The Vertebrate Fauna of Towra Point Nature Reserve

NSW GOVERNMENT
Office of Environment & Heritage
NSW National Parks & Wildlife Service

THE VERTEBRATE FAUNA OF TOWRA POINT NATURE RESERVE

FINAL REPORT

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Cover Photos

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OVERVIEW

An expanse of marsh with pools glinting in the sunlight, mangroves lining shallow embayments, and white specks of birds foraging on mudflats is most people's impression of Towra Point Nature Reserve when they glimpse it from the window of an aeroplane taking off or landing at Sydney airport. Little do most people realise, gazing down at this expanse with thoughts spun far away, the importance of this area nestled so close to the inner regions of the city. It is the last example of a complete estuarine wetland area in the Sydney region. The reserve includes the largest stretch of undeveloped sheltered-water coastline and the largest expanse of estuarine saltmarsh in the Sydney area. It supports a range of habitats that are now rare and extremely limited in the region, ranging from swamplands and estuarine saltmarsh through to littoral rainforest. Seven of the 13 vegetation communities identified within the Reserve are included within Threatened Ecological Communities listed under the NSW *Threatened Species Conservation Act 1995*.

The significance of the vegetation and coastline are reflected in the Reserve's internationally significant fauna values. Towra Point Nature Reserve is one of only three sites in central coastal New South Wales, and the only one in the Sydney region, to be recognised under the Ramsar convention as a wetland of international significance. Following is a summary of the native vertebrate fauna characteristics of the Reserve.

- In total 212 native vertebrate fauna species (excluding fish and pelagic species) have been recorded in the Reserve within the last 25 years comprising six frog, 15 reptile, 179 native bird and 12 native mammal species.
- Shorebirds and waterbirds are a feature of the Reserve. It contains one of the most important nesting sites in New South Wales for the little tern which is listed as Endangered under the NSW *Threatened Species Conservation Act 1995*. It also encompasses a significant proportion of the statewide nesting population of the Endangered Australian pied oystercatcher. A large number of shorebirds listed under international migratory bird agreements, such as the eastern curlew and bar-tailed godwit, use the intertidal flats for foraging or roosting during high tide on the sandy flats particularly Towra Spit Island. The protected inshore waters and intertidal mudflats also support a variety of other waterbirds, particularly during periods of inland drought. These areas provide important feeding habitat for a number of raptor species rare within the Sydney region, such as the eastern osprey and white-bellied sea-eagle.
- The extensive areas of saltmarsh support the only remaining breeding population of the white-fronted chat in the Sydney area. This population is listed as Endangered under the NSW *Threatened Species Conservation Act 1995.*
- The mangrove gerygone is the most noteworthy species utilising the mangrove areas and is close to its southern range limit here.
- A variety of swampland species occur, including the secretive Lewin's rail that is rarely seen but can frequently be heard calling from dense vegetation. The southern emu-wren occurs in swampy areas but also through a range of other habitats across the Reserve. The status of other cryptic wetland species is currently unknown, in particular the Australasian bittern that is listed as Endangered under the NSW *Threatened Species Conservation Act 1995.*
- Forests provide important habitat for a number of species, some of which are poorly known within Sydney such as the greater broad-nosed bat and the masked owl. The white-bellied sea-eagle nests in littoral bangalay forest on Towra Point, one of the few nest sites known in Sydney. When key tree species are in flower the coastal scrub and eucalypt forest provides feeding habitat for the Vulnerable grey-headed flying-fox. Some species that are patchily distributed in forest habitat elsewhere in the region are relatively common in the Reserve, such as the brown gerygone.

A vital key to ongoing conservation of the native fauna values of the Reserve, particularly the internationally recognised wader and other waterbird values, is the lack of public access. Never the less it is estimated that 25 bird species and two mammal species have been lost from the Reserve in the last 25 years. Ongoing active management is required to avoid further species loss. Critical current programs include management to protect and promote the nesting of the little tern on Towra Spit Island, including a reserve-wide and off-reserve fox baiting program. The instigation of an active management program for white-fronted chat is similarly critical in order to reduce the likelihood of this species being lost not only from the Reserve but thereby also as a breeding species from the entire Sydney area.

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1.1 Project Rationale

Information that describes the type, distribution and status of biodiversity in NSW is required by many arms of the Office of Environment and Heritage (OEH) for regulatory, conservation assessment and land management purposes. In the Sydney Basin Bioregion over 60 per cent of extant native vegetation occurs in OEH reserves making it the largest individual custodian of native flora and fauna in the region. Since 2003, the Metropolitan Branches of the Parks and Wildlife Group and the group now called Regional Operations have funded a Biodiversity Survey Priorities (BSP) program with the aim of providing all reserves with an equivalent level of information on flora and vertebrate fauna, irrespective of size and location, and to ensure that biodiversity data collection is approached in a strategic and systematic way. Between 2003 and 2012 28 reserve areas have been surveyed for fauna or flora or both, addressing the largest data gaps and making data available in stand-alone, easily accessible reports and maps. This work has altered previous knowledge of the distribution of many threatened species and Threatened Ecological Communities (TECs).

In 2009 a number of reserves in the southern Sydney metropolitan area were prioritised for systematic fauna survey and reporting. Work has been completed in the Royal National Park (NP), Heathcote NP and Garawarra State Conservation Area (SCA) reserve complex (DECCW 2011a) and in Kamay Botany Bay National Park (DECCW 2011b). This report presents the results for Towra Point Nature Reserve (NR), and a report for Georges River NP is being prepared concurrently. This report synthesises the results of systematic fauna survey undertaken in 2006 (Schulz 2006) and field survey undertaken for the BSP project in 2013 and brings it together with other available information on vertebrate fauna in Towra Point NR.

1.2 Project Aims

The primary objectives of the surveys were to:

- Undertake a review of previous systematic fauna survey effort across Towra Point NR and identify gaps for particular fauna groups, habitats or areas.
- Undertake a limited amount of systematic fauna survey to fill in the biggest gaps identified above.
- The specific objectives of this report are to:
- Document the methodology of the survey techniques applied.
- Document, review and collate information on the terrestrial vertebrate fauna of the Reserve, bringing together results of the BSP survey project with those of previous studies to provide an accurate species inventory.
- Make an assessment of the contribution that Towra Point NR makes towards the protection of vertebrate fauna in the region, with a focus on threatened and migratory fauna species.
- Identify broad-scale patterns in fauna habitat use across the Reserve and identify habitats of particular conservation significance in a regional context.
- Identify major threatening processes to native fauna in Towra Point NR.
- Identify priorities for conservation and management of terrestrial vertebrate fauna in the Reserve and propose management strategies to maintain or enhance the current fauna values.

1.3 Study Area

1.3.1 Location and study area boundaries

Towra Point NR is located on the south shore of Botany Bay, approximately 16 kilometres south of the centre of Sydney (Map 1). It is situated on the Kurnell Peninsula within the Sutherland Shire. The study area used for this report is confined to the boundaries of Towra Point NR, which covers approximately 633 hectares of land. The boundaries of the Reserve are subject to change over time as the sections of shoreline above the high water mark are altered by wave action and other natural

processes (M. Prentice pers. comm.). Subtidal habitat included in the study area is restricted to that occurring within the boundaries of the Reserve, such as in Weeney Bay, and does not include other areas within the contiguous Towra Point Aquatic Reserve. Fish and pelagic fauna that occur with varying frequency in offshore waters but do not use the shoreline for resting, foraging or nesting purposes are not included in this report. Hence species such as terns and cormorants which roost on the shoreline are included, while species that only come ashore as beachwashed or stranded individuals, such as the little penguin (*Eudyptula minor*) and marine mammals, are not included.

1.3.2 Geomorphology, soils, elevation and climate

The Reserve falls within the Sydney Basin Bioregion (Thackway and Creswell 1995), a region defined by extensive sandstone landscapes. The underlying geology of Towra Point NR however is entirely Quaternary sand as Towra Point is a tidal deltaic environment (Roy and Crawford 1981) formed from a range of depositional processes arising from wave, current and wind action. The result is a combination of primary and secondary deltaic landscape features (Roy and Crawford 1981). The primary features represent the shape of the whole Towra peninsula encompassing the Georges River channel and river mouth, shoals and adjoining bays. The secondary features are the local environments derived from changes to the primary depositional landscape. This includes the features that are immediately recognisable in the Reserve today including the intertidal flats, mud basins, deltaic spits and deltaic dunes.

The geology and geomorphology of the Reserve has been described in detail in the report by the Australian Littoral Society (1977) and geomorphological and hydrological changes since 1984 have been detailed in the report by DECCW (2010a). In summary (adapted from DECCW 2010a): “Ten thousand years ago, the sea level was about 25 metres below its current level and Towra Point did not exist, as it was part of the area covered by the entrance of the Georges, Cooks and Hacking rivers into the ocean. Kurnell headland was separated from the rest of Kurnell Peninsula by this combined river mouth. Further sea level rise over the following 3000 years submerged the earlier Pleistocene sediment to form an estuary in both Botany and Bate bays and extended the river entrances westward. Aeolian sand deposits from a source in Bate Bay formed a barrier between Botany and Bate bays thereby separating the Hacking River entrance to those of the other two river systems. Dunes formed on this barrier due to the prevailing southerly winds and migrated northwards, towards Kurnell headland. Marine sand was transported through Botany Heads and deposited in the estuary, providing the sediment for future tidal deltas. Waves and tidal currents shaped Botany Bay by moving the older sediments and the new marine sand. The effects of wind and waves destroyed the sand barrier and caused the reworking of sediments into beach ridges then into transgressive dunes at Kurnell. Marine sand from Botany Bay and fluvial mud from the Georges River evolved in stages to develop a levee along the southern shore of the bay and further reworking of sediments formed the basis of Towra Point. The development of Towra Point is a result of the dynamics between wind, wave and tidal processes. The rising sea level raised the regional groundwater table and freshwater swamps formed in low-lying areas of the Reserve. Muddy river-borne sediments that were deposited in low energy areas, such as Woolooware and Quibray bays, provided nutrient-rich sediment for the growth of mangroves and saltmarsh communities. Wind and wave action, especially from the south-east, have caused progressive erosion of Towra Beach and subsequent accretion on the western side of Towra Point where a sand spit formed.”

Anthropogenic alterations of the coast on the north side of Botany Bay have changed natural wave patterns and have intensified the natural erosion and accretion on Towra Point (DECCW 2010a). For example, Towra Spit Island was formed from Towra Point in 1991 due to erosion by wind and waves and is continuously changing shape and moving in a south-west direction (NPWS 1998). Accretion of sediment caused Towra Spit Island to join the mainland at Carters Island in 1997 and is close to joining again at the time of this report preparation. In 2004, sediment joining Towra Spit Island to Carters Island was dredged and used to restore Towra Beach and to maintain Towra Spit Island as an island. Erosion of Towra Beach, caused by natural processes but intensified by anthropogenic change, resulted in the death of fringing vegetation and saltwater inundation of Towra Lagoon in the mid 1970s and threatened to bifurcate the Reserve with the potential eventual loss of the Elephant’s Trunk area (Jones 2009).

Towra Point NR is low-lying, rarely exceeding four metres above sea level (Map 2). An exception is the area known as The Knoll on the south shores of Weeney Bay, which rises to 17 metres above sea level, the highest point of the Reserve. One of the interesting features of the Reserve is the low sand dunes that surround the intertidal flats. These deltaic dunes generally run east-west across the Reserve. Unlike the old headland dune systems found at Kurnell headland, the younger dunes within

Towra Point NR retain some mineral enrichment in the soil and are therefore more fertile. These dunes sustain a number of terrestrial vegetation communities that have a strong littoral influence. The dune systems also include a number of small low-lying depressions that are periodically irrigated by rainfall and freshwater drainage channels. These form lagoons and small wetlands which can become brackish if exposed to tidal waters.

