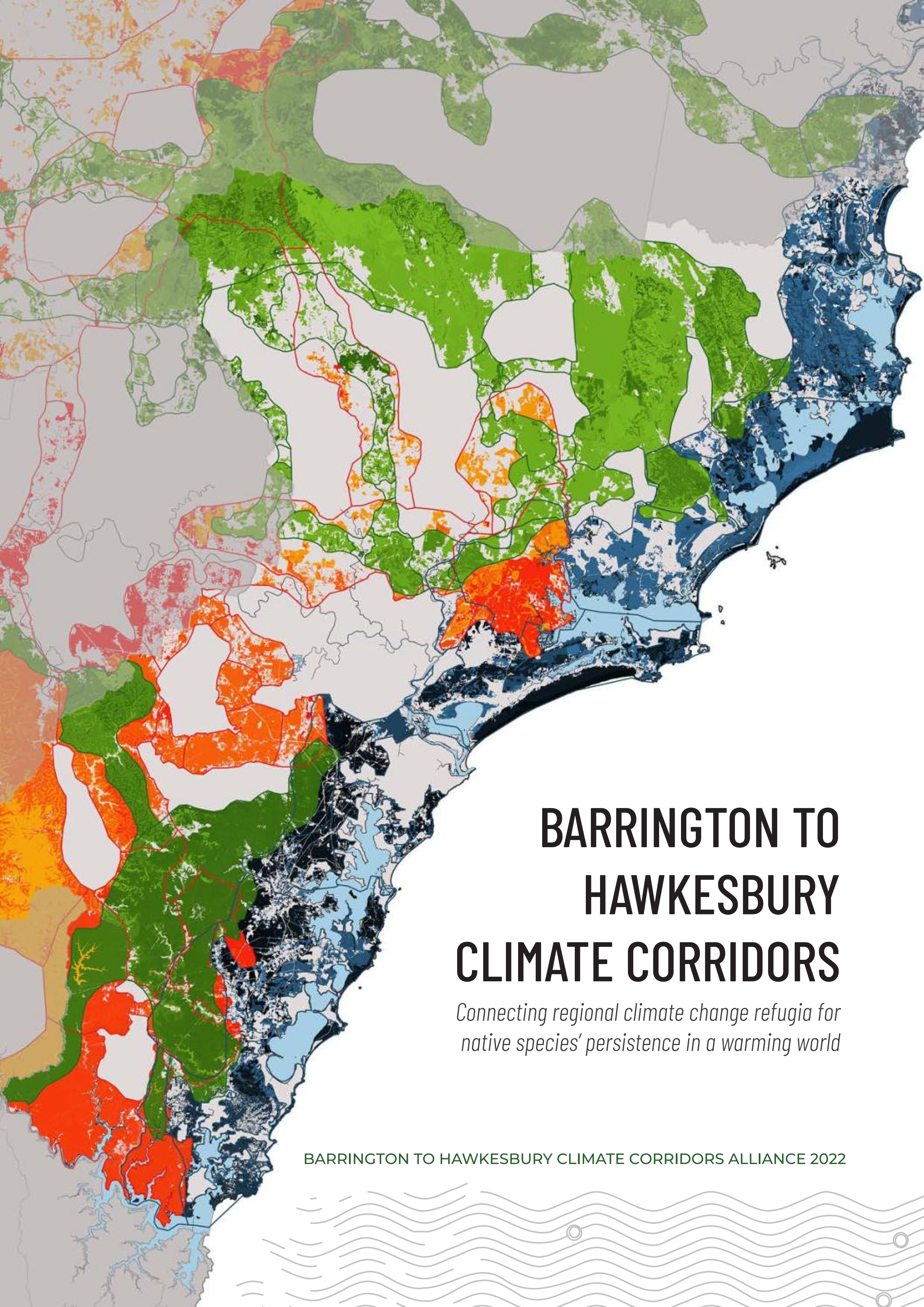

BARRINGTON TO HAWKESBURY CLIMATE CORRIDORS

Connecting regional climate change refugia for native species' persistence in a warming world

BARRINGTON TO HAWKESBURY CLIMATE CORRIDORS ALLIANCE 2022

Lead Author: Paul Winn
Contributors: Jo Lynch, Nicola Bowskill

The founding organisations of the Barrington to Hawkesbury Climate Corridors Alliance include:

The Community Environment Network (CEN) was formed in 1997 as an over-arching body to support individuals and groups in Lake Macquarie, Wyong and Gosford who are working for the environment.

EcoNetwork Port Stephens founded in March 1993 is a not-for-profit and 100% volunteer-run organisation dedicated to the interest of all who treasure and want to preserve the natural beauty and biodiversity of the Port Stephens estuary, peninsulas and rural hinterland.

The Hunter Bird Observers Club (HBOC) formed in 1976, and is the largest club in the Hunter Region that caters specifically for those with an interest in bird life in its natural habitat.

The Hunter Community Environment Centre (HCEC) was established in 2004 to encourage and facilitate environmental and social justice advocacy and education in the Hunter region.

The National Parks Association NSW – Hunter branch has been active in the region for 65 years with early community meetings held in Newcastle to protect Barrington Tops and Myall Lakes contributing to the formation of the state wide association seeking to protect, connect and restore the integrity and diversity of natural systems in NSW and beyond, through national parks, marine sanctuaries and other means.

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Hunter Bird Observers Club

NATIONAL PARKS ASSOCIATION OF NSW
protecting nature through community action

Hunter Community Environment Centre

Community Environment NETWORK

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BARRINGTON TO HAWKESBURY CLIMATE CORRIDORS ALLIANCE 2022

Foreword

There is no doubt that the loss of biological diversity has come to be regarded as both the world's, and Australia's, most pressing environmental issue.

Internationally, the COP15 meeting is currently seeking to give biodiversity the same levels of international protection as climate change with Scientist Johan Rockstrom observing that we "rely on the continuing capacity of nature to operate as a carbon sink and buffer us from the worst impacts of climate change"; Amongst many other reports published recently, the World Economic Forum's Global Risk Report 2022 described biodiversity loss as "one of the biggest dangers we face".

In Australia, multiple annual National State of the Environment reports - over decades - have cited biodiversity loss as the country's most significant environmental issue. This year's publication highlighted the fact that we have lost more mammal species in the last two centuries than any other continent in the world...and that 19 ecosystems are now showing signs of, or are at near collapse.

And in NSW and the Lower Hunter, Central and Mid-North Coast regions – significant biodiversity losses as a result of land clearing/ habitat destruction and fragmentation, pollution, the impacts of natural resource extraction and climate change have been well documented over many years.

The Barrington to Hawkesbury Climate Corridor Alliance report: "Connecting regional climate refugia for native species' persistence in a warming world", has drawn on numerous state, regional and local data sources and presents both historical trends, and the emerging critical threats to a range of species across the region over the next 50 years.

Importantly - it also identifies a compelling opportunity to strategically manage and preserve some of the most important natural assets in the Lower Hunter, Central and Mid-North Coast of NSW region of NSW....and in doing so, effectively stem the trend of biodiversity loss and help combat some of the worst predicted impacts of future climatic variability.

The report advocates for the implementation of a strategic, protected regional network of connected habitats/climate corridors (Barrington to Hawkesbury Climate Corridors). This would include areas already of recognized international conservation significance (Myall Lakes & Hunter Estuary listed under the Ramsay Convention on Wetlands), Greater Blue Mountains World Heritage Area in the south of region, and

Barrington Tops World Heritage Area in the north, as well as existing National Parks and State Forests, extending to other strategic public and private lands.

The clear strength of the proposal, is that it offers the potential to deliver multiple benefits to both the community and the region through -

- **Permanent protection of our most valuable ecosystems and forested areas – not only from clearing, but from further fragmentation and degradation;**
- **Stemming of the unacceptable rate of biodiversity losses and species extinction across the region (and nation)**
- **Establishing a viable network of protected corridors and refugia capable of facilitating species movement, adaptation and persistence into the future in the face of climatic variability**
- **Conservation at a scale that makes sense, and for which there are many existing mechanisms capable of contributing to its realisation.**

The challenges to implementation are many, but leadership and commitment to advancing the strategies proposed in this report offer an inordinate opportunity to deliver greater certainty to the conservation priorities that critically need to be addressed in the region, as well as tangibly contributing to meeting the “stated aims” of so many existing State, Regional and Local Government Plans.

Meredith Laing

Former Director: HCCREMS (Hunter & Central Coast Regional Environmental Strategy 1997-2018)

Barrington Plateau, Manna gum (Eucalyptus viminalis) and Messmate stringybark (Eucalyptus obliqua, HCEC

Executive Summary

This report recommends urgent conservation measures to limit the significant loss of biodiversity projected for the Barrington Tops to the Hawkesbury River region.

The last five years have seen abrupt ecological changes. Recent reports suggest that unless major conservation action is taken in New South Wales, it is likely that another 44 native species will be extinct in the next two decades, and almost 500 NSW native species are not expected to survive the next 100 years.

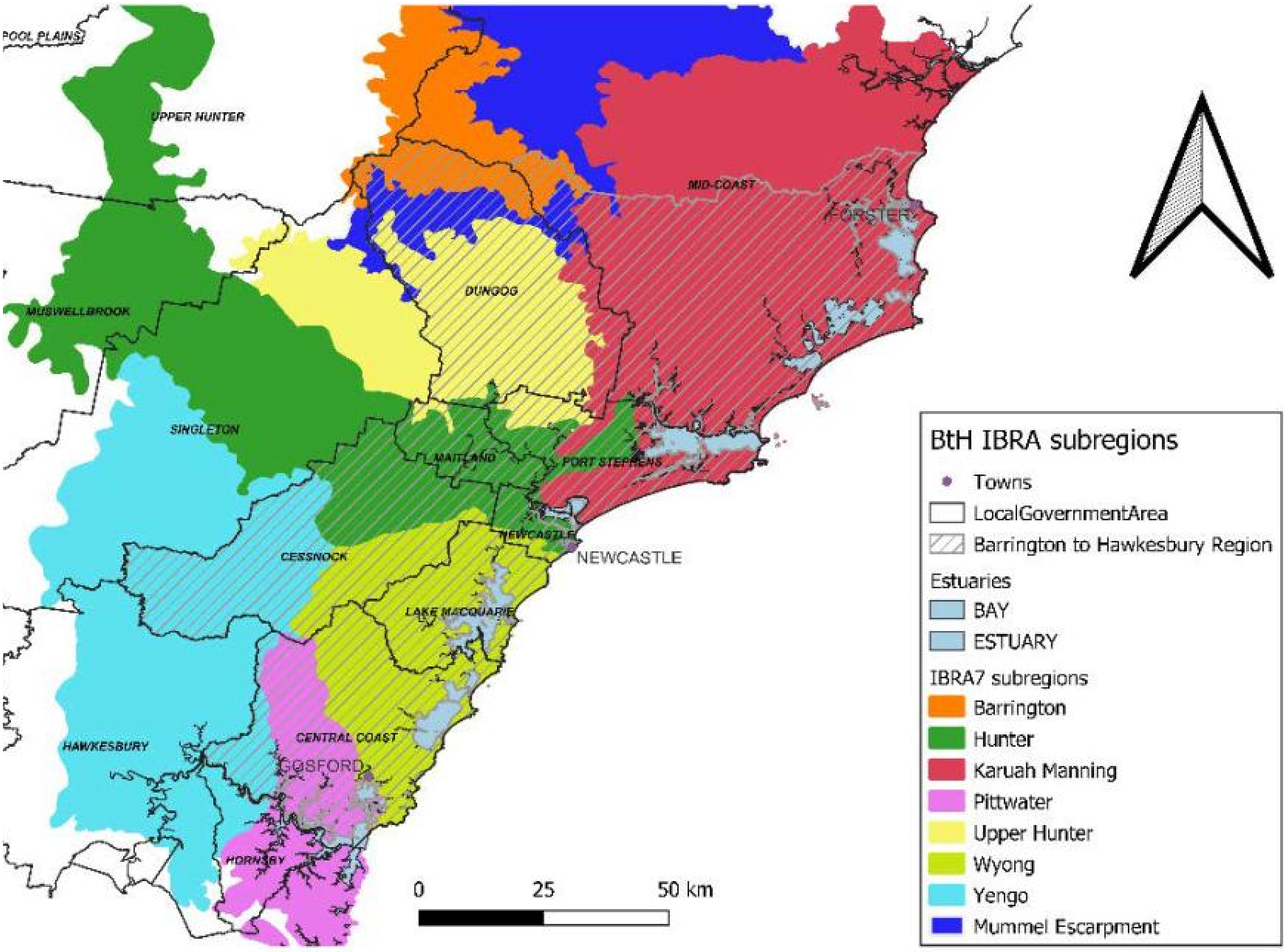
The State's environment is in a poor and deteriorating condition as a result of increasing pressures from climate change, habitat loss, invasive species, pollution and resource extraction. In 2020, almost 100,000 ha of native vegetation was lost in NSW, an increase of 60 percent compared to relatively stable land clearing rates from 2010 to 2015. In 2016, NSW land clearing laws and threatened species protections were wound back to allow landholders to more easily clear native vegetation for agriculture, forestry, and urban development.

The pace of the changing climate is intensifying existing threats to native species. Land clearing and habitat fragmentation and degradation erodes climate resilience by driving down native population numbers, blocking movements and disrupting natural ecological processes. The intensity of logging has increased and has now been shown to increase fire risk. Bushfires and floods are becoming more frequent and more extreme, pest and weed invasions are increasing as native ecosystems come under stress, and potential shifts in human populations will likely result in the conversion of additional natural areas to forestry, agriculture and settlements.

Under a plausible worst case climate scenario, predictions suggest as many as 45 percent of NSW Threatened fauna species and 72 percent of NSW Threatened flora species will have little or no suitable habitat remaining in 50 years. Essential 'climate refugia' for the greatest number of threatened fauna species are predicted to be in the northern and central east coast which is also where the spatial range and number of species and individuals are projected to greatly diminish. Suitable habitat for almost 60 percent of threatened fauna species on the north coast and tablelands are projected to decline in response to climate change. Some of the most important climate refugia for protection surround the towns of Upper Myall and Wingham in the lower north coast LGA of Mid-coast, and Evans Head in the Richmond LGA.

The NSW coastal region between Barrington Tops and the Hawkesbury River connects two World Heritage Areas. The region spans almost 1.13 million ha (11,300 km2) and includes the Local Government Areas (LGA) of Central Coast, Lake Macquarie, Cessnock, Newcastle, Maitland, Port Stephens, Dungog, and the former Great Lakes Council area of Mid Coast LGA.

The region straddles the southern-most end of the North Coast Bioregion and the northern-most end of the Sydney Basin Bioregion, overlapping eight IBRA sub-bioregions. Centred on the Hunter River Valley, a major break in the Great Dividing Range and a vital link between coastal and inland NSW, the region encompasses an overlap between tropical and temperate zones where the current geographic limits of many species are found.

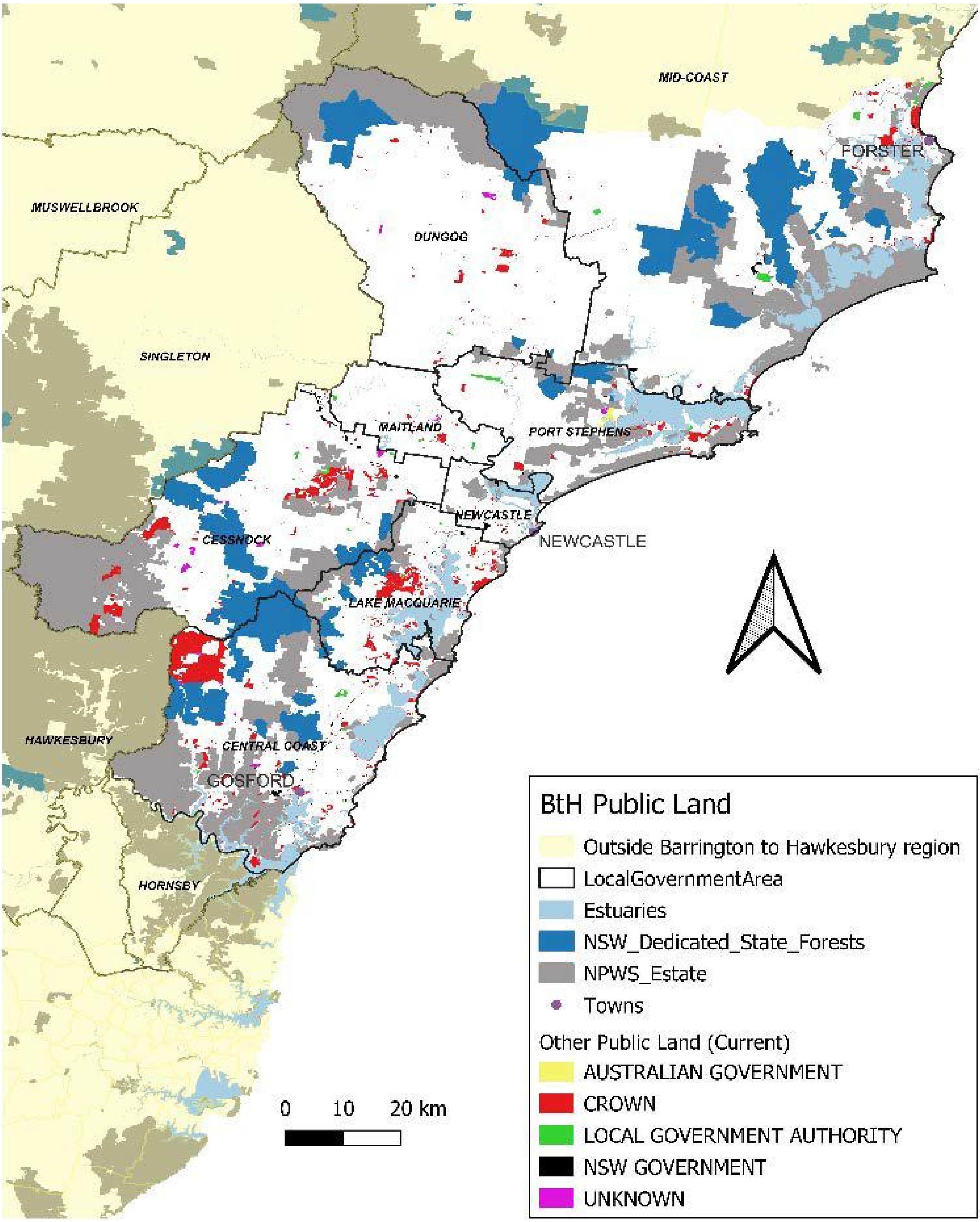


Map A: Sub-bioregions of Barrington to Hawkesbury region

The Barrington to Hawkesbury (BtH) region is of international conservation significance encompassing the Myall Lakes and Hunter Estuary, listed under the Ramsar Convention on Wetlands, and connects the Greater Blue Mountains World Heritage Area in the south to the Barrington Tops World Heritage Area in the north.

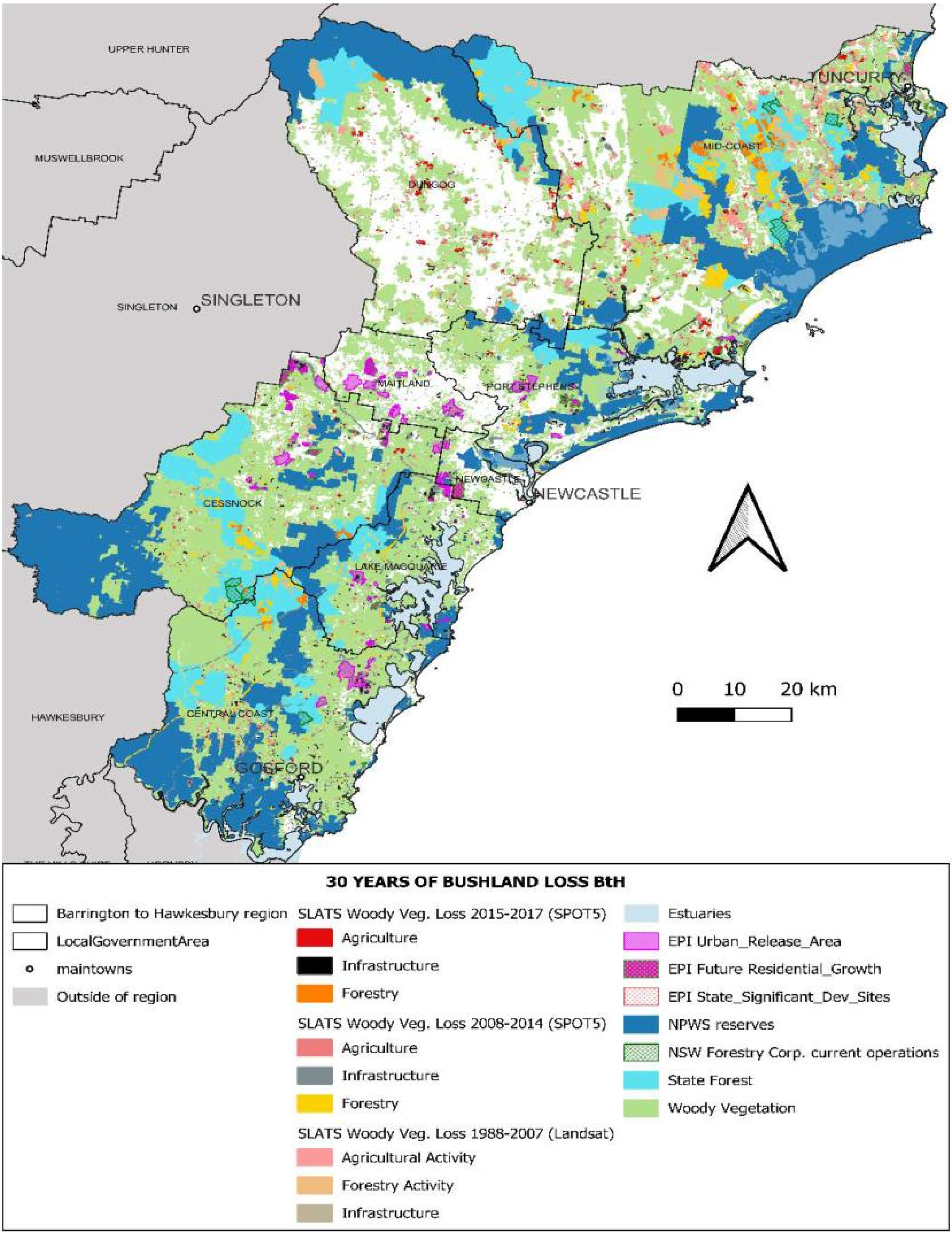
Native bushland covers about 60 percent of the region, half of which is mapped as key fauna habitats, and more than a third is made up of ten endangered Ecological Communities of National Environmental Significance.

National Park reserves total about 240,000 ha (21.3%), with State Forests covering almost 120,000 ha (11%), and other Public Lands a further 44,400 ha (4%). The region is home to nine NSW Endangered Populations, 106 Threatened terrestrial fauna species and 116 Threatened terrestrial flora species.

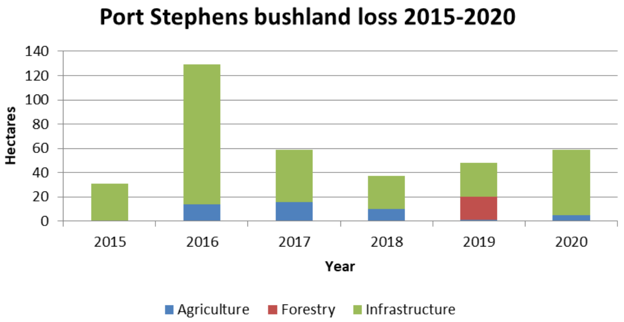


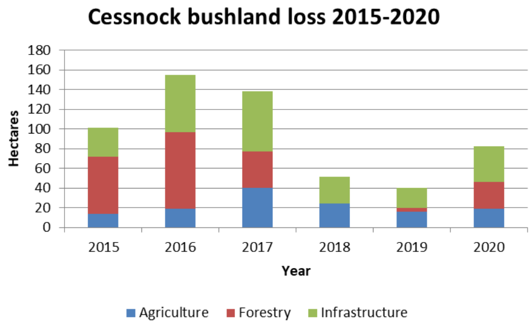
Map B: Barrington to Hawkesbury Public Land

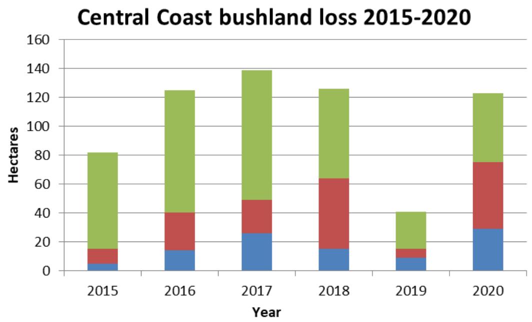
The natural environment of the region is under intense pressure from agriculture, forestry, and urban development. The last ten years have seen over 7,000 ha of the region's native bushland earmarked for "greenfield" urban development. From 2008 to 2017, about 6,500 ha of bushland was lost in the region, almost a third due to logging in southern Mid-coast LGA.

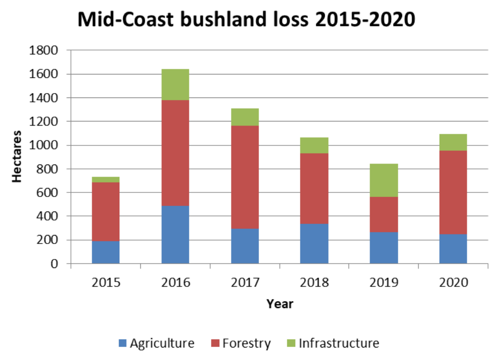


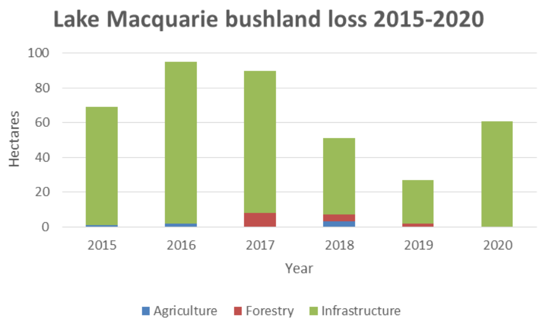
Map C: Department of Planning and Environment (DPE) annual State Land and Tree Study (SLATS) woody vegetation loss 1988 to 2017 in the Barrington to Hawkesbury (BtH) region. Environmental Planning Instrument (EPI) Urban Release Areas, Future Residential Growth, and State Significant Development Sites. NSW Forestry Corporation current operation plans. Woody Vegetation - Eby and Law (2008 -updated 2019).

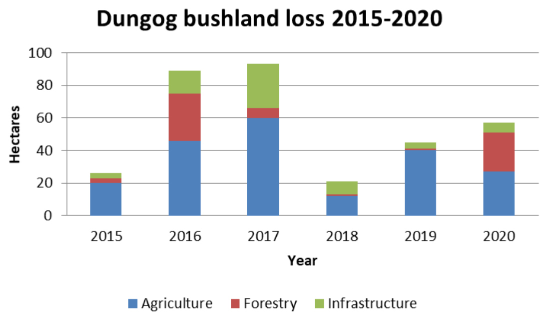

Port Stephens bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure

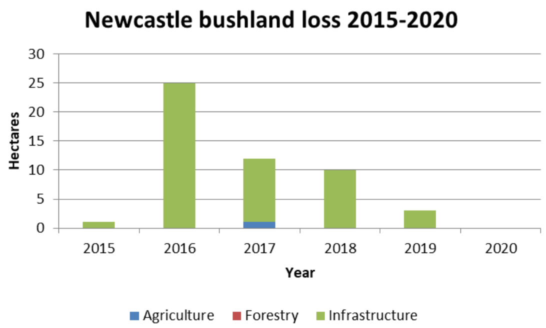

Cessnock bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure

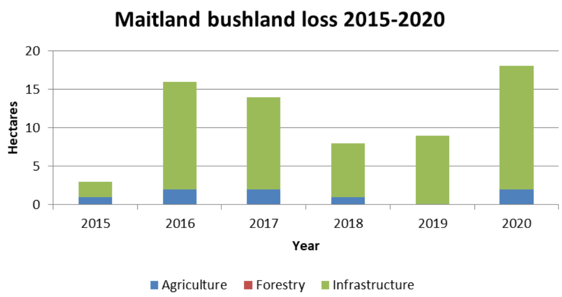

Central Coast bushland loss 2015-2020
Hectares
Year


Mid-Coast bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure


Lake Macquarie bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure


Dungog bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure


Newcastle bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure


Maitland bushland loss 2015-2020
Hectares
Year
Agriculture
Forestry
Infrastructure

We accessed spatial datasets available from the NSW Climate Refugia portal to estimate future suitable habitat for threatened species in 2070. These datasets visually project available suitable habitat for selected threatened species for each decade to 2070 under a business as usual emissions pathway. Projections are based on global and regional climate models represented as four plausible temperature and rainfall scenarios;

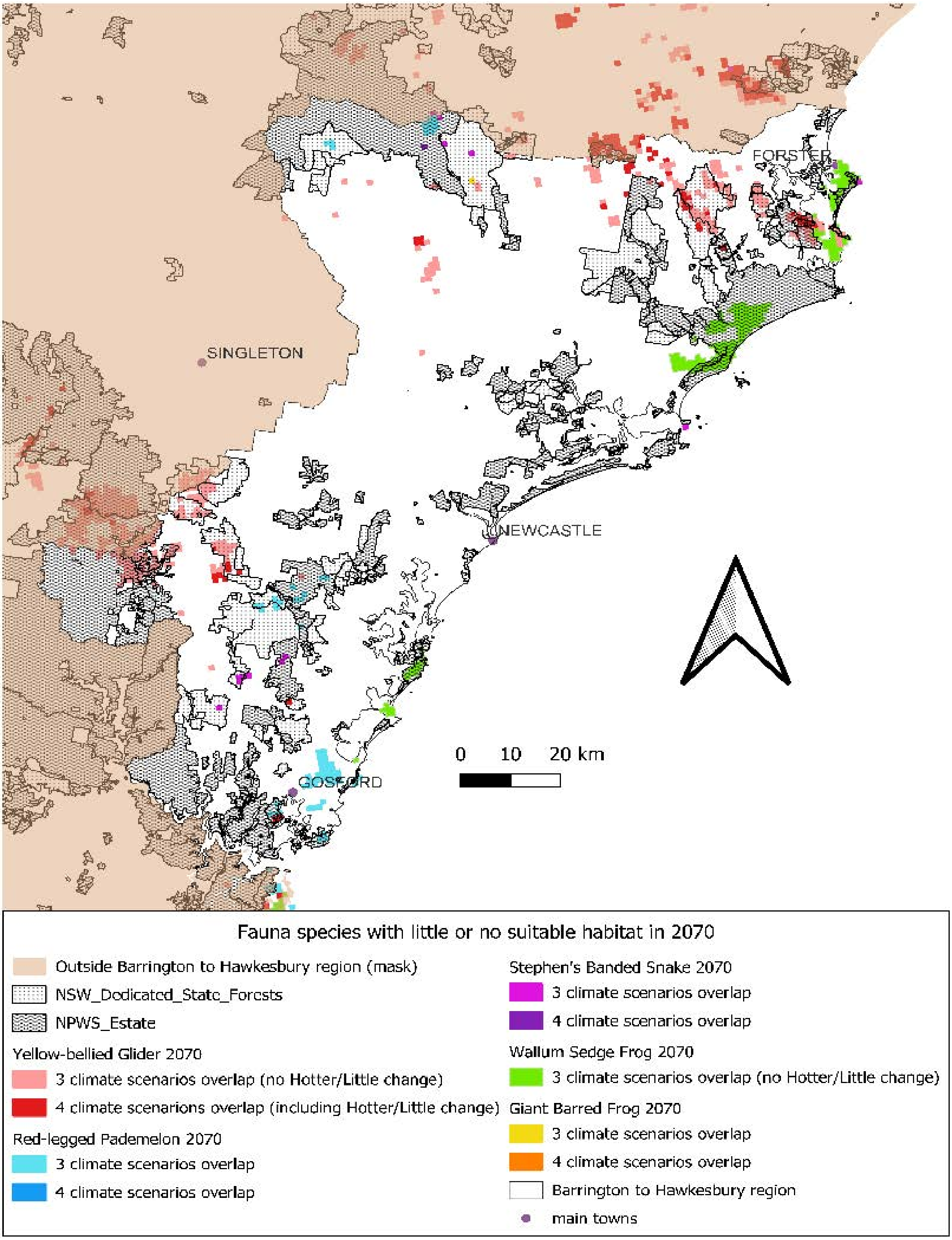
1. **Warmer/Wetter - the highest rainfall and the least impact on most species' habitat,**
2. **Hotter/Wetter,**
3. **Warmer/Drier, and**
4. **Hotter/Little change in rainfall -the driest and greatest impact for most species' habitat.**

The map outputs are based on habitat suitability models that assess the relationship between species' occurrence patterns and environmental characteristics and indicate that threatened species in North Coast, Hunter and Greater Sydney regions face substantial threat from climate change.

Areas of suitable habitat within generally unfavourable landscapes are referred to as 'refugia' which represent areas that biodiversity can persist in, or retreat to, until the surrounding landscapes becomes favourable to expand. Map outputs estimate such areas likely to retain conditions broadly suitable for the target species. They do not indicate the probability that a target species will successfully colonise an area, but identify areas likely to serve as climate refugia to 2070. By assessing habitat suitability across the range of plausible future climate scenarios, viable populations in the region can be secured and their migration to such refugia facilitated for the full range of future climate consequences.

Using these spatial datasets, we identify areas where suitable habitats for threatened fauna species under all four climate change scenarios overlap in 2070. The Hotter/Little change scenario represents the worst-case climate future for as many as 58 percent of fauna species on the NSW north coast and tablelands. Significant range contractions are projected for 44 percent of the fauna species' habitat examined in the Barrington to Hawkesbury region under the Hotter/Little change scenario.

These climate refugia for multiple species under multiple climate scenarios provide clear priorities for biodiversity adaptation efforts. Overlapping areas for the three climate change scenarios that have less impact on suitable habitat for these fauna is also presented for conservation. Regional refugia must be protected from current stresses such as habitat loss and degradation which erodes its capacity to accommodate viable populations. Populations of threatened species projected to become climatically unsuitable under all climate scenarios are at substantial risk from climate change, and should become a particular focus of conservation effort.



Map D: Critical climate refugia for 6 Threatened fauna species in 2070

Under the worst case climate change scenario, six fauna species (13 percent of projected) are predicted to have little or no suitable habitat remaining in the region in 2070. These species are:

- **Red-legged Pademelon**
- **Yellow-bellied Glider,**
- **Stephens Banded Snake**
- **Wallum Sedge Frog,**
- **Giant Barred Frog, and**
- **Red-crowned Toadlet**

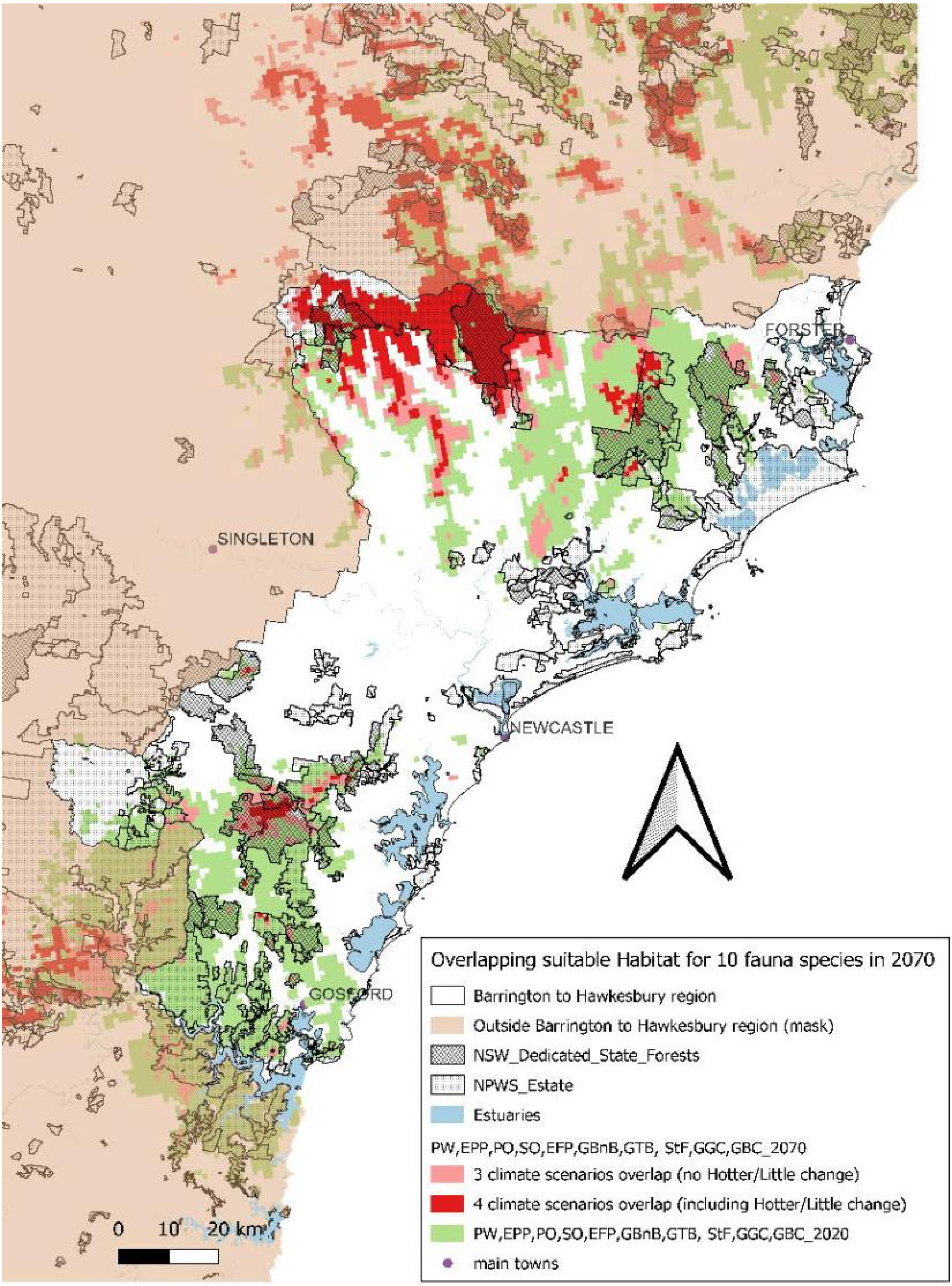
Future suitable habitat for these species under more favourable climate scenarios (Warmer/Wetter, Hotter/Wetter, Warmer/Drier) is predicted to be largely restricted to upland National Parks and State Forest. Chichester, Massey's Creek, Wang Wauk, Bulahdelah, Bachelor, Pokolbin, Corrabare, and Olney State Forests are predicted to be critical climate refugia for these regional populations in 2070

Large areas of privately owned bushland will also be critical to these species' survival under less severe scenarios, particularly the large private moist bushland west and north of Myall River State Forest, along the ridgelines between the Allyn, Williams, and Paterson Rivers, and elevated privately-owned bushland between Tuggerah Lake and Gosford.

Of the 48 fauna species for which future suitable habitat is modelled for the region to 2070, the worst case Hotter/Little change future is projected to result in:

- **21 species (44%) suffering range contractions, 6 of which will have little or no suitable habitat (13%).**
- **15 species (31%) remaining relatively stable, and**
- **12 species (25%) experiencing range expansions.**

Yellow-bellied glider, Image credit: Matt Wright
Accessed via: https://www.faunagraphic.com.au/Mammals/Large/i-TdkrJcS/A



Map E: Overlapping climate refugia for 10 Threatened fauna species in 2070

We overlay suitable habitat data to determine common areas of suitable habitat for ten fauna species predicted to suffer range contractions in the region to 2070. These include:

- **5 mammals**
  - Parma Wallaby
  - Eastern Pygmy Possum
  - Eastern False Pipistrelle
  - Golden-tipped Bat
  - Greater Broad-nosed Bat
- **4 birds**
  - Powerful Owl
  - Sooty Owl
  - Gang-gang Cockatoo
  - Glossy Black Cockatoo
- **1 amphibian**
  - Stuttering Frog

Suitable habitats for these species in 2070 are also projected to be largely restricted to upland State Forest and National Parks of the region.

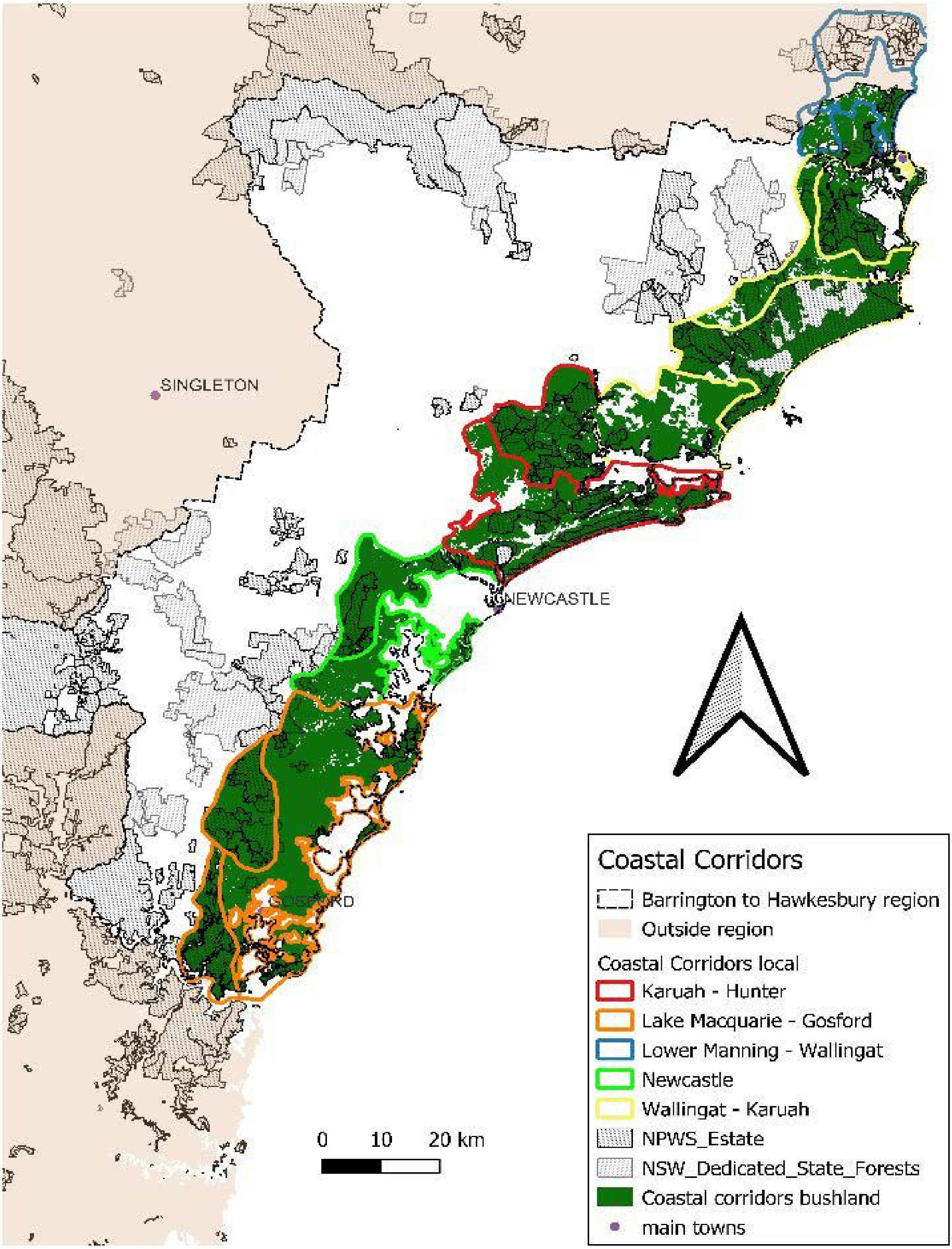
Under a worst case climate scenario, Chichester, Massey's Creek, and Olney State Forest will be essential climate refugia for these species in 2070. Large areas of privately-owned bushland will also be crucial, particularly the large area of private forest west and north of Myall River State Forest in Mid-coast LGA, and between the Allyn, Williams, and Paterson Rivers in the Dungog LGA.

In 2070, we estimate existing National Parks and State Forests of the region will support climate refugia for as many as 60 percent of the threatened fauna species modelled as contracting in the region under the worst case climate scenario. However, to allow for populations to move as climate patterns shift, these areas must be protected from further degradation and functionally connected with large protected landscape scale corridors.

The two most frequently recommended biodiversity climate adaptation strategies are to expand protected areas and conserve and restore corridors and connected areas. As climatic conditions change in the coming decades, the persistence of many populations of native species will depend on their ability to colonise newly suitable habitat. Large-scale corridors that span climatic gradients enhance the capacity of species to shift to new, more climatically favourable areas, allowing species to respond to shifting climates through natural dispersal rather than requiring active intervention.

Five Coastal Climate Corridors, twelve Dry Climate Corridors, and five Moist Climate Corridors identified in 2007 by NSW Government are recommended for protection from further bushland loss and degradation. This will require the transfer of State Forests to secure conservation tenure as Regional Parks under the *National Parks and Wildlife Act* and appropriate Local Environment Plan zoning, provision of stewardship payments, and targeted acquisition of private bushland for conservation purposes.

The total area of the Dry, Moist, and Coastal Climate Corridors in the region is 810,000 ha. While a number of overlaps occur, corridors extend considerable distances outside of the region. Some of these extended corridors, such as Paterson to West Barrington, West Coastal Ranges to escarpment, Pokolbin, and Pokolbin to Karuah, also need to be conserved. These Corridors provide core linkages across the Hunter Valley. Ecological restoration such as restoring native vegetation, installing fauna overpasses and underpasses across highways, removal of aquatic barriers, and rehabilitation of mined areas will all play essential roles in the conservation and utility of these corridors.



Map F: Proposed Coastal Climate Corridor

The five Coastal Climate Corridors encompass projected critical 2070 habitats for:

- **Stephen's Banded Snake,**
- **Rosenberg's Goanna ,**
- **Wallum Sedge Frog,**
- **Stuttering Frog,**
- **Eastern Pygmy Possum,**
- **Red-legged Pademelon,**
- **Yellow-bellied Glider,**
- **Greater Broad-nosed Bat,**
- **Powerful Owl, and**
- **Sooty Owl.**

Coastal wetlands are a major habitat of importance on the region's coast. Many species of frogs and migratory wading birds are restricted to these coastal environments and wetlands. The Koala and Squirrel Glider are key species with important populations in these coastal forests, though much of the habitat is fragmented.

