Maitland

Vegetation canopy assessment report

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Final v1.0	23/09/2021	Taylor Hume Giorginna Xu Christy Englezakis Rebecca Sims	Beth Kramer Christy Englezakis	Beth Kramer
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W. www.nghconsulting.com.au

E. ngh@nghconsulting.com.au

BEGA - ACT & SOUTH EAST NSW
Suite 11, 89-91 Auckland Street
(PO Box 470) Bega NSW 2550
T. (02) 6492 8333

BRISBANE
T3, Level 7, 348 Edward Street
Brisbane QLD 4000
T. (07) 3129 7633

CANBERRA - NSW SE & ACT
Unit 8, 27 Yallourn Street
(PO Box 62) Fyshwick ACT 2609
T. (02) 6280 5053

GOLD COAST
19a Philippine Parade
Palm Beach QLD 4221
(PO Box 466 Tugun QLD 4224)
T. (07) 3129 7633

NEWCASTLE - HUNTER & NORTH COAST
Unit 2, 54 Hudson Street
Hamilton NSW 2303
T. (02) 4929 2301

SYDNEY REGION
Unit 17, 21 Mary Street
Surry Hills NSW 2010
T. (02) 8202 8333

WAGGA WAGGA - RIVERINA & WESTERN NSW
35 Kincaid Street (PO Box 5464)
Wagga Wagga NSW 2650
T. (02) 6971 9696

WODONGA
Unit 2, 83 Hume Street
(PO Box 506) Wodonga VIC 3690
T. (02) 6067 2533

NSW • ACT • QLD • VIC
W. www.nghconsulting.com.au
ABN 31 124 444 622 ACN 124 444 622

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Acronyms and abbreviations

Term	Definition
API	Aerial photograph interpretation
BC Act	*Biodiversity Conservation Act 2016* (NSW)
CHA	Core habitat area
Cwth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment (Cwth)
DCP	Development Control Plan
DPIE	Department of Planning, Industry and Environment (NSW)
EEC	Endangered ecological community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
HN	Habitat nodes
LGA	Local government area
LEP	Local Environment Plan
LSPS	Local Strategic Planning Statement
m	metres
MGP	Maitland Greening Plan
PCT	Plant community type
SE	Standard error
USDA	United States Department of Agriculture
USDAFS	United States Department of Agriculture Forest Services
VIS	Vegetation information system

Executive summary

Maitland City is one of the fastest growing regional cities in Australia and is seeking to balance development and economic expansion concurrently with protection of the natural environment. Under the *Hunter Regional Plan 2036* Maitland is identified as a priority area for infill and greenfield development within the Greater Newcastle continuous urban area. Development pressures, which have accelerated over time, have reduced vegetation cover and connectivity across the landscape.

In response, Maitland City Council have engaged NGH Pty Ltd to complete a series of spatial data creation and analysis exercises. Key deliverables of this project have included an updated baseline vegetation mapping layer, urban canopy assessment and identification of focal fauna wildlife corridors. The project has been largely desktop-based, with some ground truthed verification of vegetation by Council officers.

This project encompasses an opportunity analysis, identifying initiatives that provide an effective resource-to-outcome benefit for vegetation protection and enhancement and landscape connectivity, with the aim to improve biodiversity conservation. The project delivers a current dataset that will support conservation planning decisions, informing strategic advice that will support the development of effective environmental policy and planning, including a new biodiversity strategy.

An updated (2021) native vegetation spatial layer was created, building on prior work by Hill (2003). Comparison between native vegetation cover in 2003 and 2021 shows:

- All vegetation communities, excluding Alluvial River Oak Forest, Freshwater Wetland Complex and Kurri Sand Swamp Woodland, experienced a net loss, indicating that when clearing occurred, any revegetation works undertaken were insufficient to offset the loss
- Lower Hunter Spotted Gum Ironbark Forest has experienced clearing of more than 420 ha, or approximately 15% net loss
- Over 92% of the extent of all endangered ecological communities in the local government area are located on private land, which has significant implications for the establishment and achievement of retention targets.
- Since 2003, there has been a net loss of 602.92 ha of remnant native vegetation.

Since European settlement (using 1750 pre-clear data), Maitland has lost (net) more than 30,000 ha of native vegetation. Only 20% of pre-clear vegetation cover remains as at 2021 (a total of 7,857 ha remnant native vegetation, down from 37,990 ha). Subsequently, as demonstrated through this canopy assessment, the 2002 targets have not been achieved and there has been an overall net loss in the vegetation communities identified for conservation in the Maitland Greening Plan (table below).

Maitland Greening Plan proposed conservation outcomes and status as of 2021

Local significance (local extent)	Vegetation community	Conservation outcome	Status as of 2021
< 10%	• Hunter Valley Dry Rainforest • Alluvial Tall Moist Forest • Swamp Oak Sedge Forest	• No further clearing • LEP protection • Priority for revegetation	• Net loss has occurred for each of these communities

Local significance (local extent)	Vegetation community	Conservation outcome	Status as of 2021
> 10%	• Central Hunter Riparian Forest • Hunter Lowlands Red Gum Forest • Swamp Oak Rush Forest	• No net loss • Limited clearing (10%) with revegetation	• Net loss has occurred for each of these communities
< 10%	• Hunter Valley Moist Forest • Coastal Foothills Spotted Gum Ironbark Forest • Seaham Spotted Gum Ironbark Forest • Lower Hunter Spotted Gum Ironbark Forest • Swamp Mahogany Paperbark Forest	• No net loss • Lower Hunter Spotted Gum Ironbark Forest (minimum 6.75% locally) supplemented long term through revegetation	• Net loss has occurred for each of these communities • Lower Hunter Spotted Gum Ironbark Forest • reduced in extent by 15%
> 10%	• Freshwater Wetland Complex	• None described	• No change

Across the Maitland local government area there is 6,120 ha of tree canopy (over 3 m height; based on analysis of LiDAR-derived tree canopy as May 2021). Five point one percent (5.1%) of this total, or 314.6 ha is located within Council road reserve.

An additional analysis to determine how much of the Maitland native vegetation community mapping is located within the road corridor revealed that 131.9 ha (or 1.5% of the total) native vegetation extent (of 8,533 ha) is located within the road reserve. This figure includes non-forest vegetation communities (e.g., wetlands) and does not represent tree canopy alone.

In terms of ground cover (based on i-Tree canopy estimates using 2015-2016 Google Earth imagery), grass was the most common land cover class, comprising 63% (mean SE ±2.57) of the total Council area, followed by tree canopy cover at 17.9% (mean SE ±1.84) (over 3 m height). The LiDAR assessment returned a result of 15.59% tree canopy cover (over 3 m height) as of 2021. While there appears to be a general decline in tree canopy extent within the local government area from 2015-16 to 2020-21, care should be taken with regards to interpreting extent of canopy cover change between the two time periods, using the two different approaches directly. Both approaches are reliable methods of area estimation in their own right, however i-Tree Canopy and LiDaR use fundamentally different methods of area determination. The former uses a statistical point sampling method whereas the latter uses a high precision mapping approach. Considering these differences, it is likely that the decline in % tree canopy cover may be substantially greater than 2.3% over the past six years, given that LiDAR will identify a greater canopy area than i-Tree would, due to higher accuracy and a different definition of canopy.

The suburb of Cliftleigh had the lowest percentage of tree canopy cover (0.4%) and Ashtonfield the highest percentage (52.8%), based on i-Tree analysis. Whilst the follow up analysis using the 2021 LiDAR-derived data resulted in the similar top and bottom suburb in terms of canopy cover, this analysis method showed Ashtonfield to have 52.4%, and Mount Dee and Cliftleigh 1% tree canopy, respectively. As can be expected, the urban centre of Maitland has the lowest area of tree canopy cover and the highest extent of impervious surface.

Twelve ‘keystone’ fauna species have been suggested for use as interpretive health indicators specific to Maitland City’s vegetation.

Wildlife corridors have been identified across the Maitland local government area, based on the habitat and movement requirements of focal fauna guilds. Corridors are identified at the following scales:

1. Urban linkage opportunity
2. Local significance – i.e., general corridor condition and connectivity value of linkages facilitating movement within the local government area
3. Sub-regional significance – i.e., linkages enabling movement into, or out of the local government area.
4. Regional significance – i.e., where the local government area forms a critical role in connecting external core habitat areas, enabling wildlife to move across Maitland

Key recommendations

The data created through this project should be used to support both existing and new environmental initiatives, policies and plans. Recommendations include (but are not limited to):

Strategic measures

- Review and update planning tools including the Local Environment Plan, Development Control Plan and Manual of Engineering Standards.
- Consider the current native vegetation and wildlife corridor spatial data to identify priority areas for rezoning, reserve designation or the application of specific planning controls, such as for the preservation of connectivity.
- Engage with neighbouring Council's to develop and implement Blue and Green Grid projects that increase regional connectivity and achieve broadscale conservation outcomes.
- Update the Maitland Greening Plan; prepare a Maitland Urban Canopy (or Urban Forest) Strategy.
- Update the Maitland LGA plant species list, incorporating landscaping and restoration sections, with guidance on how to achieve connectivity and canopy cover.
- Set and monitor a native vegetation cover target and an urban canopy cover target.

Education

- Prepare fact sheets and other material to assist the community in understanding the importance of urban canopy.
- Information should be provided to landholders about programs that assist and benefit landholders that protect native vegetation.

On-ground actions

- Investing in tree planting and offsetting tree removal in road reserves and on public land.
- Direct Council acquisition, greening programs and private property conservation initiatives within identified wildlife corridors.
- Target retrofits and new crossing infrastructure within identified wildlife corridors, considering the results of any future investigation into vehicle-collision hotspots.

Research and future projects

- Vehicle-collision hotspot analysis.
- Study to confirm presence of focal species used in the corridor assessment; consider how this may incorporate citizen science.

- Conduct a more in-depth local habitat linkages assessment.
- Collect baseline data on the identified keystone flora and fauna species as an indicator of ecosystem health.

1. Introduction

The Maitland Local Strategic Planning Statement (LSPS) sets a 20-year land use vision for Maitland, with the ambition to ensure that growth is socially, economically and environmentally sustainable. It is readily acknowledged that Maitland City faces challenges when it comes to balancing development and economic expansion with protection of the natural environment.

The current estimated population of 83,200 residents is expected to increase to more than 110,600 residents by 2040 (Maitland City Council, 2020), placing additional pressure on the remaining remnant native bushland and associated biodiversity.

'**Our natural environment**' is one of the key themes set out in the Community Strategic Plan, in recognition of the desire of the community to care for and protect the environment from the impacts of planning and development activities. The current *Maitland Greening Plan* supports the achievement of these strategic environmental objectives by outlining measures to protect and enhance vegetation. The Plan, which was adopted in 2002, may not however respond adequately to contemporary environmental and development pressures, which have accelerated over time, reducing vegetation cover and connectivity across the landscape.

Sustainability, climate change, water security and loss of biodiversity were all important issues identified by the community during development of the LSPS. The community want more trees to cool the suburbs, encourage outdoor activity, and contribute to neighbourhood character.

NGH have been engaged by Maitland City Council (Council) to update baseline vegetation and develop heat mapping for the Maitland Local Government Area (LGA), as well as interpret this data to support the development of environmental initiatives, policy and plans. This update informs an opportunity analysis, identifying initiatives that provide an effective resource-to-outcome benefit for vegetation protection and enhancement and landscape connectivity, with the ultimate aim of improving biodiversity conservation. The project delivers a current dataset that will support conservation planning decisions, based on prioritised actions.

1.1 Project objective

The aim of the project is to update vegetation mapping for Maitland City to establish the current status of vegetation across the LGA and inform strategic advice that will support the development of effective environmental policy and planning, including a new biodiversity strategy.

1.2 Project scope

The following scope of work was implemented to achieve Council's project objective:

1. The 2003 vegetation mapping dataset (Hill, 2003) was updated, including consideration of condition
2. Urban vegetation cover was assessed and quantified using high precision LiDAR data
3. Focal fauna wildlife corridors were identified
4. Keystone flora and fauna species have been suggested
5. Provision of strategic advice to support policy development
6. Creation of an urban heat mapping layer (reported on separately).

2. Methods

2.1 Consultation

A consultative and collaborative approach has been taken, incorporating an inception meeting with the broader NGH project team as well as fortnightly progress meetings.

NGH facilitated a workshop (over Teams) on 8th June 2021. This was attended by Council officers representing a number of directorates with a responsibility for natural area planning and/or management. The workshop covered the methods implemented (or proposed), results (where available) and the potential use of the outputs for each of key project deliverables:

- Native vegetation mapping
- Urban canopy
- Wildlife corridor mapping
- Urban heat map.

The objectives of the first workshop were to confirm native vegetation condition classes, choose fauna species for use in the wildlife corridor spatial analysis, and consider opportunities to utilise each output.

A second workshop occurred on 5th August 2021, the purpose of which was to provide Council with an overview of the Project results and further consider how the outputs can be used in planning decisions and policy development. This workshop was attended by a broader group of Council officers and was an opportunity to discuss the project applications across Council work areas, to inform the final report and recommendations.

2.2 Desktop assessment

2.2.1 Literature review

A review of the relevant literature and Council's current vegetation mapping was undertaken to support development of the various Project datasets and provide appropriate planning advice. The literature review considered the following documents and data (Table 2-1).

Table 2-1 Database resources

Resource	Database
New South Wales (NSW), regional and local policies and planning instruments	• State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017 • Hunter Regional Plan 2036 • Lower Hunter Regional Conservation Plan • Lower Hunter Regional Strategy 2006-2031 • Maitland Local Strategic Planning Statement 2040+ • Maitland Local Environmental Plan 2011 • Maitland Development Control Plan 2011 • Maitland Greening Plan
Commonwealth and State	• *Environment Protection and Biodiversity Conservation Act 1999*

Resource	Database
threatened species databases	(EPBC Act) Protected Matters Search Tool • Bionet • Vegetation types database (Department of Planning, Industry and Environment) (DPIE)
Journal articles, published literature and other tools/guidelines regarding wildlife corridors, ecological values relevant to the LGA and urban greening/urban heat management initiatives, including (but not limited to)	• NSW Healthy Planning Expert Working Group (2018). Urban Cooling with Green Infrastructure • DPIE (2015) Urban Green Cover in NSW • AdaptNSW (DPIE) (2020) Hunter and Central Coast Enabling Regional Adaptation • University of NSW, UHI-DS- Microclimate and Urban Heat Island Mitigation Decision – Support Tool • Greener Spaces Better Place guides • Hurley, J., Amati, M., Deilami, K., Caffin, M., Stanford, H., Azizmohammad, S. (2020) Where will all the trees be? - an assessment of urban forest cover and management for Australian cities, prepared for Hort Innovation by the Centre for Urban Research, RMIT University, Melbourne and Greener Spaces Better Places. • Lower Hunter Regional Sustainability Planning and Strategic Assessment project outcomes, such as, Lower Hunter vegetation mapping, planning for green open space in urbanising landscapes and general approach to planning connectivity from local to regional scales (GAP CloSR).

2.2.2 Data acquisition & review

Multiple datasets were acquired from numerous sources, including Maitland City Council, SEED, NSW Spatial Services and BioNet. All data used in this project were subject to stringent quality control procedures before their application to analyses (e.g., assessment of temporal, spatial, geometric and attribute content). For a complete list of data and what each dataset was used for, refer to Table 2-2. Careful consideration was given regarding the landscape features to be included in the focal species analysis modelling, as well as to the precision and accuracy of the spatial data layers representing those features.

Table 2-2 Data list with sources and task application

Dataset	Filename	Source	Used for task items		
			Veg map update	Policy advice	Heat mapping
Aug 2020 Aerial photography (R, G, B bands only)	WMS via MetroMaps	Maitland City Council 2021	√	√	
May 2021 Aerial photography (R, G, B bands only)	WMS via MetroMaps	Maitland City Council 2021	√	√	
Vegetation community mapping (Hill 2003)	maitlandveg	Maitland City Council 2021	√	√	√
Pre-European vegetation mapping	lhcc_pre1750veg	Maitland City Council 2021		√	

Dataset	Filename	Source	Used for task items		
			Veg map update	Policy advice	Heat mapping
Updated Maitland Native Vegetation mapping 2020-21 (from ITEM 1)	Maitland Native Vegetation mapping 2020-21	Maitland City Council 2021		√	√
Land zoning	LZN	Maitland City Council 2021		√	√
Maitland Local Environmental Plan 2011	FLD & URA	Maitland City Council 2021		√	
Future development areas	Future_development	Maitland City Council 2021		√	
Land tenure/ownership	Cadastre	Maitland City Council 2021		√	
Suburbs	Suburbs	Maitland City Council 2021		√	√
LGA boundary	Maitland_LGA	Maitland City Council 2021	√	√	√
Protected estate (i.e. National parks and nature reserves)	Parks	Maitland City Council 2021		√	
Council open-space	Crown_Council_Lan d	Maitland City Council 2021		√	
Private/Voluntary conservation properties	Environmental_Proje cts	Maitland City Council 2021		√	
Waterways & wetlands	Clip and ship - Topography Maitland, Cessnock, Dungog, Singleton, Port Stephens, Newcastle LGAs	NSW Spatial Services 2021		√	
Bionet species records	Various	Bionet 2021		√	
Green corridors	GreenCorridors	Maitland City Council 2021		√	
Upper Hunter vegetation communities (VIS 4894)	HunterUpper_E_489 4.shp	SEED 2021		√	
Lower Hunter PCTs (VIS 4513)	HunterLowerEEC_E _4513.shp	SEED 2021		√	
Mid-north Coast FE_NAME (VIS 3886)	MidNthCoast_EcoLo gical_E_3886.shp	SEED 2021		√	
Landsat 8 Bands 10 & 11	LC08_L1TP_089083 _20191208_202008 25_02_T1	USGS EROS 2021			√
BOM observed temperatures	IDCJAC0010_06142 8_1800_Data	BOM 2021			√

Dataset	Filename	Source	Used for task items		
			Veg map update	Policy advice	Heat mapping
BSA demographic data and socio-economic indices (e.g., age, SEIFA, etc)	2016 Census GCP All Geographies for NSW Data Pack	ABS 2021			√
LiDAR-derived tree canopy (>3m height)	BR02718_Maitland_TreeCanopy_Above3m	Maitland City Council 2021		√	√

2.3 Native vegetation mapping layer update

2.3.1 GIS spatial analysis

The existing natural vegetation mapping (Umwelt, 2009; following Hill, 2003) was updated using an aerial photograph interpretation (API) approach which utilised the most recently acquired, Council-supplied imagery from two time periods (2020 and 2021, see Table 2-2). Using a systematic 1km x 1km grid, mapped vegetation was reviewed against the underlying high spatial resolution imagery at a scale of 1:10,000. Based on this review, one of two responses were made to update the data, each with its own set of actions:

1. **Removal** of polygons or parts thereof in response to vegetation loss:
   i. Where remnant vegetation had been cleared, polygons of mapped native vegetation were edited to reflect the new boundary of the remaining vegetation community.
2. **Addition** of polygons in response to previously unmapped vegetation or emergence of new regrowth:
   i. Three types of instances arose which necessitated new polygons to be mapped, namely: identification of previously unmapped remnant vegetation; emergence of regrowth; and mapping of revegetation works.
   ii. Previously unmapped remnant and regrowth patches were distinguished from each other by reviewing the relevant patch against historical imagery available from the Spatial Collaboration Portal https://portal.spatial.nsw.gov.au/. Vegetation which was present in older imagery (>20 years) was identified as previously unmapped remnant vegetation, while vegetation which showed emergence in more recent years after clearing was identified as potential regrowth.
   iii. Previously unmapped remnant - Due to the scale of earlier mapping being at a coarser scale than current mapping, in some instances smaller viable patches of remnant vegetation (i.e., ≤1ha) had not been mapped. In these instances where unmapped remnant vegetation was detected, the vegetation was digitised as a new polygon (patches ≤0.1ha were not mapped). The new vegetation community type was initially classified according to adjacent remnant vegetation. All new vegetation polygons were flagged for recommended field verification.
   iv. Potential regrowth - In cases where regrowth of previously removed native vegetation was evident, new polygons were digitised. These vegetation patches were classified according to adjacent remnant vegetation polygons and were flagged for recommended field verification.

v. Regeneration/revegetation works – where efforts to revegetate areas with native species were evident in the aerial imagery, the vegetation was mapped and flagged for ground-truthing.
vi. Each patch of mapped vegetation was assigned a vegetation community based of the results of the ground truthing and vegetation in the immediate surrounding area.
vii. Endangered ecological communities (EECs) listed under the *Biodiversity Conservation Act 2016* were updated as part of this process. EECs were determined through BC Act Plant Community Type (PCT) classification of vegetation that were identified in the Lower Hunter region vegetation mapping. The corresponding PCTs were checked in BioNet for EEC listings.

A quality control process was undertaken by a senior GIS officer to ensure the integrity of the final native vegetation mapping layer. The quality control process included systematic checks of (1) new attributes for consistency and correct use of class naming, and spelling checks, and (2) geometric checks of the spatial data using a combination of the 'Check Geometry' and 'Repair Geometry' tools in ESRI ArcMap to identify topology errors caused by digitising (e.g., self-intersections and null geometry) and then fix them, respectively. The mapping geometry was also checked for polygon overlaps and slivers and corrected where necessary.

2.3.2 Condition assessment

An important part of the native vegetation mapping update was the assessment and classification of vegetation condition. This task involved two key steps, namely (1) the on-screen visual appraisal of the newly mapped vegetation, ground truthed by Council, based on *a priori* condition assessment criteria, and (2) the development and application of vegetation condition classification which was applied to the entire mapped vegetation layer. Each of these steps are described in further detail below.

Condition assessment of newly mapped vegetation

The condition of newly mapped vegetation (i.e., previously unmapped remnant, new regrowth and/or regeneration) was visually evaluated against the latest high-definition aerial imagery (Metromaps 2021) through a process of onscreen API, applying predetermined assessment criteria to assign condition classes. Condition was assessed based on the following criteria:

- Condition of structure
- Presence/extent of weed cover
- Presence of canopy dieback.

Classes within each of these evaluation criteria are detailed in Table 2-3 based on the careful scrutiny of current and historical aerial imagery.

Some adjustment was made to initial classification of condition in response to ground-truthed information (see Section 2.3.3 for further detail).

Table 2-3 Initial vegetation classes used to classify newly mapped vegetation

Classification title	Classes	Explanation
Condition	Mostly unmodified Part clearing of trees and shrubs	Resultant changes in forest structure through clearing and/or regeneration were detected and

Classification title	Classes	Explanation
	Part clearing with regeneration occurring Other	classified through comparison of current and historical imagery to assist in detecting clearing and regeneration.
Weeds	0-25% 25-50% 50-75% 75-100%	The percentage cover of exotic vegetation was estimated using API and was estimated based upon the proportion of exotic species relative to native vegetation cover as was detectable in the imagery.
Canopy Dieback	Yes, potential dieback visible No dieback visible	Presence of brown patches in tree canopies or bare branches due to die back were recorded.

Development and application of a global condition class

Given the dynamic nature of vegetation in the landscape and the emergence of new vegetation in response to historical clearing and thinning of remnant vegetation over time, with some emerging vegetation not always reflecting the original vegetation community, these differences in vegetation condition needed to be acknowledged. In consultation between Council and NGH, a vegetation classification approach was developed to reflect the different types of vegetation condition based on its history. The resultant classification system and definitions of each class are described in Table 2-4.

Table 2-4 Condition classes developed and applied to all mapped vegetation according to condition type

Classification title	Classes	Explanation
Vegetation Classification	Remnant	Native remnant vegetation as mapped by Hill (2003) and/or matured regrowth and/or recovered regrowth sufficiently reflecting the state of original vegetation community.
	Disturbed remnant	Includes remnant vegetation which was not mapped previously by Hill (2003) due to extensive undergrowth clearing (which has now grown back), scattered trees or the vegetation patch was smaller than the mapping scale tolerance at that time (i.e., <1 ha in size).
	Young regrowth	Regrowth that is <10 years old (based on time of first appearance in the historical aerial image time series).
	Maturing regrowth	Regrowth that is >10 years old.
	Ecological restoration	Areas of ecological restoration that are >5 years in age and measured from establishment. The woody regrowth may include elements of the pre-clearing community or vegetation that is progressing toward the pre-clearing condition (i.e., the vegetation is a distinct successional phase that does not resemble the pre-clearing condition but given time and adequate management will progress toward its pre-clearing state). Where the substrate has changed significantly and the pre-clearing regional ecosystem is unachievable, an alternative target vegetation type and regional ecosystem may be applied, if possible. May also include any native

Classification title	Classes	Explanation
		vegetation that may be greater than 5 years old but was unable to be correlated with a relevant vegetation community (as described in Appendix B of the Maitland Vegetation Main Report; Hill, 2003).

2.3.3 Ground-truthing

All polygons flagged for ground-truthing was assessed by an experienced botanist from Council. The vegetation was then assigned a vegetation classification (see above) and community type (in accordance with Hill, 2003).

Where ground-truthing could not be undertaken, (i.e., due to access restrictions), the vegetation classification and community of the patch of vegetation was determined by API.

2.4 Urban tree canopy cover & impervious surface area assessment

Two different methods of tree canopy assessment were utilised to estimate extent of urban tree canopy across the LGA, namely (1) estimating tree canopy extent from an earlier time period (2015/16) using the free on-line i-Tree Canopy tool; and (2) precisely calculating current tree canopy extent using high-definition 2021 LiDAR imagery. The decision was made in consultation with Council to initially fulfill the task of estimating tree canopy cover using the i-Tree Canopy point sampling method, as the May 2021 LiDAR dataset was not yet user-ready at the time work needed to commence. Once the 2021 LiDAR data became available, however, high-precision calculations of tree canopy cover were also undertaken, allowing for additional accurate determination of the extent of tree canopy by suburb within urban and rural zones, within Council-controlled properties, as well as within the road corridor (see Section 2.5.1).

