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Northern Beaches Council Biodiversity Planning Review

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Abbreviations

Abbreviations	
AEP	Annual Exceedance Probability (relating to floods and expressed as a percentage)
API	Aerial Photographic Interpretation
AOBV	Area of Outstanding Biodiversity Value
a.s.l	Above sea level
BAM	Biodiversity Assessment Method
BC Act	NSW *Biodiversity Conservation Act 2016*
BSF	Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions
CM Act	NSW *Coastal Management Act 2016*
CM SEPP	NSW State Environmental Planning Policy (Coastal Management) 2018
CUS	Coastal Upland Swamp in the Sydney Basin Bioregion
DCP	Development Control Plan
DFEC	Duffys Forest Ecological Community in the Sydney Basin Bioregion
DPIE	NSW Department of Planning Industry and Environment
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESBS	Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion
FM Act	NSW *Fisheries Management Act 1994*
FWCF	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
GANSW	Government Architect NSW
GIS	Geographic Information System
KHP SEPP	NSW State Environmental Planning Policy Koala Habitat Protection
KC	Ku-ring-gai Council
LCC	Lismore City Council
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
LLS Act	NSW *Local Land Services Act 2013*
NBC	Northern Beaches Council

Abbreviations	
NPW Act	NSW *National Parks and Wildlife Act 1974*
NPWS	National Parks and Wildlife Service
OEH	Office of Environment and Heritage
PCT	Plant Community Type
PSGF	Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion
RFEF	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
SEPP 19	NSW State Environmental Planning Policy No. 19 – Bushland in Urban Areas
SFW	Sydney Freshwater Wetlands in the Sydney Basin Bioregion
SOFF	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
SSC	Sutherland Shire Council
SSF	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
TEC	Threatened Ecological Community
TG	Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions

Executive summary

Northern Beaches Council (NBC) is reviewing its planning instruments and developing a new, integrated Local Environment Plan (LEP) and Development Control Plan (DCP) to guide its long-term land-use planning, including the provision of new biodiversity planning controls to deal with protection of native vegetation, wildlife habitat and connectivity, and threatened entities (threatened species, threatened ecological communities and threatened populations).

The scope of this project includes:

- A review of the currency and robustness of existing wildlife habitat/corridor and threatened entities mapping across the Northern Beaches Local Government Area (LGA)
- The identification of appropriate methodologies to update, validate and consolidate existing wildlife habitat/corridor and threatened entities (species and communities) mapping using industry standards
- The undertaking of recommended desktop analysis and field studies
- The development of consolidated and updated core habitat/biodiversity corridor and threatened entities spatial layers fit for adoption by the NBC planning instruments

This report is accompanied by two consolidated and revised spatial layers:

- Core habitat and biodiversity corridors spatial layer
- Threatened entities spatial layer including threatened species (TS) and threatened ecological communities (TECs)

The current report carried investigations to refine these layers and ensure a defensible and consistent result across the study area.

The core habitat and biodiversity corridor layer has identified vegetation features which connect larger areas of remnant bushland to facilitate dispersal of wildlife and plant populations across the landscape. Map categories were broadly consistent with the urban biodiversity framework set out under the NSW Government Architect's Greener Places Urban Green Infrastructure Guide (draft) (GANSW, 2020). This Biodiversity Planning Review identified a consolidated biodiversity corridor layer, incorporating core habitat areas and biodiversity corridor areas, suitable for adoption into the new Northern Beaches DCP.

The threatened entities (species and communities) layer includes the following:

- Identifies selected threatened species records and habitat
- Presents the likely pattern of distribution of threatened ecological communities (TECs), as declared under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and NSW *Biodiversity Conservation Act 2016* (BC Act).

The TEC component is based upon the existing 'Native Vegetation of the Sydney Metropolitan Area v3.1' mapping administered by the Office of Environment & Heritage (OEH, 2016). The threatened species component has reviewed and consolidated existing data and spatial resources to ensure new DCP provisions are current and consistent across those former council areas prior to the amalgamation into the Northern Beaches Council in May 2016. Prioritised limited field surveys were carried out to refine the base mapping of OEH (2016).

The results of the project have:

- Identified significant areas of core habitat areas and a network of biodiversity corridor areas across the LGA
- Reviewed and identified important key biodiversity assets, particularly threatened entities listed under the BC Act, and the EPBC Act. These threatened entities include likely or confirmed occurrences of, or habitat for threatened species, populations and ecological communities

1 Introduction

1.1 Background

Since amalgamation of the Northern Beaches Council (NBC) in May 2016, land use planning has been controlled by four different Local Environment Plans (LEPs) and three Development Control Plans (DCPs). Following the release of the 'Greater Sydney Region Plan' and the 'North District Plan' by the Greater Sydney Commission in March 2018, NBC is reviewing its planning instruments and developing a new, integrated LEP and DCP to guide its long-term land use planning, including the provision of new biodiversity planning controls to deal with protection of native vegetation, wildlife habitat and connectivity, and threatened entities (threatened species, threatened ecological communities and threatened populations).

SMEC has been engaged by NBC to carry out the biodiversity planning review in collaboration with NBC. The program of works forming part of the project included:

- Review the currency and robustness of existing wildlife habitat/corridor and threatened entities mapping across the Northern Beaches Local Government Area (LGA)
- Identify appropriate methodologies to update, validate and consolidate existing wildlife habitat/corridor and threatened entities (species and communities) mapping using industry standards
- Undertake recommended desktop analysis and field studies
- Develop consolidated and updated core habitat/corridor and threatened entities spatial layers fit for adoption by the NBC planning instruments

This report forms part of the final deliverable, and accompanies the two spatial layers developed as part of this project:

- Core habitat and biodiversity corridors spatial layer
- Threatened entities spatial layer

1.2 Aims and Objectives

The objective of this report is to provide a detailed description of the methodology undertaken to complete the planning review and development of the GIS spatial layer. The report includes:

- Detailed description of the derivation of the GIS layers
- The results of the review, specifically
  - A description of key wildlife habitat (identified as 'core habitat') and biodiversity corridors
  - A description of key biodiversity assets with specific reference to assets recognised through NSW and Commonwealth legislation
  - Outcomes of field validation
  - Details of any information gaps identified during the review process
- Discussion that may be relevant to the ecological values identified
- Recommendations including opportunities for further refinement of spatial layers and/or future surveys
- Appendices containing
  - Inventory of threatened species recorded within the LGA
  - Inventory of threatened ecological communities occurring within the LGA
  - Maps of the completed spatial layers

1.3 Study area

The study area for this project is restricted to the boundary of the Northern Beaches LGA. For the purposes of mapping TECs and threatened species habitat in this report, the 'deferred lands' which remain under Warringah LEP 2000 have been excluded from the study area, however mapping of core habitat areas and biodiversity corridor areas include the deferred lands. For the purposes of this project, terrestrial land is considered to be land that falls within the NBC GIS shapefile *'Water Feature Corridor'* specifically, the land occurring above the 'Ocean' and 'Tidal' attributes within the shapefile. While only land within this study area is part of the project deliverables, adjoining terrestrial

areas outside the study area, including threatened species records and other biodiversity values such as those values equivalent to core habitat, have been considered for this project's assessment.

1.4 Existing environment

Northern Beaches Council was formed in May 2016 following the amalgamation of three council areas:

- Manly Council
- Warringah Council
- Pittwater Council

Northern Beaches LGA comprises a land area of 254 square kilometres and is bound by the South Pacific Ocean to the east, Pittwater and Cowan Creek to the north, Ku-ring-gai LGA to the west, and Middle Harbour and Sydney Harbour to the south. The LGA contains a mix of low, medium and high-density residential properties and commercial precincts. However, the LGA also possesses a large and significant area of intact remnant native vegetation and areas of biodiversity value, including areas within bushland reserves, crown land, private land and National Parks.

Key biodiversity assets present within Northern Beaches LGA include:

- Ku-ring-gai Chase National Park, Garigal National Park, Sydney Harbour National Park (managed by the NSW Government)
- Large areas of intact remnant native vegetation and wildlife habitat (core habitat) in the Manly Dam Catchment, Narrabeen Lagoon Catchment and areas adjoining Pittwater Estuary
- Threatened Ecological Communities (TECs) listed under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Threatened species, including species endemic to the LGA, listed under both the BC Act and EPBC Act
- Little Penguin Area of Outstanding Biodiversity Value (AOBV)

1.5 Statutory considerations

The legislative instruments outlined in Table 1-1 have been considered as part of the planning review.

Table 1-1 Relevant legislation

Name	Description
Commonwealth Legislation	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Designed to protect national environmental assets, known as matters of national environmental significance (MNES), which include threatened species of flora and fauna, endangered ecological communities, and migratory species, as well as other protected matters. Among other things, it defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna, and communities. MNES identified in the EPBC Act are: • world heritage properties • national heritage places • Ramsar wetlands • nationally threatened species and communities • migratory species protected under international agreements • the Commonwealth marine environment • the Great Barrier Reef Marine Park • nuclear actions • a water resource in relation to coal seam gas development and large coal mining development.

Name	Description
NSW Legislation	
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is the overarching planning legislation in NSW that provides for the creation of planning instruments that guide land use. The EP&A Act also provides for the protection of the environment, including the protection and conservation of native animals and plants. This includes threatened species, populations and ecological communities, and their habitats of biodiversity values.
Biodiversity Conservation Act 2016 (BC Act)	The *Biodiversity Conservation Act 2016* (BC Act) and its supporting regulations commenced on 25 August 2017. The BC Act repealed the *Threatened Species Conservation Act 1995* (TSC Act) along with other natural resource management legislation, while retaining the TSC Act species list. The BC Act sets out the environmental impact assessment framework for threatened species, threatened ecological communities and Areas of Outstanding Biodiversity Value (formerly critical habitat) for Major Projects and local development.
Fisheries Management Act 1994 (FM Act)	The objectives of the FM Act are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. Objectives of the Act include: (a) To conserve fish stocks and key fish habitats (b) To conserve threatened species, populations and ecological communities of fish and marine vegetation (c) To promote ecologically sustainable development, including the conservation of biological diversity.
Coastal Management Act 2016 (CM Act)	The objective of the *Coastal Management Act 2016* (CM Act) is to manage the coastal environment in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of NSW. The study area contains areas mapped the Coastal Management SEPP as 'coastal wetland area' and 'proximity to coastal wetlands'. This legislation establishes clear outcome-orientated management objectives for each area to ensure councils apply appropriate management tools and development controls. The management objectives for the coastal wetlands area are as follows: (a) to protect coastal wetlands and littoral rainforests in their natural state, including their biological diversity and ecosystem integrity, (b) to promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests, (c) to improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration, (d) to support the social and cultural values of coastal wetlands and littoral rainforests, (e) to promote the objectives of State policies and programs for wetlands or littoral rainforest management.
National Parks and Wildlife Act 1974 (NPW Act)	The NPW Act provides for the conservation of NSW's natural and cultural heritage, including habitat, ecosystems, biological diversity, landforms and landscapes of significance, and places/objects/features of

Name	Description
	significance to Aboriginal peoples. The NPW Act also aims to foster public appreciation, understanding and enjoyment of natural and cultural heritage and promote its conservation.
State Environmental Planning Policy Koala Habitat Protection (KHP SEPP)	State Environmental Planning Policy Koala Habitat Protection (KHP SEPP) aims to protect the koala and its habitat by incorporating prescriptions for consent authorities to consider during the assessment of development applications. Koala Habitat Protection SEPP contains prescriptions for the consideration of koala habitat for developments within LGAs listed on Schedule 1 of the policy, of which NBC is a listed LGA.
State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP)	The CM SEPP commenced on 3 April 2018. It aims to promote an integrated and coordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the *Coastal Management Act 2016*. Development in coastal wetlands and littoral rainforests, regardless of land zoning, has been controlled since the 1980s. The CM SEPP largely carries forward pre-existing controls from the now repealed SEPP 14 (Coastal Wetlands) and SEPP 26 (Littoral Rainforests). The CM SEPP identifies development controls to help protect and manage sensitive coastal environments, manage risks from coastal hazards and support appropriate development (DPE, 2015). The CM SEPP imposes targeted development controls for these areas, to guide appropriate development within the coastal zone. The CM Act and CM SEPP apply to land that is mapped within one or more of the four coastal management areas, which are not mutually exclusive. Where a site is mapped as more than one coastal management area, the development controls for each of those coastal management areas will apply.
State Environmental Planning Policy No. 19 – Bushland in Urban Areas (SEPP 19)	SEPP 19 aim to protect and preserve bushland within the urban areas because of its value to the community, its aesthetic value, and its value as a recreational, educational, and scientific resource. SEPP 19 contains prescriptions for the consideration of urban bushland for developments within LGAs listed on Schedule 1 of the policy, of which former Warringah Council and Manly Council are listed LGAs.

2 Methods

This section describes the methodology to map core habitat/corridor and threatened entities (species and communities) occurrence and habitat.

2.1 Literature review

Prior to the development of the methodology to generate the biodiversity corridor and threatened entity spatial layers, a literature review was carried out. A draft methodology (including literature review) identifying proposed criteria to be used in this project was subject to independent expert peer review (Keystone Ecological 2019 and EconPlan 2019) prior to suggested improvements and application of the methodologies described below.

The literature review consisted of a review of existing wildlife habitat/corridor and threatened entities mapping across the LGA and a range of associated documentation. A brief summary of the key documents that have shaped the proposed methodology is provided in Table 2-1 below.

