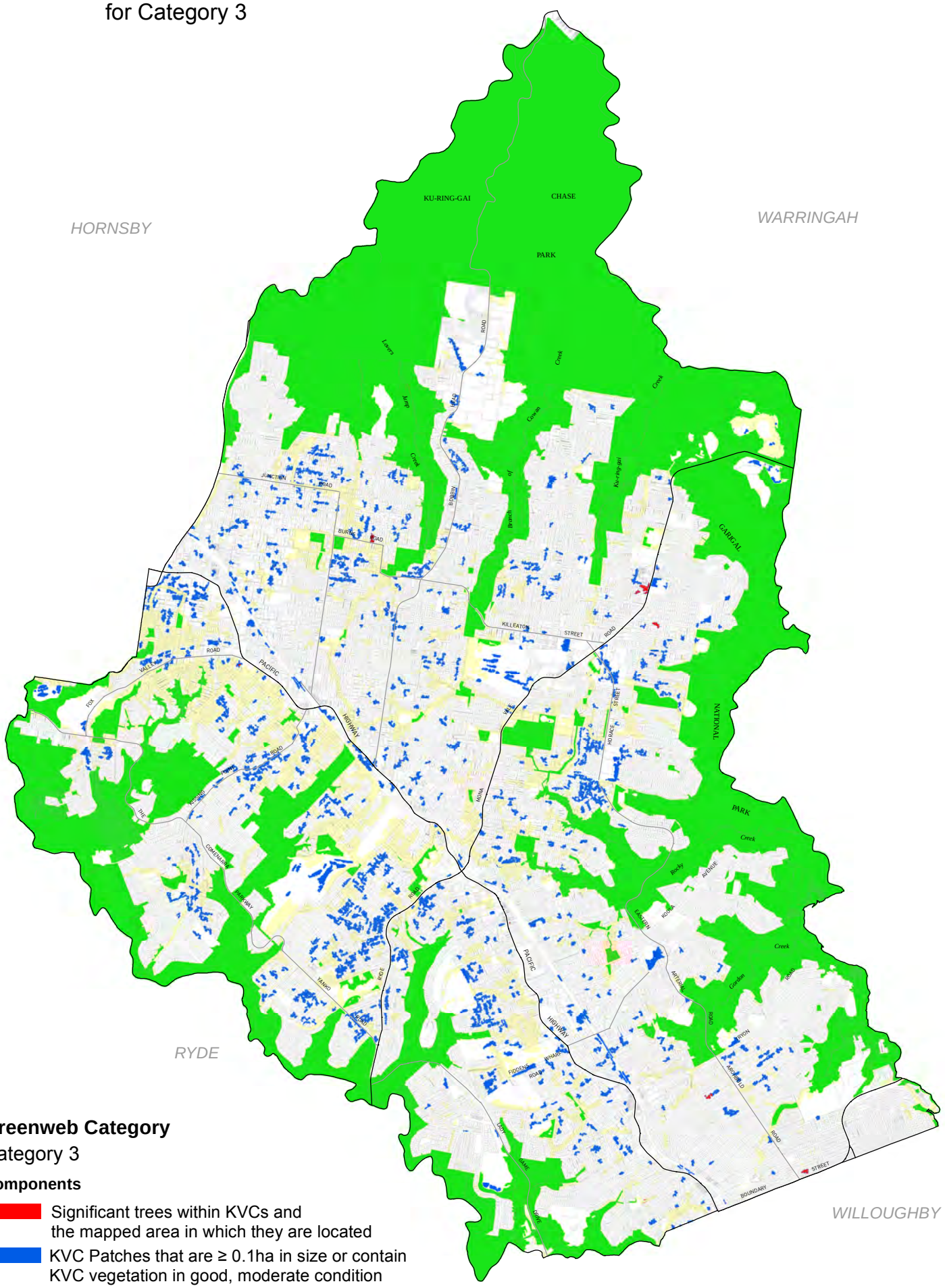
- Category 1, 2, 4, 5
- Category 3

0 0.5 1 2 Kilometres

Draft Greenweb:

Showing Detailed Category Information for Category 3

Created 8/02/2013



Greenweb Category

Category 3

Components

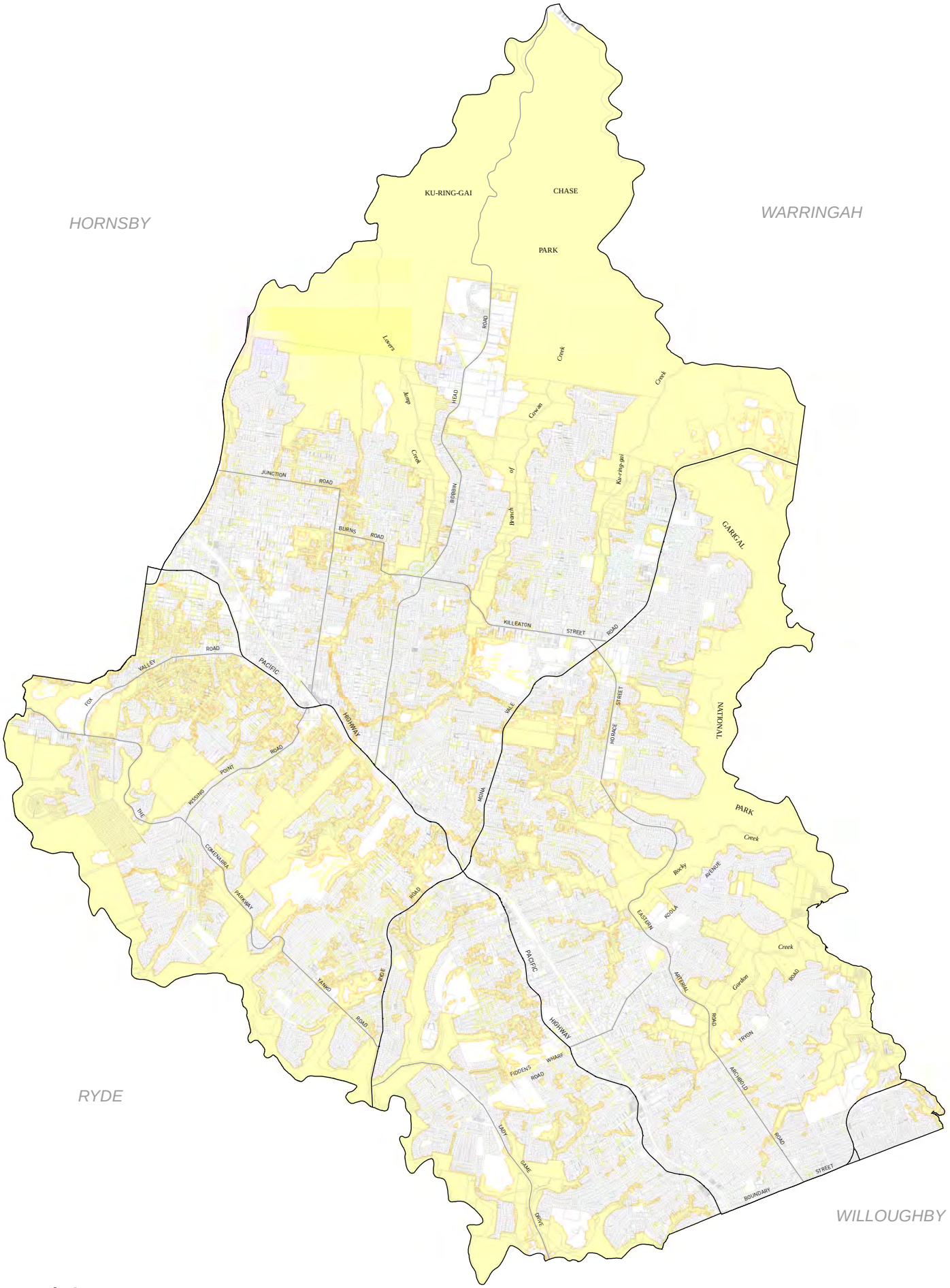
- Significant trees within KVCs and the mapped area in which they are located
- KVC Patches that are ≥ 0.1ha in size or contain KVC vegetation in good, moderate condition

Other

- Category 2, 4, 5
- Category 1

Draft Greenweb:
Showing Category 4

Created 8/02/2013



Greenweb Category

Category 1, 2, 3, 5

Category 4

Draft Greenweb:

Showing Detailed Category Information for Category 4

Created 8/02/2013

Greenweb Category

Category 4

Components

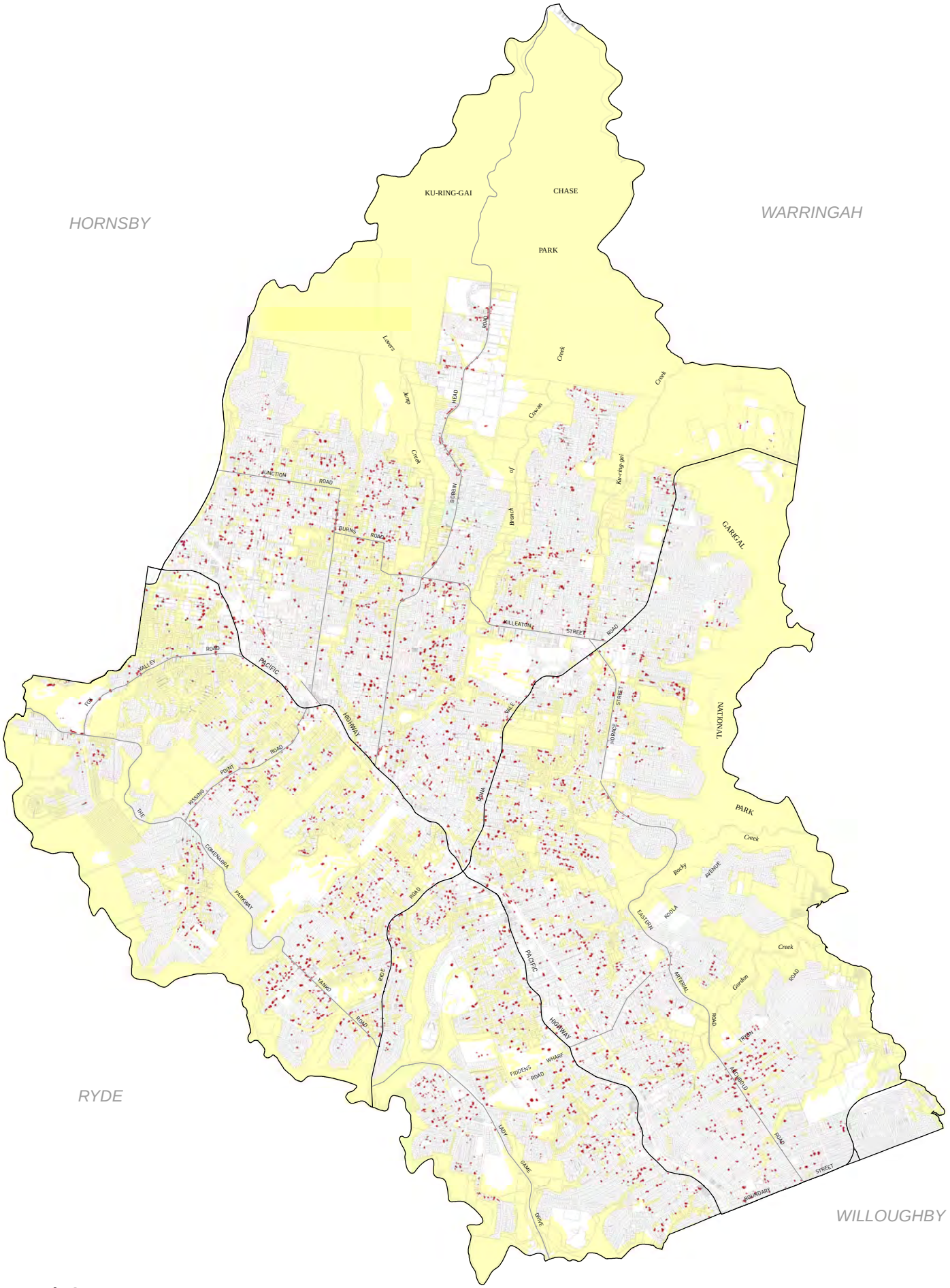
- 8m Buffer of Category 1
- 8m Buffer of Category 2
- Areas lacking vegetation within Biodiversity Corridors