Each method presents its own suite of pros and cons. For example, the key advantages of the i-Tree Canopy approach are that it is affordable and easy to carry out by technically unskilled officers (no GIS skills or software required), making routine reporting feasible, and it estimates extent cover for any other land-cover classes that are defined, such as impervious surfaces, grass, shrubs and water. Furthermore, change detection analysis of land-cover classes over time can be conducted using either Google Earth Pro time-series or externally acquired aerial imagery. A number of disadvantages to the approach are that a mapped tree canopy GIS layer is not produced; the on-line tool only uses the latest available Google Maps™ imagery which is not always up-to-date or of predictable quality; and the approach can be time consuming, especially when many land-classes are defined as a sufficiently high number of sample points needs to be collected to reduce the standard error of estimation to the required level within each land-cover class.

The determination of canopy extent using LiDAR-derived mapping, on the other hand, provides high precision calculations of tree canopy extent. The canopy extent layer itself can be used in a multitude of other applied spatial analyses, such as canopy ‘gap analysis’ to strategically plan potential future planting efforts. However, production of LiDAR-derived tree canopy data can be prohibitively expensive to acquire, and skilled GIS personnel and software are required to produce the necessary data and conduct analyses for reporting.

Each method of canopy extent estimation as it was applied in the current study is discussed in detail in Sections 2.4.1 and 2.4.2 below.

2.4.1 The i-Tree Canopy method

Background

The i-Tree Canopy tool is an on-line facility developed by the United States Department of Agriculture (USDA) Forest Services to photo-interpret tree canopy and other land cover classes using available Google Maps™ imagery (USDAFS 2021) and estimate the area of each class using a point sampling method. The tool provides a user-friendly interface to facilitate the classification of digital aerial images, by prompting the user to identify pre-determined landcover classes at a series of random points. These are subsequently interpreted to determine the cover type at each point centre. This process produces statistical estimates of cover with a known error of estimation.

In the photo interpretation stage, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree canopy, herbaceous shrub, grass, bare ground, impervious surface [building, impervious surface, road], water). From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). The more points used, the lower the error becomes.

The main benefit of using this approach is that it is a rapid, statistically robust and low-cost method of estimating tree canopy and other land cover areas such as impervious surfaces. It has a strong track record, having been used in a national project to benchmark Australia's urban tree canopy (Jacobs, et al. 2014), as well as numerous individual Australian LGAs for estimating urban canopy cover, e.g., City of Charles Sturt (Seed Consulting Services 2016); City of Burnside (Seed Consulting Services 2016); Campbelltown City Council (Seed Consulting Services 2016); City of Boroondara (Greenspace 2017); City of Norwood Payneham & St Peters (Martinez 2018).

In addition, given the simplicity of the interface and the process, training of Council staff members will be undertaken to enable Maitland City Council to perform i-Tree Canopy assessments in-house using a predefined set of points, making it possible to carry out change detection analyses against alternative time periods. This would enable regular and reliable updates in the percentage canopy cover reporting, without the cost of having to contract external specialists to process and map new vegetation cover data sets.

The main disadvantage is that tree canopies are not individually mapped. Results can only be summarised by predefined spatial units, such as suburb or ABS meshblock.

Survey point selection

All 50 suburbs within the Maitland City LGA were individually assessed. Of these 50 suburbs, 42 were contained entirely within the LGA boundary and seven (7) were partially overlapped with neighbouring council boundaries. Only areas within the Maitland City boundary were assessed, and so care should be taken when comparing suburb-level assessments of land-cover for the partially-contained suburbs (Cliftleigh, Woodville, Greta, Allandale, Lamb Valley, Tocal and Bishops Bridge) with those suburbs entirely contained within the LGA.

Each suburb was assessed as a separate i-Tree Canopy project, classifying a minimum of 280 points per suburb, or enough points to attain a standard error (SE) <2% across all land-cover classes. The maximum number of points sampled for a suburb was 460. In total across all suburbs, 15,602 points were sampled.

The land-cover within each suburb was assessed using the prevailing Google Maps™ imagery available on the i-Tree Canopy platform at the time of sampling. The Maitland LGA area was assessed against aerial images from two different time periods, with the eastern two thirds of the region (including the majority of urban areas) covered by an image captured on 10 January 2016 and the western third (including the lake area on Swamp and Bishops Creek) by an image captured on 22 August 2015. The land-cover estimates produced in this report are therefore relevant for the period 2015-2016. City officers will be trained how to carry out a change detection analysis against imagery from other time periods, which will produce comparative land-cover estimates.

Land-cover categories

When setting up an i-Tree-Canopy project, the set of land-cover classes to be assessed needs to be identified before point sampling begins. These classes cannot be changed once sampling has commenced.

To ensure that estimation of tree canopy cover and other land cover classes for Maitland City was statistically comparable with those of other LGAs assessed by the Benchmarking Australia's *Urban Tree Canopy 2014* report (Jacobs, et al. 2014), the land-cover classes used in this project were initially based on those of the latter project as a starting point, which were: Tree, Shrub, Grass/Bare Ground and Hard Surface. However, to provide greater definition and therefore greater functional application of the land-cover classes for decision-making by the City, two of these land-cover categories were split into further sub-categories, resulting in a total of seven (7) land-cover classes. The final land-cover classes used in the i-Tree Canopy Cover assessment can be found in Table 2-5 along with the comparable land-cover classes used by the Australia Benchmark (2014) project, and a list of features included in each class.

Table 2-5 Land-cover classes estimated using the i-Tree Canopy tool

Cover classes defined in this project	Comparable Australia Benchmark 2014 classes	Description	Tree canopy	Green space	Potential to plant
Tree	Tree	Tree canopy cover >3m high, including native and exotic tree species, orchards	√	√	√
Shrub	Shrub	Canopy cover <3m high, hedges, ornamental garden shrubs, grapevines	X	√	√
Grass	Grass/bareground	Grasslands, lawns, paddocks, most agricultural crops, tilled fields	X	√	√
Bareground/soil	Grass/bareground	Dirt roads & footpaths, sites cleared for development, railway corridor reserve	X	X	√
Impervious surface - building	Hard surface	Man-made structures such as buildings & swimming pools	X	X	X
Impervious surface - road	Hard surface	Sealed roads, footpaths, pavements, tarmac, airport runway	X	X	X
Water	Hard surface	Lakes, dams, natural waterbodies with water surface visible, temporary flooded areas	X	X	X

i-Tree Canopy settings

The settings used when establishing each i-Tree Canopy project were as follows:

- ***project location***: none selected (the i-Tree Canopy software is capable of calculating approximate ecosystem service benefits provided by trees as part of the output. These calculations are based on USA specific metrics related to weather and pollution and tree species. However, as this was not within the scope of the project, this analysis component was not used and no selections were made)
- ***land-cover categories:*** these are user-defined categories entered into the i-Tree Canopy settings (see Table 2-5 for list of land-cover classes used);
- ***benefit options***: 'Tree' (this setting identifies which of the land-cover categories represent "tree cover")
- ***currency***: AUD $
- ***units***: metric

Aerial photo-interpretation (API) of land-classes

API is open to interpretation by the user, which may lead to an inherent level of error in the classification, particularly if the quality of the imagery is poor. Such error was minimized as much as possible through consultation with other users to determine a consensus for contentious points, and also by considering the surrounding land-cover context and comparing images in other time periods. In particular, the high-resolution Maitland aerial imagery (2020, 2021) viewable via MetroMaps was used for reference, if features were not identifiable in the Google Maps™ imagery.

Collation of results

Once point sampling across all suburbs had been completed, the summary statistics (area, % cover and related SEs) which are produced by i-Tree Canopy as a pdf document were extracted and collated into a centralised spreadsheet dataset.

To spatially display the area and % cover estimates of tree canopy and impervious surface categories, the various land class files were joined to the Maitland LGA suburbs layer. These various joins were exported as individual shapefiles (Figure 2-1).

MaitlandLGA_GRASS_cover_by_suburb_2016.shp
MaitlandLGA_IMPERVIOUS_BUILDING_cover_by_suburb_2016.shp
MaitlandLGA_IMPERVIOUS_ROAD_cover_by_suburb_2016.shp
MaitlandLGA_SHRUB_cover_by_suburb_2016.shp
MaitlandLGA_SOIL_BAREGROUND_cover_by_suburb_2016.shp
MaitlandLGA_TREE_CANOPY_cover_by_suburb_2016.shp
MaitlandLGA_WATER_cover_by_suburb_2016.shp

Figure 2-1 i-Tree Canopy spatial data filenames

Other outputs produced by i-Tree Canopy include .csv and .kml format files of the sampled points. Using the coordinates in the .csv file for each suburb, a single point shapefile of all sampled points across all suburbs with corresponding land-class categories was compiled and created. This point layer was used to estimate the relative proportion of tree canopy located on public and private property. The Crown Council Land spatial data layer was used to identify Council-controlled land.

2.4.2 Calculation of tree canopy using LiDAR-derived tree canopy data

LiDAR-derived tree canopy mapping was supplied by Maitland City at a later stage in the project to calculate current tree canopy extent across the LGA. Based on a 10 ppm^2 point cloud dataset, flown on 22 April 2021, the derived LiDAR product provides a snapshot in time of tree canopy extent >3m in height with very high spatial precision. Leveraging the high spatial resolution of the data, extent of tree canopy was calculated by suburb for urban and rural zones using the City-supplied 'Urban Zones Lands 2020' layer, as well as canopy located on public (Council-controlled properties were identified using the 'Crown_Council_Land' layer) and private (i.e., not Council-controlled) land by means of a GIS desktop analysis.

2.5 Calculation of statistics

Using the derived baseline mapping of remnant native vegetation (including EECs), urban vegetation, impervious surfaces and vegetation condition, the following was determined:

- Percentage extent of remnant native vegetation across the LGA
- Percentage of urban vegetation such as street trees and parks by suburb, including percentage of trees for urban and rural zones, both within private and public lands
- Estimated percentage impervious area by suburb
- Percentage of EEC retained in the LGA utilising Council's EEC mapping on current imagery
- Interpretation through imagery of the health of the vegetation in the native corridors and the level of introduced species
- Interpretation through imagery of the health of urban vegetation including stress and dieback of canopy trees.

Additional analysis was conducted using current native vegetation 2021, '1750 pre-clear' native vegetation and 2021 LiDAR-derived tree canopy mapping, calculate:

- Area and percentage of current 2021 urban tree canopy cover within Maitland LGA road corridors using NSW road mapping (with a 5m buffer) and 2021 LiDAR-derived tree canopy extent
- Area and percentage of current 2021 native vegetation cover within Maitland LGA road corridors using NSW road mapping (with a 5m buffer) and Maitland Native Vegetation with EEC 2020_21 mapping.
- Extent of current native vegetation cover (2021) compared with '1750 pre-clear' vegetation cover mapping. The resulting calculations included:
  - Area (in hectares) of current native vegetation within Maitland LGA and council-controlled land
  - Area (in hectares) of pre-clear native vegetation within Maitland LGA and council-controlled land
  - Percentage of native vegetation cover compared between the 1750 pre-clear vegetation mapping and the Maitland Native Vegetation with EEC 2020_21 mapping within Maitland LGA and council-controlled land
  - Percentage of native vegetation loss compared between the 1750 pre-clear vegetation mapping and the Maitland Native Vegetation with EEC 2020_21 mapping within Maitland LGA and council-controlled land.

2.5.1 Extant tree canopy cover and native vegetation cover within Maitland's road corridors

Both extant native vegetation and urban tree canopy cover within Maitland's road corridors were calculated, including canopy cover that encroached into the road reserve. Canopy cover was accounted for by applying a 5m buffer around the NSW road reserve spatial layer. These calculations were applied to both the LiDAR canopy cover mapping (i.e., tree canopy >3m in height) and the Maitland Native Vegetation with EEC 2020_21 mapping to assess both native vegetation, and canopy cover within the road corridor.

2.5.2 Extent of native vegetation cover and loss

The extent of remaining native vegetation cover within Maitland compared with pre-clear vegetation extent was determined by comparing the vegetation communities within the '1750 pre-clear' vegetation with that of the recently developed 'Maitland Native Vegetation with EEC 2020_21' mapping (Section 2.3). As the naming conventions of vegetation communities and mapping techniques have differed over time, the comparison between pre-clear and current (2021) vegetation mapping to determine the change in vegetation cover over time was challenging. As a result, rules were put in place to assist with calculating the change in vegetation cover. These were as follows:

- Where possible, vegetation was compared where the vegetation community naming conventions were the same. This was verified further by analysing the mapping, between pre-clear and current, to ensure the vegetation communities overlapped considerably to confirm that comparing like-for-like was adequate for calculating vegetation loss over time.
- Where vegetation communities did not overlap significantly or where it was obvious that a vegetation community has now been reclassified (i.e., separated into two communities or combined into one) the area (hectares) of these communities were combined to make a more accurate comparison.
- Where the vegetation community of a patch from the pre-clear mapping was reclassified as a different community, the area (hectares) of the updated communities within the patch were combined to make a more accurate comparison.
- Other pre-clear vegetation communities, that appear to no longer exist within the Maitland LGA, were analysed to ensure that naming conventions were not altered or that the vegetation community has not been re-classified. After further analysis, these communities have been classified as extinct.
- The area (hectares) was calculated by dissolving the layer for each vegetation community and then using the 'Field Calculator' and the 'Group Stats' plugin installed in QGIS to calculate the total.
- The decisions to combine areas of analysed vegetation communities between 1750 preclear and 2021 current mapping were made in QGIS using formatting formulas to reclassify vegetation communities accordingly.
- The percentages of current vegetation coverage and vegetation loss within Maitland LGA and Maitland council-controlled areas were calculated in Microsoft Excel using excel formulas.

Limitations

The comparison of vegetation communities between pre-clear and current vegetation mapping was not a clear 1:1 comparison. As a consequence, the following limitations influence the accuracy of the results:

- Changes in mapping methods between development of the pre-clear mapping and the current mapping. Vegetation patches in the 2021 mapping were able to be mapped at a finer scale, enabling vegetation to be mapped that previously was not detectable. It is possible that this may have attributed to the large increase in vegetation cover for some communities and may affect the accuracy of percentage coverage loss calculations.
- Patches of vegetation have been re-classified in current mapping. It is difficult to know if this is a consequence of changing environments over time, re-growth of vegetation after clearing, changes in vegetation community descriptions, or vegetation reclassification with further analysis of the community on the ground.

2.6 Identifying keystone flora and fauna species

Ecological indicators are commonly used by environmental management groups and scientists for the purposes of assessing the condition of the environment or monitoring trends in condition over time. A desktop analysis was undertaken to identify a succinct number of keystone species, to act as interpretive health indicators specific to Maitland's vegetation.

This assessment has considered published data sources, including a review of BioNet Atlas records within a 40 km buffer of the Maitland LGA since 2016.

Dale and Beyeler (2001) discuss several general characteristics of useful indicator species. Indicators should be easily sampled, sensitive to stresses on the system, and respond to stress in a predictable manner. As such, potential indicator species were evaluated applying the following criteria, through an extensive literature review:

- the species is sensitive to disturbance or edge effects
- disturbance to the species' habitat results in the absence of the species within an environment
- the species is easily monitored.

The selected indicator species coincide with those chosen for the focal fauna species corridor assessment (Section 2.7), providing a measurable criterion for determining improved connectivity, or were selected because they are indicator species and provide a measure of ecological condition.

2.7 Identifying wildlife corridors using focal species analysis

The results of the desktop assessment and the native vegetation mapping layer update were used to inform an analysis of the regional significance of wildlife corridors, both within and across the LGA. This analysis enabled the consideration of:

1. Local significance – i.e., general corridor condition and connectivity value of linkages facilitating movement within the LGA.
2. Sub-regional significance – i.e., linkages enabling movement into, or out of the LGA.
3. Regional significance – i.e., where the LGA forms a critical role in connecting external core habitat areas, enabling wildlife to move across Maitland

For the purposes of carrying out this analysis, a 10 km buffer was applied to the Maitland LGA boundary to define the larger regional analysis extent. A buffer of 10 km was considered sufficient to ensure that ecologically significant core habitat areas adjacent to the LGA were captured in the analysis.

In order to incorporate the diverse ways which species functionally use a landscape both in terms of resource use and movement, a focal species analysis approach was utilised. The method is a pragmatic application of species-specific parameters in the identification of landscape-level connectivity and requires careful selection of species based on their sensitivities to habitat fragmentation, requirement for primary habitat and dependence on connectivity for survival (Lambeck, 1997). The use of focal fauna species is an established method to determine landscape connectivity and has been recently applied by NGH on a number of local government conservation planning projects to identify a protected environmental network.

As a surrogate for multiple species, focal fauna guilds were used as opposed to using individual focal species. Within the context of the current study, an ecological guild is defined as any group of species that exploit the same resources, or that exploit different resources but in a related manner. This approach ensured that the different ways linkages are potentially used by different fauna groups could be considered, and efficiently maximised the number of focal fauna species which could be used in the model.

2.7.1 Selection of focal species/guilds

The first step in the analysis was to identify guilds which would effectively represent the multiple ways wildlife utilise the landscape. Once guilds had been identified, fauna species were identified within each guild (based on their habitat and movement requirements) which occur across multiple core habitat areas both in the local and adjacent regional landscape, as well as are likely to utilise vegetation within the LGA for movement and/or habitat function.

Focal fauna species were selected on the following criteria:

- Threatened or iconic species with suitable habitat mapped as being present and/or
- Confirmed or likely occurring species which are dependent on habitat connectivity for their long-term persistence in the sub-regional and greater regional area.

Altogether, 12 guilds were identified, encompassing 22 species in total (see Table 2-6 for a list of guilds and their corresponding species). This list was achieved in consultation with Council.

Focal fauna species are a surrogate for multiple species and aims to capture the manner in which the majority of wildlife moves through the landscape. The specific focal fauna species may not be confirmed in the LGA itself, however they should have the potential to occur there either intermittently, or in the future or have suitable habitat identified in a condition (or condition that could be made) suitable for that species.

Combined, these guilds and component species represent a broad range of taxonomic groups, habitat associations and different functional use of the component habitat. This approach will ensure linkage areas are identified to benefit the greatest number of native species.

2.7.2 Habitat suitability

A literature and desktop review was carried out to ascertain each species' habitat and connectivity requirements (see Appendix A for a summary of results). Suitable habitat for each of the focal fauna guilds were then identified in the LGA using the updated Maitland Native Vegetation 2020-21 mapping (Section 2.3), and across the wider region PCTs were used when available, otherwise locally defined vegetation community types were used. Vegetation layers used for the 10 km buffer region included Lower Hunter PCTs (VIS 4513), Upper Hunter PCTs (VIS 4894) and Mid-north Coast FE_NAME (VIS 3886).

Core habitat areas (CHAs) were identified for each species. CHAs are large, intact patches of remnant habitat which are of sufficient size to ensure the long-term survival of species' populations (for the current analysis CHAs are defined as suitable habitat patches large enough to ensure population persistence for at least 10 years). When analysing species-specific connectivity within a landscape, it is important for linkages to connect CHAs which support suitable habitat for that species. Ideally CHAs should have some level of legislative protection, however it was not a prerequisite for this analysis. As local habitat linkages through urban areas were also considered in this assessment, smaller habitat patches which were large enough to support at least one breeding event were also identified. These smaller remnant patches are termed habitat nodes (HNs) and act similarly to CHAs but depend upon metapopulation mixing of genetic material between individuals of nearby HNs to ensure their longer-term persistence within the urban landscape.

The literature review and desktop assessment findings were used to identify the potential habitat suitability of each vegetation community for each focal species. Based on the plant species composition within each vegetation community, these were classified as being either suitable or unsuitable habitat for each guild. 'Suitable' habitat was further defined as being either primary habitat or secondary habitat. Primary habitat included those native vegetation communities which contain plant species and plant community structure considered to be critical for successful breeding and/or feeding. Secondary habitat was defined as vegetation communities which assist species to move through the landscape to reach patches of primary habitat, but are not likely to be essential for breeding or feeding.

2.7.3 Assessment of connectivity

Once suitable habitat and CHAs/HNs had been identified for each guild, a GIS desktop analysis was carried out using proximity analyses to determine most-likely route of movement through the landscape for each of the focal guilds, as determined by suitability of habitat and the distance between habitat patches. All parameter thresholds used in each guild connectivity model are tabulated in Appendix A.

A 'structural connectivity' layer was compiled for each species by combining spatial layers of native vegetation and non-native vegetation (if available). The resultant polygons were buffered to determine which vegetation patches are 'connected' for a particular species, according to the maximum gap distance they are willing to cross to move from one patch to another. In this manner it was possible to identify the most likely routes of movement through the landscape between CHAs/HNs.

2.7.4 Identification of key corridors

The connectivity outputs for each of the 12 focal fauna guilds were overlaid to give a multiple-guild corridor. The greater the number of corridor overlaps, the more likelihood that a variety of species will utilise the linkage, and therefore the more significant this connection might be. Consideration was also given to low overlap areas as these may be supporting specialised guilds.

Table 2-6 Focal guilds and species used in the linkage assessment

Guild name	Common name	*Species name*	Class	Status
Freshwater frogs	Green and Golden Bell Frog	*Litoria aurea*	Amphibia	Conservation status in NSW: Endangered Commonwealth status: Vulnerable
	Common Eastern Froglet	Crinia signifera		Not listed
	Tusked Frog	*Adelotus brevis*		Not listed
Migratory forest bird	Regent Honeyeater	*Anthochaera phrygia*	Aves	Conservation status in NSW: Critically Endangered Commonwealth status: Critically Endangered
	Swift Parrot	*Lathamus discolor*		Conservation status in NSW: Endangered Commonwealth: Critically Endangered
Resident forest bird	Eastern Yellow Robin	*Eopsaltria australis*	Aves	Not listed
	Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*		Conservation status in NSW: Vulnerable
	Superb Fairy-wren	*Malurus cyaneus*		Not listed
Forest Owl	Powerful Owl	*Ninox strenua*	Aves	Conservation status in NSW: Vulnerable
Glider	Feathertail Glider	*Acrobates pygmaeus*	Mammalia	Not listed
	Squirrel Glider	*Petaurus norfolcensis*		Conservation status in NSW: Vulnerable
	Sugar Glider	*Petaurus breviceps*		Not listed
Arboreal mammal (herbivore/ folivore) (mid-size)	Koala	*Phascolarctos cinereus*	Mammalia	Conservation status in NSW: Vulnerable Commonwealth status: Vulnerable
Arboreal mammal (frugivore)	Grey-headed Flying-fox	*Pteropus poliocephalus*	Mammalia	Conservation status in NSW: Vulnerable Commonwealth status: Vulnerable
Ground-dwelling Mammal (Moist Forest)	Swamp Wallaby	*Wallabia bicolor*	Mammalia	Not listed

Guild name	Common name	*Species name*	Class	Status
Hollow-dependent microbats	Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Mammalia	Conservation status in NSW: Vulnerable
	Greater Broad-nosed Bat	*Scoteanax rueppellii*		Conservation status in NSW: Vulnerable
	Southern Myotis	*Myotis macropus*		Conservation status in NSW: Vulnerable
Ground dwelling mammal (Generalist)	Bush Rat	*Rattus fuscipes*	Mammalia	Not listed
Wetland associated (small mammal)	Swamp Rat	*Rattus lutreolus*	Mammalia	Not listed
	Water Rat	*Hydromys chrysogaster*		Not listed

3. Results

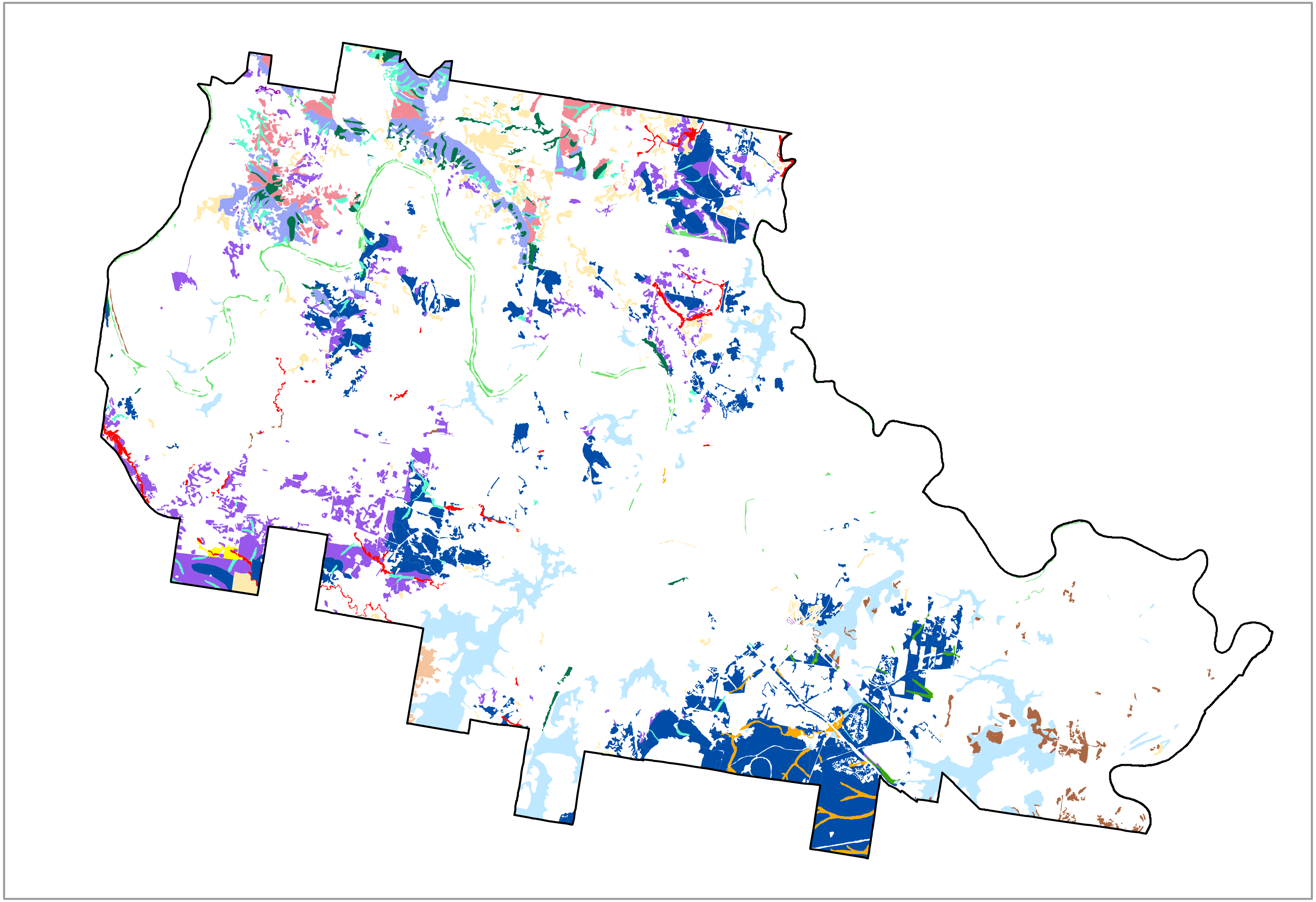
3.1 Native vegetation map update

Figure 3-1 provides a map of native vegetation across the Maitland City Council LGA, showing the current extent and spatial distribution of all native vegetation communities as of May 2021. Table 3-1 provides a detailed breakdown of the area and percentage extent of remnant, disturbed remnant, maturing regrowth and young regrowth mapped for each vegetation community.