Table 2-1 Key literature considered within the planning review

Literature	Description
Greener Places Design Guide draft (GANSW 2020)	Greener Places is a draft Green Infrastructure guide produced by the Government Architect NSW to guide the planning, design and delivery of Green Infrastructure in urban areas across NSW. It aims to create a healthier, more liveable and sustainable urban environment by improving community access to recreation and exercise, supporting walking and cycling connections, and improving the resilience of urban areas.
Draft Bushland and Waterways Manual V3 (GANSW 2018)	GANSW (2018) supports the *GANSW Bushland and Waterways Guide*, and guide provides information to relevant government agencies and specialist designers on the importance and benefits of urban habitat, and includes strategies, actions, processes and targets for connecting urban habitat and people, and for protecting, restoring, and enhancing ecological systems. The document provides a higher-level planning strategy and offers definitions of main components of a Strategic Urban Biodiversity Framework (SUBF) in the context of 'Green Infrastructure', those being 'core', 'transition' and 'potential corridor'.
Ku-ring-gai Biodiversity and Riparian Lands Study - Version 5 (KC, 2016)	Ku-ring-gai Council is a neighbouring LGA with similar mix of urban and bushland areas. The methodology used in planning within the KC "Greenweb" is outlined in the *Ku-ring-gai Biodiversity and Riparian Lands Study - Version 5*. Some key points noted in Ku-ring-gai Council's Greenweb were that: • Mapping of riparian zones throughout the LGA assigned its own width categories for core riparian zones • Similar zone categories as those in the Government Architect NSW (2018) were mapped, but also include a 'Landscape Remnant and Canopy Remnant' category • A minimum corridor width of 40 metres was defined • Use was made of the Sydney Metropolitan Catchment Management Authority (SMCMA) Regional Fauna Habitat Map (DECC 2008) for identifying core habitat • Swamp Wallaby was used as an indicator species for ground migration routes between areas of suitable habitat, whereas Brushtail Possum and Sugar Glider were used as indicator species for arboreal fauna.
Sutherland Shire Council Green Web Strategy (SSC, 2001)	Sutherland Shire Council mapped bushland areas and corridors as part of their 'Greenweb' in 2003 and incorporated it into their DCP in 2006. Within the DCP, 'core habitat' was defined as having a 3.5-hectare minimum size, a figure

Literature	Description
	that has subsequently been adopted as a suggested minimum by the GANSW (2018). SCC does not limit corridor widths but aims for corridor widths of four metres, 30 metres and 80-100 metres, noting that as each of these widths is reached a greater suite of animals can use the corridors.
Urban Green Corridors Plan – restoring and connecting urban bushland in Lismore (LCC, 2017)	Lismore City Council (LCC) is a much larger council area with less urban coverage than the Northern Beaches LGA. The larger areas of habitat extent in LCC allowed for biodiversity corridor planning theory around key species. This comparison highlights the fact that undeveloped space for corridors is limited on the Northern Beaches, and that connecting remnant bushland using a landscape approach to form corridors would be more suitable. Koalas were a key species considered within LCC's corridor planning.
Pittwater Native Vegetation Classification, pre-1750 Vegetation Mapping and Vegetation Profiles (v2.0 (East Coast Flora Survey and Bangalay, 2012).	Report and mapping was provided to SMEC. It formed the basis of the OEH 2016 map update and was based on extensive ground verification.
Warringah Council Natural Area Survey (Smith and Smith, 2005a; Smith and Smith, 2005b; Smith and Smith, 2009)	Warringah Council's Natural Area Survey surveyed and mapped the native vegetation of the Warringah Local Government Area outside Ku-ring-gai Chase and Garigal National Parks. The report drew on mapping to estimate the distribution of native vegetation types in the Warringah Local Government Area prior to European settlement, for comparison with their present distribution, to identify existing and potential biodiversity corridors linking the remnant bushland, and identify plant communities and species occurring within the LGA. The mapped corridors are broadly consistent with the zones proposed by GANSW (2018) including bushland cores and corridors.
Manly Natural Assets Survey to inform the Draft Manly LEP 2011 (Eco Logical Australia, 2011)	Eco Logical Australia ground-truthed and assessed natural assets located within prioritised areas in Manly LGA and prepared an assessment report that assessed presence and boundaries of TECs and located potential corridors. The study identified a potential corridor linking the harbour foreshores through Garigal National Park and Manly Dam Reserve in the west, extending eastwards through Manly Golf Course and Manly Lagoon to link with a corridor of coastal foreshore vegetation commencing at Queenscliff Headland extending northwards through the Warringah LGA.
Draft Pittwater LGA Wildlife Corridor Strategy (Pittwater Council, 2011)	The objective of the strategy was to identify, categorise and map biodiversity corridors within the Pittwater LGA. It determined that an adaptive and ongoing monitoring program would be required to ascertain the presence of select umbrella species in bushland reserves and corridors and corridor usage across the LGA. This approach would allow for connectivity improvements to be incorporated into future development planning and would facilitate the maintenance and improvement of habitat linkages across Pittwater LGA. The mapped corridors are broadly consistent with the zones proposed by GANSW (2018) including bushland cores and corridors.

In addition to the key resources detailed in Table 2-1 above, a review of a range of selected documents, many of which have been cited by key resources, was carried out. Scientific research should be a source of information providing the 'defensibility' of mapping decisions; however, it is difficult to translate findings into definitive

specifications, particularly when corridor functions are not explicitly defined. Generally, it is difficult to define a 'corridor' succinctly because of the complex and multiple functions that a corridor may serve (Hess and Fischer, 2001). In Hess and Fischer (2001), the authors suggest that conservationists and planners consider and document explicitly all the possible functions of corridors when designing them.

The definition of a corridor as given by the GANSW points towards the Traditional Corridor Hypothesis which posits that corridors increase immigration and emigration by functioning as movement conduits between patches (Townsend and Levey 2005). The range of ecological functions that can be considered for corridors include habitat, conduit, filter, barrier, source and sink. Some useful principles of corridor design are found in the literature review and have been applied by relevant and comparable LGAs, most notably, Ku-ring-gai and Sutherland Shire Councils.

Ku-ring-gai Council has adopted some of the fundamentals of corridor design in their planning process; these include:

- Shorter biodiversity corridors are better to minimise the exposure of flora and fauna to edge effects, but this rule may require some trade off when linking remnant vegetation in the urban environment
- Wider corridors area better
- Barriers should be minimised where possible
- Where possible, corridors should connect and incorporate a diverse range of vegetation communities and habitat types in order to provide opportunity for a greater range of species to access the corridor
- Areas identified for corridors should have practical management requirements and long-term outcomes
- 'Loop' design, where habitats are linked in a circular pattern and multiple corridors that link each habitat, are more robust than 'necklace' pattern corridors (Jordan, 2000) or corridors that end in 'dead-ends' (Tewkesbury et al, 2002).

When it comes to research into the suitable remnant bushland to be considered 'core' areas, the scientific literature not surprisingly points to a larger-is-better trend for supporting a greater range of species. Drinnan (2005) who addressed this question in a study of Sutherland LGA in southern Sydney, found that the relationship between species diversity and remnant size is not a linear one, and that there are threshold values, at between three and five hectares, below which species diversity declines rapidly. Drinnan (2005) is one of the more relevant as it specifically addresses this question in the same biogeographical region as the Northern Beaches. Smith and Smith (2009a) cite it as part of their decision to choose four hectares as a minimum patch size for 'core habitat' and it influences SCC's Greenweb design. Some key points from Drinnan (2005) include:

- Patch area is positively correlated with species richness in all studied groups (birds, frogs, plants and fungi) i.e. larger patch area leads to greater species richness.
- Perimeter to area ratio has a negative impact on species richness i.e. the more linear a patch of habitat the fewer species you will find. This was relationship was found in birds, frogs, plants and fungi.
- The connectivity of a stand of vegetation was found to have a positive correlation with the number of species recorded in all groups. All correlations were found to be significant, however compared to the other variables, connectivity was not as important to species richness.
- Within a fragmented urban environment, habitat nodes should be a minimum of 3.5 – 5 hectares, however several reserves of greater than 100 hectares should be included.

2.2 Spatial data review

Previous studies and mapping projects that have been reviewed for this project include:

- Pittwater Habitat and Wildlife Corridors Strategy, Burcher 1995
- Draft Wildlife Corridors Strategy, Pittwater Council 2011
- Smith and Smith 2009 Warringah Natural Area Survey – Vegetation History and Wildlife Corridors – 2009 Update (Draft Core Habitat and Draft Corridors)
- Warringah DCP 2011 DCP Wildlife Corridors as mapped by Smith and Smith 2005
- Former Manly Council GIS layers:
  - DCP - Manly Biodiversity
  - DCP - E2 Zones identified in Natural Assets Study 2011
- The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 GIS layers (OEH, 2016)
- Northern Beaches Council GIS layers:

  - Water Feature Corridor
  - NBC Watercourse
  - LEP Land Zoning (recreation areas)
  - BioNet Atlas Records Threatened Species
  - NBC threatened species records datasets
  - LIDAR Estimate of Canopy Height and Cover (NBC, 2019)
  - Various confidential and unpublished reports
- NSW Biodiversity Values Map
- NSW National Parks and Wildlife Service (NPWS) Estates GIS layer

2.3 Core habitat and biodiversity corridor spatial layer

The following section details the methodology for identifying and mapping the core habitat and biodiversity corridor spatial layer.

2.3.1 Core habitat areas

2.3.1.1 Core habitat definition

According to the GANSW (2020), core habitat areas form the basis of the future urban ecology network. The protection of core habitat is fundamental to preserving and enhancing urban ecology as it contains the greatest biodiversity and number of species and is representative of the original habitat structure and function that has been reduced due to urban development elsewhere. If lost, core habitat areas are unlikely to ever be replaced in their original complexity. Core habitat areas are usually located in National Park estate, council reserves, along waterways, and in larger landholdings.

Definition of core habitat areas for the purpose of this mapping layer is largely derived from Drinnan (2005) and the background discussion in the Warringah Natural Area Survey: Vegetation History and Wildlife Corridors (Smith and Smith, 2009).

The definition of core habitat adopted in this report is as follows:

- Core habitats consist predominantly of native vegetation. They may include weed thickets, but these should not be the main vegetation type.
- Patches of cleared or developed land may be present within the core habitat as long as they do not compromise its overall integrity. Such patches are not mapped or counted as part of the core habitat.
- Core habitats are generally at least 3.5 hectares in area. However, patches of vegetation smaller than 3.5 hectares in size can be considered as core habitat when the vegetation consists of a TEC or is of high biodiversity value.
- Core habitats should be continuous, not bisected by busy roads or major watercourses that are a significant barrier to fauna movements. However minor, little-used roads and tracks may be present within the core habitat.
- Core habitats need not be formal conservation reserves or bushland reserves.

This definition forms the basis of core habitat areas for this review with some additional qualifications.

Table 2-2. Criteria for mapping core habitat areas.

No.	Criteria	Reason	References
1	Patch size 3.5 hectare or greater.	Provides a threshold below which habitat potential rapidly declines. Reasons documented in Warringah Natural Area Survey.	Smith and Smith (2009), Drinnan (2005)
2	Largely intact native vegetation – all strata expected in plant community are present	Meet GANSW's definition to be "representative of original habitat structure".	GANSW (2020)

No.	Criteria	Reason	References
3	Breaks in calculation of a patch of up to 100 metres in wooded communities, or up to 30 metres for non-woody communities can be accommodated provided criterion 2 is still met on both sides of the break.	Incorporates the definition of native vegetation patch size used in the NSW Biodiversity Assessment Methodology (NSW BAM)	NSW BAM (OEH, 2017)

2.3.1.2 Core habitat area mapping

The criteria used to identify and map core habitat areas includes:

- Areas of NPWS estate
- Patches of largely intact native vegetation that are either continuous or with minor gaps such as roads, and a patch size generally over 3.5ha
- Smaller patches with no size restriction where:
  - The vegetation consists of a structurally important or intact TEC (excluding canopy only remnants and poor-quality patches), or
  - Areas individually assessed as having high threatened species values and or high connectivity values
- Core habitats identified in former Warringah and Pittwater reports were included unless obvious clearing or development had occurred in an area

The following data sources were utilised to generate the core habitat areas within the spatial layer:

- Draft core habitats as identified and mapped by Smith and Smith (2009)
- NSW National Parks Estate – map
- Pittwater 21 Development Control Plan 2014, Control B4.1 - Flora and Fauna Conservation Category 1 Land - Areas of core habitat mapped as Flora and Fauna Conservation Areas
- The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 GIS layers (OEH, 2016)
- Manly, Warringah and Pittwater LEP Land Zoning (RE 1 - recreation areas) within Northern Beaches LGA

2.3.2 Biodiversity corridor areas

2.3.2.1 Biodiversity corridor area definition

Biodiversity corridors facilitate flora and fauna movement across the landscape. The definition of corridor is not limited to providing connectivity between core areas of habitat. Within the largely urban context of the northern beaches, open areas adjacent to core habitat, even if they do not connect through to other core areas, provide many of the functions of a corridor such as permanent or temporary (refugial) habitat, a passage for species moving through the landscape, and as route for the extension of range within the urban environment by providing proximity to other "stepping stone" patches of remnant vegetation. The concept of allowing corridors to include patches of habitat with some breaks in-between is derived from standards in the NSW Biodiversity Assessment Methodology (BAM) (OEH, 2017) which allows gaps of up to 100 metres (in wooded formations) to still be considered contiguous fauna habitat. This approach allowed for limited sections of corridors to contain some developed areas but with a defensible and consistent approach, unlike that observed in some of the mapped corridors in the former Warringah LGA DCP.

Extents of native vegetation communities are generally considered to offer potential corridor habitat, even if they do not meet the condition of core habitat areas. While shape, minimum width and size are likely constraints for some fauna species, it is generally assumed that native vegetation communities in general, within reasonable distance to other core or corridor patches, should be included as biodiversity corridor.

Managed open spaces such as parks, golf courses and sporting fields are presumed to provide important transit routes for many fauna species. These areas are likely to offer opportunities for future habitat improvement along pathways and drainage lines. The GANSW aims to create incentives to improve future corridors where these habitat improvement opportunities exist. Areas of structurally and floristically simple open space, whilst offering poor foraging, breeding or resting habitat for many species may support important habitat for some species, for example, Ospreys using Pittwater Rugby Field as a nesting site. These areas may be hostile to predators, and offer important

refuge habitats. Some patches of potential habitat that are managed open space or zoned for public recreation, and may be isolated from corridor values, may support significant occurrences of habitat types such as rocky knolls or threatened flora species. Additionally, the relative security of habitat features of much Council-managed open space, even if small or isolated, gives support to assigning some of these areas of high biodiversity value as biodiversity corridor.

The sea and estuarine areas in many ways function as a core habitat area for a large range of fauna that can inhabit this interface with terrestrial landscapes. Shore birds and sea birds are obvious examples, which in Manly can include Little Penguins. The coast is also a first resting place for some migratory species. An unusual green turtle nesting event in Queenscliff in 2019 is another example of the coastal corridor's importance. This land/water interface in many cases also provides a route of travel parallel to the coastline for a range of terrestrial fauna that can move through undeveloped spaces such as beaches, dunes, cliff tops and rocky shores. These coastal edges are increasingly the target of recreational pedestrian walkways such as the Bicentennial Coastal Walk or Manly to Spit Walk which could be seen as an opportunity to further improve the linear accessibility of these corridors. It is noted that this corridor feature is a landscape association, rather than driven by vegetation. Where this corridor feature occupies land with limited or no associated vegetation, it has been retained as mapped corridor, even in areas of significant disturbance, noting that landscape derived corridor values for some mobile species rely more on fly-ways rather than vegetated habitat. Similar to managed open space discussed above, these areas may be hostile to predators and offer usable refuge.

Urban native, exotic and weedy vegetation may also provide fauna habitat. Compared to native plant communities, the large quantity of scattered fragments of such vegetation across many urban areas required a slightly different approach to assessing its corridor values. In recognition of the generally more limited value of urban native, exotic and weedy vegetation, any of the areas mapped as less than one hectare were generally excluded from the corridor layer. However, areas of this vegetation type mapped within five metres of core or other mapped corridor, regardless of the size, were included as corridor as these areas were considered to be important for connectivity.

A significant API review of the OEH (2016) map units was carried out, including urban vegetation (both exotic and native) and weeds , even if attached to or within 5m of core and another mapped corridor. The review allowed for additional map updates, including the removal of areas of urban native, exotic or weeds where clearing for development has occurred.