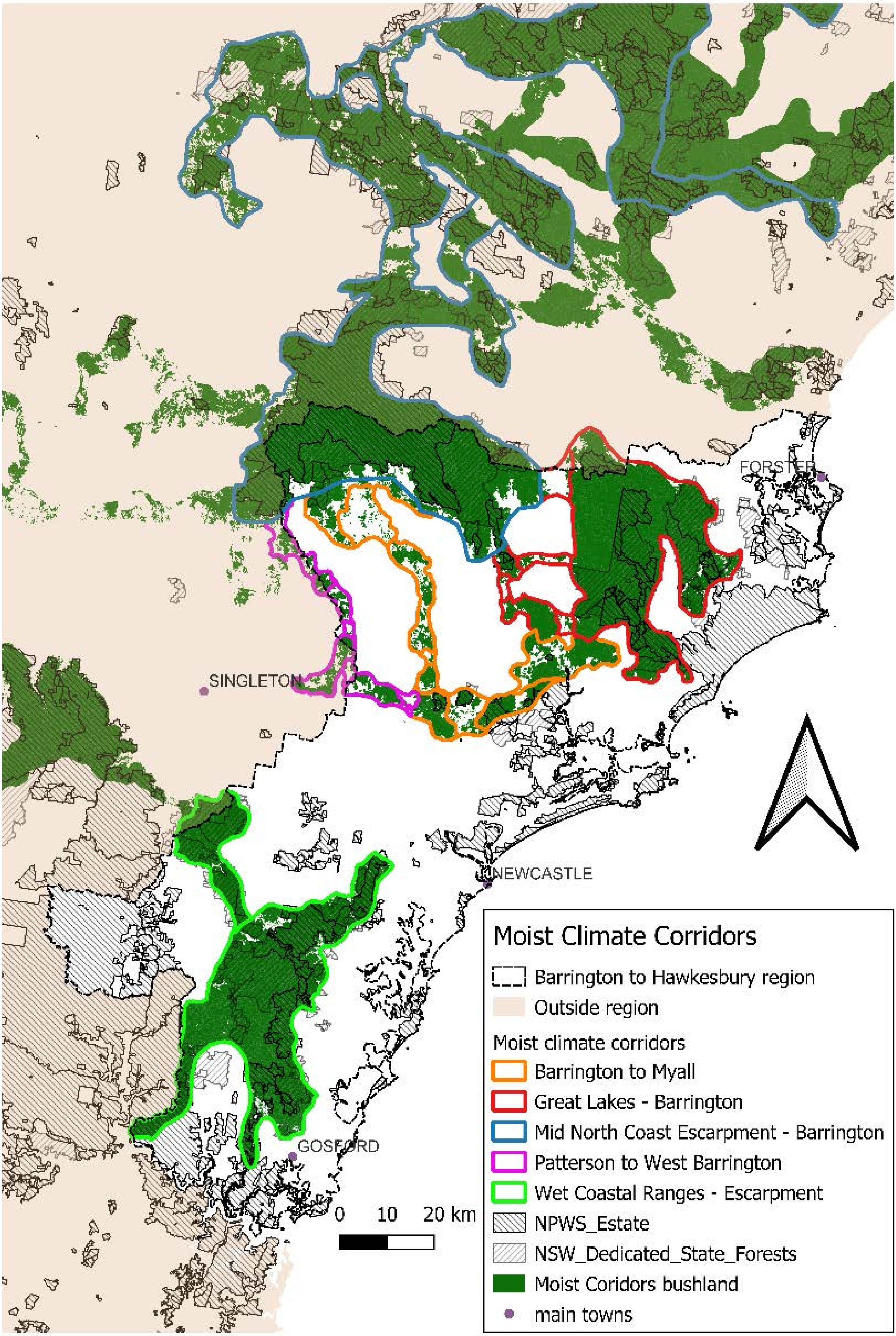
Reconnection and restoration of these forests should be a priority for future works.

The five Moist Climate corridors link high altitudinal rainforest, wet sclerophyll and moist eastern foothills forests including contiguous areas of forest across altitudinal gradients and latitudinal gradients.These Moist Climate Corridors encompass core climate change refugia for 57 percent of the species habitat projected to decline to 2070. These include:

- **Eastern Pygmy Possum**
- **Parma Wallaby**
- **Red-legged Pademelon**
- **Spotted-tailed Quoll**
- **Gang-gang Cockatoo**
- **Glossy Black Cockatoo**
- **Masked Owl**
- **Powerful Owl**
- **Sooty Owl**
- **Giant Burrowing Frog**
- **Eastern False Pipistrelle**
- **Golden Tipped Bat.**

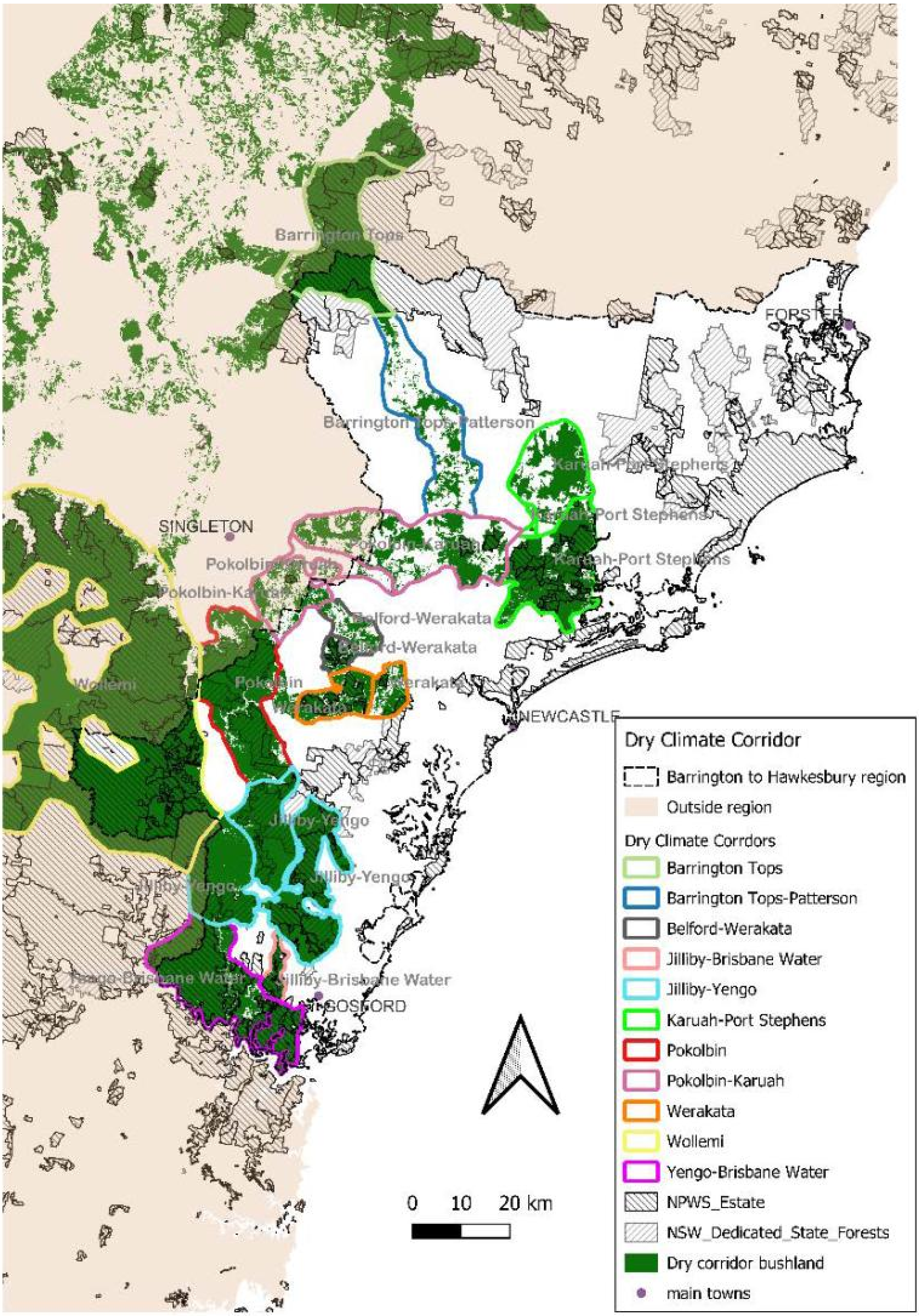
These are predominantly rainforest and high altitudinal species considered highly vulnerable to the impacts of climate change. There is an absence of moist corridor connection across the Hunter Valley due to the drier environments occurring. The Hunter Valley is a natural dry barrier for many moist habitat species.

Stephens Banded Snake, Accessed via: https://southeastsnakecatcher.com.au/stephens-banded-snake/



Map G: Proposed Moist Climate Corridors

There is a strong network of Dry Climate Corridors and associated key habitats for dry habitat assemblages across the Hunter Valley in locations where moist habitat assemblages are absent.



Map H: Proposed Dry Climate Corridors

Twelve Dry Climate Corridors encompass projected climate change refugia for the;

- **Regent Honeyeater,**
- **Red-crowned Toadlet,**
- **Yellow-bellied Glider,**
- **Eastern False Pipistrelle,**
- **Gang-gang Cockatoo,**
- **Glossy Black Cockatoo,**
- **Powerful Owl.**

In addition, the reference species for development of these Dry Climate Corridors include;

- **Brush-tailed Rock Wallaby,**
- **Broad-toothed Rat,**
- **Squirrel Glider,**
- **Brush-tailed Phascogale,**
- **Grey-headed Flying Fox,**
- **Koala,**
- **Woodland Birds,**
- **Swift Parrot, and**
- **Giant Burrowing Frog.**

Rapidly reducing greenhouse gas emissions will be necessary to avert the worst extinction predictions. However, despite positive commitments by some countries, annual global greenhouse gas emissions continue to rise, with 2021 seeing a 6.4 percent annual increase, a new record.

Regardless of emission reductions the climate will continue to change due to the accumulation of greenhouse gases already in the atmosphere, which will place enormous pressure on native species. Further fragmentation and degradation of existing habitat in State Forests and on private land must be reined in if we are to salvage some of our biodiversity from the grips of climate change. Conserving climate refugia predicted to be required under a worst case climate change scenarios and facilitating the movement of species to these refugia along identified climate corridors is fundamental to this end.

If we are to provide the greatest chance for native species to survive the ravages of climate change, these connected habitats must be protected from further fragmentation and degradation. If we wish to minimise native species' extinction, climate refugia and identified climate corridors must be legally protected.

We recommend

1. **An immediate moratorium on further land clearing within identified Climate Corridors.**
2. **A specific strategy be included in the 2041 Regional Plans for Hunter and Central Coast for the protection of Climate Corridors supported by detailed zoning and development guidelines under local environmental plans and development control plans and investment programs implemented by Local Land Services.**
3. **The Biodiversity Offset Scheme be radically amended to provide adequate stewardship payments to encourage landholders to protect, manage, and rehabilitate native vegetation within Climate Corridors.**
4. **Targeted voluntary private land acquisition of large core areas of high quality habitat and essential corridors for restoration, particularly the large areas of moist forests in southern Mid-coast, and moist and dry landscapes across the Hunter River Valley through Cessnock, Singleton, and Dungog LGAs.**
5. **State Forests be transferred to National Park reserves as Regional Parks or other appropriate reserve category and managed by local communities for conservation and recreation.**

Such action will be controversial, many depend on agriculture and forestry, and housing demand is putting upward pressure on house prices spurring governments to increase housing stocks. Agriculture, forestry, and urban development need not have the impact on the natural world they currently do. We must decouple economic prosperity from biodiversity loss and implement a rational adaptation strategy, such as this, to avoid ecological catastrophe.

These Climate Corridors were described in 2007. Adjustments should be made after a thorough examination of the functionality and connectivity of key fauna habitats, which may have been compromised by further fragmentation and degradation in the intervening 15 years.

Rosenberg's Goanna, (Varanus rosenbergi), Meri Oakwood

Contents


Spotted tail quoll, Jim Evans, Accessed via: https://blog.nationalparks.nsw.gov.au/the-cutest-native-animals-in-nsw/

Introduction

The 2021 Australian State of the Environment Report sets out the poor state and deteriorating trend of Australia's environment resulting from increasing pressures from climate change, habitat loss, invasive species, pollution and resource extraction.[1] Such changing environmental conditions and multiple pressures are creating cumulative impacts that have resulted in the abrupt ecological changes seen over the past 5 years.[2] It is estimated that a further 44 Australian native species are likely to become extinct within the next 20 years unless major conservation action is undertaken;

- **10 birds,**
- **7 mammals,**
- **6 reptiles,**
- **1 butterfly, and**
- **20 fish.**[3]

The 2021 NSW State of the Environment Report is no less alarming. Habitat loss from permanent clearing and degradation of native vegetation is identified as a key driver of the increasingly dire outlook for NSW threatened species, almost half of which are not expected to survive the next 100 years.[4]

1 Cresswell ID, Janke T & Johnston EL (2021). Australia state of the environment 2021: overview, independent report to the Australian Government Minister for the Environment, Commonwealth of Australia, Canberra. DOI: 10.26194/f1rh-7r05. https://soe.dcceew.gov.au/sites/default/files/2022-07/soe2021-overview.pdf

2 Ibid

3 Geyle et al A (2021). Butterflies on the brink: Identifying the Australian butterflies (Lepidoptera) most at risk of extinction. *Australian Entomology*, **60**, 98– 110: Geyle et al B (2021). Reptiles on the brink: Identifying the Australian terrestrial snake and lizard species most at risk of extinction. *Pacific Conservation Biology*, **27**, 3– 12; Geyle et al (2018). Quantifying extinction risk and forecasting the number of impending Australian bird and mammal extinctions. *Pacific Conservation Biology*, **24**, 157– 167; Lintermans et al (2020). Big trouble for little fish: Identifying Australian freshwater fishes in imminent risk of extinction. Pacific Conservation Biology, 26(4), 365

4 NSW Environment Protection Authority, 2021. NSW State of the Environment. https://www.soe.epa.nsw.gov.au/sites/default/files/2022-02/21p3448-nsw-state-of-the-environment-2021_0.pdf

It is estimated by the NSW Department of Planning and Environment (DPE) that without effective management, 493 NSW threatened species are likely to be extinct in 100 years.[5]

Extinctions are likely for:

- **50 birds (45%),**
- **49 mammals (51%),**
- **19 reptiles (52%),**
- **15 frogs (52%),**
- **17 invertebrates (78%),**
- **342 plants (53%), as well as**
- **54 endangered ecological communities (41%).[6]**

Within NSW, 78 species are already extinct, with a further 1,043 species Threatened: 116 Critically Endangered.[7] Long-term range contractions have been recorded for 64 percent of all native mammals.[8] About 60 percent of all described terrestrial mammals, 35 percent of amphibians, and 31 percent of all NSW birds are now listed as threatened in NSW.[9]

Threats to the natural environment are being exacerbated by ever increasing greenhouse gas (GHG) concentrations. In 2021, GHG emissions increased 6.4 percent to a new record, eclipsing the pre-pandemic peak as global economic activity resumed.[10]

This report sets out historical, current, and future threats to the biodiversity, including climate impacts, of the area between Barrington Tops and the Hawkesbury River, a coastal region covering almost 1.13 million ha (11,300 km^2) including the LGAs of Central Coast, Lake Macquarie, Cessnock, Newcastle, Maitland, Port Stephens, Dungog, and the former Great Lakes Council area of Mid Coast LGA.

We use publically available information and research to identify suitable habitat projected to be required for threatened species' survival in 2030, 2050, and 2070, under four possible future climate scenarios based on a "business as usual" emissions pathway. Finally, we set out NSW Government identified climate corridors urgently required to be protected to secure the survival of threatened species, populations and ecological communities in the area. We recommend protection mechanisms for priority private land and key public land to be transferred to the National Park Estate.

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5 NSW Department of Planning, Industry and Environment (2020). NSW Biodiversity Outlook Report Results from the Biodiversity Indicator Program: First assessment. https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/Biodiversity-Indicator-Program/biodiversity-outlook-report-first-assessment-200621.pdf

6 Nipperess DA, Faith DP, Auld TD, Brazill-Boast J & Williams KJ (2020) Expected diversity as an indicator of biodiversity status and trend: A case example using the listed threatened species and ecological communities of New South Wales, Australia, Biodiversity Indicator Program Implementation Report, Department of Planning, Industry and Environment NSW, Sydney, Australia.

7 NSW Environment Protection Authority, 2021. NSW State of the Environment. https://www.soe.epa.nsw.gov.au/sites/default/files/2022-02/21p3448-nsw-state-of-the-environment-2021_0.pdf

8 ibid

9 ibid

10 P. Bhanumati, Mark de Haan, James William Tebrake, 2022. Greenhouse Emissions Rise to Record, Erasing Drop During Pandemic. The latest data from the IMF's Climate Change Indicators Dashboard provides a worrying picture. June 30, 2022. International Monetary Fund. https://www.imf.org/en/Blogs/Articles/2022/06/30/greenhouse-emissions-rise-to-record-erasing-drop-during-pandemic

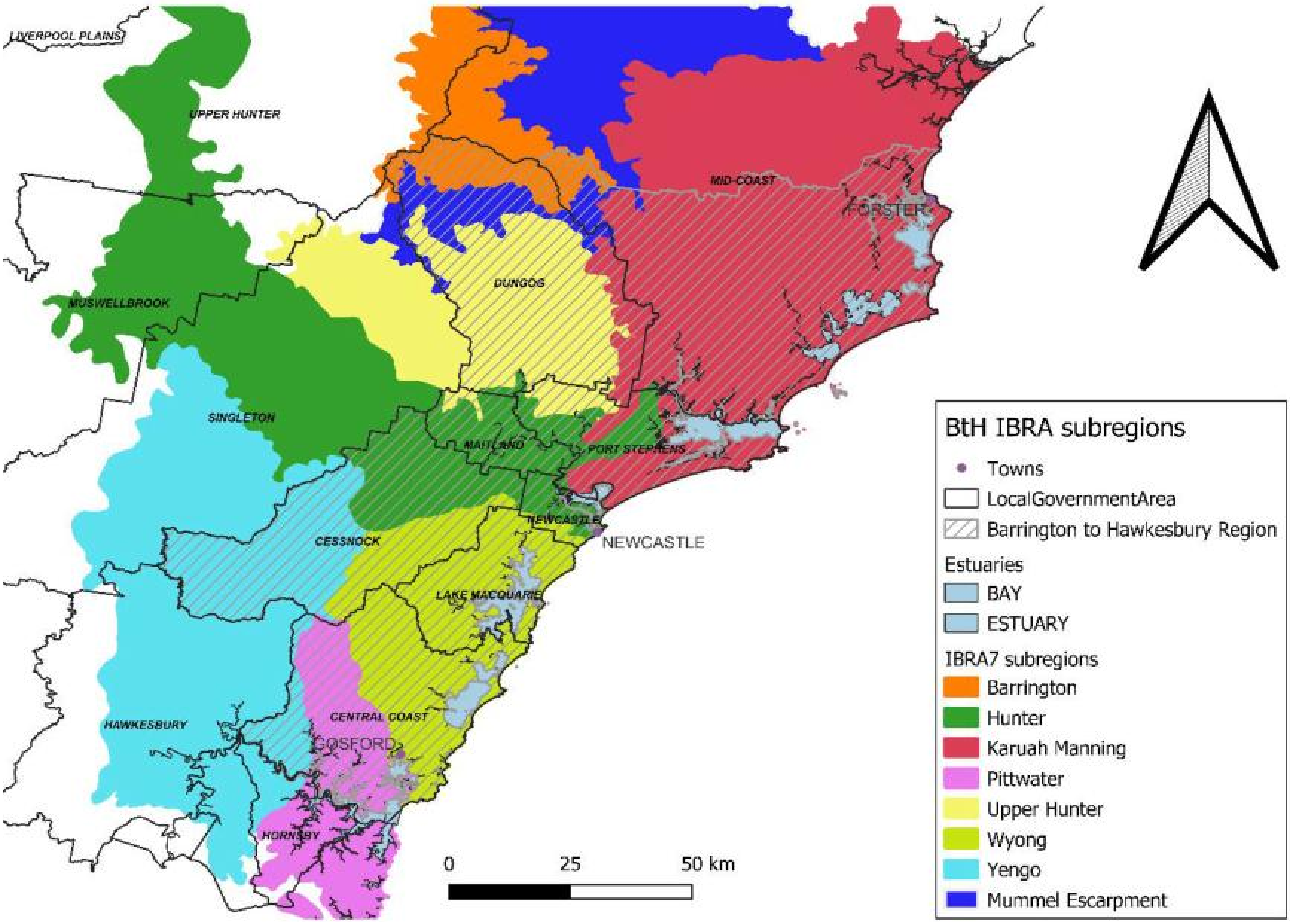
Barrington Tops, Tubrubucca Falls, HCEC

The Barrington to Hawkesbury Region

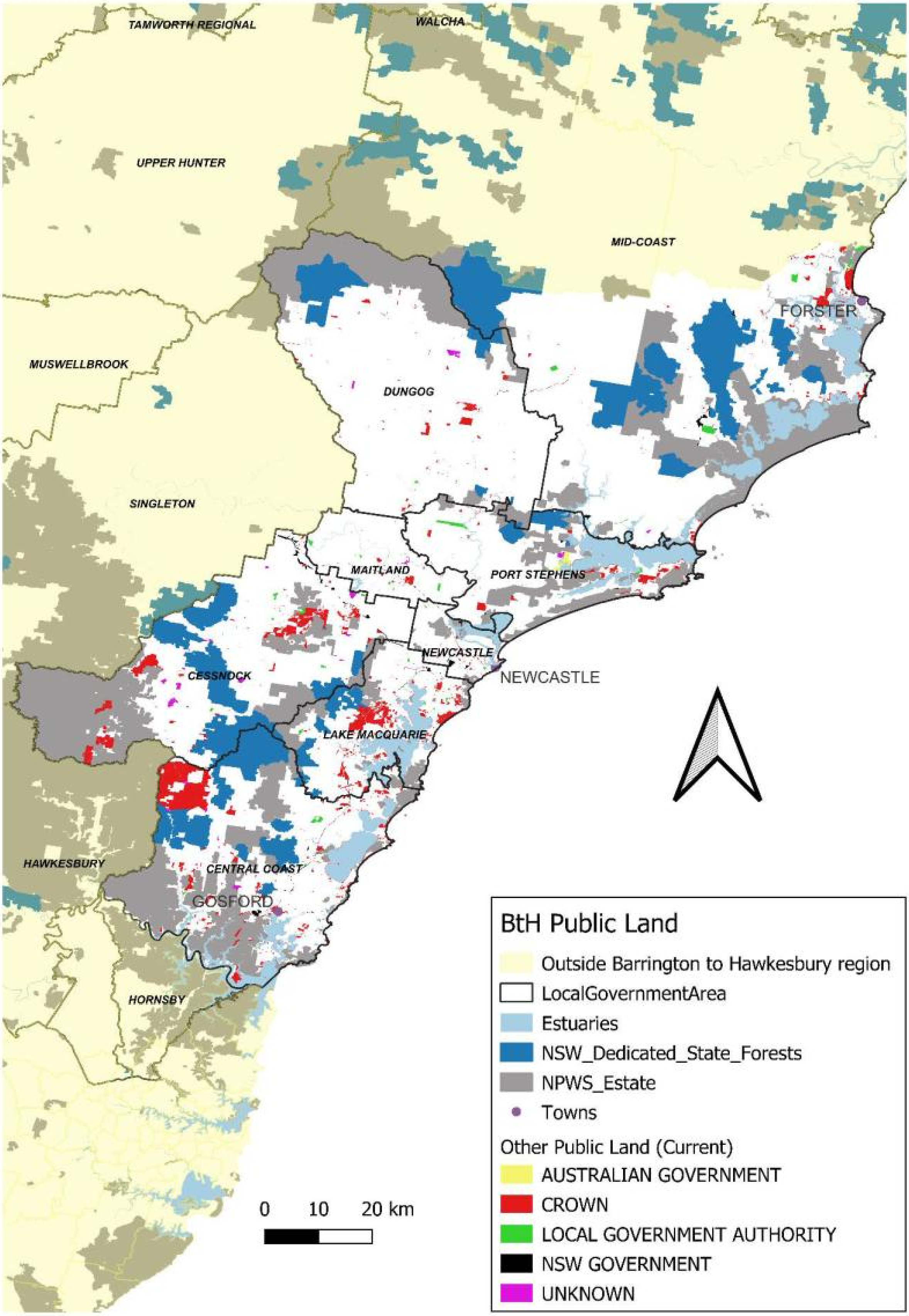
Barrington to Hawkesbury is a NSW coastal region covering almost 1.13 million ha (11,300km) between Barrington Top in the north and Hawkesbury River in the south taking in the LGAs of Central Coast, Lake Macquarie, Cessnock, Newcastle, Maitland, Port Stephens, Dungog, and the former Great Lakes Council area of Mid Coast LGA.

The area straddles the southern-most end of the North Coast Bioregion (Parts Mummel Escarpment, Barrington, Upper Hunter, Karuah Manning sub bioregions), and the northern-most end of the Sydney Basin bioregion (Wyong, and Part Pittwater, Yengo, Hunter sub bioregions) (See Map 1).

National Park reserves in the Region total about 240,000 ha (21.3%), with State Forests covering almost 120,000 ha (11%), and other Public Lands cover a further 44,400 ha (4%) (See Map 2).



Map 1: Interim Bio regionalisation of Australia sub-bioregions between Barrington and Hawkesbury.



Map 2: BTH public land. *Tenure layers: State Government of NSW and Department of Planning and Environment https://datasets.seed.nsw.gov.au/dataset/*

Wallsend, Golden wattle (Acacia Longifolia), HCEC

Environmental Values

Centred on the Hunter Valley which represents the major break in the Great Dividing Range which provides a link between coastal and inland NSW, the region incorporates an overlap between tropical and temperate zones known as the MacPherson–Macleay Overlap[11] where the limits of many species are found.[12]

The area is of great ecological significance supporting four features of high international conservation value including:

- **Myall Lakes – Ramsar Convention on Wetlands,**
- **Hunter Estuary - Ramsar Convention on Wetlands,**
- **Part Greater Blue Mountains World Heritage Area and**
- **Part Barrington Tops World Heritage Area** [13]

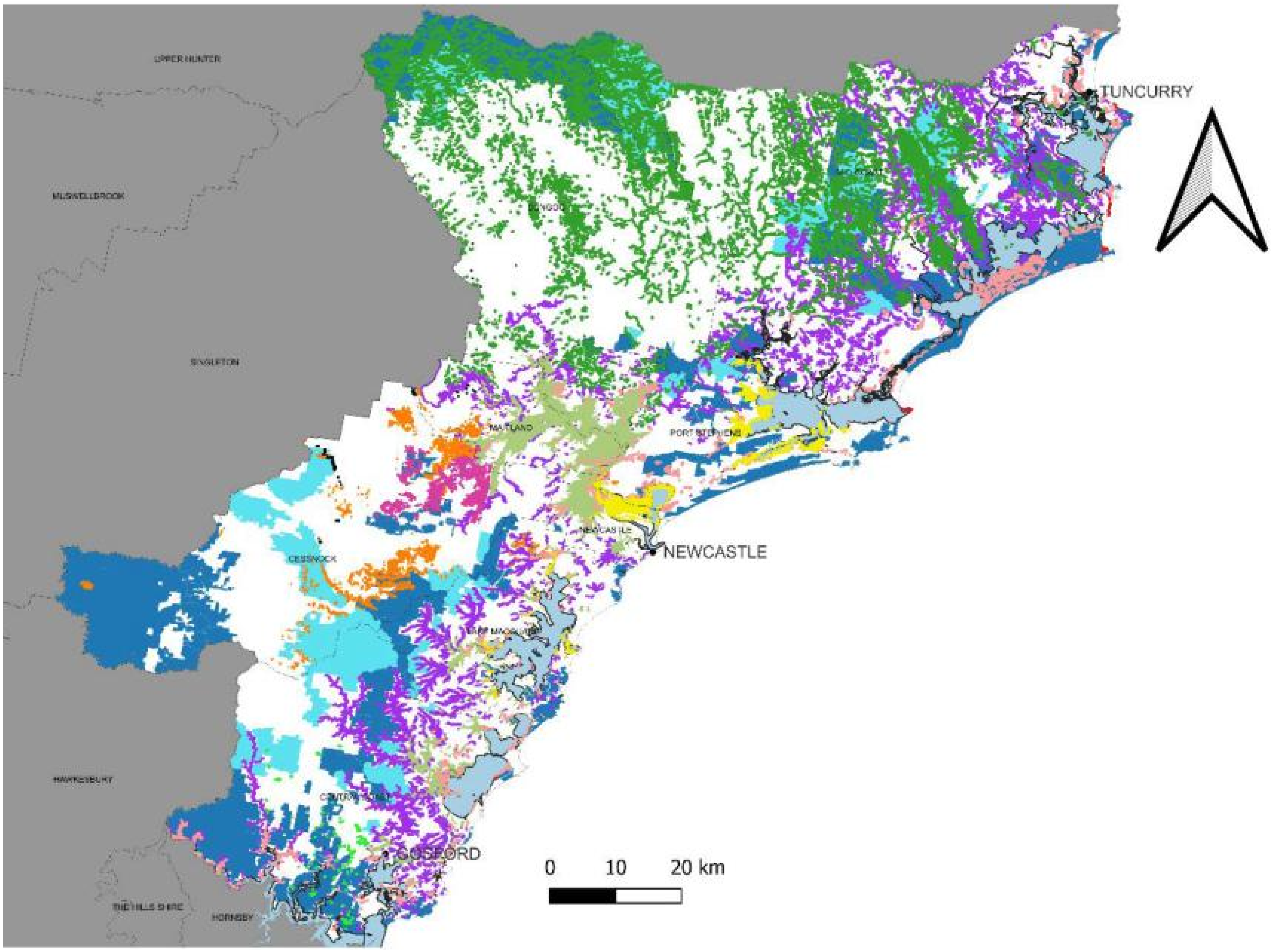
Native bushland covers about 718,000 ha or 64% of the region. About half of this native vegetation is mapped as Key Fauna Habitats[14] (342,300 ha), and 37 percent (265,000 ha) is made up of nine Ecological Communities of National Environmental Significance; five Endangered and four Critically Endangered (See Table 1 and Map 5).

11 Burbidge NT (1960) Phytogeography of the Australian Region. Australian Journal of Botany 8(2), 75–211.

12 Australian Government, 2018. Bioregional Assessment Hunter subregion. https://www.bioregionalassessments.gov.au/assessments/11-context-statement-hunter-subregion/1121-physical-geography

13 ibid

14 DPE, Upper North East and Lower North East Fauna Key Habitats. https://datasets.seed.nsw.gov.au/dataset/fauna-key-habitats-for-north-east-nswe01b8



- LocalGovernmentArea
- EPBCA Nominated - Saltmarsh
- EPBCA NOM Hinterland Sand Flat Forests and Woodlands of the Sydney Basin Bioregion

EPBCA Nominated - Hunter Valley Remnant Woodlands and Open Forests

- Yes, map unit specified in nomination

BtW EPBCA Ecological Commmunities of NES - likley occurance

- Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community
- Coastal Swamp Sclerophyll Forest of New South Wales and South East Queensland
- Coastal Upland Swamps in the Sydney Basin Bioregion
- Littoral Rainforest and Coastal Vine Thickets of Eastern Australia
- Lowland Rainforest of Subtropical Australia
- River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- AUS_adm2
- BTH Towns

Estuaries

- BAY
- ESTUARY
- NPWS reserves
- State Forest all

Map 3: BTH Ecological Communities of National Environmental Significance. Datasets: ***Australia - Ecological Communities of National Environmental Significance (Public Grids), 6/11/22. Commonwealth of Australia (2016).*** https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B184A3793-2526-48F4-A268-5406A2BE85BC%7D

Table 1: BTH Ecological Communities of National Environmental Significance.

ECOLOGICAL COMMUNITY	EPBC	Area (ha)
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	360
Lowland Rainforest of Subtropical Australia	Critically Endangered	95,816
River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria	Critically Endangered	72,835
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	364
Coastal Swamp Sclerophyll Forest of New South Wales and South East Queensland	Endangered	69,886
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland	Endangered	14,206
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered	984
Hunter Valley Remnant Woodlands and Open Forest	Nomination	6,704
Hinterland Sand Flat Forests and Woodlands of the Sydney Basin Bioregion	Nomination	4,235
TOTAL		**265,391**

The region supports;

- **7 Endangered Ecological Communities of National Environmental Significance (four Critically Endangered) and a further two ECNES nominations,**
- **9 Endangered Populations,**
- **106 Threatened terrestrial animals; 61 birds, 30 mammals, nine frogs, five reptiles, and one insect.**
- **116 Threatened terrestrial plants (See Appendix 3 and 4).**

Rosenberg's Goanna, (Varanus rosenbergi), Meri Oakwood

Stormy sky, Theen Moy, https://www.flickr.com/photos/theenmoy/27180324564/in/photostream/

Climate Change

Threats to the natural environment are being exacerbated by ever increasing greenhouse gas (GHG) concentrations. In 2021, GHG emissions increased 6.4 percent to a new record, eclipsing the pre-pandemic peak as global economic activity resumed.[15]

According to the 2022 State of the Climate report, the Australian continent is now 1.47C hotter than it was in 1910 and sea levels around the coastline are rising at an accelerating rate.

The 2019 Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report identifies that:

:

- **Changes in the land biosphere since 1970 are consistent with global warming,**
- **Annual averages of carbon dioxide (410 parts per million), methane (1866 parts per billion), and nitrous oxide (332 ppb) have increased since 2011.**
- **Total human-caused global surface temperature has increased to about 1.07°C, with each of the last four decades being successively warmer than any decade that preceded it since 1850.**
- **Average precipitation over land has increased since 1950 - a faster rate of increase since the 1980s, and mid-latitude storm tracks shifting poleward in both hemispheres, including the extratropical jet in the austral summer.**
- **The upper ocean has warmed and acidified since the 1970s and oxygen levels have dropped in many regions. Global mean sea level increased by 0.20 m between 1901 and 2018, 1.3 mm year between 1901 and 1971, 1.9 mm a year between 1971 and 2006, and 3.7 mm a year between 2006 and 2018.[16]**

In 2000, the NSW Scientific Committee listed Anthropogenic Climate Change as a key threatened process facing native species, noting that "the present protected area network was not designed specifically to accommodate climate change, and the present biodiversity values of the protected area system may not all survive under different climatic conditions." Climate change impacts in NSW such as bushfires are expected to exacerbate and surpass land-clearing, as the greatest threat to native species in the coming decades.[17]

15 P. Bhanumati, Mark de Haan, James William Tebrake, 2022. Greenhouse Emissions Rise to Record, Erasing Drop During Pandemic. The latest data from the IMF's Climate Change Indicators Dashboard provides a worrying picture. June 30, 2022. International Monetary Fund. https://www.imf.org/en/Blogs/Articles/2022/06/30/greenhouse-emissions-rise-to-record-erasing-drop-during-pandemic

16 Intergovernmental Panel on Climate Change, 2019. IPCC Sixth Assessment Report Working Group 1: The Physical Science Basis. Summary for Policymakers. https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/

17 NSW Environment Protection Authority, 2021. Op cit.

Species will likely respond to climate change in a variety of ways with varying success. Some native flora and fauna have wide physiological tolerance and some will adapt through micro-evolution or behavioural alterations. If available, sufficiently mobile species will migrate to more favourable habitat.[18] However, many species will experience significant range contractions and some will experience full displacement of current ranges, the range of others' will remain constant, and some will expand.[19] However, the survival of all species will require that some currently occupied regions remain suitable,[20] or that corridors or stepping-stones exist to enable species to track shifting climate zones.[21]

Areas of suitable habitat within generally unfavourable landscapes are referred to as 'refugia'. Refugia represent areas that biodiversity can persist in, or retreat to, until the surrounding landscapes becomes favourable to expand.[22]The persistence of species throughout the climatic disruptions of the late Quaternary was likely facilitated by the persistence of remnant populations within refugia.[23]

However, contemporary climate change is a much more significant problem than in the past due to the rapidity of the change coupled with the pervasive threats to native species from modification of land and waters by human settlements, pastoralism, agriculture, logging, invasive pests and weeds, inappropriate fire regimes, land clearing and resulting fragmentation of natural vegetation.[24] These threats erode native species resilience to climate change by disrupting species movements and natural ecological processes, and drive populations down to unviable levels.

The major threats impairing natural resilience to climate change are:

- **Land clearing and resulting loss and fragmentation of core habitats and migration corridors;**
- **Unsustainable extractive land use activities, primarily livestock grazing and logging;**
- **Changed hydrology and extraction of water;**
- **Invasive weeds and animal pests;**
- **Inappropriate fire regimes (intensities, frequencies and timings).[25]**

The rapidity with which the climate is changing is a major threat. Bushfires and floods are rapidly becoming more frequent and extreme, exotic species invasions are increasing as native ecosystems come under stress, and potential shifts in human populations will likely result in the conversion of additional natural areas to agriculture and settlements.

18 Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W. and Courchamp, F. (2012), Impacts of climate change on the future of biodiversity. Ecology Letters, 15: 365-377. https://doi.org/10.1111/j.1461-0248.2011.01736.x

19 Alagador, D., Cerdeira, J.O. and Araújo, M.B. (2016), Climate change, species range shifts and dispersal corridors: an evaluation of spatial conservation models. Methods Ecol Evol, 7: 853-866. https://doi.org/10.1111/2041-210X.12524.

20 Loarie, S. R., Carter, B. E., Hayhoe, K., McMahon, S., Moe, R., Knight, C. A., & Ackerly, D. D. (2008). Climate Change and the Future of California's Endemic Flora. *PLOS ONE*, *3*(6), e2502. https://doi.org/10.1371/journal.pone.0002502

21 Alagador et al (2016) Op cit

22 Keppel G, Van Niel KP, Wardell-Johnson GW *et al*. (2012) Refugia: identifying and understanding safe havens for biodiversity under climate change. *Global Ecology and Biogeography*, **21**, 393–404.; Keppel, G. and Wardell-Johnson, G.W. (2012), Refugia: keys to climate change management. Glob Change Biol, 18: 2389-2391.

23 Correa-Metrio, Alexander, et al.(2022) "Detrended Correspondence Analysis: A Useful Tool to Quantify Ecological Changes from Fossil Data Sets." *Boletín de La Sociedad Geológica Mexicana*, vol. 66, no. 1, 2014, pp. 135–43. *JSTOR*, http://www.jstor.org/stable/24921266. Accessed 8 Oct. 2022

24 Taylor M. & Figgis P. (eds) (2007) Protected Areas: Buffering nature against climate change. Proceedings of a WWF and IUCN World Commission on Protected Areas symposium, 18-19 June 2007, Canberra. WWF Australia, Sydney.

25 ibid

Post bushfire epicormic regrowth in eucalyptus, https://commons.wikimedia.org/wiki/File:Post_bushfire_epicormic_regrowth_in_eucalyptus,_Blue_Mountains,_NSW,_Australia_08.jpg

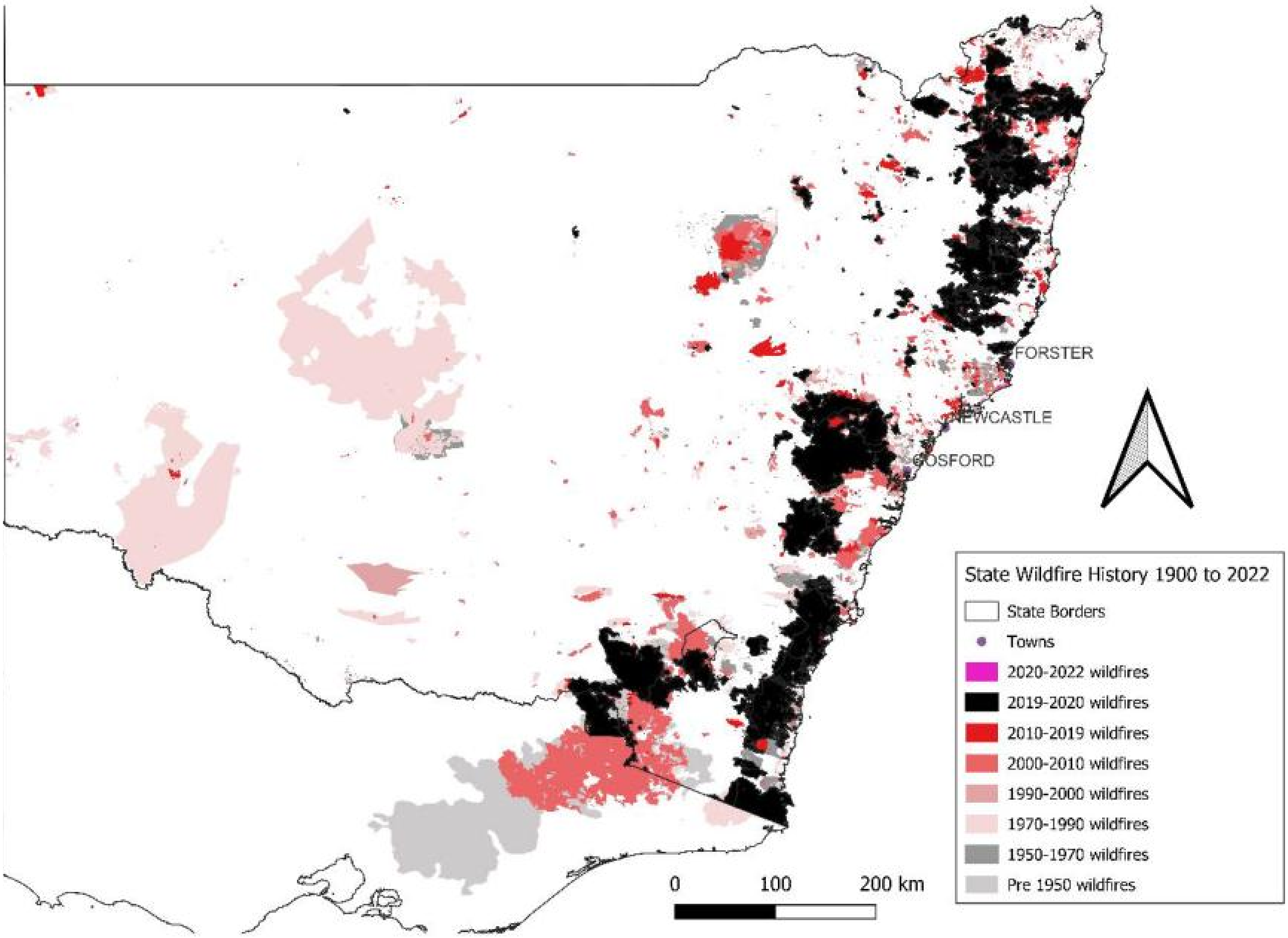
Black Summer

The Black Summer fire season was the most severe ever recorded in NSW with about 5.5 million burnt including more than one third (300,000 ha) of all NSW rainforests, and over half of the Gondwana Rainforest World Heritage Area (See Map 4). The fires killed an estimated 800 million native animals, and significantly reduced the habitat of 293 threatened animals and 680 threatened plant species. [26]

Since the Black Summer fires, overall ecological condition and ecological carrying capacity of NSW native vegetation decreased by 2 percent, to 42 percent and 31 percent respectively.

Within the immediate fire ground, ecological condition decreased from 72 percent in 2013 to 44 percent after Black Summer, a 39 percent reduction, while ecological carrying capacity decreased from 62 percent to 38 percent, a 24 percent reduction. Over 60 percent of NSW vegetation is now under pressure from too much fire. [27]

26 NSW Environment Protection Authority (2021) Op cit.
27 ibid



Map 4: NSW wildfires between 1903 and 2022. Barrington to Hawkesbury (between Forster and Gosford) shows relatively fewer areas of wildfire. *Datastes: DPE (2022) NPWS Fire History - Wildfires and Prescribed Burns.* https://datasets.seed.nsw.gov.au/dataset/fire-history-wildfires-and-prescribed-burns-1e8b6;

An estimated 56 percent of the 3 million ha of National Park reserve and other protected areas in the NSW north coast and tablelands was burnt in Black Summer. [28] Over all tenures the area affected by fire on the north coast and tablelands was 2.7 million ha including over 1.1 million ha of old growth, two thirds of which the canopy was completely or partially burnt. [29]

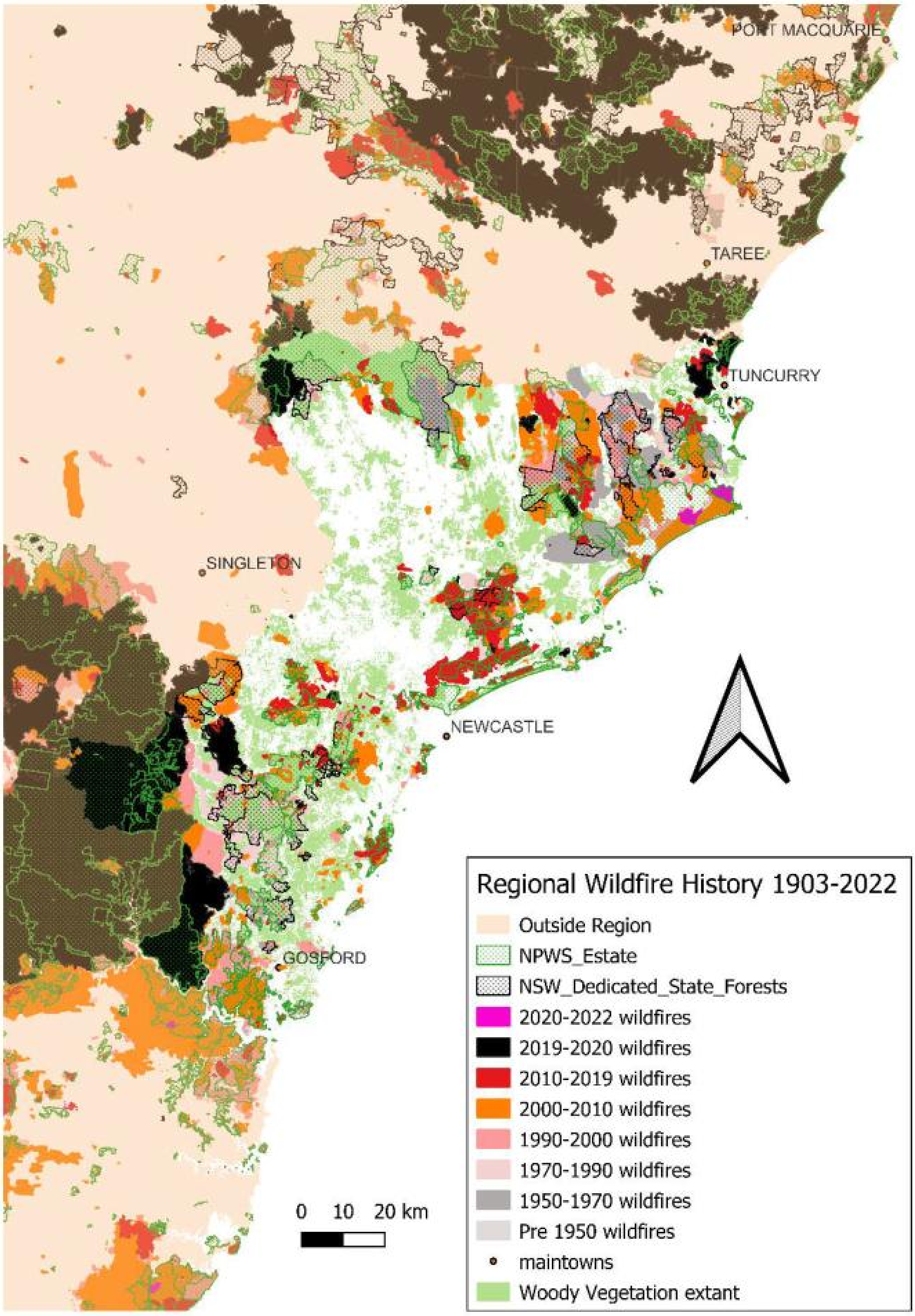
Black Summer burnt 890,000 ha of State Forests - 830,000 ha of native forests and 60,000 ha of timber plantations. [30] This represents over 40 percent of the NSW State Forest in the north east coast and tablelands. Despite the extent and severity of the Black Summer fires, logging is still undertaken in many areas essential for populations of threatened species affected by the fires.