Key findings of analysis of the updated native vegetation data reveal that:

- There is 8,533.74 ha of native vegetation across all condition classes.
- 21.7% of the entire LGA is covered by native vegetation.
- The most extensive vegetation community is that of 'Lower Hunter Spotted Gum Ironbark Forest' covering an area of 2,488.5 ha as remnant (34.5% of extent of all remnant communities) and is distributed across most of the LGA except for the extreme eastern and western sections. An additional 124.8 ha of this vegetation type has been mapped recently by NGH (2021) as disturbed remnant, maturing regrowth, young regrowth and ecological regeneration.
- 'Freshwater Wetland Complex' covers an area of 1,700.3 ha (23.9% of total native vegetation extent) however a large proportion of this community class appears to be unvegetated and located within the low-lying floodplain areas throughout the LGA.
- 'Hunter Lowlands Redgum Forest Variant' has the third largest extent of 1,060.1 ha remnant (14.9%), occurring predominantly only in the western half of the LGA. An additional 88.1 ha has been identified and mapped as disturbed remnant, maturing regrowth, young regrowth and ecological restoration.
- The vegetation community with the smallest extent was 'Hunter Lowlands Redgum Moist Forest' covering an area of only 35.8 ha (0.5% of total native vegetation extent), most of which occurs in the eastern portion of the LGA.
- Kurri Sand Swamp Woodland (41.5 ha remnant) and Alluvial River Oak Forest (89.1 ha remnant with an additional 90.79 ha as maturing regrowth and ecological restoration).
- There is 6,030.35 ha of endangered ecological communities within the LGA (Table 3-2), comprised of both remnant and disturbed remnant condition classes. Of this, only 7.2% is found within Council-managed land; the rest is on private property.
- Since 2003, there has been a net loss of 602.92 ha of remnant native vegetation (as mapped by Hill, 2003).
- Overall, an additional 832.19 ha of vegetation has been mapped recently by NGH (Table 3-1) compared to the previous mapping project (Hill, 2003). Compared to the 603 ha of vegetation removed from the 2003 mapping due to clearing (Table 3-3), this represents a net increase of approximately 229 ha of mapped vegetation. It should be noted that issues relating to methodology used and technology available by the previous mapping project have led to inaccuracies as well as discrepancy between the two mapping outcomes. Therefore, this figure needs to be interpreted with caution as it includes 131.65 ha of remnant vegetation, present in 2003 but not mapped by Hill ('Disturbed remnant'). The bulk of the increase stems from 608.14 ha of regrowth ('Young regrowth' and 'Maturing regrowth') mapped recently. Also contributing to the increase in vegetation extent is approximately 92 ha of revegetation work ('Ecological restoration').

Figure 3-1 Extant native vegetation within City of Maitland (2020-21)



Vegetation Community

- Freshwater Wetland Complex
- Alluvial River Oak Forest
- Alluvial Tall Moist Forest
- Central Hunter Riparian Forest
- Central Hunter Riparian Forest and Hunter Lowlands Redgum Forest Variant
- Lower Hunter Spotted Gum Ironbark Forest
- Hunter Lowlands Redgum Forest Variant
- Hunter Lowlands Redgum Moist Forest
- Hunter Stringybark Spotted Gum Ironbark Forest
- Hunter Valley Dry Rainforest
- Hunter Valley Moist Forest
- Kurri Sand Swamp Woodland
- Riparian
- Scattered Trees
- Seaham Spotted Gum Ironbark Forest
- Swamp Oak Alluvial Forest

Ref: 21-137 Fig Updated Maitland Native Vegetation 2020_21
Author: Rebecca Sims
Date created: 22/09/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

Service Layer Credits:

Table 3-1 Percentage extent of native vegetation across the Maitland LGA

Vegetation Community Name	Remnant - 2020-21 extent	Disturbed remnant	Maturing regrowth	Young regrowth	Ecological restoration/remnant	Ecological restoration	Total area of native vegetation (ha)	% Extent of remnant vegetation within Maitland LGA	% Extent of all native vegetation within Maitland LGA	Areas of additional new vegetation as mapped by NGH (2021) - 2020-21 extent
Alluvial River Oak Forest	89.06		86.93			3.86	**179.85**	0.23%	0.46%	90.79
Alluvial Tall Moist Forest	103.30	1.70	4.73				**109.73**	0.26%	0.28%	6.43
Central Hunter Riparian Forest	129.67	0.66	18.64			2.33	**151.30**	0.33%	0.39%	21.63
Central Hunter Riparian Forest and Hunter Lowlands Redgum Forest Variant		21.15					**21.15**	0.00%	0.05%	21.15
Freshwater Wetland Complex	1,700.28						**1,700.28**	4.33%	4.33%	0.00
Hunter Lowland Redgum Forest			7.07				**7.07**	0.00%	0.02%	7.07
Hunter Lowlands Redgum Forest Variant	1,060.05	19.72	64.34	1.08		2.96	**1,148.14**	2.70%	2.93%	88.10
Hunter Lowlands Redgum Moist Forest	35.78						**35.78**	0.09%	0.09%	0.00
Hunter Stringybark Spotted Gum Ironbark Forest	542.08	4.11	22.60				**568.79**	1.38%	1.45%	26.71
Hunter Valley Dry Rainforest	221.53	1.13	14.17				**236.83**	0.56%	0.64%	15.30
Hunter Valley Moist Forest	239.14	15.61	9.67				**264.42**	0.61%	0.67%	25.28
Kurri Sand Swamp Woodland	41.52	0.43	2.95	0.94			**45.84**	0.11%	0.12%	4.32

Vegetation Community Name	Remnant - 2020-21 extent	Disturbed remnant	Maturing regrowth	Young regrowth	Ecological restoration/remnant	Ecological restoration	Total area of native vegetation (ha)	% Extent of remnant vegetation within Maitland LGA	% Extent of all native vegetation within Maitland LGA	Areas of additional new vegetation as mapped by NGH (2021) - 2020-21 extent
Lower Hunter Spotted Gum Ironbark Forest	2,488.50	41.61	72.77	10.46		35.14	**2,648.49**	6.34%	6.74%	159.99
Seaham Spotted Gum Ironbark Forest	335.93	4.81	27.78				**368.51**	0.86%	0.94%	32.58
Swamp Oak Alluvial Forest	138.38	12.54	11.81	0.49		19.12	**182.34**	0.35%	0.46%	43.96
Community not identified			181.44	27.61	7.24	12.33	**228.62**	0.00%	0.58%	228.62
Native planting						0.99	**0.99**	0.00%	0.00%	0.99
Regeneration (identified by Hill 2009)	119.39						**119.39**	0.30%	0.30%	0.00
Riparian						3.86	**3.86**	0.00%	0.01%	3.86
Scattered Trees	456.96	8.19	41.23	1.42		4.58	**512.37**	1.16%	1.31%	55.41
Grand total	**7,701.55**	**131.65**	**566.14**	**42.00**	**7.24**	**85.16**	**8,533.74**	**19.62%**	**21.74%**	**832.19**
Maitland LGA area (Ha)							**39,250.51**			

Table 3-2 Extent of native vegetation which is an EEC retained in the LGA

Endangered ecological community	Endangered remnant EEC				Remnant EEC	Endangered disturbed EEC				Disturbed remnant EEC	Remnant & disturbed remnant		Grand total (Ha)
	Ha on private land	% on private land	Ha on public land	% on public land	Total area (Ha)	Ha on private land	% on private land	Ha on public land	% on public land	Total area (Ha)	% on private land	% on public land	
Central Hunter Riparian Forest	127.98	98.7%	1.69	1.3%	**129.67**	0.00	0.0%	0.00	0.0%	**0.00**	**98.7%**	**1.3%**	**129.67**
Central Hunter Riparian Forest and Hunter Lowlands Redgum Forest Variant	0.00	0.0%	0.00	0.0%	**0.00**	21.15	100.0%	0.00	0.0%	**21.15**	**100.0%**	**0.0%**	**21.15**
Freshwater Wetland Complex	1,562.73	91.9%	137.55	8.1%	**1,700.28**	0.00	0.0%	0.00	0.0%	**0.00**	**91.9%**	**8.1%**	**1,700.28**
Hunter Lowlands Redgum Forest Variant	1,029.99	97.2%	30.06	2.8%	**1,060.05**	17.15	87.0%	2.57	13.0%	**19.72**	**97.0%**	**3.0%**	**1,079.77**
Hunter Lowlands Redgum Moist Forest	26.60	74.4%	9.17	25.6%	**35.78**	0.00	0.0%	0.00	0.0%	**0.00**	**74.4%**	**25.6%**	**35.78**
Kurri Sand Swamp Woodland	41.52	100.0%	0.00	0.0%	**41.52**	0.43	1.0%	.00	0.0%	**0.43**	**100.0%**	**0.0%**	**41.95**

Endangered ecological community	Endangered remnant EEC				Remnant EEC	Endangered disturbed EEC				Disturbed remnant EEC	Remnant & disturbed remnant		Grand total (Ha)
	Ha on private land	% on private land	Ha on public land	% on public land	Total area (Ha)	Ha on private land	% on private land	Ha on public land	% on public land	Total area (Ha)	% on private land	% on public land	
Lower Hunter Spotted Gum Ironbark Forest	2,254.84	90.6%	233.66	9.4%	**2,488.50**	33.31	80.1%	8.30	19.9%	**41.61**	**90.4%**	**9.6%**	**2,530.11**
Seaham Spotted Gum Ironbark Forest	335.93	100.0%	0.00	0.0%	**335.93**	4.81	1.4%	0.00	0.0%	**4.81**	**100.0%**	**0.0%**	**340.74**
Swamp Oak Alluvial Forest	129.65	93.7%	8.73	6.3%	**138.38**	7.22	4.8%	5.32	42.4%	**12.54**	**90.7%**	**9.3%**	**150.92**
Grand Total	**5,509.24**	92.9%	**420.85**	7.1%	**5,930.10**	**84.07**	**1.4%**	**16.19**	**16.1%**	**100.26**	92.8%	7.2%	**6,030.35**

Table 3-3 Loss of remnant vegetation between 2003 and 2021

Vegetation community name	2003 remnant extent (Ha)	2020/21 remnant extent (Ha)	Net change in remnant area (Ha)[1]
Alluvial River Oak Forest	89.06	89.06	0.00
Alluvial Tall Moist Forest	105.21	103.30	-1.91
Central Hunter Riparian Forest	130.08	129.67	-0.41
Freshwater Wetland Complex[2]	1,705.50	1,700.28	0.00
Hunter Lowlands Redgum Forest Variant	1,127.77	1,060.05	-67.72
Hunter Lowlands Redgum Moist Forest	41.99	35.78	-6.21
Hunter Stringybark Spotted Gum Ironbark Forest	542.83	542.08	-0.75
Hunter Valley Dry Rainforest	222.92	221.53	-1.39
Hunter Valley Moist Forest	239.95	239.14	-0.81
Kurri Sand Swamp Woodland	41.52	41.52	0.00
Lower Hunter Spotted Gum Ironbark Forest	2,909.68	2,488.50	-421.18
Regeneration	124.46	119.39	-5.06
Scattered Trees	537.49	456.96	-80.54
Seaham Spotted Gum Ironbark Forest	336.90	335.93	-0.98
Swamp Oak Alluvial Forest	149.11	138.38	-10.73
Grand Total	**8,304.47**	**7,701.55**	**-602.92**

3.1.1 Comparison with Maitland Greening Plan targets (2002)

Targets for the retention of native vegetation were established under the Maitland Greening Plan (MGP), both for the overall retention of bushland and for specific vegetation communities. Even in 2002, Maitland was considered to be a highly urbanised environment (Maitland City Council 2002) and the extent of most vegetation communities had already decreased to below 10% of their original distribution. The MGP notes that much of the vegetation clearing in the LGA occurred early in the history of European settlement.

Under the MGP, each vegetation community was allocated a conservation priority and a 'Local Significance' criterion, based on the local vegetation extent. Outcomes for the identified communities, which would help to achieve the allocated targets, were also specified. The targets and outcomes for identified communities are reproduced in Table 3-4.

Table 3-4 Maitland Greening Plan vegetation retention targets

Conservation ranking	Local significance (local extent)	Vegetation community	Conservation outcome	Status as at 2021
1	< 10%	• Hunter Valley Dry Rainforest	• No further clearing	• Net loss has occurred for

[1] Net loss
[2] Adjusted to reflect 5.23 ha of FWC reclassified as Disturbed Remnant

Conservation ranking	Local significance (local extent)	Vegetation community	Conservation outcome	Status as at 2021
		• Alluvial Tall Moist Forest • Swamp Oak Sedge Forest	• LEP protection • Priority for revegetation	each of these communities
2	> 10%	• Central Hunter Riparian Forest • Hunter Lowlands Red Gum Forest • Swamp Oak Rush Forest	• No net loss • Limited clearing (10%) with revegetation	• Net loss has occurred for each of these communities
3	< 10%	• Hunter Valley Moist Forest • Coastal Foothills Spotted Gum Ironbark Forest • Seaham Spotted Gum Ironbark Forest • Lower Hunter Spotted Gum Ironbark Forest (LHSGIF) • Swamp Mahogany Paperbark Forest	• No net loss • LHSGIF (minimum 6.75% locally) supplemented long term through revegetation	• Net loss has occurred for each of these communities • LHSGIF reduced in extent by 15%
4	> 10%	• Freshwater Wetland Complex	• None described	• No change

In the almost 20 years since the MGP targets were proposed, the region has remained a centre for urban development, increasing pressures on native vegetation, with consequent impacts on the retention of vegetation communities. Subsequently, as demonstrated through this assessment, the 2002 targets have not been achieved and there has been an overall net loss in the vegetation communities identified for conservation in the MGP.

Table 3-3 shows the extent of the net loss for each of these communities. Notable findings are:

- All vegetation communities, excluding Alluvial River Oak Forest, Freshwater Wetland Complex and Kurri Sand Swamp Woodland, experienced a net loss, indicating that when clearing occurred, any revegetation works undertaken were insufficient to offset the loss
- LHSGIF, which was allocated a special retention target of 6.75% (further loss of 341 ha) in recognition of the high likelihood of clearing on private land, has experienced clearing of more than 420 ha, or approximately 15% net loss
- Over 75% of the extent of all EEC in the LGA are located on private land, which has significant implications for the establishment and achievement of retention targets.

Opportunities for retention and re-establishment of vegetation canopy are discussed further in Section 4 and Section 5.

3.2 Extant vegetation cover within Maitland's road reserves

Assessment of canopy extent (both native and non-native) within the City road corridor revealed that 5.1% of the LiDAR-derived tree canopy extent (above 3m in height) across the entire LGA occurs within the road network (i.e. 314.6ha out of a total of 6,120.0ha of tree canopy). This suggests that 12.4% of the road corridor area is covered by tree canopy, where road corridor comprises both road area with road reserve plus a 5m buffer.

A separate analysis of extent of mapped Maitland native vegetation community cover within the road corridor indicated that 1.5% of all native vegetation cover is located within the road corridor (i.e. 131.9ha out of a total of 8,533ha native vegetation extent), representing 5.2% of the buffered road network area. However, it should be noted that native vegetation cover includes non-forest vegetation communities (e.g. wetlands) and does not represent tree canopy alone.

The results of both analyses are summarised in Table 3-5.

Table 3-5 Calculations and results of overall tree canopy cover (above 3m height), as well as native vegetation extent occurring within road reserve plus 5m buffer across the Maitland LGA.

Mapping layer	Area (ha) of all vegetation cover within LGA	Area (ha) of vegetation cover within the road corridor	Area (ha) of road corridor	% of road corridor covered by canopy / native vegetation	% of total LGA tree canopy / native vegetation located within road corridor
Tree canopy extent >3m height (2021 LiDAR mapping)	6,120.04	314.6	2,537.52	12.4%	5.1%
Maitland native vegetation (2021 mapping)	8,533	131.90	2,537.52	5.2%	1.5%

3.3 Extent of native vegetation cover and loss: pre-clear to 2021

The results show that the vegetation communities from the 1750 pre-clear mapping Central Hunter Riparian Forest, Freshwater Wetland Complex, Kurri Sand Swamp Woodland have shown to have increased in area in the current 2021 mapping (Table 3-6). This is mostly because of the reclassification of vegetation in current mapping. This may also be a factor of changing environmental conditions, including altered hydrology facilitating transition towards more wetland associated vegetation communities.

All other vegetation communities have shown to decrease in coverage area, as expected by the increased clearing over time.

Since European settlement, Maitland has lost (net) more than 30,000 ha of native vegetation. Only 20% of pre-clear vegetation cover remains as at 2021 (7,857 ha, down from 37,990 ha).

Three vegetation communities previously mapped have now been removed and classified as locally extinct; Coastal Plains Smooth-barked Apple Woodland, Mangrove-Estuarine Complex, Swamp Mahogany - Paperbark Forest.

One preclear vegetation community, Coastal Foothills Spotted Gum - Ironbark Forest, appears to be no longer present in the LGA, however in more recent times this community may have been reclassified as Seaham Spotted Gum - Ironbark Forest. Current 2021 mapping indicates remnants of Seaham Spotted Gum - Ironbark Forest in the western section of Maitland, suggesting that Coastal Foothills Spotted Gum - Ironbark Forest is not yet extirpated from the region.

The vegetation communities which are most at risk of becoming locally extinct are:

- Alluvial Tall Moist Forest and Alluvial River Oak Forest (only 3% of the preclear extent of this community remains in the LGA)
- Seaham Spotted Gum Ironbark Forest (this community has reduced from 5,205 ha down to only 386 ha, a 92% reduction in extent)
- Hunter Valley Dry Rainforest (less than 20% remains).

Combined, only 14 ha of the three most at risk vegetation communities is located within Council-controlled areas.

Table 3-6 Comparison of native vegetation cover between pre-clear and 2021

Vegetation Communities		Local Government Area calculations				Council Controlled Area calculations			
Vegetation Community (pre-clear)	**Vegetation Community (2021)**	**Area ha (pre-clear)**	**Area ha (2021)**	**% cover**	**%loss**	**Area ha (pre-clear)**	**Area ha (2021)**	**% cover**	**% loss**
Alluvial Tall Moist Forest	Alluvial Tall Moist Forest and Alluvial River Oak Forest	9,696.64	289.68	2.99	97.01	333.72	14.20	4.26	95.74
Central Hunter Riparian Forest	Central Hunter Riparian Forest	55.87	151.34	270.90	-170.90	0.00	1.69	1.69	98.31
Coastal Foothills Spotted Gum - Ironbark Forest	*May now form part of Seaham Spotted Gum - Ironbark Forest*	257.51	0.00	0.00	100.00	11.82	0.00	0.00	100.00
Coastal Plains Smooth-barked Apple Woodland	Locally extinct	4.22	0.00	0.00	100.00	1.86	0.00	0.00	100.00
Freshwater Wetland Complex	Freshwater Wetland Complex	1,141.49	1,700.89	149.01	-49.01	110.23	137.61	124.84	-24.84
Hunter Lowland Redgum Forest	Hunter Lowland Redgum Moist Forest and Hunter Lowlands Redgum Forest Variant	4,309.38	1,184.28	27.48	72.52	73.00	43.86	60.09	39.91
Hunter Valley Dry Rainforest	Hunter Valley Dry Rainforest	1,284.37	236.90	18.44	81.56	0.38	0.16	41.80	58.20
Hunter Valley Moist Forest	Hunter Valley Moist Forest and Seaham Spotted Gum Ironbark Forest and Hunter Stringybark Spotted Gum Ironbark Forest	1,535.54	1,202.09	78.28	21.72	0.00	13.82	13.82	86.18
Kurri Sand Swamp Woodland	Kurri Sand Swamp Woodland	9.06	45.85	505.94	-405.94	0.00	0.00	0.00	100.00
Lower Hunter Spotted Gum - Ironbark Forest	Lower Hunter Spotted Gum Ironbark Forest	12,920.35	2,677.66	20.72	79.28	730.52	275.85	37.76	62.24
Mangrove-Estuarine Complex	Locally extinct	9.55	0.00	0.00	100.00	0.00	0.00	0.00	100.00
Seaham Spotted Gum Iron Bark Forest	Seaham Spotted Gum Ironbark Forest	5,205.02	368.62	7.08	92.92	7.45	0.00	0.00	100.00
Swamp Mahogany - Paperbark Forest	Locally extinct	1,561.27	0.00	0.00	100.00	60.52	0.00	0.00	100.00

3.4 Urban tree canopy & impervious surface area (i-Tree)

Grass was the most common land cover, making up 63% of the total LGA area (24,846 ha), followed by tree canopy at 17.9% (7,039.6 ha) (Table 3-7). The other categories: water, impervious surfaces, soil/bare ground and shrubs, made up 7.8%, 7.6%, 3.0% and 2.5% of land cover respectively.

In terms of tree canopy cover, % cover ranged from 0.4% in Cliftleigh (0.43 ha) to 52.8% (359 ha) in Ashtonfield. iTree assessment results are detailed in Appendix B.

Suburbs with the highest coverage of impervious surface (including buildings and roads) are Rutherford (32% or 861 ha), East Maitland (23% or 375 ha), Thornton (17% or 279 ha), Aberglasslyn (21% or 131 ha), Ashtonfield (18% or 125 ha), Maitland (22% or 123 ha) and Metford (39% or 120 ha). Telarah and Tenambit also have >20% impervious surface coverage.

Percentage tree canopy cover is discussed in further detail in Section 3.5, with consideration of the LiDAR-derived statistics of tree canopy distribution.

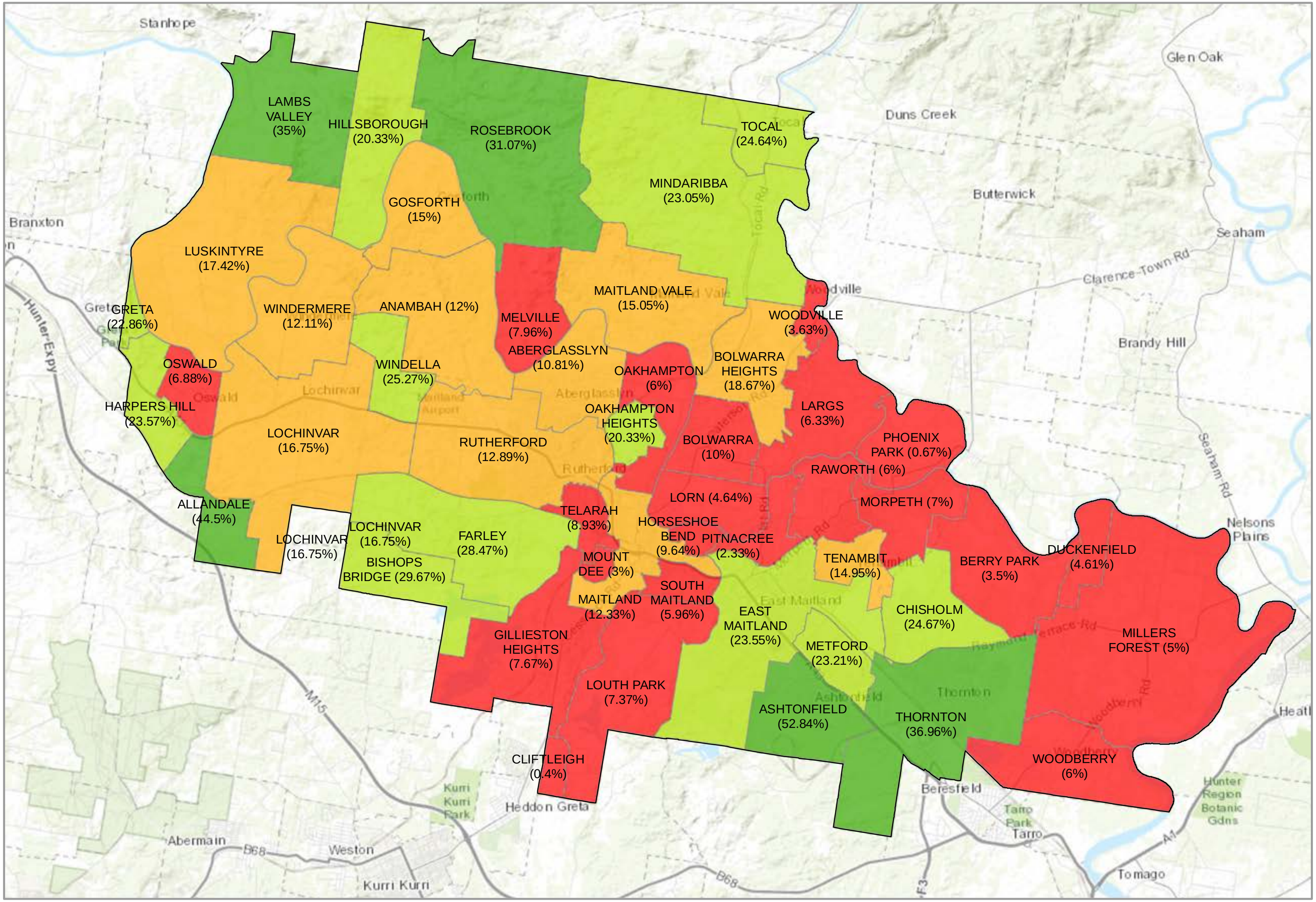
i-Tree precision can be improved by assessing more random points, which reduces the SE. Maitland City Council officers have now been trained in the use of i-Tree and it is expected that future iterations of this assessment will have improved accuracy.