The climate of Towra Point is not significantly different from the centre of Sydney, having a temperate climate characterised by warm summers and cool to mild winters. Mean monthly temperatures for January are 26.4 degrees Celsius while mean monthly temperatures in July are 17.6 degrees Celsius (Bureau of Meteorology 2011). Mean annual rainfall in Botany Bay is 1082 millimetres (Bureau of Meteorology 2011). During the summer, north-easterly and westerly winds predominate resulting in moist humid conditions. Winter winds are typically from the south and west, resulting in dry to moist conditions. Due to its coastal location, the Reserve is subject to storms of varying duration and intensity throughout the year. The water temperature in Woolooware Bay has been recorded by Sydney Water since 1994 and varies between 10 degrees Celsius and 27 degrees Celsius (DECCW 2010a).

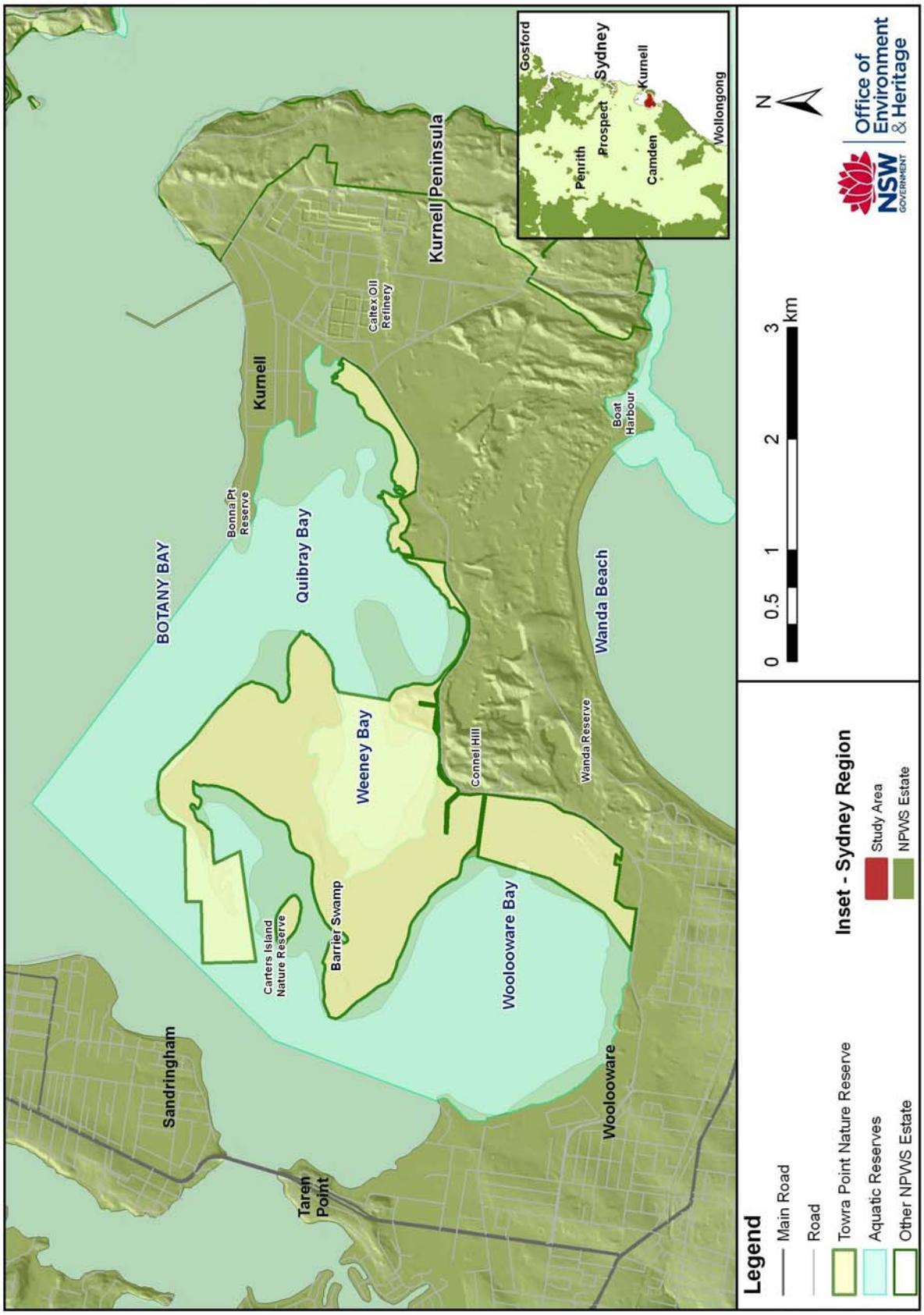
1.3.3 Vegetation

The reserve encapsulates a gradation of environments from subtidal areas to extensive intertidal mudflats and mangrove forest to occasionally tidal-flooded saltmarsh to freshwater wetlands to shallow and deep sand dunes supporting littoral forest. The vegetation of the Reserve is determined by the reach of the tide, proximity to freshwater and subtle topographical variation of the terrestrial Holocene dune formations (Australian Littoral Society 1977). The vegetation communities occurring in Towra Point NR have recently been described and mapped in the report *The Native Vegetation of Towra Point Nature Reserve* (DECCW 2011c) in the context of a study covering the Sydney metropolitan area (OEH 2013c). The vegetation mapping used for this report follows that delineated by DECCW (2011c). This vegetation mapping allocates communities to the formations and classes described by Keith (2004) to provide statewide context. By broadly following the Keith (2004) statewide class allocation of DECCW (2011c) the vegetation communities mapped in the Reserve have been grouped into 'habitat groups' for this report on the basis of similarity in vegetation structure, soil type, floristics and position in the landscape. The habitat groups, and how they relate to the vegetation communities, are described in section 4.2 and presented in Map 3.

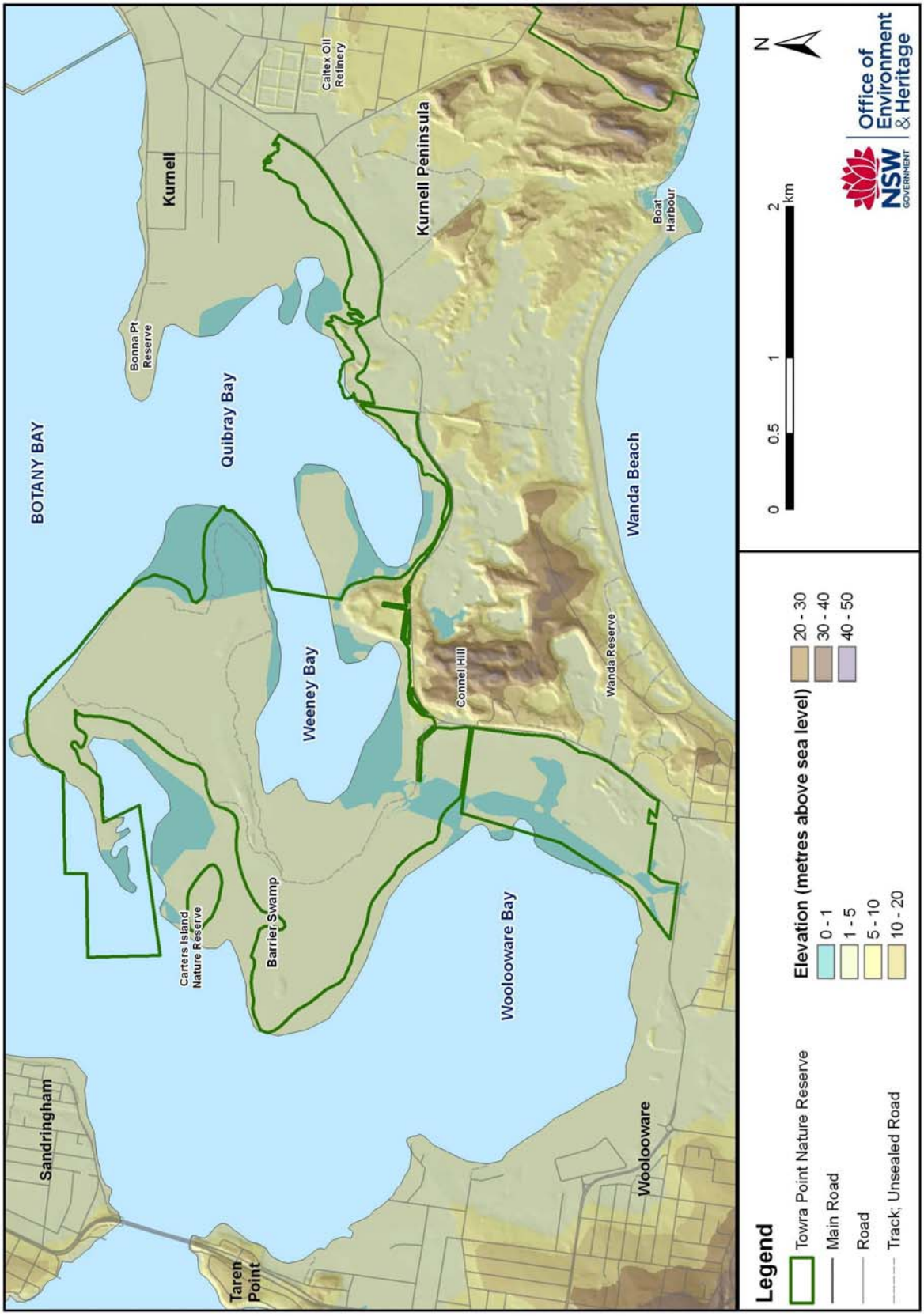
In the context of the Sydney region, the vegetation communities present in the Reserve are primarily rare and restricted in distribution. Over 50 per cent of the vegetation communities form part of Threatened Ecological Communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act).

Much of the vegetation has been highly modified since European settlement. For example, most of the vegetation on Towra Point was cleared for timber extraction, grazing and other pursuits as early as the 1830s and 1840s (Australian Littoral Society 1977, Salt 2000). Tidal-influenced communities have been altered as a result of increased sedimentation and altered current flows within Botany Bay (Australian Littoral Society 1977, Mitchell and Adam 1989, Salt 2000, Pickthall et al. 2004). More recently the extent of Estuarine Saltmarsh has greatly diminished with a 62 per cent loss between 1956 and 1999, primarily as a result of the expansion of Estuarine Mangrove (Wilton 2002, DECCW 2011c).