It was noted that areas mapped as Urban Exotic/Native, particularly in the former Manly LGA and parts of the former Warringah LGA, were mapped as such in areas or relatively open and simple vegetation compared to extensive parts of the northern study area, where areas of relatively diverse structure, species diversity, remnant local species and likely relative abundance of non-biotic habitat features such as leaf-litter and hollows were not mapped as Urban Exotic/Native. It was noted that OEH mapping had applied a variable threshold to mapping the extent, structure and floristics of the non-native map units Urban Exotic/Native, and Weeds and Exotics. This led to a lack of consistency in the mapping of these communities across the study area. Typically, the current study reduced the extent of the OEH (2016) to achieve appropriate mapping and consistency, although small areas of vegetation not mapped by OEH (2016) were mapped as, typically, Urban Exotic/Native in the current study.

Candidate areas considered in this report for inclusion as biodiversity corridor were:

- Areas of native vegetation which do not meet the criteria for core habitat area
- Areas of managed open space or zoned public recreation
- Coastal habitat within 100 metres of the ocean or tidal limit
- Areas of Urban Exotic/Native, or weedy vegetation greater than one hectare in size
- Areas of Urban Exotic/Native, or weedy areas within five metres of core habitat or biodiversity corridor, even if less than one hectare in size

These candidate areas form the basis of developing biodiversity corridor areas for this review, and the corresponding supporting methodologies are shown in Table 2-3.

Table 2-3 Criteria for mapping biodiversity corridor areas.

No.	Criteria matching Biodiversity Corridor Area	Reason	References
1	Contains native vegetation as defined in Section 5a NSW *Local Land Services Act* (LLS Act) but that does not qualify as core habitat areas	Includes definitions of 'transitional areas' and 'corridor' definition within GANSW, as well as habitat value.	GANSW (2020)
2	Areas of accepted, modified or ground-truthed PCTs derived from the source mapping of OEH (2016) attached to, or within 100 metres of core habitat areas which are predominantly vegetated even if largely exotic species	Incorporates managed open spaces which can provide a buffer fauna habitat. 100 metres has been taken from BAM definition of a continuous patch.	NSW BAM (OEH, 2017)
3	Areas of accepted, modified or ground-truthed PCTs derived from the source mapping of OEH (2016) attached to, or within 100 metres of biodiversity corridor areas which are predominantly vegetated	Incorporates managed open spaces which can provide a buffer fauna habitat. 100 metres has been taken from BAM definition of a continuous patch.	NSW BAM (OEH, 2017)
4	Areas of managed open space providing modified but suitable habitat for generalist fauna species	Includes definitions of 'transitional areas' and 'corridor' definition within GANSW, as well as habitat value.	GANSW (20120)
5	Coastal areas within 100 metres of tidal limit	Includes definitions of 'transitional areas' and 'corridor' definition within GANSW, as well as habitat value.	GANSW (2020)
6	Areas of accepted, modified or ground-truthed planted urban and exotic vegetation, or weeds and exotic vegetation greater than one ha in size	Incorporates managed open spaces or weed infestations adjacent to more intact vegetation, which can provide a buffer fauna habitat. 100 metres has been taken from BAM definition of a continuous	NSW BAM (OEH, 2017)

2.3.2.2 Biodiversity corridor area mapping

The criteria used to identify, and map biodiversity corridor areas include:

- Accepted, modified or ground-truthed PCTs as per OEH (2016) if:
  - PCTs were contiguous with mapped core habitat area
  - PCTs occurred within 100 metres of core habitat area
  - PCTs occurred greater than 100 metres from core habitat areas, but were contiguous with biodiversity corridor areas
  - PCTs occurred within 100 metres of biodiversity corridor areas.
- All land within a 100-metre buffer of the 'Ocean' and 'Tidal' attributes within the NBC GIS shapefile '*Water Feature Corridor*'
- Accepted, modified or ground-truthed Urban Exotic/Native vegetation and weeds and exotic vegetation as per OEH (2016), which are:
  - Greater than one hectare in size and within 100 metres of biodiversity corridor areas, or
  - Within five metres or contiguous to core habitat areas or biodiversity corridor areas, regardless of size.
- LEP Land Zoning (recreation areas) within 100 metres of other core habitat area or other corridor areas.
- A final selective review of corridor polygons to refine the extent of important areas of Council managed bushland and land zoned RE1 Public Recreation (LEP 2011), resulting in inclusion of some areas of corridor that do not conform to the above rules.

The following data sources were utilised to generate the biodiversity corridor areas within the spatial layer:

- NBC GIS layer 'Water Feature Corridor' identifying 'Ocean' and 'Tidal' attributes
-
- The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 GIS layers (OEH, 2016)
- LEP Land Zoning (recreation areas) within Northern Beaches LGA

2.4 Threatened entities spatial layer

The following section details the methodology for identifying and mapping the threatened entities spatial layer.

2.4.1 Threatened ecological communities (TECs)

The occurrence of TECs listed under either the BC Act or the EPBC Act were considered for inclusion into the GIS layer. OEH (2016) data formed the main source for this layer and, following ground-truthing, API review, consideration of external reports, project team expert opinion, and Council input, a draft layer of TEC polygons was collated. These inputs and data from sites visited helped create a prioritised list of sites recommended for review.

The general steps of this methodology are as follows:

- Using the source layer of OEH (2016), the current study reviewed PCT layers over the study area for spatial extent, noting any broad gaps, inconsistencies, or limitations. This included updates to areas of recent clearing for construction of buildings and sealed roads, along with clearing associated with state significant infrastructure such as the widening of Mona Vale Road. Note that the apparent clearing of vegetation outside the footprint of a significant new structure was generally not remapped as cleared in order to allow for potential still-present biodiversity values and future consideration of unapproved clearing.
- Undertaking an additional review of DPIE advice relating to updates of BioNet Vegetation Classification within the Vegetation Information System (VIS) database and proposed associated TECs as part of the rollout of the new quantitative Eastern NSW PCTs. While BioNet at the time of writing is uploading new PCTs associated with threatened entities, these are not currently listed on BioNet Vegetation Classification (VIS) application, and the current PCTs listed on VIS are retained as source data for this study.
- An equivalency table was produced for PCTs mapped by OEH (2016), aligning PCTs as potential components of candidate TECs, based on listed associations in OEH (2016) and correlating OEH (2016) map unit community descriptions, PCT descriptions and TEC final determination assemblages. A precautionary equivalence between PCT 1845 and the threatened ecological community Duffys Forest Ecological Community in the Sydney Basin

Bioregion (DFEC) has been determined for the current study, even though this association isn't currently listed as associated in VIS.

- Additional review of likely associations and occurrences of TECs through interrogation of BioNet.
- Review of location, landscape and edaphic descriptors in candidate TECs' final determinations against mapped or likely extents of PCTs in the study area
- Review of Council and external reports' mapping of TECs, or PCTs that may be components of TECs
- Prioritisation of areas of draft mapped PCTs with the potential to conform to TECs, based on composition or structure, as part of field surveys
- Areas of potential PCT discrepancy identified through desktop analysis, including API, landscape features or local knowledge, were also prioritised for field surveys. In addition to targeted field surveys, incidental observations of previously unmapped TEC extent occurred and informed adaptive field-surveys.
- The 'deferred lands' which remain under Warringah LEP 2000 have been excluded from the mapping of TECs (Figure 2) and threatened species habitat (Figure 3) in this report as this area is the subject of separate studies that are currently underway. Following receipt of information on the deferred lands, the mapping and reporting of threatened entities in this report will be updated.
- NBC has requested further refinement to mapping showing inconsistent areas of corridor extent across the study area.
- As the final determination for PSGF identifies that the community may exist as remnant trees, review of PSGF patch boundaries was undertaken to capture areas of remnant canopy not previously mapped in OEH (2016). This involved cross-validation of existing OEH (2016) polygons with canopy height and cover information derived via LiDAR (Light Detection and Ranging) remote sensing across the whole likely extent of PSGF in the study area. This LiDAR data was derived by NBC and supplied as polygons which were additionally buffered by 4m to represent each tree and its reasonable likely canopy spread. The analysis captured all trees identified by LiDAR as >18m in height within a potential PSGF distribution area refined by API, Google street view, field survey and local expert knowledge. The API review included identifying unmapped areas of canopy and individual trees, dominated by characteristic eucalypts of the TEC, when adjacent to mapped extents of component PCTs. This methodology is analogous to the BAM 2020 for differentiating "scattered trees", except in reverse and therefore identifying "native vegetation" as opposed to scattered trees. The steps include:
  - LiDAR tree polygons supplied by NBC
  - Trees not currently mapped as any vegetation community within 50m of a mapped area of the mapped PSGF community were considered.
  - Groups of more than three trees aligned to the community within 50m of each other would also be considered. For practical reasons only groups of trees within 100 m of mapped extents of component PCTs would be flagged for further validation.
  - Ground cover is assumed 100% exotic or man-made surfaces as this cannot be interpreted by LIDAR or Aerial imagery.
  - Validation used, in order of preference: aerial photographic interpretation, Google street view and site visits to identify trees from the LIDAR layer that are not part of the community

The following data sources were utilised to generate the Threatened Ecological Community spatial layer:

- The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 GIS layers (OEH, 2016)
- LIDAR Estimate of Canopy Height and Cover (for PSGF only) (NBC, 2019)

In addition to the above, various published and unpublished technical reports and studies were reviewed in generating the Threatened Ecological Community spatial layer. These related to planning applications in Terrey Hills, Duffys Forest, Belrose and Frenchs Forest, and included map amendments to local occurrences of the Duffys Forest and Coastal Upland Swamp TECs.

2.4.1.1 Generation of Base GIS layer

OEH (2016) has mapped native vegetation communities using a combination of detailed image interpretation, relationships between sample sites and abiotic environmental variables. The derived digital data layer includes fields that describe the vegetation community, interpreted dominant species and understorey characteristics, interpretation confidence, disturbance type and severity, NSW vegetation formation and classes and related PCTs. Identified

vegetation communities have been correlated to associated currently listed TECs listed under the BC Act and the EPBC Act.

Forty-eight PCTs have been mapped by OEH (2016) in the Northern Beaches LGA. Of these, 19 PCTs are listed by that study as associated with 13 potentially equivalent TECs listed under the BC Act and/or EPBC Act (Table 2-4). The current study cross-referenced these PCTs with the TEC association data in the BioNet Vegetation Classification database in order to further review potential TEC associations with mapped PCTs. An additional PCT-TEC equivalency was determined for the current project: PCT 1845 and the threatened ecological community Duffys Forest Ecological Community in the Sydney Basin Bioregion (DFEC).

For the current study, the mapping of TECs was reviewed with regard to:

- Distribution across the LGA
- Landscape location, including topography and aspect, and proximity to environmental features such as watercourses
- Associated soil landscapes and soil landscape mapping
- Aerial imagery
- Verified locations of TECs based on NBC and consultant local knowledge

Areas which were considered to have a low confidence with regard to accuracy were prioritised for field verification. A detailed methodology for field verification is described within Section 2.5.

Table 2-4 OEH (2016) map unit - PCT - TEC equivalency

OEH (2016) Map Unit Code: Name	Plant Community Type (PCT)	Threatened Ecological Community (NSW BC Act)	Threatened Ecological Community (Commonwealth EPBC Act)
S_DSF21: Coastal Sand Bangalay Forest	1793: Smooth-barked Apple - Bangalay / Tuckeroo - Cheese Tree open forest on coastal sands of the Sydney basin	Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (BSF)	-
S_SW02: Estuarine Saltmarsh	1126: Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion	Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Subtropical and temperate coastal saltmarsh
S_FrW01: Coastal Upland Damp Heath Swamp	1803: Banksia - Needlebush - Tea-tree damp heath swamps on coastal sandstone plateaus of the Sydney basin	Coastal Upland Swamp in the Sydney Basin Bioregion (CUS)	Coastal Upland Swamp in the Sydney Basin Bioregion
S_FrW02: Coastal Upland Wet Heath Swamp	1804: Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	Coastal Upland Swamp in the Sydney Basin Bioregion	Coastal Upland Swamp in the Sydney Basin Bioregion
S_DSF14: Sydney Ironstone Bloodwood-Silvertop Ash Forest	1786: Red Bloodwood - Silvertop Ash - Stringybark open forest on ironstone in the Sydney region	Duffys Forest Ecological Community in the Sydney Basin Bioregion (DFEC)	-
S_WSF06: Coastal Shale Sandstone Forest	1845: Coastal Shale-Sandstone Forest	Duffys Forest Ecological Community in the Sydney Basin Bioregion (DFEC)	-
S_HL03: Coastal Sand Mantle Heath	664: Banksia heath on aeolian sands of eastern Sydney suburbs, Sydney Basin Bioregion	Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion (ESBS)	Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion
S_FrW03: Coastal Freshwater Wetland	781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (FWCF) -or- Sydney Freshwater Wetlands in the Sydney Basin Bioregion (SFW)	-

OEH (2016) Map Unit Code: Name	Plant Community Type (PCT)	Threatened Ecological Community (NSW BC Act)	Threatened Ecological Community (Commonwealth EPBC Act)
S_RF08: Coastal Headland Littoral Thicket	910: Lilly Pilly littoral rainforest of the southern Sydney Basin Bioregion and South East Corner Bioregion	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
S_RF06: Coastal Dune Littoral Rainforest	1832: Tuckeroo - Lilly Pilly - Cheese Tree littoral rainforest on sand dunes in the Sydney basin	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
S_RF07: Coastal Escarpment Littoral Rainforest	1833: Lilly Pilly - Cabbage Tree Palm littoral rainforest on escarpment slopes and gullies of the Sydney basin	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
S_WSF11: Pittwater Spotted Gum Forest	1214: Spotted Gum - Grey Ironbark open forest in the Pittwater and Wagstaffe area, Sydney Basin Bioregion	Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion (PSGF)	-
S_FoW01: Coastal Alluvial Bangalay Forest	1794: Bangalay - Smooth-barked Apple / She-oak open forest on sandy alluvium in coastal parts of the Sydney region	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (RFEF)	River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria
S_FoW08: Estuarine Swamp Oak Forest	1234: Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (SOFF)	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community
S_FoW12: Coastal Swamp Paperbark-Swamp Oak Scrub	1236: Swamp Paperbark - Swamp Oak tall shrubland on estuarine flats, Sydney Basin Bioregion and South East Corner Bioregion	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community
S_FrW06: Estuarine Reedland	1808: Common Reed on the margins of estuaries and brackish lagoons along the New South Wales coastline	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community
S_FoW02: Coastal Flats Swamp Mahogany Forest	1795: Swamp Mahogany / Cabbage Tree Palm - Cheese Tree - Swamp Oak tall open forest on	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North	-

OEH (2016) Map Unit Code: Name	Plant Community Type (PCT)	Threatened Ecological Community (NSW BC Act)	Threatened Ecological Community (Commonwealth EPBC Act)
	poorly drained coastal alluvium in the Sydney basin	Coast, Sydney Basin and South East Corner Bioregions (SSF)	
S_FoW05: Riverflat Paperbark Swamp Forest	1798: Flax-leaved Paperbark open to closed mesic forest on alluvial riverflats in the Sydney region	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-
S_FrW13: Coastal Sand Swamp Scrub	1809: Crimson Bottlebrush - Banksia - *Melaleuca* / *Baumea* woody sedgeland in dune swales of the Sydney basin	Sydney Freshwater Wetlands in the Sydney Basin Bioregion	-
S_GL02: Coastal Headland Grassland	898: Kangaroo Grass sod tussock grassland of coastal areas of the Sydney Basin Bioregion and South East Corner Bioregion	Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions (TG)	-

2.4.1.2 Inclusion of additional source data

In addition to OEH (2016), the current study assessed additional datasets for possible inclusion within the GIS spatial layers. Some of these datasets were reviewed in the field for the current study.