28 NSW Natural Resource Commission (2020). 2019-2020 Bushfires. Extent of impact on old growth forest A joint report prepared by 2rog Consulting and the Natural Resources Commission. https://www.nrc.nsw.gov.au/completed/old-growth-remapping

29 ibid

30 NSW EPA (2021). NSW Forestry Snapshot Report 2019-2020 Implementation of NSW Forest Agreements and Integrated Forestry Operations Approvals. https://www.parliament.nsw.gov.au/tp/files/81421/EPA%20-%20NSW%20Forestry%20Snapshot%20Report%202019-2020.PDF

While site specific operating conditions are in place for logging in fire affected forest,[31] such as increased hollow tree retention etc, any additional impact to these burnt forests will necessarily reduce the available habitat for those species most affected.



Map 5: Barrington to Hawkesbury wildfires between 1900 and 2022. *Datastes: DPE (2022) NPWS Fire History - Wildfires and Prescribed Burns.* https://datasets.seed.nsw.gov.au/dataset/fire-history-wildfires-and-prescribed-burns-1e8b6; *Tenure layers:* ***State Government of NSW and Department of Planning and Environment https://datasets.seed.nsw.gov.au/dataset/***

31 See https://www.epa.nsw.gov.au/your-environment/native-forestry/bushfire-affected-forestry-operations

Recovery times will vary significantly depending on the forest type, the intensity of the fire and drought during the recovery period. At the landscape scale, post-fire recovery could take five to seven years, or more.[32]

Habitat for 25 threatened fauna species along the NSW coastal and tablelands was up to 60 percent burnt by the 2019/20 fires constituting a significant risk to key habitat elements such as hollows, nesting and food resources.[33] Losses of hollow-bearing trees through collapse in severely burnt forests may take hundreds of years to fully recover.[34] The severity of these fires, however may have increased the likelihood of the scarring and injury required to initiate hollow development.[35] By contrast loss of dense grassy habitat, such as that of the Southern Brown Nosed Bandicoot or open understorey, used by the White-footed Dunnart, may be short-lived or possibly promoted by widespread fires, particularly in areas regular burnt.[36]

The increasing frequency and severity of wildfire demands a radical rethink of how we manage forests for biodiversity conservation. Forestry practices have been shown to increase the risk of fires,[37] degrade habitats[38], increase erosion[39] and susceptibility to invasive weeds and pests, and reduce catchment water yield.[40]

Significant areas between Barrington Tops and Hawkesbury River have no documented wildfire history (See Map 5). While significant areas of Yango, Dharug, Mt. Royal National Parks, and Corrobare State Forest was burnt by the Black Summer, the region was relatively unscathed. However, National Parks and State Forest in Port Stephens Cessnock, and the former Great Lakes LGAs do have histories of recent wildfire.

32 Heath JT, Chafer CJ, Bishop TFA and Van Ogtrop FF (2016) Post-Fire Recovery of Eucalypt-Dominated Vegetation Communities in the Sydney Basin, Australia, in Fire Ecology 12, 53–79, available online at https://doi.org/10.4996/fireecology.1203053

33 Bradstock, R., Bedward, M., Price., O (2021). Risks to the NSW Coastal Integrated Forestry Operations Approvals Posed by the 2019/2020 Fire Season and Beyond: A Report to the New South Wales Natural Resources Commission. https://www.nrc.nsw.gov.au/Coastal%20IFOA%20-%20Final%20report%20-%20Fire%20regimes%20-%20UoW.pdf?downloadable=1

34 ibid

35 ibid

36 ibid

37 Wilson, N.,Bradstock, R., Bedward, M. (2002). Disturbance causes variation in sub-canopy fire weather conditions, Agricultural and Forest Meteorology, 323. https://doi.org/10.1016/j.agrformet.2022.109077.

38 See for example https://www.epa.nsw.gov.au/news/media-releases/2022/epamedia220411-forestry-corporation-fined-for-destroying-native-animal-habitat; and https://npansw.org.au/wp-content/uploads/2016/10/npa_regional-forest-agreements-have-failed-to-protect-the-environment.pdf

39 Peter G. Walsh and Stephen T. Lacey (2003). A Survey and Assessment of Post-Harvest Erosion within Native Forests Managed by State Forests of New South Wales. Research and Development Dmsion State Forests of New South Wales Sydney 2003. https://www.dpi.nsw.gov.au/content/research/areas/resources-research/forest-resources/pubs/A-Survey-and-Assessment-of-Post-Harvest-Erosion-within-Native-Forests-Managed-by-State-Forests-of-NSW.pdf

40 P.M. Cornish (1993) The effects of logging and forest regeneration on water yields in a moist eucalypt forest in New South Wales, Australia, Journal of Hydrology, Volume 150, Issues 2–4, 1993,Pages 301-322. https://www.sciencedirect.com/science/article/pii/002216949390114O

Powerful Owl,(Ninox strenua, Josh Smart, @wildy_smart

Climate refugia

At their website (nswclimaterefugia.net), Beaumont et al (2019)[41] provide visual projection of areas of future suitable habitat for 81 landscape-managed species[42] and 238 site-managed species[43] found in southeast Australia, under a "business as usual" greenhouse gas emissions scenario (RCP 8.5).

The Geographic Information System (GIS) datasets present future habitat suitability for native species under four different configurations of potential trends in temperature and rainfall represented as:

1. **Warmer/Wetter,**
2. **Hotter/Wetter,**
3. **Warmer/Drier,**
4. **Hotter/Little change in rainfall.**

Differences in the projected area of suitable habitat for each species under these four climate change scenarios represent the uncertainty of future temperatures and rainfall patterns predicted by a number of global and regional climate models. Future rainfall patterns are particularly uncertain.

Beaumont et al (2019) utilised habitat suitability modelling to assess the relationship between species' occurrence patterns and environmental characteristics to estimate which regions were likely to retain conditions broadly suitable for the species across the range of plausible future climate scenarios to 2070. They do not indicate the probability that a target species will successfully colonise an area, but rather identify areas likely to serve as refugia throughout the century. Viable populations of target species must, of course, be allowed to persist in the region and be able to migrate to the newly suitable habitat.

Key State Planning Regions containing high numbers of landscape-managed species include the North Coast, Hunter Central Coast and Greater Sydney, and the Central West and South West Riverina.[44]These authors tell us that:

- **For a given species, populations in regions projected to become climatically unsuitable under all four climate scenarios are at substantial risk from climate change.**
- **Protection of climate refugia for multiple species offer a means of**

41 Beaumont, L. J., Baumgartner, J. B., Esperón-Rodríguez, M, & Nipperess, D. (2019). Identifying climate refugia for key species in New South Wales - Final report from the BioNode of the NSW Adaptation Hub, Macquarie University, Sydney, Australia. https://www.climatechange.environment.nsw.gov.au/sites/default/files/2021-06/Identifying%20climate%20refugia%20for%20key%20species%20in%20NSW.PDF

42 9 Endangered and 72 Vulnerable terrestrial vertebrate fauna

43 34 vertebrates and 204 plants -13 Critically Endangered, 125 Endangered, and 100 Vulnerable species

44 Beaumont et al. (2019). Op cit

prioritising conservation efforts.

- **Unless reversed, current stresses, including habitat loss and degradation, may erode the capacity of some key refugial regions to maintain viable populations.**
- **Adequate resource be provided to fully assess the vulnerability to climate change of threatened species in the North Coast, Hunter and Greater Sydney regions (as well as the Shoalhaven), as habitat suitability models indicate that threatened species in these regions face substantial threat from climate change**

Beaumont et al (2019) concludes that under the worst case climate scenario presented (Hotter/ Little change – the driest scenario), 45 percent of fauna and 72 percent of flora species studied are likely to have little to no suitable habitat or areas for translocation.[45] These authors suggest the east coast region of NSW will be heavily impacted with several important refugia for threatened species projected to be located close to heavily urbanized regions. The report identifies key regions for threatened species as likely to occur around the Sydney Basin and in the north-east coast, as well as the South Eastern Highlands.

Presently, regions containing the greatest number of landscape-managed species modelled by Beaumont et al (2019) occur primarily along the northern and central eastern coast of NSW, and throughout scattered regions to the south of the South Western Slopes. By 2070, multi-species internal refugia along the coast are projected to be greatly diminished in spatial extent and the number of species they support, with the most important coastal regions being on the northern NSW coast, around the town of Upper Myall (in the former Great Lakes LGA in Mid-coast LGA), as well as Wingham in northern Mid-coast LGA, and Evans Head in the Richmond LGA.

Similar modelling was undertaken for a report to the Natural Resource Commission of the fire risk to forests under the Coastal Integrated Forestry Operations Approval (CIFOA). Bradstock et al (2021)[46] found that suitable habitat for 14 of the 24 threatened fauna species studied (58%) were projected to consistently decline in response to climate change and a further 10 species (42%) had a mixed response.

Suitable habitat for eight mammal species, four bird species, and all amphibian species (2) were predicted to decline under two projected future climate scenarios to 2030 and 2070. The two climate scenarios used were the wettest future (Warmer/wetter) and the driest future (Hotter/ Little change in rainfall). By contrast, suitable habitat for the Southern Brown Bandicoot, Squirrel Glider, and Barking Owl was predicted to increase to 2070 under both scenarios. For the remaining seven species, both an increase and decline in suitable habitat was predicted for the two future climate scenarios, with the magnitude of projected increases highly variable.[47] Of the 24 forest dependant species examined;

- **58 percent (14 species) showed consistent decline in the area of suitable habitat of between 38 and 99 percent, and**
- **42 percent (10 species) showed a mix of decline and increase in suitable habitat.**

Of the ten species studied that had mixed future responses:

- **5 exhibited consistent increases in habitat for 2030 and 2070 with higher increases under the Hotter/Little change (ECHAM5) compared with the Warmer/Wetter (MIROC32) scenario.**
- **5 showed mixed responses (predicted increases and decreases in suitable habitat), though the magnitude of change was generally greater under Warmer/Wetter compared with the Hotter/Little change scenario.[48]**

45 Beaumont et al. (2019). Op cit
46 Bradstock, et al (2021). Op cit.
47 ibid
48 ibid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Red legged Pademelon, Creative Commons Accessed via: https://australian.museum/learn/animals/mammals/red-legged-pademelon/#gallery-thumbnail


Regent Honeyeater (Anthochaera phrygia), Rebecca Citroni, HBOC BIL


Masked Owl (Tyto novaehollandiae), Dick Jenkin, HBOC BIL

Gang Gang Cockatoo (Callocephalon fimbriatum), Alwyn Simple, HBOC BIL

Climate refugia between Barrington and Hawkesbury

Using the spatial datasets provided by Beaumont et al (2019), we have identified areas in the Barrington to Hawkesbury region where future suitable habitats for threatened fauna species overlap under all four climate change scenarios for multiple species as a means of prioritising conservation efforts. Habitat loss and degradation in these areas will erode the carrying capacity of these key refugial areas.

We used the spatial data accessible from NSW Climate Refugia portal[49] to generate GIS maps to estimate future suitable habitat for threatened species within the region (See Appendix 2). Under the worst case climate scenario (4.Hotter/ Little change), six fauna species (13%) are predicted to have little or no suitable habitat in 2070 (See Map 7). These include:

- **Red-legged Pademelon**
- **Yellow-bellied Glider,**
- **Stephens Banded Snake**
- **Wallum Sedge Frog, and**
- **Giant Barred Frog.**
- **Red-crowned Toadlet (Impossible to migrate to suitable habitat across the Hunter Valley)**

Larger areas are projected to be suitable for these species under a consensus of 3 scenarios (Hotter/Little change excluded). Under these climate scenarios, suitable habitat for Yellow-bellied Gliders is predicted to contract to areas of Yango National Park, Corrabare and Pokolbin State Forest in Cessnock LGA, and Wang Wauk and Bulahdelah State Forest in Mid-coast LGA. The largest area of such suitable habitat in 2070 under less severe scenarios for the Red-legged Pademelon is predicted within elevated privately owned bushland between Tuggerah Lake and Gosford.

Overlapping areas of suitable habitat for these species under the three least severe climate futures also declines to 2070. However, these areas are consistently larger than the areas that include the Hotter/Little change scenario. We have presented these overlapping less severe climate scenarios (3 climate scenarios overlap) for fauna species projected to suffer future range contractions. Such areas for six species found to be at substantial risk from climate change must be a priority for conservation efforts.

The driest Hotter/Little change future represents the worst-case scenario for 44 percent of the regional habitat assemblages examined. Overlapping areas of suitable habitat for these species under all four climate change scenarios declines to 2070 (4 climate scenarios overlap).

49 https://nswclimaterefugia.net/map/

The region between Barrington Tops and the Hawkesbury River supports habitat for 48 of the 81 fauna species modelled by Beaumont et al (2019). Of the modelled habitat for 48 Threatened animal within the region in 2070, we estimate:

- **21 species (44%) will suffer range contractions,**
- **15 species (31%) will be relatively stable, and**
- **12 species (25%) will experience range expansions.**

These 10 fauna species with overlapping suitable habitat under all 4 possible climate scenarios include:

- **5 mammals**
  - **Parma Wallaby,**
  - **Eastern Pigmy Possum,**
  - **Eastern False Pipistrelle,**
  - **Golden-tipped Bat,**
  - **Greater Broad-nosed Bat,**
- **4 birds**
  - **Powerful Owl,**
  - **Sooty Owl,**
  - **Gang-gang Cockatoo,**
  - **Glossy Black Cockatoo.**
- **1 amphibian**
  - **Stuttering Frog.**

Suitable habitat of these species predicted to suffer range contractions to 2070 (See Map 6) were stacked to identify areas of overlapping habitat suitable. These multi-species climate refugia are largely within upland State Forest of the region.

Chichester, Massey's Creek, and Olney State Forest, in particular will be essential climate refugia in 2070 for these species. However, large areas of privately owned bushland will also be essential, particularly the large private forest west and north of Myall River National Park in Mid-coast LGA (centred around the town of Upper Myall), and along the ridgelines between the Allyn, Williams, and Paterson Rivers in the Dungog LGA (See Map 6).

In 2070, overlapping suitable habitat under all 4 possible climate scenarios, including the worst case Hotter/Little change, is also projected to contract for:

- **Rosenburg's Goanna restricted to the Barrington Tops and Myal Lakes National Park, Bachelor, Wang-wauk, Nerong, and Myall River State Forest, and surrounding private land,**

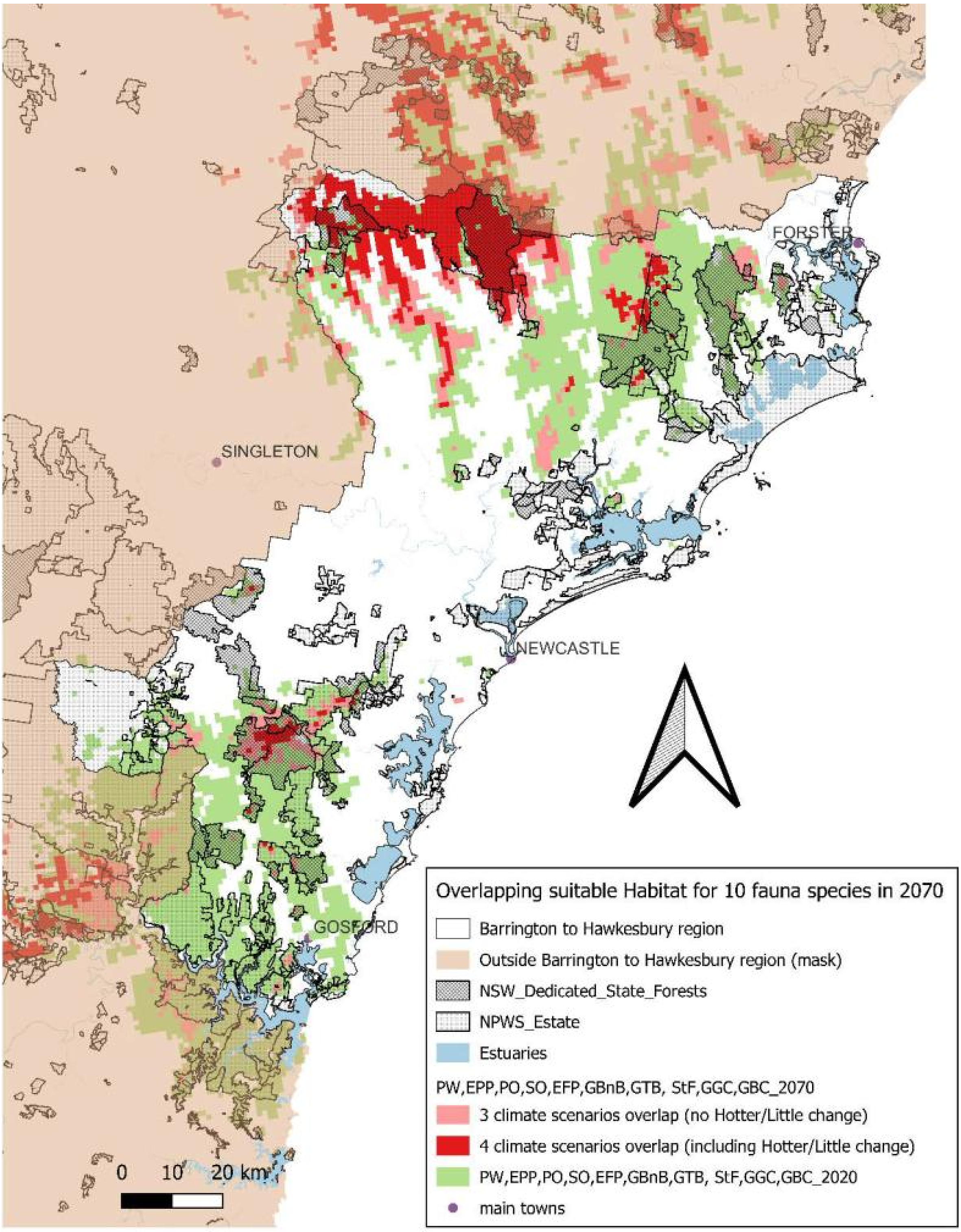
Giant Barred Frog, (Mixophyes iteratus), Josh Smart, @wildy_smart

- Masked Owl and Spotted-tailed Quoll restricted to climate refugia in Chichester, Wang Wauk, and Bachelor State Forests.
- The Giant Burrowing Frog will be restricted to the southern National Parks and Myall Lakes and Barrington Tops National Parks, Olney and Ourimbah State Forest, and private coastal bushland south of Forster, west of Myall River National Park, and between Tuggerah Lake and Gosford, and
- Regent Honeyeater will be restricted to areas of private bushland south of Mount Royal National Park (See Appendix 2).

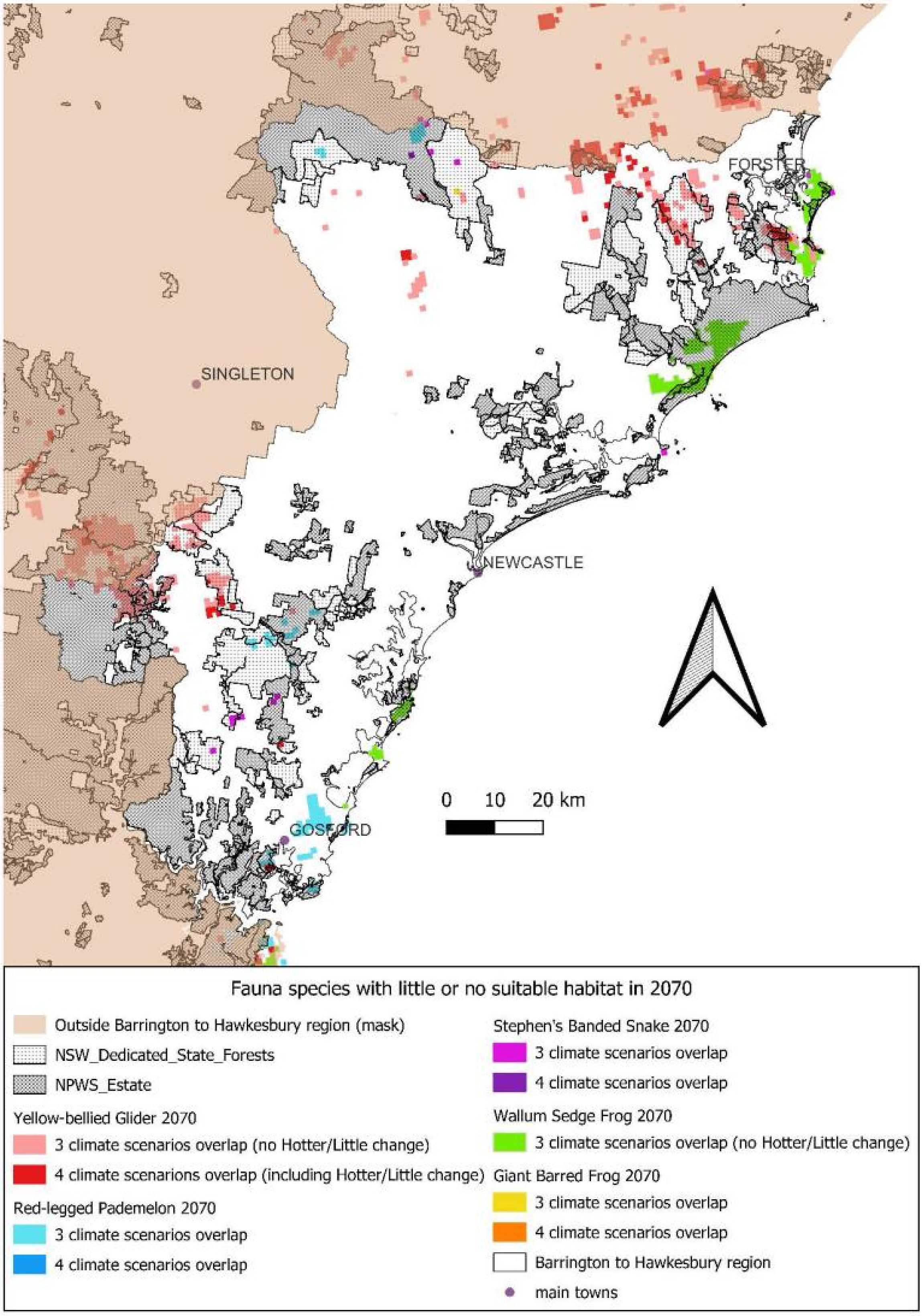
Species for which modelled suitable habitat in the region experiences range expansions or remain stable include:

1. Barking Owl
2. Black Falcon
3. Blue-billed Duck
4. Brush-tailed Phascogale
5. Bush Stone-curlew
6. Comb-crested Jarcana
7. Davie's Tree Frog
8. Eastern Cave Bat
9. Eastern Chestnut Mouse
10. Eastern Grass Owl
11. Eastern Osprey
12. Frecked Duck
13. Grey-headed Flying Fox
14. Little Bent-winged BatLittle Eagle,
15. Little eagle
16. Littlejohn's Tree Frog
17. Olive Whistler
18. Red Crowned Fruit Dove
19. Rufous Scrub Bird
20. Southern Myotis
21. Speckled Warbler
22. Spotted Harrier
23. Squirrel Glider
24. Swift Parrot
25. Turquoise Parrot
26. Varied Sittella
27. Yellow-bellied Sheathtail Bat

Red-crowned Toadlet, (Pseudophryne australis), Accessed via: https://www.krg.nsw.gov.au/Environment/Your-local-environment/Wildlife/Wildlife-galleries/Frogs-and-fish



Map 6: Overlapping suitable habitat under all 4 climate scenarios (red) and under 3 climate scenarios – Worst case Hotter/Little change in rainfall excluded (pink), for 10 fauna species modelled by Beaumont et al (2019) to decline in the Barrington to Hawkesbury region to 2070. Overlapping suitable habitat for these species in 2020 presented (green) for comparison. Species include Parma Wallaby (PW), Eastern Pygmy Possum (EPP), Powerful Owl (PO), Eastern False Pipistelle (EFPP), Greater Broad-nosed Bat (GBnB), Stuttering Frog (StF), Gang-gang Cockatoo (GGC), and Glossy Black Cockatoo (GBC). Digital data: Beaumont et al (2019) Consensus fauna models https://nswclimaterefugia.net/map/; Tenure layers State Government of NSW and Department of Planning and Environment https://datasets.seed.nsw.gov.au/dataset/



*Map 7: Fauna species likely to have little or no suitable habitat by 2070 under all 4 climate scenarios (darker shade), and under 3 climate scenarios – Hotter/Little change climate model removed (lighter shade). Digital data: Beaumont et al (2019) Consensus fauna models https://nswclimaterefugia.net/map/; Tenure layers **State Government of NSW and Department of Planning and Environment https://datasets.seed.nsw.gov.au/dataset/***

State forest logging, Harley Kingston, https://www.flickr.com/photos/harlz_/4295797661/in/photostream/

Native vegetation loss and degradation

Clearing of native vegetation and destruction of habitat has been identified as the single greatest threat to biodiversity in NSW.[50] Land clearing has been implicated in the listing of 60 percent of Australia's threatened species under the EPBC Act.[51] Almost 90 percent of all threatened species in NSW face pressure from native vegetation clearing.[52]

Clearing of any area of native vegetation, including areas less than 2 ha, may have significant impacts on biological diversity.[53] When native vegetation is cleared, habitat becomes smaller in area, and the remaining habitat is divided into smaller separate fragments making it harder for animals to roam or migrate and for plants to disperse.[54] Habitat fragmentation creates small isolated populations with limited gene flow leading to inbreeding and reduced ability to adapt to environmental change.[55] Fragmentation decreases food availability, and increase the amount of edge habitat where predation and edge effects are more likely. The hostile cleared land surrounding these fragments limits movement between patches, making small isolated populations subject to local extinction from random events, such as fire, pests, and disease.[56] [57]

The first piece of legislation that regulated clearing in NSW, the *State Environmental Planning Policy No. 46 (SEPP 46)*, was introduced in 1995 and was quickly followed by the *Native Vegetation Conservation Act 1997*.[58] Both pieces of legislation prohibited any clearing of any vegetation that pre-dated European settlement in 1788, without a formal development consent.[59]

50 Coutts-Smith A & Downey PO (2006). The Impact of weeds on threatened biodiversity in New South Wales. Technical series No. 11, CRC for Australian Weed Management, Adelaide, January 2006. https://www.researchgate.net/publication/264240230_The_Impact_of_Weeds_on_Threatened_Biodiversity_in_New_South_Wales

51 Kearney SG, Carwardine J, Reside AE, Fisher DO, Maron M, Doherty TS, Legge S, Silcock J, Woinarski JCZ, Garnett ST, Wintle BA & Watson JEM (2018). The threats to Australia's imperilled species and implications for a national conservation response. Pacific Conservation Biology 25(3):231–244.

52 NSW Environment Protection Authority (2021). Op cit.

53 NSW Scientific Committee, 2001. Clearing of native vegetation - key threatening process listing - final determination.

54 Commonwealth of Australia (2016). Central Hunter Valley eucalypt forest and woodland: a nationally-protected ecological community.
https://www.awe.gov.au/sites/default/files/documents/central-hunter-valley-eucalypt-forest-guide.docx

55 ibid

56 ibid

57 National Climate Change Adaptation Research Facility (NCCARF), Wildlife Corridors and Climate Change Adaptation. https://www.nccarf.jcu.edu.au/terrestrialbiodiversity/documents/Corridor_FINAL.pdf

58 Australian Greenhouse Office, Canberra (2000). Land Clearing: A Social History. National Carbon Accounting System Technical Report No. 4

59 A. Bombell, D. Montoya (2014). Native vegetation clearing in NSW: a regulatory history. NSW Parliamentary Research Service.

In 2005, the NSW Government repealed the *Native Vegetation Conservation Act 1997* and implemented the *Native Vegetation Act 2003*, a piece of legislation which aimed to end broad scale land clearing across rural NSW.[60] The 2003 Act retained all existing prohibitions and specified that any application to clear land would only be approved if landholders could demonstrate that they were maintaining or improving native vegetation outcomes elsewhere on their property.[61]

In 2014, land clearing legislation in NSW came under extensive review. In August 2017, the NSW government repealed the *Native Vegetation Act 2003*,[62] and introduced the *Biodiversity Conservation Act 2016*, which allowed rural land holders to clear paddock trees, thin native vegetation, and remove 'invasive native scrub' under a self-assessable framework.[63]

From 2014 to 2020, land clearing of native woody vegetation (bushland) increased from 32,000 ha to 51,400 ha, with a peak of 60,000 ha in 2018 (See Chart 2a). Rates of clearing of non-woody vegetation, such as native shrubs and ground covers were also high.[64]

In 2020, across NSW Department of Planning and Environment (DPE) estimate almost 100,000 ha of native vegetation was lost;

- **47,200 ha of non-woody. and**
- **51,400 ha of woody vegetation due to agriculture, forestry, and infrastructure.[65]**

DPE class three types of woody vegetation clearing; agriculture, forestry, and infrastructure – urban development, mining and related activities, major infrastructure activities such as installing power lines, water pipelines, highways, roads and major works, and fence lines and firebreaks etc.

The 2020 DPE vegetation change report identifies a six percent reduction in woody vegetation loss to 51,300 ha compared to 2019 as a result of a decrease in losses due to agricultural activities of 22 percent to 13,000 ha.[66] In 2020, woody vegetation losses due to forestry activities increasing by 25 percent to 30,000 ha and losses due to infrastructure increased ten percent to 8,400 ha (See Charts 2a – 2d).[67]

Heagney et al (2021) found that market drivers have the greatest influence on agricultural land clearing rates, with price signals explaining 38 % of total clearing rates at the state scale. Livestock prices had the greatest influence on state-wide clearing rates followed by crop prices (See Charts 1a and 1b).[68]

60 Heagney, E., Falster, D., & Kovač, M. (2021). Land clearing in south-eastern Australia: Drivers, policy effects and implications for the future. Land Use Policy, 102, 105243. https://doi.org/10.1016/j.landusepol.2020.105243

61 A. Bombell, D. Montoya (2014). Native vegetation clearing in NSW: a regulatory history. NSW Parliamentary Research Service.

62 Heagney, E., Falster, D., & Kovač, M. (2021).Op cit.

63 NSW Department of Planning, Industry and the Environment (2019) Clearing in Accordance With Self-assessable Codes of the Repealed Native Vegetation Act 2003 https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/clearing-in-accordance-with-self-assessable-codes-under-the-native-vegetation-act

64 NSW Environment Protection Authority (2021).Op cit.

65 DPE, 2022a. Woody vegetation change Statewide Landcover and Tree Study Summary report 2020. https://www.environment.nsw.gov.au/research-and-publications/publications-search/woody-vegetation-change-statewide-landcover-tree-study-summary-report-2020; DPE, 2022b. Results woody vegetation change statewide landcover and tree study 2020 (XLS 594KB). https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/landcover-science/2020-landcover-change-reporting; DPE, 2022c Woody and non woody landcover change rural regulated land Summary report 2020. https://www.environment.nsw.gov.au/research-and-publications/publications-search/woody-and-non-woody-landcover-change-rural-regulated-land-summary-report-2020; DPE, 2022d. Results for landcover change on rural regulated land 2020 (XLSX 972KB). https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/landcover-science/2020-landcover-change-reporting

66 DPE, 2022b. Op cit.

67 DPE, 2022b. Op cit.

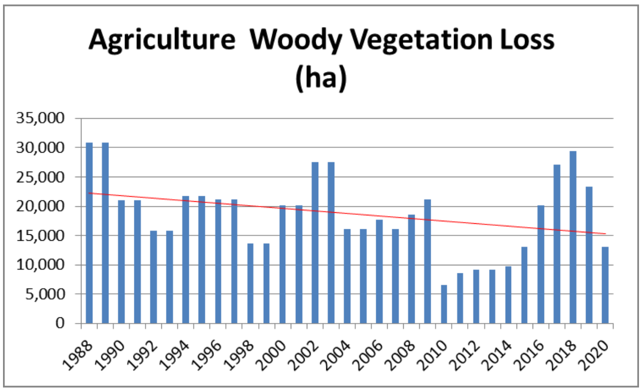
68 Heagney et al (2021). Op cit.

A

B

Charts 1a and 1b: Change in land clearing, priced received, and livestock prices. Taken from Heagney et al (2021).[69] ***Market variables graphed to show time lag to clearing****

69 Heagney et al (2021). Op cit.



Charts 2a: All NSW Woody Vegetation loss (ha) between 1988 and 2020. agricultural

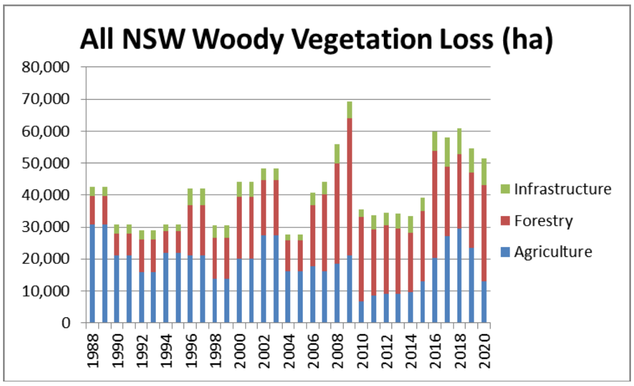


Chart 2b: Woody vegetation loss due to Activity between 1988 and 2020

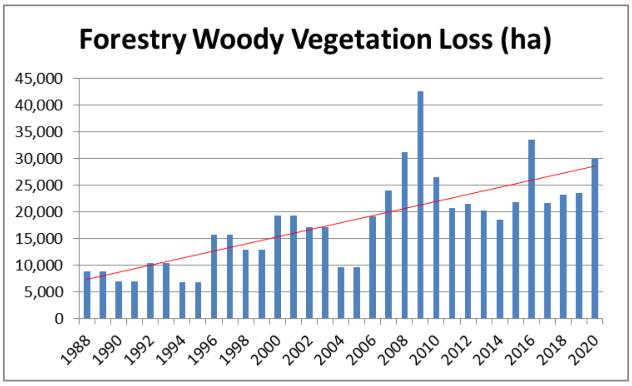


Chart 2c: Woody vegetation loss due to forestry activities between 1988 to 2020

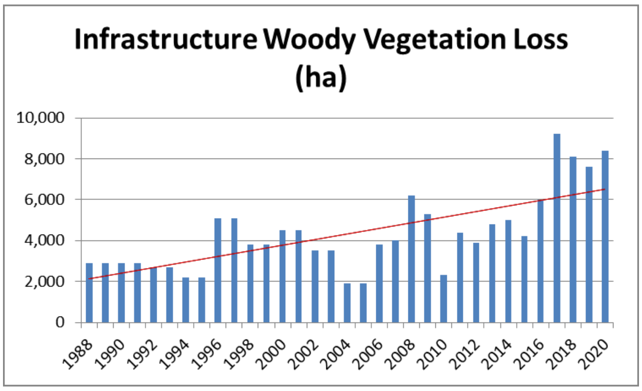


Chart 2d: Woody vegetation loss due to infrastructure development between 1988 and 2020

Regional bushland loss

Spatial data available from DPE Statewide Landcover and Tree Study (SLATS)[70] identifies land clearing from 1988 to 2018. Land clearing within the Barrington to Hawkesbury region for the years 1988 to 2010 is only mapped in the largely rural LGAs of Cessnock, former Great Lakes, and Dungog. Over this period about 5,837 ha of bushland was lost in these LGAs (See Table 2) at an annual average of 265 ha.

Table 2: SLATS Woody Vegetation loss 1988 to 2010 for the former Great Lakes, Cessnock, and Dungog LGAs

LGA	Actvity	Area (ha)	Average annual loss (ha)
MID-COAST*	Agricultural Activity	2,925	133
	Forestry Activity	1,191	54
	Infrastructure	862	39
		4,978	**226**
DUNGOG	Agricultural Activity	127	6
	Forestry Activity	541	25
	Infrastructure	2	0
		670	**30**
CESSNOCK	Agricultural Activity	66	3
	Forestry Activity	52	2
	Infrastructure	71	3
		188	**9**
TOTAL		**5,837**	**265**

Comprehensive SLATS mapping for 2008 to 2017 identifies 6,540 ha of bushland lost due to agriculture, forestry, and infrastructure development across the region. The average annual bushland loss mapped for this period was 654 ha (See Table 3).

During this period average annual bushland loss for the Barrington to Hawkesbury portion of Mid-coast LGA (former Great Lakes LGA) increase from 226 ha to 306 ha, due to a 4-fold escalation in annual average loss associated with forestry activities (54ha to 206ha), and a halving of bushland loss associated with agriculture activities (133ha to 61ha) (See Tables 3 and 4, and Map 8).

70 State Government of NSW and Department of Planning and Environment (2012). SLATS LANDSAT Woody Vegetation Change - NSW 1988 – 2010. https://datasets.seed.nsw.gov.au/dataset/nsw-slats-landsat-woody-change-derived-vector-database-1988-2010f5add

Table 3: SLATS Woody Vegetation loss in the Barrington to Hawkesbury region 2008-2017

LGA	Actvity	Area (ha)	Average annual loss (ha)
MID-COAST*	Agriculture	608	61
	Infrastructure	390	39
	Forestry	2060	206
		3,058	**306**
CENTRAL COAST	Agriculture	123	12
	Infrastructure	441	44
	Forestry	483	48
		1063	**106**
CESSNOCK	Agriculture	119	12
	Infrastructure	328	33
	Forestry	345	35
		792	**79**
LAKE MACQUARIE	Agriculture	27	3
	Infrastructure	445	45
	Forestry	231	23
		538	**54**
PORT STEPHENS	Agriculture	26	3
	Infrastructure	383	38
	Forestry	94	9
		485	**49**
DUNGOG	Agriculture	290	29
	Infrastructure	73	7
	Forestry	55	6
		418	**42**
NEWCASTLE	Agriculture	1	0
	Infrastructure	117	12
		118	**12**
MAITLAND	Agriculture	8	1
	Infrastructure	58	6
		66	**7**
TOTAL		**6,540**	**654**

***Former Great Lakes LGA – southern Mid-coast LGA**

Publically available SLATS spatial data is currently restricted to before 2018. Digital data is available for the period 2015 to 2020.[71] However, the data does not differentiate the former LGAs of the amalgamated Mid-coast LGA (10,000 km^2).

71 DPE (2022) Woody vegetation change Statewide Landcover and Tree Study Summary report 2020. https://www.environment.nsw.gov.au/research-and-publications/publications-search/woody-vegetation-change-statewide-landcover-tree-study-summary-report-2020: https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/landcover-science

For the six years from 2015 to 2020 bushland loss in the eight LGAs (including all the 10,000 km^2 Mid-coast LGA) totalled over 9,000ha, at an annual average rate of 1,516 ha (See Table 4).

Removing Mid-coast LGA from the data presented for the ten years 2008 to 2017 (Table 3), the total bushland loss was 3,482 ha, at an average annual rate of 348 ha. Within the seven LGAs (Mid-coast excluded) land clearing for the five years 2015-2020 totalled 2,408 ha (400 ha a year), an increase of 15 percent on the previous period. Increasing infrastructure development has been largely responsible for the increases in the LGAs (Tables 3 and 4). However, for Mid-coast LGA, forestry activities are the main driver of land clearing.

- **Mid-coast annual average land clearing rates for the period 2015 to 2020 was 1,114 ha a year, 58 percent due to forestry activities. Forestry accounted for 3,864 ha of bushland loss out of a total of 8,685 ha for the LGA.**
- **Cessnock shows a tripling of land clearing rates, from 30 ha a year from 1998-2010 to 79 ha a year 2008-2017, to 95 ha a year 2015-2020.**
- **Dungog went from 32 ha a years between 1988 and 2010, to 42 ha a years from 2008-2017, and to 55 ha a years from 2015 to 2020. The only LGA with increases in agricultural land clearing over these periods was Dungog.**
- **Lake Macquarie shows an increase in annual average land clearing rates from 54 ha a years from 2008 to 2017, to 66 ha a years from 2015 to 2020.**
- **Port Stephens bushland loss went from 49 ha a years from 2008 to 2017 to 61 ha from 2015 to 2020.**
- **Maitland went from 7 ha a years from 2008 to 2017 to 11 ha a year between 2015 to 2020**
- **Central Coast remained at 106 ha for both periods.**
- **Newcastle was the only LGA to have reduced land clearing rates, where the rate went from an average of 12 ha a year in 2008-2017 to 8 ha a year in 2015 to 2020.**

Table 4: SLATS woody vegetation loss 2015 -2020 for the 8 LGAs between Barrington and Hawkesbury.

LGA		2015	2016	2017	2018	2019	2020	Total	Average
MID-COAST COUNCIL	Agriculture	188	485	295	333	267	245	1813	302
	Forestry	498	895	868	599	293	711	3864	644
	Infrastructure	46	259	144	134	285	140	1008	168
	Total	**732**	**1639**	**1307**	**1066**	**845**	**1096**	**6685**	**1114**
CENTRAL COAST COUNCIL	Agriculture	5	14	26	15	9	29	98	16
	Forestry	10	26	23	49	6	46	160	27
	Infrastructure	67	85	90	62	26	48	378	63
	Total	**82**	**125**	**139**	**126**	**41**	**123**	**636**	**106**
CESSNOCK CITY COUNCIL	Agriculture	14	19	40	24	16	19	132	22
	Forestry	58	78	37	-	4	27	204	41
	Infrastructure	29	58	61	27	20	36	231	39
	Total	**101**	**155**	**138**	**51**	**40**	**82**	**567**	**95**
LAKE MACQUARIE CITY COUNCIL	Agriculture	1	2	-	3	-		6	2
	Forestry	-	-	8	4	2		14	5
	Infrastructure	68	93	82	44	25	61	373	62
	Total	**69**	**95**	**90**	**51**	**27**	**61**	**393**	**66**
NEWCASTLE CITY COUNCIL	Agriculture	-	-	1	-	-		1	1
	Forestry	-	-	-	-	-			
	Infrastructure	1	25	11	10	3		49	10
	Total	**1**	**25**	**12**	**10**	**3**		**50**	**8**
PORT STEPHENS COUNCIL	Agriculture	-	14	16	10	1	5	46	9
	Forestry	-	-	-	-	19		19	19
	Infrastructure	31	115	43	27	28	54	298	50
	Total	**31**	**129**	**59**	**37**	**48**	**59**	**363**	**61**
DUNGOG SHIRE COUNCIL	Agriculture	20	46	60	12	40	27	205	34
	Forestry	3	29	6	1	1	24	64	11
	Infrastructure	3	14	27	8	4	6	62	10
	Total	**26**	**89**	**93**	**21**	**45**	**57**	**331**	**55**
MAITLAND CITY COUNCIL	Agriculture	1	2	2	1	-	2	8	1
	Forestry	-	-	-	-	-			
	Infrastructure	2	14	12	7	9	16	60	9
	Total	**3**	**16**	**14**	**8**	**9**	**18**	**68**	**11**
Total loss		**1,045**	**2,273**	**1,852**	**1,370**	**1,058**	**1,496**	**9,093**	**1,516**

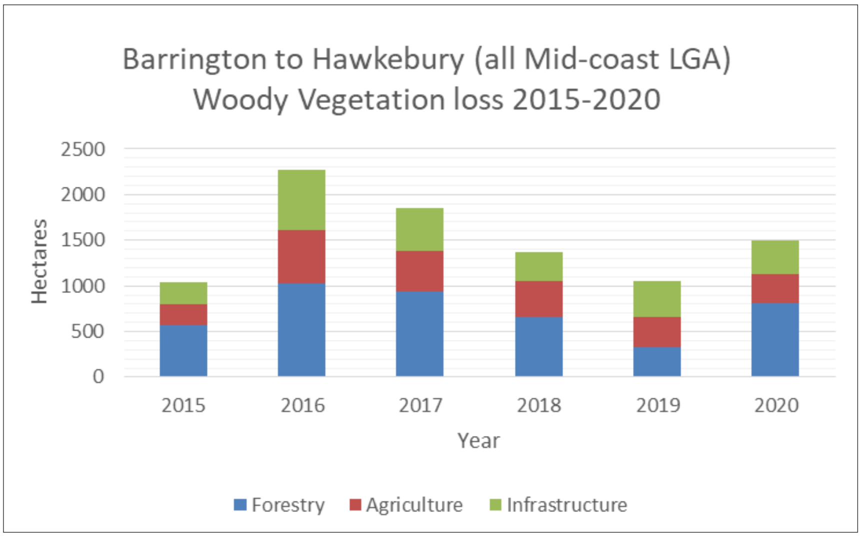


Chart 3: Woody vegetation loss in the 8 LGAs of the region segmented into Agriculture, Forestry, and Infrastructure classes. Included all Mid-coast LGA.

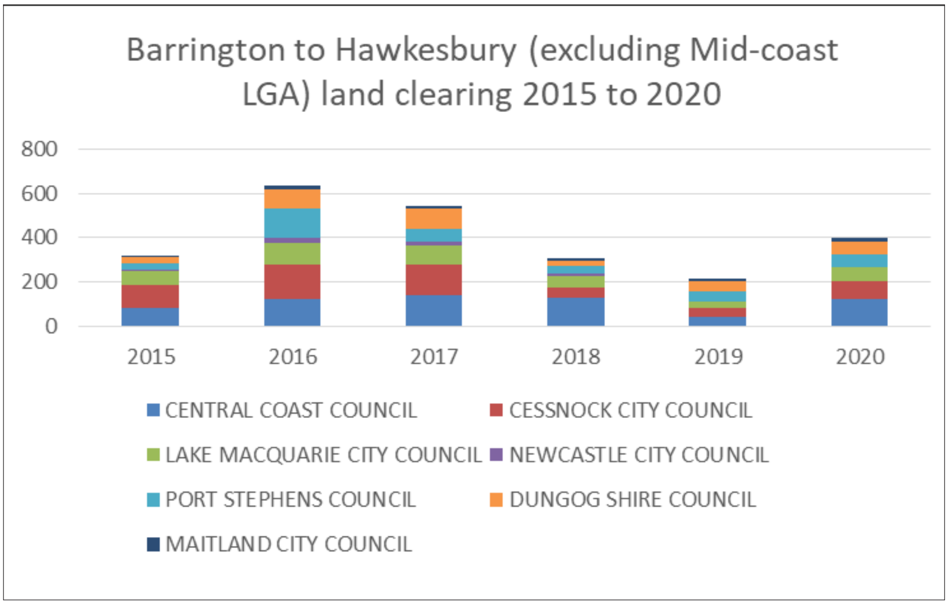


Chart 4: Woody vegetation loss in the 7 LGAs of the region segmented into Agriculture, Forestry, and Infrastructure classes. Does not included Mid-coast LGA.

Between 2015 and 2020, a significant spike in land clearing is evident in 2016 and 2017 (See Charts 3, 4, and 5). Large contributors to this was a spike was Mid-coast (forestry activities +400 ha, agricultural activities +300, infrastructure development +200ha), and Port Stephens (infrastructure development +120 ha). However, the spike was evident across all LGAs (See Charts 5a-5h and Table 4)

Mid-coast, Dungog, Cessnock, and Central Coast host large areas of State Forest , with forestry related land clearing increasing between 2015 and 2020 in Mid Coast, Dungog and Central Coast (See Charts 5a – 5h and Table 4). Smaller areas of State Forest exist within Lake Macquarie and Port Stephens LGA, with sporadic land clearing rates due to forestry activities in these LGAs (See Chart 5d and 5f and Table 4).