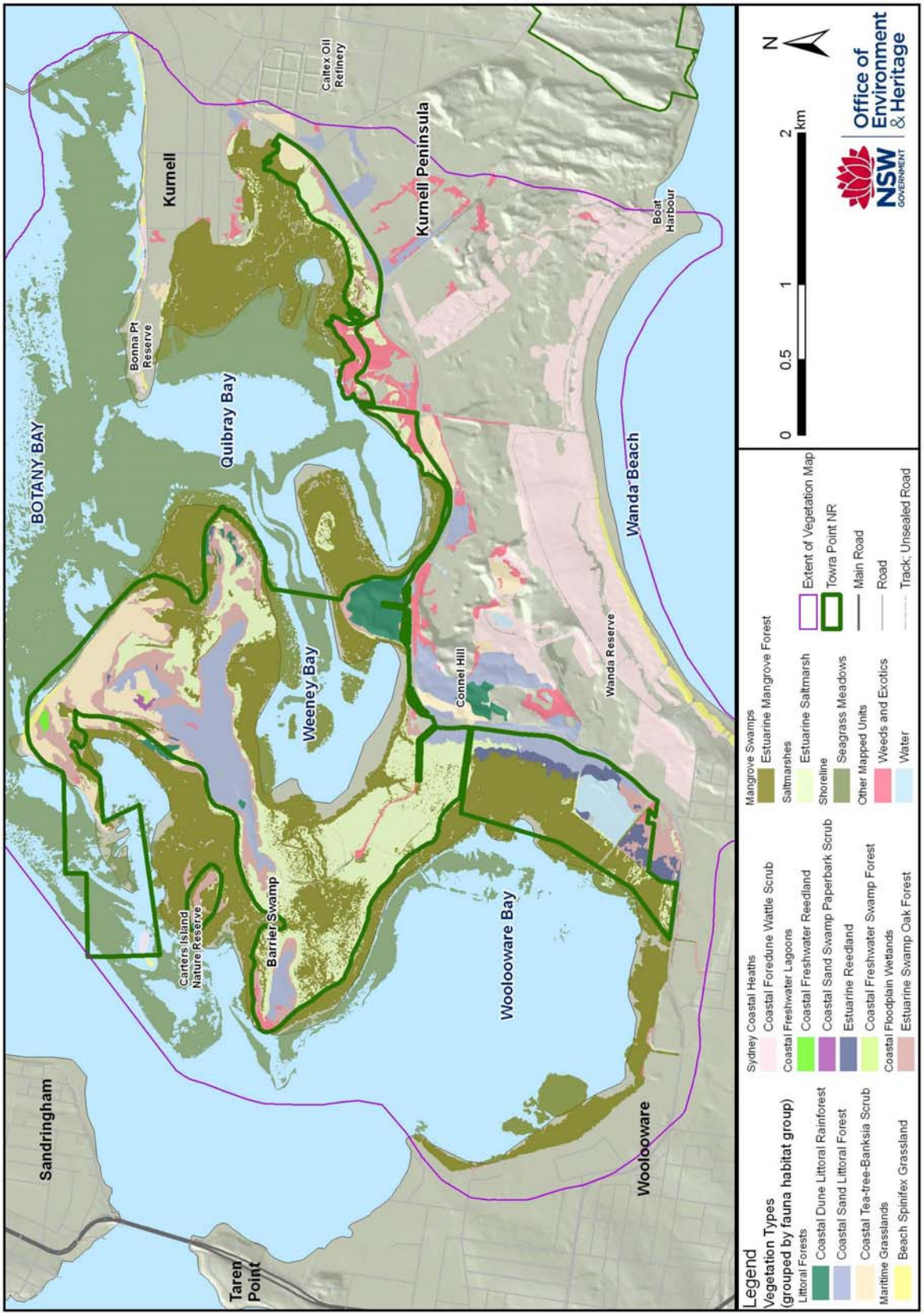
Map 1: Location of Towra Point Nature Reserve and the adjoining Towra Point Aquatic Reserve



Map 2: Elevation of Towra Point Nature Reserve



Map 3: The native vegetation of Towra Point Nature Reserve (from DECCW 2011c)



1.3.4 Fire history

Wildfires are uncommon in the Reserve, with past fires the result of escaped camp fires or arson (DECC 2007d). Consequently, fire is considered a low threat to the values of the Reserve (DECC 2007d). There are no records of hazard reduction burns within the Reserve and there are no plans for hazard reduction burns in the future (J. Bishop pers. comm.).

1.3.5 Past and present land use

There has been such a long and extensive history of human-related impacts on the Reserve that it is almost impossible to disconnect discussion on the characteristics of the native vegetation from the patterns of land use. NPWS (2001a) suggests that the wetlands of Towra Point provided valuable resources for the local Aboriginal people, who made use of the plants, fish and invertebrates for food. This may be evidenced by the scattered aboriginal middens found in the soil profile of the deltaic dunes (Roy and Crawford 1981). While indigenous Australians shaped the landscape of Towra Point over many thousands of years, by far the most rapid changes have arisen since European arrival.

Although Towra Point is a naturally erosive landscape, these processes have been accelerated by man-made influences. There are suggestions that the earliest European impacts may have arisen from the harvesting of mangroves to provide alkaline ash for soap factories on north Botany Bay (Mitchell and Adam 1989) while still under crown tenure in the very early 1800s. Land which includes the current reserve was originally granted to a Captain Burnie in 1815 (Mitchell and Adam 1989) and the transfer to private tenure heralded a range of agricultural endeavours, the affects of which are still evident today. Cattle and horses were run in the early days of private ownership, but there is little evidence of intensive disturbance until 1861 (Mitchell and Adam 1989). After gaining ownership of the land in 1861 Thomas Holt began an intensive programme of clearing and improvement. Land was cleared and divided into paddocks, some cultivated with corn and others used for sheep and cattle grazing (Mitchell and Adam 1989). Sheep were fitted with neck bags of buffalo grass (*Stenotaphrum secundatum*) seed to help spread the development of pasture grasses (University of Sydney 2011) and indeed the first plantings in Australia of buffalo grass were undertaken on the Kurnell Peninsula (Mitchell and Adam 1989). The experiments failed and the sheep flock was later buried in an attempt to improve soil fertility (Australian Littoral Society (ALS) 1977). Infestations of buffalo grass and lantana (*Lantana camara*) are now widespread across the Reserve with the latter now forming impenetrable thickets across much of the east dune systems. It is estimated that 30 per cent of the plant species present in the Reserve are exotic species (NPWS 2001a).

Clearing of the native vegetation on Towra Point also destabilised the dune systems with sand reported to have moved 27 feet a year between 1885 and 1913 (ALS 1977). One of the impacts of this drifting sand is that the shape of the dune fields is likely to have been altered and has subsequently encroached on wetlands (Adam and Stricker 1989).

Impacts from activities undertaken in areas that adjoin or are proximate to Towra Point have also resulted in lasting changes to the landscape of the Reserve. Since the middle of last century, reclamation and construction of protective walls on the northern rim of Botany Bay for Sydney airport and Port Botany has reflected additional wave energy onto Towra Point. These accelerated coastal processes have increased the erosion of shorelines and resulted in damage to seagrass beds, native vegetation, beaches and wetlands (ALS 1977). Sand eroded from Towra Beach is being transported westward and is building sandspits towards the mouth of the Georges River. The erosion of Towra Beach has resulted in sea water over-topping the rear beach dunes and flooding Towra Lagoon (ALS 1977).

Other impacts originated from the establishment of oyster farms in Weeney and Quibray bays in the 1860s which may well have used the timber resources from Towra Point for farming infrastructure (Salt 2000). Nearby sand extraction from the massive Kurnell dune systems has modified the shape of the adjoining landscape and changed drainage patterns. The proximity of heavy industry and major port facilities has increased the use of waterways for transportation with occasional impacts arising from oil spill (Allaway 1979).

Towra Point was earmarked for a wide variety of developments in the post-war boom of the 1950s and 1960s. This included heavy industry, an airport and a number of residential estate proposals including a Florida-style housing development (ALS 1977). The drive to develop the area resulted in detailed survey in 1971 which saw a large number of survey transects established across the dunes, the scars of which can still be seen in places today.

Contemporary impacts on the Reserve have also arisen from recreational pressures. Prior to the declaration of the Nature Reserve, the area was used for recreational fishing, camping and boating activities. In 1975, responding to its obligations under international agreements to protect endangered and migratory birds and important wetlands, the Federal government acquired 281.7 hectares of land at Towra Point for conservation purposes. In March 1982 these lands were transferred to the NSW State government for dedication as a nature reserve. On 6 August 1982 Towra Point NR was gazetted under the NSW *National Parks and Wildlife Act 1974* (NPWS 2001a). There have been a number of subsequent additions to the Reserve and in 1987 the Towra Point Aquatic Reserve was established adjacent to the nature reserve, under the NSW *Fisheries and Oyster Farms Act 1935*.

Currently the Reserve is managed solely for the maintenance and protection of biodiversity values. However, despite the access restrictions afforded by the declaration of a nature reserve, use from boats and personal water craft, particularly in and around intertidal zones, remains. An increase in visitation by horses and dogs is also suggested (NPWS 2001a). Activities such as dredging within other parts of Botany Bay have resulted in altered current flows and wave actions that also influence the Reserve. For example, saltwater intrusion into the formerly freshwater Towra Lagoon is attributed to increased wave action and altered currents generated in Botany Bay by the construction of the third runway at Sydney Airport (DECCW 2010a, Bear 2011, White 2011). It is likely that further development of the Botany Bay coast will impact on the shoreline of the Reserve.

1.4 Project Team

This project was completed by the Biodiversity Survey and Data Group within the Metropolitan Branch, Regional Operations of the Office of Environment and Heritage, Department of Premier and Cabinet. It was funded under the Biodiversity Survey Priorities program. In 2012-13 Elizabeth Magarey undertook project management, background research, survey site selection, field survey planning and logistics. The 2013 field surveys were undertaken by Martin Schulz and Elizabeth Magarey, with assistance from Jason Bishop and Peter Irish. Martin Schulz wrote the draft report, with input, revisions and edits by Elizabeth Magarey. Jason Bishop provided valuable information on current management and access to a variety of relevant reports. Cheyne Ramsay provided additional information on fauna work conducted within the Reserve. Daniel Connolly and Renee Woodward provided valuable information on the vegetation of the Reserve that greatly assisted with defining the fauna habitat groups. Valuable comments on various earlier drafts of this report were provided by Daniel Connolly, Jason Bishop, Debbie Andrew and Kylie Madden. Report maps were produced by Elizabeth Magarey using templates produced by Kylie Madden. Kerry Oakes designed the report cover and formatted the report.

The 2006 systematic fauna survey was funded by the National Parks and Wildlife Service (NPWS) Botany Bay Area (Schulz 2006). Martin Schulz undertook all background research and field survey, with assistance from Susanne Callaghan, Barry Hodgson and Debbie Andrew.

The Reserve comprises the last example of a complete estuarine wetland area in Sydney. Photo © M. Schulz

2 Towra Point Nature Reserve as a Ramsar Site

2.1 What Is A Ramsar Site?

The Convention on Wetlands (also known as the Ramsar Convention) aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. Its mission statement is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar Convention Secretariat 2011). The Convention encourages member countries to nominate sites to the List of Wetlands of International Importance, known as Ramsar sites. These nominated sites are to contain representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity based on a set of criteria. The Convention is an inter-governmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (Ramsar Convention Secretariat 2011). It was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975, and it is the only global environmental treaty that deals with a particular ecosystem. The Convention's member countries cover all geographic regions of the planet, including Australia. Australia was one of the first countries to become a Contracting Party to the Convention and designated the world's first Ramsar site, Cobourg Peninsula, in 1974. In 2013 Australia has 65 nominated sites, totalling 8,080,103 hectares of designated land in the List of Wetlands of International Importance (Dept of Sustainability, Environment, Water, Population and Communities 2011a).

There are 11 nominated sites in NSW, including three sites in the coastal central region of the State: Myall Lakes, Hunter Estuary Wetlands and Towra Point NR (DECC 2006, Dept of Sustainability, Environment, Water, Population and Communities 2011a).

2.2 Towra Point Nature Reserve Ramsar Site

In order for a wetland to be recognised as internationally significant it must meet at least one Ramsar listing criterion (Ramsar Convention Secretariat 2011). Towra Point NR was listed as a Ramsar site in 1984 under the pre-1999 criteria 1a, 2a, 2b, 3b and 3c (NPWS 1998). These criteria translate to the current criteria 1, 2, 3 and 6 (from DECCW 2010a) as follows.

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Criterion 6: A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of waterbird.

In a recent ecological character description of the Towra Point NR Ramsar site (DECCW 2010a) it was considered that Ramsar criteria 2 and 3 were met. Criterion 2 was met based on the site supporting three species listed under the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act): the magenta lilly pilly (*Syzygium paniculatum*), green and golden bell frog and the grey-headed flying-fox. Criterion 3 was met based on the following reasons: supporting the second most important breeding area in New South Wales for the little tern (NPWS 2003); three species occurring at or close to their southern range limit, the brown honeyeater, mangrove gerygone and incorrectly cited the wallum froglet (see Table 7) (Schulz 2006); provides critical links for ecological connectivity for a number of species including the grey-headed flying-fox and the white-fronted chat which is now found in only two locations in Sydney, one of which is Towra Point (Schulz 2006); supports other species that are uncommon in the Sydney region including the Lewin's rail, buff-banded rail, restless flycatcher, little egret, striated heron and the tawny grassbird (Schulz 2006); and the mangrove and saltmarsh communities and adjacent seagrass beds provide critical habitat and food for juvenile fish and crustaceans, a number of which are of economic importance.