The additional source data was incorporated into the base GIS layer when:

- The mapped extent of the TEC was consistent with the known ecology, landscape features, and known or predicted distribution of the TEC across the LGA
- Non-threatened vegetation had been mapped within the base dataset in the same location

Where there was a positive correlation between the TEC mapping within the base GIS layer and the additional source later, the base GIS layer was retained.

Areas which were considered to have a low confidence with regard to accuracy were flagged for field verification. A detailed methodology for field verification is described within Section 2.5.

2.4.2 Threatened species

2.4.2.1 Threatened fauna

Threatened fauna mapping included identification of habitat areas of high importance for the survival of relevant species within the locality as defined for "Species Credit Species" under the NSW Biodiversity Assessment Methodology (BAM). This placed a focus on species that either do not have strong association with plant community types to provide surrogate indications of likely presence, or areas of habitat where native vegetation PCTs are not present. The reason for this choice in methodology is that under the NSW BC Act, assessment of threatened fauna is already mandated in areas with PCTs that offer important habitat. Habitat areas for a total of four threatened species were identified as these species are associated with localised occurrences such that restricted habitat use can be meaningfully mapped.

Important polygon mapping in areas outside of native vegetation was undertaken for the following threatened fauna species:

- Little Penguin (*Eudyptula minor*) habitat
- Grey-headed Flying-fox (*Pteropus poliocephalus*) camps
- North Head Long-nosed Bandicoot (*Perameles nasuta*) population
- Bush Stone-curlew (*Burhinus grallarius*) habitat

The core habitat areas and biodiversity corridor spatial layer mapping as part of this project has refined and identified all areas of vegetation or coastal and estuarine habitat likely to be associated with other threatened fauna species.

Threatened fauna populations listed under either the BC Act or EPBC ACT were mapped using existing NBC map layers, expert reports and data quality reviewed BioNet records.

2.4.2.2 Threatened flora

Flora records are primarily sourced from the BioNet Atlas and NBC supplied records. The sources for each record are retained in the field attributes of the threatened entities spatial layer. A data quality review process identified records that were:

- likely planted species outside their natural range
- novel occurrences outside typical habitat or range
- records with conflicting metadata that could not be readily resolved.

Where these records were confidently deemed to be invalid, they were no longer considered. Older records (greater than 20 years old) were not automatically filtered out, but the likelihood of areas around those records still supporting habitat or long-term lifecycle processes was assessed where possible. Limited personal communication with species experts and recorders of records was made in order to clarify some inconsistent or unexpected record data.

Threatened flora records within BioNet are classified by their level of sensitivity. The NSW Department of Planning Industry and Environment's (DPIE) Sensitive Species Data Policy sets out how 'sensitive' species will be categorised, and the levels of disclosure allowed. For the most sensitive species, the location of records are denatured (e.g. the precise geographic coordinates for the sensitive species are intentionally generalised).

Table 2-5 DPIE threatened species record sensitivity categories

DPIE Sensitivity Classification	Definition and applicability
Non-sensitive species	Species deemed non-sensitive have been mapped by buffering their source point records by 30m to represent the general location. Within this buffer, suitable habitat was not limited to only PCTs listed as associated in BioNet, due to limitations of accuracy and completeness of PCT extent. Where other habitat limitations were identified in BioNet, such as additional area surrounding landscape features, these buffers have been mapped around these identified landscape features when they are associated with a record, in addition to the 30m buffer. Where records have been confidently identified as not occurring in the projected record location, the corrected location point is buffered appropriately or the lot(s) that meet the location description are mapped. Where species location descriptions or species' extent is described as an extensive area, such as with a suckering plant or cluster of individuals occurring over an area, that area is buffered around.
Category Sensitive 1 species	No records of species in this category are provided to licenced or registered BioNet users. The only species currently listed as Sensitive 1 is the Wollemi Pine *Wollemia nobilis*, considered unlikely to occur in the study area.
Category Sensitive 2 species	These species are considered to be at serious risk from threats such as disturbance or exploitation. For species in this category, geographic coordinates of sightings are supplied 'denatured' in order to generalise the locality. Category Sensitive 2 species records are therefore not considered in this project. These species include the orchid species *Microtis angusii* and *Genoplesium baueri*.
Category Sensitive 3 species	These species are considered to be at medium to high risk of threats such as disturbance or exploitation and coordinates are supplied at 'as held' accuracy to licensed clients. SMEC and NBC are licenced users of BioNet. As-held records do not necessarily equate to exact locational details, and records have been interpreted with reference to their geographic accuracy. For this reason, NBC cannot publish or readily infer the locations of these species, and as such, broad areas of likely occupancy for these species have been developed for the project, generally based on lot or landscape features, principally to reduce fidelity to non-licenced viewers of record locations.

The threatened flora species mapped within the threatened entities spatial layer and the threatened species polygon parameter is detailed within Table 2-6.

Table 2-6 Threatened species and mapping parameter

Species	DPIE Sensitivity classification	Threatened species polygon parameter around records[1]
Acacia bynoeana	Non-sensitive species	30 meter buffer around records
Acacia terminalis subsp. terminalis	Non-sensitive species	30 meter buffer around records
Asterolasia elegans	Non-sensitive species	30 meter buffer around records
Callistemon linearifolius	Sensitive 3	After data was quality reviewed, the species habitat was mapped as those lots which intersect with a 30 metre buffer around records.
Chamaesyce psammogeton	Non-sensitive species	30 meter buffer around records
Epacris purpurascens var. purpurascens	Non-sensitive species	30 meter buffer around records[2].
Eucalyptus camfieldii	Non-sensitive species	30 meter buffer around records
Grevillea caleyi	Sensitive 3	The extent of any PCT polygon, after merging polygons of the same PCT, that intersects with a 30 meter buffer around records. Additionally, any further contiguous polygon extents that are PCTs listed as associated PCTs in BioNet (1845 and 1786 in the study area)
Haloragodendron lucasii	Non-sensitive species	Entire lots that encompass record, and 100m buffer around associated dripping cliff-face habitats (In line with BAM habitat limitation)
Hibbertia puberula	Non-sensitive species	100 meter buffer around records due to likely spatial inaccuracies of records, cryptic nature and poorly understood taxonomy, and likely under-reporting of records in study area
Hibbertia superans	Non-sensitive species	30 metre buffer around records
Kunzea rupestris	Non-sensitive species	100 metre buffer around records, as per BioNet habitat constraint

[1] Records that were precautionarily considered valid after review

[2] One record incorrectly projected has been mapped as the entire lot that matches verbatim location

Species	DPIE Sensitivity classification	Threatened species polygon parameter around records[1]
Lasiopetalum joyceae	Non-sensitive species	30 metre buffer around records
Leptospermum deanei	Non-sensitive species	30 metre buffer around records
Persoonia hirsuta	Sensitive 3	30 metre buffer around records has been merged with managed bushland or open space supported by localised pattern of records of species
Pimelea curviflora var. curviflora	Non-sensitive species	30 metre buffer around records
Prostanthera marifolia	Sensitive 3	30 metre buffer around buffer has been merged with generally lot-based areas of managed bushland or open space supported by localised pattern of records of species
Rhodamnia rubescens	Non-sensitive species	30 metre buffer around records
Senecio spathulatus	Non-sensitive species	30 metre buffer around records
Syzygium paniculatum	Non-sensitive species	The species has a history of being planted and a precautionary method to identify naturally occurring plants and their habitat is to identify plants in or within 30m of native vegetation. Such retained records have been buffered by 30m.
Tetratheca glandulosa	Non-sensitive species	30 metre buffer around records

2.5 Field validation

2.5.1 Threatened entities spatial layer – threatened ecological communities

The study area has been the subject of extensive previous survey efforts such as OEH (2016) and those described in Table 1-1. Of particular note is the survey effort associated with East Coast Flora Survey and Bangalay (2012) which included 1947 rapid data points.

As part of the TEC mapping methodology, mapped areas of TECs included those separately labelled as 'Potential TEC' due to a higher level of uncertainty that the TECs occur in those locations. This early classification provided the basis for field validation surveys.

For the purpose of field validation, mapped TEC were categorised into two groups:

- Priority area for field review: TECs which had been classified as 'Potential TEC' within the desktop review because:
  - API identified poor correlation between imagery of vegetation with mapped vegetation type
  - API identified potential changes in vegetation extent since OEH (2016)
  - Location or landform attributes expected to be associated with the TEC are not likely to be present
- Secondary priority for field review:
  - External reports identified TECs or PCTs differently to OEH (2016)
  - Vegetation extents between mapping sources do not align
  - Local individual knowledge (SMEC, NBC, external experts) identifies likely TECs or PCTs differently to OEH (2016)

Field validation data collected at each location, where possible, the following data, applicable to the whole polygon:

- Canopy - 3 dominant canopy species
- Mid-storey - 3 dominant mid-storey species
- Under-storey - 3 dominant under-storey species
- Ground-layer - 3 dominant ground-layer species
- Presence or absence of TEC descriptors (e.g. floodplain, laterite, sand deposit, coastal headland etc) as described in NSW Threatened Species Scientific Committee Final Determinations
- Additional limited notes to assist in interpreting the presence of the TEC

The current survey consolidated collected data to prioritise further desktop or field assessments. Collected data was compared to the descriptions within the TEC's Final Determinations, and if it was considered a reasonably likely to confident identification for the presence of a TEC, that polygon was relabelled from 'Potential' TEC to the mapped TEC. Some existing polygons were required to have boundaries remapped as part of updates to TEC mapping. Note that where additional extents of TECs were mapped, PCT identification was not made.

This process of refining, consolidation, desktop review and field survey has resulted in all TECs being mapped as the TEC name with one of the following attribute options being attributed to the TEC polygon:

- Ground-truthed TEC
- Source data TEC confirmed
- Previous vegetation mapping TEC (OEH, 2016)
- SMEC applied equivalency of DFEC to all residual areas of PCT 1845 mapped by (OEH, 2016)
- Pittwater Wagstaffe Spotted Gum Forest TEC LiDAR mapping

2.5.2 Threatened entities spatial layer – threatened species

As discussed in 2.4.2, important threatened species records, and their habitat, were mapped across the study area. A number of data quality reviews were carried out for threatened flora and fauna species records. As part of this process, habitat areas were modelled for some species where habitat types were limited to known breeding habitats (Grey-headed Flying-fox colonies) or to localised occurrences of local landscape features, assemblages and locations (the flora species *Prostanthera marifolia* and *Persoonia hirsuta*). Field validation was carried out to ground-truth the current edges of Grey-headed Flying-fox colonies. Field validation was carried out for two flora species where records occur on the edge or outside of the proposed habitat area models. These two flora species *Prostanthera marifolia* and *Persoonia hirsuta*, are Sensitive 3 species, and are listed because of their very small population size and/or limited geographic extent. The Sensitive 3 species, *Callistemon linearifolius* and *Grevillea caleyi* were also reviewed. While *Grevillea caleyi* has a very restricted natural range and PCT association, *Callistemon linearifolius* has a broad range of PCT, landform and location associations, meaning that the veracity of mapped record locations could be aided by field review, although this was hampered by inaccessibility due to private property constraints.

Field validation involved collection of the following data:

- Canopy - 3 dominant canopy species
- Mid-storey - 3 dominant mid-storey species
- Under-storey - 3 dominant under-storey species
- Ground-layer - 3 dominant ground-layer species
- Presence/absence of habitat features or species occurrence

The current study identified limited new extents of threatened flora species and their habitats.

3 Results

3.1 Core habitat and biodiversity corridor spatial layer

3.1.1 Core habitat areas

Core habitat areas have been most commonly mapped within NBC reserves, along waterways, and in larger lots. They tend to be of a size that has maintained their viability and are generally larger than 3.5 hectares in area. Highly linear and obviously edge effected areas are not included, although areas of native vegetation between two hectares and 3.5 hectares which support particularly high or intact biodiversity values have generally been included. Where exceptional patches of native vegetation habitat of less than two hectares were identified, these were also mapped as core. A summary of mapped core areas by suburb is provided in Table 3-1.

The lands identified as core habitat areas show a strong correlation to supporting significant threatened species and TEC values, and some notable examples are provided in Table 3-1.

A data-driven, multi-page figure of core habitat area within the Northern Beaches LGA is contained within the separate Biodiversity Planning Review Map Booklet.