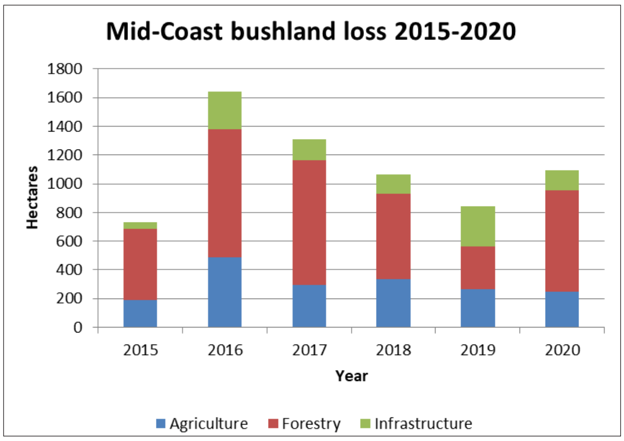


Chart 5a: Mid-coast LGA land clearing 2015 - 2020

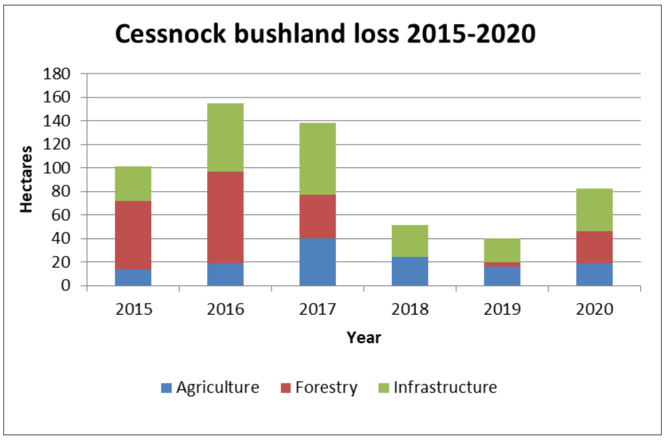


Chart 5b: Cessnock LGA land clearing 2015 - 2020

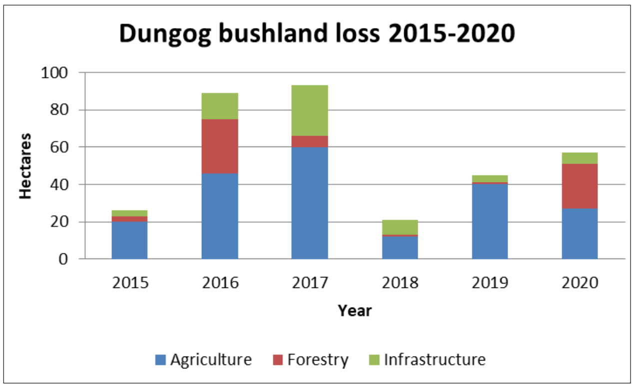


Chart 5c: Dungog LGA land clearing 2015 - 2020

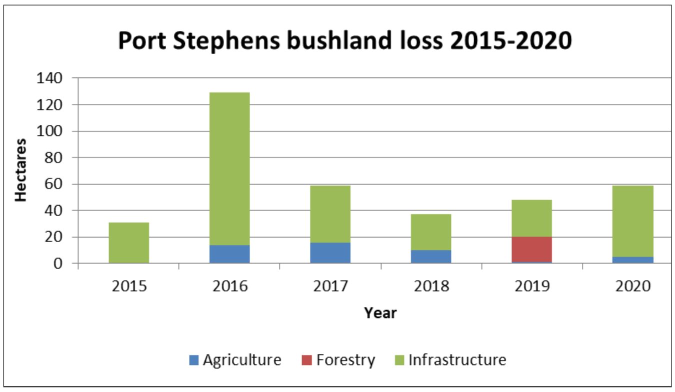


Chart 5d: Port Stephens's LGA land clearing 2015 - 2020

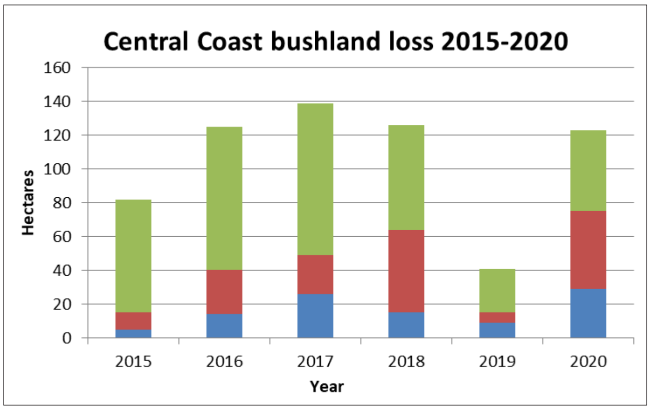


Chart 5e: Central Coast LGA land clearing 2015-2020

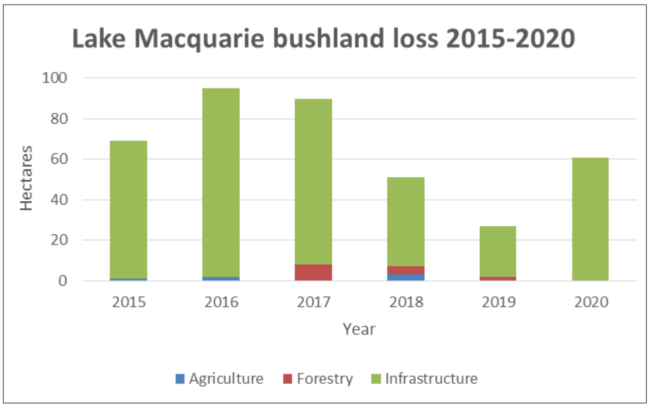


Chart 5f: Lake Macquarie LGA land clearing 2015-2020

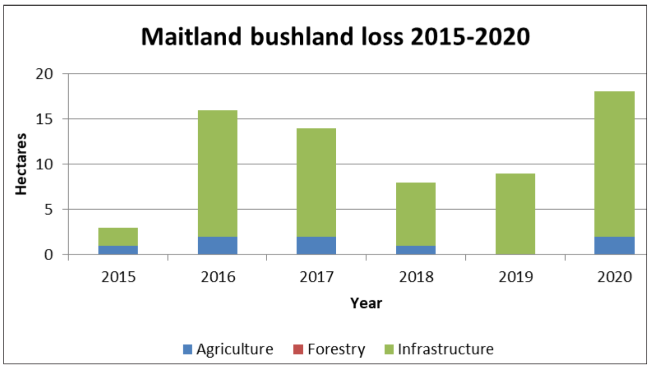


Chart 5g: Maitland LGA land clearing 2015 - 2020

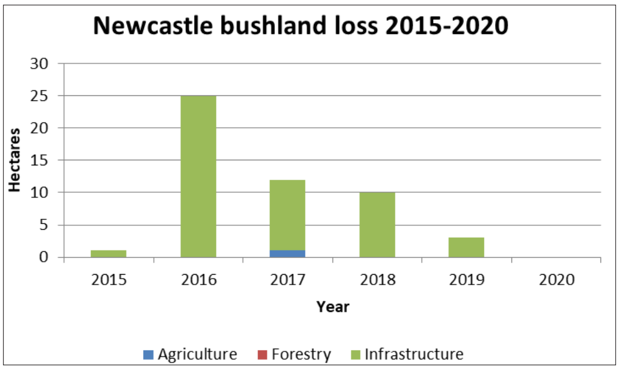
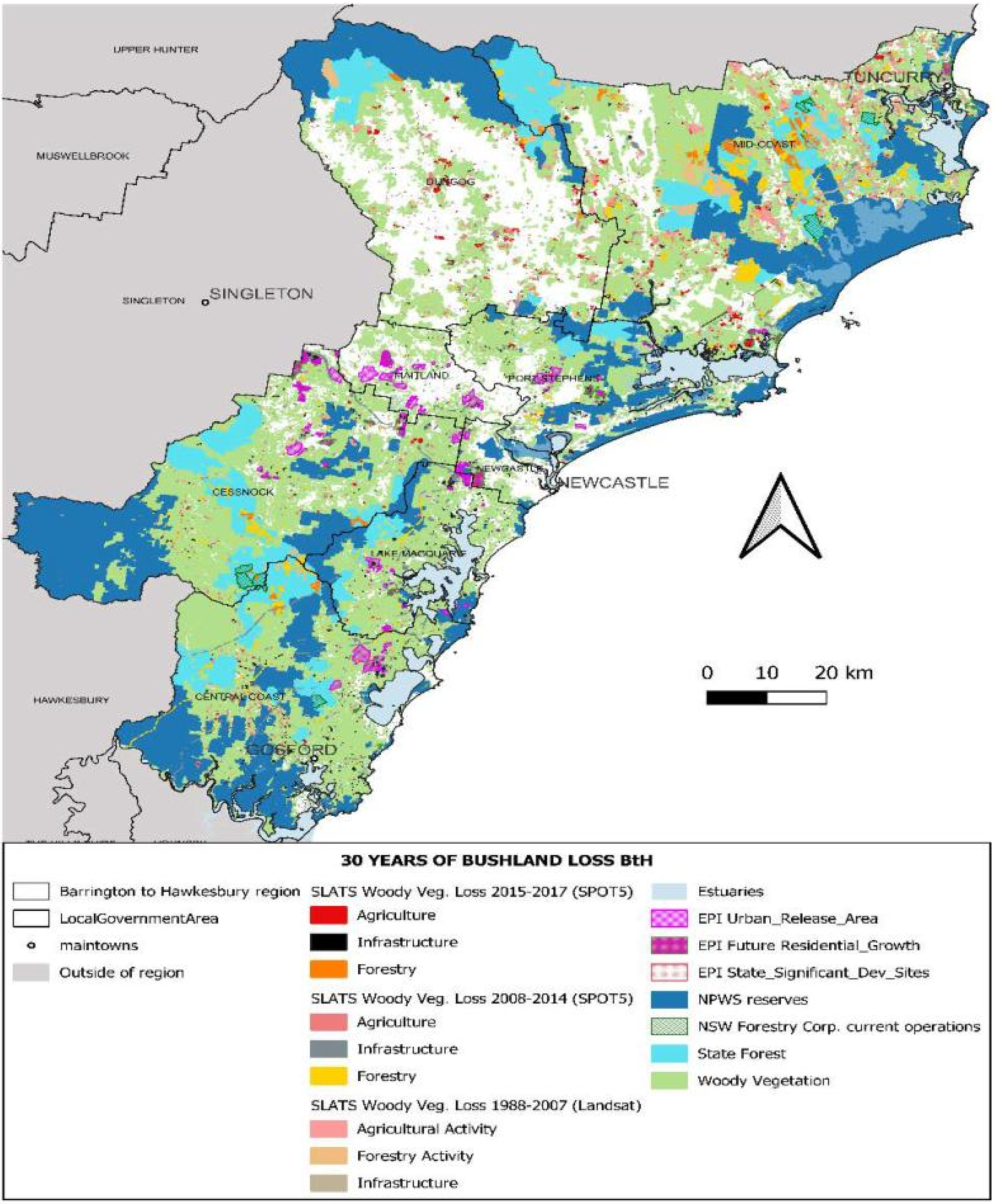


Chart 5h: Newcastle LGA land clearing 2015 - 2020



Map 8: BTH Woody Vegetation loss 1988 – 2018; Environmental Planning Instrument EPI) (See LGA detail Appendix 1).[72]

72 State Government of NSW and Department of Planning and Environment (2012). SLATS LANDSAT Woody Vegetation Change - NSW 1988 – 2010. https://datasets.seed.nsw.gov.au/dataset/nsw-slats-landsat-woody-change-derived-vector-database-1988-2010f5add: State Government of NSW and Department of Planning and Environment (2020a). SLATS - Woody Vegetation Change - NSW 2015 and 2016. https://datasets.seed.nsw.gov.au/dataset/woody-change-data-slats-2015: State Government of NSW and Department of Planning and Environment (2020b). SLATS - Woody Vegetation Change - NSW 2008-2014. https://datasets.seed.nsw.gov.au/dataset/spot-woody-change-data-5-10m-2008-201006e27: State Government of NSW and Department of Planning and Environment (2022). SLATS - Woody Vegetation Change - NSW 2017 and 2018. https://datasets.seed.nsw.gov.au/dataset/woody-change-data-slats-2015-clone-c276-clone-a495

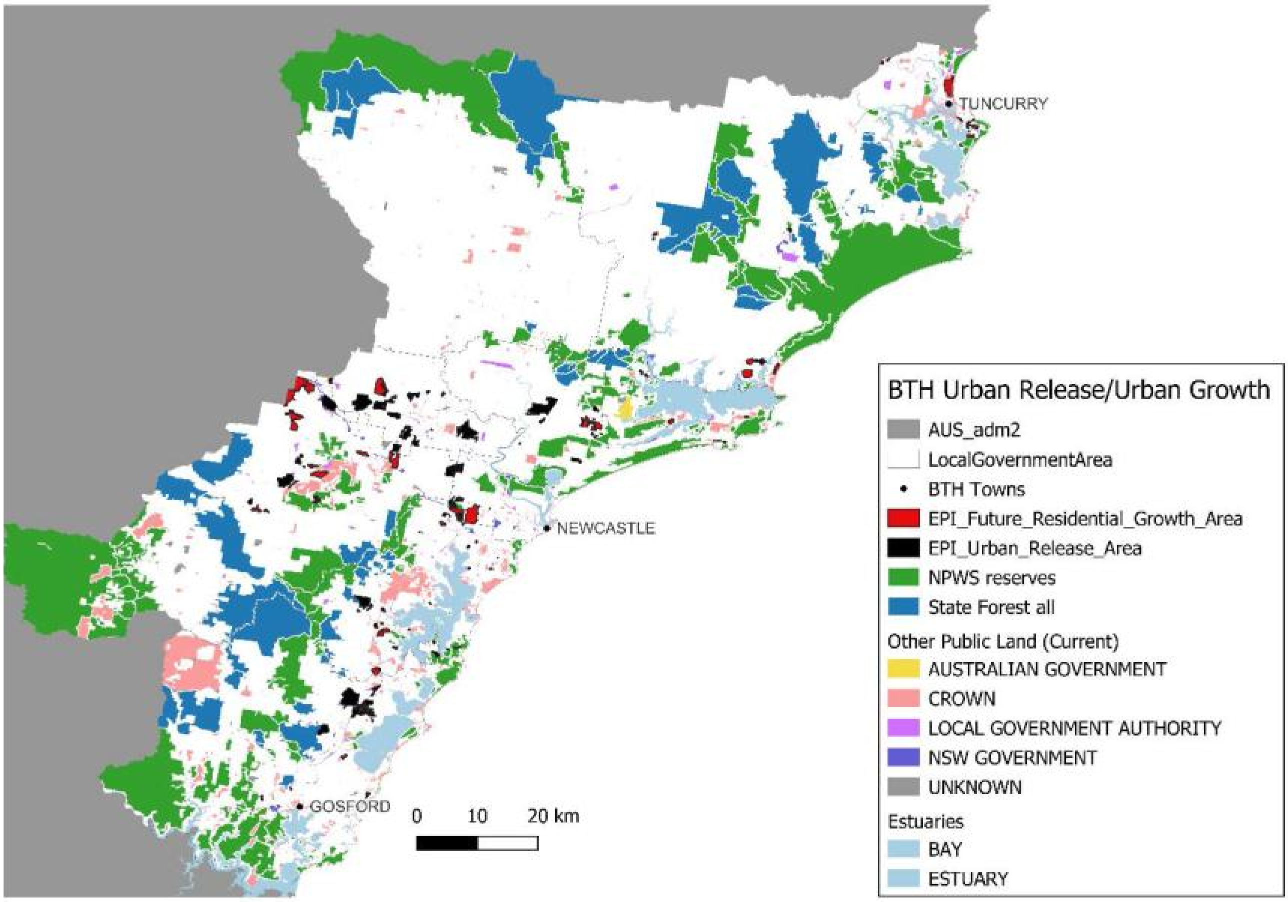
An additional 8,850 ha of bushland is under threat from urban development. In the ten years to 2020, almost 10,300 ha in the region had been released for "greenfield" urban development (See Maps 8 and 9);

- **Maitland LGA 2,922 ha,**
- **Cessnock LGA 2,842 ha,**
- **Central Coast LGA 1,941 ha,**
- **Lake Macquarie LGA 1,078 ha,**
- **Port Stephens LGA 1,068 ha**
- **Newcastle LGA 348 ha,**
- **Former Great Lakes portion of Mid Coast LGA 116 ha.**

These "Urban Release Areas" included 4,630 ha of native vegetation.

An addition 3250 ha of native vegetation in the area is threatened under Environmental Planning Instrument (EPI) "Future Residential Areas" of 4942 ha (See Maps 8 and 9). Bushland under threat from Future Residential Areas in the LGAs of the region are as follows:

- **Central Coast 248 ha,**
- **Cessnock 1251 ha,**
- **Mid-coast 615 ha,**
- **Lake Macquarie 430 ha,**
- **Newcastle 400 ha,**
- **Port Stephens 276 ha,**
- **Maitland 28 ha.**



Map 9: Environmental Planning Instrument (EPI) Urban Release Areas and Future Residential Growth in the BtH region.

Some of the ‘Urban release’ areas overlap with ‘future urban growth’ areas. In all about 14,000 ha in the region is earmarked for development, including State Significant Development sites in Central Coast LGA. These development sites contain 7,000 ha of bushland.

Wallsend, Link Road Forest, HCEC

Forestry activities – degradation, fire, and loss of hollow-bearing trees

Native vegetation covers almost 70 percent of NSW, yet only 15 percent is in near natural condition. [73] This significantly reduces the capacity of the vegetation to provide suitable habitat for the maintenance of viable populations and the ecological processes underpinning them. In 2013, average native species carrying capacity of NSW was down to 33 percent of the original, and after the Black Summer fires this was 31 percent.[74]

A hollow-bearing tree is generally an old tree, live or dead, containing visible cavities in the trunk or branches for hollow-dependent animal nesting, roosting or denning sites. When no alternatives exist, the low abundance of hollow-bearing trees within a landscape is a limiting factor for many fauna populations.[75] Species diversity in forests is often strongly linked to the abundance of hollow trees, as arthropods, reptiles, birds and mammals all utilise hollow-bearing trees for food, shelter and nesting.[76]

Hollow trees are often dispersed with standing and fallen dead trees, both of which provide essential habitat for a wide variety of native animals and are important to the functioning of many ecosystems. The removal of living hollow trees, as well as dead old trees (either standing or on the ground) can have a range of environmental consequences for a wide variety of vertebrates, invertebrates and microbial species.[77]

Forestry practices have greatly reduced the density of hollow-bearing trees, especially where repeated harvesting events have occurred.[78] Culling of mature trees to reduce competition with younger, production trees has specifically targeted large hollow-bearing trees, with some forest types gradually shifting in the relative

73 Cresswell et al (2021). Op cit.
74 ibid
75 Gibbons & Lindenmayer (2002) Tree Hollows and Wildlife Conservation in Australia.
76 Smith, G., Mathieson, M., Hogan, L., (2007) Home range and habitat use of a low-density population of greater gliders, Petauroides volans (Pseudocheiridae: Marsupialia), in a hollow-limiting environment. Wildlife Research 34, 472-483.
77 Gibbons & Lindenmayer (2002) Op cit.
78 Ross Y (1999) 'Hollow bearing trees in native forest permanent inventory plots in south-east Queensland. Forest ecosystem research and assessment technical papers 99-23.' Department of Natural Resources, Queensland.

composition of tree species toward those desired for timber.[79]

For forestry operations in State Forests, rotation intervals between harvesting events of between 30 to 90 years are insufficient to allow for hollow development.[80] Under the operating conditions for logging operations in State Forests, trees representing between five and eight percent of timber volume are retained in clumps of less than 2 ha, with addition trees retained along drainage lines etc.[81] However, these scattered clumps and lines are susceptible to damage from logging and post-harvest burning, or poor health from changes in abiotic conditions.[82] Retained trees, particularly those containing hollows and pipes, are prone to early mortality from repeated exposure to harvesting events over their lifespan, with the average age of hollow-bearing trees in harvested areas decreasing as the few remaining very old trees die.[83]

The density of hollow-bearing trees in conservation reserves that have previously been logged should gradually increase until reaching equilibrium of recruitment and loss, albeit with a long time lag in some areas. Wildfire may temporarily disrupt the age structure of these forests but in the long term can also promote hollow formation in standing trees. However, wildfire is a particular threat where the hollow resource is restricted to large, senescent hollow-bearing trees that are susceptible to burning.[84]

As with wildfires, logging alters fuel dynamics, a major factor in fire risk. Logging and wildfire can significantly alter the height and density of vegetation in forests, influencing the sub-canopy microclimate that increases forest flammability. Fuel moisture is typically lower and Forest Fire Danger Index higher in forests with lower and sparser vegetation.[85]

A recent study of 119 sites in coastal forest in south-eastern Australia over three consecutive fire seasons found for at least 60 years after logging, temperature, vapour pressure deficit, windspeed and Forest Fire Danger Index (FFDI) decreased with time since logging, while relative humidity and fuel moisture content increased.[86]

The study found fuel was available to burn 1.4 times more often in recently logged sites compared to sites that had not been logged for 71 years. Recently logged sites were also predicted to have a high Fire Danger Rating (12–24) on 24 days, compared to just two days at sites last logged 71 years ago. Logging, and to a lesser extent wildfire, was found to create hotter, drier and windier conditions beneath the tree canopy in forests, that were consequently more flammable. The study concludes that logging increases the risk of fire.[87]

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79 NSW Scientific Committee (2007) Loss of hollow-bearing trees - key threatening process listing – final determination. https://www.environment.nsw.gov.au/Topics/Animals-and-plants/Threatened-species/NSW-Threatened-Species-Scientific-Committee/Determinations/Final-determinations/2004-2007/Loss-of-Hollow-bearing-Trees-key-threatening-process-listing

80 ibid

81 NSW EPA (2018) Coastal Integrated Forestry Operations Approval.

82 NSW Scientific Committee (2007). Op cit.

83 ibid

84 NSW Scientific Committee (2007). Op cit

85 B.J. Pickering, T.J. Duff, C. Baillie, J.G. Cawson (2021). Darker, cooler, wetter: forest understories influence surface fuel moisture Agric. For. Meteorol., 300 (2021). 108311.

86 Wilson, N.,Bradstock, R., Bedward, M. (2002). Disturbance causes variation in sub-canopy fire weather conditions, Agricultural and Forest Meteorology, 323, 2022, 109077,

87 ibid

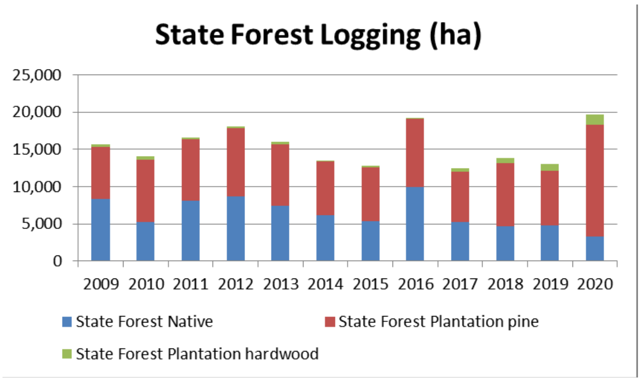


Chart 6a: State Forest logging (ha); native, plantation pine, and plantation hardwood between 2009 and 2020

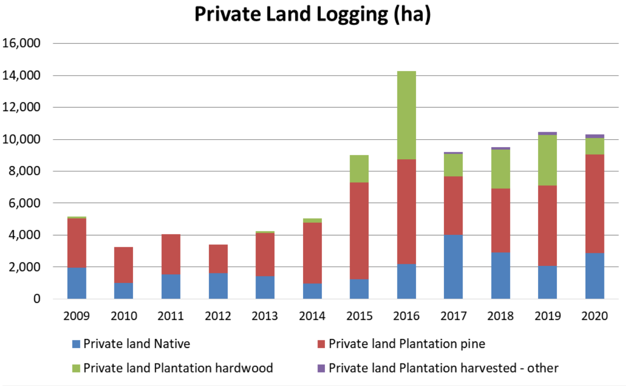


Chart 6b: Private land logging (ha); native,plantation pine, and plantation hardwood between 2009 and 2020

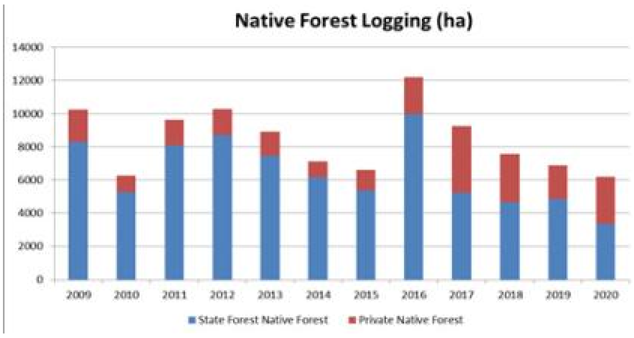


Chart 6c: Native forest logging (ha); State Forest and private land logging between 2009 and 2020

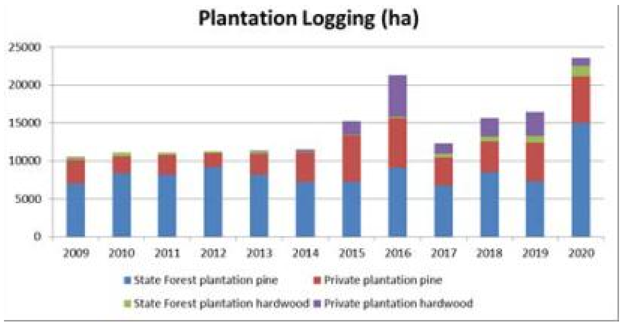


Chart 6d: Plantation logging (ha); State Forest plantation pine and plantation hardwood, and private land plantation pine and plantation hardwood logging between 2009 and 2020.

SLATS data reveals that in 2020, about 20,000 ha of forest was cleared for logging, up from 16,000 ha in 2009. Private native forest logging has been slowly increasing over this time with a concomitant reduction in State Forest logging (See Charts 6a and 6b). In 2009, about 7,000 ha of forest was logged on private land compared to about 17,500 ha in 2020. Overall, native forest logging has reduced in area between 2009 and 2020; from a little over 10,000 ha in 2009 to just over 6,000 ha in 2020 (See Chart 6a), and plantation logging area from over 10,000 ha in 2009 to about 27,000 ha in 2020 (See Charts 6c and 6d)

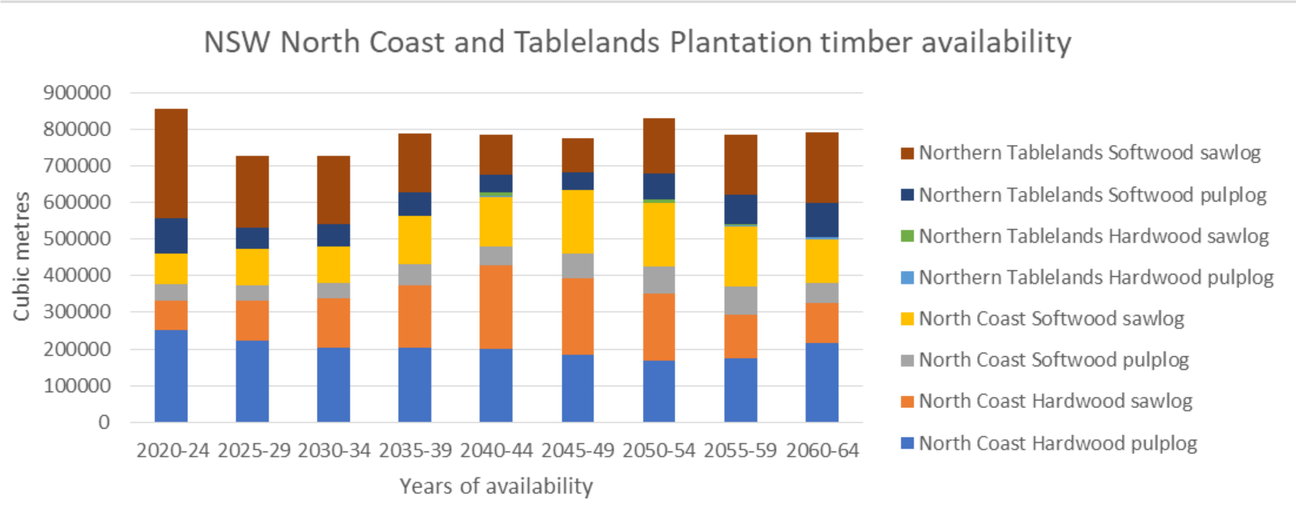


Chart 7. Plantation timber availability from the NSW North Coast and Tablelands from 2020 - 2064

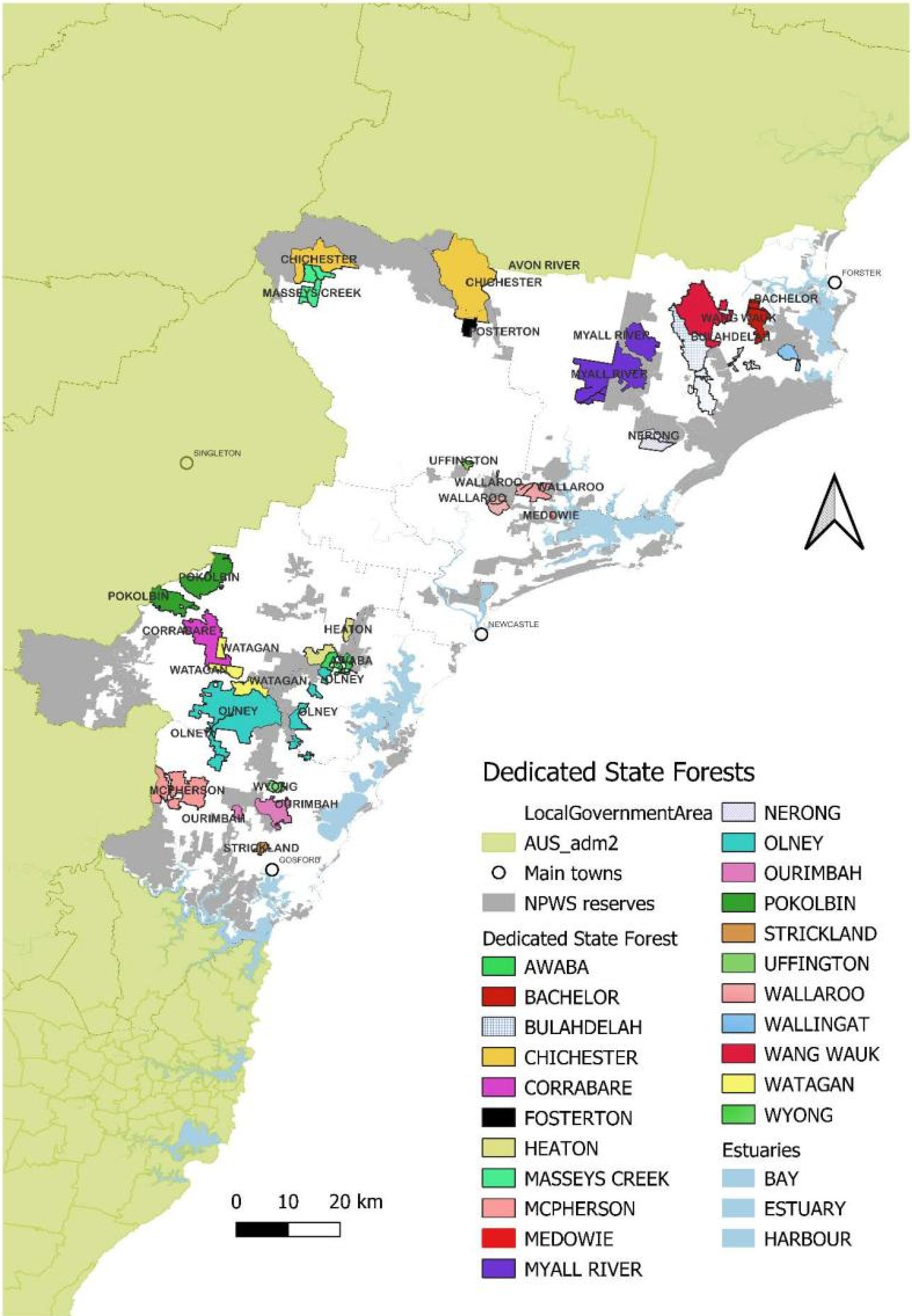
Forestry Corporation of NSW is the largest plantation manager in NSW, managing approximately 260,000 ha of hardwood and softwood plantations. Total timber plantations on land on the NSW North Coast and Tablelands can supply about 8.5M m3 a year, and about 8M m3 is available out to 2064 (See Chart 7). [88]

Native forest protection must become the key land management goal of the NSW Government. The current industrial-scale logging of native forests is no longer an acceptable impact. If threatened species are to survive the changing climate we must jealously guard against any additional pressures and appropriately manage these areas for conservation.

88 Legg, P Frakes, I & Gavran, M 2021, Australian plantation statistics and log availability report 2021, ABARES research report, Canberra, October, DOI: https://doi.org/ 10.25814/ xj7c-p829

Table 5: State Forests proposed to be transferred to National Park Estate (See Map 10)

State Forest Name	Area (ha)
ABERDARE	6
AVON RIVER	641
AWABA	1,784
BACHELOR	2,636
BULAHDELAH	8,476
CHICHESTER	21,415
CORRABARE	5,210
FOSTERTON	852
HEATON	2,424
MASSEYS CREEK	3,241
MCPHERSON	6,498
MEDOWIE	50
MYALL RIVER	13,726
NERONG	2,177
OLNEY	18,772
OURIMBAH	7,158
POKOLBIN	8,462
STRICKLAND	484
UFFINGTON	330
WALLAROO	3,612
WALLINGAT	1,243
WANG WAUK	8,370
WATAGAN	3,890
WYONG	728
TOTAL	**122,184**



Map 10: Dedicated State Forest proposed to be transferred to the National Park Estate within the Barrington to Hawkesbury region (See Table 5).

Urban development – bushland loss and Biodiversity Offset Scheme

As part of the suite of Land Management and Biodiversity Conservation Reforms that commenced in August 2017, the NSW Government introduced the *State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017* (Vegetation SEPP) to regulate vegetation clearing.

The Vegetation SEPP identifies when clearing will trigger the Biodiversity Offsets Scheme (BOS), which is set out in the *Biodiversity Conservation Act 2016* (BC Act). Council permits may be required for clearing that falls below the Biodiversity Offsets Scheme Threshold (BOS Threshold) and any clearing that exceeds the BOS Threshold will be assessed and approved by the independent Native Vegetation Panel (Panel).

The NSW Biodiversity Offsets Scheme was established in 2017 under the Biodiversity Conservation Act 2016 (the Act) to, 'maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, with the principles of ecologically sustainable development'. The Scheme enables landholders to establish in-perpetuity Biodiversity Stewardship Agreements (BSAs) on sites to generate biodiversity credits, which can be sold to offset the negative impact of development on biodiversity. The Biodiversity Conservation Trust (BCT) monitors and supports landholders to manage BSA Sites, and makes payments from funds held for biodiversity management.

Proposed development that involves the clearing of native vegetation must undertake a Biodiversity Development Assessment Report to determine an offset obligation, in biodiversity credits, to compensate for the biodiversity loss proposed. These reports are considered by consent authorities (such as a council, for local development, or by the Minister for Planning for major projects). An offset obligation is then included in the conditions of development approval.

The Scheme also allows developers to pay into the Biodiversity Conservation Fund and transfer their obligations to the BCT. This allows the developer to proceed with their project before offsets are in place. The BCT must then buy the required credits. However, the biodiversity credit market consists of almost 1400 different types of ecosystem credits in 364 different offset trading groups, and 867 different species credits. Around 86 percent of ecosystem offset trading groups and 97 percent of species credits have never been traded.

Since the introduction of the Scheme in mid-2017, the value of land developer payments has reached $115 million. However, the unfunded developer liability under the Scheme is over $80 million. Only 23 percent (175) of the Offset Obligations held by the Biodiversity Conservation Trust (746) have been acquitted.[89]

A major criticism of the Scheme is, rather than it being used as a last resort, when no alternative is available to clearing the land, it has become the default mechanism for protecting species and ecosystems in the face of land clearing for urban development.

The conclusion of the NSW Auditor General's Performance Audit of the BOS[90], was that the Scheme was poorly conceived, designed, and implemented. The Audit Office found the Department of Planning and Environment (DPE) has not effectively designed core elements of the NSW Biodiversity Offsets Scheme, and did not establish a clear strategy to develop the biodiversity credit market or determine whether the Scheme's operation and outcomes are consistent with the purposes of the Biodiversity Conservation Act 2016.

89 See BOP outcomes dashboard - https://www.bct.nsw.gov.au/info/biodiversity-offsets-program-outcomes

90 NSW Audit Office (2022). Effectiveness of the Biodiversity Offsets Scheme. https://www.audit.nsw.gov.au/sites/default/files/documents/FINAL%20-%20Effectiveness%20of%20the%20Biodiversity%20Offsets%20Scheme.PDF

The Auditor found the credit supply is lacking and poorly matched to growing demand, with the potential for undersupply of in-demand credits for numerous endangered species. This appears to be the biggest failing of the Scheme. The lack of credits available on the market due to the focus of DPE on the development of vegetated land and identifying the number of credits required for it to be cleared. However, very little focus on ensuring high conservation value vegetation is protected to enable those credits to be purchased.

The Auditor identifies 90 percent of offset sites under the scheme were not being monitored to ensure the required environmental benefits were being delivered. Indeed, as DPE does not maintain a public register of biodiversity credits with complete information, it cannot check that developments have been acquitted with the required credits. DPE is not, therefore, able to assess the Scheme's overall effectiveness.[91]

Key concerns of the Auditor were for the Scheme's integrity, transparency, and sustainability. The risk, identified by the Auditor, is that biodiversity gains made through the Scheme will not be sufficient to offset losses resulting from the impacts of development.

The BOS is premised on the misguided notion that threatened species populations and ecosystems can persist while we continue to reduce the area of available habitat. The only biodiversity offset scheme that could work for threatened species protection is one that increases the area of high quality habitat, rather than ever diminishing habitat area under the current BOS.

The current BOS must be replaced with a mechanism that better prioritises brownfield urban development and infill, radically restricts the ability to remove native vegetation, and provides adequate support and incentives for landholders to conserve high quality habitat, important linkages and corridors.

Threatened Species in the Barrington to Hawkesbury region rely on significant areas of bushland on private land: 42 percent of the native vegetation of the region is on private land. Bushland loss due to urban sprawl is occurring in all the LGAs of the region, but is particular acute in Port Stephens Maitland, Cessnock, Newcastle, and Central Coast LGAs.

National Park Reserve System

Remaining habitats in State Forests, Crown Land and private land has been reduced to 30 percent of original carrying capacity. While, the public National Park reserve system, which covers just 9.6 percent of land in NSW, has an average ecological carrying capacity of 63 percent of original.[92] Nearly two-thirds (62 percent) of the area covered by NPW reserves retain at least 60 percent of original ecological carrying capacity, whereas only 2 percent of the total area of other tenures have that level of habitat condition. Some types of plant diversity are now largely only found in NPW reserves, due to clearing and fragmentation in other tenures, the proportion that uniquely persists in NPW reserves has increased from 8 percent to 9 percent. In other tenures, this proportion has decreased from 42 percent to 28 percent. This loss of persisting diversity across other tenures accounts for most of the 20 percent loss of original plant diversity State wide.

Clearly, if we are to secure the future of many threatened species, significant additions to National Park reserves are urgently required. While the secure protection of biodiversity on all public land should be the priority for conservation efforts in the Barrington to Hawkesbury region, the transfer of public lands to National Park tenure must also include adequate funds to manage these areas for conservation of species, populations, and ecosystems.

91 NSW Audit Office (2022). Op cit

92 NSW Environment Protection Authority (2021). Op cit.

View into the Hunter Valley - Barrington Tops National Park, Schopier, https://commons.wikimedia.org/wiki/File:View_into_the_Hunter_Valley_-_Barrington_Tops_National_Park.jpg

Expanded protected areas, refugia, and climate corridors

The two most frequently recommended biodiversity climate adaptation strategies are to expand protected areas and by conserving or restoring corridors or connected areas.[93] As climatic conditions change in the coming decades, the persistence of many populations of native species will depend on their ability to colonize newly suitable habitat. However, areas that facilitate this dispersal must be identified and protected from land uses that block such movement.[94]

Large-scale corridors that span climatic gradients can enhance the capacity of species to shift to new, more climatically favourable areas, allowing species to respond to shifting climates through natural dispersal rather than requiring active intervention. Regional scale corridors are particularly important to connect habitat refugia that may be critical to species' survival. Corridors can promote the movement of individuals between different populations, increasing gene flow and reducing genetic bottlenecks and drift associated with isolated populations, increasing the resilience of species to adapt to climate change.

Even small changes in climate may mean that species must travel considerable distances over land to stay within their preferred climatic "envelope". Corridors must, therefore, be large enough to support entire populations as they move – landscape corridors with high quality core habitat spanning large areas.

Ecological restoration plays an essential role in corridor conservation, in terms of restoring native vegetation, design of overpasses and underpasses across highways and canals, removal of aquatic barriers, and rehabilitation of mined areas.

Key directions for enhancing natural resilience have been reported as:

- **Identify and protect climate refugia**
- **Conserve large-scale migration corridors**
- **Maintain viable populations to enable adaptation**
- **Reduce threatening processes at the landscape scale**
- **Conserve natural processes and connectivity at the landscape scale and**
- **Special interventions to avert extinctions.[95]**

93 Beier, Paul. (2012). Conceptualizing and Designing Corridors for Climate Change. Ecological Restoration. 30. 312-319. 10.3368/er.30.4.312.

94 Carroll, C, Parks, SA, Dobrowski, SZ, Roberts, DR (2018) Climatic, topographic, and anthropogenic factors determine connectivity between current and future climate analogs in North America. *Glob Change Biol*. 2018; 24: 5318– 5331. https://doi.org/10.1111/gcb.14373

95 Taylor M. & Figgis P. (eds) (2007) Protected Areas: Buffering nature against climate change. Proceedings of a WWF and IUCN World Commission on Protected Areas symposium, 18-19 June 2007, Canberra. WWF Australia, Sydney.

Within the Barrington to Hawkesbury region, existing National Parks and the transfer of State Forests to the National Park Estate would accommodate most (70%) of the threatened species' suitable habitat in 2070 modelled by Beaumont et al (2019). However, to allow for populations to move as climate patterns shift, these areas must be functionally connected with large landscape scale corridors.

Five regional Coastal Climate Corridors were identified in 2007 by the then Department of Environment and Climate Change (See Map 11). From north to south, these include:

- **Lower Manning to Wallingat**
- **Wallingat to Karuah**
- **Karuah to Hunter**
- **Newcastle, and**
- **Lake Macquarie to Gosford.**

Twelve Dry Climate Corridors (See Map 12) were also identified including from north to south:

- **Barrington Tops,**
- **Barrington Tops to Paterson,**
- **Barrington to Muswellbrook,**
- **Karuah to Port Stephens,**
- **Pokolbin to Karuah,**
- **Belford to Karuah,**
- **Werakata,**
- **Pokolbin,**
- **Jilliby to Yango,**
- **Jilliby to Brisbane Waters**

Five Moist Climate Corridors (See Map 13) were additionally identified from north to south:

- **Mid North Coast Escarpment to Barrington**
- **Barrington to Myall**
- **Great Lakes To Barrington**
- **Paterson to West Barrington**
- **West Coastal Ranges to the Escarpment.**

In total, these Climate Corridors total 1,675,650 ha. However, the total area of the land of the Dry, Moist, and Coastal Climate Corridors in the region is 810,000 ha. While a number of overlaps occur, 80 percent of the 820,000 ha Mid North Coast Escarpment to Barrington corridors extend considerable distances along the escarpment to the north of the region.

Corridors that extend outside the region that provide vital linkages across the Hunter Valley are recommended for protection. These include the Moist West Coastal Ranges to Escarpment and Paterson to West Barrington Climate Corridors, and the Dry Pokolbin and Pokolbin to Karuah Climate Corridors.

While restoring native vegetation, installing overpasses and underpasses across highways, removal of aquatic barriers, and rehabilitation of mined areas will all play an essential role in the functionality of these corridors, conserving native vegetation within these corridors and protecting it from further degradation must begin now.

These Climate Corridors were described in 2007. Adjustments should be made after a thorough examination of the functionality and connectivity of key fauna habitats within these Climate Corridors, which may have been compromised by further fragmentation and degradation in the intervening 15 years.

Coastal Climate Corridors

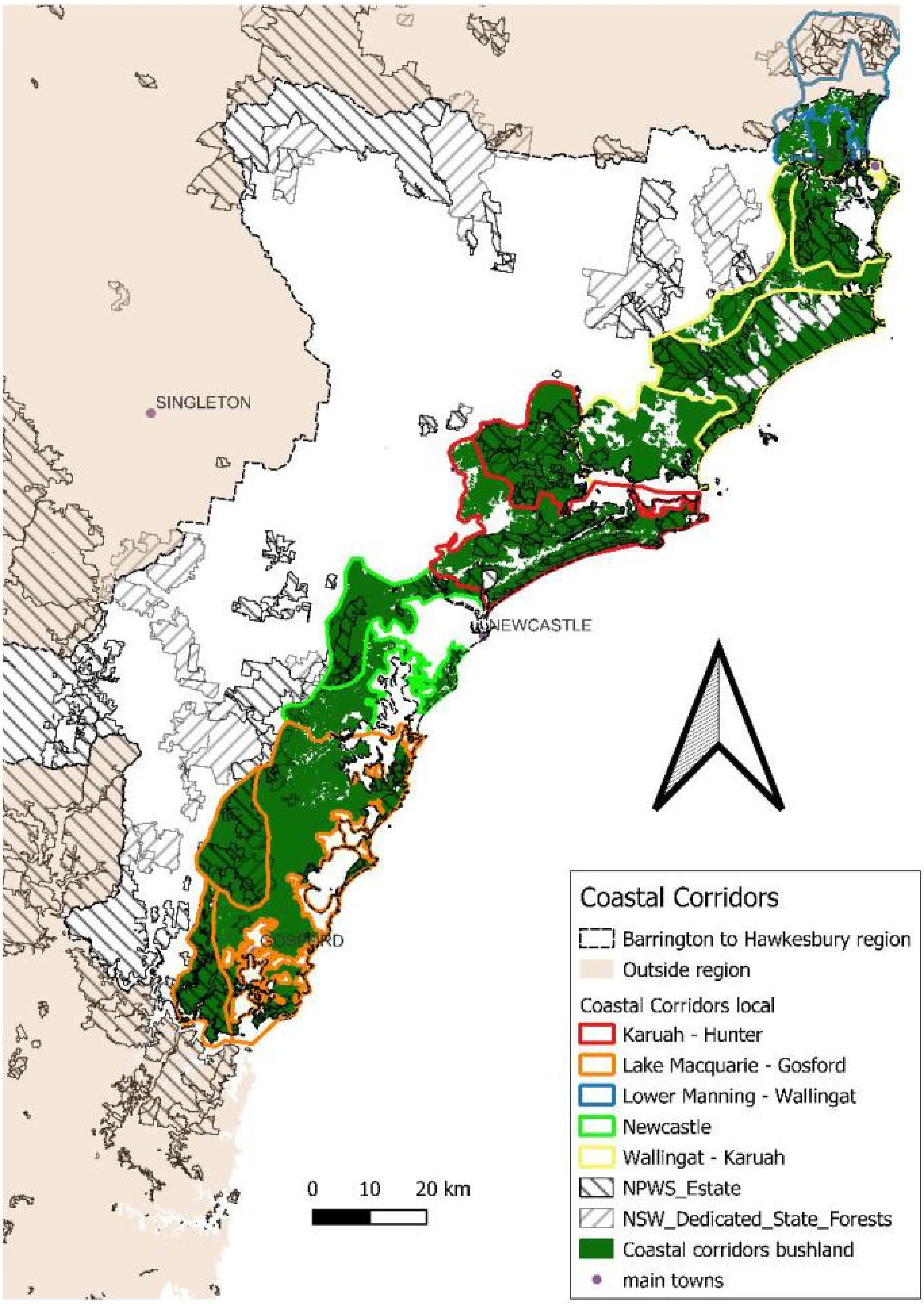
The Coastal Climate Corridors total almost 380,000 ha, and includes 260,000 ha of native vegetation, and 134,000 ha of key fauna habitats.