Table 3-7 Estimated percentage of land-cover classes including urban tree canopy and impervious area by suburb, including percentage of trees within private and public lands (i-Tree canopy assessment results)

Cover class	Description	No. survey points	% cover[3]	Cover mean SE	Area (Ha)	Area mean SE
Tree	Trees with canopy height over 3m	2,505	17.9%	1.84	7,039.59	15.80
Shrub	Canopy height under 3m, includes vineyards, ornamental shrubs and hedges, shrubby heathlands	413	2.5%	0.79	965.34	5.76
Grass	Lawns, sports fields, grasslands, pasturelands, croplands	9,521	63.3%	2.57	24,845.63	20.64
Impervious Buildings	Building, rooftop, tanks, swimming pools	636	3.7%	0.83	1,444.23	5.98
Impervious Road	Sealed roads, sealed footpaths, parking lots, driveways	594	3.9%	0.90	1,544.56	6.83
Soil/Bare Ground	Dirt, tilled field, unvegetated ground, unsealed road or footpath	558	3.0%	0.99	1,191.30	7.16
Water	Dams, lakes, wetlands with water present	1,375	7.8%	1.36	3,074.75	10.17
	TOTAL	**15,602**				

[3] This includes approx. 2% SE (ranging from 0.79 to 2.57%)

Figure 3-2 Estimated Urban Tree Canopy Cover Across City of Maitland LGA



Maitland local government boundary

% Tree Canopy Cover

- 0 - 10%
- 11 - 20%
- 21 - 30%
- 31 - 53%

Data Attribution
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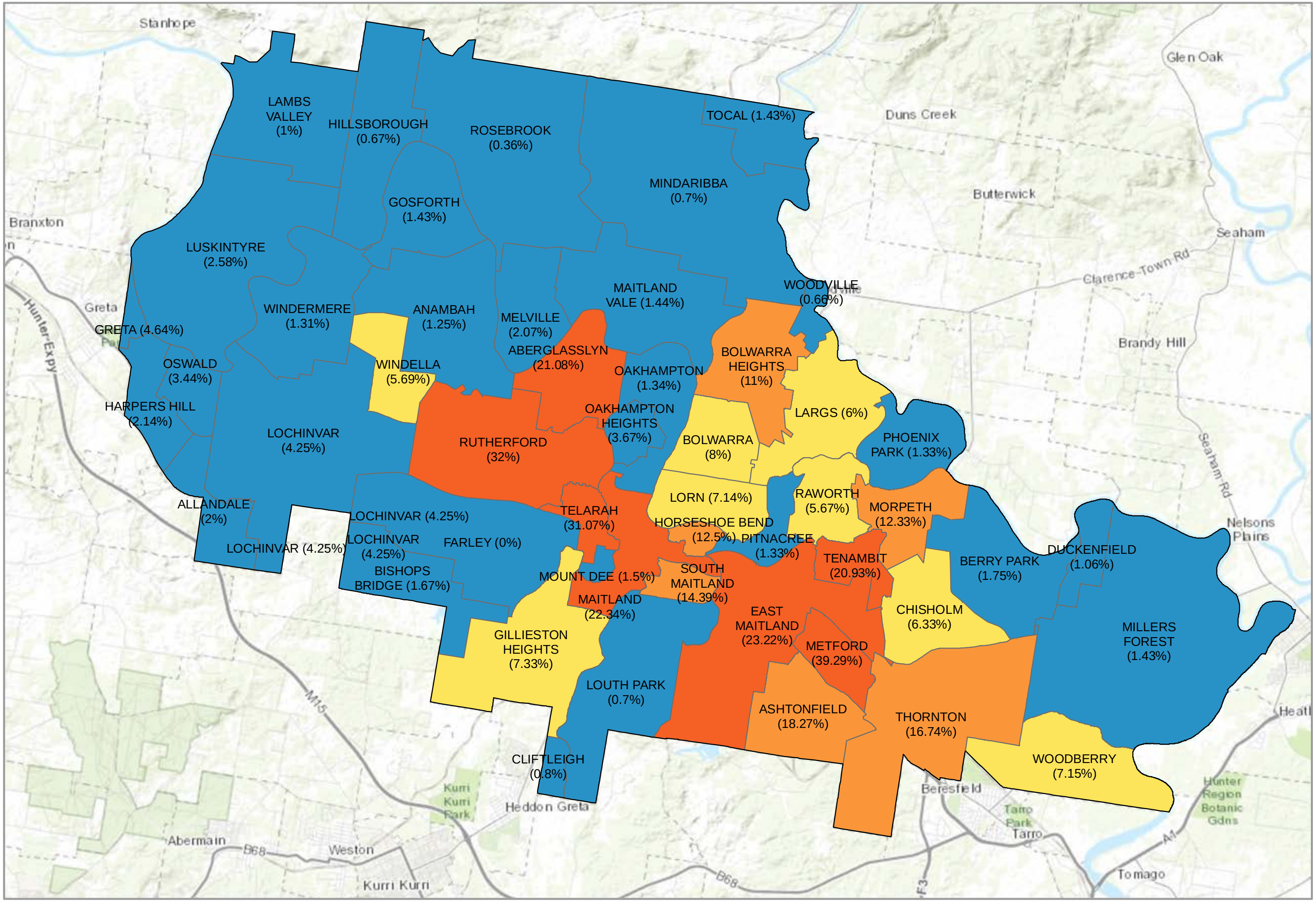
© NSW SS-SDS 2021
© NSW OEH 2021
Ref: 21-137 Fig_3_2_UrbanTreeCanopyCover
Author: Rebecca Sims
Date created: 29/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 3-3 Estimated Impervious Surface Cover Across City of Maitland LGA (including roads & buildings)



Maitland local government boundary

Impervious Surface % Cover

- <5%
- 5-10%
- 10-20%
- 20-40%

Data Attribution
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© NSW OEH 2021
Ref: 21-137 Fig_3_3_Impervious Surface Cover
Author: Rebecca Sims
Date created: 29/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

3.5 Urban tree canopy (LiDAR-derived)

Based on findings from analysis of the LiDAR-derived urban tree canopy results, Maitland LGA supports an area of 6,120 ha of tree canopy (over 3 m in height). This represents 15.6% of the total LGA area. When compared with the i-Tree Canopy results, which reports that tree canopy was at 17.9% coverage of the LGA for the 2015-16 period, it appears that there has been at least a 2.3% decline in % tree canopy coverage from one period to the next (approximately 920 ha, which represents a 13.1% decline in total tree canopy area extent from 2015-16 to 2021). However, care should be taken with regards to interpreting extent of canopy cover change between the two time periods by comparing the two different approaches. Both approaches are reliable methods of area estimation in their own right, however i-Tree Canopy and LiDAR use fundamentally different methods of area determination. The former uses a statistical point sampling method whereas the latter uses a high precision mapping approach. Considering these differences, it is likely that the decline in % tree canopy coverage may be substantially greater than 2.3% over the past six years, given that LiDAR will identify a greater canopy area than i-Tree would, due to higher accuracy and a different definition of canopy.

While 22% of the LGA is currently classified into urban zoning and rural zoning accounts for the remaining 78%, both urban and rural areas support a similar percentage canopy coverage of approximately 15% (15.64% of urban area; and 15.42% of rural area is covered by tree canopy).

Key finding of the study include:

- The suburbs with the lowest % tree canopy coverage are those of Mount Dee (1.2% or 0.79 ha), Cliftleigh (1.3% or 1.44 ha), Phoenix Park (1.7% or 8.77 ha), Woodville (2.0% or 2.5 ha) and Pitnacree (2.8% or 6.85 ha).
- Suburbs supporting the highest tree canopy coverage are those of Ashtonfield (52.4% or 355.2 ha), Allandale (39.1% or 166.23 ha), Thornton (36.0% or 597.56 ha) and Lambs Valley (28.9% or 313.58 ha).
- Of the total canopy extent greater than 3m in height (6,120 ha), only 6.7% is located on Council-controlled land, representing an area of 409.63 ha.

Table 3-8 Tree canopy area and percentage cover compared between the rural and urban zone, and across private and public land

Suburb	Rural Zone								Urban Zone									
	Public (ha)			Private (ha)			Totals		Public (ha)			Private (ha)			Totals			
	No tree canopy cover	Tree canopy	Total rural public area	No tree canopy cover	Tree canopy	Total rural private area	Total canopy in rural area (ha)	% canopy cover in Rural zone	No tree canopy cover	Tree canopy	Total urban public area	No tree canopy cover	Tree canopy	Total urban private area	Total canopy in urban area (ha)	% canopy cover in urban zone	Total canopy area (ha)	% canopy cover in suburb
ABERGLASSLYN	9.3	1.4	10.7	228.1	21.3	249.3	22.7	8.7	26.6	17.1	43.6	294.5	22.2	316.7	39.3	10.9	61.9	10.0
ALLANDALE	0.0	0.0	0.0	258.4	166.2	424.7	166.2	39.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	166.2	39.1
ANAMBAH	0.0	0.0	0.0	596.3	98.1	694.4	98.1	14.1	0.0	0.0	0.0	457.2	7.3	464.5	7.3	1.6	105.4	9.1
ASHTONFIELD	3.7	12.8	16.4	131.5	304.4	435.9	317.1	70.1	9.8	12.6	22.4	177.2	25.5	202.6	38.1	16.9	355.2	52.4
BERRY PARK	0.0	0.0	0.0	850.7	40.8	891.6	40.8	4.6	0.0	0.0	0.0	1.8	0.2	2.0	0.2	7.6	41.0	4.6
BISHOPS BRIDGE	0.1	0.0	0.1	500.6	146.3	646.9	146.4	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.4	22.6
BOLWARRA	0.2	0.1	0.2	280.0	10.0	290.0	10.1	3.5	17.4	1.7	19.1	111.0	27.2	138.2	28.9	18.4	39.0	8.7
BOLWARRA HEIGHTS	0.3	0.3	0.6	328.5	39.5	367.9	39.7	10.8	14.0	7.8	21.8	246.3	80.7	327.0	88.5	25.4	128.2	17.9
CHISHOLM	2.6	0.3	2.9	118.3	4.0	122.3	4.3	3.4	2.3	1.4	3.7	392.6	111.1	503.7	112.5	22.2	116.8	18.5
CLIFTLEIGH	0.0	0.0	0.0	106.1	1.4	107.5	1.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.3
DUCKENFIELD	8.6	2.1	10.7	218.1	13.3	231.4	15.4	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.4	6.4
EAST MAITLAND	68.4	24.3	92.6	366.1	109.2	475.3	133.5	23.5	169.1	130.4	299.5	621.2	123.6	744.7	254.0	24.3	387.5	24.0
FARLEY	0.0	0.0	0.0	849.7	270.8	1120.5	270.8	24.2	0.0	0.0	0.0	139.4	21.4	160.8	21.4	13.3	292.2	22.8
GILLIESTON HEIGHTS	3.2	0.3	3.5	884.9	48.0	932.8	48.2	5.1	12.5	1.8	14.3	217.6	9.7	227.3	11.5	4.8	59.8	5.1
GOSFORTH	0.0	0.0	0.0	567.1	99.2	666.2	99.2	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.2	14.9
GRETA	0.0	0.0	0.0	58.0	16.7	74.7	16.7	22.3	0.0	0.0	0.0	7.2	1.0	8.2	1.0	12.2	17.7	21.3
HARPERS HILL	0.0	0.0	0.0	289.8	93.4	383.2	93.4	24.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.4	24.4
HILLSBOROUGH	0.0	0.0	0.0	779.4	172.5	951.8	172.5	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	172.5	18.1

Suburb	Rural Zone								Urban Zone								Total canopy area (ha)	% canopy cover in suburb
	Public (ha)			Private (ha)			Totals		Public (ha)			Private (ha)			Totals			
	No tree canopy cover	Tree canopy	Total rural public area	No tree canopy cover	Tree canopy	Total rural private area	Total canopy in rural area (ha)	% canopy cover in Rural zone	No tree canopy cover	Tree canopy	Total urban public area	No tree canopy cover	Tree canopy	Total urban private area	Total canopy in urban area (ha)	% canopy cover in urban zone		
HORSESHOE BEND	0.1	0.0	0.1	67.9	2.6	70.5	2.6	3.7	3.1	0.4	3.5	22.1	5.5	27.7	5.9	19.1	8.6	8.4
LAMBS VALLEY	0.0	0.0	0.0	771.3	313.6	1084.9	313.6	28.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	313.6	28.9
LARGS	1.5	3.9	5.5	640.7	19.8	660.5	23.7	3.6	6.1	2.5	8.6	85.9	12.8	98.7	15.3	14.3	39.0	5.0
LOCHINVAR	0.0	0.0	0.0	1029.6	179.9	1209.5	179.9	14.9	10.0	1.1	11.1	745.8	58.7	804.5	59.8	7.3	239.7	11.8
LORN	0.9	0.1	1.0	354.8	14.2	369.0	14.3	3.9	11.2	1.1	12.3	59.1	16.6	75.7	17.7	20.1	32.0	7.0
LOUTH PARK	0.4	0.0	0.4	981.1	35.8	1016.9	35.8	3.5	0.0	0.0	0.0	157.2	26.6	183.8	26.6	14.5	62.5	5.2
LUSKINTYRE	0.0	0.0	0.0	1669.1	242.1	1911.2	242.1	12.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	242.1	12.7
MAITLAND	8.6	1.0	9.6	257.6	18.4	276.0	19.4	6.8	52.4	8.2	60.6	172.8	29.6	202.4	37.8	14.4	57.1	10.4
MAITLAND VALE	0.0	0.0	0.0	929.3	176.8	1106.0	176.8	16.0	0.0	0.0	0.0	22.7	0.5	23.2	0.5	2.1	177.3	15.7
MELVILLE	0.1	0.0	0.1	517.7	41.7	559.5	41.7	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7	7.5
METFORD	0.5	0.3	0.8	0.0	0.0	0.0	0.3	41.9	23.8	19.7	43.5	207.4	53.8	261.2	73.6	24.1	73.9	24.2
MILLERS FOREST	1.2	0.2	1.5	2739.0	114.9	2854.0	115.2	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	115.2	4.0
MINDARIBBA	0.0	0.0	0.0	1902.9	548.4	2451.4	548.4	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	548.4	22.4
MORPETH	1.1	0.3	1.4	333.9	8.8	342.7	9.1	2.7	16.1	6.4	22.5	96.8	16.3	113.1	22.7	16.7	31.8	6.6
MOUNT DEE	0.0	0.0	0.0	62.5	0.8	63.3	0.8	1.3	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.1	0.8	1.2
OAKHAMPTON	50.2	1.4	51.6	428.4	26.4	454.7	27.8	5.5	0.5	0.0	0.5	2.5	0.2	2.7	0.3	8.5	28.1	5.5
OAKHAMPTON HEIGHTS	0.1	0.0	0.1	57.3	2.5	59.9	2.6	4.3	41.7	22.3	64.0	56.5	16.6	73.2	39.0	28.4	41.5	21.1
OSWALD	0.2	0.0	0.2	259.3	16.8	276.0	16.8	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	6.1
PHOENIX PARK	0.0	0.0	0.0	516.9	8.8	525.7	8.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	1.7

Suburb	Rural Zone								Urban Zone								Total canopy area (ha)	% canopy cover in suburb
	Public (ha)			Private (ha)			Totals		Public (ha)			Private (ha)			Totals			
	No tree canopy cover	Tree canopy	Total rural public area	No tree canopy cover	Tree canopy	Total rural private area	Total canopy in rural area (ha)	% canopy cover in Rural zone	No tree canopy cover	Tree canopy	Total urban public area	No tree canopy cover	Tree canopy	Total urban private area	Total canopy in urban area (ha)	% canopy cover in urban zone		
PITNACREE	0.1	0.0	0.1	239.7	6.7	246.4	6.7	2.7	0.0	0.0	0.0	0.2	0.1	0.3	0.1	37.5	6.9	2.8
RAWORTH	0.0	0.0	0.0	306.5	11.6	318.1	11.6	3.6	7.9	1.1	9.1	86.8	8.1	95.0	9.2	8.9	20.8	4.9
ROSEBROOK	0.4	0.0	0.4	1487.0	551.5	2038.5	551.5	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	551.5	27.0
RUTHERFORD	0.0	0.0	0.0	10.3	0.7	11.0	0.7	6.2	121.7	60.6	182.2	1036.3	112.0	1148.3	172.5	13.0	173.2	12.9
SOUTH MAITLAND	1.5	0.3	1.8	133.4	8.4	141.8	8.7	6.0	1.9	0.1	2.0	27.3	1.6	28.8	1.6	5.3	10.3	5.9
TELARAH	0.7	0.1	0.9	44.3	0.6	44.9	0.8	1.7	11.7	1.2	13.0	135.4	16.0	151.4	17.2	10.5	18.0	8.6
TENAMBIT	4.5	0.0	4.6	98.5	6.7	105.2	6.8	6.2	11.7	8.1	19.8	110.6	21.1	131.6	29.2	19.3	36.0	13.8
THORNTON	112.8	33.4	146.2	358.9	433.8	792.7	467.3	49.8	36.7	19.6	56.4	556.2	110.7	666.9	130.3	18.0	597.6	36.0
TOCAL	0.0	0.0	0.0	323.5	104.6	428.1	104.6	24.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.6	24.4
WINDELLA	0.0	0.0	0.0	64.3	34.0	98.3	34.0	34.6	3.0	0.1	3.1	243.9	46.0	290.0	46.2	15.7	80.1	20.5
WINDERMERE	0.0	0.0	0.0	810.4	91.9	902.3	91.9	10.2	0.0	0.0	0.0	8.4	0.1	8.5	0.1	1.5	92.0	10.1
WOODBERRY	2.6	0.0	2.6	674.9	35.1	710.0	35.1	4.9	27.3	1.2	28.6	104.4	10.9	115.2	12.1	8.4	47.3	5.5
WOODVILLE	0.0	0.0	0.0	122.9	2.5	125.4	2.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	2.5	2.0
Grand Total	**283.7**	**82.9**	**366.5**	**25605.5**	**4715.4**	**30320.9**	**4798.2**	15.6	**638.3**	**326.8**	**965.1**	**6604.3**	**993.7**	**7597.9**	**1320.4**	15.4	**6118.6**	15.6

3.6 Keystone species

A list of 645 fauna species were returned from the BioNet database search. Of these species, 12 fauna species have been identified to represent health indicator species for the vegetation within Maitland LGA. The fauna species have been categorised by guild to represent the habitat zones the species occupy or exploit:

- Amphibians
  - Green and Golden Bell Frog (*Litoria aurea*)
  - Eastern Dwarf Tree Frog (*L. fallax*)
  - Broad-palmed Frog (*L. latopalmata*)
  - Peron's Tree Frog (*L. peronii*)
- Arboreal mammal (folivore)
  - Koala (*Phascolarctos cinereus*)
- Forest Owls
  - Powerful Owl (*Ninox strenua*)
- Gliders
  - Feathertail Glider (*Acrobates pygmaeus*)
  - Squirrel Glider (*Petaurus norfolcensis*)
  - Sugar Glider (*P. breviceps*)
- Hollow-dependent microbats
  - Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
  - Greater Broad-nosed Bat (*Scoteanax rueppellii*)
  - Southern Myotis (*Myotis macropus*).

Amphibians are often considered fitting indicator species within a variety of environments due to their semi-permeable skin and biphasic life cycle (Waddle, 2006). Abundance of amphibian populations may be used as an indicator of ecosystem health or habitat quality. Amphibians rely on waterbodies and riparian vegetation for foraging, breeding and traversing. Two threatened frog species and two common species were selected to represent this guild (see above list).

The Koala is an iconic Australian animal that is threatened under the BC Act and EPBC Act. This species has highly specific habitat requirements due to its restrictive diet, and limited ability to utilise the land use matrix. As such, the species is particularly sensitive to habitat loss and fragmentation, making this species an ideal indicator species for Maitland LGA. It is also readily identified and reasonably easy to observe.

Forest owls, such as the Powerful Owl, are likely to play a functional role in forest communities because of their position as apex predators. The presence of apex predators contributes significantly to the maintenance of biological diversity and may indicate the integrity of an important part of the forest ecosystem. As such, the Powerful Owl was selected as a key health indicator species

Gliders are considered suitable indicators within the Maitland LGA as the guild is heavily influenced by changes in forest composition and structure near edges due to highly specific feeding and nesting requirements. The guild is dependent on linkages through landscapes as they rely on their ability to glide between trees. Gliders rely on corridors with continuous tree canopy with tree spaced closer than 40 m apart.

Microbats often have specific environmental requirements, as such they are considered important indicators of levels of biodiversity. They display taxonomic stability, are easily monitored for population changes and are a high trophic level guild. Microbats prey on insects, which are acknowledged as favoured indicators for a range of environmental degradation issues. Insects are good indicators for declining water quality and high levels of pesticide (Blackthorn, 2013). As insects are difficult to monitor for change, changes in microbat community structure may infer these environmental changes. Hollow-dependent microbats utilise both riparian and forest vegetation, as such they can be used to measure the health of both environments within the Maitland LGA.

3.7 Wildlife corridors

Individual connectivity outputs for each of the guilds can be viewed in Appendix D.

Broad connectivity trends within the individual connectivity outputs show that the mobile guilds, such as the arboreal frugivore mammal (flying-fox), winter migrant bird, hollow-dependent microbats and forest owl guilds are significantly less constrained by barriers and gaps in structural connectivity. They are able to more easily traverse larger distances between their core habitat patches. However, the ability of these guilds to persist within the landscape is dependent upon the retention and protection of quality habitat patches throughout the landscape matrix. Core breeding habitat needs to be protected from edge effects by suitable edge buffers, while primary feeding habitat needs to be retained to ensure a diversity of feeding options are available and so that travelling costs between these sites and roosting/nesting sites do not become too great. In the case of forest owls, prey habitat is of importance while for flying foxes, bottle-neck shortages in winter and spring foraging habitat need to be retained and protected, despite the patch being isolated. For both forest owls and the microbats suitable roosting habit with mature hollow-bearing trees needs to be retained. Unlike the other mobile guilds, forest owls do not appear to have connectivity extended across the central urban areas of the LGA.

Guilds such as resident forest birds, while mobile in a similar sense to the previously mentioned guilds, are somewhat constrained by the need for some structural connectivity across the landscape, with individuals less willing to cross very large gaps. These guilds require quality core habitat which is protected from edge effects for suitable breeding habitat and, being insectivorous, required intact vertical vegetation structure to assist feeding.

Gliders are the most constrained in terms of their connectivity needs. These species require trees with suitable canopy height and distance to ensure safe take-off and landing to move across the landscape. Due to extensive forest clearing through urbanisation, options for this guild are extremely limited. Three tenuous local linkages remain within the urban footprint:

- extending from the south-eastern corner of Louth Park traversing north-east across East Maitland towards a last remaining habitat node in Metford
- running north-south from Rutherford, across Farley and Bishop’s Ridge to the Cessnock LGA
- extending from Ashtonfield and Thornton south, extending northwards through the west section of Thornton towards a remaining connected (albeit connected by two narrow linkages) habitat node in Chisholm.

For ground-dwelling mammals such as swamp wallaby and arboreal folivores like koala, there do not appear to be any major regional corridors, apart from a potentially important corridor across the northern extent of Maitland LGA extending from Lambs Valley via Hillsborough and Rosebrook to

Mindaribba. However, there are a few important sub-regional corridors. One extends from core habitat in Webbers Creek in the north in a south-easterly direction diagonally across Rosebrook towards Melville, another extending from core habitat in Ashtonfield and Thornton south, extending northwards through the west section of Thornton towards a remaining connected habitat node in Chisholm, in a similar manner to that of the glider guild. A third extends from Allandale towards Farley. A number of local connectivity patches remain within the central west section of the LGA at Windermere, as well as Bolwarra Heights, Maitland Vale and Mindaribba.

Connectivity outputs for wetland associated reptiles indicated important subregional corridors extending from the south from Allandale and Farley towards the centre of the LGA at Aberglasslyn, as well as from Louth Park, Ashtonfield and south Thornton towards Chisholm. Two large subregional corridors are apparent in the north, one extending from Lambs Valley to Windermere/Windella via Gosforth, and the other from Tocal via Mindaribba towards Bolwarra Heights. Much of this connectivity is related to linkage between vegetated forest habitat, wetlands and permanent waterbodies.

The wetland associated mammals highlight critical aquatic linkages not picked up by the other guilds. A number of important cross regional corridors traverse the LGA in both a north south and east west direction, follow major waterway-related movement corridors. There is also a major connective regional corridor extending east-west along the southern boundary of the LGA, traversing alternately across wetlands and vegetated habitat. Further linkage is evident between primary vegetated habitat from Lambs Valley towards Luskintyre and south Hillsborough. This is the only guild which shows complete north-south connectivity extending from Allandale and Farley via Rutherford (in two locations) Aberglasslyn towards Maitland Vale and Mindaribba in the north. There is also a wide connectivity region extending from the south and south eastern suburbs towards wetlands in Chisholm, Tenambit and Morpeth.

3.7.1 Corridors and linkages

Figure 3-4 shows the degree of overlap between areas of guild connectivity. It identifies that the Maitland LGA area in general is within the causeway of a number of regionally important and highly threatened guilds. The overlapping connectivity map was further analysed to arrive at a regional corridor map (Figure 3-5). Appendix C provides detail about each of the identified corridors (with corridor components numbered from 1 to 36), including the linkage significance for each of the guilds which are likely to use that particular corridor.

The connectivity assessment results revealed that Maitland LGA is located between important core habitat areas for a number of these guilds both to the north and south, as well as to the west and east, thereby constituting an important regional corridor area in its entirety for mobile guilds such as arboreal frugivore mammal (flying-fox), winter migrant bird, hollow-dependent microbats and forest owl guilds. Retention of remnant suitable resting and seasonal feeding patches within the LGA are particularly vital for the frugivore mammal and migrant forest bird guilds.