Additionally, the Reserve was considered to meet two new Ramsar criteria (from DECCW 2010a) as follows.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions. This inclusion was based on the site being considered to provide: critical mangrove habitat for juvenile fish and crustaceans for the common silver biddy (*Gerres ovatus*), yellow fin bream (*Acanthopagrus australis*), flat-tail mullet (*Liza argentea*) and luderick (*Girella tricuspidata*) (Williams 1990); a critical migratory shorebird stopover point for the replenishment of fat reserves; and an important site for little tern conservation in NSW (Keating and Jarman 2004).

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. This inclusion was based on the site supporting significant fish habitat in the form of saltmarsh, mangroves and seagrass as a nursery and food source for at least 25 fish species of economic importance, including the yellowfin bream, silver biddy (*Gerres subfasciatus*), luderick, sea mullet (*Mugil cephalus*), dusky flathead (*Platycephalus fuscus*) and sand whiting (*Sillago ciliata*).

However, the recent ecological character description (DECCW 2010a) considered Criteria 1 and 6 no longer applied. Criterion 1 was no longer met due "to an administrative decision that changed the biogeographic classification from the Interim Biogeographic Regionalisation for Australia (IBRA) to Australian Drainage Divisions. Towra Point is in the Southeast Coast Drainage Division (SE Coast) which is substantially larger than the Sydney Basin Bioregion under IBRA. The SE Coast stretches from the New South Wales-Queensland border south to the Victoria-South Australia border. In the SE Coast mangroves are common in New South Wales estuaries, whereas saltmarsh is more common in Victoria. Towra Point is estimated to support six per cent of New South Wales mangroves and only two per cent of New South Wales saltmarsh. While it is a near-natural mangrove-saltmarsh community, it is not considered to be outstanding or unique in comparison with other areas of the SE Coast". In relation to Criterion 6 the site is no longer considered to support at least one per cent of the estimated international population of the eastern curlew (e.g. Bamford et al. 2008). However, given the reduction in shorebird habitat within the East Asian-Australasian Flyway and resultant changing populations the applicability of this criterion requires regular review (DECCW 2010a).

The reserve is no longer considered to support at least one per cent of the international population of the eastern curlew. Photo © J. Bishop

3 Methods Used To Build the Species Inventory

3.1 Compilation of Existing Fauna Data

This project sought to bring together information on vertebrate fauna in the Reserve from as many resources as possible. The major source was the Atlas of NSW Wildlife (OEH 2013a, accessible on the BioNet website). Other sources included opportunistic sightings made by OEH staff and park visitors, information from researchers working on specific species within the Reserve, and records obtained from literature, unpublished reports, and on line wildlife observation forums.

3.1.1 Systematic fauna survey data

Systematic fauna surveys are those for which the same methods are employed at each site, or at each time a site is visited. This includes timed search efforts within fixed areas. These surveys record all species found using the method, and importantly record nil results where no animals were found. In this way the survey effort is recorded wherever sites are located in the park.

Prior to July 2012 three studies had undertaken survey in Towra Point NR using the same techniques as described in section 3.4 (hereafter referred to as OEH standard systematic fauna survey techniques) (Table 1). The primary systematic survey was conducted in May 2006 (Schulz 2006). That survey took the same approach as the BSP survey, selecting sample sites in all major vegetation communities based on examination of aerial photography and the knowledge of OEH ranger staff (note that that survey was undertaken prior to the DECCW (2011) vegetation mapping). Site attribute sheets were completed at each survey location, as described in section 3.4 of this report.

Table 1: OEH standard systematic fauna survey effort prior to July 2012

Project	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Harp trapping	Bat ultrasonic call recording	Nocturnal call playback	Timing of survey
Rapid fauna habitat assessment of the SMCMA area (DECC 2008a)				1			March 2007
Georges River biodiversity study (NPWS 2000)	4						February 1999
Towra Point NR fauna survey (Schulz 2006)	13		7	8		6	15-29 May 2006

A range of other fauna survey methods have been undertaken in the Reserve over many years. This includes point- or transect-based survey techniques, such as the transects used in the monthly wader and other waterbird counts undertaken by the NSW Wader Study Group. A summary of these surveys is provided in Table 2. Note that the methods differ between surveys and from the techniques described in section 3.4 of this report. Details of site localities and techniques have been entered into the fauna module of the Atlas of NSW Wildlife for a number of these surveys, but not all.

Table 2: Other fauna survey effort prior to July 2012. Methods differ between surveys and from those described in section 3.4 of this report

Project	Point-based diurnal bird survey	Transect-based bird counts	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Transect spotlighting	Bat ultrasonic call recording	Nocturnal streamside search	Nocturnal call playback	Cage trapping	Elliott trapping	Hairtube sampling	Pitfall trapping	Infra-red camera trapping	Timing of survey
Atlas of Australian Birds (method described in Barrett et al. (2003))	17													1998-2001
Towra Point NR fauna survey (methods described in Schulz (2006))								3 (eastern grass owl only)	3 (total of 9 trap nights)	4 (total of 400 trap nights)	4 (total of 1450 trap nights)			May 2006
Fauna surveys in support of the proposed development of a wildlife corridor on the Kurnell Peninsula (methods described in UBM Ecological Consultants (2009))	3		3	3		3					3 (294 trap nights)	3 (45 trap nights)		January-February 2009
Ecological assessment of Towra Point Nature Reserve (methods described in Jones (2009))					4				1 (total of 24 trap nights)	2 (total of 180 trap nights)			2 (total of 7 trap nights)	February 2009

Project	Point-based diurnal bird survey	Transect-based bird counts	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Transect spotlighting	Bat ultrasonic call recording	Nocturnal streamside search	Nocturnal call playback	Cage trapping	Elliott trapping	Hairtube sampling	Pitfall trapping	Infra-red camera trapping	Timing of survey
NSW Wader Study Group (initially Australasian Wader Study Group) monthly wader and other waterbird counts (Straw 1996, unpublished data since 1996)		Monthly counts at 19 locations from a boat around the shoreline and also at H1 lagoon												Mid 1990s-present
An investigation of management options for Towra Point Botany Bay (Australian Littoral Society 1977)		Sightings collected during 1977 (and collated from a variety of observers prior to this)	Two general searches of area in June and July		25 person hours on 1 night				6 (total of 18 trap nights)	10 (total of 660 trap nights)	Total of 15 tubes (number of trap nights not documented)			1977

3.1.2 Other Atlas of NSW Wildlife records

The Atlas of NSW Wildlife (OEH 2013a, accessible on the BioNet website) was the primary resource used to access data on the fauna of the Reserve. Records within the Atlas of NSW Wildlife derive from observations made by: OEH staff; naturalists and bird watchers; scientific researchers; bush regenerators; people undertaking active management in the Reserve; environmental consultants; neighbours; and other visitors to the park. These records have various levels of reliability depending on the type of observation, as well as the certainty and identification experience of the observer.

3.1.3 Literature review

As part of this project fauna records were collated from various written sources that have not been entered into the Atlas of NSW Wildlife, including consultancy reports (e.g. Table 2). An important source of species records was the report by the Australian Littoral Society (1977).

3.1.4 Unpublished and other information

As part of this project an effort was made to collate fauna sightings made by various naturalists and reserve staff that had not previously been entered into the Atlas of NSW Wildlife or documented in the literature. Websites and forums were scanned for sighting information including Birding Aus and NSW Birdline.

3.2 Review of Existing Records

3.2.1 Review of status of existing fauna species records

For each species, a compiled list of records from within and around the Reserve was reviewed. Each species was then allocated to one of the following classes:

- **Accepted**: Species for which there are *reliable* and *accurate* records; or species for which there is some evidence and can reasonably be presumed to exist due to suitable habitat within the Reserve and reliable records in the surrounding area. This category includes species that are resident, visitors or vagrants. It also includes species that have become locally extinct but have been reliably recorded in the past.
- **Excluded (pelagic species)**: Marine species that do not utilise the subtidal waters within the Reserve (e.g. protected waters of Weeney Bay) or come ashore to rest. Records are based on beachwashed or stranded specimens or individuals seen flying or swimming off the outer shoreline of the Reserve e.g. off Towra Beach.
- **Excluded (poor locational accuracy)**: Species for which all records had low spatial reliability (generally the accepted cut-off for records was those with a stated accuracy of 1000 metres), or the description indicated that the species was actually seen elsewhere *and* for which there was no other supporting evidence of its occurrence.
- **Excluded (unconfirmed, potential misidentification or data entry error)**: Species that had either been recorded via a data entry error or incorrect citation, or are considered unconfirmed. These were identified by highlighting all species that had no suitable habitat in the Reserve and/or were outside their known range *and* for which no supporting evidence existed to indicate they were actually reliably-recorded vagrants or recent extinctions. Excluded species are detailed in section 5.1.
- **Excluded (introduced or non-local species that do not have wild populations)**: Species that are introduced or not native to the area and do not have known established wild populations in the Reserve or neighbouring lands. This includes species considered most likely to be aviary escapees or dumped animals.

3.3 Analysis of Previous Survey Effort

Prior to the commencement of the 2013 field survey, an analysis was performed to identify gaps in the fauna survey effort previously undertaken within the Reserve.

3.3.1 Gap analysis of systematic survey effort

The aim of systematic survey is to ensure that each of the habitat types contained within a given area is systematically sampled in proportion to the land area they occupy. The primary stratum used as a surrogate for habitat type was vegetation community, using the draft digital map produced by DECCW (2011c). The survey strategy aimed to sample each vegetation community and where possible to include repeat sampling within each habitat group to provide reasonable reliability that potential variation within each stratum were captured. Such replication of sites serves to strengthen the reliability of patterns derived from collected data.

The exception to the above rule was Estuarine Mangrove Forest which was not sampled in proportion to the area it occupies in the Reserve. This was due to the difficulty in undertaking many of the systematic techniques in this habitat type and the low possibility of detecting some fauna groups (e.g. reptiles).

The gap analysis quantitatively assessed the level of existing OEH standard systematic fauna survey for each fauna group within each vegetation community and habitat group and identified gaps in survey effort. The following gaps in fauna survey were found.

Herpetofauna

No systematic frog or reptile searches had been conducted within the Reserve using OEH standard systematic fauna survey techniques. The 2006 fauna survey (Schulz 2006) was undertaken during the month of May, when reptile activity is low and spring/early summer breeding frogs are inactive. Similarly the herpetofauna surveys undertaken by the Australian Littoral Society (1977) were conducted in the months of June and July. Therefore, the frog and reptile fauna within the Reserve had been under-sampled. Additionally, there were single documented records of a number of species in the Reserve and their status was uncertain.

Insectivorous Microbats

The 2006 fauna survey (Schulz 2006) was undertaken during a month of relatively low bat activity; harp trapping was deployed but no ultrasonic surveys undertaken. Microbats, including several species listed under the TSC Act that have the potential to occur, were therefore under-sampled.

3.4 OEH Standard Systematic Fauna Survey Techniques

The systematic fauna survey methods used in the BSP survey and the 2006 survey were based on those developed by the NPWS Biodiversity Survey Coordination Unit (NPWS 1997) and are in this document referred to as OEH standard systematic fauna survey techniques. The methods sample the following vertebrate fauna groups: diurnal and nocturnal birds, diurnal and nocturnal reptiles, bats, arboreal and ground-dwelling mammals and amphibians. Consistency in the use of the systematic techniques allows a comparison between fauna species detected across different vegetation communities and environments within the study area as well as comparisons with consistent surveys of environments elsewhere.

Sites were selected using a combination of a geographic information system (*ArcMap 9.2*) and field assessment. Systematic survey sites were 100 metres by 200 metres (two hectares) in area. Sites were placed as far away from each other as possible. However, due to the size and shape of the Reserve and the location of different vegetation types, site spacing in some sections was closer than would be ideal from a statistical perspective. The placement of harp traps to capture microbats was limited by the risk of vandalism and the availability of suitable fly-ways.

Field surveyors were supplied with field proformas to facilitate comprehensive, consistent recording of field data and to increase accuracy and efficiency of data entry into the Atlas of NSW Wildlife. The names of observers and recorders were noted on every data sheet to aid data verification and entry.