A key faunal species for the region's coast is the Koala with important populations in the coastal forests throughout this area, however much of the habitat is fragmented. Reconnection and restoration of these forests should be a priority for future works. Key faunal species such as Brush-tailed Phascogale and Squirrel Gliders will also benefit from the enhancement of coastal forests on the region. These Coastal Climate Corridors encompass projected critical habitats for Stephen's Banded Snake, Rosenberg's Goanna , Wallum Sedge Frog, Stuttering Frog, Easter-Pigmy Possum, Red-legged Pademelon, Yellow-bellied Glider, Greater Broad-nosed Bat, Powerful Owl, and Sooty Owl to 2070, and will assist in the migration of these and other species to newly suitable habitats as the climate changes.

Much of this habitat is on private land, which must be protected from further fragmentation if we are to salvage some of our biodiversity from the grips of climate change.

Table 6: Details of Coastal Climate Corridors between Barrington and Hawkesbury

Corridor name	Feature	Reference sp. 1	Reference sp.2	HCV	Key habitats (ha)	Vegetation (ha)	Area (ha)
Karuah - Hunter	Reserve buffer	Koala	Green and Golden Bell Frog	high	16,017	23,993	28,643
Wallingat - Karuah	Linkage across Floodplain	Koala	Green and Golden Bell Frog	high	12,042	21,409	35,282
Wallingat - Karuah	Linkage across Floodplain	Koala	Grey-headed Flying Fox	high	5,871	15,330	22,172
Wallingat - Karuah	Reserve buffer	Koala	Eastern Chestnut Mouse	high	23,882	43,405	47,762
Newcastle	Protect and enhance	Squirrel Glider	Grey-headed Flying Fox		6,270	15,101	22,347
Newcastle	Linkage across Floodplain	Squirrel Glider	Grey-headed Flying Fox		4,858	12,578	19,692
Lake Macquarie - Gosford	Reserve buffer	Koala		high	14,191	16,523	19,776
Lake Macquarie - Gosford	Reserve buffer	Squirrel Glider	Koala	high	8,830	11,700	15,008
Karuah - Hunter	Linkage across Floodplain	Koala	Squirrel Glider	high	14,681	36,225	55,668
Wallingat - Karuah	Reserve buffer	Koala	Grey-headed Flying Fox	high	9,471	20,876	27,138
Lake Macquarie - Gosford	Valley floor linkage	Squirrel Glider	Wallum Froglet	high	17,483	44,021	84,658
TOTALS					**133,596**	**261,161**	**378,147**



Map 11: Proposed protected Barrington to Hawkesbury Coastal Climate Corridor[96]

96 Dept of Environment and Climate Change (2007), Wildlife Corridors for Climate Change – Landscape Selection Process, Key altitudinal, Latitudinal and Coastal Corridors, An internal report, DECC, N.S.W. Datasets: State Government of NSW and Department of Planning and Environment (2010a). Climate Change Corridors (Coastal Habitat) for North East NSW. https://datasets.seed.nsw.gov.au/dataset/climate-change-corridors-coastal-habitat-for-north-east-nsw

While there are relatively large areas of extant vegetation in the Coastal corridors, the percentage of Key Habitat and Old Growth is relatively low overall. The area of Key Habitat is a subset, in many cases a small subset, of the existing vegetation. Likewise, the area of old growth is a very small percentage of extant vegetation, in many cases less than 5% of the area.

Priorities for particular corridor features should focus on improving the marginal areas, for example joining of stepping stone remnants and enhancing existing lower-quality vegetation stands. The protection of existing High Conservation Value (HCV) vegetation can include improving reserve buffers, and providing links from the coast to the hinterland as well as between coastal habitats.

Coastal wetlands are a major habitat of importance on the region's coast. Many species of frogs and migratory wading birds are restricted to coastal environments and the wetlands of the region. Over the long term, these important areas can provide stronghold populations for coastal fauna. Projects which restore natural drainage and allow for the wetland systems to exist without pressure from agriculture and urban development will enhance the viability of wetlands of the region.

Key reference species for the Coastal Climate Corridors include Koala, Grey-headed Flying Fox, Eastern Chestnut Mouse, Squirrel Glider, Wallum Froglet, and Green and Gold Bell Frog.

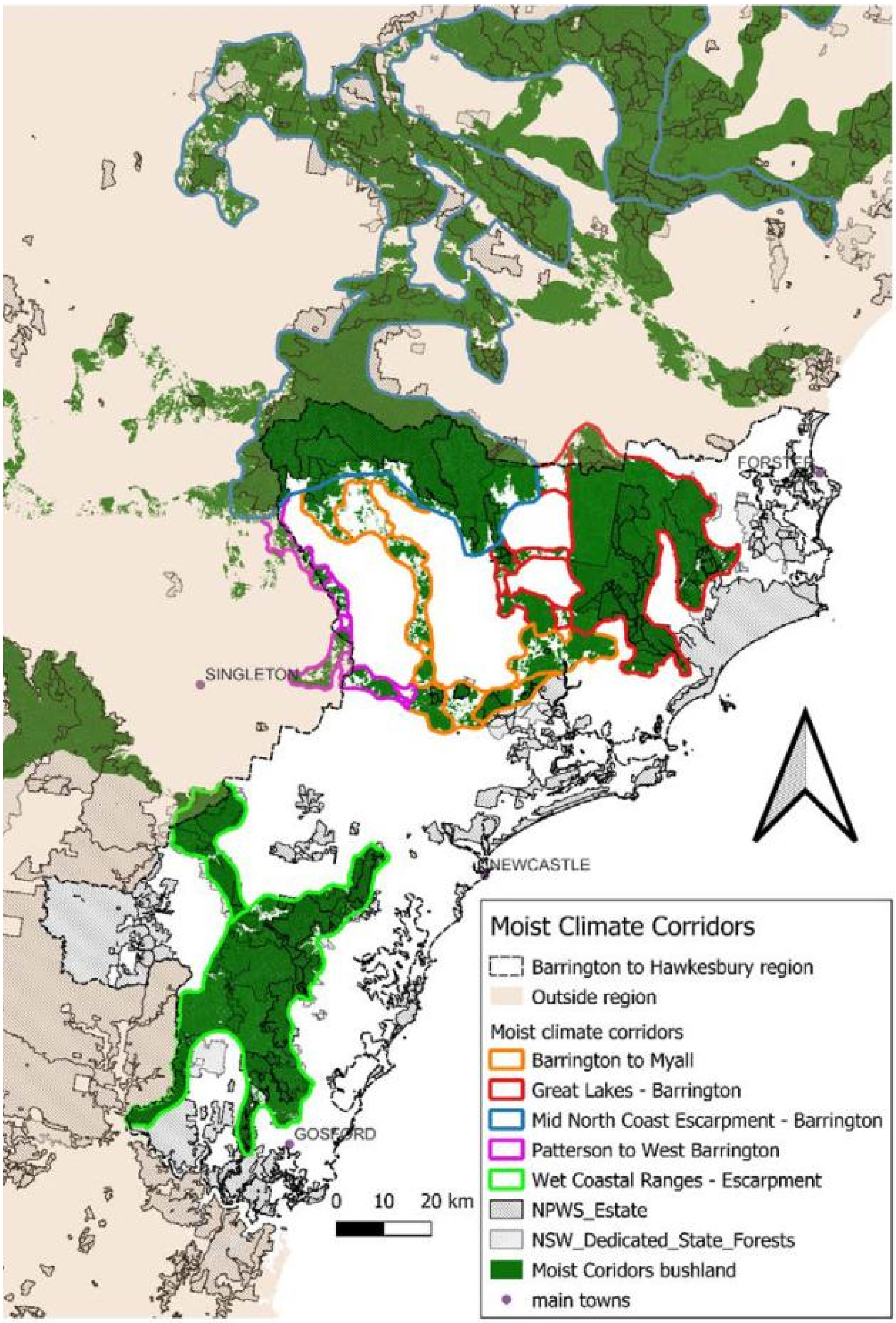
Moist Climate Corridors

The Moist Climate Corridors total about 1.4 million ha, including over 1 million ha of native vegetation, 470,000 ha of key fauna habitats, 260,000 ha of old growth forest, and over 200,000 ha of rainforest. However, about 80 percent of the 817,000 ha Mid North Coast Escarpment to Barrington Corridor is outside the region.

Table 7: Details of Moist Climate Corridors between Barrington and Hawkesbury

Corridore name	Reference sp.1	Reference sp.2	Voluntary Conservation Agreement	HCV	Key habitat (ha)	Vegetation (ha)	Rainforest (ha)	Old growth (ha)	Corridor area (ha)
Barrington to Myall	Grey-headed Flying Fox	Sooty Owl	priority		7,772	36,040	3,091	3,649	64,321
Great Lakes - Barrington	Stuttering Frog	Sooty Owl	priority	high	54,923	121,080	6,398	18,619	116,288
Mid North Coast Escarpment - Barrington	Giant Barred Frog	Sooty Owl	priority	high	330,593	737,888	196,903	235,111	817,410
Patterson to West Barrington	Koala	Grey-headed Flying Fox			365	12,390	1,130	1,802	21,916
Wet Coastal Ranges - Escarpment	Yellow-bellied Glider	Sooty Owl	priority	high	75,918	105,584	673	-	121,775
TOTALS					**469,571**	**1,012,982**	**208,195**	**259,181**	**1,141,711**

The Moist corridors link major moist habitats such as high altitudinal rainforest and wet sclerophyll and moist eastern foothills forests. The moist habitat assemblage corridors network links contiguous areas of forest across altitudinal gradients and latitudinal gradients. Reference species are predominantly rainforest and high altitudinal species considered quite vulnerable to the impacts of climate change.[97]



Map 12: Proposed protected Barrington to Hawkesbury Moist Climate Corridor[98]

97 The Department of Environment and Climate Change (2007) FAUNA CORRIDORS FOR CLIMATE CHANGE Landscape Selection Process Key Altitudinal, Latitudinal and Coastal Corridors for response to Climate Change Hunter Central Rivers Catchment Management Authority (HCRCMA).

98 State Government of NSW and Department of Planning and Environment (2010b). Climate Change Corridors (Moist Habitat) for North East NSW. https://datasets.seed.nsw.gov.au/dataset/climate-change-corridors-moist-habitat-for-north-east-nsw

Reference species include Sooty Owl, Yellow-bellied Glider, Grey-headed Flying Fox, Koala, Stuttering Frog, and Giant Barred Frog. These are predominantly rainforest and high altitudinal species considered quite vulnerable to the impacts of climate change.

These Moist Climate Corridors encompass critical habitat for Giant Burrowing Frog, Eastern False Pipistrelle, Golden Tipped Bat, Eastern Pigmy Possum, Parma Wallaby, Red-legged Pademelon, Spotted-tailed Quoll, Gang-gang Cockatoo, Glossy Black Cockatoo, Masked Owl, Powerful Owl, Sooty Owl to 2070.

There is an absence of moist corridor connection across the Hunter Valley due to the drier environments occurring there and the fact that the Hunter Valley is a natural dry barrier for many moist habitat species. The corridors designated HCV Linkages highlight the areas where populations of moist assemblage species will be present in the corridor based on the presence of areas of key habitat.[99]

99 *ibid*

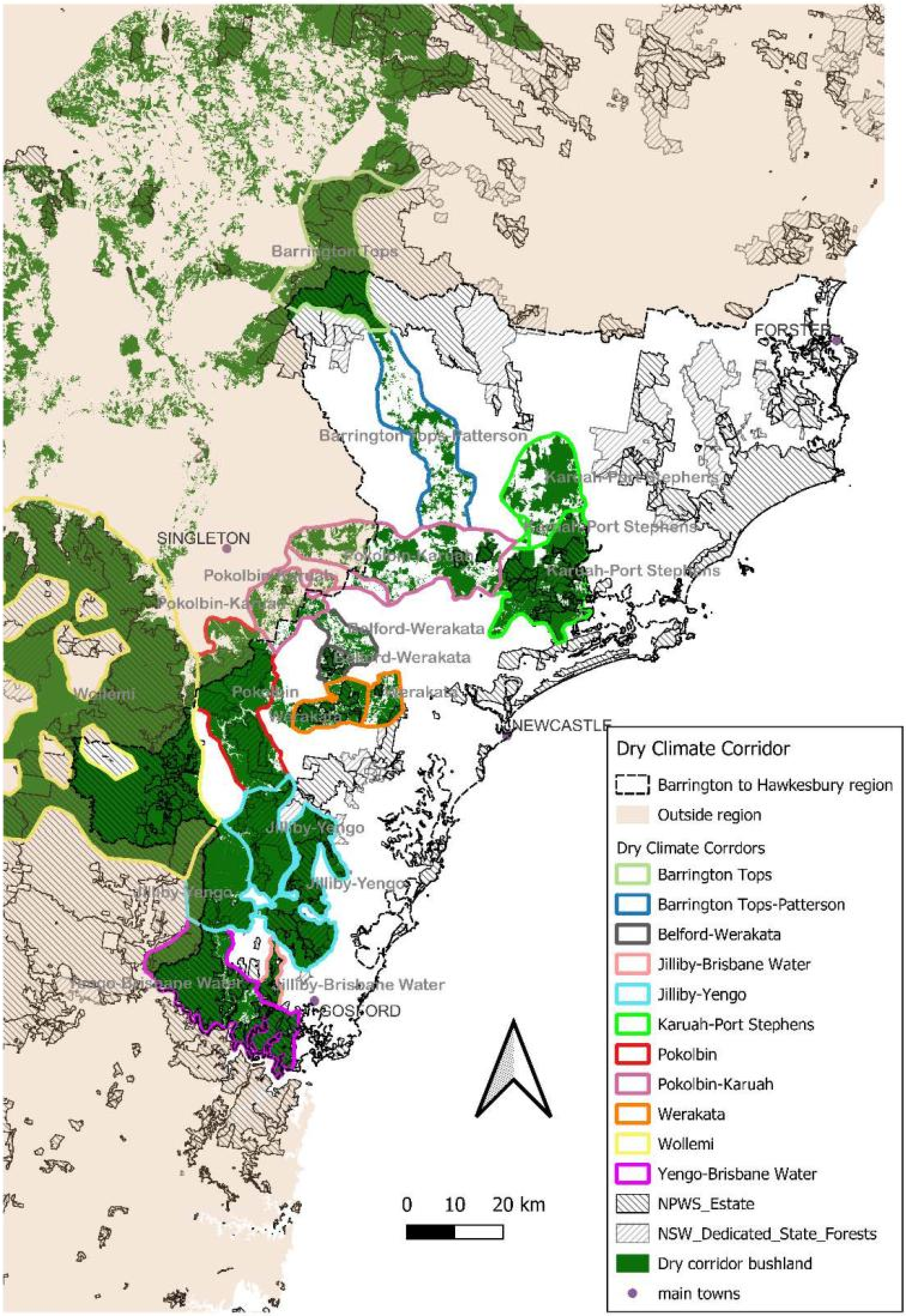
Dry Climate Corridors

There is a strong network of corridors and associated key habitats for dry habitat assemblages across the Hunter Valley in locations where moist habitat assemblages are absent. The Hunter Valley has historically represented a 'dry' barrier to many moist habitat fauna species. HCV Linkages highlight the areas where good populations of dry assemblage species should be already utilising the corridor based on the presence of areas of key habitat.[100]

Table 8: Details of Dry Climate Corridors between Barrington and Hawkesbury

Corridor name	Feature	Reference sp. 1	Reference sp. 2	HCV	Vegetation (ha)	Key habitats (ha)	Old growth (ha)	Coridor area (ha)
Barrington Tops	Reserve Buffer	Broad-toothed Rat		HCV	39,898	30,110	9,017	41,677
Barrington Tops-Patterson	Stepping Stone Remnants	Squirrel Glider	Grey-headed Flying-fox		10,296	893	443	36,758
Belford-Werakata	Valley Floor Linkages	Woodland Birds	Squirrel Glider		2,709	662	-	7,395
Belford-Werakata	Reserve Buffer	Woodland Birds	Squirrel Glider		3,024	2,678	-	4,172
Jilliby-Brisbane Water	Reserve Buffers and Linkages	Red-crowned Toadlet		HCV	3,871	2,823	-	4,272
Jilliby-Yengo	Protect and Enhance Existing	Koala	Giant Burrowing Frog	HCV	23,098	14,247	-	24,604
Jilliby-Yengo	Reserve Buffers and Linkages	Koala	Giant Burrowing Frog	HCV	26,786	22,406	-	29,847
Jilliby-Yengo	Valley Floor Linkages	Koala	Giant Burrowing Frog	HCV	18,160	15,682	-	20,383
Karuah-Port Stephens	Reserve Buffers and Linkages	Coastal Emu	Koala	HCV	27,194	17,684	2,915	34,190
Karuah-Port Stephens	Valley Floor Linkages	Coastal Emu	Koala	HCV	14,109	886	1,254	25,394
Karuah-Port Stephens	Linkage across Floodplain	Coastal Emu	Koala	HCV	167	11	10	1,110
Pokolbin	Valley Floor Linkages	Woodland Birds	Brush-tailed Rock Wallaby	HCV	38,382	16,479	-	44,883
Pokolbin-Karuah	Valley Floor Linkages	Woodland Birds	Brush-tailed Phascogale		21,750	4,755	3,164	49,571
Pokolbin-Karuah	Linkage across Floodplain	Woodland Birds	Brush-tailed Phascogale		269	3	-	7,417
Pokolbin-Karuah	Valley Floor Linkages	Woodland Birds	Brush-tailed Phascogale		6,430	2,707	-	18,234
Werakata	Reserve Buffers and Linkages	Woodland Birds	Swift Parrot	HCV	9,490	6,315	-	11,529
Werakata	Valley Floor Linkages	Woodland Birds	Swift Parrot	HCV	4,239	1,690	-	7,018
Yengo-Brisbane Water	Reserve Buffers and Linkages	Red-crowned Toadlet		HCV	40,730	24,595	-	44,334
Totals					**229,444**	**129,316**	**16,803**	**324,255**

100 The Department of Environment and Climate Change (2007) FAUNA CORRIDORS FOR CLIMATE CHANGE Landscape Selection Process Key Altitudinal, Latitudinal and Coastal Corridors for response to Climate Change Hunter Central Rivers Catchment Management Authority (HCRCMA).



Map 13: Proposed protected Barrington to Hawkesbury Dry Climate Corridor[101]

101 State Government of NSW and Department of Planning and Environment (2010). Climate Change Corridors (Dry Habitat) for North East NSW. https://datasets.seed.nsw.gov.au/dataset/climate-change-corridors-dry-habitat-for-north-east-nswf5a7e

The Dry Climate Corridors total almost 320,000 ha, including 230,000 ha of native vegetation, 130,000 ha of key fauna habitats, and 17,000 ha of old growth forest.

These Dry Climate Corridors encompass projected critical climate refugia in 2070 for the Regent Honeyeater, Red-crowned Toadlet, Yellow-bellied Glider, Eastern False Pipistrelle, Gang-gang Cockatoo, Glossy Black Cockatoo, Powerful Owl, and Speckled Warbler.

Key reference species for the Dry Climate Corridors include Brush-tailed Rock Wallaby, Broad-toothed Rat, Squirrel Glider, Brush-tailed Phascogale, Grey-headed Fling Fox, Koala, Woodland Birds, Swift Parrot, Giant Burrowing Frog, and Red-crowned Toadlet. [102]

The cleared floodplains of the region represent major barriers to dispersal for many species. It is recognised that considerable resources would be required to complete these links however their importance should not be ignored. The higher productivity, access and permanent water of the major river systems will make these areas a high priority for conservation activities to address climate change. These have been refugia in past droughts and should be a high priority for future conservation efforts. Projected increased salinity in these areas may mean land becomes available for conservation as farming becomes unviable. [103]

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102 State Government of NSW and Department of Planning and Environment (2010).Op cit

103 ibid

Sooty Owl, (Tyto tenebricosa), Josh Smart, @wildy_smart

Conclusion and recommendations

We recommend:

1. **An immediate moratorium on further land clearing within identified Climate Corridors.**
2. **A specific strategy be included in the 2041 Regional Plans for Hunter and Central Coast for the protection of Climate Corridors supported by detailed zoning and development guidelines under local environmental plans and development control plans and investment programs implemented by Local Land Services.**
3. **The Biodiversity Offset Scheme be radically amended to provide adequate stewardship payments to encourage landholders to protect, manage, and rehabilitate native vegetation within Climate Corridors.**
4. **Targeted voluntary private land acquisition of large core areas of high quality habitat and essential corridors for restoration, particularly the large areas of moist forests in southern Mid-coast, and moist and dry landscapes across the Hunter River Valley through Cessnock, Singleton, and Dungog LGAs.**
5. **State Forests be transferred to National Park reserves as Regional Parks or other appropriate reserve category and managed by local communities for conservation and recreation.**

The internationally significant Barrington to Hawkesbury region is centred on the Hunter Valley which represents the major break in the Great Dividing Range providing a link between coastal and inland NSW and represents an important overlap between tropical and temperate zones, as such the limits of many species are found here.

The region provides climate refugia critical for the survival of viable populations of many of the State's Threatened species. Sixty percent of fauna species' habitat modelled in south-eastern Australian are represented, 44 percent of which will likely suffer significant range contractions over the next 50 years. Under a worst case climate change scenario, 13 percent of the fauna species examined between Barrington Tops and the Hawkesbury River are at risk of regional climate related extinction.

Despite being relatively unaffected by the Black Summer wildfires, native species of the region are under intense pressure from agriculture, forestry and urban development. The intensity of logging has increased and has now been shown to increase fire risk. The last ten years has seen over 7,000 ha of region's native bushland earmarked for "greenfield" urban development. From 2008 to 2017, about 6,500 ha of bushland was lost in the region, almost a third due to logging in southern Mid-coast LGA. Habitat fragmentation and degradation erodes resilience to climate change by driving down native species population numbers, blocking movements and disrupting natural ecological processes.

The pace of the changing climate is intensifying existing threats to native species and is likely to become the greatest threat to native species in the coming decades. Under the worst case climate future suitable habitat for 45 percent of the NSW Threatened fauna modelled is unlikely to be sufficient to support viable populations, and habitat for almost 60 percent of native fauna modelled for the NSW north coast and tablelands are projected to consistently decline in response to climate change.

Our research suggests the Barrington to Hawkesbury region may offer viable climate change refugia for a greater number of Threatened fauna species than elsewhere in NSW. The percentage of Threatened fauna habitat modelled to decline to 2070 in the Barrington to Hawkesbury region is found to be significantly lower than reported for the entire NSW northeast, with 44 percent declining compared to 58 percent for the northeast.

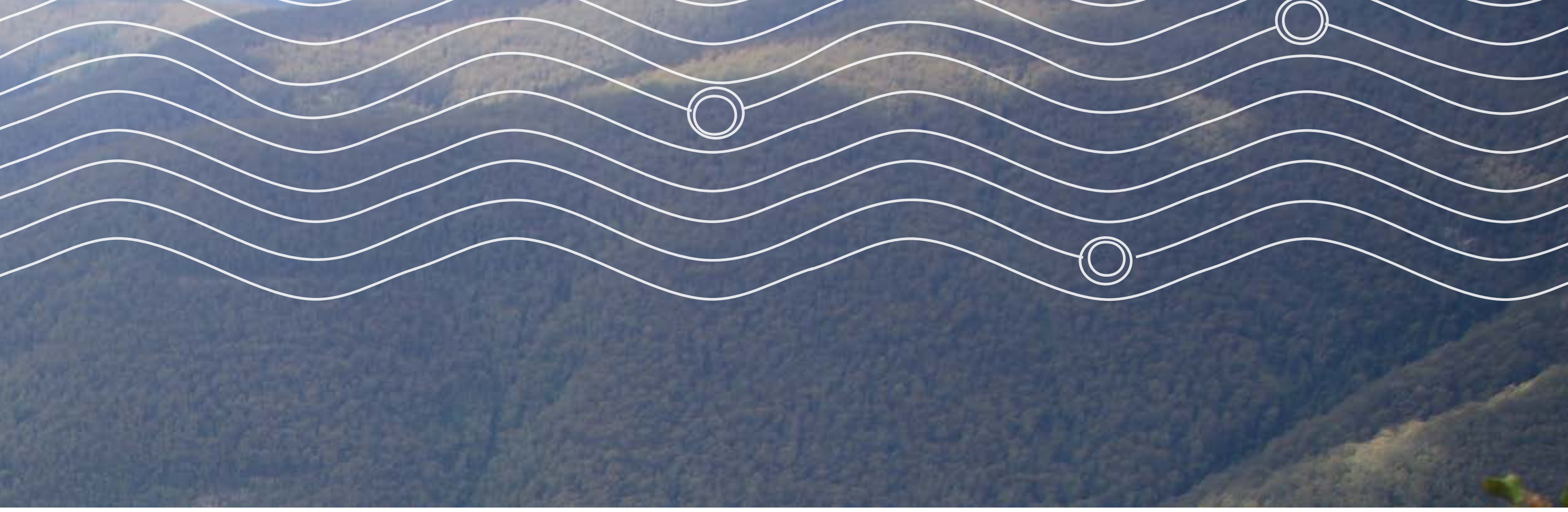
We further estimate that 13 percent of the species projected for the region, under a worst case climate scenario, will have insufficient habitat. Reported State-wide estimates suggest 45 percent of modelled fauna species will have little or no suitable habitat in 2070.

The Barrington to Hawkesbury region offers the advantage of elevated coastal foothills and escarpment forests functionally connected with coastal and valley floor habitats enabling species to migrate to these more suitable elevated habitats as the climate changes. These large-scale functioning corridors span climatic gradients and enhance the capacity of populations to shift to new climate refugia, allowing species to respond to shifting climates and extreme events through natural dispersal rather than requiring active intervention.

If we are to provide the greatest chance for native species to survive the ravages of climate change, these connected habitats must be protected from further fragmentation and degradation. If we wish to minimise native species' extinction, climate refugia and identified Climate Corridors must be legally protected.

Five Coastal Climate Corridors, twelve Dry Climate Corridors, and five Moist Climate Corridors identified in 2007 by NSW Government are recommended for protection from further regional bushland loss and degradation. This will require the transfer of State Forests to secure conservation tenure as Regional Parks or other appropriate reserve caategory under the National Parks and Wildlife Act 1974, and appropriate Local Environment Plan Zoning and the provision of stewardship payments and targeted acquisition for private bushland conservation.

The five described Coastal Climate Corridors will improve reserve buffers, and provide links from the coast to the hinterland as well as between



coastal habitats. These Coastal Climate Corridors encompass critical habitats for half of the native fauna species projected to decline in the region to 2070, and will assist in the migration of these and other species to newly suitable habitats as the climate changes. Key faunal species of these Climate Corridors include the Koala, Squirrel Glider, and Brush-tailed Phascogale with important populations in the coastal forests throughout this area, however much of the habitat is fragmented. Reconnection and restoration of these forests must be a priority for future works.

The five Moist Climate Corridors link high altitudinal rainforest and wet sclerophyll and moist eastern foothills forests and link contiguous areas of forest across altitudinal and latitudinal gradients. However, they do not connect across the Hunter Valley representing a barrier for many moist habitat species. Reference species are predominantly rainforest and high altitudinal species considered highly vulnerable to the impacts of climate change. These Moist Climate Corridors encompass critical habitat for almost 60 percent of the species projected to decline to 2070 in the region.

There is a strong network of twelve Dry Climate Corridors and associated key habitats for dry habitat assemblages across the Hunter Valley in locations where moist habitat assemblages are absent. These Dry Climate Corridors encompass projected critical habitat for 40 percent of the species projected to decline by 2070.

These 22 Climate Corridors incorporate about 74 percent of the region. However, Climate Corridors that extend outside the region along the region's western boundary within Singleton LGA, provide vital linkages across the Hunter Valley. These include the Moist West Coastal Ranges to Escarpment and Paterson to West Barrington Climate Corridors, and the Dry Pokolbin and Pokolbin to Karuah Climate Corridors.

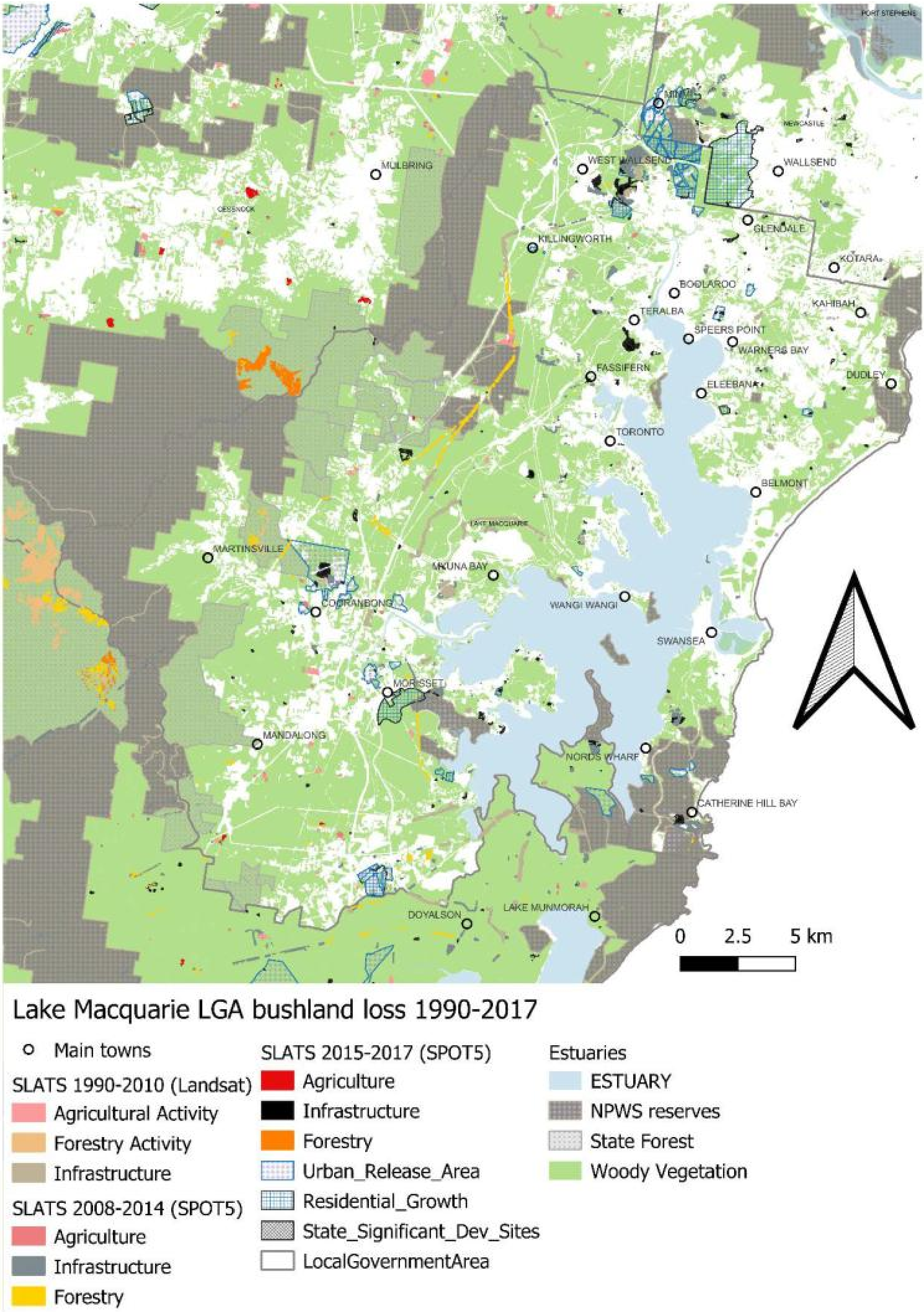
Rapidly reducing greenhouse gas emissions will be necessary to avert the worst extinction predictions. However, despite positive commitments from some countries, annual global greenhouse gas emissions continue to rise, with 2021 seeing a 6.4 percent increase, a new record.

Further fragmentation and degradation of existing habitat in State Forest and on private land must be reined in if we are to salvage some of our biodiversity from the grips of climate change. Conserving climate refugia predicted to be required under a worst case scenario and facilitating the movement of species to these refugia along identified climate corridors is fundamental to this end.

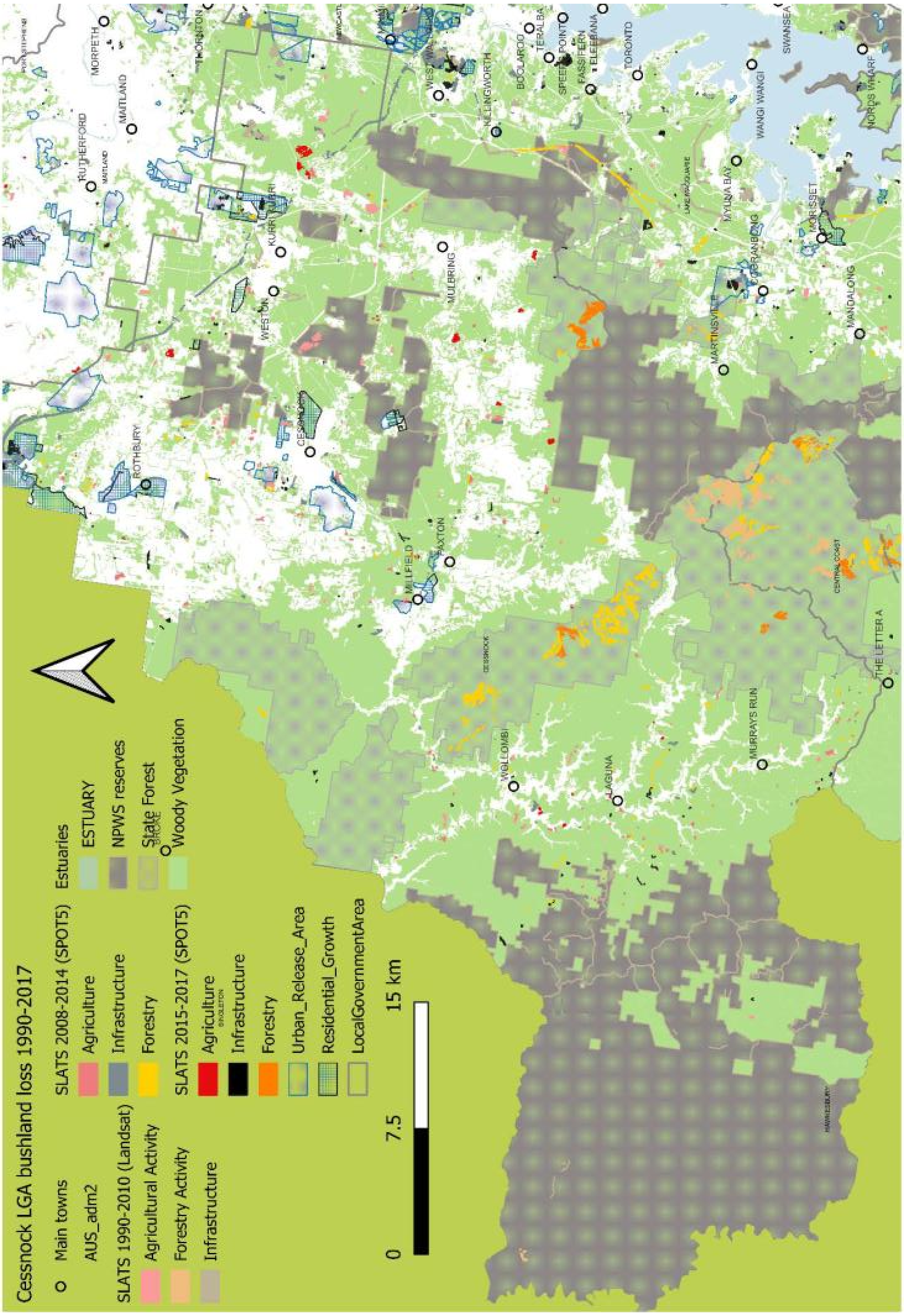
Such action will be controversial, many depend on agriculture and forestry, and housing shortages are putting upward pressure on house prices spiring governments to increase housing stocks to alleviate the shortage. Agriculture, forestry, and urban development need not have the impact on the natural world they currently do. We must decouple economic prosperity from biodiversity loss and implement a rational adaptation strategy, such as this, to avoid ecological catastrophe.

Appendix 1

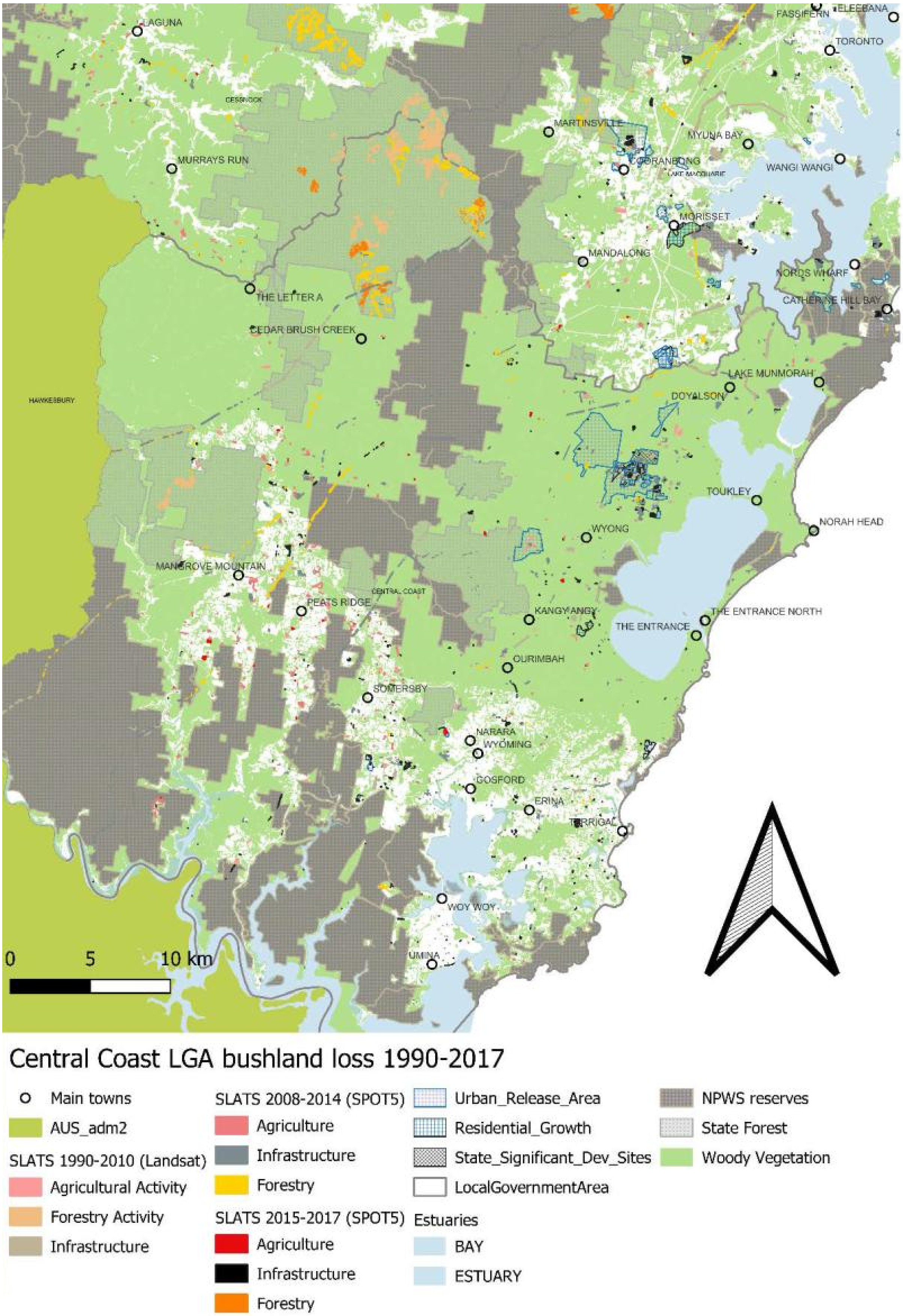
Lake Macquarie land clearing 1990 to 2017



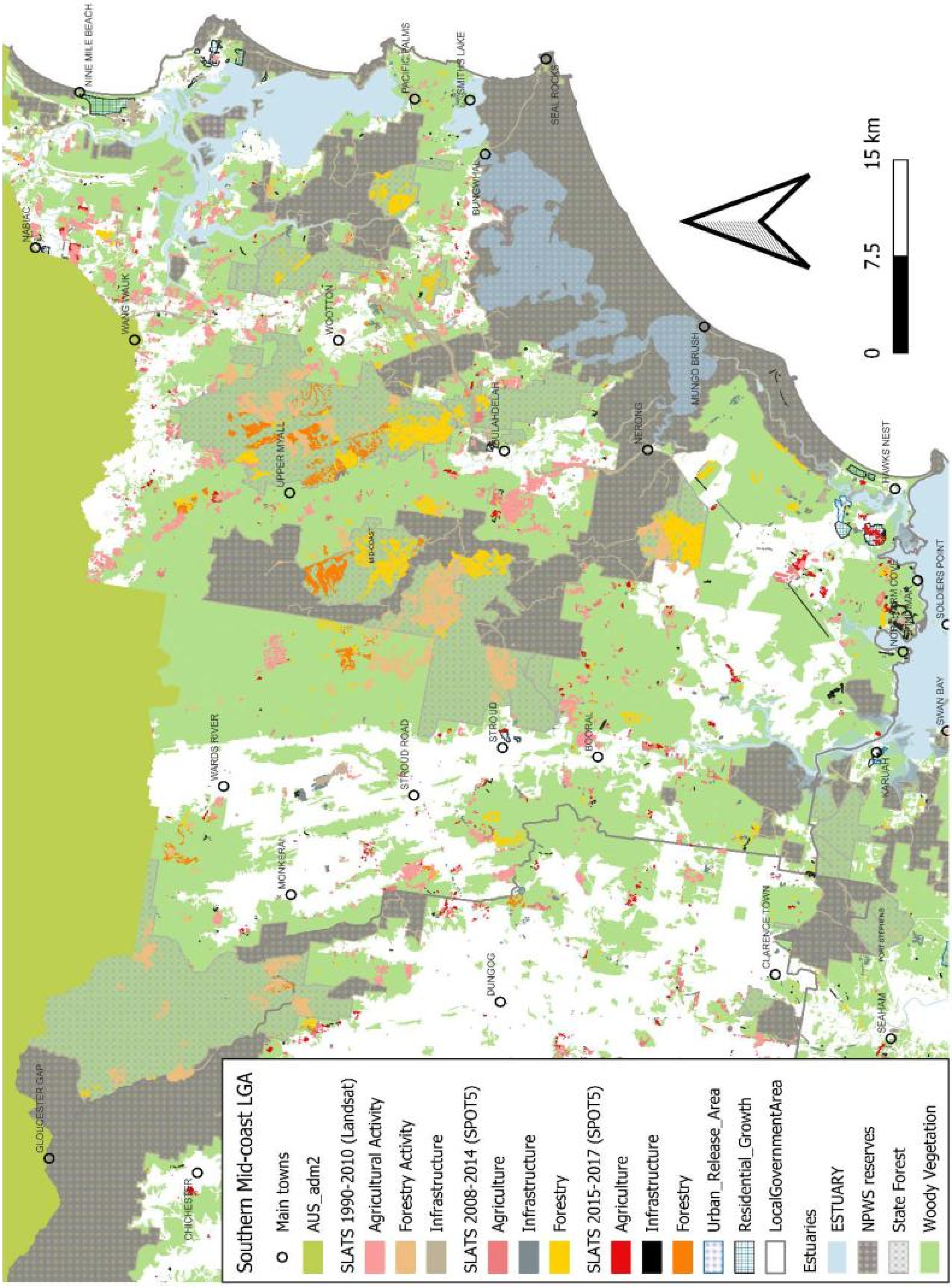
Cessnock land clearing 1990 to 2017



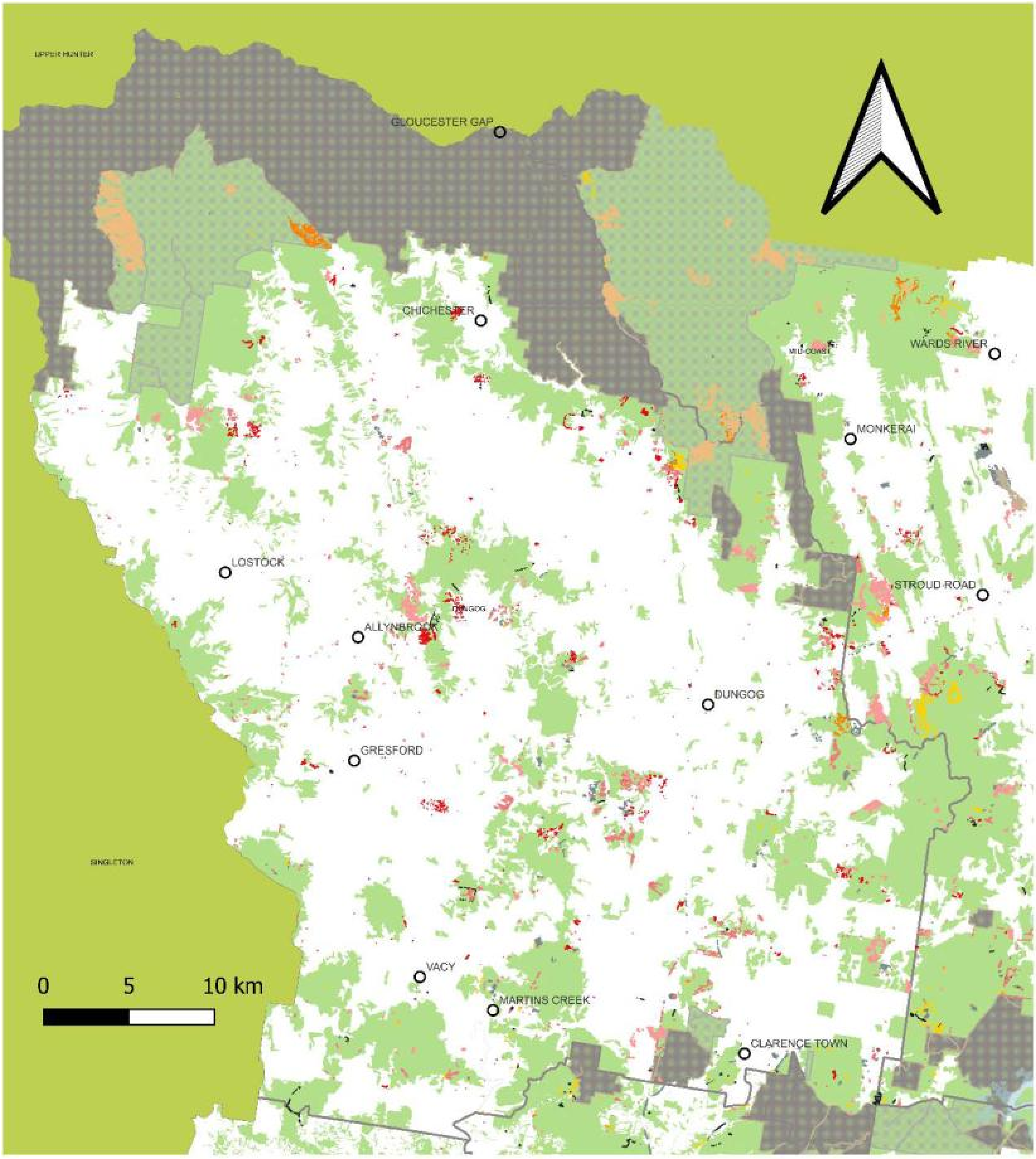
Central Coast land clearing 1990 to 2017