A potential regional corridor extends diagonally across the LGA from Allandale and Farley via Rutherford and Aberglasslyn towards Maitland Vale, Bolwarra Heights and Mindaribba in the north. A further regional corridor extends across the southern boundary of the LGA in an east-west direction, as well as across the northern boundary in an east-west direction from Webbers Creek via Rosebrook, Mindaribba towards Butterwick.

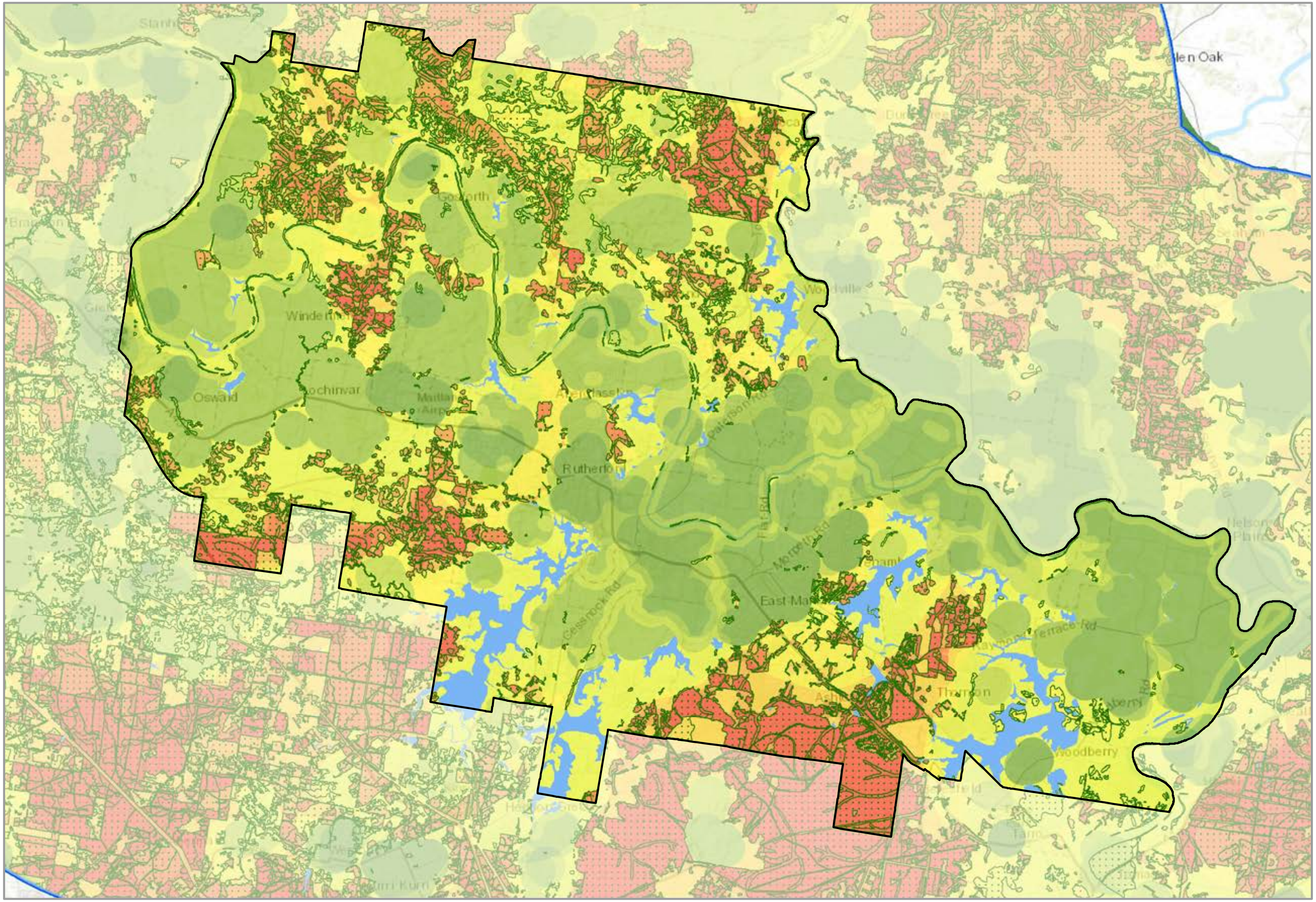
There are a number of subregional corridors extending from Lambs Valley via Luskintyre towards Windermere, and northwards via Gosforth towards Rosebrook, and westwards via north Anambah and Melville towards Maitland vale and Bolwarra Heights, then northwards towards Mindaribba.

Important subregional corridors in the south extend from Louth Park and Ashtonfield via Metford and Thornton to last remaining habitat nodes within Chisholm, East Maitland, Tenambit and Morpeth.

Within these latter subregional corridors, there are numerous critical local linkages which need further attention to identify local barriers which threaten the remaining vestiges of connectivity within these developing urban centres.

Numerous urban linkage opportunities are evident throughout the urban matrix where rehabilitation or assisted revegetation within both open space and private property could help to improve or re-establish connectivity for some species. Five such opportunities have been identified in Appendix C and Figure 3-5, however more opportunities may exist.

Figure 3-4 Map showing degree of overlap between guild connectivity



- Maitland local government boundary
- Extent of analysis area
- Habitat patch
- Freshwater Wetland Complex

Number of guild connectivity overlaps

1
2
3
4
5
6
7
8
9
10
11
12

Increasing guild overlap

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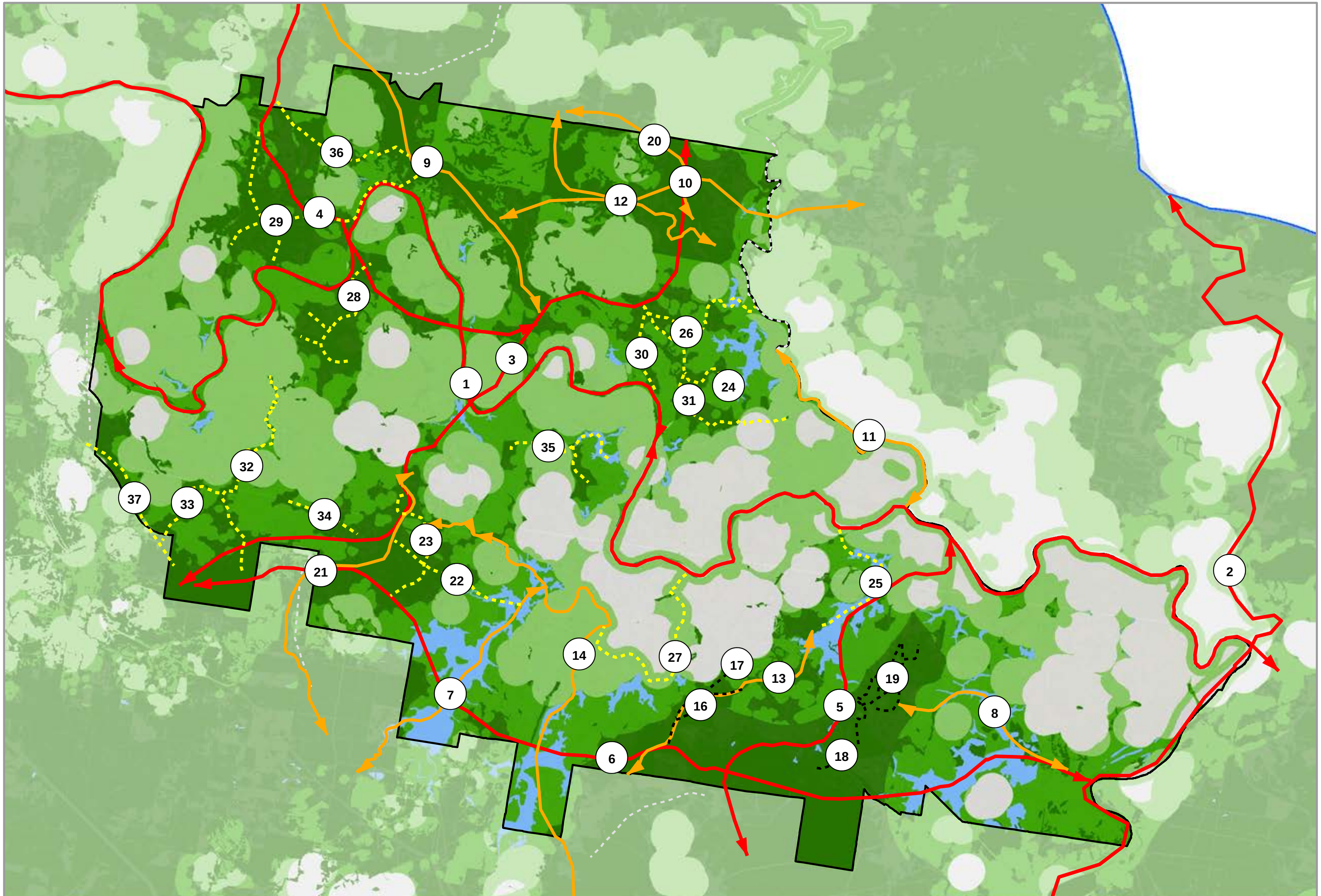
Ref: 21-137 Connectiity_Heat_Map
Author: Rebecca Sims
Date created: 22/09/2021
Datum: GDA94 / MGA zone 56

NGH

0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 3-5 Regional connectivity assessment - Connectivity significance map (City of Maitland)



Corridor Significance

- Regional Corridor
- Sub-regional Corridor
- Local Corridor
- Urban Linkage Opportunity
- Corridor outside Maitland LGA
- Maitland local government boundary
- Extent of analysis area

Degree of overlap between guild linkages

- 1-3 overlapping guilds (mobile)
- 4-5 overlapping guilds
- 6-7 overlapping guilds
- 8-12 overlapping guilds
- Habitat patch
- Freshwater Wetland Complex

Data Attribution
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© NSW OEH 2021
Ref: 21-137 Fig Regional Corridor significanc
Author: Rebecca Sims
Date created: 1/03/2022
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

Service Layer Credits:

4. Strategic measures for vegetation retention and enhancement

The protection and enhancement of native vegetation is critical within urban and peri-urban areas, particularly in fast-growing regions. Maitland is identified under the *Hunter Regional Plan 2036* as a priority area for development, with the Maitland Corridor growth area and Central Maitland and East Maitland Strategic Centres to be established as key areas for infill and greenfield development within the Greater Newcastle continuous urban area.

4.1 Policy alignment

A comprehensive strategic framework supports the implementation by Council of polices to protect and enhance vegetation. Documents prepared by the Commonwealth and NSW governments specifically address connectivity and canopy enhancement, as do a number of existing Council polices and/or initiatives. This project is aligned with the goals and outcomes established under this framework.

A summary of relevant documents and provisions is set out in Table 4-1.

Table 4-1 Strategic framework

Document	Key provisions
Commonwealth	
Australia's Strategy for Nature 2019-2030	• Goal 2 – care for nature in all its diversity: o Objective 5 – improve conservation management of Australia's landscapes, waterways, wetlands and seascapes: o enhance the extent and connectivity of government and non-government managed areas o support landholder protection of ecosystems through stewardship or similar methods o retain and/or restore native vegetation and connecting habitats. o Objective 7 – reduce threats and risks to nature and build resilience: o design and manage protected area networks o improve planning, regulation and impact assessment o retain, protect and restore landscape-scale corridors o retain, protect and restore native vegetation in urban, peri-urban and agricultural contexts. o Objective 9 – enrich cities and towns with nature: o increase tree canopy o create greenways and urban green space o better integrate urban ecology into land use planning
Australia's Native Vegetation Framework	• Goal 1 – increase the national extent and connectivity of native vegetation: • Outcome – establishment and implementation of mechanisms for strategic land use planning to encourage revegetation, build conservation connectivity and limit vegetation clearing. • Goal 2 – maintain and improve the condition and function of native vegetation: • Outcome – increased effort to maintain and improve the condition and functionality of native vegetation through investment and management priorities, communicating information, and capacity building of landholders, users and managers.

Document	Key provisions
State	
Hunter Regional Plan 2036	• Goal 2 – a biodiversity-rich natural environment: • Direction 14 - protect and connect natural areas through investment and modelling to identify connectivity.

Greater Newcastle Metropolitan Plan 2036 (GNMP)	• Outcome – enhance environment, amenity and resilience for quality of life:
	  • Strategy 12: enhance the Blue and Green Grid and the urban tree canopy – Maitland is identified as an area requiring improvements to Blue and Green Grid connections.
	  • Key actions include:
	    o increasing tree canopy cover and greening urban areas, buildings, transport corridors and open spaces to enhance the urban forest
	    o working with the DPIE to protect regionally significant biodiversity corridors through strategic certification.

Local	

Maitland Local Strategic Planning Statement 2040+ (LSPS)	1. Local Planning Priority 10 – protect, conserve and enhance our natural environment including waterways, floodplains and wetlands:
	  • Action – develop an Environmental Strategy to protect, conserve and enhance our natural environment.
	  • Review DCP provisions to enhance water quality and waterway health to achieve ecologically sustainable outcomes and water sensitive urban design principles.
	2. Local Planning Priority 13 – improve the accessibility and connectivity of our City's Green and Blue Grid:
	  • Action – protect and enhance biodiversity corridors identified in Council's Greening Plan and LSPS in future planning of greenfield development and investigation areas.

Maitland Local Environment Plan 2011 (LEP)	3. Section 1.2 Aims: • protect and maintain the extent, condition, connectivity, resilience of natural ecosystems, native vegetation… 4. Zone E2 and E3 Objectives for protection and management.

Maitland Development Control Plan 2011 (DCP)	5. Part B Environmental Guidelines:
	  • Section B.5 Tree Management – requires consideration of habitat and corridor function for tree clearing permit applications
	  • Section B.7 Riparian Land and Waterways – requires development to preserve and enhance the viability, condition, connectivity and extent of native riparian vegetation.

Maitland +10 Community Strategic Plan (MCSP)	6. Key theme – our natural environment:
	  • Action - identify remnant native vegetation and habitat for retention and enhancement:
	    o Measure – increased native vegetation cover for improved habitat, floodplain restoration and enhanced river health

4.2 Planning measures

Local government has a 'tool kit' of measures at their disposal, which provide a range of options for conservation planning. Key planning mechanisms are summarised below.

4.2.1 Maitland Local Environmental Plan 2011

A LEP should be focussed on upfront strategic planning that considers the impact of future development on biodiversity and the broader environment as early as possible in the planning process. The objective is to avoid new development in environmentally sensitive areas, manage cumulative impacts and provide greater development certainty.

The LEP can play a critical role in achieving biodiversity conservation outcomes (including for both threatened species and remnant native vegetation). The LEP is the primary strategic planning tool to communicate Council's objective of a greater focus on biodiversity values in development design, management, and operation. Through land use zoning and environmental overlays, the LEP can be used to identify and protect areas of high conservation value through the creation of reserves, biodiversity corridors and new connections. It can also promote and encourage certain types of activities and development through streamlined approval processes and discourage or prohibit inappropriate development.

A key focus of the LSPS is to protect and enhance biodiversity corridors, particularly in future greenfield and investigation areas. One measure by which to achieve this is a review of the LEP (and DCP) to ensure land use conflicts are minimised through the implementation of environmental or recreational overlays in areas of highest priority. This is discussed further in the sections below.

Other ways in which the LEP could reflect Council's and the Region's strategic priorities is to:

7. Provide for higher levels of protection and specific planning controls to achieve Blue and Green Grid priorities under the GNMP and LSPS, through LEP provisions.
8. Investigate the feasibility of the addition of a new clause and overlay for biodiversity, to better protect high conservation value areas, supported by a new definition for ***environmentally sensitive land***. This would more broadly capture sensitive biodiversity features that do not meet the relatively narrow definition of ***environmentally sensitive areas*** (LEP, Dictionary). Example wording is as follows:

   Development consent must not be granted to development on land to which this clause applies unless the consent authority has considered the following matters—

   (a) any potential adverse impact of the proposed development on any of the following—

   (i) a native vegetation community

   (ii) the habitat of any threatened species, population or ecological community

   (iii) a regionally significant species of plant, animal or habitat

   (iv) a habitat corridor

   (v) a wetland

   (vi) the biodiversity values within a reserve, including a road reserve or a stock route; and

   (b) any proposed measures to be undertaken to ameliorate any such potential adverse impact.

- Consider allowing ***environmental protection works*** to occur without consent in the RU1 RU2 and E2 zones. This may assist landholders to undertake property management activities associated with stewardship agreements without a requirement for Council consent. This is particularly relevant in the Maitland LGA, where over 95% of remnant vegetation is located on private land, which means measures to make environmental protection more attractive to, and easier for, landholders are critical; such measures would also make conservation agreements more attractive to landholders. This can be relatively low risk with respect to landholders considering it to be a 'licence to clear', as Council can be very prescriptive regarding the extent of allowable works.

Consider the application of E2 zoning for waterways and riparian areas. It is noted that the current LEP does not utilise waterway zone designations; should the LEP be updated and waterway zones incorporated, these may be appropriate, however waterway zones, generally only apply to channels and banks and are may therefore be inadequate to protect riparian areas and adjacent land.

4.2.2 Maitland Development Control Plan 2011

The DCP is a supplementary strategic planning tool that supports the provisions of the LEP. It can provide more detailed controls to support the biodiversity conservation objectives of the LEP and the LSPS and should be used to guide development design, management, and operational elements, to maintain or improve biodiversity values.

Given the prioritisation of the Maitland Corridor growth area and Central Maitland and East Maitland Strategic Centres as key areas for infill and greenfield development within the Greater Newcastle continuous urban area, it is critical that the DCP is robust enough to respond to development pressures and ensure the avoidance, mitigation and management of these constraints is satisfactorily implemented.

Relevant actions to be implemented under the DCP could include:

- Review development controls in Section B.5 of the DCP to ensure remnant vegetation is recognised as an asset that can be incorporated into detailed design of neighbourhoods and other developments. Where vegetation removal is not prohibited by the LEP, ensure specific criteria is included for the adequate justification of any vegetation removal. Specify compliance with the mitigation hierarchy and develop an offset policy for application where impacts are unavoidable.
- Review development controls in Section B.7 of the DCP to ensure future greenfield development integrates waterways and riparian areas as elements of the Blue and Green Grid. This would help to activate these spaces and improve management outcomes.
- Update the Maitland LGA plant species list (currently located in the Maitland Greening Plan) with a species profile for each species, including habitat requirements and include it as an Appendix to the DCP. Include provisions requiring development proponents to implement the species list for landscaping and restoration.
- Consider the inclusion of a wildlife corridor map and supporting provisions/control parameters in the DCP to inform proponents of development in the vicinity of a corridor, of requirements to retain and enhance connectivity.

4.2.3 Manual of Engineering Standards

Part 3: Environment, Vegetation and Heritage Protection of Council's Manual of Engineering Standards, should be reviewed in line with any amendments made to the LEP and DCP, to ensure that the operational aspects of development align with the approval framework.

A high-level review of this document has identified a number of simple amendments that could be made in the short term to align with other Council polices/plans, as well as contemporary best practice:

- Add relevant definitions to Part 2: General Requirements, for example, ***native vegetation***, ***Tree Preservation Order***, ***habitat***
- Add a new section to address engineering standards for construction adjacent to waterways and riparian areas
- Section 4.1 Tree Disturbance – reference AS 4970-2009 Protection of trees on development sites
- Section 8 Landscape and Vegetation - reference the Maitland LGA plant species list.

4.2.4 Reserves and corridors

Council can create reserves for the conservation of high value or sensitive areas, which will protect such areas from other land uses and inappropriate development, as well as provide linkages for wildlife movement. Relevant considerations when identifying land for future reserves include adequate patch size and/or opportunity for restoration, to minimise edge effects and meet thresholds for connectivity.

'Patch size' refers to an area of habitat that is of a size suitable to support native species, acknowledging that different species have variable requirements. In an urban environment, a habitat patch may be too small to, for example, support a viable breeding population of a particular species, however will contribute significantly to the viability of the broader ecosystem as part of ***metapopulations***: assemblages of local populations that are connected by migration (Hanski & Gilpin 1991). According to metapopulation theory, the greater the number of patches and the closer they are, the better their colonisation (Hanski & Thomas 1994).

Careful planning, based on the best available data, is required to select appropriate areas for biodiversity conservation, as local government resources for the management of reserves are limited. The native vegetation and wildlife corridor spatial data prepared for this project provides current information to enable the targeted identification of areas of highest priority for reserve designation.

An environmental zone should be applied to reserves identified for the protection of biodiversity. Other reserves, where the priority is not biodiversity conservation, should be zoned for the purpose of recreation.

Specific development controls may also be adopted for land within and adjacent to corridors. This could include appropriate zoning under the LEP, i.e., environmental zones as a preference, recreational zones as an alternative. Council should consider the implementation of 'Additional Local Provisions', particularly as the recent vegetation and corridor spatial data informs the adaptation of the standard clauses to the circumstances of the LGA.

As previously noted, corridor maps could be integrated into the DCP. This has been done by a number of Sydney councils, as well as most councils in South East Queensland. Corresponding mitigation requirements are then set out under the DCP, such as revegetation within buffer areas, landscaping requirements and lighting controls.

A 2016 guideline prepared by the Southern Sydney Regional Organisation of Councils, *Connected Corridors for Biodiversity: Guide to regulatory tools, financial incentives and other machan isms for promoting biodiversity conservation of private property*,[4] provides further guidance regarding regulatory mechanisms.

Waterways and riparian areas

Relevant planning measures include:

- Rezoning waterways and riparian areas to E2 Environment Management wherever practicable, to minimise incompatible uses within waterway corridors. Where this is not possible, land should be rezoned to Public Recreation.
- Preparing a Waterway and Riparian Land Use Study or Strategy, that identifies land for conservation and recreation. This provides for forward planning of areas to be dedicated to

[4] SSROC Guideline.

Council through future development. These areas should be identified in an appropriate mapping layer on Council's Intramaps platform.

These actions align with, and would help to achieve:

- Strategy 12 of the GNMP
- Priorities 10 and 13 of the LSPS
- LEP Zone E2 and E3 objectives
- Section B.7 of the DCP
- Improved measure of habitat and river health in accordance with the MCSP.

Reserves

All existing and future priority reserves should be reviewed to ensure that they are appropriately zoned. E2 Environmental Conservation, should be applied for the protection of biodiversity, particularly remnant vegetation, however E3 Environmental Management also provides for restoration and protection outcomes whilst providing for sustainable development. RE1 Public Recreation may be suitable in circumstances where urban canopy outcomes are a priority, as parks, sporting fields, walking trails or cycle ways provide opportunities to establish urban vegetation.

Existing and future Council reserves suitable for the establishment of biodiversity stewardship sites should also be identified. These will have the added benefit of enabling Council to offset the impact of their activities (Part 5, *Environmental Planning and Assessment Act 1979*). Rezone stewardship sites to E2 Environmental Conservation to reflect their purpose.

The mapping undertaken through this Project identifies key locations across the LGA where designation as a reserve or stewardship site will achieve the complementary benefit of maintaining, consolidating or establishing guild connectivity for the focal species considered.

Biodiversity corridors

Reducing the isolation of bushland remnants can reduce the risk of local extinctions and by maximising connectivity, the diversity, functioning and survival of urban bushland can be enhanced. Habitat connectivity is key to reducing biodiversity loss and can increase colonisation rates, improving diversity and strengthening existing populations (Damschen et al., 2019).

Urban and peri-urban corridors between suburbs, recreational parks and the conservation estate, can raise community awareness and actively engage the community in conservation and management activities (DSEWPC, 2012). Urban nature can support healthy and sustainable inner-city and urban populations of species, and cities have been found to have greater species richness than might otherwise be expected. A study by Ketti (2012) found that at least 20% of the world's bird species and 5% of plant species occur in cities. Within urban areas, biodiversity is not restricted to nature parks and other forms of open space. Utility rights-of-way (including road reserves and powerline corridors) along with backyard habitat are important components of conservation planning because they increase biodiversity in cities and improve quality of life for residents (Rudd et al., 2002).

Key core habitat nodes and corridors in the Maitland LGA are identified in Section 3.7. These represent the highest priority for conservation and should be protected, to the greatest extent possible.

Appropriate zoning, where not already in place, is an effective way to achieve this. Ensure areas within established and future corridors are appropriately zoned. Environmental zone, preferably E2

Environmental Conservation, should be applied for the protection of biodiversity. Habitat connectivity can be created or reinstated through such zoning and/or development standards that specify or promote conservation management.

4.3 Vegetation cover targets

The setting of canopy cover targets is context dependent and can be flexible across an urban area to account for uneven distribution of vegetation, land tenure and the types of uses or activities within a particular area. Australia's 202020 Vision Guide, *How to Grow an Urban Forest* (Greener Spaces Better Places, 2014) although premised on increasing green space in the 2013-2020 timeframe, is generally considered to provide a best practice approach to developing canopy targets, as it sets out an approach for local governments which is informed by the unique circumstances of the organisation and locality.

Key considerations for Council when establishing canopy targets, based on the data derived through this Project are:

1. Maitland currently has an estimated 15.6% (6,120 ha) tree canopy cover (>3m in height) across the LGA (estimated using 2021 LiDAR imagery). This means that 84.4% of the LGA is either hard surface, grass bare ground or colonised by weed species. Whilst this poses challenges for biodiversity conservation and liveability, it also means there are considerable opportunities for expansion of the urban greenspace network.
2. Only 6.7% or 409.6 ha of tree canopy is located on Council-controlled land.
3. Maitland currently has 21.74% native plant community cover across the LGA (this estimate includes freshwater wetland areas and non-woody plant communities).
4. Since 2009, remnant vegetation has reduced by approximately 603 ha. Remnant vegetation currently makes up 19.62% of the native vegetation within the LGA (2.12% is other native vegetation) and is in decline. Remnant vegetation is generally considered a high priority for conservation.
5. Approximately 92% of all remnant vegetation in the LGA is located on private land. It is therefore critical to protect the remaining extent on public land and implement planning controls, conservation partnership programs and greenspace acquisitions, to protect vegetation on private land to the greatest extent possible. Measures to increase native vegetation on public land, where it can be more readily protected, will also be essential to growing the urban canopy.
6. Public land within the LGA provides an immediate opportunity to increase canopy cover. Priority areas for revegetation include road reserves, which have only 5.2% native vegetation cover, which would provide for both increased canopy and improved habitat connectivity across the LGA.