Site Attributes

A site attribute form, aiming to characterise fauna habitat, was filled out at every systematic site where survey techniques were conducted. A 20 by 20 metre quadrat typical of the overall 100 by 200 metre site was used for the assessment. The site attribute locates and describes the location in a format that is comparable to other sites. Data relating to physio-geographic, disturbance, structural and floristic, microhabitat and stream categories were recorded. Standard codes provided by the Australian Soil and Land Survey Handbook (McDonald et al. 1990), particularly for vegetation (i.e. Walker and Hopkins 1990) were used wherever possible.

Diurnal Bird Survey

Diurnal bird censuses comprised a twenty-minute observation and listening search within a two hectare (100 by 200 metre) area, conducted by an experienced bird surveyor. Censuses were conducted during periods of relatively high bird activity (usually in the early morning) and reasonable detectability (e.g. low wind). All bird species and the abundance of individuals seen or heard were recorded. Individuals were scored as on-site if they were detected within the two hectare plot. Individuals detected outside the plot, in adjacent vegetation types or flying overhead were recorded as off-site.

Diurnal Herpetofauna Search

A standard half hectare (50 by 100 metre) area was searched for one person-hour at each site. Censuses were restricted to the period between mid-morning to late afternoon, when temperature and insolation were sufficient to ensure maximum reptile activity.

This census technique entailed active searching of potential reptile and frog microhabitats within the half hectare area. Active or basking reptiles were identified by sight or captured and identified by the use of keys. Sheltering or cryptic species were detected by searching around, under and within fallen logs, litter, decorticating and fallen bark, rock outcrops, crevices and other likely shelter sites. Incidental observations of other fauna were also recorded.

Nocturnal Site Spotlighting Survey

This census technique was undertaken during the 2006 surveys and not repeated in 2013. The technique comprised searching for arboreal mammals along a 200 metre transect within a site for half a person hour. Fifty watt spotlights were used to scan the vegetation for animals and enable detection of reflected eye shine. Surveyors also listened intently for fauna calls during the survey period. All fauna observed or heard within the census period were recorded, noting whether they were on or off site.

Harp Trapping

While ultrasonic recorders were used principally to detect high-flying bat species, collapsible bat traps, known as harp traps (Tidemann and Woodside 1978), capture low-flying species. Sites were selected for their perceived potential to interrupt bats along their flight paths. Traps were positioned on tracks, the interface between mangroves and terrestrial vegetation or within gaps between trees where adjacent vegetation may 'funnel' flying bats. The standard technique deploys a harp trap for two consecutive nights at a site, in the warmer months between spring and autumn. However, during the 2006, 2007 and 2013 surveys some sites were only trapped for one night. This variation to the standard survey effort is recorded in the fauna module of the Atlas of NSW Wildlife, but both one and two night trapping sites are included in the summary in Table 5.

Traps were checked during the night and each morning. Captured bats were identified by external morphology, forearm measurement and body weight, and keyed out where necessary using Parnaby (1992a) and Churchill (2008). Animals were released either in the early morning or on the following night at the point of capture.

Bat Ultrasonic Call Recording

Ultrasonic recorders (Corben 1989) are particularly useful for the detection of high-flying species, which often comprise more than one third of an area's bat species (Parnaby 1992b), yet are under sampled by harp trapping (Richards 1992). Additionally, ultrasonic detectors are useful in identifying bats using areas that are unsuitable for the siting of harp traps, such as along tidal channels, close proximity to high use public areas and where there are no tracks or other situations suitable for the siting of harp traps. The method requires the recording and identification of high frequency, echo-location "calls" made by bats, which, except for one or two species, are ultrasonic, that is, inaudible to humans.

The recording equipment for the surveys consisted of either an *Anabat II* detector and digital flash card recorder or a combined *Anabat SD1* or *Anabat SD2* detector, each housed within a Tupperware box for weather protection. The box was set up at sites where bats were expected to fly, such as over water bodies, along tracks within forest and other open areas. The standard technique deploys an Anabat detector overnight at a site, set to commence detection at dusk and turn off at dawn. During the night, a delay switch operates to turn on the recording device when bat activity is detected and then de-activated the device while no bat activity is occurring.

Anabat recordings were transferred onto computer and analysed by Martin Schulz. Troublesome calls were further verified by Narawan Williams. Calls identified with 'definite' and 'probable' degree of confidence were entered into the fauna module of the Atlas of NSW Wildlife.

Nocturnal Call Playback for Threatened Forest Owls

This census technique was undertaken during the 2006 surveys and not repeated in 2013. Nocturnal birds and mammals are often detected only when they vocalise for territory or social contact, behaviour which can be elicited by broadcasting specific calls. A standard survey census involved broadcasting the calls of each of the four large forest owls – powerful owl (*Ninox strenua*), masked owl, sooty owl (*Tyto tenebricosa*) and barking owl (*Ninox connivens*) – from the centre of a site. Prior to call broadcasts, on arrival at the site, the surrounding area was searched by spotlight for five minutes to detect any fauna in the immediate vicinity and then a ten minute period of listening was undertaken.

A pre-recorded compact disc of each species' call series was played, amplified through a megaphone. Calls of each species were played for five minutes, followed by a five minute listening period. The surrounding area was again searched by spotlight after a final ten minute listening period. After the census, the response or presence of any fauna, date and time that a response occurred, and weather details such as amount of cloud cover was recorded. Very windy periods were avoided where possible.

Survey Site Locations

At the completion of the 2013 survey a total of 37 OEH standard systematic fauna survey sites were established and surveyed in Towra Point NR and entered into the fauna module of the Atlas of NSW Wildlife. Table 5 shows the number of OEH standard systematic fauna survey techniques undertaken in each vegetation community. Maps 4 and 5 show the location of OEH standard systematic fauna survey techniques in Towra Point NR.

3.5 Targeted Fauna Survey Techniques Deployed in 2013

In addition to the Elliott trapping, cage trapping and hair-tube sampling undertaken in the Reserve in 2006 (Table 2, Schulz 2006), the following targeted survey techniques were undertaken in 2013.

Nocturnal Call Playback in Sea Rush Areas

Target Species: Eastern grass owl and Australasian bittern.

Potential Australasian bittern habitat. Photo © M. Schulz

Prior to call broadcasts a ten minute period of listening was undertaken to detect any fauna species calling. A pre-recorded compact disc of the call of eastern grass owl and Australasian bittern was then played, amplified through a megaphone. Calls of each species were played for five minutes, each followed by a five minute listening period. At one census only the eastern grass owl call was played. After the census, the response or presence of any fauna, date and time that a response occurred, and weather details such as amount of cloud cover was recorded. This technique sampled extensive sea rush areas bordering saltmarsh along Captain Cook Drive and the Towra Point Track causeway. This survey effort was not entered into the fauna module of the Atlas of NSW Wildlife and so is presented in Table 3 below. The locations of these censuses are displayed in Map 6.

Table 3: Location and timing of nocturnal call playback in sea rush areas

Description of location	Easting*	Northing	Date	Start	Finish	Species played
Alongside Captain Cook Drive just west of electricity substation	334187	6234385	13/02/2013	20:55	21:20	Australasian bittern, eastern grass owl
Captain Cook Drive just east of riding school	333212	6233914	13/02/2013	21:28	21:53	Australasian bittern, eastern grass owl
Woolooware Shorebird Lagoon	330145	6232433	13/02/2013	22:05	22:30	Australasian bittern, eastern grass owl
Towra Point Track causeway just north of first row of swamp oak	330225	6233650	13/02/2013	23:00	23:25	Australasian bittern, eastern grass owl
Adjacent to radar sheds	329577	6234066	13/02/2013	23:30	23:55	Australasian bittern, eastern grass owl
Captain Cook Drive opposite Cronulla Sewage Treatment Plant	330420	6233110	13/02/2013	22:35	22:50	Eastern grass owl

*Eastings and northings in GDA94, zone 56

Infra-red Camera Trapping

Target Species: Cryptic native and introduced mammals such as the short-beaked echidna, brown antechinus (*Antechinus stuartii*), long-nosed bandicoot (*Perameles nasuta*), bush rat (*Rattus fuscipes*), feral cat and deer; cryptic birds such as crakes and rails; and large reptile species such as the lace monitor (*Varanus varius*) and the eastern snake-necked turtle.

This technique involved setting up cameras triggered by infra-red motion sensors. Moultrie GameSpyi60 Digital Game Camera with Infrared Flash were used, as well as one Reconyx. One camera was set at each location and left in place for between 54 and 56 days. The cameras were attached to a trunk, sapling or stake between ground level and one metre above the ground. The cameras faced either toward bait scattered on the ground (with bait consisting of a mix of rolled oats, peanut butter and honey) or towards a point of expected fauna activity (such as the edge of a water body). On detecting a moving heat source each Moultrie camera was set to take a five second video followed by a still photograph, with a delay of ten minutes between subsequent images. The internal white flash of the camera was set to be triggered in low light (including night time). At the end of the period the cameras were collected, the memory cards downloaded and all species that had tripped the camera were identified by Martin Schulz.

A total of 11 infra-red camera traps were set, one in each of Coastal Dune Littoral Forest, Coastal Sand Littoral Forest, Coastal Freshwater Reedland, Coastal Sand Swamp Paperbark Scrub, Estuarine Saltmarsh and non-vegetated shoreline and five in Estuarine Swamp Oak Forest.

Table 4: Timing of the BSP 2013 survey

Timing	Systematic techniques employed	Targeted techniques employed
13 to 15 February 2013	Diurnal bird survey, diurnal herpetofauna search, harp trapping, bat ultrasonic call recording.	Nocturnal call playback in sea rush areas and setting of infra-red camera traps.
10 April 2013	-	Collection of infra-red camera traps.

3.6 Opportunistic Techniques

During the implementation of the systematic and targeted survey work in 2006, 2007 and 2013, opportunistic techniques were employed wherever possible. These included the following.

Incidental Records

Incidental records are point localities of fauna encountered opportunistically during the survey. This is an opportunity to augment the number of records of species that are not well sampled by standard systematic survey techniques, such as large ground mammals, raptors, non-vocalising birds and secretive or cryptic species. The date, time, observer, map grid location (usually obtained from a GPS) and microhabitat of the animal was recorded on a data sheet.

Scanning of the Shoreline

Shoreline areas and exposed intertidal mudflats were scanned for birds, particularly for potentially occurring threatened shorebird species. This was primarily undertaken in 2006.

Traverses of Swampland and Islands

During the 2006 survey extensive areas of swampland were traversed in search of cryptic waterbird species, such as the Australasian bittern, quail, crakes and rails. In addition, all islands within the Reserve were visited, for varying periods of time.

Bat Ultrasonic Call Recording by Boat

In March 2007, as part of the SMCMA area rapid fauna habitat assessment, a limited amount of bat ultrasonic call recording was undertaken in the Reserve. This involved using a hand-held Anabat detector on a boat at two locations (in Weeny Bay and north of Carters Island) for between 15 minutes and half an hour, targeting potential habitat of the large-footed myotis (*Myotis macropus*).