Table 3-1 Description of core habitat Areas

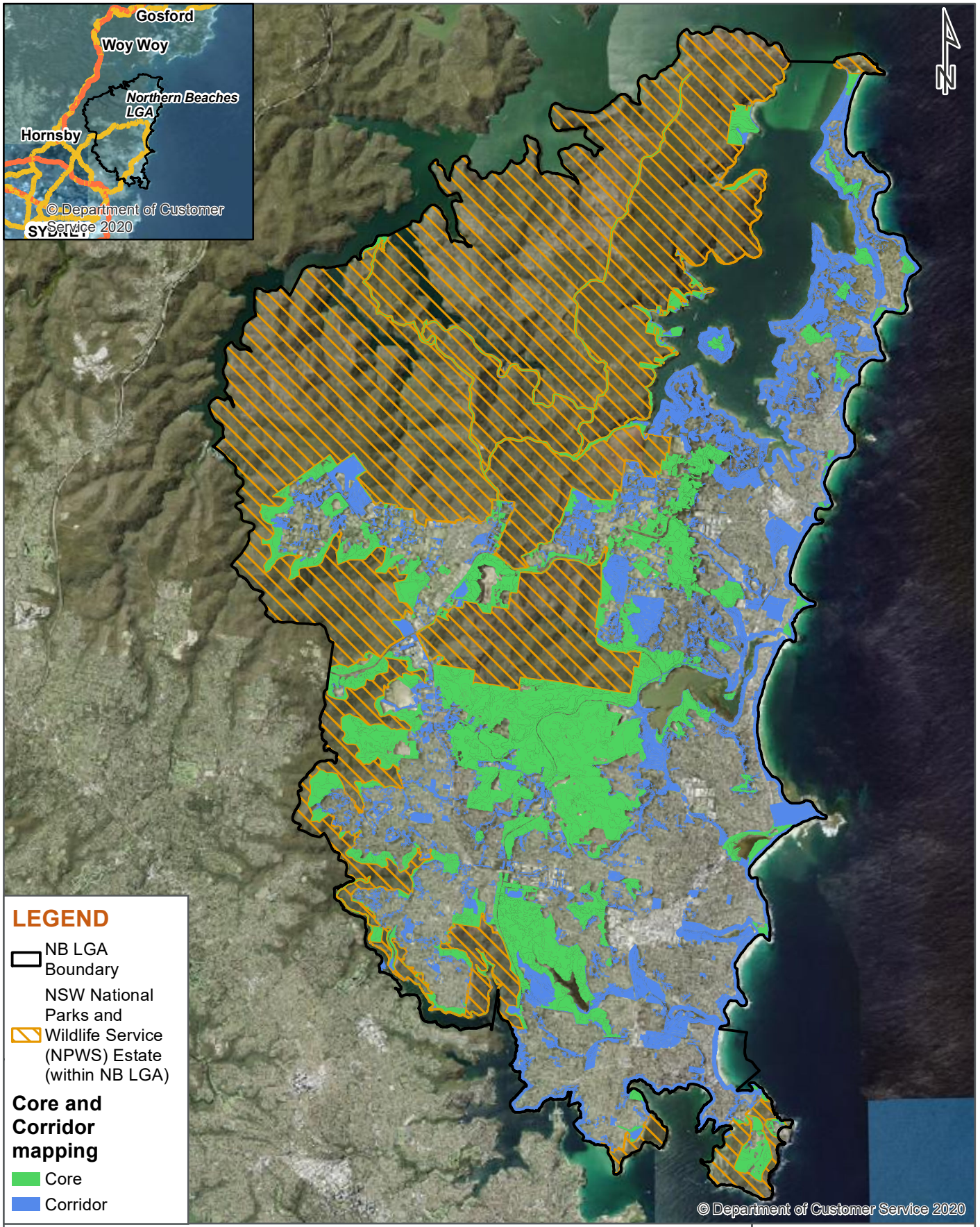
Suburb	Description of Core Habitat Areas
Palm Beach	The Pittwater wildlife corridor map provides the closest fit to the core and corridor model undertaken by this project, with areas designated 'Major Habitat' in many ways analogous to the new core habitat areas. These are referred to as previously mapped core in the following descriptions. Pittwater's mapping also contained a Category 1 Flora and Fauna - Core Bushland layer. It was found that although many of these areas contained intact plant communities, many lacked sufficient size or connectivity to be considered core under the current model. Barrenjoey Headland was a previously mapped core area of 'Major Habitat' under Pittwater's wildlife corridor layers, but was increased in extent to include dune vegetation on the sand-spit which is covered in largely intact native plant communities, except for small narrow walking tracks that do not qualify as significant fragmentation. Further south along the Palm Beach ridgeline, Sunrise Reserve is an example of previously mapped Category 1 Flora and Fauna - Core Bushland that could not be incorporated as a core habitat area but is retained as a biodiversity corridor area. This reserve contains approximately 0.8 hectares of good quality bushland within a context of fragmented remnants and residential landscape. McKay Reserve and Palm Beach Forest retain their status as a core habitat area.
Avalon Beach	The Careel Bay mangroves and surrounding saltmarsh and swamp oak forest are new additions to core habitat areas within the core habitat and corridor spatial layer. Careel Headland Reserve is also a new addition. Stapleton Reserve's inclusion as a core habitat area remains unchanged. Avalon Beach dunes and Avalon Headland are both relatively small patches that are newly included as core but are important elements within the coastal corridor. Some resilience and connectivity is provided in both cases by proximity to the coastal corridor. Angophora Reserve remains a relatively large core habitat basically unchanged in extent, supporting species such as Powerful Owl and one of the world's largest intact patches of PSGF.
Bilgola Beach Bilgola Plateau	Attunga Reserve between Bilgola Beach and Newport remains a largely unchanged core. A very small portion of core habitat area contiguous to Angophora Reserve occurs within the Bilgola Plateau.

Suburb	Description of Core Habitat Areas
Newport	Attunga Reserve between Bilgola and Newport remains a largely unchanged core habitat besides some removal of low-condition vegetation west of Porter Reserve. On the coastline south from Bungan Head, several smaller coastal remnants from the former corridor layer were mapped as core habitat area based on their condition, resilience and location on the coastal corridor. This includes vegetation behind Bungan Beach, with important stands of Littoral Rainforest and the critically endangered Brush Turpentine (*Rhodamnia rubescens*). An addition of a new core habitat area occurs within the upper valley of McMahons Creek.
Ku-ring-gai Chase Great Mackerel Beach Currawong Beach Coasters Retreat Morning Bay Lovett Bay Elvina Bay Cottage Point	On the western side of Pittwater, core habitat area associated with Ku-ring-gai Chase National Park remains mostly unmodified. This core habitat area contains large areas of undisturbed remnant vegetation and threatened species habitat of high biodiversity value as a result of the protection afforded by the surrounding NPWS estate. Most of the settled area of Mackerel Beach is mapped as core habitat area. Residential development is interspersed with native vegetation and essentially embedded within a core habitat area. Coasters Retreat has become a core habitat area. Other water-access-only communities on the western shore such as Lovett Bay and Elvina Bay also mostly fit into the core habitat area category. Only larger patches of historic disturbance in these areas have remained outside of core habitat and fall in the corridor category.
Scotland Island	A patch of core habitat area occurs within the middle of Scotland Island (Elizabeth Park), surrounded by biodiversity corridor habitat.
Bayview	Large portions of the leafy suburb of Bayview were mapped as Priority 1 Corridor within previous Pittwater mapping. There is a large core offered by Ku-ring-gai National Park to the west, and central core area on the escarpment area south of the Minkara Resort. The newly mapped core has retreated south slightly from previous mapping, possibly as result of the development. The important core areas within Bayview support species such as Barking Owl.
Mona Vale	A small area of core habitat area occurs in North Mona Vale headland, in association with surrounding biodiversity corridor habitat.
Warriewood	Warriewood Wetlands remains core wetland areas. Narrow, linear patches of swamp oak forest along creek lines in the Warriewood valley, such as the surrounds of the Warriewood Wastewater Treatment Plant, did not meet the definition of core habitat area. On the coastline, several smaller coastal remnants from the former corridor layer were mapped as core habitat area based on their condition, resilience and location on the coastal corridor. These include Turrimetta Headland and Narrabeen Headland. Small patches of core habitat area occur on the western boundary of the suburb within Heydon Reserve, Ingleside Chase Reserve and Irrawong Bushland Reserve, supporting Barking Owl (Kavanagh *et al*., 2015).
Ingleside	Core areas in Ingleside were one of the areas of greatest change in core mapping. Clearing and changes in land use have reduced the area of intact native vegetation. Ingleside Chase Reserve to Katandra Bushland Sanctuary and areas around Mona Vale Road remain part of an important large remnant core habitat area contiguous with Garigal National Park, supporting threatened species such as Red-crowned Toadlet, Giant Burrowing Frog' Eastern Pygmy Possum and *Grevillea caleyi*. Major stream corridors connect areas outside the study area to Narrabeen Lagoon 2015) which

Suburb	Description of Core Habitat Areas
	support Southern Myotis, Large Bent-winged Bat and Little Bent-winged Bat (Kavanagh *et al*.)
Duffys Forest	The majority of core habitat area within Duffys Forest is associated with vegetation that is contiguous with Ku-ring-gai National Park. An isolated patch of core habitat area occurs within the NSW Gun Club. Anembo Reserve also falls within a core habitat Area. The suburb's core habitat areas support some of the largest extents of the eponymous TEC Duffys Forest Ecological Community, and significant proportions of *Grevillea caleyi*. The suburb is largely surrounded by significant bushland such as Ku-ring-gai Chase National Park, with recent nearby sightings of Koala in the adjoining National Park.
Terry Hills	Situated between areas of national parks, there were few isolated core habitat areas with the exception of a single patch of core habitat area identified between Myoora and Larrool Roads. Patches of core habitat area in the north and west of the suburb are associated with vegetation contiguous to Ku-ring-gai Chase National Park. Core habitat areas associated with Dundundra Falls Reserve and Dardabong Reserve remain largely unchanged. Vegetation contiguous with Garigal National Park southwards towards Oxford Falls also remains relatively unchanged from previous corridor mapping.
Elanora Heights	Extents of core habitat area occur within the western portions of Elanora Heights, adjacent to Garigal National Park, and immediately west of Elanora Country Club. Along the northern boundary of the suburb, small patches of core habitat area occur within Heydon Reserve.
North Narrabeen	Narrabeen Reserve remains a core habitat area. A large tract of core habitat area occurs immediately north of Narrabeen Lagoon through Deep Creek Reserve, Lumeah Reserve, Woorarra Lookout Reserve, and Bilarong Reserve. On the coastline, a small coastal remnant from the former corridor layer was mapped as core habitat area based on its condition, resilience and location on the coastal corridor. This includes Narrabeen Headland.
Narrabeen	Key patches of core habitat area within Narrabeen include Jamieson Park and Narrabeen Lagoon foreshore area west to South Creek. Sanctuary Island, within Narrabeen Lagoon, is a newly mapped patch of core habitat area within the suburb. Jamieson Park provides good roosting habitat, as well as potential nesting sites, for Barking Owls and records for Large-eared Pied Bat in Jamison Park (Kavanagh *et al*., 2015). Riparian and wetland habitat along Deep Creek in North Narrabeen and Ingleside support Black Bittern and Osprey (Kavanagh et al., 2015).
Collaroy	Two patches of core habitat area have been mapped within Collaroy. A relatively large isolated patch of core habitat area occurs east of the escarpment from Collaroy Plateau around the Collaroy Centre. On the coastline, core habitat area has been mapped along the sand dunes of Long Reef Beach, surrounding Long Reef Surf Life Saving Club, and continuing eastward along the northern shore of Dee Why Lagoon. This area is included within core habitat area as a result of its condition, resilience and location on the coastal corridor.
Dee Why	Core habitat area within Dee Why is restricted to Dee Why Lagoon Reserve and Long Reef (Griffith Park), supporting important habitat for birds such as White-bellied Sea Eagle, Pied and Sooty Oystercatchers and Black Bittern, along with numerous migratory wading birds listed under the EPBC Act (Smith and Smith, 2000). This core habitat area continues northwards into the suburb of Collaroy, as discussed above. This area is included within core habitat area as a result of its condition, resilience and location on the coastal corridor.

Suburb	Description of Core Habitat Areas
Cromer	A small patch of core habitat area occurs around South Creek to the east of Cromer Golf Club. This area continues eastward along the southern shore of Narrabeen Lagoon towards Jamieson Park, as discussed above. This patch of core habitat area is supported by biodiversity habitat corridor through the golf club, and contains suitable good roosting habitat, as well as potential nesting sites for Barking Owls (Kavanagh *et al.*, 2015). Seepage areas support occupied habitat for Red-crowned Toadlet, and stream, wet heath and hanging swamps support populations of Giant Burrowing Frog, with Pygmy Possum widespread in larger patches of vegetation supporting floral food resources (Kavanagh et al., 2015) A significant tract of core habitat area occurs west of Cromer Golf Club within 'Deferred Land Matter' zoned lands through to the Wakehurst Parkway in the north and west. Part of Narrabeen Lagoon State Park falls within this tract of core habitat. The southernmost extent of the core habitat area is close to the Cromer-Oxford Falls suburb boundary, within which Maybrook Avenue Bushland Reserve is mapped. Heath Monitor is known to breed within Cromer's mapped core habitat areas (Kavanagh et al., 2015).
Oxford Falls	A large portion of Oxford Falls is mapped as core habitat area, as a result of relatively less development within the suburb, and large, contiguous tracts of native vegetation with high biodiversity value. Consequently there is a high level of connectivity through the suburb with this functionality evident as supporting breeding populations of Eastern Pygmy Possum, Red-crowned Toadlet, Giant Burrowing Frog and Heath Monitor (Kavanagh et al., 2015), and the only known Sooty Owls in northern metropolitan Sydney associated with the rainforests of Middle Creek and adjacent Snake Creek flowing down from Belrose (Kavanagh *et al*., 2015).
Belrose	Much of the core habitat area within Belrose, adjacent to the residential areas east of Forest Way, is contiguous with the large tract of core habitat area occurring across Oxford Falls, Ingleside, and Terry Hills. Perentie Park falls within a core habitat area. West of Forest Way, much of the native vegetation that is contiguous with Garigal National Park has been mapped as core habitat area. This includes, intact remnant vegetation west of the Super Centre, the former recycling and rubbish depots, and educational facilities. These core habitat areas support breeding populations of Heath Monitor (Kavanagh et al., 2015), and likely populations of Southern Brown Bandicoot. Koala was recently identified adjoining Garigal National Park. Oxford and Snake Creeks are important drinking locations for Glossy Black Cockatoo (Kavanagh et al., 2015)
Davidson	Similar to Belrose, much of the native vegetation that is contiguous with Garigal National Park has been mapped as core habitat area. This includes intact remnant vegetation at Allworth Reserve west of Macfarlane Oval.
Frenchs Forest	Core habitat areas within Frenchs Forest include CUS in Wellman Reserve near the Forestway Shopping Centre. This reserve is directly linked to the core of Garigal National Park. Jindabyne Reserve is part of core habitat area although with a more reduced extent. Wellman Reserve, supporting Giant Burrowing Frog, is an important link to Garigal National Park. Core habitat area is mapped along Wakehurst Parkway, north of Northern Beaches Hospital and south of Warringah Road around Warringah Aquatic Centre.
Forestville	Core habitat area within Forestville includes Gwarrra Reserve, adjacent to Garigal National Park, which runs along the western boundary of Forestville along Middle Harbour. Claire Deane Bushland Sanctuary, Forestville Park, and Cook Reserve also occur within core habitat areas.

Suburb	Description of Core Habitat Areas
Killarney Heights	Much of the core habitat area within Killarney Heights occurs within or adjacent to Garigal National Park, specifically along Middle Harbour and Bantry Bay. Cashel Crescent Reserve occurs within core habitat area.
Allambie Heights	Within Allambie Heights, important areas of core habitat area occur within Manly Warringah Memorial Park (Manly Dam), and Cootamundra Drive Reserve. This tract of core habitat area is known to contain areas of high biodiversity value, including TECs and habitat for threatened species such as the Eastern Pygmy Possum (Kavanagh et al., 2015) and *Prostanthera marifolia*. Core habitat area also includes Gumbooya Reserve, not previously mapped as core habitat, and Allenby Park which supports Powerful Owl.
Beacon Hill	Within Beacon Hill, core habitat area occurs within Allenby Park and Wedgewood Reserve. Patches of core habitat area also occur in the north of Beacon Hill within Brooker Reserve, and north towards Red Hill.
Brookvale	A small and isolated patch of core habitat area occurs within Brookvale, south of Warringah Road and north of Beacon Hill Road adjacent to the former and historic Brookvale Brickworks. A second patch of core habitat area, contiguous with tracts of core habitat area adjoining Allenby Park, occurs within Council bushland west of Northern Beaches TAFE.
North Curl Curl	Core habitat area within North Curl Curl is restricted to Dee Why Head. This area is included within core habitat area as a result of its condition, resilience and location on the coastal corridor. It was not previously mapped as core habitat.
Manly Vale North Balgowlah	Council-managed land behind Manly Vale Public School, adjoining Manly Dam Reserve, and Condover Street Reserve has been mapped as core habitat area. This core habitat area runs south towards Burnt Bridge Creek Deviation and Swaine Reserve. This tract of core habitat area is known to contain areas of high biodiversity value, including TECs and habitat for threatened species.
Seaforth	Vegetation within and adjacent to Seaforth Oval has been mapped as core habitat area. This area is part of a large tract of core habitat area running through Allambie Heights, Killarney Heights, and Forestville.
Balgowlah	An isolated patch of core habitat area occurs within Wellings Reserve. This core habitat area is supported by biodiversity corridor along North Harbour and extending south to Sydney Harbour National Park (Dobroyd Head).
Balgowlah Heights Clontarf	Key core habitat area occurs within Tania Park and Castle Rock Reserve, adjacent to Sydney Harbour National Park on Dobroyd Head, and forms part of a larger wildlife habitat corridor around North Harbour.
Manly	An isolated patch of core habitat area occurs on North Head. This patch of core habitat area contains areas of high biodiversity value, including EBSB and Littoral Rainforest, and habitat for the endangered Long-nosed Bandicoot population. It also contains habitat for the endangered Little Penguin population, including the Area of Outstanding Biodiversity Value (AOBV; formerly Critical Habitat).