Key to developing any target is comprehensive and current baseline data, such as obtained through an urban canopy assessment. The data generated by this project provides a strong starting point for the establishment of relevant and practical targets.

4.3.1 Measuring canopy cover

Extent of tree canopy within the Maitland LGA was measured using recently acquired LiDAR-derived tree canopy (Aerometrex 2021), which provides an extremely high level of spatial accuracy for determining extent of current tree canopy. Furthermore, the coverage of canopy stratification is a useful resource for analysing to a finer-scale the functional quality of remaining connectivity for gliders within urban areas. These high precision data layers are critical to leverage in the planning of both fine-scale wildlife linkages and strategic planning and planting of biodiversity corridors and green infrastructure within the city urban areas.

While this type of mapping is of the highest spatial resolution available, it does not account for contributions of green infrastructure.

Even where not measurable through spatial analysis, there are many elements that contribute significantly to urban green space and biodiversity. These include such features as:

- Community gardens
- Balcony plants
- Urban gardens and ponds
- Green roofs and walls.

Community involvement and education is critical to expanding the green footprint. Fact sheets and website information are easy and practical ways to communicate this information and provide links to external resources. Other ways to encourage urban greening could include garden competitions, such as the recent Maitland Hanging Garden and Green Wall Competition and sustainability and greening workshops. Other local government programs of relevance include the Waverley Council Living Connections Initiative, which assists property owners to create native gardens, to increase connectivity across the LGA,[5] and free tree programs.

4.3.2 Developing targets

Different jurisdictions have adopted variable targets in respect of increasing canopy cover and there is a range of guidance material that also sets out desirable targets, for example:

- The NSW Government's target for canopy cover across Greater Sydney is 40% by 2058 (Greater Sydney Commission, 2018); the City of Melbourne also has a 40% target, however this is to be achieved by 2040 (City of Melbourne, 2012).
- Brisbane City Council has adopted a 'functional' canopy target of 50% by 2031. This has been determined based on the requirement for people to access shaded, cooler and visually pleasing walking and cycling corridors, i.e., targets are associated with particular functions and do not apply to total LGA canopy cover (Brisbane City Council, 2020).
- Greener Spaces Better Places adopted a 20% by 2020 urban green space target for all urban areas, at the national scale.

Other ways in which targets could be determined include:

- Incremental targets - increasing canopy cover by a small amount every 5-10 years, to achieve a long-term overall canopy cover target. This may make what appears to be a large target that is difficult to achieve, more realistic and acceptable. For example, a 40% target may not seem insurmountable when the achievement of an additional 10% canopy cover every 10 years is the incremental target. Targets could be further defined by land use within the LGA, establishing different targets, for example, rural, suburban and urban zones.
- Building upon those established in 2002, under the Maitland City Council Greening Plan, informed by current mapping that identifies a continuing reduction in pre-clearing extent. Targets could consider vegetation communities individually, with particular consideration of

[5] Waverley Council Living Connections.

locally endemic and endangered ecological communities. This approach would complement, and be in addition to, an overall LGA canopy target.

- Access – targets based on the extent of population able to access green space, for example, 50% of the population in urban Maitland should be within 500 m of a park or reserve by 2030; or all reserves and parks serviced by public transport by 2030.
- Land use – the City of Sydney used detailed vegetation mapping (a similar level of detail is provided in the mapping for this project) to identify land use themes; streets, parks and properties. An overall canopy target was then determined by the sum of individual land use targets. A similar approach could be adapted for the Maitland LGA, for example, streets, parks, urban areas and rural areas.

An Urban Canopy Strategy is critical to establishing the objectives for canopy cover, describing the methods by which these will be achieved and specifying how canopy cover is calculated. This could be supported by a Street Tree Masterplan, which establishes zones within the LGA to guide appropriate planting, protection and maintenance of street trees, as these make up a significant proportion of urban canopy within urban areas. Best practice examples of Street Tree Masterplans are implemented by City of Sydney,[6] Wingecarribee Shire Council,[7] and Waverley City Council.[8]

Workshop 2 (Section 2.1) asked participants 'what is a relevant target for Maitland's native vegetation cover?' At present, there is 21.74% native vegetation cover. Workshop participants suggested that an appropriate target would be anywhere from 30 to 40%.

4.4 Opportunities

4.4.1 Environmental (Biodiversity) Strategy

It is understood that Council is in the initial stages of preparing an Environmental, or Biodiversity, Strategy (final nomenclature to be determined by Council) for the LGA, in accordance with the relevant action under Local Planning Priority 10 of the LSPS. The Environmental or Biodiversity Strategy would sit within the hierarchy of the Strategic Framework outlined in Table 4-1 and incorporate specific actions for improved biodiversity outcomes, informed by the priorities set out in Council's policy documents, such as the LSPS. Regional priorities, such as established under the GNMP, would also be reflected in these actions. The Strategy document will be a lower order document and non-statutory. Actions should therefore:

- reflect, and contribute to, the desired outcomes described in the higher order documents
- inform any program of amendments of higher order documents, for example, development controls and re-zoning measures that contribute to the protection and retention of biodiversity, thereby helping to achieve local and regional priorities
- prioritise processes and practical measures that will achieve higher order strategic themes, such as collaborating with adjacent Councils to improve Blue and Green Grid connections.

4.4.2 Maitland Greening Plan

Council's current review of the Maitland Greening Plan provides an opportunity to adopt a best practice urban greening approach that will support expansion of the urban canopy and the

[6] https://www.cityofsydney.nsw.gov.au/strategies-action-plans/street-tree-master-plan-2011
[7] https://www.wsc.nsw.gov.au/Council/Strategies-and-Plans/Street-Tree-Master-Plan
[8] https://www.waverley.nsw.gov.au/residents/trees_and_gardens/trees_on_public_land/street_tree_masterplan

protection of Maitland's urban forest. A recent study undertaken by NGH identified that best practice urban greening is led by a suite of strategic documents, supported by technical guidelines for implementation. This provides an opportunity to integrate the *Urban Green Cover in NSW Technical Guidelines* (OEH, 2015) into Council policy, which will also support development provisions under the LEP and DCP.

4.4.3 Regional corridors

Established Blue and Green Grid connections in the Greater Newcastle Region are currently limited to the Newcastle LGA. Future Blue and Green Grid connections are identified as a priority under the GNMP, linking waterways and terrestrial greenspaces through Maitland and across the Newcastle, Cessnock and Port Stephens LGAs. As well as providing for recreation and increased greenspace, if designed correctly, these will provide critical wildlife corridors from inland national parks and reserve areas to coastal habitat.

The importance of corridors

Maitland and the Greater Newcastle region is subject to ongoing development and a rapidly growing population, which causes fragmentation of habitat and barriers to wildlife movement. Without the ability to move among and within natural habitats, species become more susceptible to fire, flood, disease, and other environmental disturbances and show greater rates of local extinction. A fragmented landscape is often associated with a rapid loss of some fauna species and an increase in others (typically generalists), creating an ecological imbalance which may drive additional species loss. Localised extinctions are most likely to occur in landscapes with low native vegetation cover, low landscape connectivity, degraded native vegetation and intensive land use (Fischer and Lindenmayer, 2007). Katti (2014) notes that globally, cities have lost on average 30% of the native species which are found in the surrounding region.

There are benefits to people and nature through enhancing and connecting urban green spaces. Urban green spaces provide many public health benefits from contact with nature such as relaxation, stress reduction, enhanced physical activity and mitigation of exposure to air pollution, excessive heat and noise (Department of Environment and Energy, 2017). Buckley et al. (2019) have shown that there is a direct link between spending time in nature and human mental health and wellbeing, equating to a substantial but not previously recognised economic value for accessible protected areas and conservation. Recent studies have also looked at the way that urban green spaces benefit the human population during a pandemic (SARS-CoV-2). Azevedo et al. (2020) identified that close access to green spaces has assisted to maintain human physical and mental health during periods of lockdown.

Urban vegetation and associated ecosystem services also help address the broader issues of climate change and the urban heat island effect (Greener Spaces, Better Places, 2019), a key issue that Council seeks to address through increasing canopy cover.

5. Recommendations

5.1 Urban tree canopy cover

Due to the latest 2021 LiDAR-derived urban canopy cover mapping being available for tree canopy assessment across the LGA, it was possible to estimate the current tree canopy extent within the suburbs (at an urban and rural level) and also determine how much of this canopy is located within Council-controlled areas to very high spatial accuracy. It is strongly recommended that once further LiDAR-derived products such as mapping of impervious surfaces and water bodies become available, that plantable surface area on Council-controlled properties be determined through GIS desktop analysis.

New retention targets should be established for Maitland's vegetation communities, in line with current state and regional guidelines, referenced against the current mapped extent as detailed in Table 3-1. These targets should form part of an Urban Canopy Strategy that is adopted by Council, to ensure resources and support for actions that will achieve the ratified targets for each of these communities and an overall LGA canopy target.

Development provisions (DCP and LEP) requiring that proponents demonstrate a contribution to the achievement of urban canopy cover through, for example, the retention of corridors and integration of reserves into greenfield development proposals, should be adopted. This could be supported by guidelines for development proponents, detailing acceptable methods for the integration of green features into future urban areas.

Fact sheets could also be prepared that assist the community in understanding the importance of urban canopy and how they can contribute to its protection and expansion on their own properties.

5.2 Keystone flora and fauna species

Baseline data is required for these keystone flora and fauna species to be used as an indicator of ecosystem health.

Council could actively promote existing citizen science projects to encourage data collection relevant to these keystone species. These could include:

- The Australian Museum FrogID project (https://www.frogid.net.au/)
- NSW Government's I Spy Koala (https://citizen-science.seed.nsw.gov.au/project/i-spy-koala-nsw-government)
- Birdlife Australia's Birdata (https://birdata.birdlife.org.au/get-started)
- International data partner of Atlas of Living Australia, iNaturalist (https://www.inaturalist.org/).

Alternatively, Council may like to work with research institutes (i.e., University of Newcastle) to propose research topics that would capture data relating to population dynamics for some (or all) of the proposed keystone species.

5.3 Strategic measures for vegetation retention and enhancement

In addition to the actions outlined in Section 4, the following measures are recommended to support Council's development of a robust conservation framework and enhancement of the urban canopy:

1. **Spatial files** created during this Project (Appendix E) should be saved as corporate layers. These have been provided to Council.
2. **Update the Maitland Greening Plan** - prepare a Maitland Urban Canopy (or Urban Forest) Strategy. This should describe the benefits of urban canopy and set out Council's reasons for prioritising the establishment of an urban forest. Priorities and specific targets for protecting and increasing urban canopy/forest should be included in this document:
    - Targets should consider current development commitments, as well as Council's and the community's desired outcomes, for example:
        - increased habitat
        - urban cooling
        - improved connectivity
        - species-specific requirements.
3. Consider the current native vegetation and wildlife corridor spatial data to **identify priority areas** for rezoning, reserve designation or the application of specific planning controls, such as for the preservation of connectivity. Prioritisation should be undertaken in consultation with Council's planning, environment, maintenance and development teams and consider:
    - Development priorities
    - Land use
    - Areas in which development has been approved, however may not have commenced
    - Community expectations
    - Timing of future LEP and DCP amendments, as this would provide a practical opportunity for the coordination and integration of these aspects.
4. Where rezoning is proposed, **consult with private landholders** and implement programs to minimise impacts and promote the retention of vegetation and corridors. Information should be provided to landholders about programs that assist and benefit landholders that protect native vegetation, including:
    - Biodiversity Stewardship Agreements and the Biodiversity Offsets Scheme (NSW)
    - Other private land conservation initiatives such as wildlife refuge and voluntary conservation agreements
    - Agriculture Biodiversity Stewardship Package (Commonwealth)
    - Land for Wildlife
    - Landcare Australia revegetation projects
    - Greenfleet revegetation and carbon offset programs
    - Greening Australia revegetation and carbon credits scheme.
5. Continue to implement the relevant actions to achieve Council's **LSPS commitments**, including:
    - Working with ecologists and landowners to identify conservation areas. To align with the findings of the updated vegetation mapping, prioritise:
        - private land on which there is remnant vegetation

    - areas of greenfield development that could provide landscape connectivity through the dedication of green space.
  - Compliance and enforcement for vegetation protection and to ensure conditions requiring habitat restoration and greening measures are implemented
  - Adopting best practice tree management and urban greening policies
  - Prepare a Biodiversity Strategy that includes specific goals and actions relevant to vegetation protection and enhancement, contemporary urban greening, corridors and connectivity. This should also reflect any urban canopy targets contained within the Greening Plan/Urban Canopy/Urban Forest Strategy, and set out actions that will help to achieve these targets.
  - Implementing stronger development controls to protect biodiversity corridors from future development
  - Advance the Blue and Green Grid at both the local and regional scale

6. Update the Maitland LGA **plant species list**, incorporating landscaping and restoration sections, with guidance on how to achieve connectivity and canopy cover.
7. **Engage with neighbouring Council**'s to develop and implement Blue and Green Grid projects that increase regional connectivity and achieve broadscale conservation outcomes.
8. The primary focus of the focal species assessment was to assess the regional significance of wildlife linkages within and across Maitland, at a relatively coarse level. The corridor outputs are therefore not an exhaustive map of fine-scale wildlife corridors within the Maitland LGA. Council should consider undertaking a more detailed conservation planning exercise to identify **local habitat linkages**, with a particular focus on the rapidly urbanising area.
9. Define (in the Biodiversity Strategy) an appropriate timeframe to **repeat the analysis** of native vegetation extent (i.e., every 5 years) and urban tree canopy cover (i.e., i-Tree annually; LiDAR every 3 to 5 years, depending on affordability).

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Appendix A Parameters used in the analysis of species-specific connectivity

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
Arboreal mammal (frugivore)	Grey-headed Flying Fox	Small	<40km from breeding camp	-	-	-	10,000	GHFF are able to fly up to 40km from their roost site to forage for food, however individuals are likely to travel <20km. Low availability of winter foraging habitat can present a foraging bottleneck for GHFF, therefore mapped winter foraging habitat (Eby, Sims & Bracks 2019) clipped to most current extent, were used as the basis of determining connectivity for this species. If foraging patches were within 10km they were considered connected for this species.	Fragmentation, insufficient foraging resources (winter flowering trees)
Arboreal mammal (folivore)	Koala	Medium	7-52	10	100	50	200	Koala are habitat specialists which are dependent on linkage; can move between patches <100-200m apart if no threats present (McAlpine et al 2007). May disperse 3-4 km (4-10 km possible) (McAlpine et al 2007). Core habitat areas were identified as contiguous primary habitat >=50ha; habitat nodes were identified as contiguous primary habitat >= 20ha. Nodes were considered connected intervening primary and secondary habitat did not exceed 200m.	Residential, commercial, industrial development, roads, dogs, weeds
Freshwater frogs	Green and Golden Bell Frog	Amphibian	0.1	0.5	1	5	500	Core habitat was identified as suitable primary habitat. Connectivity was based on a radial expansion buffer of 500m from suitable habitat used; success of temporary expansion of population distributions during wet weather events are dependent on land-cover types surrounding	Roads with no culverts, developed urban surfaces, open dry areas, polluted areas

[9] Able to support at least 1-2 breeding events
[10] Able to support 10 year persistence
[11] Adjusted for urban area*

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
								the population permanent location.	
Freshwater frogs	Common Eastern Froglet	Amphibian	2.4km				600		
Freshwater frogs	Tusked Frog	Amphibian	>10				50-500		
Glider	Sugar Glider	Small	0.5	1	50	5	25	One of the strongest determinants of glider occupancy (presence) on the urban fringe is the height of hollow-bearing trees (Francis et al. 2015). Therefore, to identify habitat nodes, contiguous remnant primary habitat was selected. To ensure proper buffering for edge effects, 5 ha patches with a 50m buffer were considered suitable as a node. With regards to connectivity, all glider species require remnant forest with mature tree canopies of sufficient height for connectivity. The gliding process (volplaning) and the distance travelled depends on the height of the tree from which they are gliding, with taller trees allowing longer glides. Squirrel Gliders can glide up to 80 m, but 20 to 40 m is more typical. Gaps greater than 70 m are considered a physical barrier to squirrel glider movement. To model connectivity, a gap of 25m between suitable remnant forest habitat and/or non-native canopy (using NSW Woody vegetation extet (TERN 2011) was set as the threshold. Gaps greater than 25m were considered a barrier.	Canopy gap 20-35m
Glider	Feathertail Glider	Small	0.4-2	5	50	5	50		Canopy gap >30m

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
Glider	Squirrel Glider	Small	6.2	7	75	5	70		50-100 m glide distance (depending on slope)
Ground dwelling mammal (Generalist)	Bush Rat	Small	280m	1	-	3	50	The Bush Rat lives in forests, woodlands and heath and prefer to live in the dense forest understorey, sheltering in short burrows under logs or rocks and lining their nests with grass. They are not found often in urban areas. Males may travel up to 1 km a night foraging for food. During breeding time, he may travel up to 2 km in search of a female. While 10 individuals may occupy 1 hectare, woodland patches <1ha have been found to have significantly lower invertebrate diversity due to increase dessication. Therefore, core habitat nodes were identified as contiguous habitat patches of >=3ha size to ensure sufficient buffering maintain invertebrate food supplies. Connectivity was modelled based on a 50m gap between primary and secondary habitat (while this is a conservative model, Goosem reported that *Rattus* spp crossed 20m road gaps uninhibited except during breeding season).	Urbanisation
Ground-dwelling Mammal (Moist Forest)	Swamp Wallaby	Medium-large	15-40	50	150	10	250	Swamp wallaby are larger herbivorous terrestrial mammals requiring bushland linkages of habitat for refuge. While these wallaby species show adaptable persistence within the peri-urban and suburban landscape, their long-term survival should not be taken for granted. Research has shown that the species is prone to local extirpation within isolated habitat fragments due to, amongst other factors, threat of roadkill and predation by domestic dogs and red foxes (Ramp et al. 2014). Swamp Wallaby prefer habitats with dense forest cover and thick understorey. They tend to be more cryptic in their behaviour, not moving far from dense cover. Core habitat nodes were selected as primary	Large multi-lane roads; high fences/walls (>1.5m high)

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
								habitat patches of >=10ha, which could be connected to secondary habitat for cover. Connectivity was assessed based on a gap size of 250m between patches of primary and/or secondary habitat.	
Hollow-dependent microbats	Eastern False Pipistrelle	Small					12000	Microbats require two essential habitats; one suitable to diurnal roosting and sufficient for extended periods of torpor and other sites for nocturnal foraging. These microbat species are dependent upon mature trees with hollows for roosting. For movement microbats prefer low vegetation clutter is preferred for clear flight path. Myotis prefer close proximity to a water body and/or riparian zones. Core habitat nodes were selected as contiguous remnant primary habitat within 12km of water. Connectivity was based on movement of up to 12km between suitable primary habitat.	Disturbance of roosting and breeding sites, loss of habitat, particularly roosting sites and the use of pesticides adjacent to foraging areas are all listed as threats (Churchill, 1998).
Hollow-dependent microbats	Greater Broad-nosed Bat	Small							
Hollow-dependent microbats	Southern Myotis	Small	5-277	1	22	1	<30000		

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
Migratory forest birds	Regent Honeyeater	Bird	no data	-	-	10	5000	It is likely that Regent Honeyeater movements are dependent on spatial and temporal flowering and other resource patterns. Current knowledge suggests their movement and settlement patterns reflect high spatiotemporal variability in the timing and intensity of flowering events in their preferred food trees. Swift Parrots breed only in Tasmania and then fly across Bass Strait to forage on the flowering eucalypts in open box–ironbark forests of the Australian mainland. Core habitat for this guild was identified as primary habitat >=10ha in size. Connectivity was based on a gap of up to 5km between primary and/or secondary habitat.	Requires winter flowering feed trees
Migratory forest birds	Swift Parrot	Bird	no data	-	-	10	5000		Requires winter flowering feed trees
Resident forest bird	Eastern Yellow Robin	Bird	5-6	5	-	5	2500	Feed on invertebrates, either by foraging on the trunks and branches of eucalypts and other woodland trees or on the ground, digging and probing amongst litter and tussock grasses. Require intact woodland patch of 5ha+ when resident and breeding, can move seasonally and will follow tracks of remnant and regrowth vegetation. Flight is laborious so birds prefer to hop to the top of a tree and glide down to the next one. Birds are generally unable to cross large open areas. Sensitive to edge effects. Therefore, selection of habitat nodes were based on a minimum primary habitat patch size of 5ha. Connectivity was modelled based on a gap of up to 1km between primary and/or secondary habitat.	Fragmentation, insufficient woodland patch size within ca 50m of edge
Resident forest bird	Grey-crowned Babbler (eastern	Bird	1-50	-	-	5	2500		

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
	subspecies)								
Resident forest bird	Superb Fairy-wren	Bird	5-6	-	-	5	2500		
Forest Owl	Powerful Owl	Bird		-	-	100	2000	The Powerful Owl is found in open forests and woodlands, as well as along sheltered gullies in wet forests with dense understoreys, especially along watercourses. The main component of the Powerful Owl diet across its range is Ringtail Possum, this may be supplemented by other arboreal possums and gliders depending on the geographic location and prey present. Nest sites are selected high up in old, large living eucalypts (150 + years old). Nest hollows are large and can be about 1metre deep with an entrance nearly .5 m wide (Cooke et al. 2002). A major threat to the Powerful Owl is a loss of suitable large hollow bearing trees which has a direct impact on the availability of nest sites and also reduces habitat that supports arboreal marsupials which comprise the majority of the owl's diet. Identification of core habitat was based on selection of primary remnant forest within a patch size of >=100ha. Primary habitat could be embedded within secondary habitat remnant forest as it constituted extended hunting grounds. Connectivity was modelled using a 2km and 5km radius from primary nesting habitat.	Loss of forest with suitable tree hollows
Wetland associated (reptile)	Eastern Snake-necked Turtle	Reptile	10km	-	-			Most of the Eastern Snake-necked Turtle's time is spent in the water, but it can make overland movements in search of new waterholes and nesting areas.While it will traverse through terrestrial environments for breeding habitat, it requires clear passage (undistrubed environments) to move through environments safely. The	Roads with no culverts, predation on nests

Guild	Species	Body size	Home range size (ha)	Min breeding patch size (ha)[9]	Min population patch size[10]	Habitat node area used in analysis (ha)[11]	Gap-crossing threshold (m)	Connectivity comment	Barrier
								ability to move between suitable forest/vegetation, wetland and a permanent water body is an important requirement. Turtles have been known to move up to 2km between wetlands and 500m between wetland and forest where they may remain buried for prolonged periods. Connectivity was assessed based on a 500m gap between suitable primary habitat including both vegetated habitats and wetlands.	
Wetland associated (small mammal)	Swamp Rat	Small	0.2-0.5; 4	-	-			Swamp Rat prefer coastal heath, sedgelands, dune scrub and grassland areas (ALA 2020). Water rat prefer wetland habitats characterised by dense, low-lying vegeation, low-density canopy cover and shallow, narrow water bodies (Speidewinde et al., 2013). Forage underwater in permanent bodies of fresh or brackish water (Australian Museum 2019). Dense vegetation is a pre-requisite for breeding. Make nests in burrows up to 1m deep, or in dense vegetation where ground in saturated (Van Dyck & Strahan, 2008). Water rat burrows in banks of rivers and lakes (Australian Musuem 2019). Water rat males move 1-4km per night along watercourses or in estuaries, overlapping the range of several females (Harris, 1978). Can disperse larger distances when changing conditions stimulate movement (Vernes, 1998). Connectivity was modelled using a 200m buffer on watercourses and 500m gap between vegetated patches of primary and secondary habitat.	Cleared open paddocks, urbanisation, loss of habitat, roads, predation by domestic species
Wetland associated (small mammal)	Water Rat	Small	2-10	-	-				

Appendix B i-Tree canopy assessment results

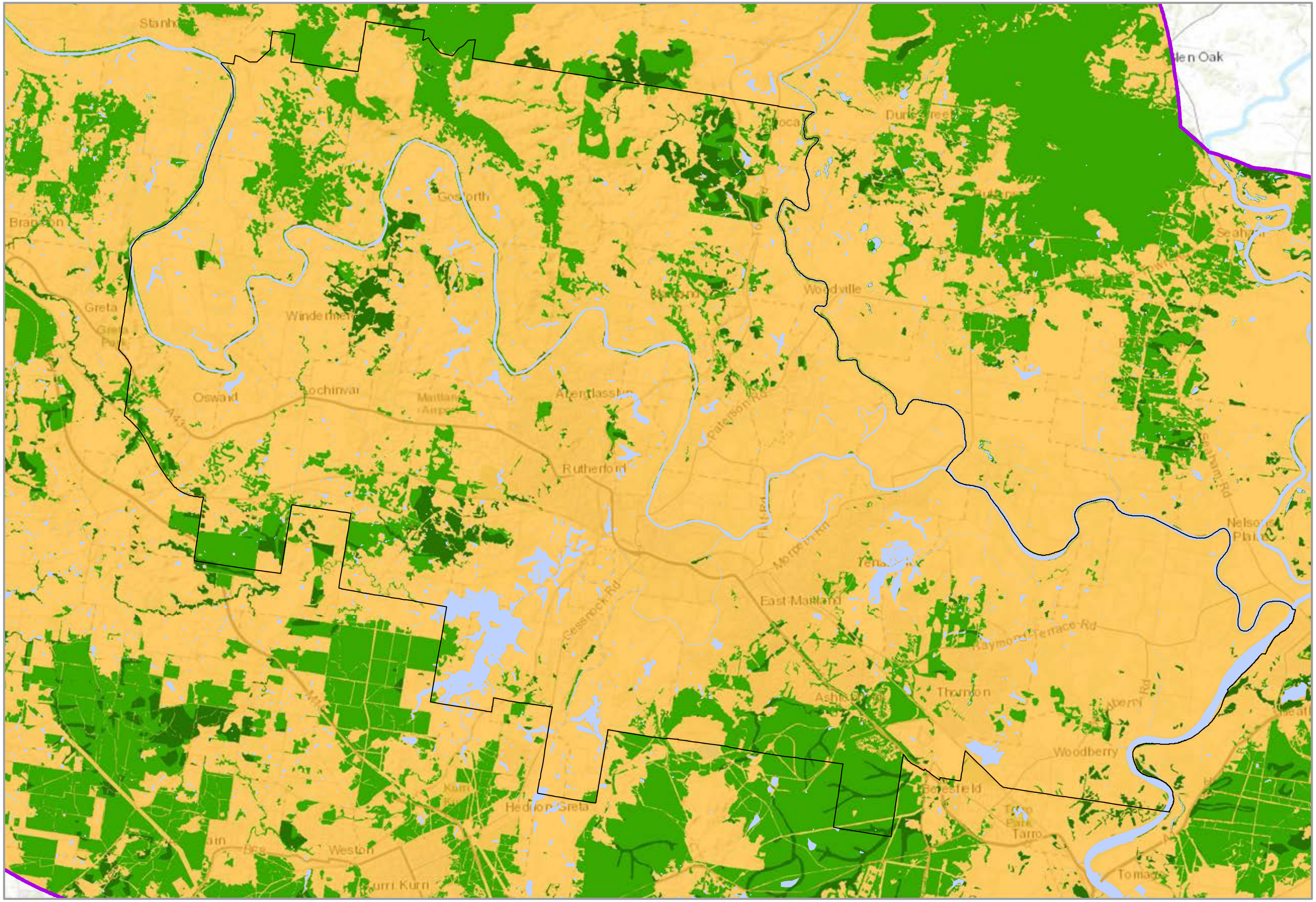
Please see the attached Excel (embedded within this PDF document).