3.7 Survey Limitations

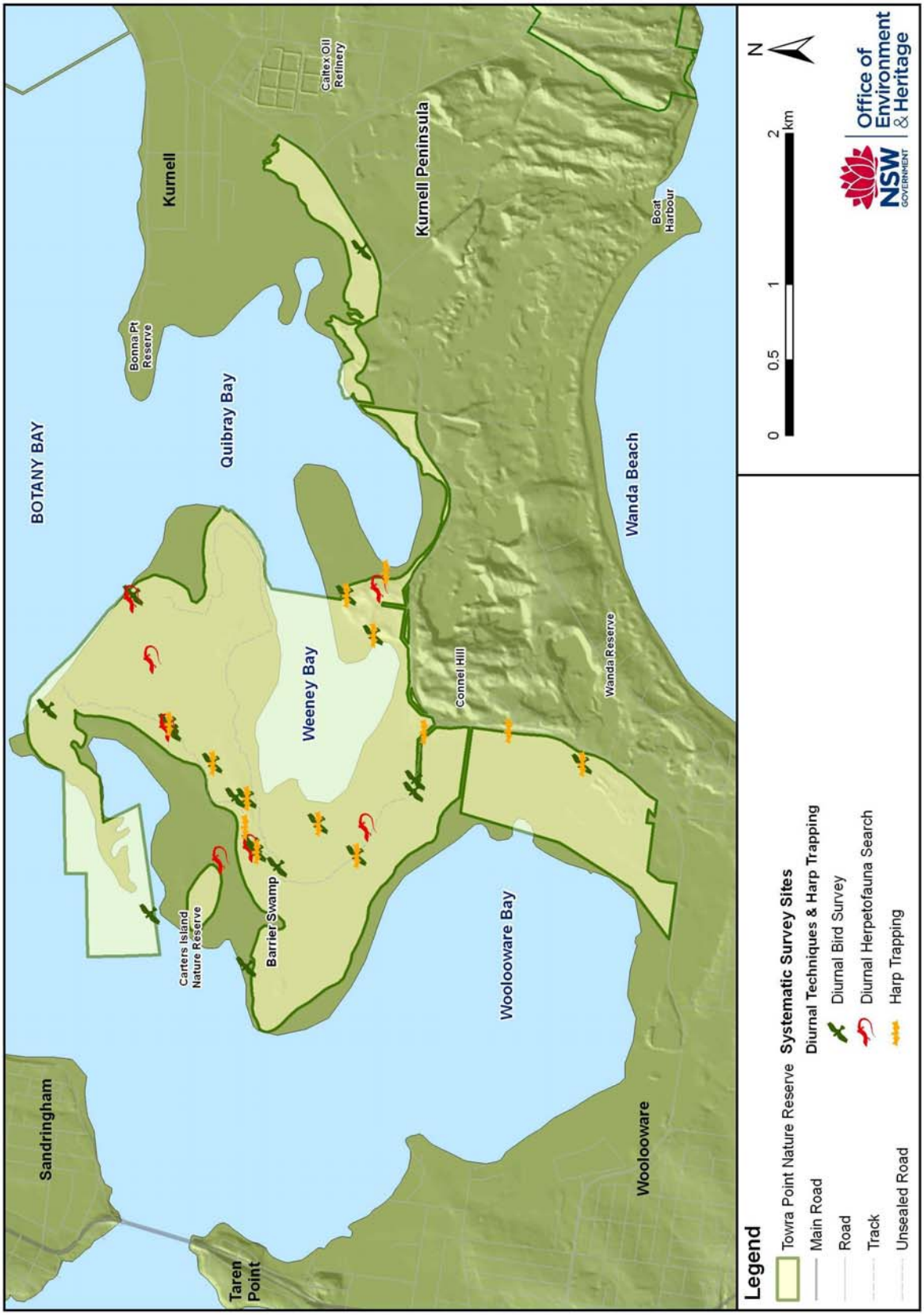
At the completion of the 2013 survey it is considered that all vertebrate fauna groups except amphibians have been systematically sampled to an adequate level to provide a baseline understanding of terrestrial vertebrate fauna. No systematic frog searches were conducted during the 2006 or 2013 surveys, due to the season of the former survey period and the absence of rain during or prior to the latter survey period. Therefore frog species are not considered adequately surveyed. The inventory of frogs in the Reserve was developed for this report in conjunction with records in the Atlas of NSW Wildlife. Even so, the current status of many frog species remains uncertain and further systematic frog surveys would be beneficial to address this information shortfall.

Additionally, a shortcoming of the systematic surveys was the failure to undertake repeated sampling for *all* fauna groups in *every fauna* habitat group. In many habitat groups the sample size was limited to one or two samples (Table 5).

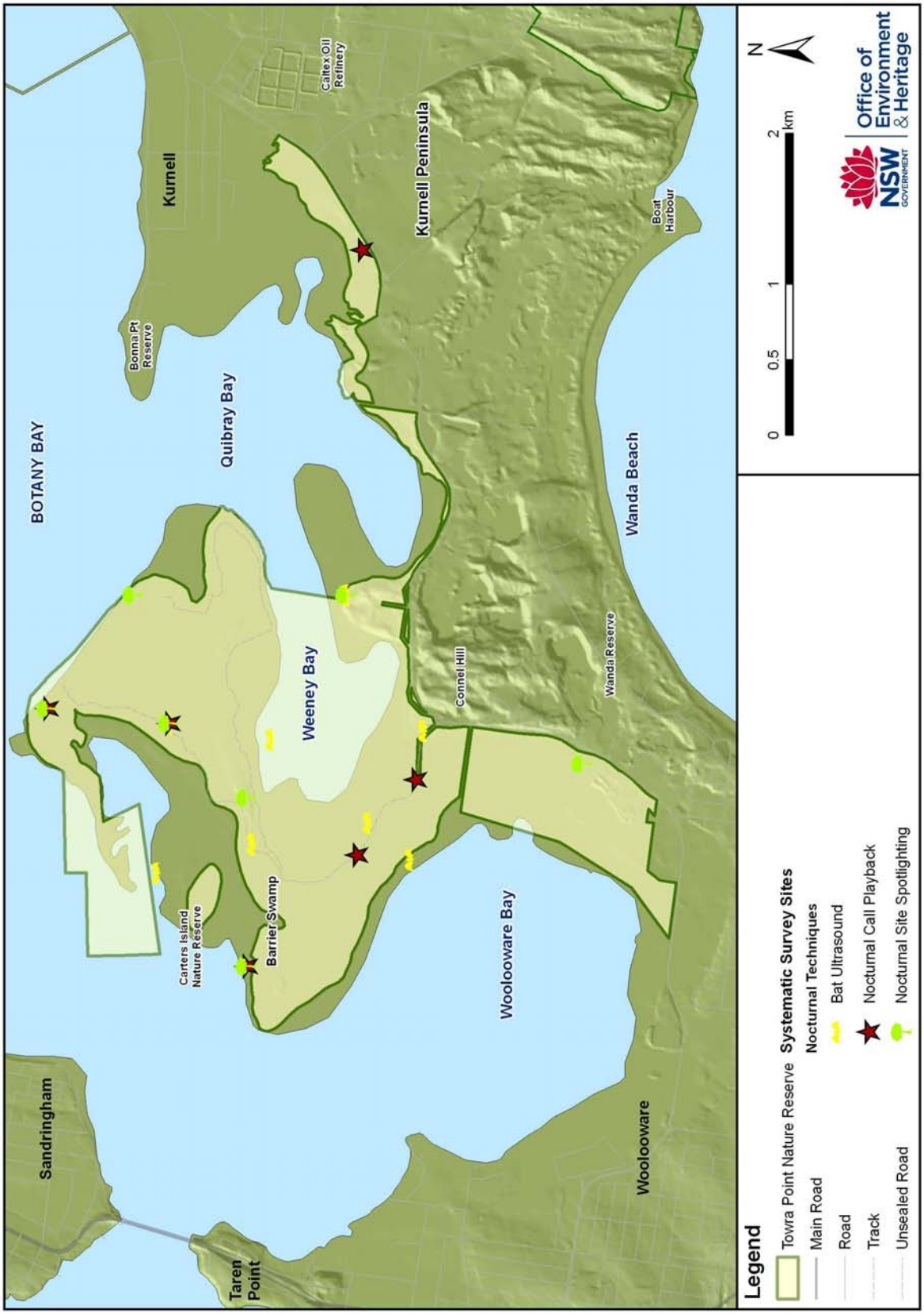
3.8 Species Not Recorded for Twenty-five Years

The review of all known information on fauna of the Reserve included compilation of a list of species which were not recorded during the 2006 or 2013 surveys and have no confirmed sightings for the last 25 years. The primary sources of these species records were the Australian Littoral Society (1977) and the Atlas of NSW Wildlife (OEH 2013a). Assessing the reason that these species have not been confirmed in the Reserve in recent years is beyond the scope of this report.

Map 4: Location of OEH standard systematic fauna survey sites using diurnal techniques and harp trapping in Towra Point Nature Reserve



Map 5: Location of OEH standard systematic fauna survey sites using nocturnal techniques in Towra Point Nature Reserve



Map 6: Location of targeted fauna survey techniques undertaken in Towra Point Nature Reserve during the 2006 and 2013 surveys

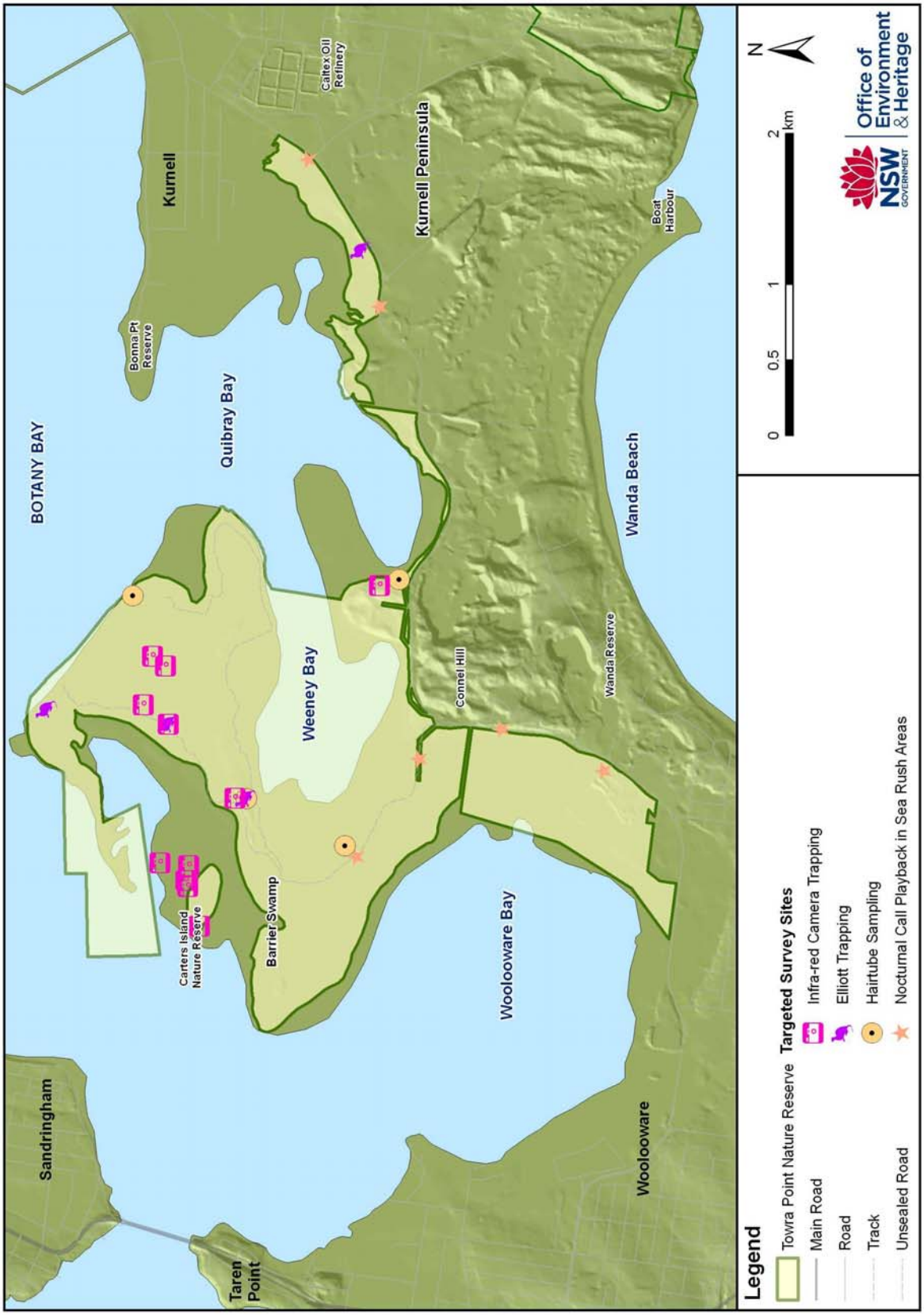


Table 5: Vegetation communities within Towra Point Nature Reserve and corresponding allocation of systematic fauna survey effort as at June 2013 (as stored in the fauna module of the Atlas of NSW Wildlife)

Fauna habitat group (section 4.2) and vegetation community (DECCW 2011c)	Area (hectares)	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Harp trapping	Bat ultrasonic call recording	Nocturnal call playback for threatened forest owls
Littoral Forests*							
Coastal Dune Littoral Rainforest	14		1				
Coastal Sand Littoral Forest	59	10	2	4	7	2	2
Coastal Tea-tree-Banksia Scrub	32	1	1	1			
Maritime Grasslands^							
Beach Spinifex Grassland	2						
Sydney Coastal Heaths							
Coastal Foredune Wattle Scrub	1.46						
Coastal Freshwater Lagoons#							
Coastal Freshwater Reedland	0.69	1					
Coastal Sand Swamp Paperbark Scrub	0.73						
Estuarine Reedland	10						
Coastal Freshwater Swamp Forest	0.52						
Coastal Floodplain Wetlands							
Estuarine Swamp Oak Forest	54	2	1	2	3	2	1
Mangrove Swamps							
Estuarine Mangrove Forest	162	2	1		2	2	
Saltmarshes							
Estuarine Saltmarsh	132	3	1			1	2
Shoreline^							
Seagrass Meadows	38						
Non-vegetated shoreline (not mapped)		1				1	
Unassigned to a community (weeds etc.)		1			1		1
Total number of sites of each technique		21	7	7	13	8	6

* = Edges of this habitat on The Knoll had bird observations undertaken; ^ = Sampled by the NSW Wader Study Group monthly counts; # = This habitat was visited but site locations are mapped as the adjoining forest community.