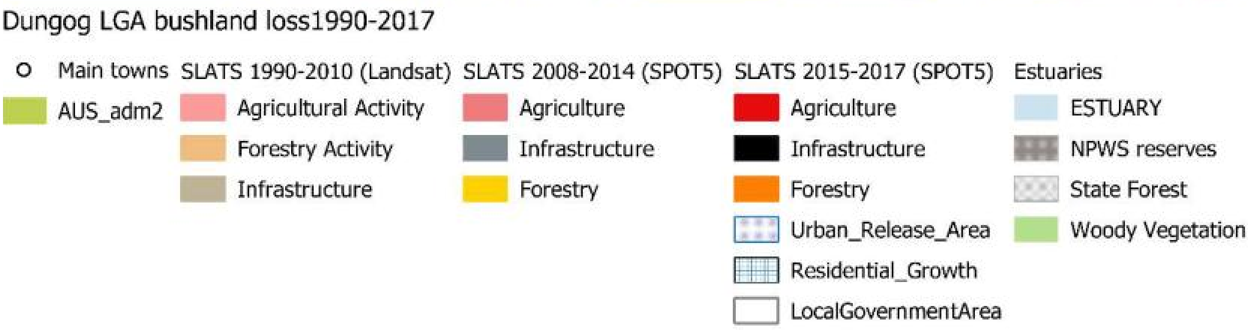


Mid-coast land clearing 1990 to 2017

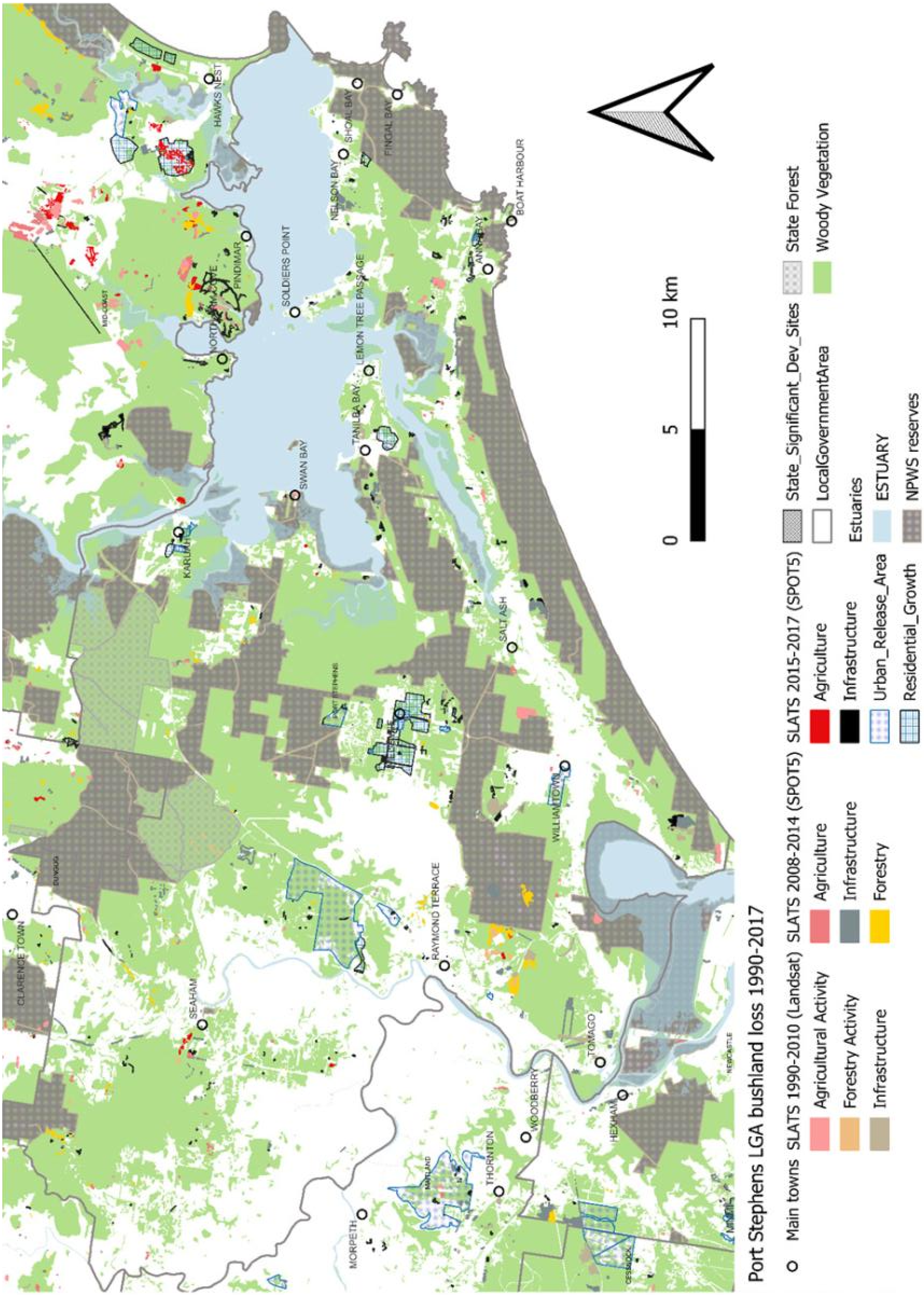


Dungog land clearing 1990 to 2017

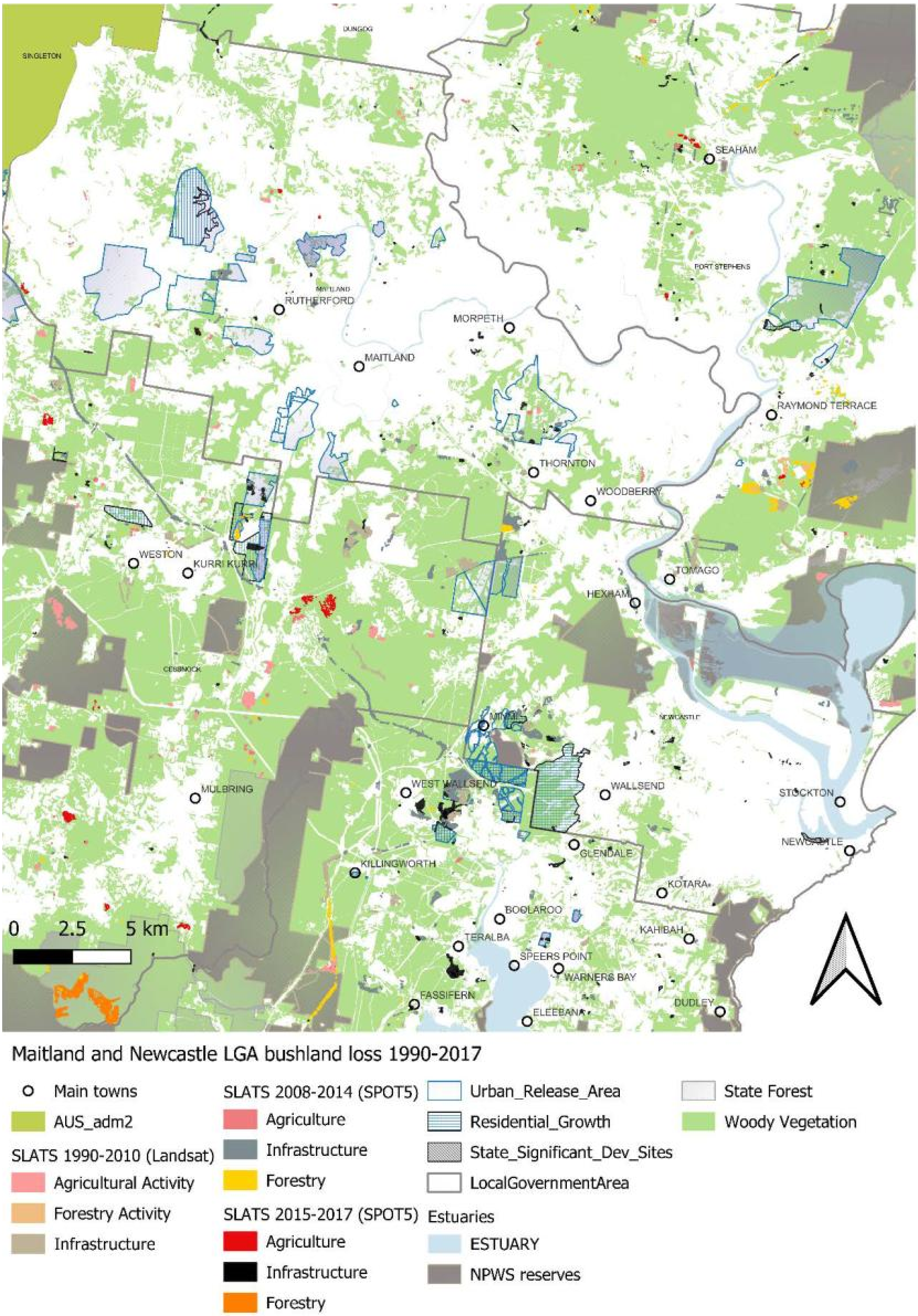




Port Stephens land clearing 1990 to 2017



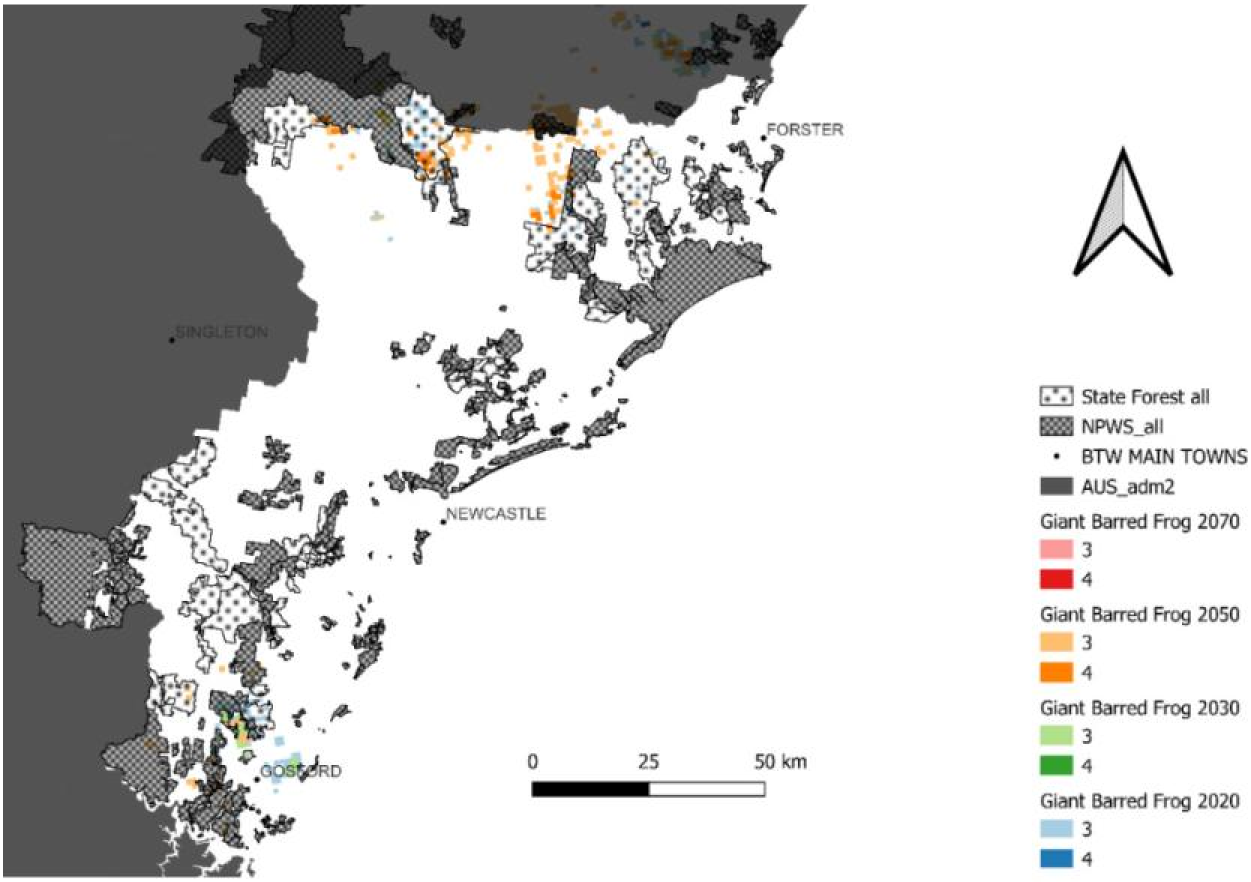
Maitland and Newcastle land clearing 1990 to 2017



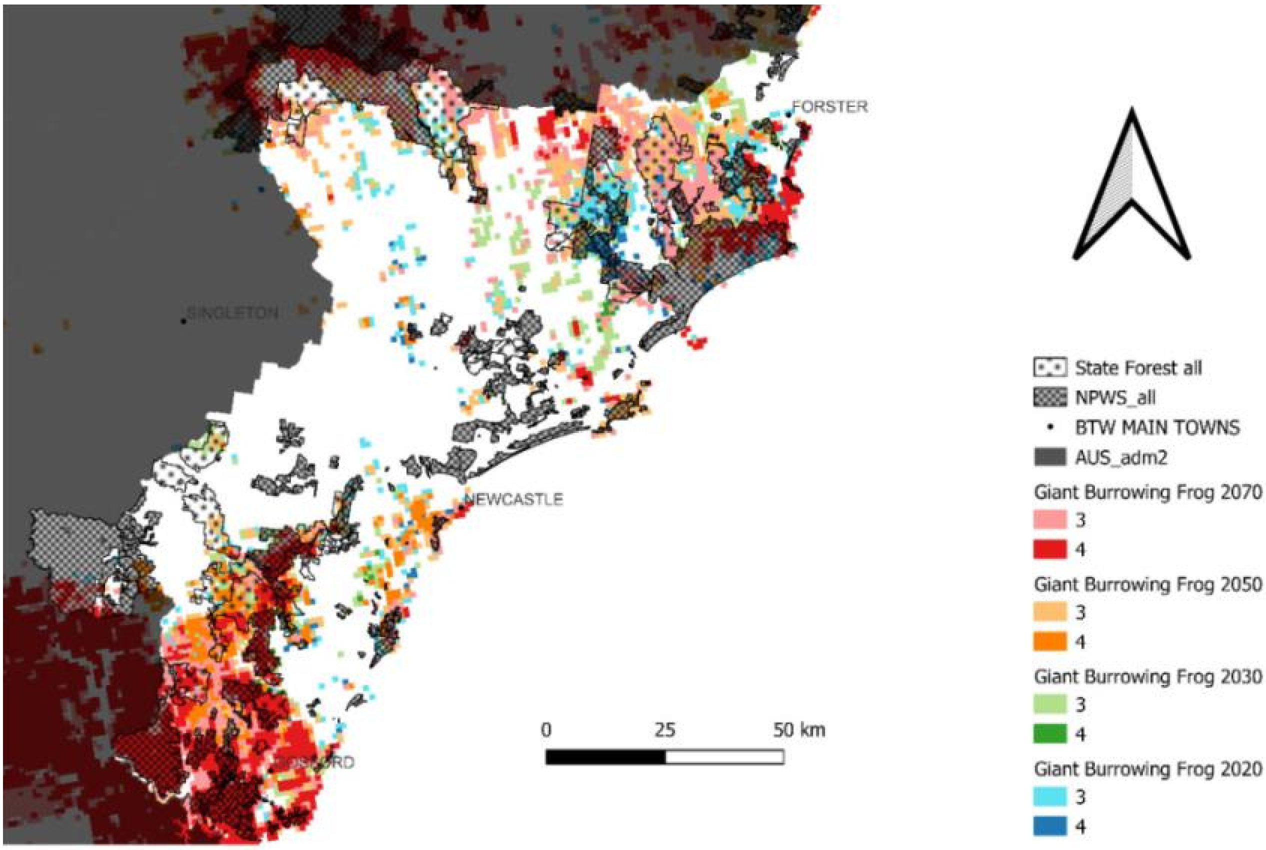
Appendix 2:

Fauna Habitat models projected to 2070 depicting overlapping climate refugia predicted under 3 climate changing scenarios (Hotter/Little change in rainfall excluded) and under all 4 climate changing scenarios (Hotter/Little change in rainfall include)

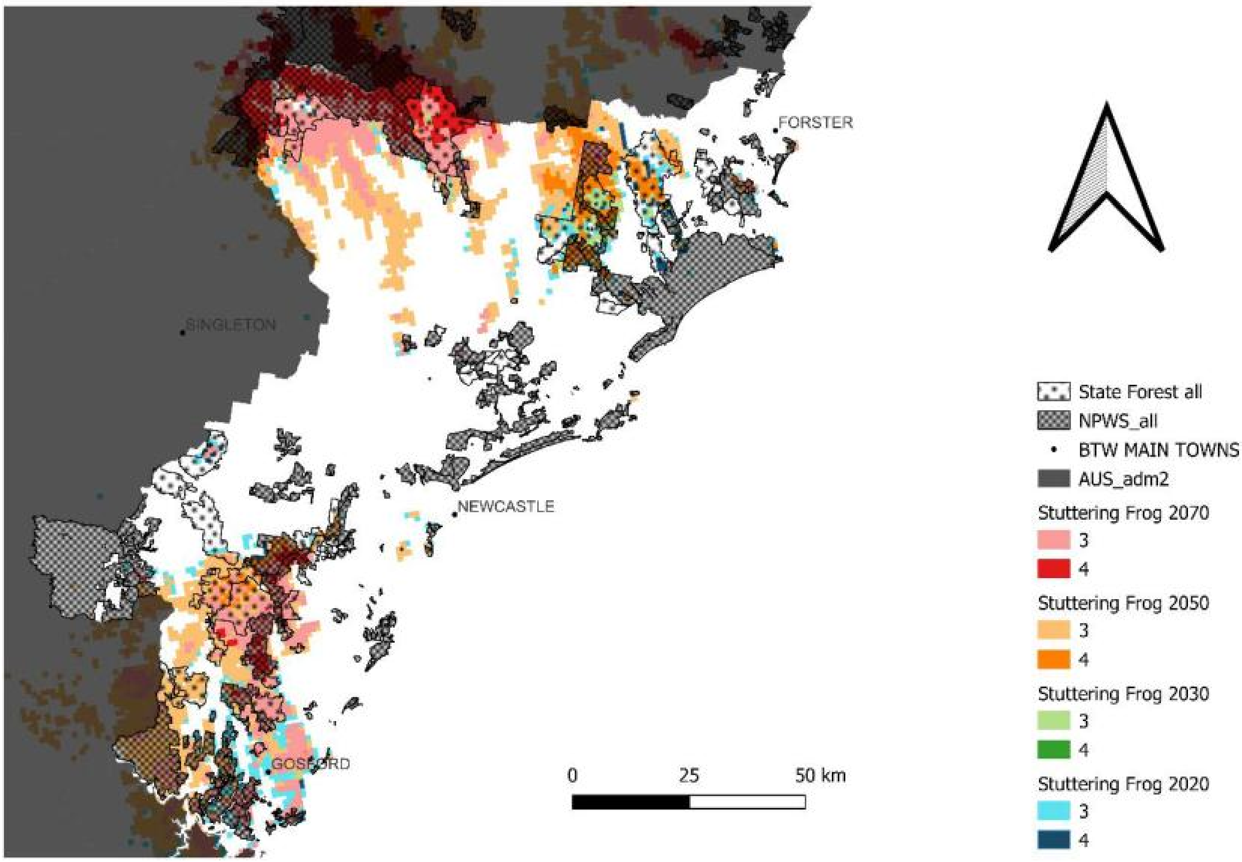
Amphibians



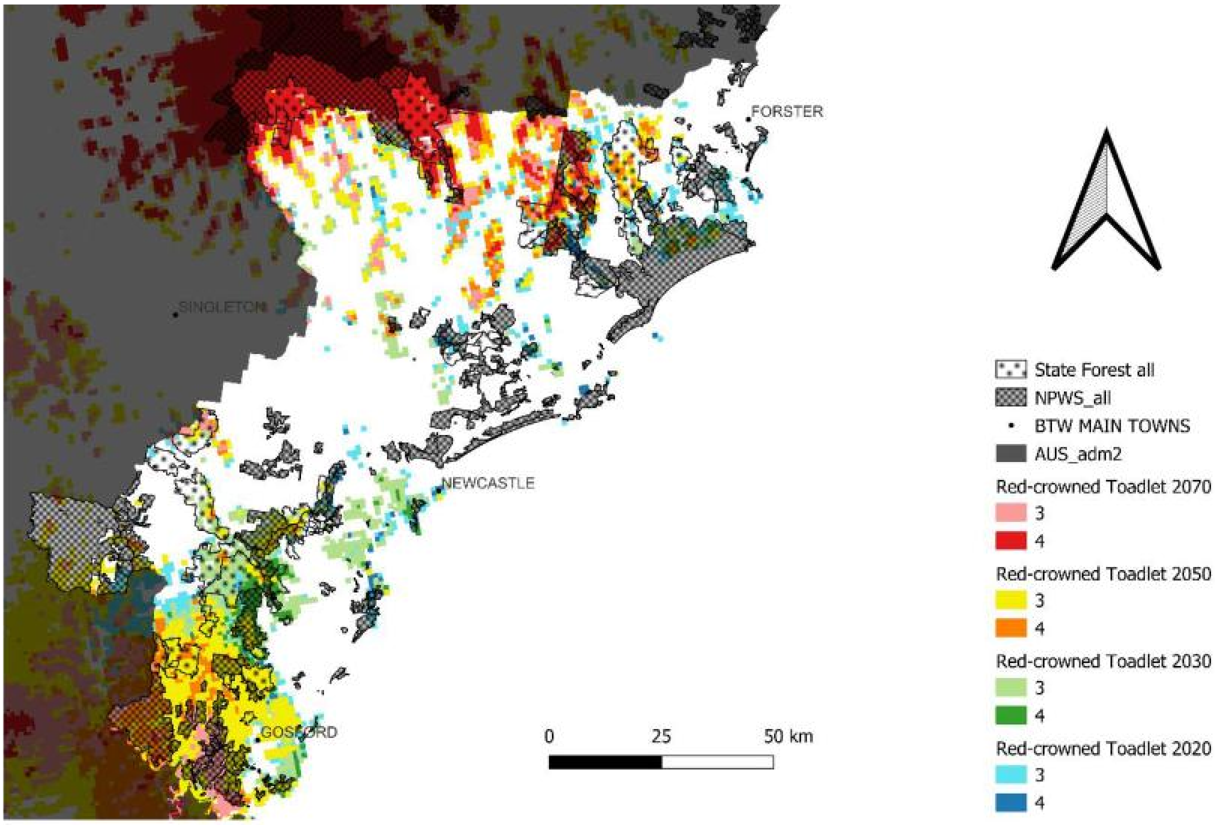
Giant Barred Frog Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070



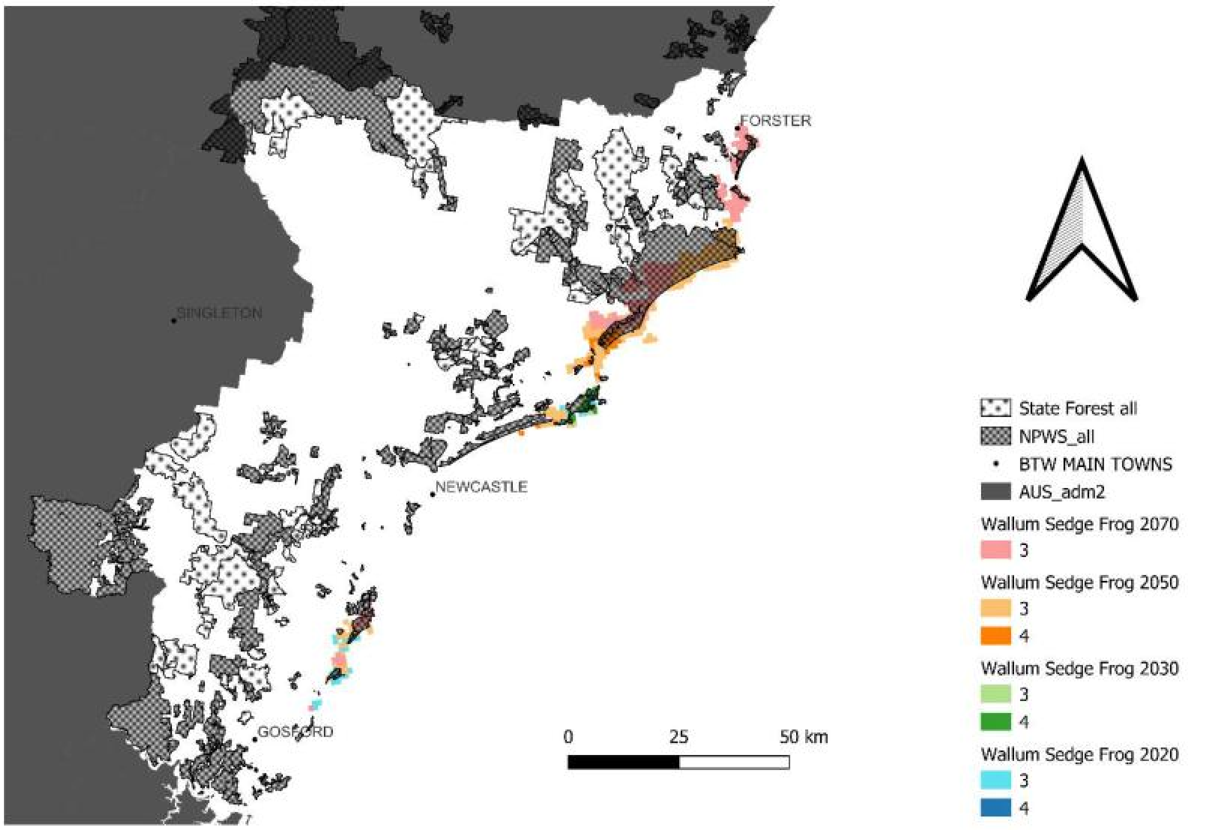
Giant Burrowing Frog Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



Red-crowned Toadlet Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

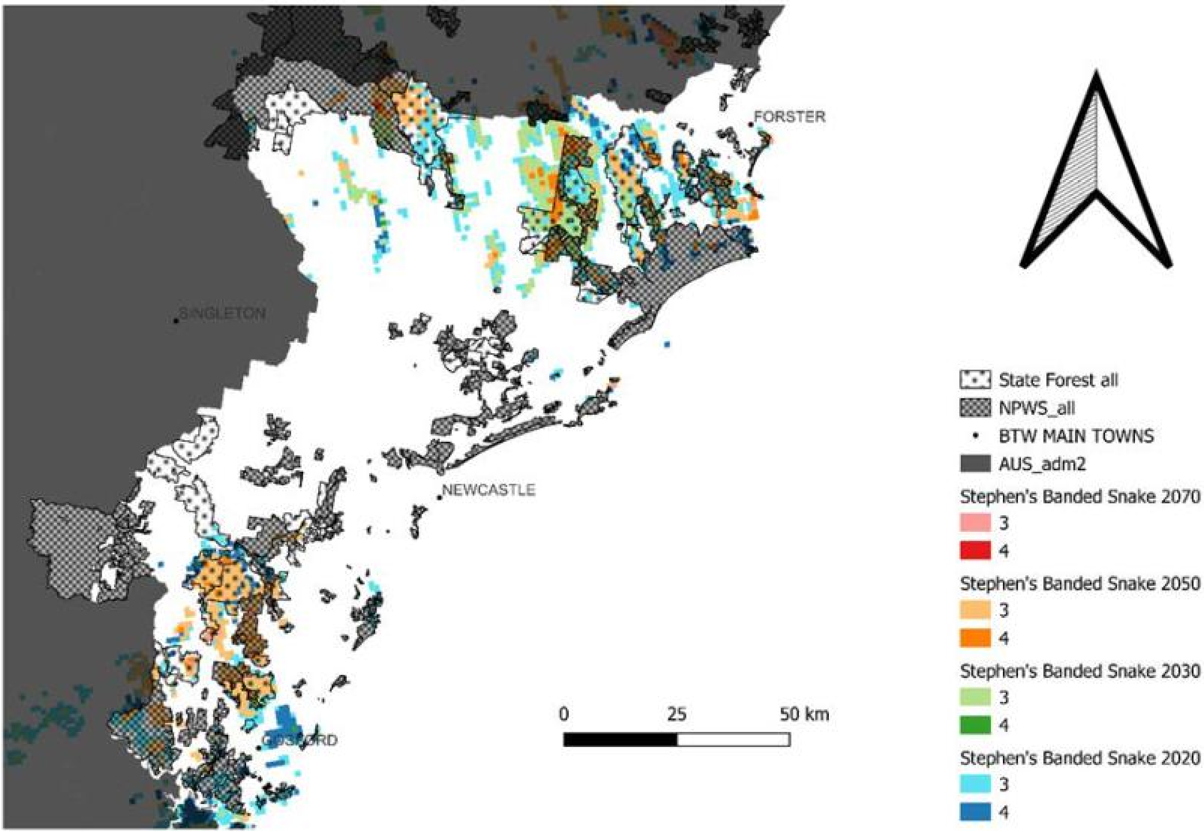


Stuttering Frog Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070

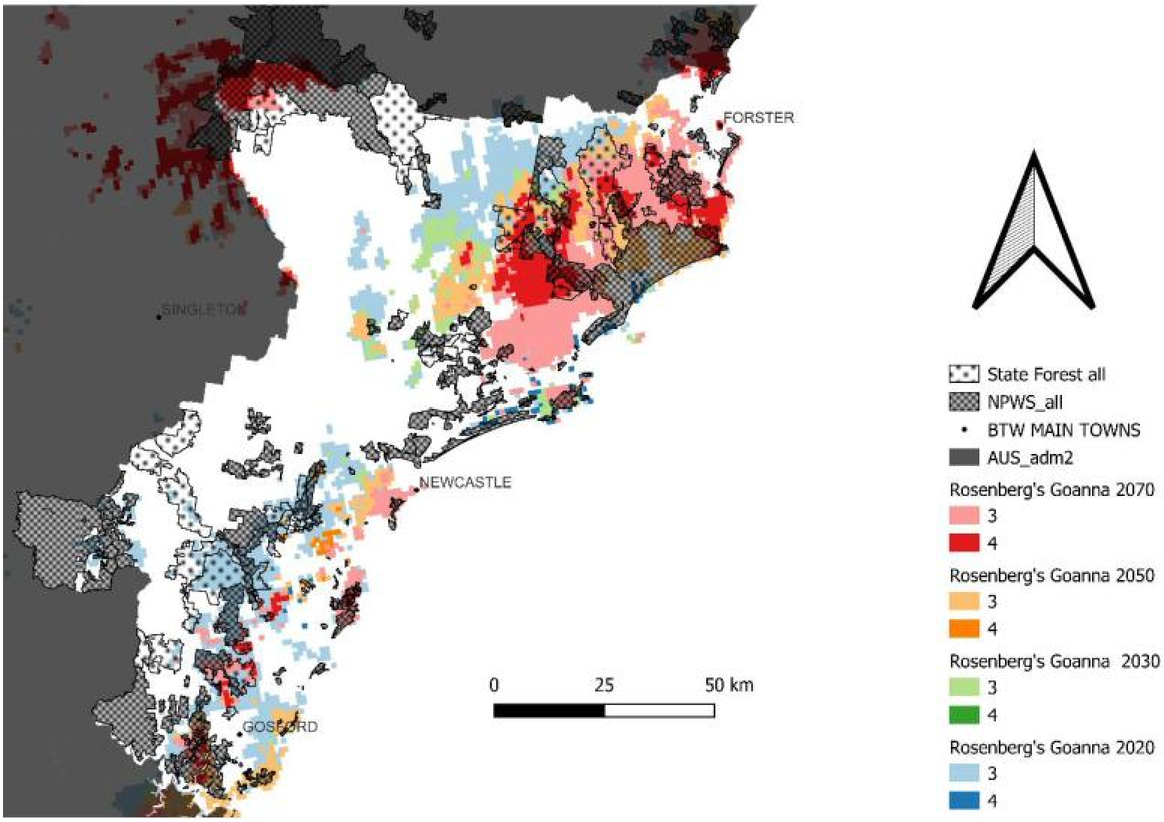


Wallum Sedge Frog Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070

Reptiles

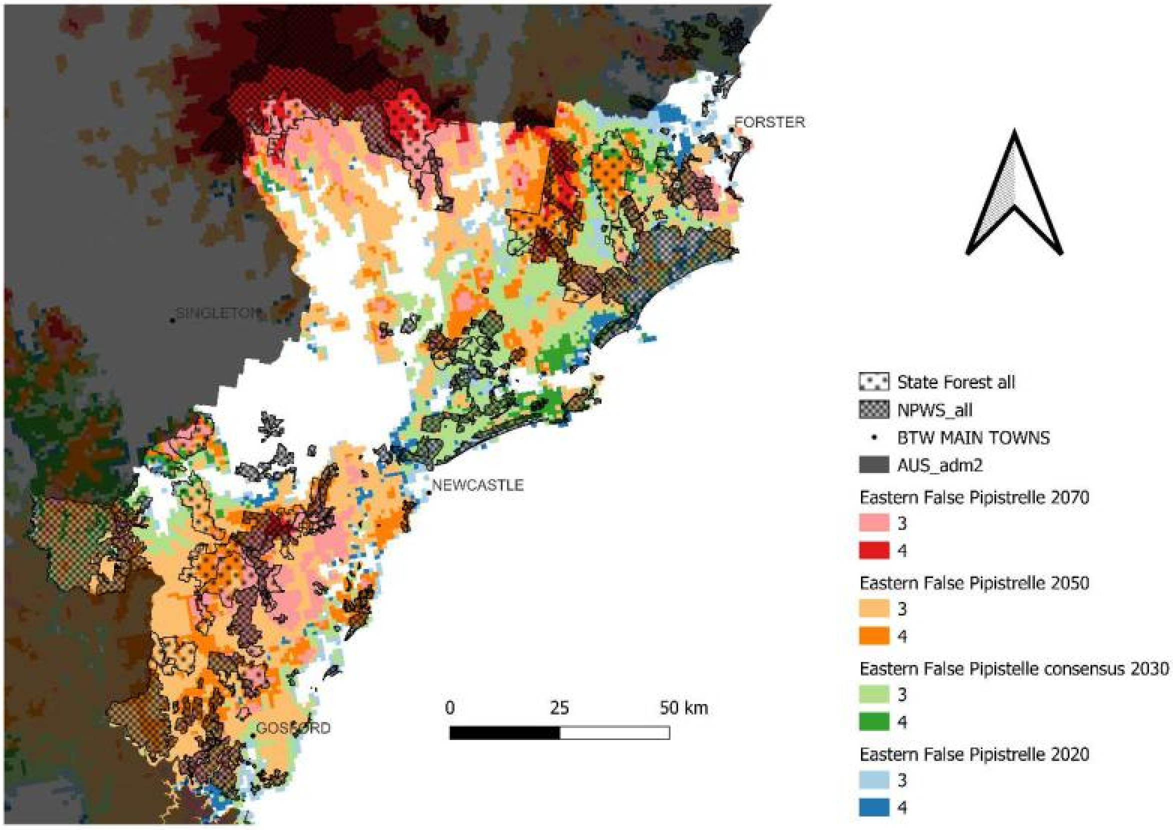


Stephen's Banded Snake Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

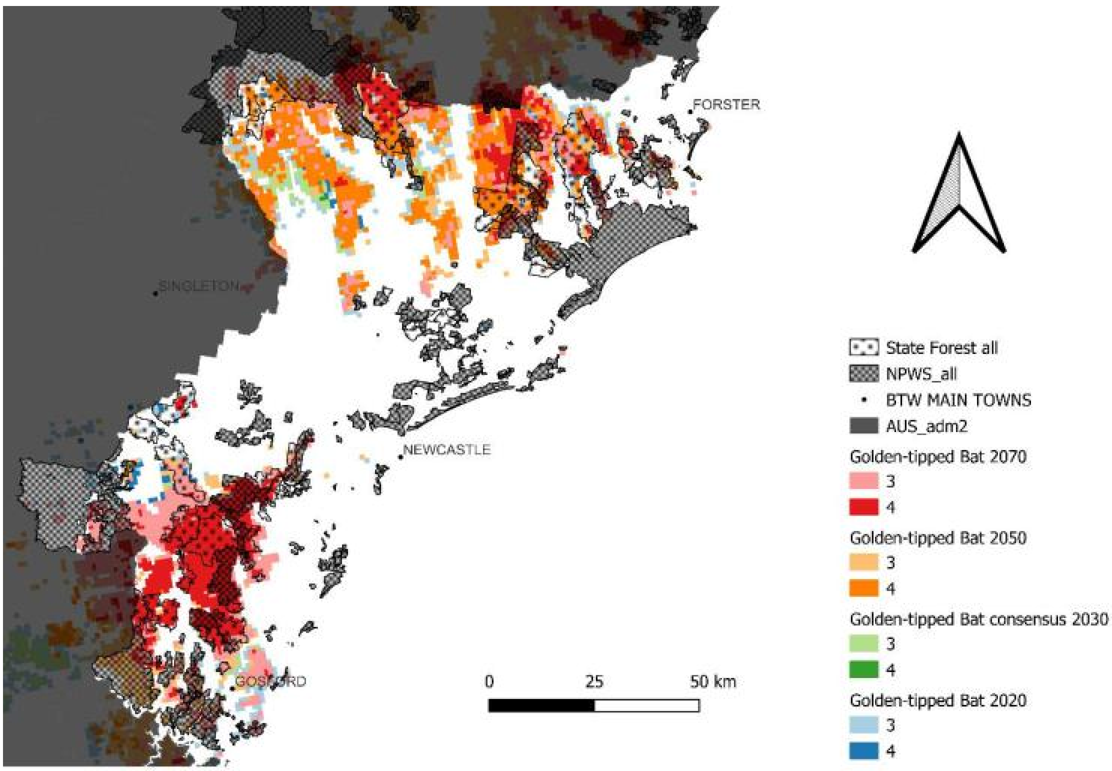


Rosenberg's Goanna Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

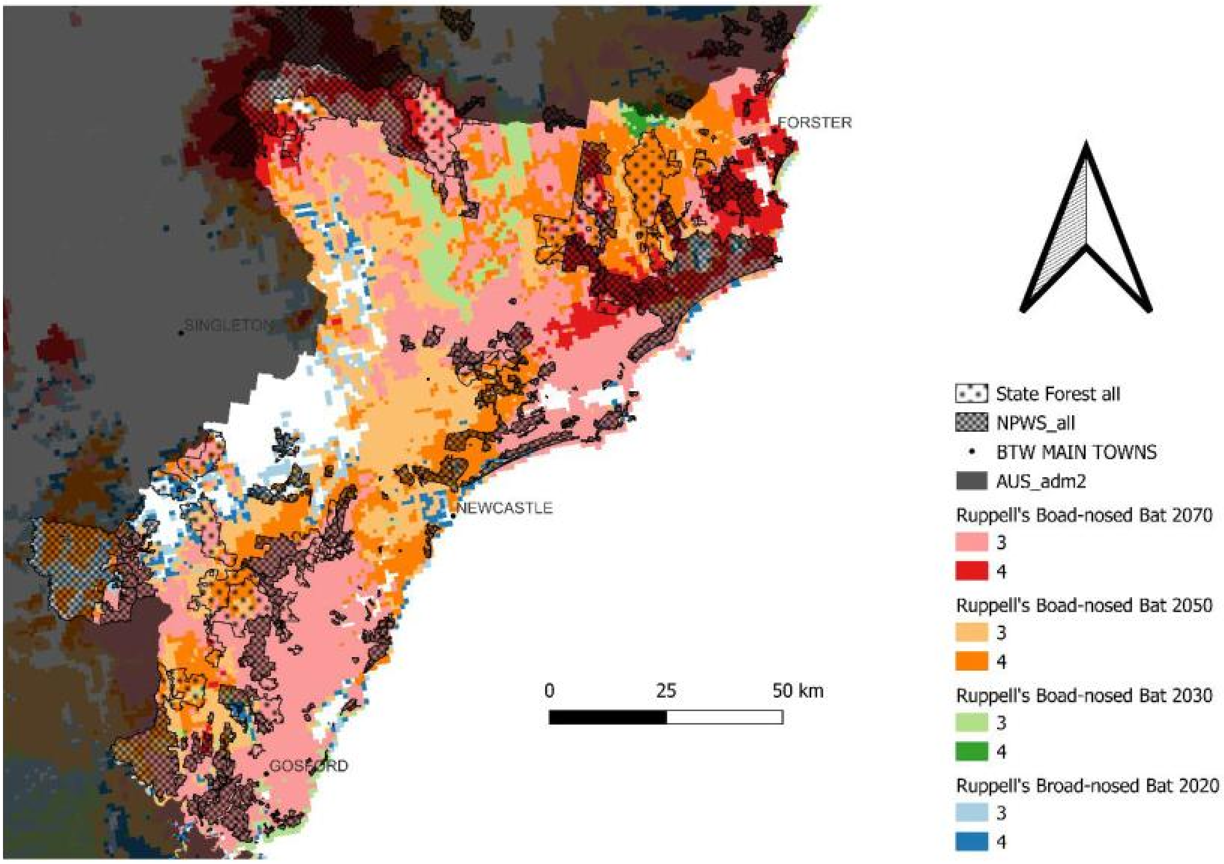
Mammals



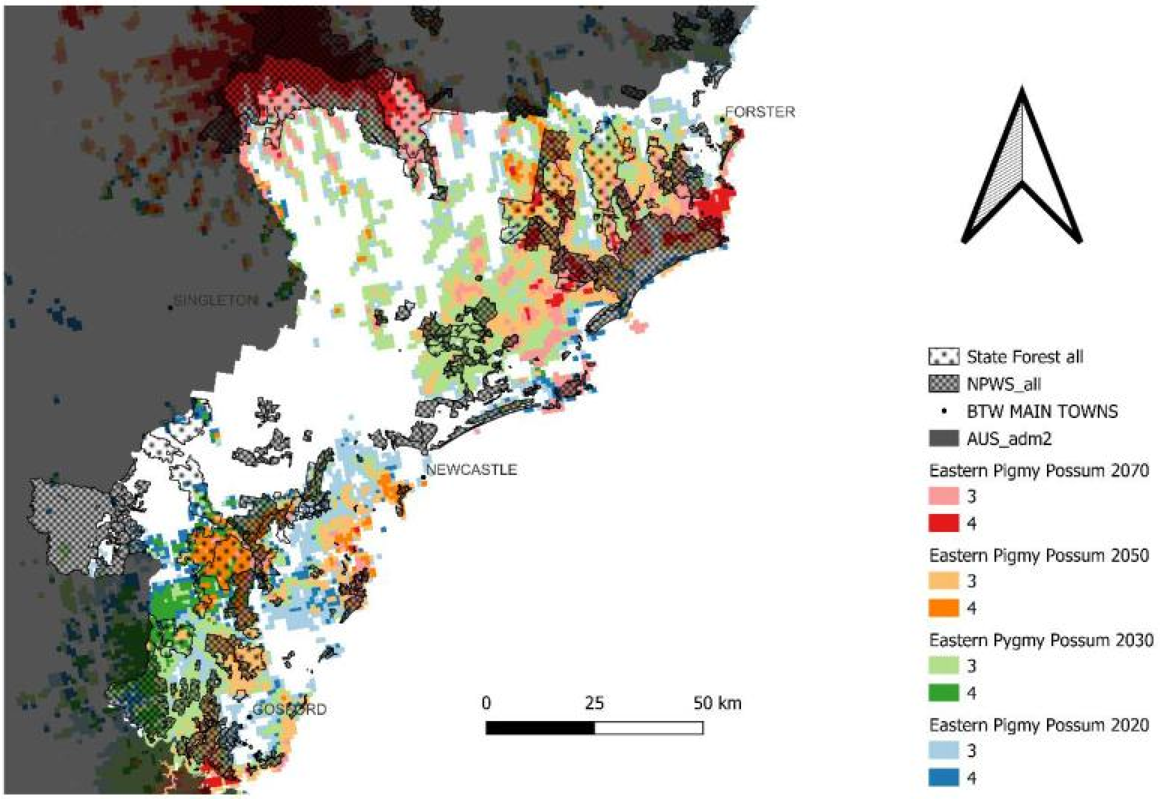
Eastern False Pipistelle Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



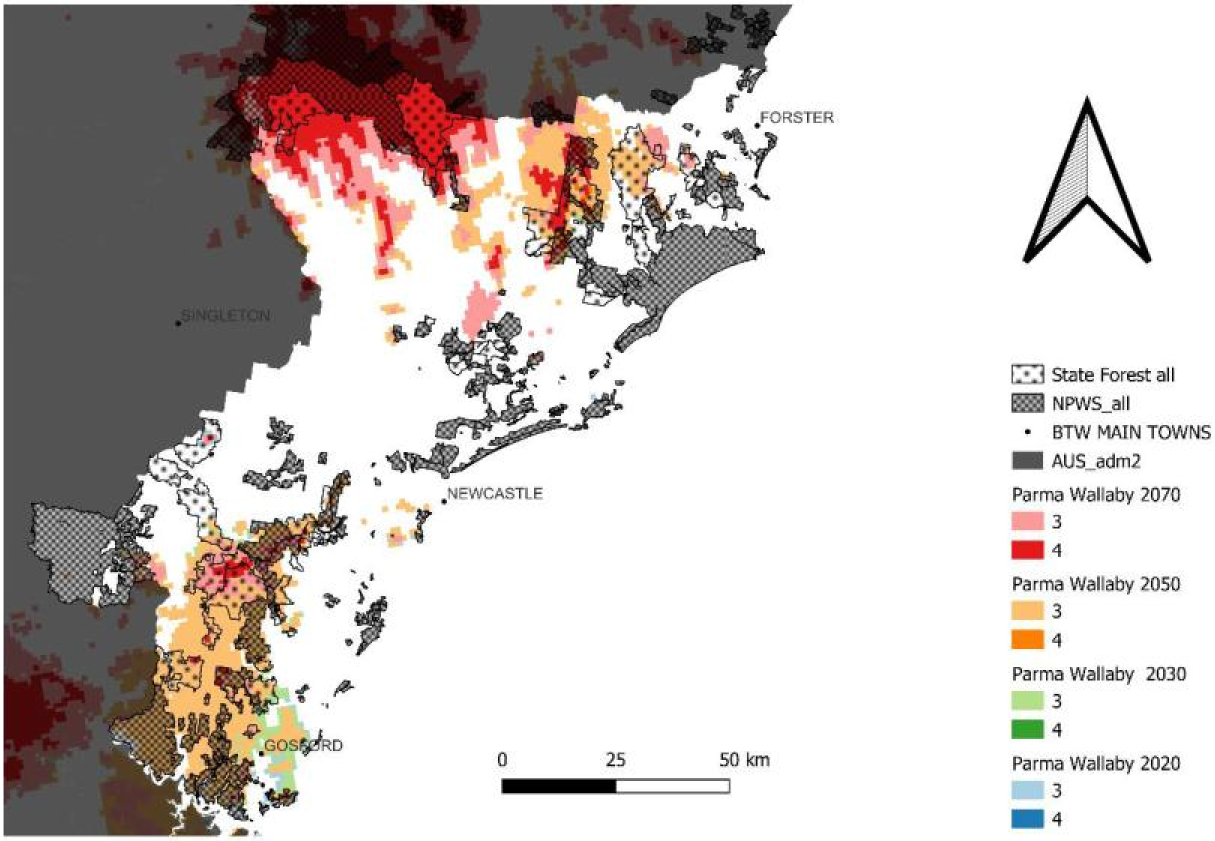
Golden-tipped Bat Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070