Appendix C Maitland wildlife corridor details

Please see the attached Excel (embedded within this PDF document).

Appendix D Connectivity maps for each focal fauna guild

Figure 1 Guild Connectivity - Arboreal Frugivores - Grey-headed flying-fox



Maitland local government boundary
Extent of analysis area
Waterways & water bodies
Winter foraging habitat in remnant forest
All potential flying-fox habitat
Connectivity (based on 10km radius from winter foraging habitat)

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© NSW OEH 2021

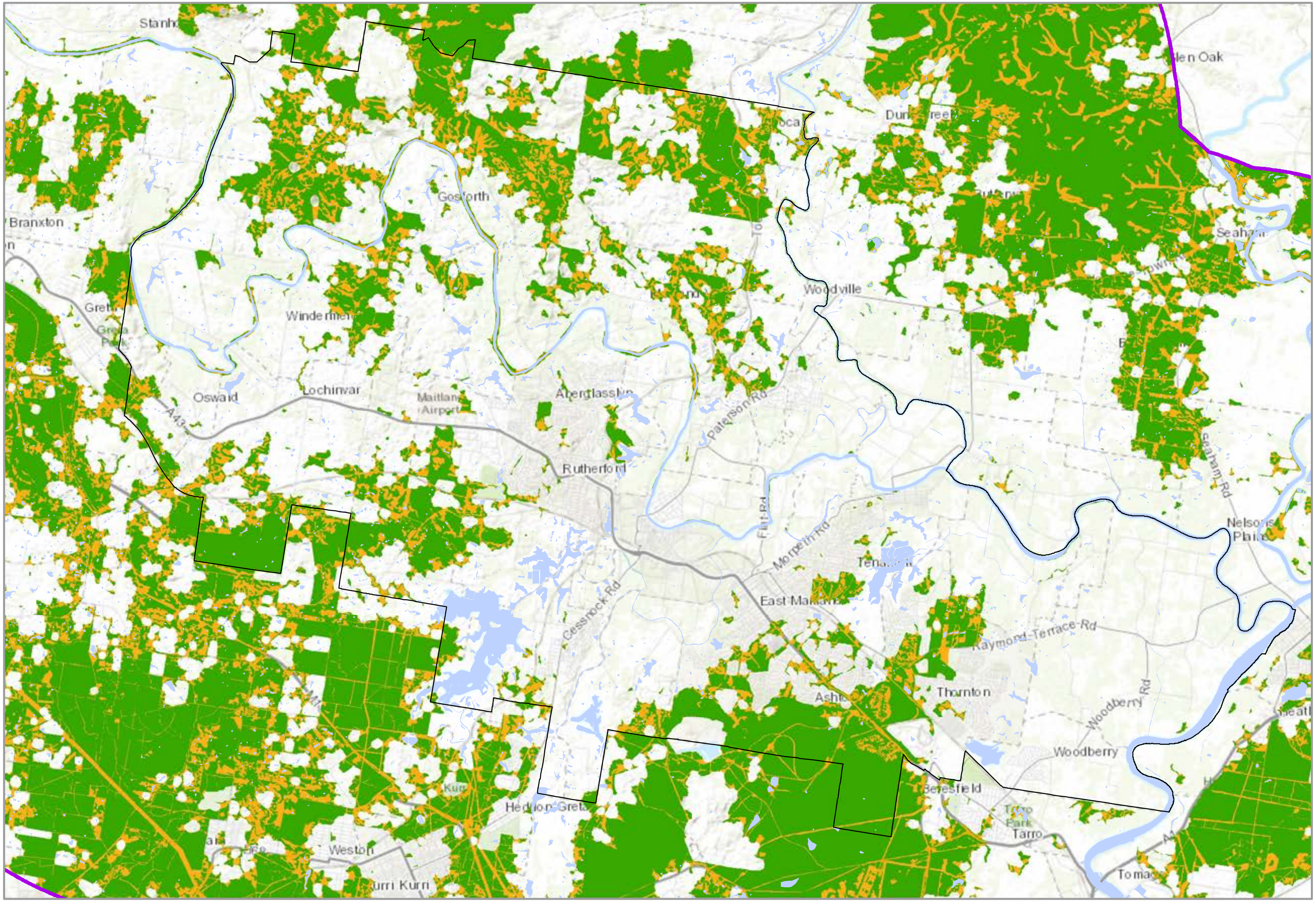
Ref: 21-137 Fig_1_Guild_Connectivity_GHFFox
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 2 Guild connectivity - Arboreal foliovore - Koala



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Koala habitat
- Connectivity (based on 200m gap)

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© ESRI Base Maps 2021
Ref: 21-137 Fig_2_Guild_Connectivity_Koala
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

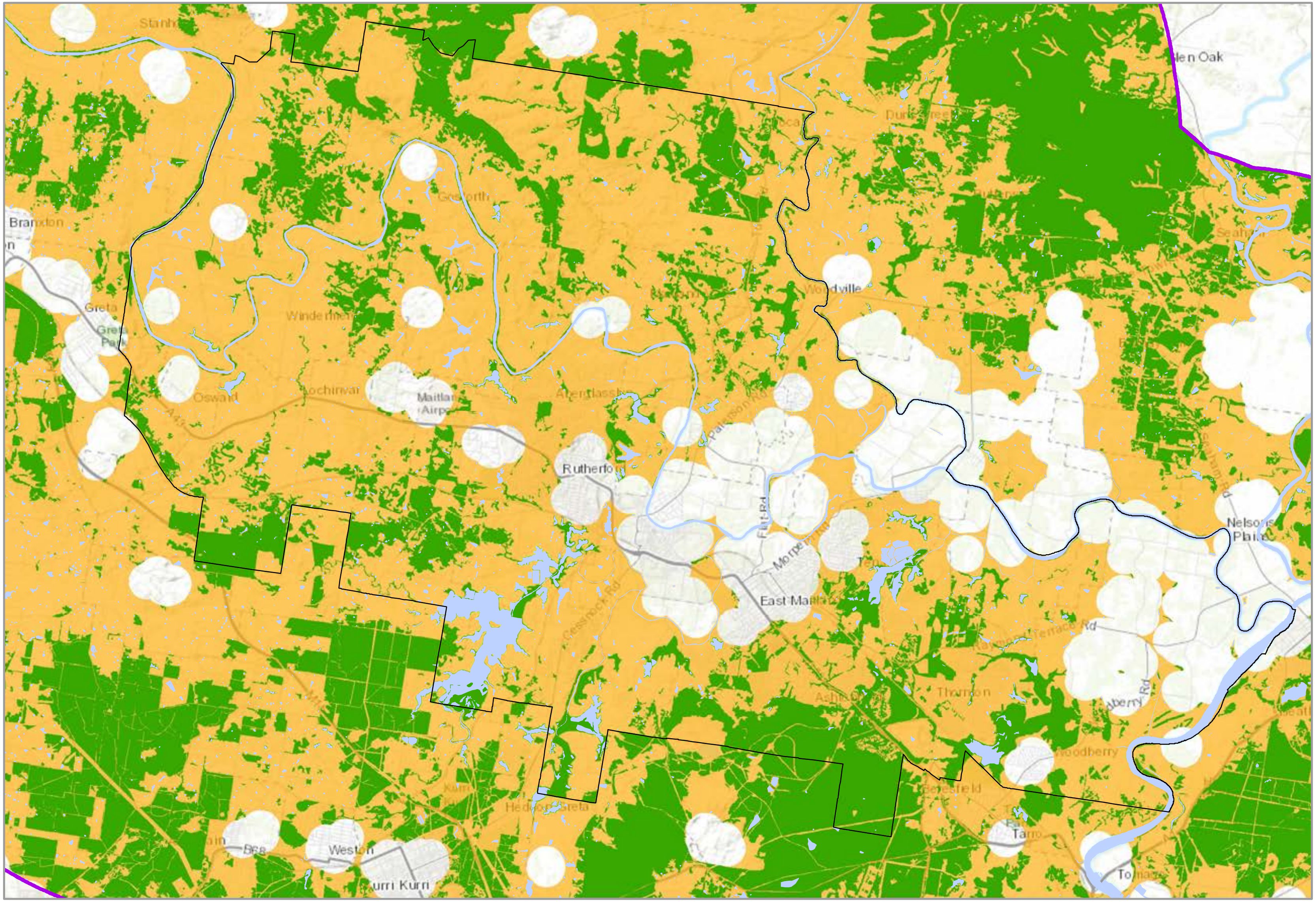

Figure 3 Guild Connectivity - Freshwater Frogs - Green & golden bell frog, common eastern froglet & tusked frog

- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Freshwater frog habitat
- Connectivity (based on 500m radial expansion, not yet adjusted for urban landcover

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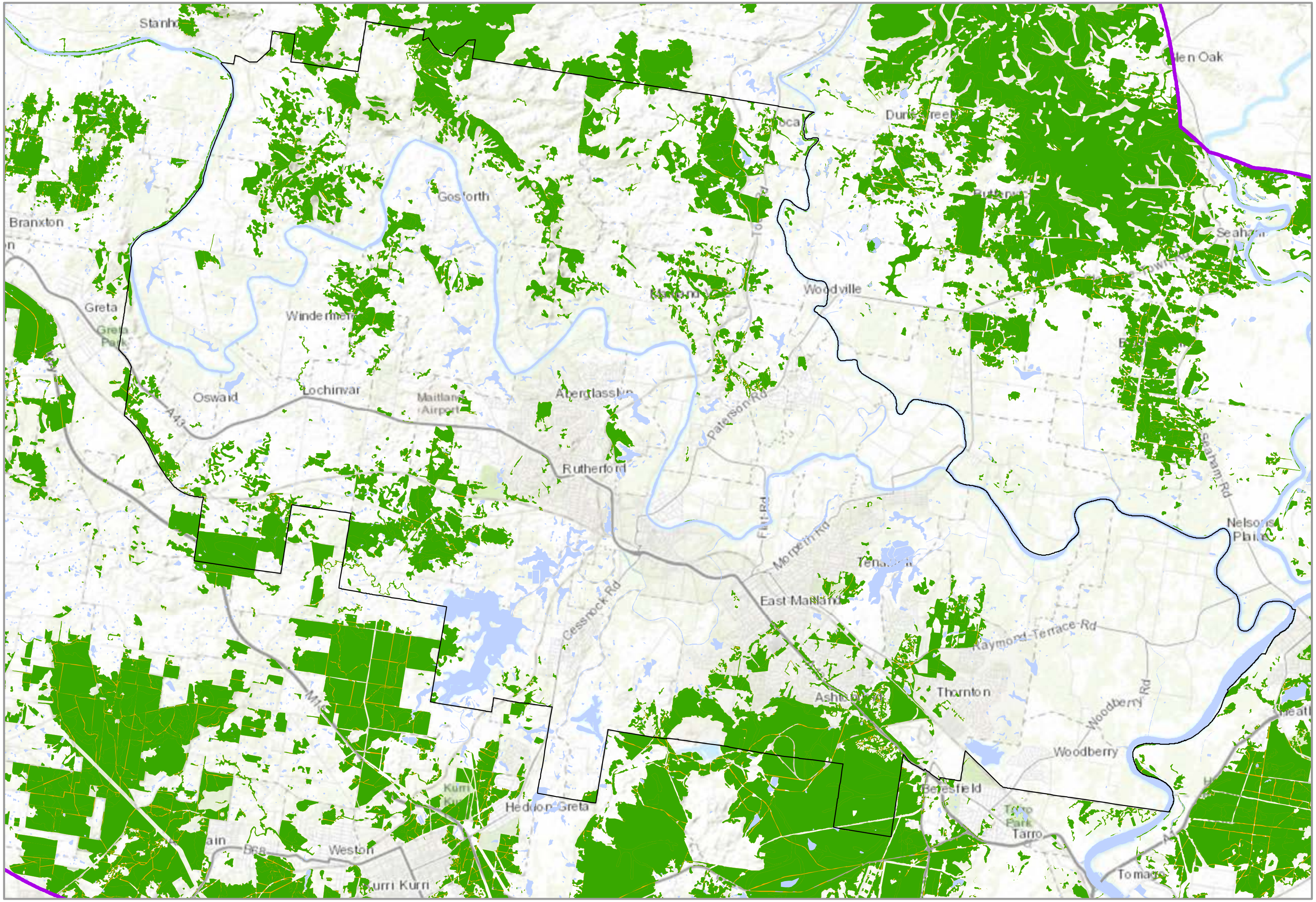
Ref: 21-137 Fig_3_Guild_Connectivity_FWFrogs
Author: Rebecca Sims
Date created: 30/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 4 Guild Connectivity - Arboreal Gliders - Sugar glider, feathertail glider & squirrel glider



Maitland local government boundary

Extent of analysis area

Waterways & water bodies

Glider habitat

Connectivity (based on 25m gap)

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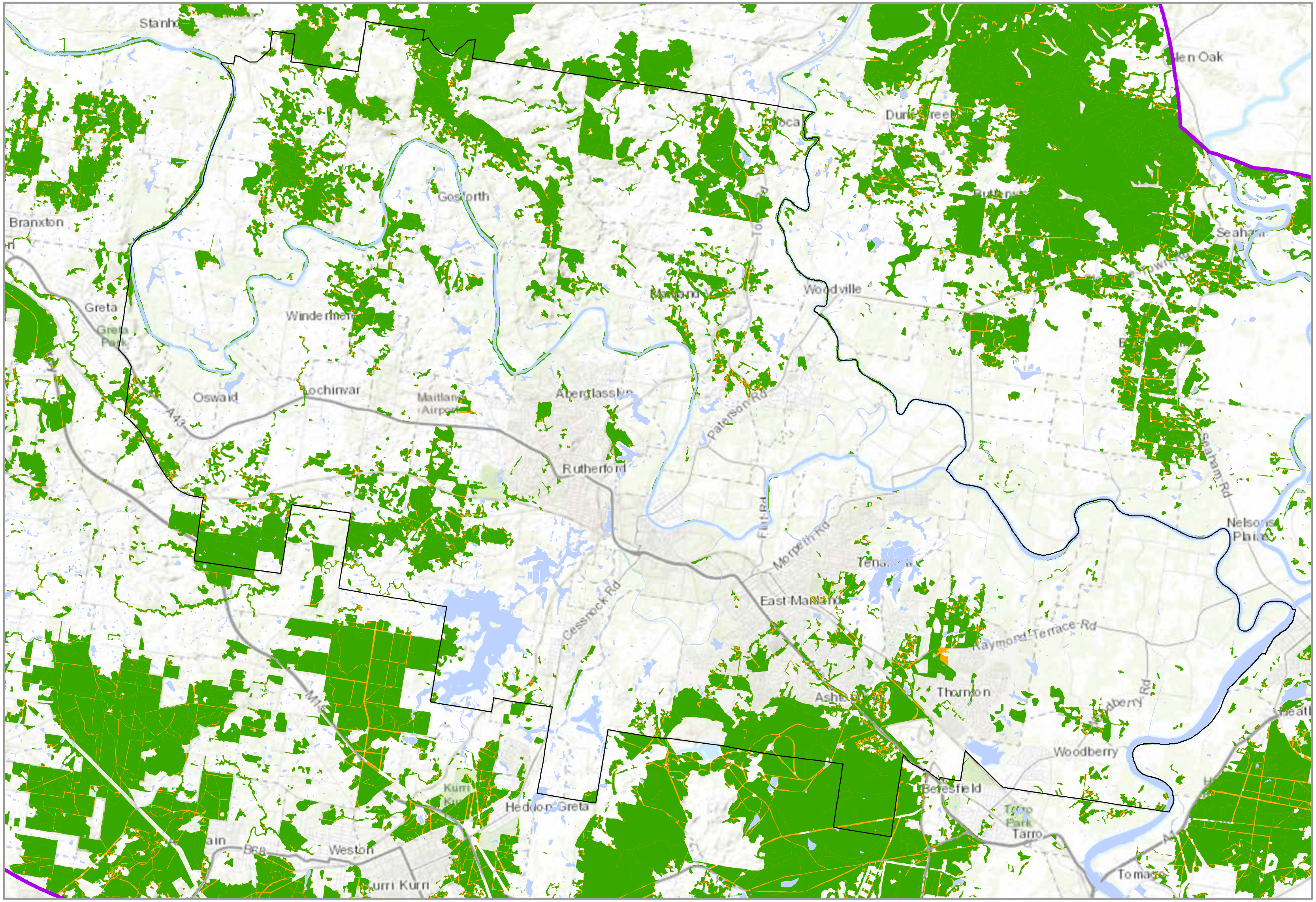
Ref: 21-137 Fig_4_Guild_Connectivity_Gliders
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

NGH

0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 5 Guild connectivity -Ground-dwelling mammal (Generalist)- Bush Rat



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Bush rat habitat
- Connectivity (based on 50m gap)

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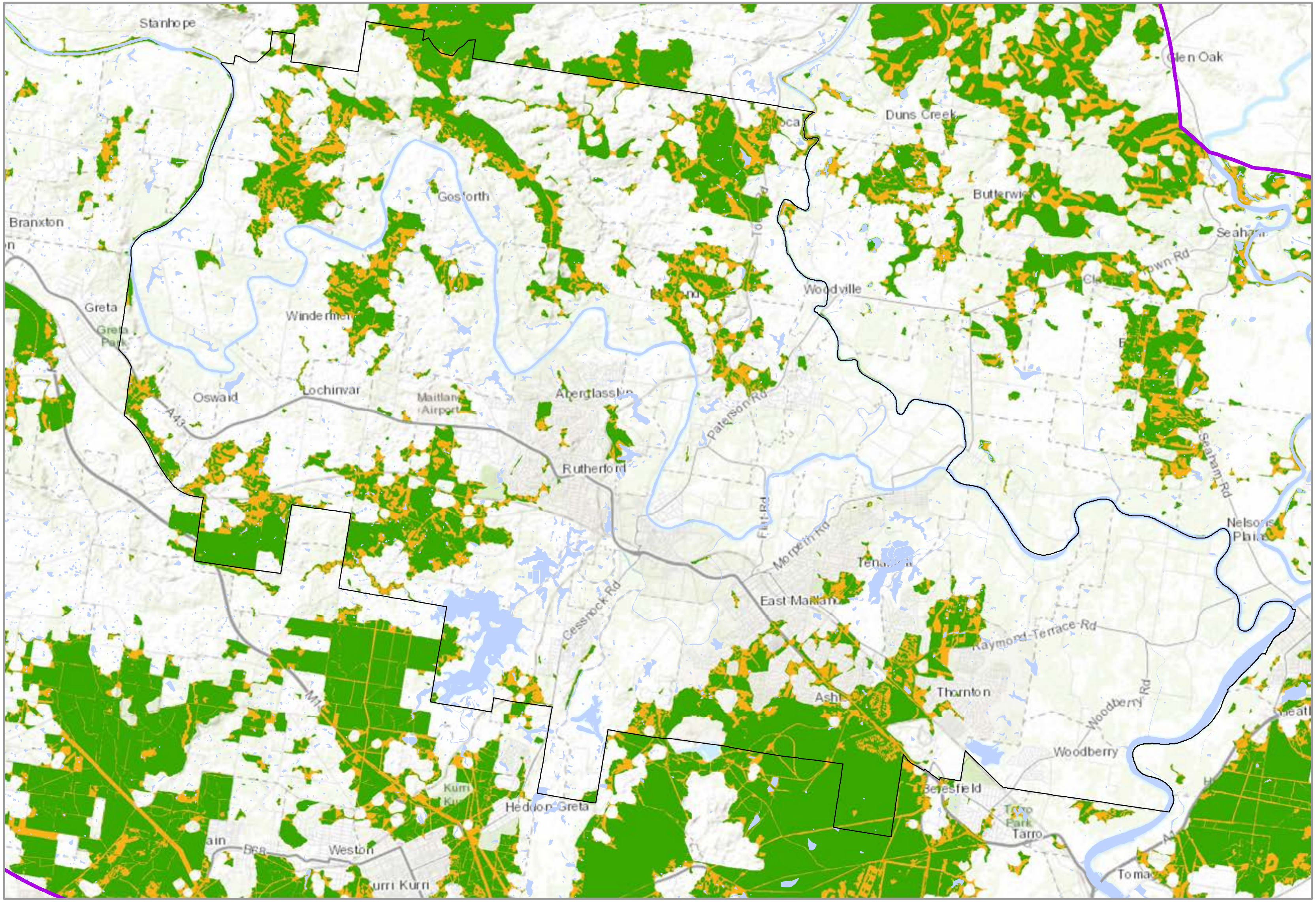
Ref: 21-137 Fig_5_Guild_Connectivity_BushRat
Author: Rebecca Sims
Date created: 30/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 6 Guild connectivity - Ground-dwelling mammal - Swamp wallaby



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Swamp wallaby habitat
- Connectivity (based on 250m gap)

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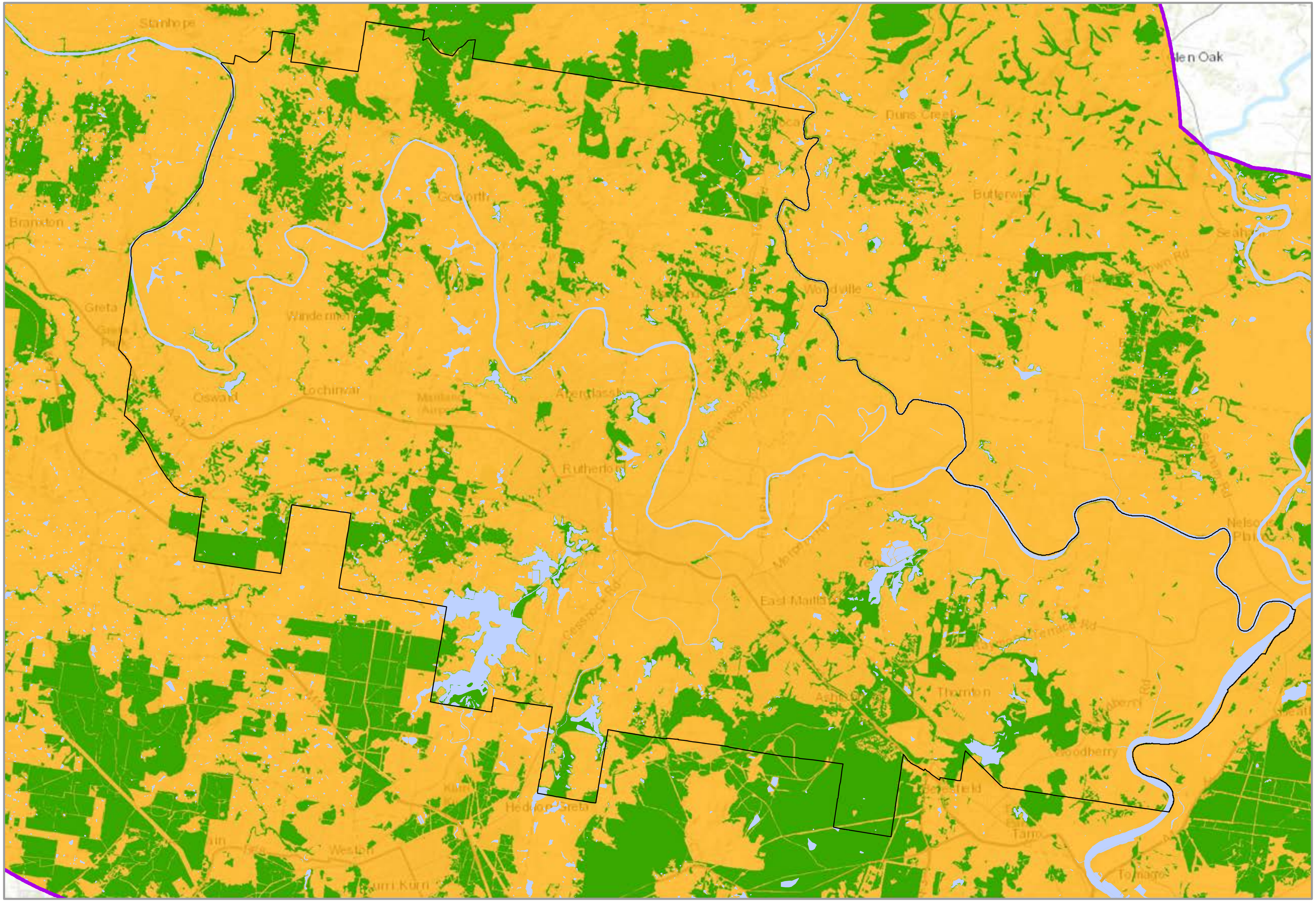
Ref: 21-137 Fig_6_Guild_Connectivity_SwampWallaby
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 7 Guild Connectivity - Hollow-dependent Microbats - Eastern false pipistrelle, greater broad-nosed bat & southern myotis



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Microbat habitat
- Connectivity (based on 12km gap)

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Ref: 21-137 Fig_7_Guild_Connectivity_Microbats
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