4 Methods Used To Assess and Prioritise Species, Habitats and Threats

4.1 Species

Two separate ranking processes were undertaken to help identify fauna species that deserve focus given their conservation status. An initial rank was used to identify a suite of priority species. This subset was then ranked again using a different set of criteria to identify management priorities.

4.1.1 Definition of priority species

After completion of the field survey and compilation of the species inventory, the fauna species list was examined to identify priority species. Each of the priority species were given a species profile to detail their current status in the Reserve, as presented in Section 6. A priority species is any fauna species with record(s) from within the park boundary that meets one or more of the following criteria.

- **Listed as threatened under the TSC Act and/or the EPBC Act.** This includes all species reported within the Reserve that currently occur, are known to have occurred in the past, or for which there are unconfirmed or spatially inaccurate records. Note that the shorebird community occurring on the relict tidal delta sands at Taren Point, listed as an Endangered Ecological Community under the TSC Act, has not been given a profile due to the precise definition of the community which does not include Towra Point NR.

- **Listed under bilateral migratory bird agreements (incorporated in to the EPBC Act).** This includes all species recorded within the Reserve that are listed under one or more of the bilateral migratory bird agreements to which the Australian Government is a signatory. The migratory bird agreements are: China-Australia Migratory Bird Agreement (CAMBA) (Commonwealth of Australia 1995a), Japan-Australia Migratory Bird Agreement (JAMBA) (Commonwealth of Australia 1995b), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) (Commonwealth of Australia 2006).
- **Recognised as Key Threatening Process.** This includes all terrestrial vertebrate fauna species recorded from the Reserve that are listed as Key Threatening Processes under the TSC Act and/or the EPBC Act.

4.1.2 Setting management ranking for native priority species

Land managers are faced with a long list of priority fauna species (including threatened species), however not all species require an equivalent level of management effort at the current time. Some species warrant quite specific active management, further survey or monitoring to increase their chances of survival in the long term, while others simply require ongoing protection of the Reserve. In order to inform the management effort required at the current time, each of the native priority species identified within the Reserve has been ranked into a class according to its level of priority for active conservation management. The ranking system is derived from expert knowledge rather than quantitative assessment.

The rankings are defined as follows. The term region means the Sydney Basin Bioregion.

Highest: Species that are likely to become extinct from the region in the short to medium term without action at a site by site level and for which the Reserve plays a key role in the regional conservation of the species.

High: Species that are at risk of becoming extinct or severely declining in the region without management of key habitats and abatement of threats and for which the Reserve holds a significant amount of foraging, roosting, wintering or breeding habitat relative to the amount reserved across the region.

Moderate: Species for which there is inadequate information to assess their status in the Reserve and are not reserved in high numbers elsewhere in the region. If more information is gained on these

species in the survey area and other reserves in the region, a review of their status would likely see them moved to one of the other priority categories.

Low: Species which either: a) have breeding, roosting, foraging and wintering habitat well represented in the regional reserve system and are subject to few threats in the Reserve; b) have uncertain status in the Reserve and are known to be well represented elsewhere in the regional reserve system (note that the status of these species would require revision were evidence of a sizeable resident breeding population detected); or c) are vagrants or rare irregular visitors.

Nil: Species for which there are only anecdotal record(s) with minimal information and/or which would be considered to now be extinct from the study area.

4.2 Fauna Habitats

4.2.1 Definition of fauna habitat groups

The Reserve incorporates a range of environments from intertidal mud flats and beaches to mangrove forests to heathland to littoral rainforest (Map 3). This range of environments is reflected in the variation in the fauna habitat types available. Much of the fauna habitat is in the form of native vegetation communities. The recent native vegetation mapping of the Reserve (DECCW 2011c) allocated communities to the statewide formations and classes described by Keith (2004). By broadly following the Keith statewide class allocation the vegetation communities mapped in Towra Point NR have been grouped into fauna habitat groups for this report. In addition to the native vegetation there is one unmapped habitat type that has been allocated a fauna habitat group in this report (shorelines).

Fauna habitat groups act as a surrogate for environments utilised by a suite of fauna with similar habitat requirements. They represent the different environmental gradients that occur across Towra Point NR and, being a mappable unit, are able to be easily applied for targeted management of the Reserve. It must be remembered, however, that the habitat groups were not derived from statistical analysis of fauna records and consequently do not necessarily represent true fauna assemblage boundaries for each taxonomic group. Nevertheless the habitat groupings provide a useful broad-scale basis for understanding fauna distribution patterns across the Reserve.

The fauna habitat groups, seven of which are defined by their native vegetation communities and one of which is defined by other features are described below and summarised in Table 6. The native vegetation descriptions below are a summary of vegetation information presented in the report *The Native Vegetation of Towra Point Nature Reserve* (DECCW 2011c). Each of the fauna habitat groups is given a profile in section 7 of this report.

Littoral Forests

Vegetation Communities Included: Coastal Dune Littoral Rainforest, Coastal Sand Littoral Forest and Coastal Tea-tree-Banksia Scrub
Corresponding Statewide Class: This habitat group includes communities allocated to three statewide classes – Littoral Rainforests, North Coast Wet Sclerophyll Forests and Coastal Headland Heaths.

Littoral Forests is the dominant terrestrial tree-ed vegetation community within the Reserve, occupying 105 hectares. The most common community in this group is Coastal Sand Littoral Forest. Tree species in this community range from bangalay and/or swamp mahogany on drier soils to tall coast banksia (*Banksia integrifolia*) and swamp oak (*Casuarina glauca*) on less well drained soils. Tuckeroo (*Cupaniopsis anacardioides*) is a common subcanopy species and a high diversity of vines occurs. It is present on the central parts of Towra Point, Pelican Point and along Captain Cook Drive. Coastal Tea-Tree-Banksia Scrub (occupying 32 hectares) occurs on low dune systems on the north side of Towra Point and parts of Quibray Bay. The canopy is dominated by coast banksia and coast tea-tree (*Leptospermum laevigatum*) which varies in height depending on exposure to prevailing winds and past disturbance. Coastal Dune Littoral Rainforest is much more limited in extent, only occupying 14 hectares of the Reserve, principally on The Knoll as well as small patches on Towra Point. This community often merges with Coastal Sand Littoral Forest and is dominated by a low closed canopy of tuckeroo, and other rainforest trees such as the magenta lilly pilly, lilly pilly (*Acmena smithii*), whalebone tree (*Streblus brunonianus*) and cheese tree (*Glochidion ferdinandi*). Emergent trees may include bangalay, coast banksia and swamp oak. Due to the floristic alliances of these vegetation communities, and their intergrading in the Reserve, they have been included in one habitat group despite their varying statewide class allocation. Much of this habitat group is heavily weed infested, particularly by lantana, bitou bush and boneseed and in places by the African olive (*Olea europaea*

cuspidata) such as on The Knoll. Intensive weed removal and bush regeneration has been undertaken in some patches.

Maritime Grasslands

Vegetation Communities Included: Beach Spinifex Grassland
Corresponding Statewide Class*:* Maritime Grasslands

Maritime Grasslands comprises one vegetation community, Beach Spinifex Grassland, which occurs on sections of primary sand dune backing sand beaches. It is dominated by a sparse cover of hairy spinifex (*Spinifex sericeus*) and scattered succulent herbs such as pigface (*Carpobrotus glaucescens*) and the introduced coast pennywort (*Hydrocotyle bonariensis*). There may be scattered low shrubs present, such as coast wattle (*Acacia longifolia* subsp. *sophorae*). It typically occurs in the vegetation succession inland of sand beaches, such as behind Pelican Point and Towra Beach, that is occasionally flooded by waves during king tides, high swell conditions entering Botany Bay or storm events. A large amount of this habitat has been lost within the Reserve due to beach erosion events over the last three decades resulting in many beach areas now being backed by an actively eroding sand wall topped with Coastal Foredune Wattle Scrub or Littoral Forests.

Sydney Coastal Heaths

Vegetation Communities Included: Coastal Foredune Wattle Scrub
Corresponding Statewide Class: Sydney Coastal Heaths

Sydney Coastal Heath comprises just one scrubland vegetation community which primarily occurs behind beaches, particularly on Towra Spit Island and behind western sections of Towra Beach. It comprises dense low scrub dominated by coast tea-tree and coastal wattle that has been pruned by the wind. Much of this habitat group is heavily infested with lantana, bitou bush and boneseed. In places some patches of this community have been actively eroded by large wave events, such as along parts of Towra Beach.

Coastal Freshwater Lagoons

Vegetation Communities Included: Coastal Freshwater Reedland, Coastal Sand Swamp Paperbark Scrub, Estuarine Reedland and Coastal Freshwater Swamp Forest. This fauna habitat also includes freshwater and brackish open water areas, such as in Towra Lagoon.
Corresponding Statewide Class: Coastal Freshwater Lagoons (plus a very small amount of Coastal Floodplain Wetlands)

Coastal Freshwater Lagoons are limited in occurrence within Towra Point NR; the most widespread community is Estuarine Reedland which occupies 10 hectares of the Reserve. It occurs in environments inundated by brackish water, such as on the landward side of saltmarsh flats, with the most extensive occurrence behind Woolooware Bay. It is characterised by tall dense swards of the common reed (*Phragmites australis*). Salt tolerant species which are frequently present are sea rush (*Juncus kraussii*), bare twig-rush (*Baumea juncea*) and the small herb creeping brookweed (*Samolus repens*). Coastal Sand Swamp Paperbark Scrub is restricted to the permanently saturated margins of Mirrormere on Towra Point. This community is characterised by dense stands of swamp paperbark (*Melaleuca ericifolia*) with scattered emergent swamp oak. The ground layer has a very diverse and abundant cover of sedges, rushes and taller reeds, including twig-rushes (*Baumea* spp.) and common reed. Coastal Freshwater Reedland is confined to parts of Towra Lagoon where it is dominated by common reed, cumbungi (*Typha orientalis)* and the reed *Elaeocharis sphacelata*. The continuous cover of reedlands may include scattered swamp oak or swamp paperbark on the drier margins of the lagoon. Coastal Freshwater Swamp Forest is the most restricted vegetation community in this habitat group only covering 0.59 hectares in the Mirrormere area of the Reserve. This community is distinguished by a tree cover of swamp oak and broad-leaved paperbark (*Melaleuca quinquinervia*), a subcanopy of mesic trees such as sweet pittosporum (*Pittosporum undulatum*) and cheese tree, and a diverse array of herbs, grasses, rushes and sedges, including the red-fruit saw-sedge (*Gahnia sieberiana*) and the pouched coral-fern (*Gleichenia dicarpa*). Also included in this habitat group are open water areas such as Towra Lagoon. Note that Woolooware Shorebird Lagoon is not included in this habitat group, with the exception of dense swards of common reed abutting the lagoon on the landward side.