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COORDINATE SYSTEM GDA 1994 MGA Zone 56

FIG NO. 3-1

FIGURE TITLE Northern Beaches: Core and Corridor mapping

PROJECT NO. 30012850

PROJECT TITLE NBC Biodiversity Planning Review

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3.1.2 Biodiversity corridor area

The study area has an abundance and diversity of biodiversity corridor values, forming an extensive web. Because of this, the corridor assessment for this project identified the local values of vegetated corridor habitat and considered the distances between them as 'stepping-stone' corridors. Biodiversity corridors identified in this report provide for connectivity at a local - Northern Beaches scale, whereas, many of the core habitats mapped and described above provide for more regional connectivity which extends beyond the Northern Beaches.

Unbroken connectivity of vegetated corridors between areas of core habitat was not always present. The introduction of connections that incorporate less vegetated or highly developed areas could not always be adequately supported by an acceptable level of defensibility. The coastal corridor areas vary considerably in quality in many parts of the LGA in terms of vegetated connectivity and impediments resulting from existing developments.

The incorporation of the coastal fringe, 100 metres from the low tide mark, notably maps the connections between important patches of estuarine or littoral habitat, such as headlands and dunes, that are isolated from each other.

The description of corridor locations across the LGA are described by suburb in a generally north to south order is detailed within Table 3-2.

Biodiversity corridor areas mapped within the LGA are shown in Figure 3-1. A data-driven, multi-page figure of biodiversity corridor areas is contained within the separate Biodiversity Planning Review Map Booklet.

Table 3-2 Description of Biodiversity Corridor Areas

Suburb	Description of Biodiversity Corridor Areas
Palm Beach	The core habitat offered by Barrenjoey head is connected by the most northerly corridor in the LGA consisting of Palm Beach Golf Course and Governor Phillip Park. This corridor is typical of those offered by open spaces with some disturbed vegetation with room for future improvement in corridor value. Connection to the next core area to the south, McKay Reserve, is offered by the coastal corridor along the western shoreline of the peninsular although terrestrial vegetation along this route is fragmented. Down the centre of the peninsular, urban canopy and remnant ridgeline pockets of vegetation including Sunrise Reserve, provide better but incomplete linkages. McKay Reserve is itself a linear shaped reserve and is well connected to the coastal corridor with its proximity to the western shoreline and unbroken linkages through to the east coast both at the southern end of Palm beach and to the Whale Beach headland.
Avalon Beach Clareville Bilgola Plateau Bilgola Beach Newport Bayview Church Point	Careel Creek provides an important corridor both length ways along the peninsular and in bridging the eastern and western shores by linking Avalon Beach to Careel bay. A public walkway runs along the southern half of this corridor and although a small break is show in the mapping, this should be considered a continuous route incorporating the watercourse. The watercourse is partially channelised but may offer opportunities for future naturalisation. Core habitat areas in the rest of the lower peninsular are generally well connected through corridors formed from good retention of urban canopy and remnant vegetation found along cliff lines and slopes in suburbs such as Clareville and Newport. The biodiversity corridor areas that fall within the core habitat and corridor spatial layer are, in most cases, within areas that were mapped by Pittwater wildlife corridor map as category 1 and 2 corridors, however linkages previously designated as category 3 corridors and habitat potential are generally not included. On the coastal edge from Bungan Beach to Narrabeen a series of headland reserves such as Mona Vale and Turrimetta Head give additional relevance to the coastal corridor. Further inland, areas around Church Point and Bayview are well connected with proximity to the high-quality core areas of Ku-ring-gai National Park to the west.

Suburb	Description of Biodiversity Corridor Areas
	Corridors are offered by high urban canopy coverage and remnants particularly along gullies and slopes. Church Point and Bayview in some ways form a bridge between the core of Ku-ring-gai National Park through to the peninsular. This linkage, however, is restricted because of the higher density urbanised areas of Mona Vale, and the relatively narrow restriction of the peninsular at that point. Some connectivity from Bayview northward is offered by the coastal corridor along Pittwater.
Ku-ring-gai Chase Great Mackerel Beach Currawong Beach Coasters Retreat Morning Bay Lovett Bay Elvina Bay Cottage Point	Very small pockets of biodiversity corridor area connect core habitat areas where there has been low density residential or recreational development.
Scotland Island	Biodiversity corridor habitat surrounds a patch of core habitat area within the middle of Scotland Island (Elizabeth Park).
Warriewood Narrabeen (north)	On the coastal flats between Mona Vale and Narrabeen Lagoon including the Warriewood Valley, riparian corridors and parks provide a series of narrow but continuous corridors from the coast and lagoon to Warriewood Wetlands and the Ingleside Chase Reserve. Mona Vale Golf Course and Kitchener Park remain a corridor incorporated into the coastal corridor as previous mapped. Pittwater Rugby Park ('Rat Park'), which currently hosts an Osprey nest, is a new addition to the corridor layer.
Ingleside	Ingleside is placed between Garigal and Ku-ring-gai National Parks and is generally enclosed by bushland areas, much of which has been designated as core habitat area. The large areas of bushland have some areas of good connectivity mapped within the core layer itself, although there are divisions created by the widening of Mona Vale Road in several places. Approximately half of the non-core areas in the rural areas of Ingleside is mapped as biodiversity corridor area. Retention of maximum corridor width in Ingleside, particularly north of Mona Vale Road, ties in with maintaining a regional level corridor as shown in Pittwater's Draft Wildlife Strategy Regional Corridors (Pittwater Council, 2011).
Duffys Forest	Good connectivity is maintained to the core habitat area mapped across the remnant at the NSW Gun Club. This core habitat area acts as a hub for corridors that link together Ku-ring-gai National Park, in which the suburb is embedded. Clusters of corridor elements connect the NSW Gun Club through to Scribbly Park to the north west, south through remnant bushland to Waterfall Gully and north east through the more vegetated sections of the Terry Hills Golf Course.
Terry Hills	Terry Hills also forms a gap in Ku-ring-gai National Park. Connectivity across the suburb in the north-south axis are greatest to the west of Kallaroo Rd. The more urban central areas of Terry Hills show limited opportunities for corridors. Retained canopy cover and remnants along property boundaries provide some biodiversity corridor areas east of McCarrs Creek Road and in the southern extent of the suburb.
Elanora Heights North Narrabeen	Connectivity along a biodiversity corridor area is provided from core habitat areas within Warriewood Wetlands through Progress Park and along Mullet Creek to Narrabeen Lagoon. Connectivity is further enhanced via biodiversity corridor areas

Suburb	Description of Biodiversity Corridor Areas
	running along the foreshore of Narrabeen Lagoon through to core habitat areas within Deep Creek Reserve, and up to Nareen Reserve. Retained canopy cover provides linkages as biodiversity corridor between Garigal National Park and Elanora Country Club, as well as east towards Ingleside Chase Reserve.
Oxford Falls	Given that a large proportion of Oxford Falls is mapped as core habitat area, biodiversity corridor area is limited through the suburb, mainly providing linkages along Oxford Falls Road and through Middle Creek.
Belrose	Biodiversity corridor areas linking large core habitat areas divided by the suburb of Belrose are generally consistent with previous Warringah corridor mapping. Vegetation within the Belrose Super Centre provides the northernmost links; other good-sized remnant patches in the vicinity of Morgan Road also provide east to west connectivity, the division created by Forest Way itself notwithstanding. A priority 1 corridor previously mapped in the former Warringah LGA that crossed Forest Way at the Wakehurst Football Club oval west to Frenchs Creek is still evident but in a modified form.
Davidson Frenchs Forest Forestville	Former Warringah corridor mapping did not map corridors through the urban areas of Davidson or Forestville. The core habitat and corridor spatial layer identified small patches of corridor elements scattered throughout the suburbs, providing connectivity between core habitat areas mapped in the north-south and east-west extents of the suburbs, or adjoining suburbs such as Oxford Falls or Belrose. The significant priority 1 corridor from the former Warringah mapping that follows the Wakehurst Pathway through the site of the new Northern Beaches Hospital is mapped, however clearing for the hospital has been taken into account and the major roads are shown as breaks in the corridor. Riparian based linkages almost connect Jindabyne Reserve to core areas to the north.
Killarney Heights	Retained canopy cover provides important biodiversity corridor areas between large tracts of core habitat areas within the east and west of the suburb.
Allambie Heights	Allenby Park retains some fragmented connectivity to the west via remnants along Aquatic Drive and through Goroka Park. Gumbooya Reserve also retains connections with stepping-stone routes found approximately in zones previously mapped as continuous corridors. These include the slopes behind Brookvale industrial areas and fragmented vegetation to the west centred around Gilai Reserve.
Beacon Hill	Retained canopy cover and recreation areas, such as Beacon Hill Reserve and Governor Phillip Lookout, provide linkages between core habitat areas in Allenby Park within the suburbs of Oxford Falls and Frenchs Forest.
Narrabeen (south) Cromer Wheeler Heights Collaroy Collaroy Plateau	There is good correlation between biodiversity corridor areas and previously mapped corridors in these localities, although some now fall short of their potential linkages to core habitat areas. An extensive and contiguous corridor connects Narrabeen Lagoon and Dee Why Lagoon via the Cromer Valley by incorporating riparian areas, parks and the Cromer Golf Course. The remnant bushland found on the cliff lines of Collaroy below Edgecliff Boulevard and Lincoln Ave provide long linear strips in an area that is otherwise low in consistent vegetation cover. These escarpments were incorporated into previously mapped corridors which linked cores near Jamieson Park at Narrabeen Lagoon to Dee Why Lagoon. The new mapping shows areas of poor connectivity in linkages between of Narrabeen and Dee Why Lagoons. The small unnamed reserve on Suffolk Ave provides one route with linking some sporadic corridor elements.

Suburb	Description of Biodiversity Corridor Areas
North Curl Curl Brookvale North Manly Manly Vale Freshwater Queenscliff	In this relatively densely urbanised area, mapped biodiversity corridor areas conform to similar patterns as previously mapped. Curl Curl Lagoon and Green Dale Creek still form an important route from the coast inland which ends abruptly at the industrial areas of Brookvale. This corridor now incorporates most parks and sports fields adjacent to the watercourses. Manly Lagoon also forms an important corridor connected by the sea. A previously overlooked linkage through to the core habitat areas around Manly Dam is now identified along Manly Creek through Millers Reserve. A long section of biodiversity corridor area follows the coastline from Curl Curl Lagoon south around the headlands and along beaches and associated coastal dune vegetation towards North Head. Core habitat areas in Manly remain relatively isolated; North Head in particular is highly isolated from a terrestrial standpoint as demonstrated by the disjunct population of Long-nosed bandicoots. The coastal biodiversity corridor area in Manly takes on additional significance through the areas incorporating habitat for the endangered population of Little Penguins on North Head, including the AOBV. Potential terrestrial movement along the harbour-side section of the coastal corridor is increased by foreshore vegetation associated with the path along the Manly to Spit Walk.
Seaforth North Balgowlah Fairlight Balgowlah Balgowlah Heights Clontarf	A significant biodiversity corridor area runs along the Sydney Harbour Foreshore through Seaforth and Clontarf linking core habitat areas within Garigal National Park and Sydney Harbour National Park. The biodiversity corridor area continues around North Harbour foreshore through Balgowlah, Fairlight, and Manly linking up core habitat on North Head. Connectivity though stepping-stones provides linkages along biodiversity corridor areas through Balgowlah, Balgowlah Heights, and North Balgowlah to important core habitat area around Manly Dam.

3.2 Threatened entities spatial layer

3.2.1 Threatened ecological communities (TECs)

Thirteen TECs listed under the NSW BC Act were identified within the Northern Beaches LGA. Of these, seven TECs were also listed under the Commonwealth EPBC Act. One of these, River Flat Eucalypt Forest, was listed under the EPBC Act (as critically endangered) in 2020.

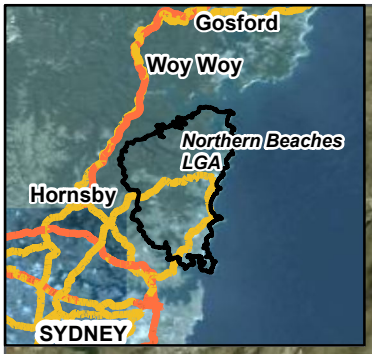
The TECs occurring within the Northern Beaches LGA are summarised in Table 3-3.

The locations of TECs occurring within the Northern Beaches LGA are shown in Figure 3-2. A data-driven, multi-page figure of TECs is presented in the separate Biodiversity Planning Review Map Booklet. Descriptions of the TECs, including location patterns and mapping confidence, is detailed within Sections 3.2.1.1 to 3.2.1.13 below.

Table 3-3 TECs occurring within Northern Beaches Local Government Area

Threatened Ecological Community (BC Act name)	Status (BC Act)	Status (EPBC Act)
Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions	Endangered	Not Listed
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Vulnerable
Coastal Upland Swamp in the Sydney Basin Bioregion	Endangered	Endangered

Threatened Ecological Community (BC Act name)	Status (BC Act)	Status (EPBC Act)
Duffys Forest Ecological Community in the Sydney Basin Bioregion	Endangered	Not Listed
Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion	Critically Endangered	Endangered
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Not listed
Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Critically Endangered
Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion	Endangered	Not listed
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Critically Endangered
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Endangered
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Not listed
Sydney Freshwater Wetlands in the Sydney Basin Bioregion	Endangered	Not listed
Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	Not listed



N

LEGEND

- NB LGA Boundary
- NB Deferred Lands
- NSW National Parks and Wildlife Service (NPWS) Estate (within NB LGA)

NB TEC Mapping

- Bangalay Sand Forest
- Coastal Saltmarsh
- Coastal Upland Swamp
- Duffys Forest Ecological Community
- Eastern Suburbs Banksia Scrub
- Freshwater Wetlands on Coastal Floodplains
- Littoral Rainforest
- Pittwater Spotted Gum Forest
- River Flat Eucalypt Forest
- Swamp Oak Floodplain Forest
- Swamp Sclerophyll Forest on Coastal Floodplains
- Sydney Freshwater Wetlands
- Themeda Grassland on Seacliffs and Headlands

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COORDINATE SYSTEM GDA 1994 MGA Zone 56

FIG NO. 3-2

FIGURE TITLE Northern Beaches: TEC mapping

PROJECT NO. 30012850

PROJECT TITLE NBC Biodiversity Planning Review

CREATED BY FA13847

SOURCES Metromap © Aerometrex 2020, public_NSW_Imagery: © Department of Customer Service 2020, SMEC 2021, Northern Beaches Council 2021, Roadnet MDS 2020, The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 (OEH, 2016) VIS_ID 4489; and The NSW National Parks and Wildlife Service (NPWS) Estate © State Government of NSW and Department of Planning, Industry and Environment 2000.