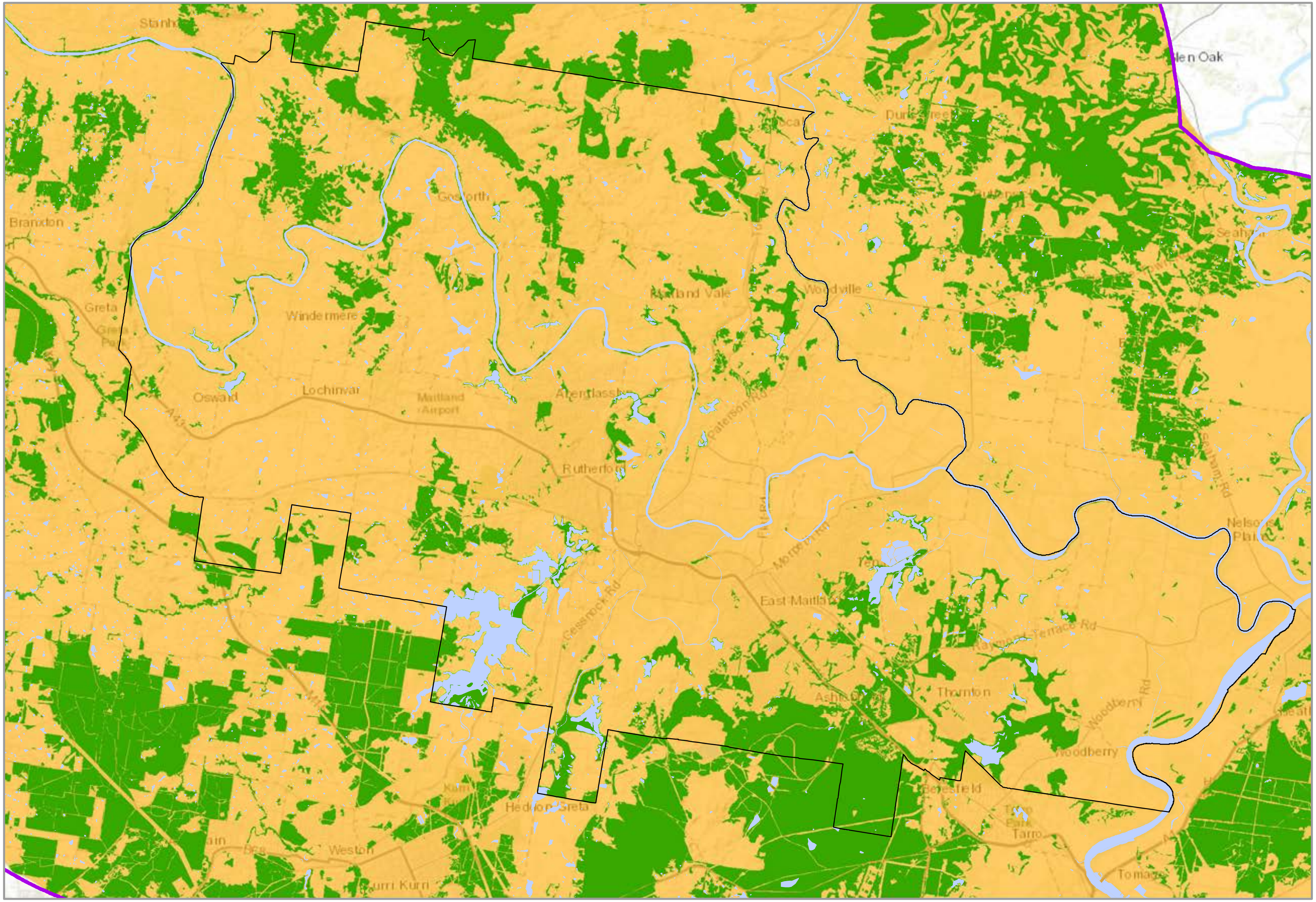

Figure 8 Guild Connectivity - Migratory Forest Birds - Regent honeyeater & swift parrot

- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Migratory forest bird habitat
- Connectivity (based on 5km gap)

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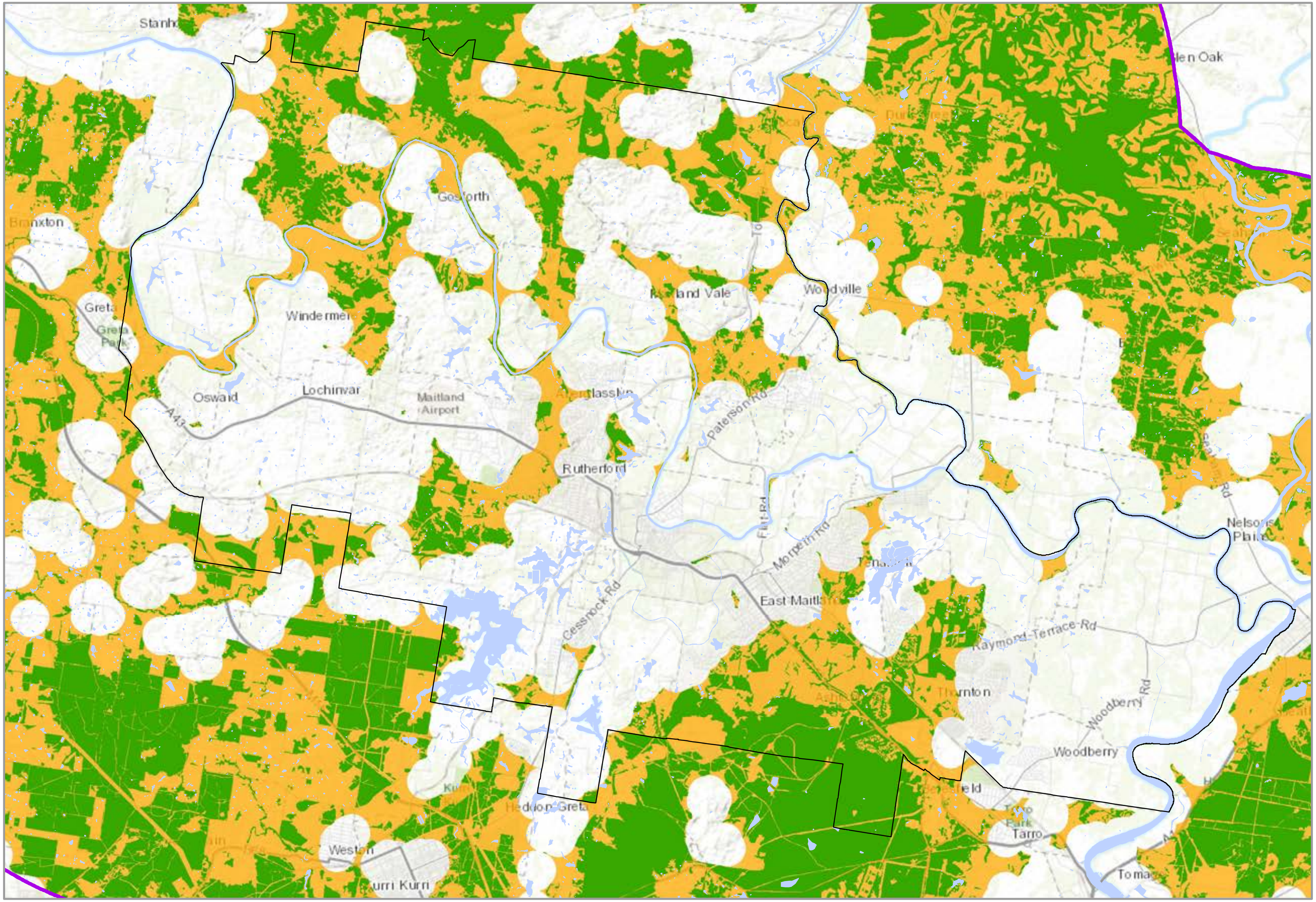
Ref: 21-137 Fig_8_Guild_Connectivity_MigratoryForestBirds
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

NGH

0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 9 Guild Connectivity - Resident Forest Birds - Eastern yellow robin, grey-crowned babbler & superb fairy-wren



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Eastern yellow robin, grey-crowned babbler & superb fairy-wren habitat
- Connectivity (based on 1km gap)

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Ref: 21-137 Fig_9_Guild_Connectivity_ResidentForestBirds
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

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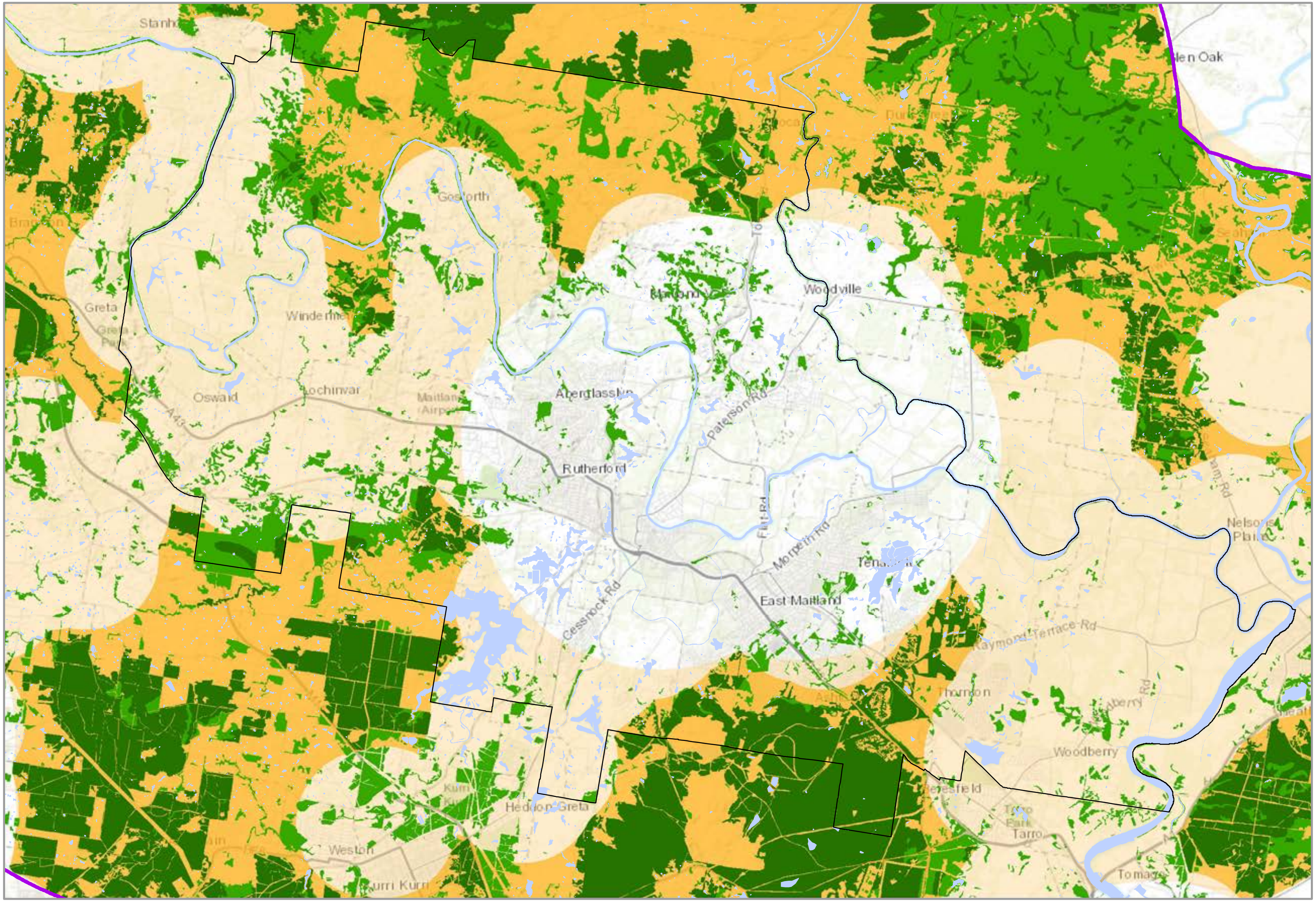
0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 10 Guild Connectivity - Forest Owl - Powerful owl



Maitland local government boundary
Extent of analysis area
Waterways & water bodies
Suitable nesting habitat
Remnant forest habitat
Connectivity (based on 2km radius from nesting habitat)
Connectivity (based on 5km radius from nesting habitat)

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Ref: 21-137 Fig_10_Guild_Connectivity_ForestOwl
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

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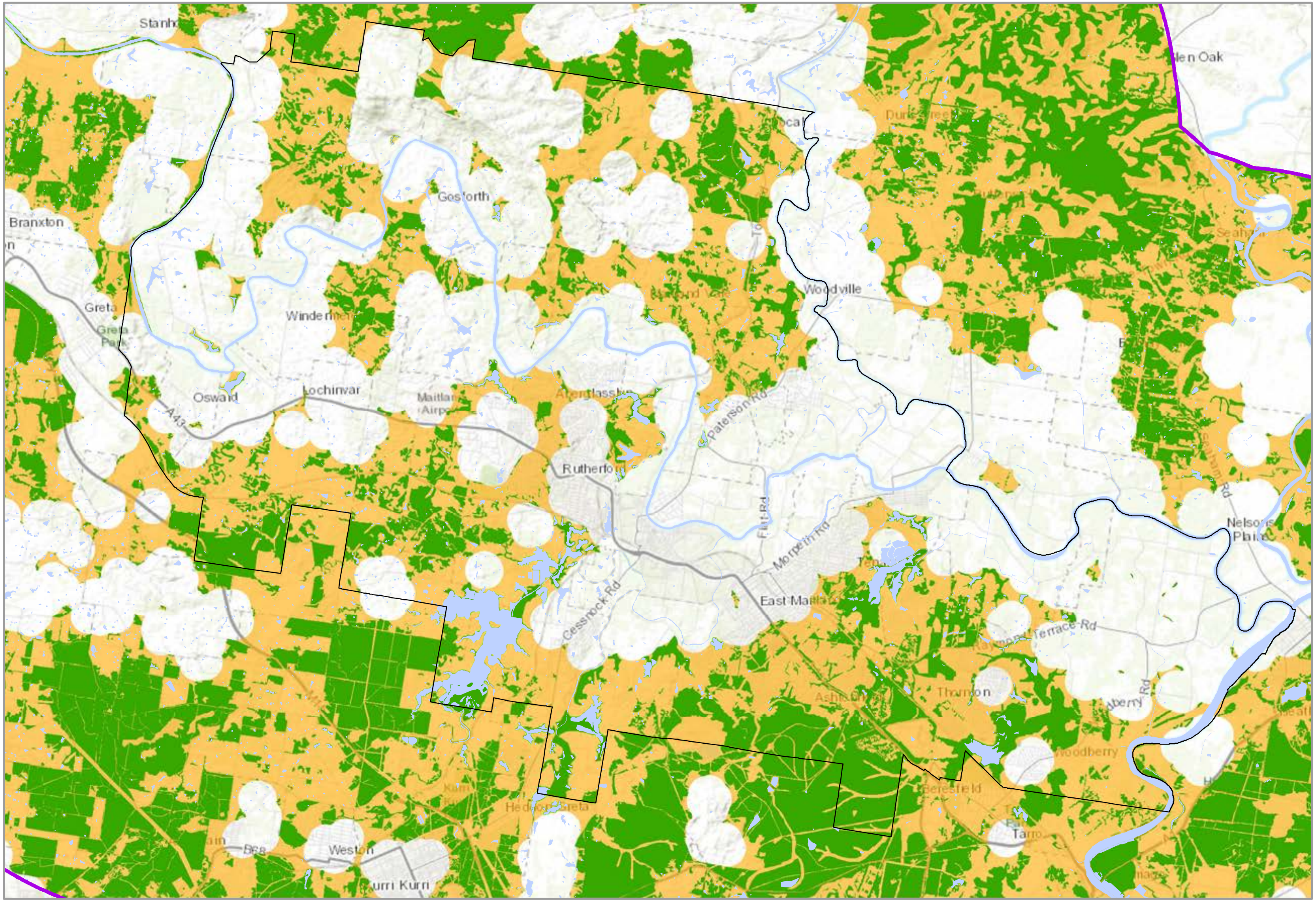
0 0.5 1 2 Km

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 11 Guild Connectivity - Wetland-associated Reptile - Eastern snake-necked turtle



Maitland local government boundary

Extent of analysis area

Waterways & water bodies

Eastern snake-necked turtle habitat

Connectivity (based on 500m gap)

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Ref: 21-137 Fig_11_Guild_Connectivity_Turtle
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

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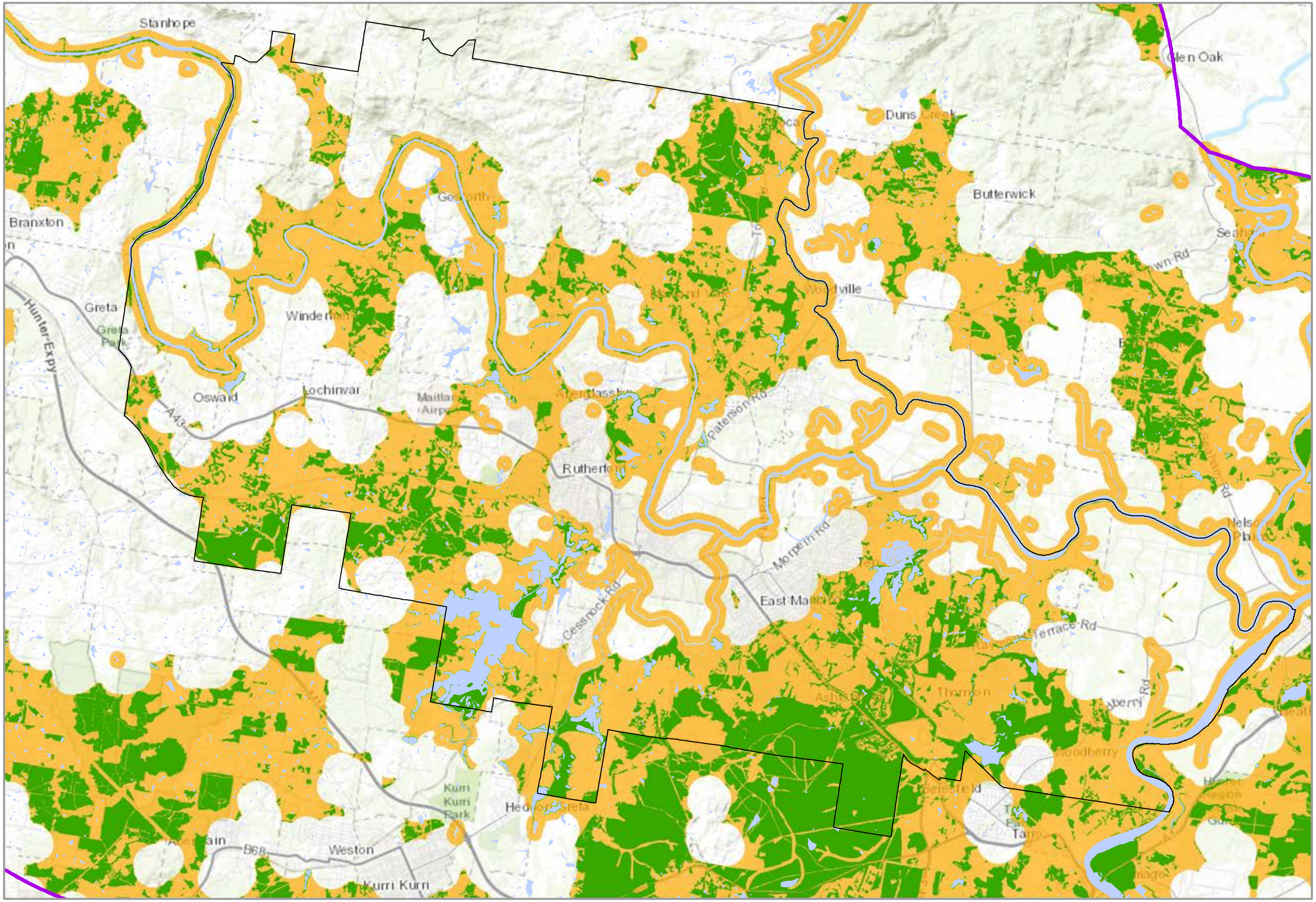
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 12 Guild Connectivity - Wetland-associated Small Mammals - Swamp rat & water rat



- Maitland local government boundary
- Extent of analysis area
- Waterways & water bodies
- Wetland-associated small mammal habitat
- Connectivity (based on 200m buffer to watercourses and 500m gap between vegetated patches

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Ref: 21-137 Fig_12_Guild_Connectivity_WetlandMammals
Author: Rebecca Sims
Date created: 19/07/2021
Datum: GDA94 / MGA zone 56

0 0.5 1 2 Km

NGH

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Appendix E Data files created during this Project

File or folder name	Data type	Description
NATIVE VEGETATION MAPPING		
Maitland_Native_Vegetation_with_EECs_2020_21_version1_1	Shapefile	Updated native vegetation mapping based on Hill (2003) with condition classes added
21-137 MAITLAND NATIVE VEGETATION STATISTICS - EXTENT AND CHANGE 2009 - 2021	Excel	Area statistics relating to native plant communities, includes changes in extent between 2009-2021
I-TREE CANOPY OUTPUTS		
21_137_iTree Estimate of Urban Vegetation and Impervious Surface Cover 2021060	Excel	Area statistics relating to land-cover classes including tree canopy cover, shrubs, grass, impervious surface and water. Area estimates are for the period 2015/2016.
MaitlandLGA_GRASS_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class GRASS, displayed by suburb
MaitlandLGA_IMPERVIOUS_BUILDING_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class IMPERVIOUS SURFACE (BUILDING), displayed by suburb
MaitlandLGA_IMPERVIOUS_ROAD_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class IMPERVIOUS SURFACE (ROAD), displayed by suburb
MaitlandLGA_IMPERVIOUS_SURFACE_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class IMPERVIOUS SURFACE (BUILDING & ROAD), displayed by suburb
MaitlandLGA_SHRUB_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class SHRUB, displayed by suburb
MaitlandLGA_SOIL_BAREGROUND_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class SOIL/BARE GROUND, displayed by suburb
MaitlandLGA_TREE_CANOPY_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class TREE CANOPY, displayed by suburb
MaitlandLGA_WATER_cover_by_suburb_2016	Shapefile	Area estimates for the land-cover class WATER, displayed by suburb
I-TREE CANOPY PROJECT DATA		
Maitland landcover classes	FILE	i-Tree Canopy Land cover class list which was used for the estimation of land cover area for the current project
_REPORTS	SUB FOLDER	This folder contains the i-Tree Canopy reports for each suburb within Maitland LGA (pdf format) as generated for the 2021 canopy assessment project

File or folder name	Data type	Description
_PROJECT FILES	SUB FOLDER	This folder contains the iTree Canopy project files for each suburb within Maitland LGA (itrcnpy format) as generated for the 2021 canopy assessment project
_POINTS	SUB FOLDER	This folder contains the saved locations of sample points captured for each suburb (csv and kml format). These are also converted to ESRI geodatabase format (see sub-sub folder KMLtoLAYER).
Suburb-boundaries	SUB FOLDER	This folder contains the boundary layers for each of the suburbs within Maitland LGA as used in the 2021 canopy assessment project.
FOCAL SPECIES ANALYSIS OUTPUTS		
CONNECTIVITY	SUB FOLDER	
ArborealMammalFoliovore_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for arboreal foliovore mammals (i.e. koala)
ArborealMammalFrugivore_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for arboreal frugivore mammals (i.e. grey headed flying foxes)
ArborealMammalGlider_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for arboreal gliders
ForestOwl_CONNECTIVITY_2KM	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity (based on 2km radius) for forest owls (i.e. powerful owl)
ForestOwl_CONNECTIVITY_5KM	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity (based on 5km radius) for forest owls (i.e. powerful owl)
FreshwaterFrog_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for freshwater frogs
GroundDwellerGeneralist_CONNECTIVITY_	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for generalist ground dweller (i.e. bush rats)
GroundDwellerMoistForest_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for moist forest ground dwellers (i.e. swamp wallaby)
HollowDepMicrobat_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for hollow dependent microbats
MigratoryForestBird_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for migratory forest birds
ResidentForestBird_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for resident forest birds

File or folder name	Data type	Description
WetlandAssociatedMammal_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for wetland associated mammals
WetlandAssociatedReptile_CONNECTIVITY	Shapefile	Polygon feature layer delineating areas of potential landscape connectivity for wetland associated reptiles
CONNECTIVITY OVERLAPS	SUB FOLDER	
COMBINED_FOCAL_SPECIES_CONNECTIVITY_OVERLAP	Shapefile	Polygon feature layer showing degree of overlap between guild landscape connectivity
CORE HABITAT	SUB FOLDER	
ArborealDwellerFoliovore_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for arboreal foliovore mammals (i.e. koala)
ArborealDwellerFrugivore_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for arboreal frugivore mammals (i.e. grey headed flying foxes)
ArborealDwellerGlider_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for arboreal gliders
ForestOwl_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for forest owls (i.e. powerful owl)
FreshwaterFrog_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for freshwater frogs
GroundDwellingMammal_Generalist_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for generalist ground dweller (i.e. bush rats)
GroundDwellingMammal_MoistForest_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for moist forest ground dwellers (i.e. swamp wallaby)
HollowDepMicrobats_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for hollow dependent microbats
MigrantForestBird_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for migratory forest birds
ResidentForestBird_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for resident forest birds
WetlandAssocMammal_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for wetland associated mammals
WetlandAssocReptile_CORE_HABITAT	Shapefile	Polygon feature layer delineating core habitat areas for wetland associated reptiles
INDICATIVE CORRIDOR LINES	SUB FOLDER	
Maitland_Significance_of_Fauna_Corridors_and_Linkages_2021	Shapefile	Line feature layer indicating the location and orientation of potential fauna linkages within the LGA and their regional, sub-regional and local significance

File or folder name	Data type	Description
SPECIES HABITAT	SUB FOLDER	
HABITAT_SUITABILITY_ALL_SPECIES	Shapefile	Polygon feature layer indicating potential suitable habitat for species included in the focal guild analysis. Vegetation communities and PCTs are classified as either primary ('1'), secondary ('2') or unsuitable ('0') habitat for each species.