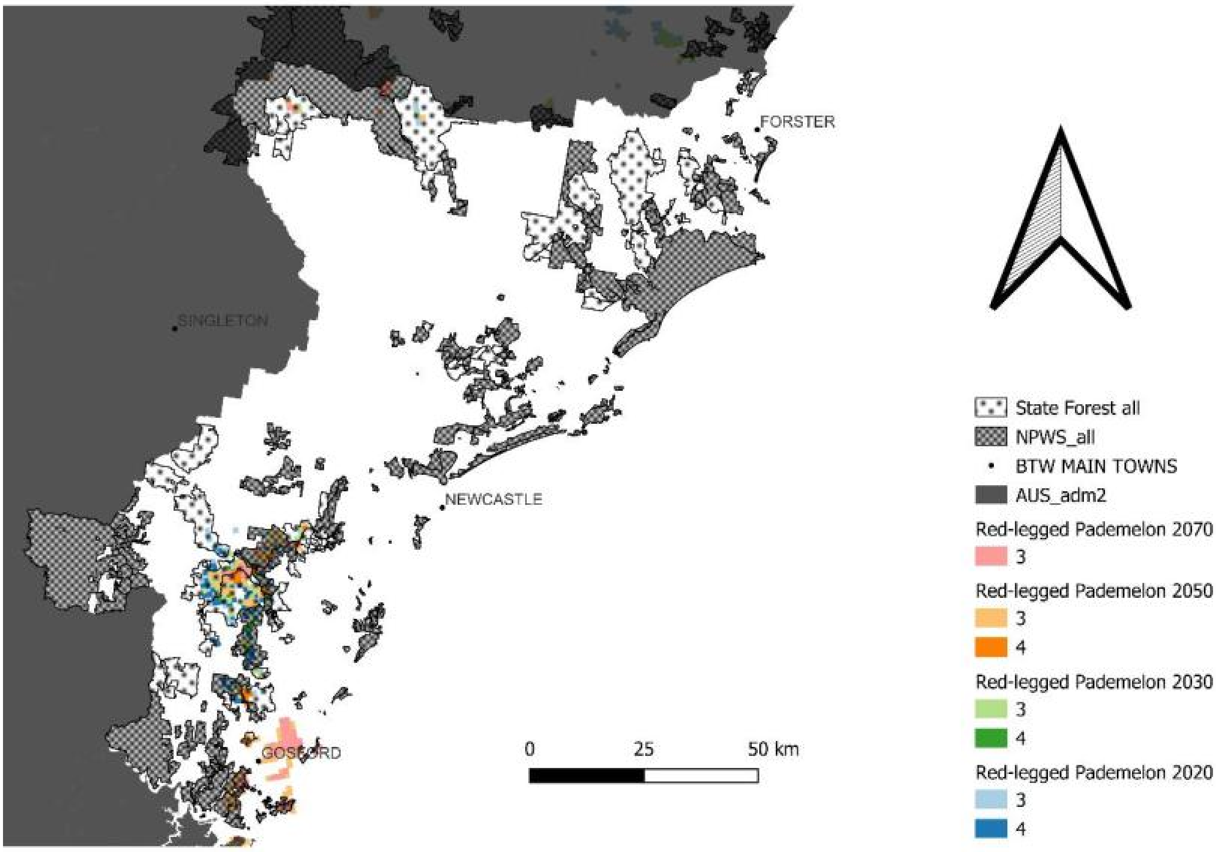
Greater Broad-nosed Bat Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



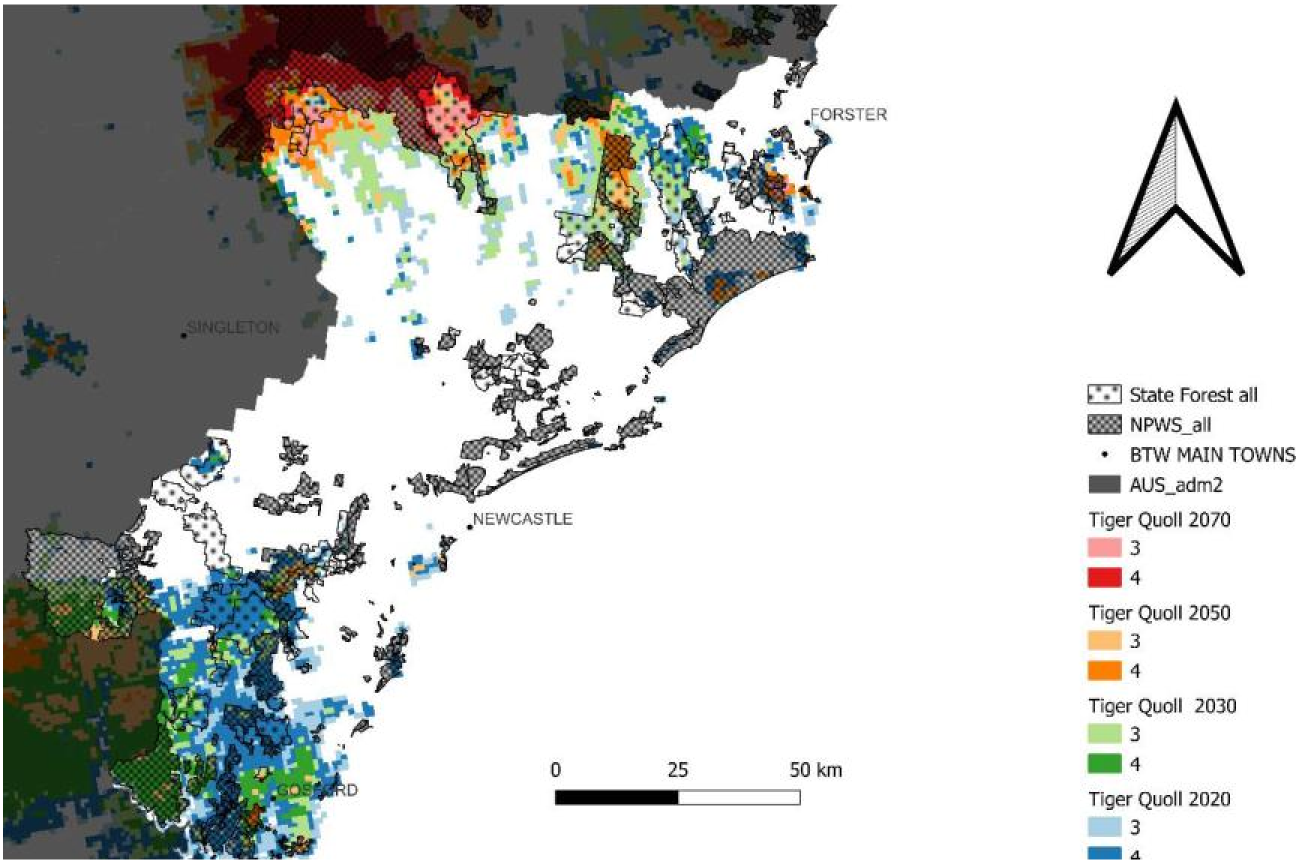
Eastern Pygmy Possum Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



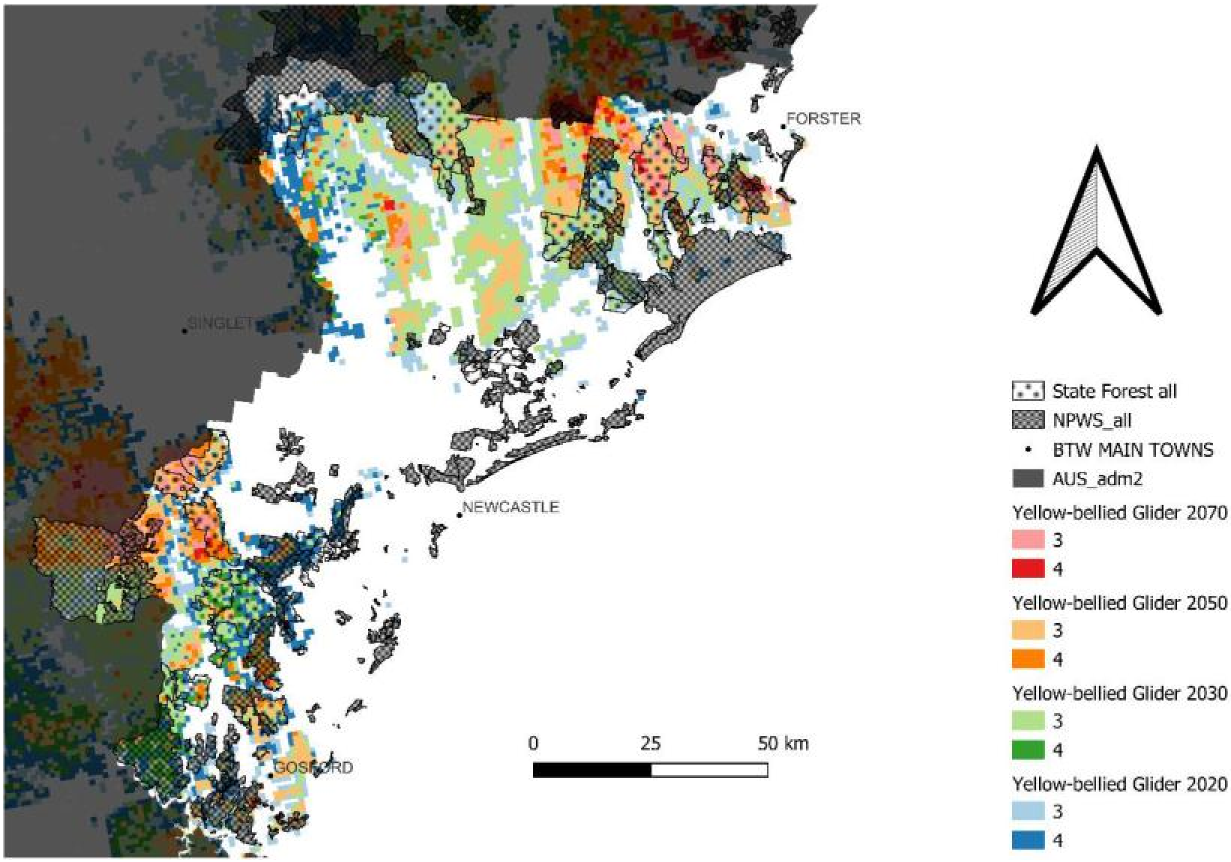
Parma Wallaby Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070



Red-legged Pademelon Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

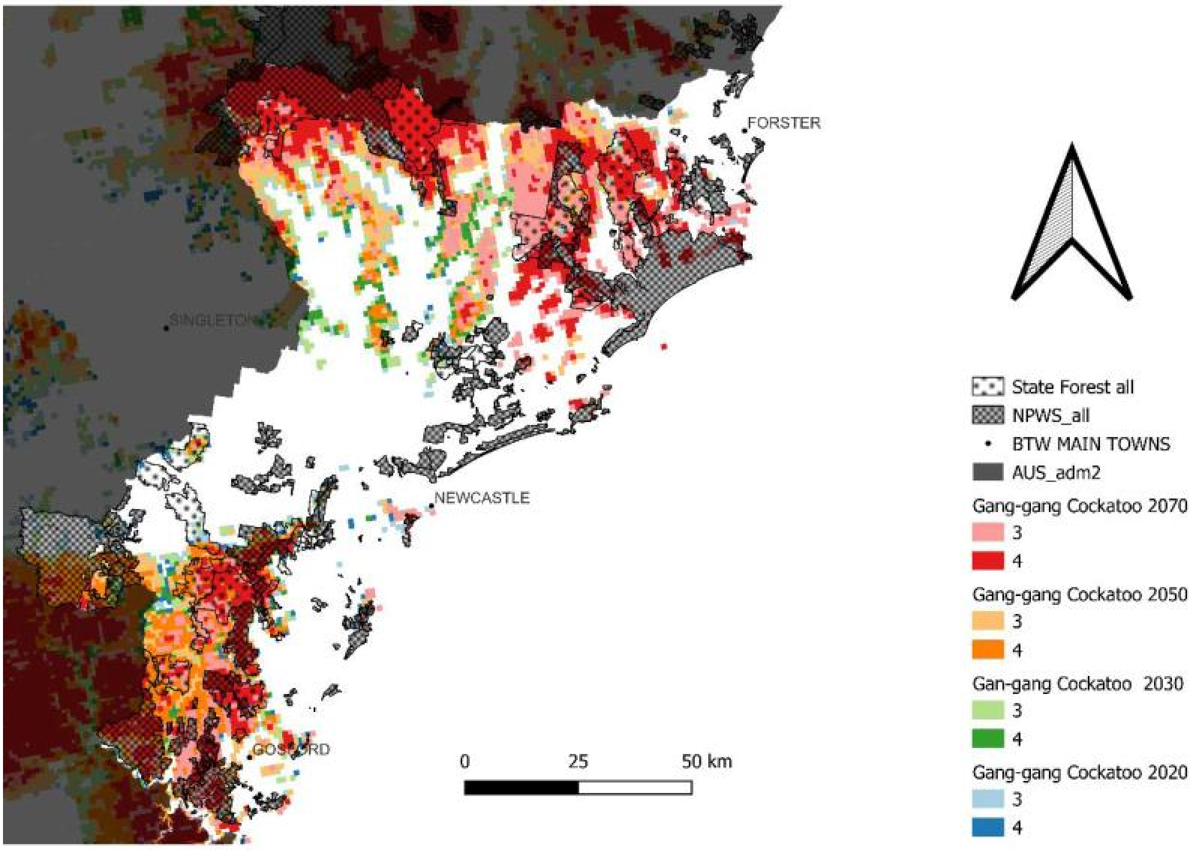


Spotted-tailed Quoll Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

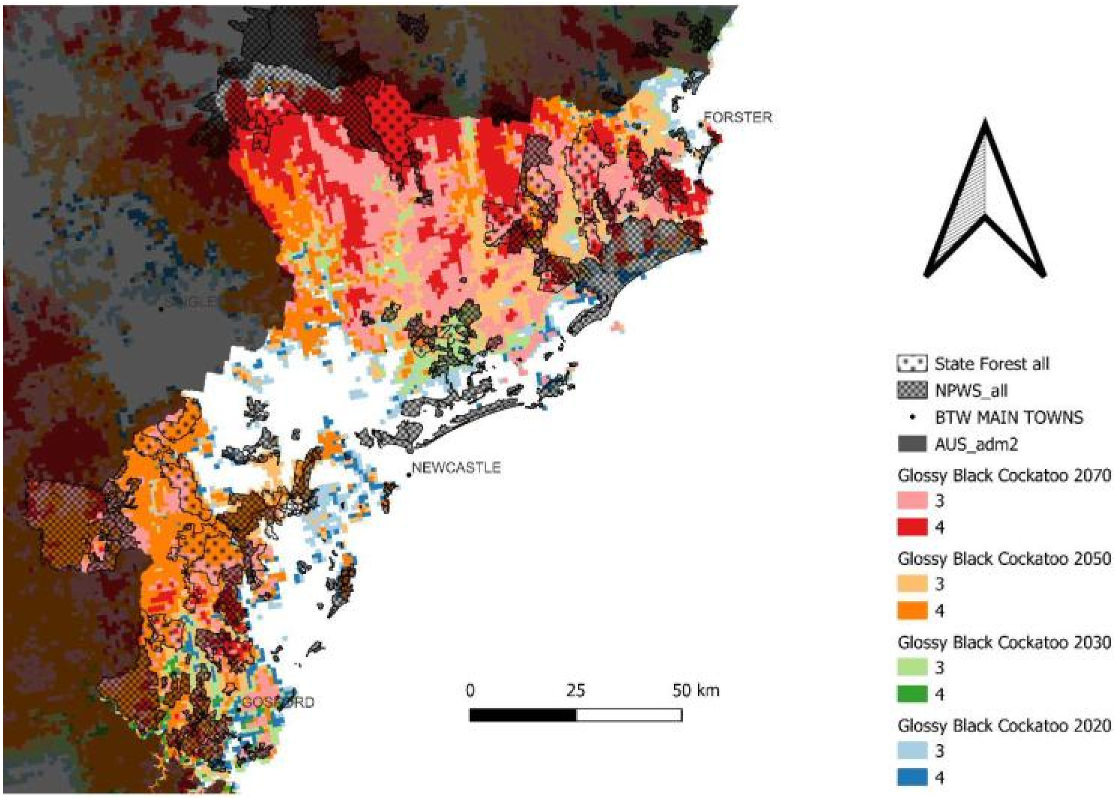


Yellow-bellied Glider Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070

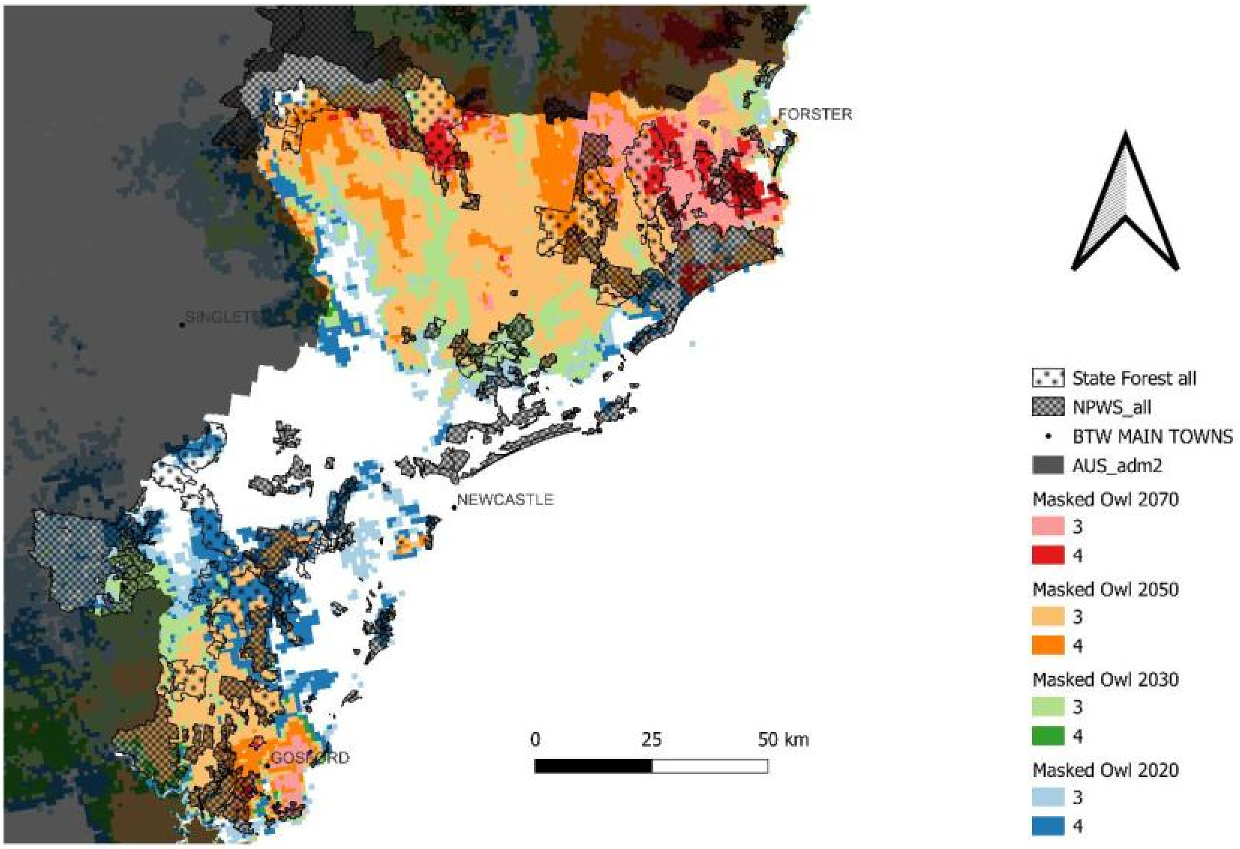
Birds



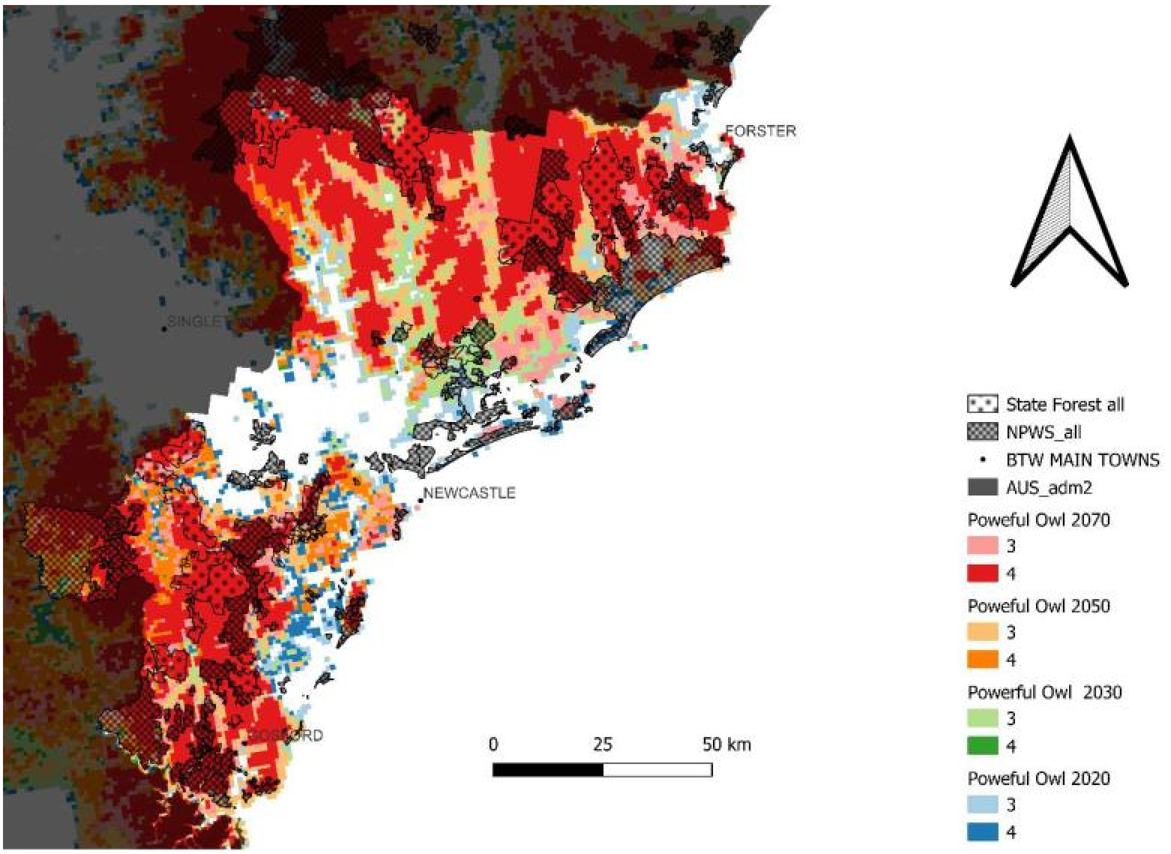
Gang-gang Cockatoo Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



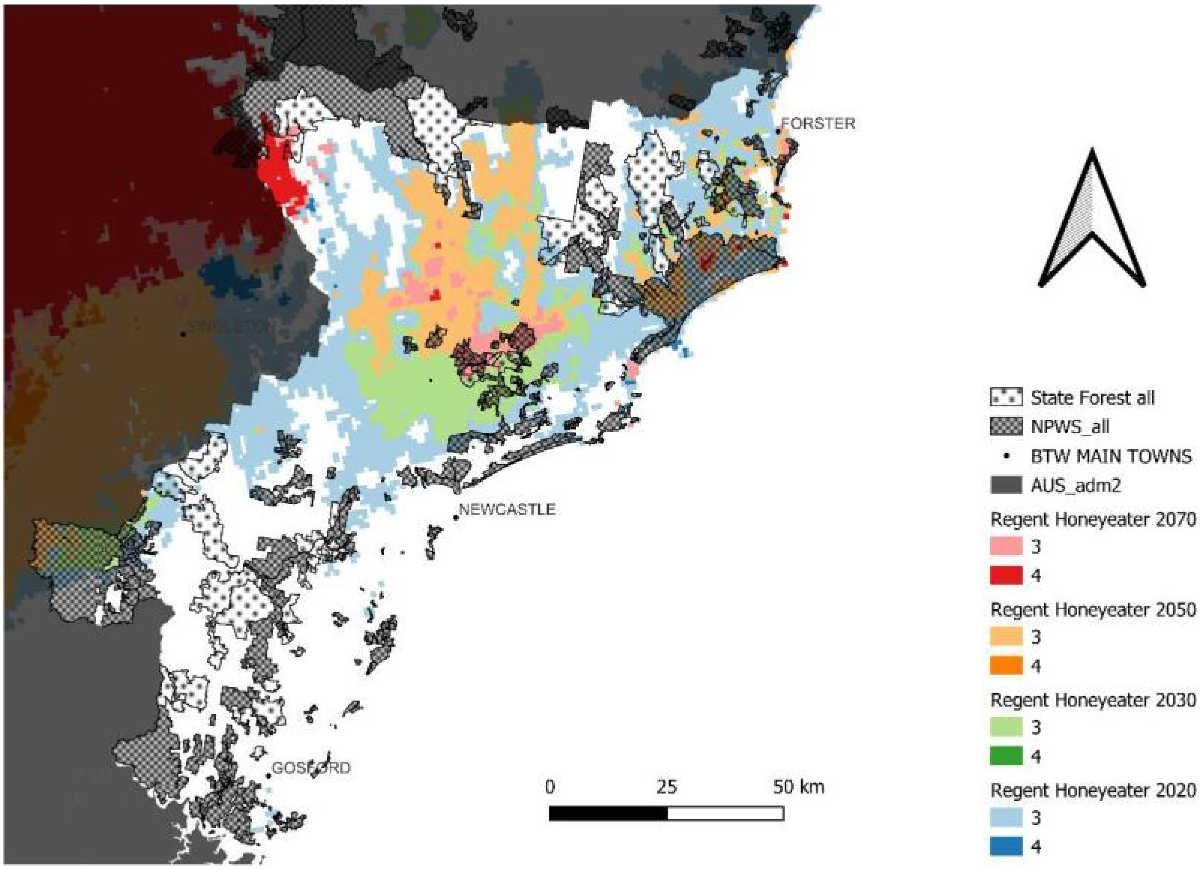
Glossy Black Cockatoo Suitable Modelled Habitat under 3 and 4 climatic scenarios projected to 2070



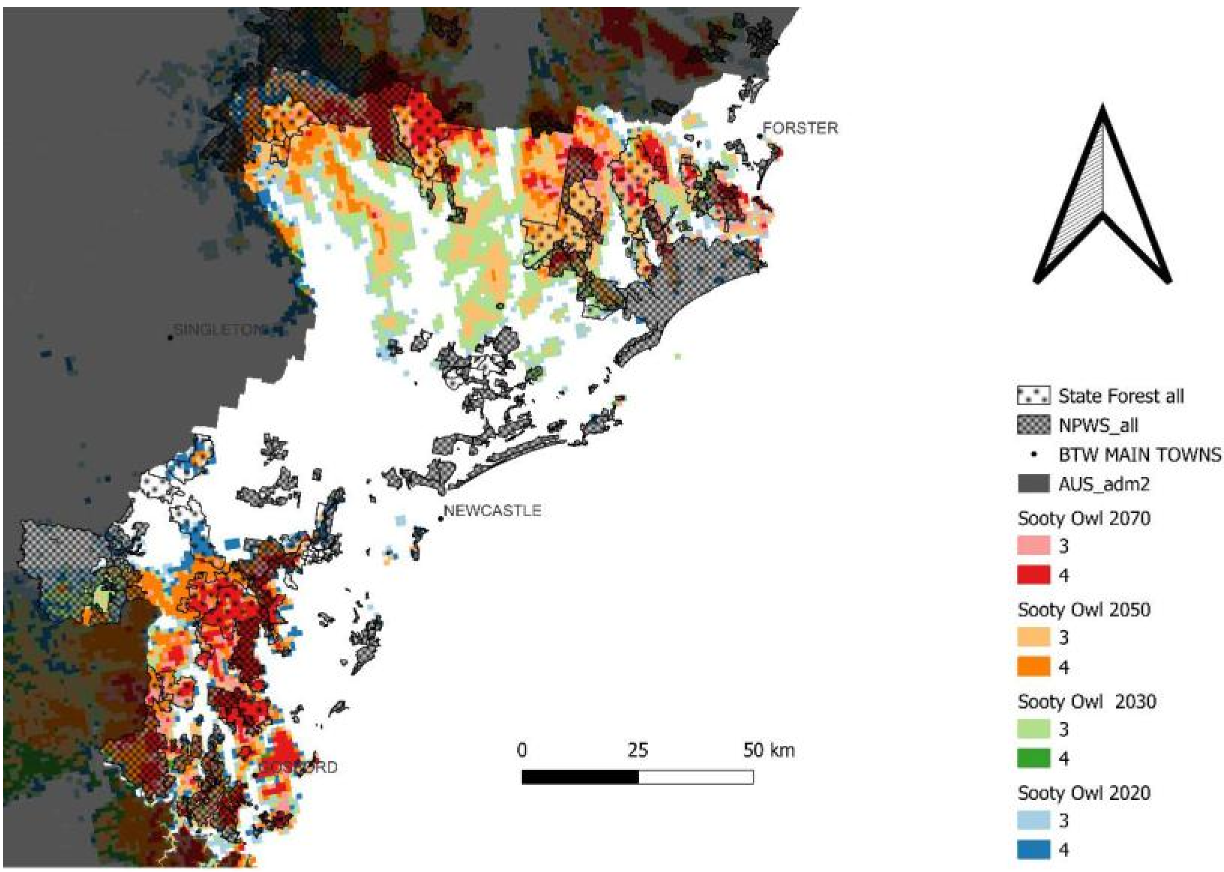
Masked Owl Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070



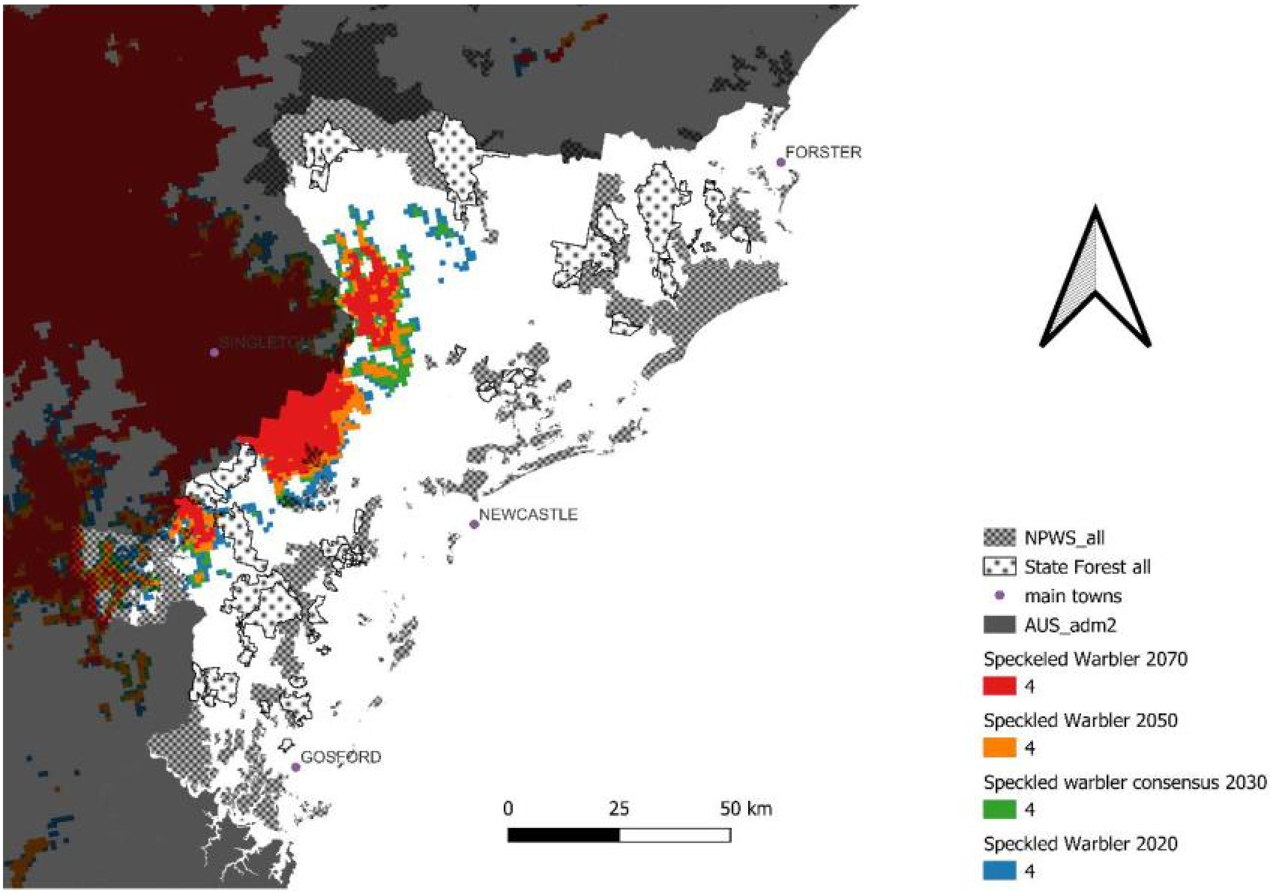
Powerful Owl Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070



Regent Honeyeater Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070

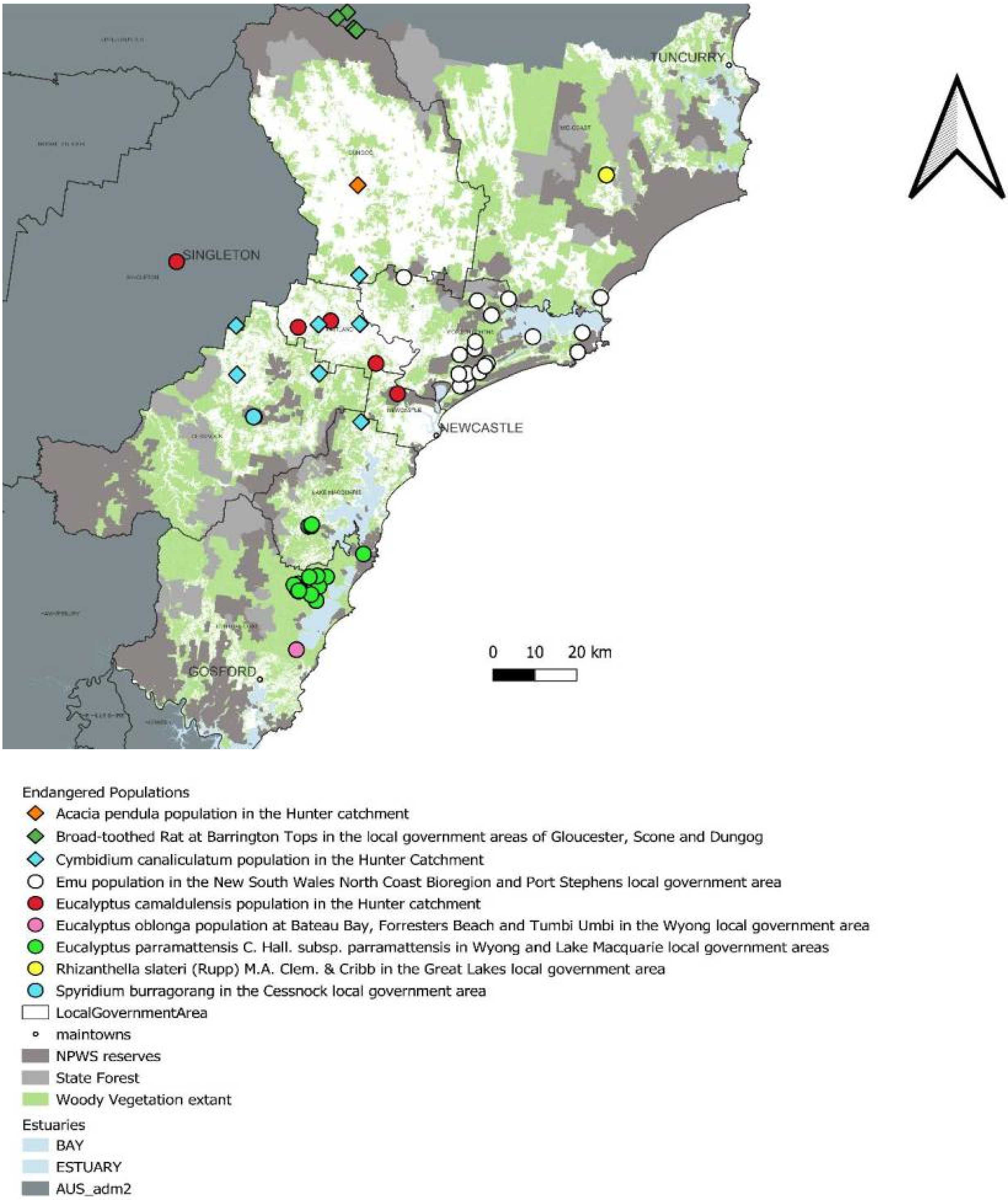


Sooty Owl Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070

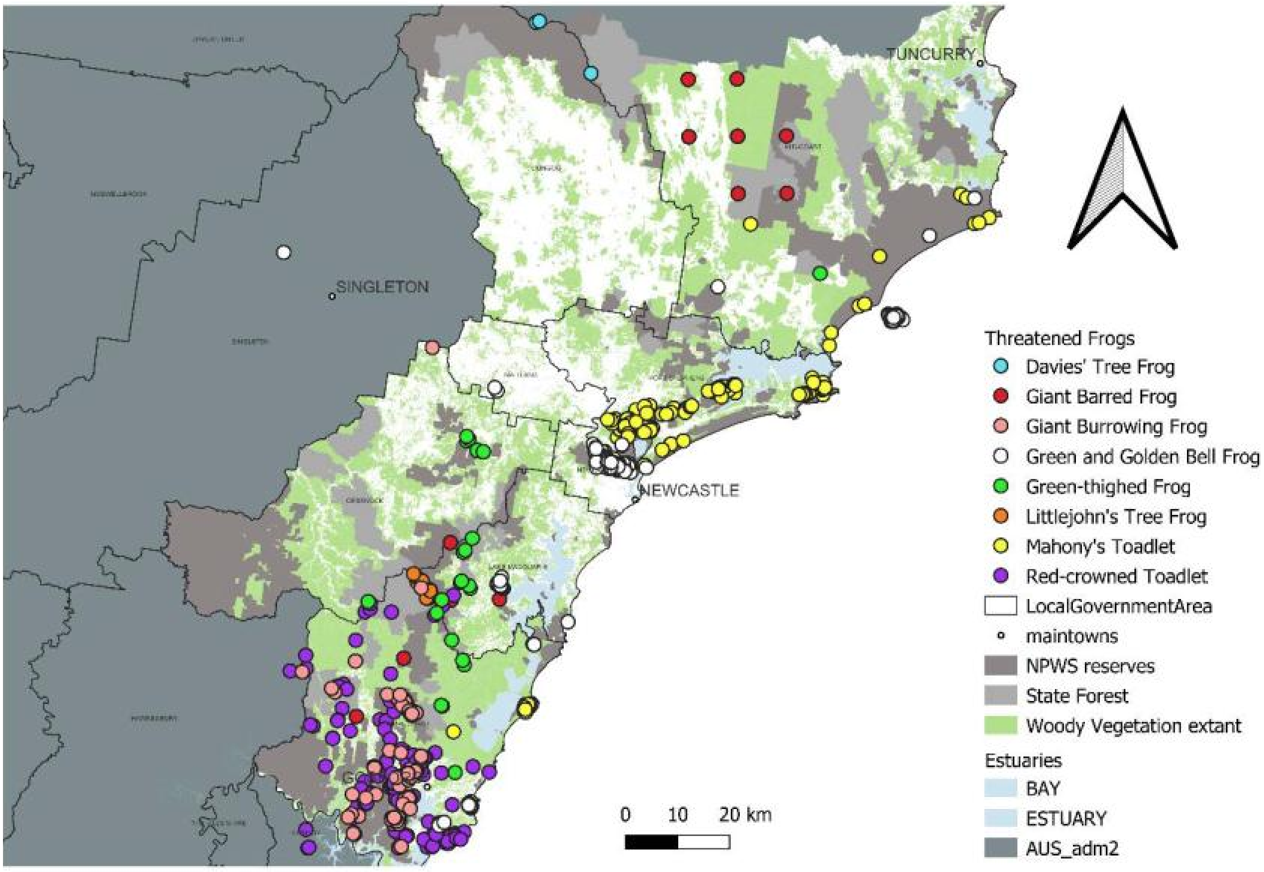


Speckled Warbler Suitable Modelled Habitat under 3 and 4 climatic scenarios projected by decades to 2070

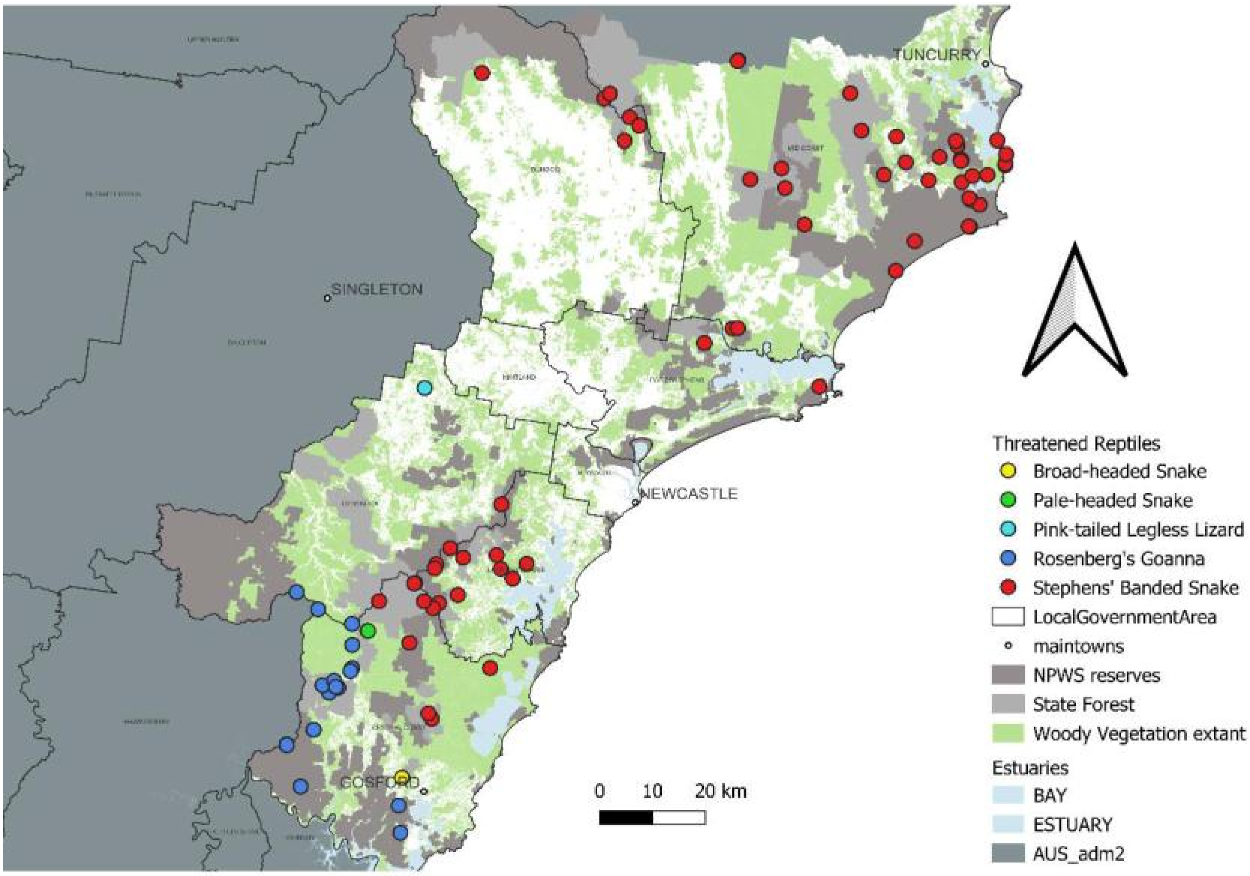
Appendix 3: Maps of Threatened Species Records (BioNet 2000-2022)



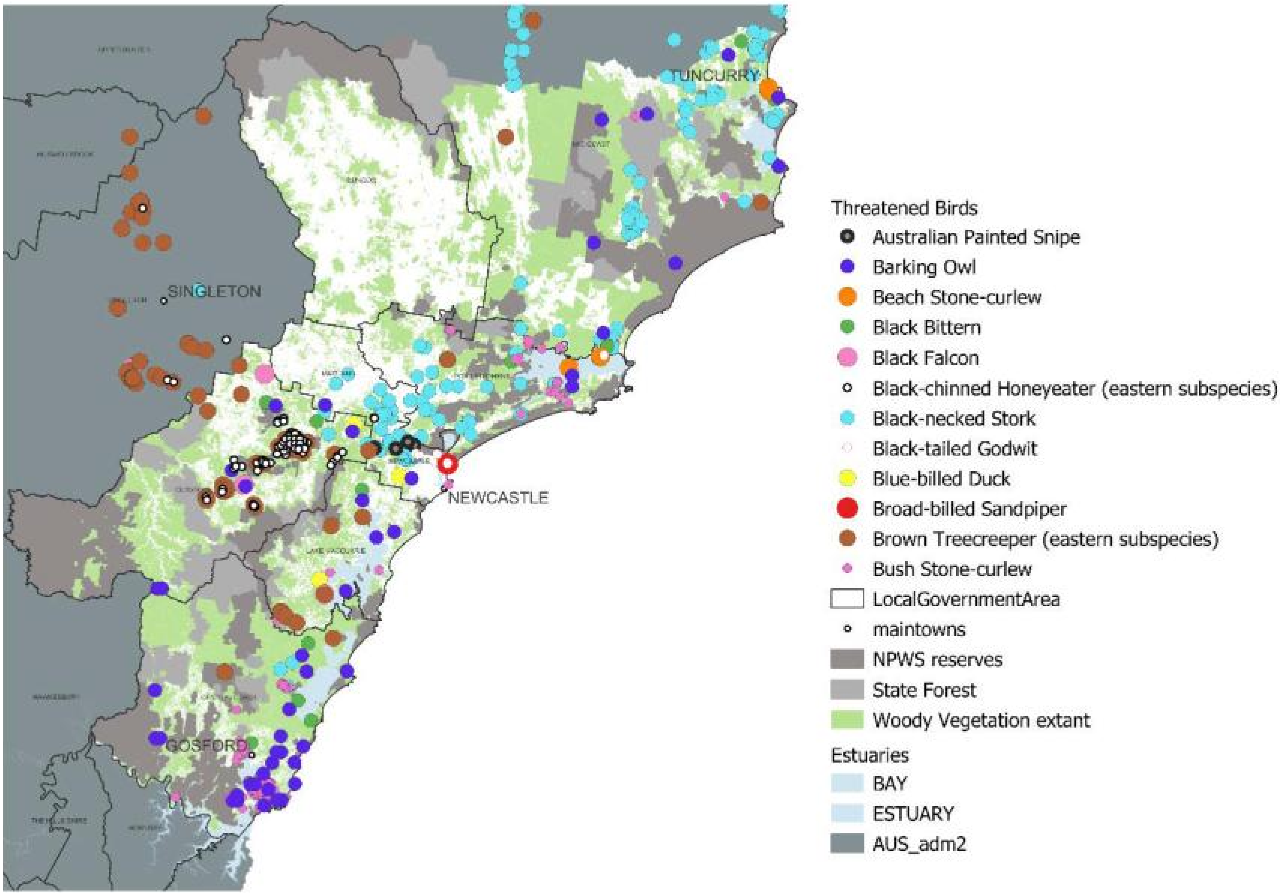
Barrington to Hawkesbury Endangered Populations – Note The Coastal Emu Population may be functionally extinct, as it reportedly consists of just two individuals.