Other

- Category 2, 3, 5
- Category 1

Draft Greenweb:
Showing Category 5

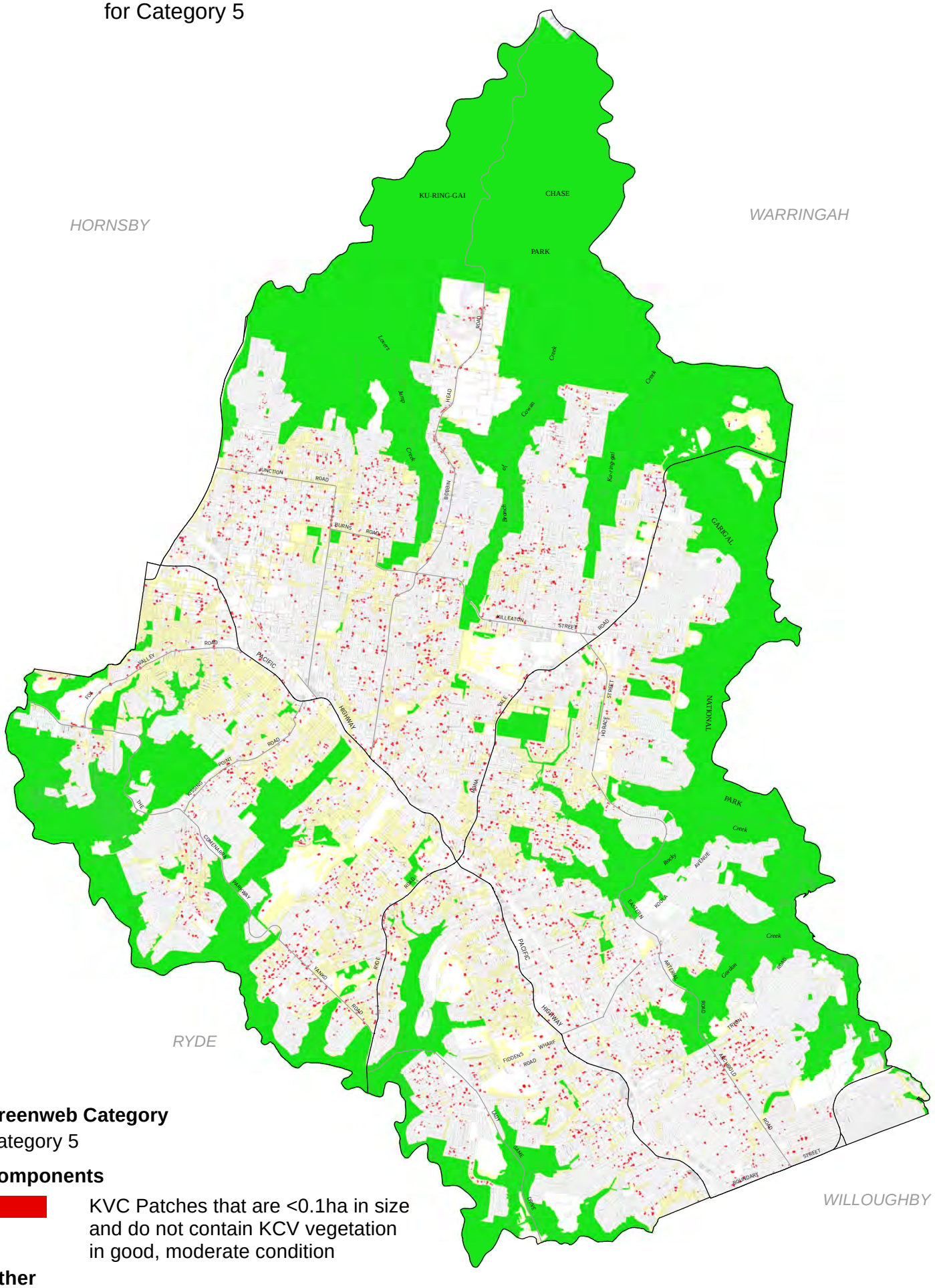
Created 8/02/2013



Draft Greenweb:

Showing Detailed Category Information for Category 5

Created 8/02/2013



Greenweb Category

Category 5

Components

KVC Patches that are <0.1ha in size and do not contain KCV vegetation in good, moderate condition

Other

Category 2, 3, 4

Category 1