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Last updated by: FA13847 on 8/12/2021 at 16:03

3.2.1.1 Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions

Table 3-4 Summary of Bangalay Sand Forest within Study Area

Bangalay Sand Forest (BSF)	
BC Act status:	Endangered
EPBC Act status:	Not Listed
Location Pattern	Found as three small remnants between c. 0.1 ha and c. 0.2 ha around Boondah Road and Shearwater Drive in Warriewood valley
Confidence	High – limited extent makes assessment inputs limited, but landscape position, landform and floristic assemblage strongly correlated.

3.2.1.2 Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-5 Summary of Coastal Saltmarsh within Northern Beaches LGA

Coastal Saltmarsh	
BC Act status:	Endangered
EPBC Act status:	Vulnerable
Location Pattern	Found across the study area along the estuarine waterways of Pittwater and Middle Harbour, and on the edges of coastal lagoons.
Confidence	Moderate – difficulties in aerial interpretation may result from overhanging adjoining canopies and floristic delineation from adjacent wetland forbs
Comment	Approximately 4.78 hectares of PCT 1837 was identified to be Coastal Saltmarsh. Paragraph 5 of the Final Determination for Coastal Saltmarsh states: *'Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions is frequently found as a zone landward of mangrove stands. Occasional scattered mature Avicennia marina trees occur through saltmarsh at some sites, and Avicennia (and less frequently Aegiceras corniculatum) seedlings may occur throughout saltmarsh. In brackish areas dense stands of tall reeds (Phragmites australis, Bulboschoenus spp., Schoenoplectus spp., Typha spp.) may occur as part of the community.'* Candidate areas where mangrove canopy was observed through API to be open enough to allow a native ground strata were identified. Areas along the landward zone of mangroves such as those behind the large Careel Bay mangrove stands, or mangroves at Mackerel Beach, were identified as likely meeting the description of Coastal Saltmarsh TEC.

3.2.1.3 Coastal Upland Swamp in the Sydney Basin Bioregion

Table 3-6 Summary of Coastal Upland Swamp within Northern Beaches LGA

Coastal Upland Swamp (CUS)	
BC Act status:	Endangered
EPBC Act status:	Endangered

Coastal Upland Swamp (CUS)	
Location Pattern	Found almost entirely in the western parts of the study area, generally within core bushland areas.
Confidence	Moderate – a large number of relatively small polygons. Areas of wet heath left long unburnt may meet the criteria for this TEC but are difficult to identify unless subject to detailed survey and analysis. Some areas visited were recently burnt, making identification of floristic and structural characters somewhat complicated. Some edges of areas ground-truthed as CUS were reduced from their mapped extent. Conversely, limited areas mapped as heath were included in CUS.
Comment	Opportunities to identify additional instances of upland swamps were found in riparian layers supplied by Council including 'Wetland Layer' which identified numerous hanging swamp objects, which were likely to align with the TEC, however the generalised nature of the layer meant that it was considered only for survey planning. Additional locations of CUS were incorporated as a result of ecological impact reports and Council-commissioned reports.

3.2.1.4 Duffys Forest Ecological Community in the Sydney Basin Bioregion

Table 3-7 Summary of Duffys Forest Ecological Community within Northern Beaches LGA

Duffys Forest Ecological Community (DFEC)	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	Generally restricted to laterite landscapes associated with ridgetops from west of Manly Dam north to the northern edge of Duffys Forest, and along the ridges of Mona Vale Road from the top of Warriewood Valley west to the boundary of the study area towards St Ives.
Confidence	High – some precautionary interpretation applied to encompass uncertain assemblage extents. Sites generally well visited and accessible. All areas mapped as PCT 1845 were accepted as meeting the TEC. More widely, the assemblage that PCT 1845 describes is considered by the current study as a component of the TEC.
Comment	Duffys Forest Ecological Community (DFEC) stands out as a community of high importance to the Northern Beaches LGA which holds close to 90% of its remnants. As with all TEC occurrences where species assemblages fit the community determination, including soil type would ideally be identified, however there is some scope for further investigation of the definition. Smith & Smith (2000) described several variants of DFEC. Smith & Smith (2005a and 2005b) also acknowledge there was some inconsistency with their finding as the 2002 Scientific Committee Final Determination but still went on to identify 'Blackbutt Turpentine' and Angophora - White Mahogany Forest are variants of DFEC. The Angophora - White Mahogany form was especially noted as very unique and limited in range. As discussed above, the assemblage of species of the 'Blackbutt Turpentine' and 'Angophora -White Mahogany Forest' variants does poorly align to the characteristic species described in Final Determination for the community, but the assemblage that PCT 1845 describes is considered by the current study as a component of the TEC in the current study. The update of the 2005 Warringah Natural Area Survey (NAS) by Ecological (2010) noted that the SMCMA community S_WSF06 Coastal Shale-Sandstone Forest shows some affinity to the NAS endangered ecological Duffys Forest communities, Blackbutt-Turpentine Forest and Angophora White-Mahogany Forest, however, it was unclear whether the legal status of all mapped S_WSF06 Coastal Shale-Sandstone Forest is an endangered ecological community (DECCW 2009). Their recommendation was to review the correlation of the SMCMA

Duffys Forest Ecological Community (DFEC)	
	vegetation community S_WSF06 Coastal Shale Sandstone Forest with the NAS Duffys Forest communities Silvertop Ash-Brown Stringy Bark Forest and Blackbutt-Turpentine Forest to determine whether there is a change to the legal conservation status of the NAS communities. In summary, Coastal Shale-Sandstone Forest (now PCT 1845) is acknowledged as having a relationship with both DFEC and the more westerly Shale Sandstone Transition Forest by BioNet Vegetation Classification database, and has been precautionarily included in the current study as a component of DFEC even though it does not match well with regard to the dominant characteristic species.

3.2.1.5 Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion

Table 3-8 Summary of Eastern Suburbs Banksia Scrub within Northern Beaches LGA

Eastern Suburbs Banksia Scrub (ESBS)	
BC Act status:	Critically Endangered
EPBC Act status:	Endangered
Location Pattern	In the study area this TEC is restricted to North Head on sand deposits
Confidence	High – land well visited and accessible.
Comment	Most known and potential sites are located within Sydney Harbour National Park. One area within the North Head Wastewater Treatment Plant has been added to the spatial layer.

3.2.1.6 Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-9 Summary of Freshwater Wetlands on Coastal Floodplains within Northern Beaches LGA

Freshwater Wetlands on Coastal Floodplains	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	Along Middle and Deep Creeks draining into Narrabeen Lagoon, and at Warriewood Wetlands
Confidence	High – sites visited and with strong aerial identification signature.

3.2.1.7 Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-10 Summary of Littoral Rainforest within Northern Beaches LGA

Littoral Rainforest	
BC Act status:	Endangered
EPBC Act status:	Critically Endangered

Littoral Rainforest	
Location Pattern	From Church Point and Bayview north across the Pittwater peninsular to Palm Beach, typically on Narrabeen soils. Another isolated patch in the steep south-facing slopes along the northern edge of Narrabeen Lagoon.
Confidence	Moderate. Small patches likely show a similar signature to mesophyllic exotic weeds which may also form components of the local extent. Some areas adjacent to OEH (2016) mapped component PCT areas show a similar pattern of dense canopy.
Comment	Small pockets of this community in areas of coastal scrub or escarpments would appear to be recovering from lack of fire or disturbance or colonising through succession such as in hind dune situations. In some case even areas previously mapped as weed dominant can provide for the succession to a closed structure required for the recovery of this community. Examples have been seen where lantana thickets become smothered by *Cissus antarctica*, allowing for trees such as *Glochidion, Livistona* etc. to establish. In some areas, minor inconsistencies were noted between Littoral Rainforest TEC mapping in the OEH (2016) layer and the SEPP (Coastal Management) map. The threatened entities layer always incorporated the greater extent. For example, the SEPP mapping added significantly to the patch mapped by OEH (2016) at the northern side of Bilgola Beach.

3.2.1.8 Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion

Table 3-11 Summary of Pittwater and Wagstaffe Spotted Gum Forest within Northern Beaches LGA

Pittwater Spotted Gum Forest	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	Found on Narrabeen soils around Pittwater, from Morning Bay in the west, south to Bayview and north to the western parts of the suburb of Palm Beach.
Confidence	High – restricted to known locality, well visited with a strong aerial identification signature
Comment	OEH 2016 mapping of this community states that sampling density is high, and that the assemblage, particularly the component species Spotted Gum (*Corymbia maculata*) provides a strong crown signature on digital imagery. This community's extent was therefore initially expected to be accurately defined in the mapping, with no effort to locate additional PSGF being performed. However, ground-truthed and modelled expert advice, as well as local knowledge from Council, noted that areas of PSGF occurred beyond the range identified by OEH 2016 as remnant canopy scattered in parts of Pittwater. As PSGF may occur as remnant canopy only with a cleared or disturbed understorey, consequently, LIDAR modelling has identified further extents of the assemblage.

3.2.1.9 River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-12 Summary of River-flat Eucalypt Forest within Northern Beaches LGA

River Flat Eucalypt Forest (RFEF)	
BC Act status:	Endangered

River Flat Eucalypt Forest (RFEF)	
EPBC Act status:	Critically Endangered
Location Pattern	Around Pittwater, found along the lowest reaches of Careel Creek, and around Great Mackerel Beach. In the Narrabeen Lagoon catchment, along Middle, South and Deep Creeks draining into Narrabeen Lagoon, and around limited areas of the lagoon edge.
Confidence	High – sites visited and with strong aerial identification signature and landscape association
Comment	Landscape constraint of occurring within a coastal floodplain is an important determinant. Council's 1% AEP flood modelled extent has informed this determining landscape feature of coastal floodplains. The mapped extents generally sit above the more waterlogged soil profiles of Swamp Oak Floodplain Forest.

3.2.1.10 Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-13 Summary of Swamp Oak Floodplain Forest within Northern Beaches LGA

Swamp Oak Floodplain Forest (SOFF)	
BC Act status:	Endangered
EPBC Act status:	Endangered
Location Pattern	Along the lagoon edges and estuarine creeks draining into Manly and Curl Curl Lagoons; the edges of Dee Why and Narrabeen Lagoons, including Narrabeen Creek catchment particularly around Warriewood Wetlands; edges of Middle Harbour Creek between Carroll Creek and Roseville Bridge; and around south-east Pittwater and Careel Bay.
Confidence	High – this community has a distinctive aerial imagery
Comment	PCT 1232 is floristically compatible with the TEC Swamp Oak Floodplain Forest. Landscape constraint of occurring within a coastal floodplain is an important determinant. Council's 1% AEP flood modelled extent has informed this determining landscape feature of coastal floodplains. By applying these constraints an additional 25.68 hectares of Swamp Oak Floodplain Forest TEC were identified within the LGA.

3.2.1.11 Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Table 3-14 Summary of Swamp Sclerophyll Forest within Northern Beaches LGA

Swamp Sclerophyll Forest on Coastal Floodplains (SSF)	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	Within Warriewood Valley, downstream along Mullet Creek above Irrawong Reserve and downstream from south of Mater Maria College along Fern Creek in Warriewood; within the Narrabeen Lagoon catchment, along central parts of Deep Creek and the mouth of South Creek around Cromer Golf Course; along the western edge of Dee Why Lagoon; and associated with Cahill Creek at Bayview Golf Course.

Swamp Sclerophyll Forest on Coastal Floodplains (SSF)	
Confidence	Moderate. Relatively small patches likely show a similar signature to mesophyllic exotic weeds or adjoining non-forested wetland moist forest, or be confused with other forested wetlands, particularly in identifying edges of the community.
Comment	PCT 1231 is floristically compatible with Swamp Sclerophyll Forest. Landscape constraint of occurring within a coastal floodplain is an important determinant. Council's 1% AEP flood modelled extent has informed this determining landscape feature of coastal floodplains. By applying these constraints, an additional 9.95 ha of Swamp Sclerophyll Forest were identified. This community generally occurs in soils less affected by estuarine influences of Swamp Oak Forest but is more waterlogged than River Flat Eucalypt Forest.

3.2.1.12 Sydney Freshwater Wetlands in the Sydney Basin Bioregion

Table 3-15 Summary of Sydney Freshwater Wetlands within Northern Beaches LGA

Sydney Freshwater Wetlands (SFW)	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	Localised to dune swales on North Head, behind Dee Why Lagoon, Nareen Park north of Narrabeen Lagoon, and around the lake near the mouth of Deep Creek at Narrabeen Lagoon.
Confidence	Moderate. The fern and sedge dominated extents have a distinctive aerial image, although exotic and weedy edges of weed incursions make identifying edges somewhat difficult. Identification of underlying dune swales is obscured by vegetation.

3.2.1.13 Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions

Table 3-16 Summary of Themeda grasslands within the Northern Beaches LGA

Themeda Grassland on Seacliffs and Headlands (TG)	
BC Act status:	Endangered
EPBC Act status:	Not listed
Location Pattern	On headlands supporting soils derived from Narrabeen geology, from Long Reef north, including Long Reef Headland, Narrabeen Head, the northern headland of Bongin Bongin Bay, South Bilgola Headland, and at the northern edge of Barrenjoey Headland.
Confidence	Moderate. While landscape features are readily identified, the aerial imagery may have poor fidelity to native grasslands, and easy differentiation from native and exotic cover is constrained.

3.2.2 Threatened species

Twenty-five threatened species listed under the BC Act and/or EPBC Act were mapped within the threatened entities spatial later as occurring within the Northern Beaches LGA. These include:

- Twenty-one threatened flora species listed under the BC Act; thirteen of which are also are listed under the EPBC Act
- Four threatened fauna species listed under the BC Act, one of which is also listed under the EPBC Act

The locations of threatened entities occurring within the LGA is shown in Figure 3-3. A data-driven, multi-page figure of the core habitat area is contained within the separate Biodiversity Planning Review Map Booklet.