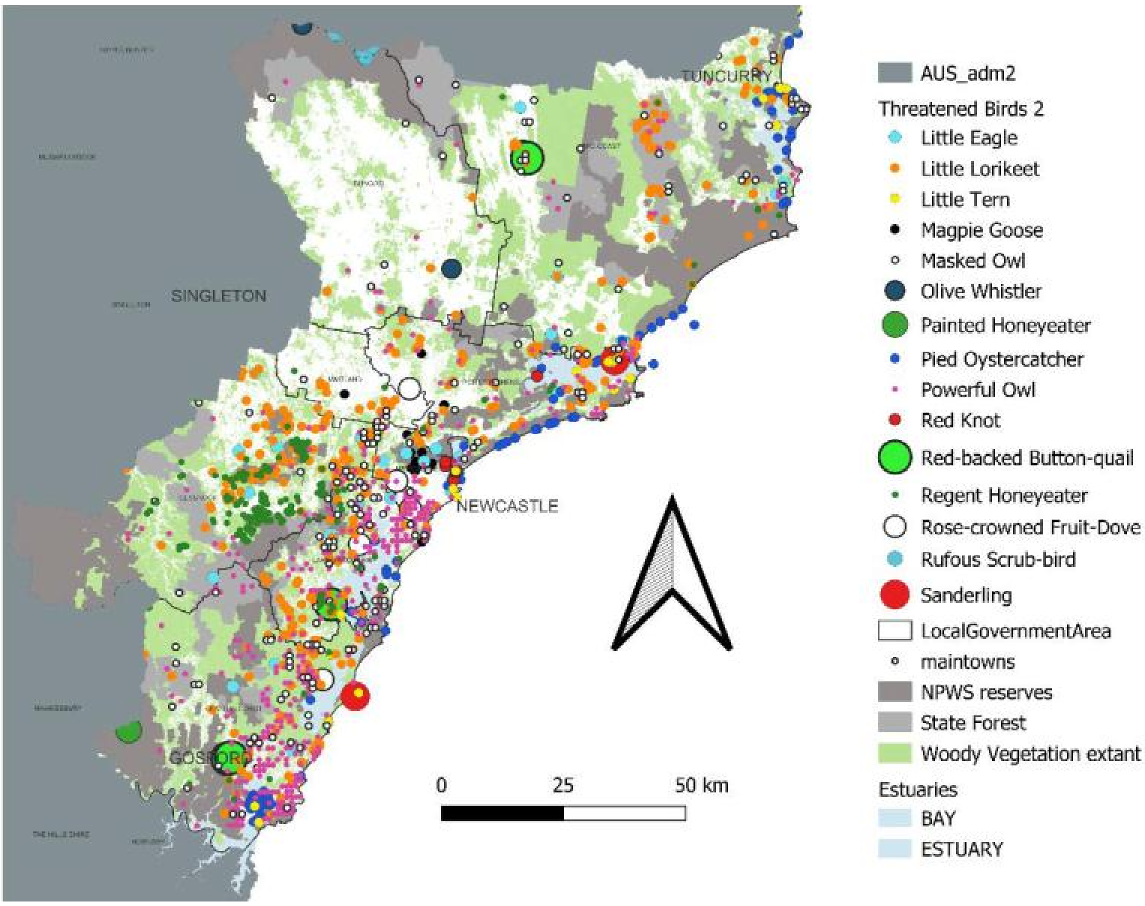
BTH Threatened Frogs



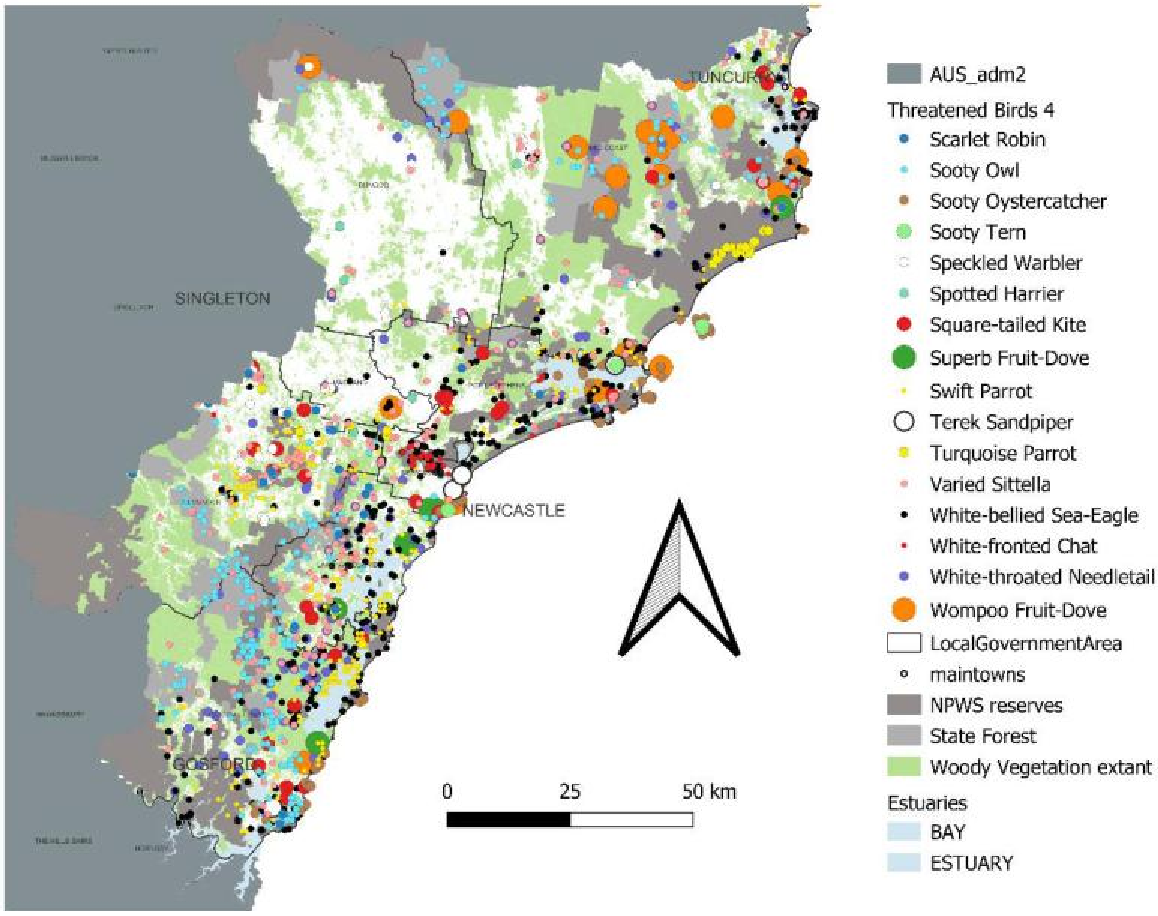
BTH Threatened Reptiles



BtH Threatened birds 1



BTH Threatened birds 2



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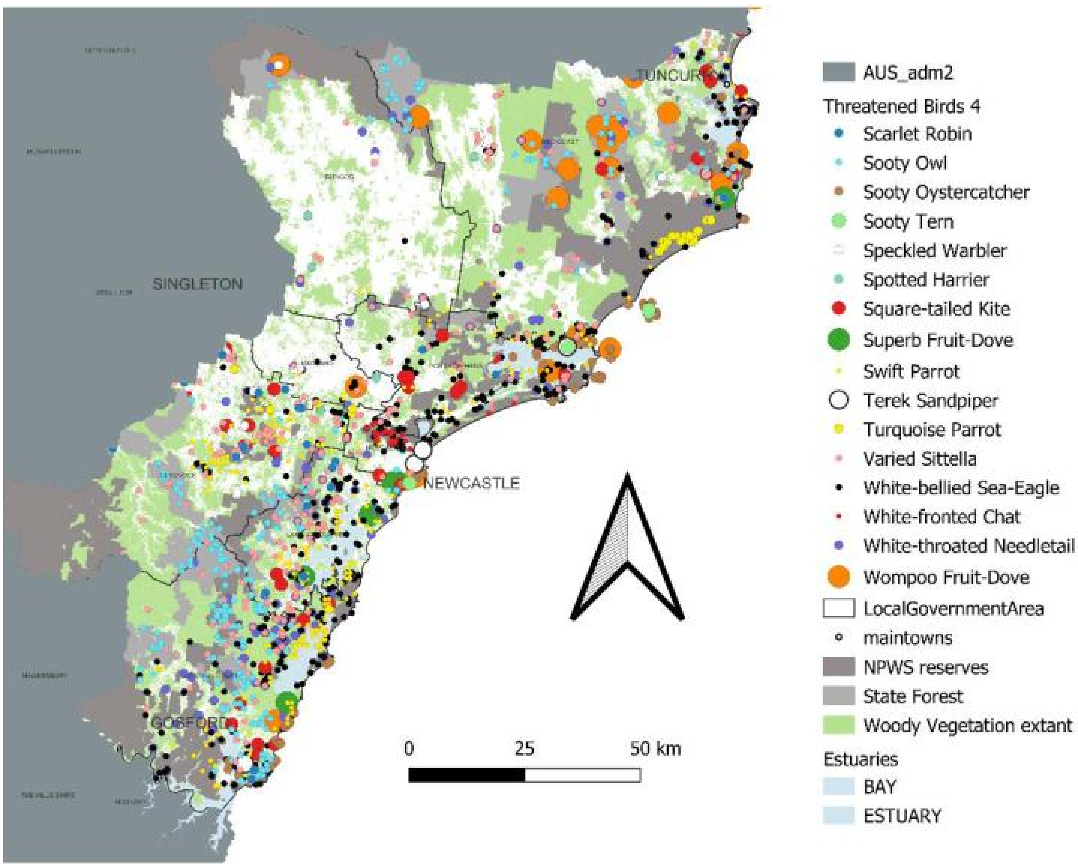
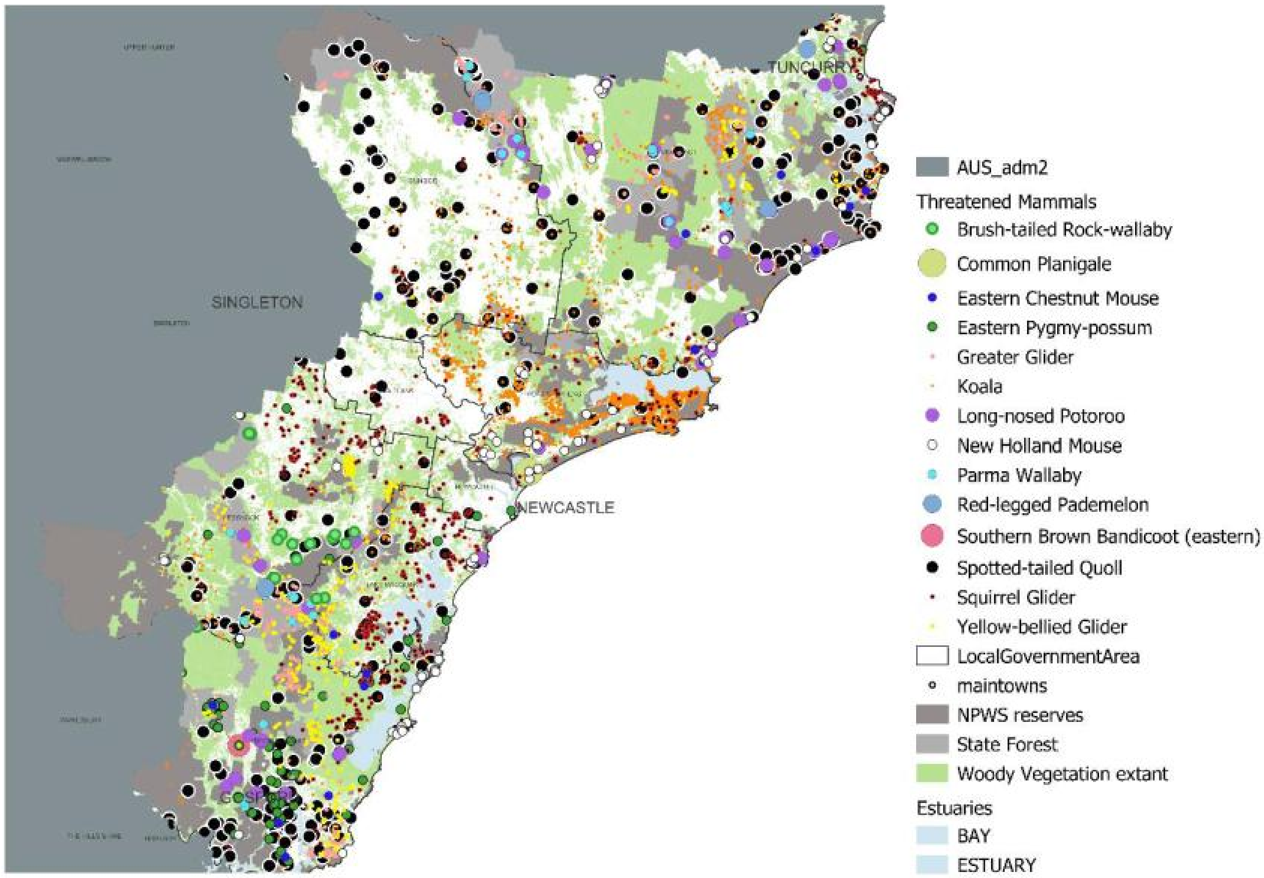
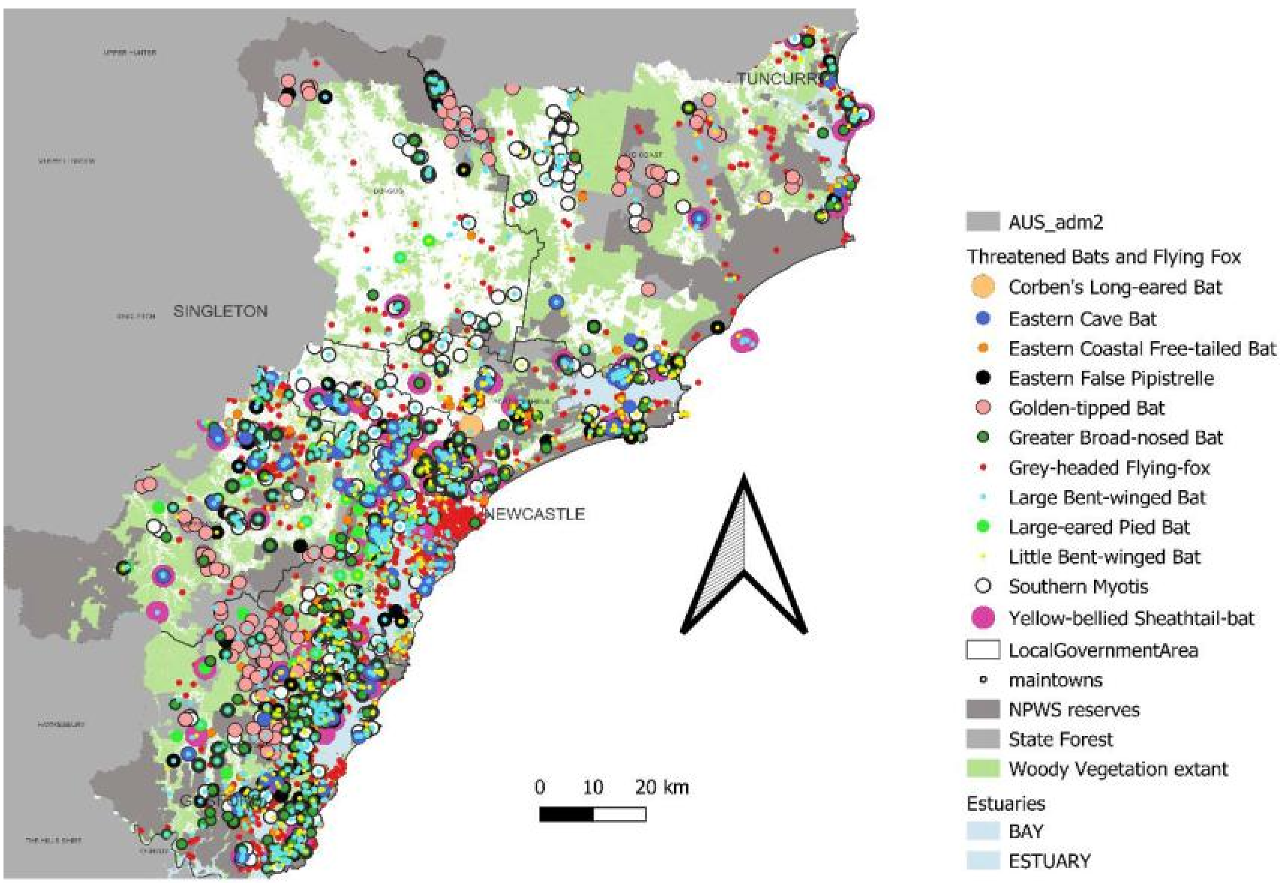


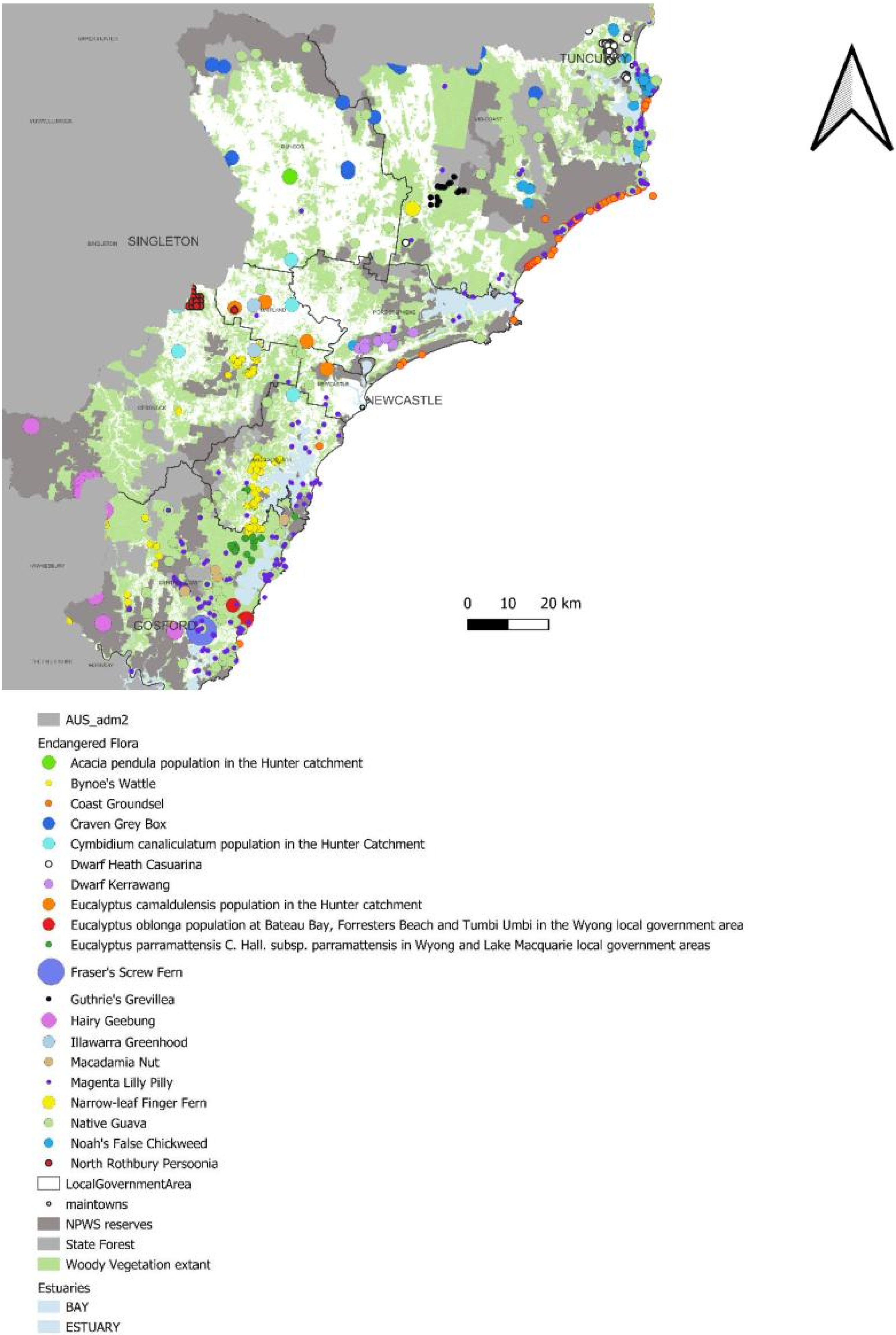
BTH Threatened birds 4



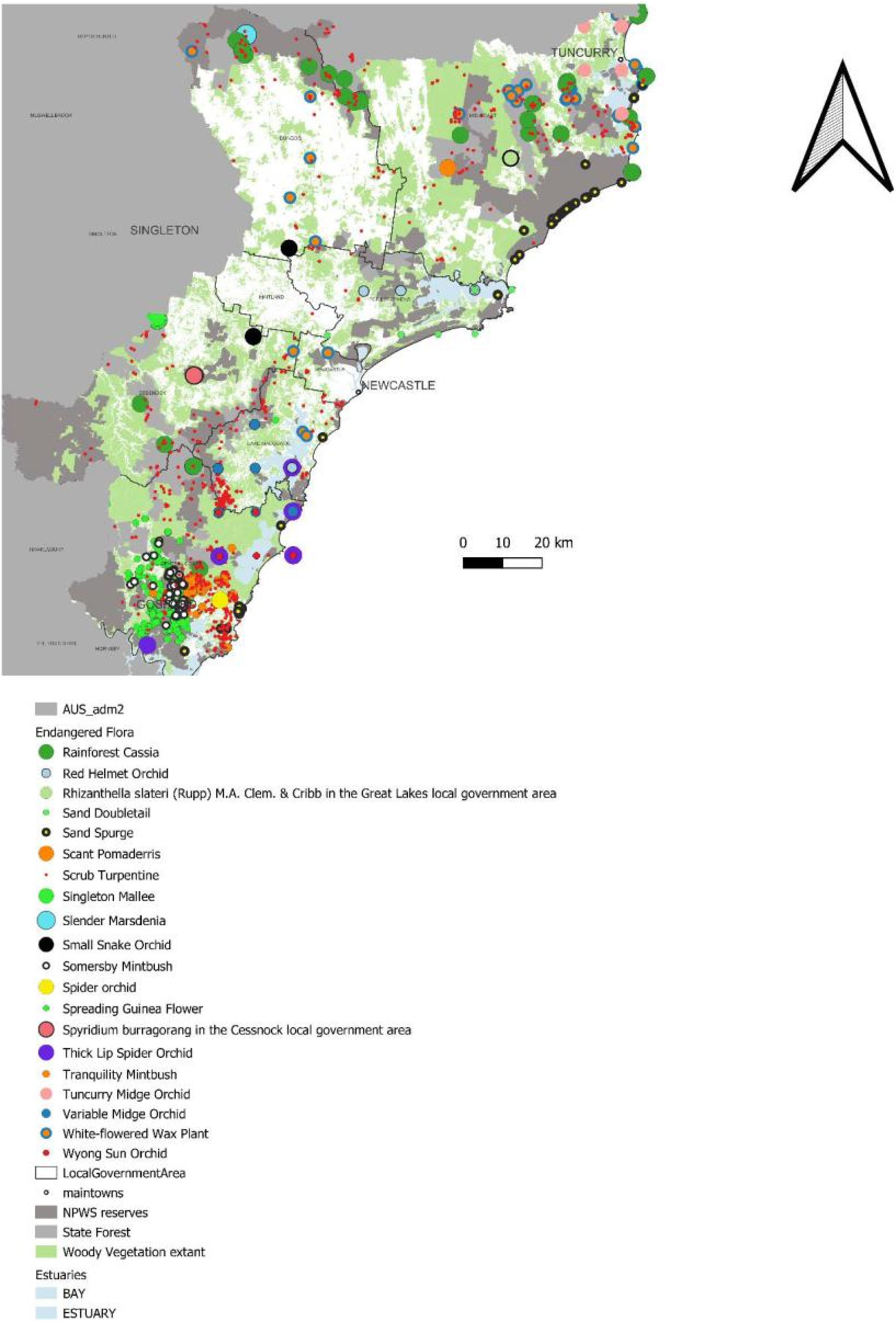
BTH Threatened mammals (flightless)



BTH Threatened bats and flying fox



BTH Endangered plants 1



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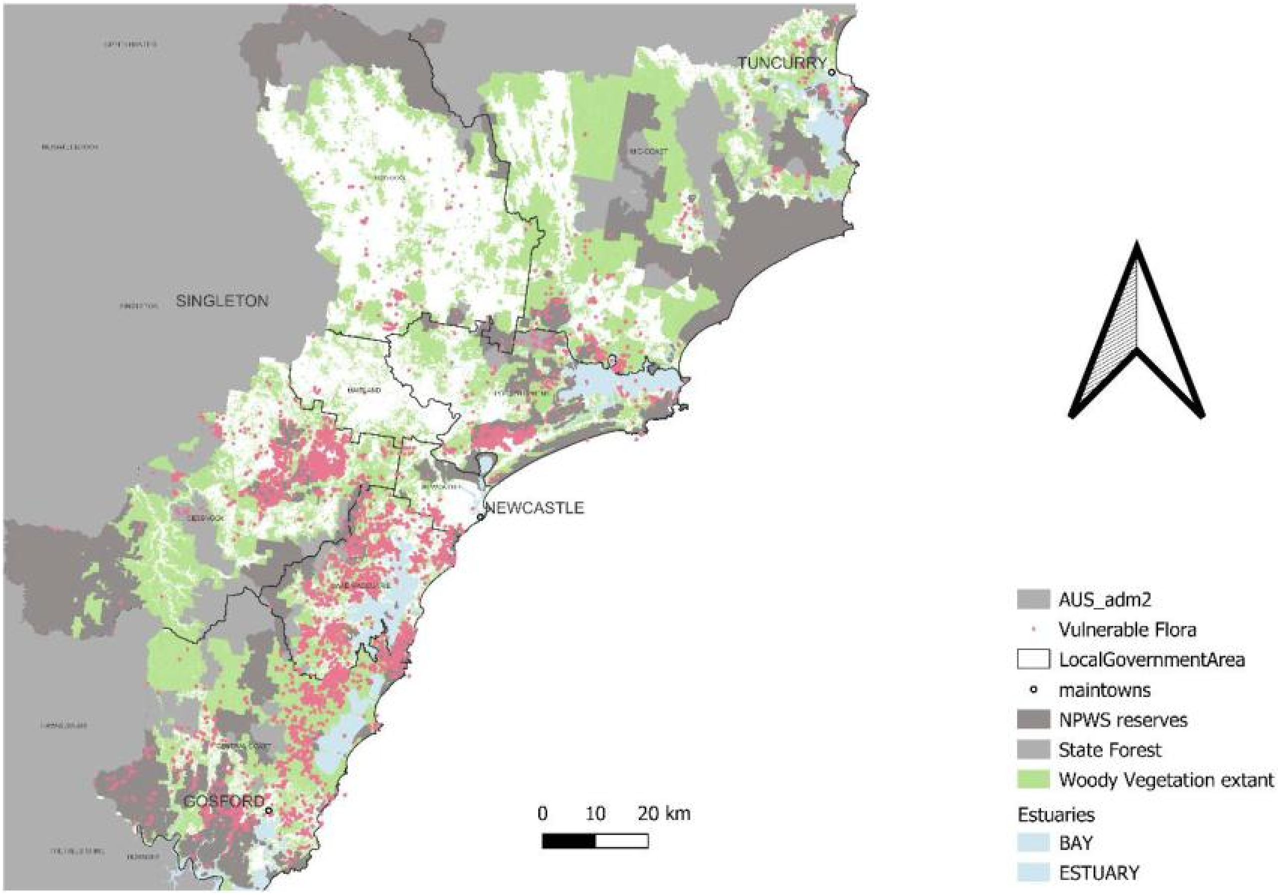
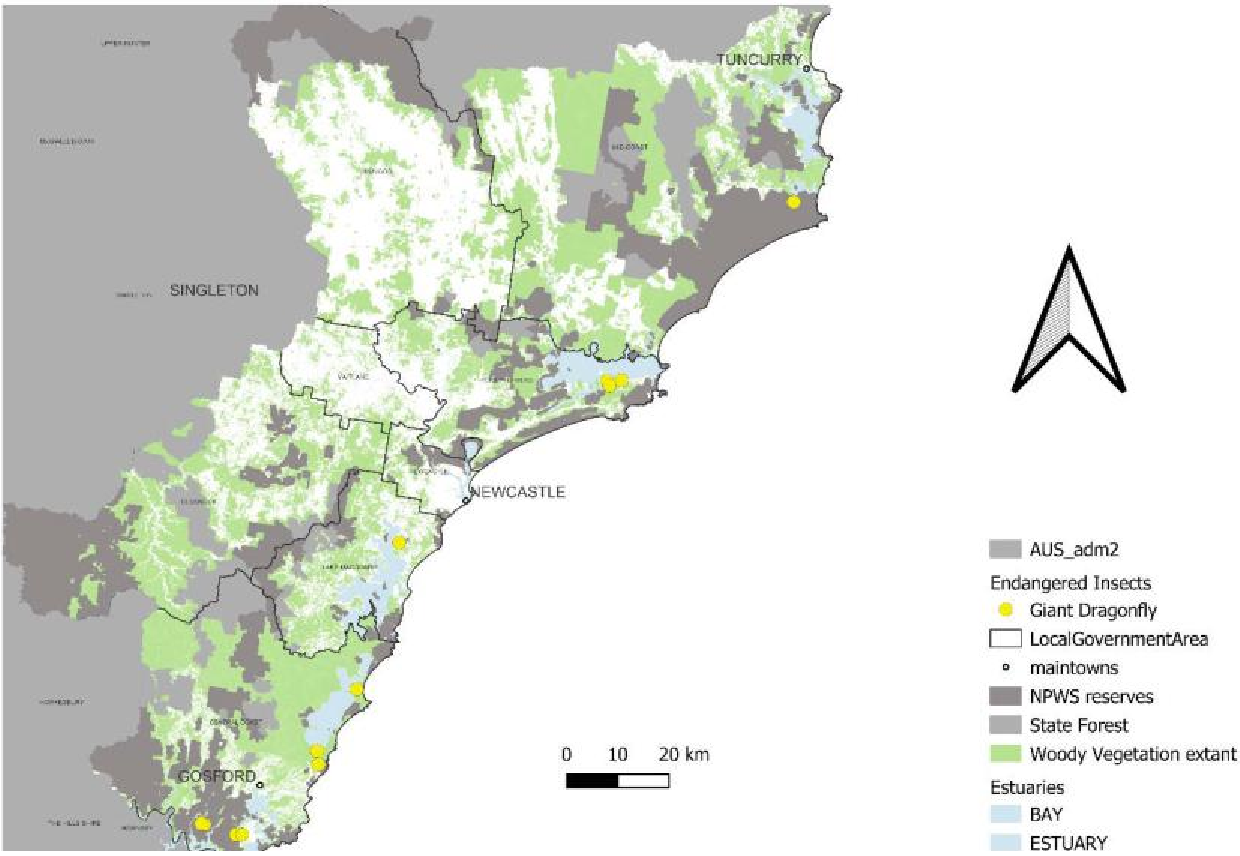


BTH Threatened plants



Threatened insects

Appendix 4: BTH Species List - BioNet post 2020 records

Threatened Fauna list

Aves	Australian Painted Snipe	Rostratulidae	Rostratula australis	E1,P
Aves	Sanderling	Scolopacidae	Calidris alba	V,P
Aves	Red Knot	Scolopacidae	Calidris canutus	P
Aves	Curlew Sandpiper	Scolopacidae	Calidris ferruginea	E1,P
Aves	Great Knot	Scolopacidae	Calidris tenuirostris	V,P
Aves	Broad-billed Sandpiper	Scolopacidae	Limicola falcinellus	V,P
Aves	Black-tailed Godwit	Scolopacidae	Limosa limosa	V,P
Aves	Eastern Curlew	Scolopacidae	Numenius madagascariensis	P
Aves	Terek Sandpiper	Scolopacidae	Xenus cinereus	V,P
Aves	Red-backed Button-quail	Turnicidae	Turnix maculosus	V,P
Aves	Sooty Tern	Laridae	Onychoprion fuscata	V,P
Aves	Little Tern	Laridae	Sternula albifrons	E1,P
Aves	Gang-gang Cockatoo	Cacatuidae	Callocephalon fimbriatum	V,P,3
Aves	Glossy Black-Cockatoo	Cacatuidae	Calyptorhynchus lathami	V,P,2
Aves	Little Lorikeet	Psittacidae	Glossopsitta pusilla	V,P
Aves	Swift Parrot	Psittacidae	Lathamus discolor	E1,P,3
Aves	Turquoise Parrot	Psittacidae	Neophema pulchella	V,P,3
Aves	Barking Owl	Strigidae	Ninox connivens	V,P,3
Aves	Powerful Owl	Strigidae	Ninox strenua	V,P,3
Aves	Eastern Grass Owl	Tytonidae	Tyto longimembris	V,P,3
Aves	Masked Owl	Tytonidae	Tyto novaehollandiae	V,P,3
Aves	Sooty Owl	Tytonidae	Tyto tenebricosa	V,P,3
Aves	Rufous Scrub-bird	Atrichornithidae	Atrichornis rufescens	V,P
Aves	Brown Treecreeper (eastern subsp	Climacteridae	Climacteris picumnus victoriae	V,P
Aves	Pilotbird	Dasyornithidae	Pycnoptilus floccosus	P
Aves	Speckled Warbler	Acanthizidae	Chthonicola sagittata	V,P
Aves	Regent Honeyeater	Meliphagidae	Anthochaera phrygia	E4A,P
Aves	White-fronted Chat	Meliphagidae	Epthianura albifrons	V,P
Aves	Painted Honeyeater	Meliphagidae	Grantiella picta	V,P
Aves	Black-chinned Honeyeater (easter	Meliphagidae	Melithreptus gularis gularis	V,P
Aves	Grey-crowned Babbler (eastern su	Pomatostomidae	Pomatostomus temporalis temporalis	V,P
Aves	Varied Sittella	Neosittidae	Daphoenositta chrysoptera	V,P
Aves	Olive Whistler	Pachycephalidae	Pachycephala olivacea	V,P
Aves	Dusky Woodswallow	Artamidae	Artamus cyanopterus cyanopterus	V,P
Aves	Hooded Robin (south-eastern form	Petroicidae	Melanodryas cucullata cucullata	V,P
Aves	Scarlet Robin	Petroicidae	Petroica boodang	V,P
Aves	Flame Robin	Petroicidae	Petroica phoenicea	V,P
Aves	Diamond Firetail	Estrildidae	Stagonopleura guttata	V,P

Order	Common Name	Family	Genus species	BCA,EPBCA
Mammalia	Spotted-tailed Quoll	Dasyuridae	Dasyurus maculatus	V,P
Mammalia	Brush-tailed Phascogale	Dasyuridae	Phascogale tapoatafa	V,P
Mammalia	Common Planigale	Dasyuridae	Planigale maculata	V,P
Mammalia	Southern Brown Bandicoot (easte	Peramelidae	Isoodon obesulus obesulus	E1,P
Mammalia	Koala	Phascolarctidae	Phascolarctos cinereus	E1,P
Mammalia	Eastern Pygmy-possum	Burramyidae	Cercartetus nanus	V,P
Mammalia	Yellow-bellied Glider	Petauridae	Petaurus australis	V,P
Mammalia	Squirrel Glider	Petauridae	Petaurus norfolcensis	V,P
Mammalia	Greater Glider	Pseudocheiridae	Petauroides volans	P
Mammalia	Rufous Bettong	Potoroidae	Aepyprymnus rufescens	V,P
Mammalia	Long-nosed Potoroo	Potoroidae	Potorous tridactylus	V,P
Mammalia	Parma Wallaby	Macropodidae	Macropus parma	V,P
Mammalia	Brush-tailed Rock-wallaby	Macropodidae	Petrogale penicillata	E1,P
Mammalia	Red-legged Pademelon	Macropodidae	Thylogale stigmatica	V,P
Mammalia	Grey-headed Flying-fox	Pteropodidae	Pteropus poliocephalus	V,P
Mammalia	Yellow-bellied Sheathtail-bat	Emballonuridae	Saccolaimus flaviventris	V,P
Mammalia	Eastern Coastal Free-tailed Bat	Molossidae	Micronomus norfolkensis	V,P
Mammalia	Large-eared Pied Bat	Vespertilionidae	Chalinolobus dwyeri	V,P
Mammalia	Eastern False Pipistrelle	Vespertilionidae	Falsistrellus tasmaniensis	V,P
Mammalia	Southern Myotis	Vespertilionidae	Myotis macropus	V,P
Mammalia	Corben's Long-eared Bat	Vespertilionidae	Nyctophilus corbeni	V,P
Mammalia	Golden-tipped Bat	Vespertilionidae	Phoniscus papuensis	V,P
Mammalia	Greater Broad-nosed Bat	Vespertilionidae	Scoteanax rueppellii	V,P
Mammalia	Eastern Cave Bat	Vespertilionidae	Vespadelus troughtoni	V,P
Mammalia	Little Bent-winged Bat	Miniopteridae	Miniopterus australis	V,P
Mammalia	Large Bent-winged Bat	Miniopteridae	Miniopterus orianae oceanensis	V,P
Mammalia	Broad-toothed Rat	Muridae	Mastacomys fuscus	V,P
Mammalia	Eastern Chestnut Mouse	Muridae	Pseudomys gracilicaudatus	V,P
Mammalia	New Holland Mouse	Muridae	Pseudomys novaehollandiae	P
Mammalia	Hastings River Mouse	Muridae	Pseudomys oralis	E1,P
Insecta	Giant Dragonfly	Petaluridae	Petalura gigantea	E1

Threatened Flora list

Family	Genus species	Common name	BCA	EPBCA
Fabaceae (Mimosoideae)	Acacia pendula	Acacia pendula population in the	E2	
Myrtaceae	Darwinia fascicularis subsp. oligantha	Darwinia fascicularis subsp. oligantha population in the Baulkham Hills and	E2	
Myrtaceae	Eucalyptus camaldulensis	Eucalyptus camaldulensis population in the Hunter catchment	E2	
Myrtaceae	Eucalyptus oblonga	Eucalyptus oblonga population at Bateau Bay, Forresters Beach and Tumbi Umbi in the Wyong local	E2	
Myrtaceae	Eucalyptus parramattensis subsp. parramattensis	Eucalyptus parramattensis C. Hall. subsp. parramattensis in Wyong and Lake Macquarie local government	E2	
Myrtaceae	Eucalyptus seeana	Eucalyptus seeana population in the Greater Taree local government area	E2	
Orchidaceae	Cymbidium canaliculatum	Cymbidium canaliculatum population in the Hunter Catchment	E2,P,2	
Orchidaceae	Diuris tricolor	Pine Donkey Orchid population in the Muswellbrook local government area	E2,V,P,2	
Apocynaceae	Cynanchum elegans	White-flowered Wax Plant	E1	E
Apocynaceae	Marsdenia longiloba	Slender Marsdenia	E1	V
Apocynaceae	Parsonsia dorrigoensis	Milky Silkpod	V	E
Apocynaceae	Tylophora woollsii	Cryptic Forest Twiner	E1	E
Araliaceae	Astrotricha crassifolia	Thick-leaf Star-hair	V	V
Asteraceae	Olearia cordata		V	V
Asteraceae	Ozothamnus tesselatus		V	V
Asteraceae	Picris evae	Hawkweed	V	V
Asteraceae	Rutidosis heterogama	Heath Wrinklewort	V	V
Asteraceae	Senecio spathulatus	Coast Groundsel	E1	
Campanulaceae	Isotoma fluviatilis subsp. fluviatilis			X
Casuarinaceae	Allocasuarina defungens	Dwarf Heath Casuarina	E1	E
Casuarinaceae	Allocasuarina simulans	Nabiac Casuarina	V	V
Casuarinaceae	Allocasuarina thalassoscopica			E
Convolvulaceae	Wilsonia backhousei	Narrow-leafed Wilsonia	V	
Dilleniaceae	Hibbertia procumbens	Spreading Guinea Flower	E1	
Dilleniaceae	Hibbertia puberula		E1	
Dilleniaceae	Hibbertia spanantha	Julian's Hibbertia	E4A,2	CE
Dilleniaceae	Hibbertia superans		E1	
Elaeocarpaceae	Tetratheca glandulosa		V	
Elaeocarpaceae	Tetratheca juncea	Black-eyed Susan	V	V
Ericaceae	Epacris purpurascens var. purpurascens		V	
Ericaceae	Leucopogon fletcheri subsp. fletcheri		E1	
Euphorbiaceae	Amperea xiphoclada var. pedicellata		E4	X
Euphorbiaceae	Chamaesyce psammogeton	Sand Spurge	E1	
Fabaceae (Caesalpinioideae	Senna acclinis	Rainforest Cassia	E1	
Fabaceae (Faboideae)	Dillwynia tenuifolia		V	
Fabaceae (Faboideae)	Pultenaea maritima	Coast Headland Pea	V	
Fabaceae (Faboideae)	Swainsona sericea	Silky Swainson-pea	V	
Fabaceae (Mimosoideae)	Acacia bynoeana	Bynoe's Wattle	E1	V
Fabaceae (Mimosoideae)	Acacia pubescens	Downy Wattle	V	V
Fabaceae (Faboideae)	Dillwynia tenuifolia	Dillwynia tenuifolia Sieber ex D.C. in the Baulkham Hills local government area	E2,V	
Goodeniaceae	Velleia perfoliata		V	V
Grammitidaceae	Grammitis stenophylla	Narrow-leaf Finger Fern	E1,3	
Haloragaceae	Haloragis exalata subsp. exalata	Square Raspwort	V	V
Juncaginaceae	Maundia triglochinoides		V	
Lamiaceae	Prostanthera askania	Tranquility Mintbush	E1	E
Lamiaceae	Prostanthera cineolifera	Singleton Mint Bush	V	V
Lamiaceae	Prostanthera densa	Villous Mint-bush	V	V
Lamiaceae	Prostanthera junonis	Somersby Mintbush	E1	E
Linderniaceae	Lindernia alsinoides	Noah's False Chickweed	E1	
Lindsaeaceae	Lindsaea fraseri	Fraser's Screw Fern	E1,3	
Malvaceae	Commersonia prostrata	Dwarf Kerrawang	E1	E
Malvaceae	Lasiopetalum joyceae		V	V

Myrtaceae	Angophora inopina	Charmhaven Apple	V	V
Myrtaceae	Callistemon linearifolius	Netted Bottle Brush	V,3	
Myrtaceae	Darwinia biflora		V	V
Myrtaceae	Darwinia glaucophylla		V	
Myrtaceae	Darwinia peduncularis		V	
Myrtaceae	Eucalyptus camfieldii	Camfield's Stringybark	V	V
Myrtaceae	Eucalyptus castrensis	Singleton Mallee	E1	
Myrtaceae	Eucalyptus fracta	Broken Back Ironbark	V	
Myrtaceae	Eucalyptus glaucina	Slaty Red Gum	V	V
Myrtaceae	Eucalyptus largeana	Craven Grey Box	E1	E
Myrtaceae	Eucalyptus parramattensis subsp. decadens		V	V
Myrtaceae	Eucalyptus pumila	Pokolbin Mallee	V	V
Myrtaceae	Eucalyptus sp. Howes Swamp Creek		E1	E
Myrtaceae	Kunzea rupestris		V	V
Myrtaceae	Melaleuca biconvexa	Biconvex Paperbark	V	V
Myrtaceae	Melaleuca deanei	Deane's Paperbark	V	V
Myrtaceae	Melaleuca groveana	Grove's Paperbark	V	
Myrtaceae	Micromyrtus blakelyi		V	V
Myrtaceae	Rhodamnia rubescens	Scrub Turpentine	E4A	CE
Myrtaceae	Rhodomyrtus psidioides	Native Guava	E4A	CE
Myrtaceae	Syzygium paniculatum	Magenta Lilly Pilly	E1	V
Orchidaceae	Caladenia tessellata	Thick Lip Spider Orchid	E1,P,2	V
Orchidaceae	Chiloglottis platyptera	Barrington Tops Ant Orchid	V,P,2	
Orchidaceae	Corunastylis sp. Charmhaven (NSW896673)		E4A,P,2	CE
Orchidaceae	Corybas dowlingii	Red Helmet Orchid	E1,P,2	
Orchidaceae	Cryptostylis hunteriana	Leafless Tongue Orchid	V,P,2	V
Orchidaceae	Dendrobium melaleucaphilum	Spider orchid	E1,P,2	
Orchidaceae	Diuris arenaria	Sand Doubletail	E1,P,2	
Orchidaceae	Diuris bracteata		E1,P,2	X
Orchidaceae	Diuris flavescens	Pale Yellow Doubletail	E4A,P,2	CE
Orchidaceae	Diuris pedunculata	Small Snake Orchid	E1,P,2	E
Orchidaceae	Diuris praecox	Rough Doubletail	V,P,2	V
Orchidaceae	Diuris tricolor	Pine Donkey Orchid	V,P,2	
Orchidaceae	Diuris venosa	Veined Doubletail	V,P,2	V
Orchidaceae	Genoplesium insigne	Variable Midge Orchid	E4A,P,2	CE
Orchidaceae	Genoplesium littorale	Tuncurry Midge Orchid	E4A,P,2	CE
Orchidaceae	Prasophyllum petilum	Tarengo Leek Orchid	E1,P,2	E
Orchidaceae	Pterostylis chaetophora		V,P,2	
Orchidaceae	Pterostylis elegans	Elegant Greenhood	V,P,2	
Orchidaceae	Pterostylis gibbosa	Illawarra Greenhood	E1,P,2	E
Orchidaceae	Pterostylis riparia		V,P,2	V
Orchidaceae	Rhizanthella slateri	Eastern Australian Underground Orchid	V,P,2	E
Orchidaceae	Rhizanthella slateri	Rhizanthella slateri (Rupp) M.A. Clem. & Cribb in the Great Lakes LGA	E2,V,P,2	E
Orchidaceae	Thelymitra adorata	Wyong Sun Orchid	E4A,P,2	CE

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