3.2.2.1 Threatened flora

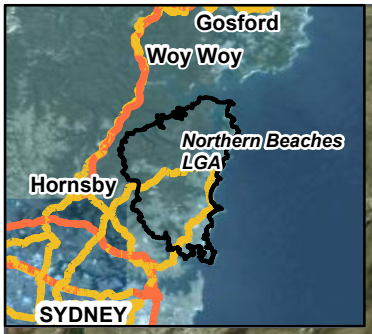
Twenty-one threatened plant taxa have been mapped as valid records across the LGA following a quality review of records. Descriptions of the threatened flora species, including location patterns and mapping confidence, is detailed within Table 3-17.

Table 3-17 Description of threatened flora species occurring within Northern Beaches LGA

Species	BC Act status	EPBC Act status	Distribution in Study Area	Confidence of combined records and continued existence of plants at sites
Acacia bynoeana	Endangered	Vulnerable	Middle Harbour catchment: mainly Frenchs Forest, Seaforth.	Low - all records over 100 years old.
Acacia terminalis subsp. *terminalis*	Endangered	Endangered	Generally coastal southern parts of the study area, including Dobroyd Head, Balgowlah Golf Club, Allambie, Spring Cove, North Manly, Brookvale and Curl Curl	Moderate – most records less than 20 years old.
Asterolasia elegans	Endangered	Endangered	Hewitt Park Reserve, Bilgola. Single record.	Moderate – single record, not visited.
Callistemon linearifolius	Vulnerable	Not listed	Scattered over mainly northern part of study area.	Moderate – most sites not accessible for field validation although broad associations often present
Chamaesyce psammogeton	Endangered	Not listed	Various coastal sites from North Head to Barrenjoey	High. Recent records and relatively stable habitat and ecologies.
Epacris purpurascens var. *purpurascens*	Vulnerable	Not listed	Generally found within Duffys Forest to Terry Hills, with isolated records around Narrabeen and North Narrabeen. Coastal and Terry Hills Country Club records not on Atlas.	Moderate. Many sites under development or degradation pressure
Eucalyptus camfieldii	Vulnerable	Vulnerable	Over much of the study area.	Low. Few newer records. Most records over 20 years old
Grevillea caleyi	Critically Endangered	Critically Endangered	Ridgetops of Belrose, Duffys Forest, Terrey Hills and Ingleside.	Moderate. Sites likely persist but as soil stored seed or as cryptic individuals. New extents as incidental records during current surveys.
Haloragodendron lucasii	Endangered	Endangered	One record near edge of Ku-ring-gai Chase	Moderate.

Species	BC Act status	EPBC Act status	Distribution in Study Area	Confidence of combined records and continued existence of plants at sites
			National Park, Duffys Forest	
Hibbertia puberula	Endangered	Not listed	Single record, Forestville.	Moderate. Single valid record in 1946 although a number of recent records of a *Hibbertia* species that may be *H. puberula* have been made in the locality
Hibbertia superans	Endangered	Not listed	Uncertain number of records	Moderate – poorly detailed record data
Kunzea rupestris	Vulnerable	Vulnerable	West Head and Ingleside	Moderate – habitat likely stable, although recent clearing along Mona Vale Road likely removed the habitat in one site.
Lasiopetalum joyceae	Vulnerable	Vulnerable	Cottage Point, Duffys Forest and Ingleside	High
Leptospermum deanei	Vulnerable	Vulnerable	Within NBC LGA but outside study area within Garigal National Park, Ingleside	High. While records are within LGA, all are in Garigal NP.
Persoonia hirsuta	Endangered	Endangered	Most around Oxford Falls – Red Hill	Moderate – no plants sighted during current limited fieldwork
Pimelea curviflora var. *curviflora*	Vulnerable	Vulnerable	Across much of central and southern parts of the site	High – a cryptic species with substantial populations in some locations
Prostanthera marifolia	Critically Endangered	Critically Endangered	Manly Dam Reserve and Wakehurst Parkway	High, recent observation indicates substantial recruitment following fire.
Rhodamnia rubescens	Critically Endangered	Not Listed	Generally coastal, principally around Fairy Bower (Manly) and littoral rainforest of the Pittwater Narrabeen shales such as Avalon	Moderate - while until recently common in suitable habitat, and not threatened, records were relatively few as it was not listed as threatened until its rapid severe decline due to Myrtle Rust. Number of live, healthy or reproductive plants now low. Surviving plants may be in habitat previously assessed as only marginal.
Senecio spathulatus	Endangered	Not Listed	Sand-dune south of Dee Why Headland	Low. Single record.
Syzygium paniculatum	Endangered	Vulnerable	Widespread across study area	High that records persist as live plants in locations recorded. Moderate that all plants are naturally recruited with some records likely to have been planted individuals. New records of plants

Species	BC Act status	EPBC Act status	Distribution in Study Area	Confidence of combined records and continued existence of plants at sites
				not apparently planted were identified in the current survey.
Tetratheca glandulosa	Vulnerable	Not listed	Widespread across centre and north of study area.	High



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LEGEND

- NB LGA Boundary
- NB Deferred Lands
- NSW National Parks and Wildlife Service (NPWS) Estate (within NB LGA)

NB Threatened Species Habitat Mapping

- Acacia bynoeana (Flora)
- Acacia terminalis subsp. terminalis (Flora)
- Asterolasia elegans (Flora)
- Bush Stone-Curlew (Fauna)
- Callistemon linearifolius (Flora)
- Chamaesyce psammogeton (Flora)
- Epacris purpurascens var. purpurascens (Flora)
- Eucalyptus camfieldii (Flora)
- Euphorbia psammogeton (Flora)
- Grevillea caleyi (Flora)
- Grey Headed Flying fox - Balgowlah Grey-headed Flying-fox camp (Fauna)
- Grey Headed Flying fox - Cannes Reserve Flying-fox camp (Fauna)
- Grey Headed Flying fox - Warriewood Wetlands Flying-fox camp (Fauna)
- Haloragodendron lucasii (Flora)
- Hibbertia puberula (Flora)
- Hibbertia superans (Flora)
- Kunzea rupestris (Flora)
- Lasiopetalum joyceae (Flora)
- Leptospermum deanei (Flora)
- Little penguin Critical Habitat 'A' (Fauna)
- Little penguin Critical Habitat 'A' and Long-nosed bandicoot Habitat (Fauna)
- Little penguin Critical Habitat 'B' (Fauna)
- Little penguin Critical Habitat 'B' and Long-nosed bandicoot Habitat (Fauna)
- Little penguin Potential Habitat (Fauna)
- Little penguin Potential Habitat and Long-nosed bandicoot Habitat (Fauna)
- Little penguin and Long-nosed bandicoot (Fauna)
- Long-nosed bandicoot (Fauna)
- Melaleuca biconvexa (Flora)
- Melaleuca deanei (Flora)
- Persoonia hirsuta ssp.hirsuta (Flora)
- Pimelea curviflora var. curviflora (Flora)
- Prostanthera marifolia (Flora)
- Rhodamnia rubescens (Flora)
- Senecio spathulatus (Flora)
- Syzygium paniculatum (Flora)
- Tetratheca glandulosa (Flora)

DATE 13/05/2021

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COORDINATE SYSTEM GDA 1994 MGA Zone 56

FIG NO. 3-3

FIGURE TITLE Northern Beaches: Threatened species habitat mapping

PROJECT NO. 30012850

PROJECT TITLE NBC Biodiversity Planning Review

CREATED BY FA13847

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Last updated by: FA13847 on 8/12/2021 at 18:01

3.2.2.2 Threatened fauna

Four threatened fauna species and/or their distributions have been mapped within the Threatened Entity spatial layer. Descriptions of the threatened fauna species, including location patterns and mapping confidence, are provided within Table 3-18.

Table 3-18 Description of threatened fauna species occurring within Northern Beaches LGA

Species	BC Act status	EPBC Act status	Distribution in Study Area	Confidence of combined records veracity
Bush Stone-Curlew (*Burhinus grallarius*)	Endangered	Not listed	Populations of Bush Stone-curlews occur near developed areas, often associated with drainage lines and sediment ponds	High
Grey-headed Flying-foxes (*Pteropus poliocephalus*)	Vulnerable	Vulnerable	Grey-headed Flying-fox sightings are scattered across the LGA due to their wide-ranging feeding habits. BioNet atlas records are not incorporated. Camps have been mapped at 3 locations based on survey reports and one site visit. Camp size can fluctuate seasonally. Camps include: • Burnt Bridge Reserve, Balgowlah • Cannes Reserve, Avalon • Warriewood Wetlands	High
Little Penguin (*Eudyptula minor*) population	Endangered	Not listed	Terrestrial habitat for the endangered Little Penguin population is incorporated from Schedule 1 (Map D) of the Manly DCP. It is noted that this mapping extends beyond that identified for the Area of Outstanding Biodiversity Value (AOBV; formerly Critical Habitat) due to the inclusion of all properties and their cadastral extents within the declared population area.	High
North Head Long-nosed Bandicoot (*Perameles nasuta*) population	Endangered	Not listed	Restricted to North Head and Eastern Hill in Manly. Fully incorporated and unmodified from Council's layer for Schedule 1 (Map D) of the Manly DCP 2013.	High

4 Conclusions and Recommendations

This project has reviewed existing documents, associated mapping and spatial data to prepare a methodology, incorporating field assessment, that has further developed and refined GIS layers mapping:

- Core habitat and biodiversity corridors
- Threatened ecological communities and threatened species habitat mapping

4.1 Core habitat and biodiversity corridors

This layer has identified habitat features which connect areas of remnant bushland to facilitate dispersal of wildlife and plant populations across the landscape.

Within the study area, core habitat areas have been most commonly mapped within Council reserves, along waterways, and in vegetation patches in larger or undeveloped landholdings. They tend to be of a size that has maintained their viability and are generally larger than 3.5 hectares in area and may be associated with the edges of National Parks adjoining the study area. Highly linear and obviously edge effected areas are not included, although some areas of native vegetation less than 3.5 hectares which support particularly high or intact biodiversity values have been mapped as core habitat.

The lands identified as core habitat areas show a strong correlation to supporting significant threatened species and TEC values.

Biodiversity corridor areas occur over much of the study area, with a general pattern of fewer, wider corridors in the eastern part of the study area, and a network of narrower, reticulate corridors in the west of the study area.

4.2 Threatened entities

This layer identified threatened species records and habitat, and the distribution of threatened ecological communities (TECs), as declared under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Biodiversity Conservation Act 2016* (BC Act). The threatened entities component required review and consolidation of existing data and spatial resources, and was supported by limited field assessment, and this process has identified significant 'data-gaps' where future field survey would refine TEC distribution mapping.

The TEC mapping identified extents of TECs in a generally localised pattern closely aligned to location and landform features such as soil and landscape position. Within this pattern of distribution, intactness of TECs varied but included some moderate sized and relatively intact patches to linear, fragmented and/or disturbed patches.

Thirteen TECs listed under the BC Act were identified within the Northern Beaches LGA. Of these, seven TECs were also listed under the EPBC Act.

Habitat areas for twenty-five threatened species listed under the BC Act and/or EPBC Act were mapped within the threatened entities spatial layer, with twenty-one threatened flora species listed under the BC Act; thirteen of which are also are listed under the EPBC Act, and four threatened fauna species listed under the BC Act, one of which is also listed under the EPBC Act.

4.3 Recommendations

The following future updates are recommended in order to refine the accuracy and comprehensiveness of mapped core habitat corridors and threatened entities within the Northern Beaches LGA: as new information becomes available and threatened species legislation is updated the mapping outputs of the current project should be updated as part of future reviews of the LEP / DCP. These updates may incorporate:

- New or refined records of threatened species
- Changes to threatened entities listings, both newly listed species. Populations and threatened ecological communities, or updates to these threatened entities' threat levels
- Vegetation mapping by third parties (e.g. flora and fauna assessments as part of Das, approved Biodiversity Development Assessment Reports, or approved Biodiversity Stewardship Assessment Reports)
- Incorporation of other habitat features that may be collected by Council during its day-to-day operations, into a dataset suitable to inform any future habitat models. This could include data collected directly or indirectly by Council such as external tree reports and internal tree assessments for hollows/stags/tree species distribution, bark type. This would inform the patterns of habitat features across the LGA

- Updating the report and GIS data/outputs for any advice from Scientific Committee and its administrator, and DPIE, regarding the status and intent of aberrant communities affiliated with DFEC. This may include PCT-TEC associations, either as per updates to the DFEC determination listing, any new TEC listings, or changes to VIS and the proposed east coast PCT updates.

5 References

Drinnan, I.N. (2005) *The search for fragmentation thresholds in a southern Sydney suburb.* Biological Conservation, vol. 124, pp: 339-349.

Eco Logical Australia (2011) *Manly Natural Assets Survey to inform the Draft Manly LEP 2011*. Prepared for Manly Council. Eco Logical Australia, Sydney.

GANSW (2020) *Greener Places Design Guide draft.* Government Architect NSW, Pitt Street, Sydney.

GANSW (2018) *Draft Bushland and Waterways Manual V3.* Government Architect NSW, Pitt Street, Sydney.

Hess, G. R. and Fischer, R. A. (2001) *Communicating clearly about conservation corridors*. Landscape and Urban Planning, vol 55, pp: 195-208.

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

Kavanagh R., Law B., Lemckert F. and Stanton M. (2015). *Threatened Fauna of the Narrabeen Lagoon Catchment, Survey and Status of Threatened Species*. Report prepared for Warringah Council. Niche Environment and Heritage, Sydney.

KC (2016) *Ku-ring-gai Biodiversity & Riparian Lands Study Version 5*. Ku-ring-gai Council, Pacific Highway, Gordon.

LCC (2017) *Urban Green Corridors Plan – restoring and connecting urban bushland in Lismore*. Lismore City Council, Oliver Avenue, Goonellabah

NBC (2019) Northern Beaches Council GIS Layers: *Canopy 18m Plus 4m Buffer.shp, Canopy 18m Plus 4m Buffer Oct2020.shp, Canopy18mPlus.shp, Canopy18mPlus_Oct2020.shp*. Dee Why NSW 2099

OEH (2016) *SMCMA Native Vegetation of the Sydney Metropolitan Area - Version 3.1 VIS_ID 4489 GIS layers*. Office of Environment and Heritage, Goulburn Street, Sydney.

OEH (2017) *Biodiversity Assessment Method*. Office of Environment and Heritage, Goulburn Street, Sydney.

Smith & Smith (2000) *Dee Why Waterbird survey. Report to Warringah Council.* P&J Smith Ecological Consultants, Sydney.

Smith and Smith (2005a) *Warringah Council Natural Area Survey: Vegetation History and Wildlife Corridors*. P&J Smith Ecological Consultants, Sydney.

Smith and Smith (2005b) *Warringah Council Natural Area Survey: Vegetation Communities and Plant Species.* P&J Smith Ecological Consultants, Sydney.

Smith and Smith (2009) *Warringah Council Natural Area Survey: Vegetation History and Wildlife Corridors - 2009 Update.* P&J Smith Ecological Consultants, Sydney.

SSC (2001) *Sutherland Shire Council Green Web Strategy*. Sutherland Shire Council. Elton Street, Sutherland.

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

Townsend, P. and Levey, D. (2005) An experimental test of whether habitat corridors affect pollen transfer. Ecological Society of America, vol 82, issue 2, pp: 466-475

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