Coastal Floodplain Wetlands

Vegetation Communities Included: Estuarine Swamp Oak Forest
Corresponding Statewide Class: Coastal Floodplain Wetlands

Coastal Floodplain Wetlands, comprising one vegetation community Estuarine Swamp Oak Forest, is a widespread habitat group. Typically, it forms a narrow fringing forest on tidal flats between mangroves/saltmarsh flats and terrestrial forests. It is characterised by dense stands of swamp oak above a thick ground cover of salt tolerant herbs, rushes and sedges. Prevalent ground layer species include sea rush and the bare twig-rush (*Baumea juncea*). Seaward edges of this community may have small grey mangroves (*Avicennia marina*) present, while a variety of weeds frequently encroach from adjoining habitats, in particular lantana and buffalo grass (*Stenotaphrum secundatum*).

Mangrove Swamps

Vegetation Communities Included: Estuarine Mangrove Forest
Corresponding Statewide Class: Mangrove Swamps

Mangrove Swamps occupies 162 hectares of the Reserve, occurring along much of the shoreline except that exposed to higher energy wave actions such as much of Towra Beach. The dominant species is grey mangrove, which often forms monotypic stands with an understorey of open mudflat sometimes with scattered saltmarsh herbs on the fringes. The river mangrove (*Aegiceras corniculatum*) is found in small patches, occasionally forming pure stands where freshwater from runoff causes lower salinities, such as at north Weeney Bay.

Saltmarshes

Vegetation Communities Included: Estuarine Saltmarsh
Corresponding Statewide Class: Saltmarshes

Saltmarshes occupies 132 hectares of the Reserve, frequently intergrading with Mangrove Swamps. In some localities mangroves are in the process of colonising saltmarsh (e.g. adjacent to the Towra Point Track causeway) as has been recorded elsewhere in the region (Williams et al. 2004). Throughout the saltmarsh flats, salinities vary greatly according to tidal influence, evaporation and freshwater accumulation. Some of the areas are flooded regularly, while at slightly higher elevations flooding is rare. After rain, freshwater accumulates and adds extra water to the marsh, leaving pools of standing water when the tide recedes. Chenopod species, in particular beaded glasswort (*Sarcocornia quinqueflora*), dominate areas more frequently inundated by the tides, while sea rush occupies the more elevated terrestrial margin. Local scalds occur in small depressions where intensely saline deposits accumulate from the evaporation of tidal waters preventing the growth of any plants at all (Keith 2004).

Shoreline

Vegetation Communities and Other Environments Included: Seagrass Meadows as well as unvegetated shoreline habitats (not mapped in DECCW (2011c)) such as sandy beaches, intertidal mudflats and open tidal waters.
Corresponding Statewide Class: None, but does include Seagrass Meadows

This habitat group incorporates shoreline environments that do not support terrestrial vegetation including sandy beaches, intertidal mudflats and inshore waters, as well as Seagrass Meadows. It also includes Woolooware Shorebird Lagoon since this is tidally influenced, but excludes the areas of dense common reed that abut the lagoon margin.

Unassigned Map Units

Areas mapped by DECCW (2011c) as Weeds and Exotics or Undifferentiated Regenerating Shrubs have not been incorporated in to fauna habitat groups for this report. This includes cleared areas.

4.2.2 Assessing the conservation significance of fauna habitats

The rapid fauna habitat assessment of the SMCMA area (DECC 2008a) identified ‘priority fauna habitats’ in the Sydney area based on their “exceptional importance for the conservation of vertebrate fauna, particularly threatened and regionally significant species and their restricted occurrence within the CMA”. As a means of assessing the importance of habitats in Towra Point NR to the conservation of native fauna, the habitat groups defined herein were compared to the DECC (2008a) ‘priority fauna habitats’ and assigned as priority habitat as appropriate. The allocation of priority fauna habitats also considered the number of highest, high and moderate conservation management priority species recorded in each habitat group and the extent to which the habitat is represented in reserves within the Sydney basin.

Table 6: Summary of fauna habitat groups and their relation to vegetation communities, statewide formations and statewide classes

Fauna habitat group	Statewide formation (Keith 2004 as allocated in DECCW 2011c)	Statewide class (Keith 2004 as allocated in DECCW 2011c)	Vegetation community (DECCW 2011c)
Littoral Forests	Rainforests	Littoral Rainforests	Coastal Dune Littoral Rainforest
Littoral Forests	Wet Sclerophyll Forest	North Coast Wet Sclerophyll Forests	Coastal Sand Littoral Forest
Littoral Forests	Heathlands	Coastal Headland Heaths	Coastal Tea-tree-Banksia Scrub
Maritime Grasslands	Grasslands	Maritime Grasslands	Beach Spinifex Grassland
Sydney Coastal Heaths	Heathlands	Sydney Coastal Heaths	Coastal Foredune Wattle Scrub
Coastal Freshwater Lagoons	Freshwater Wetlands	Coastal Freshwater Lagoons	Coastal Freshwater Reedland
Coastal Freshwater Lagoons	Freshwater Wetlands	Coastal Freshwater Lagoons	Coastal Sand Swamp Paperbark Scrub
Coastal Freshwater Lagoons	Freshwater Wetlands	Coastal Freshwater Lagoons	Estuarine Reedland
Coastal Freshwater Lagoons	Forested Wetlands	Coastal Floodplain Wetlands	Coastal Freshwater Swamp Forest
Coastal Floodplain Wetlands	Forested Wetlands	Coastal Floodplain Wetlands	Estuarine Swamp Oak Forest
Mangrove Swamps	Saline Wetlands	Mangrove Swamps	Estuarine Mangrove Forest
Saltmarshes	Saline Wetlands	Saltmarshes	Estuarine Saltmarsh
Shoreline	Mostly unallocated as not vegetated, but includes Saline Wetlands	Mostly unallocated as not vegetated, but includes Seagrass Meadows	Seagrass Meadows plus shoreline lacking terrestrial vegetation including beaches and intertidal flats.

4.3 Threats to Fauna

4.3.1 Identifying threats to native fauna

Effective management of the native fauna species and habitats in the Reserve requires an understanding of the threats currently posed. This project aimed to identify the threats currently acting in the Reserve, as well as threats that have the potential to emerge in the near future. Threats were identified on the following basis: Key Threatening Processes listed under the TSC Act and/or the EPBC Act; observations made during the 2006 and 2013 field surveys; expert knowledge of the vulnerabilities of particular fauna species; threats noted in published or unpublished literature; threats mentioned during discussions with park staff and naturalists during the course of the project.

4.3.2 Setting priorities for threats

To enable management to be targeted towards threats that pose the greatest risk to native fauna in the Reserve, all of the threats identified during the course of the project were classed and ranked as follows. These classes and rankings were derived from expert knowledge rather than quantitative assessment, and will require review and revision in the future when more comprehensive information on the local and regional conservation status of, or further research on threats posed to, each species becomes available.

Key Current Threats

A key current threat is one that currently threatens one or more highest, high or moderate conservation management priority fauna species. Key current threats are prioritised as follows.

Very High*:* Known or potentially impacting one or more Highest Conservation Management Priority fauna species and/or more than half of the High Conservation Management Priority fauna species.

High: Known or potentially impacting less than half of the High Conservation Management Priority fauna species and/or over half of the Moderate Conservation Management Priority fauna species.

Moderate: Known or potentially impacting less than half of the Moderate Conservation Management Priority fauna species.

Other Current Threats

Threats that currently have the potential to impact on fauna species not identified as highest, high or moderate conservation management priority species.

Future Threats

Threats that do not currently act within the Reserve but have the potential to become significant in the short to medium term future.

5 The Species Inventory

5.1 Unconfirmed Species Records

Following the field surveys and the review of fauna records, several species previously recorded in Towra Point NR were excluded from the species inventories provided in this report. Pelagic species that do not come ashore to rest, forage or nest were excluded. Terrestrial species were excluded where they were only represented by records with high spatial inaccuracy, by unconfirmed sightings, by probable mis-identifications or database errors, or are introduced or non-local species that do not have established wild populations in or adjacent to the study area. Table 7 provides a list of all species excluded from the species inventories and the reason they have been omitted. Fish species were also excluded as they are beyond the scope of this report.

Table 7: Species recorded in Towra Point Nature Reserve which have been removed from the species inventories provided in this report

Common name	Scientific name	Reason for omission from species inventory
Wallum froglet	*Crinia tinnula*	*Incorrect citation* – this species was stated as occurring in the Reserve by DECCW (2010a) citing Schulz (2006) as the reference source. However, this species was not recorded by Schulz (2006) and is not known from the Reserve.
Blue-billed duck	*Oxyura australis*	*Spatially inaccurate record* – there is a single record from 'Kurnell Lagoon' in December 1990 but this is located south of Captain Cook Drive rather than within the Reserve. Little suitable deep freshwater habitat is present for this species within the Reserve. This species is very rare in the Sydney area (Hoskin et al. 1991). It is also mentioned as occurring in DECCW (2010a), but no primary reference source for this species within the Reserve could be found. Therefore, the species is considered unconfirmed.
Brown cuckoo-dove	*Macropygia amboinensis*	*Unconfirmed species* – there is a single record in January 2009 from The Knoll (UBM Ecological Consultants 2009). Since this pigeon is a rainforest and wet forest species that is typically regarded as sedentary (Higgins and Davies 1996) and there are no records of this species documented elsewhere on the Peninsula such as Kamay Botany Bay NP (e.g. DECCW 2011a) this record is currently considered unconfirmed.
Black-browed albatross	*Thalassarche melanophris*	*Pelagic species* – seen off Towra Beach (M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
Wedge-tailed shearwater	*Ardenna pacifica*	*Pelagic species* – seen off, and beachwashed on, Towra Beach (M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
Short-tailed shearwater	*Ardenna tenuirostris*	*Pelagic species* – seen off, and beachwashed on, Towra Beach and beachwashed on Carters Island (OEH 2013a, M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
Fluttering shearwater	*Puffinus gavia*	*Pelagic species* – seen off Towra Beach (M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
Little penguin	*Eudyptula minor*	*Pelagic species* – seen off Towra Spit Island, Towra Beach and the entrance of Quibray Bay, including over shallows exposed at low tide (M. Schulz pers. obs.) but does not come ashore to rest, forage or

Common name	Scientific name	Reason for omission from species inventory
		nest.
Australasian gannet	*Morus serrator*	*Pelagic species* – seen off Towra Spit Island, Towra Beach and the entrance of Quibray Bay, including over shallows exposed at low tide (Schulz 2006) but does not come ashore to rest, forage or nest.
Bush stone-curlew	*Burhinus grallarius*	*Unconfirmed species* – a sighting of a single individual was recorded at 'Towra Point' in 1982 (OEH 2013a). It is likely that the record is erroneous, possibly deriving from the sighting of a beach stone-curlew.
South Island pied oystercatcher	*Haematopus finschi*	*Unconfirmed species* – a sighting of a single individual was reported in March 2007 (Birdline NSW 2013). However, follow-up visits by a variety of observers failed to locate this bird and it was suspected to have been an incorrectly cited juvenile-plumaged Australian pied oystercatcher (Birdline NSW 2013). The South Island oystercatcher is a vagrant to Australia with only six confirmed records (e.g. Geering et al. 2007, Birdlife Australia Rarities Committee decisions and case summaries (BARC 2013)). This record is considered unconfirmed since it was not reviewed by the Birds Australia Rarities Committee.
Banded lapwing	*Vanellus tricolor*	*Unconfirmed species* – this species is mentioned as occurring in DECCW (2010a) but no primary reference source could be found. Therefore, the species is considered unconfirmed.
Hudsonian godwit	*Limosa haemastica*	*Unconfirmed species* – a single bird was reported from mudflats at the west end of Towra Beach in October 2000 (OEH 2013a). This species is a vagrant to Australia with only five confirmed records (e.g. Higgins and Davies 1996, Geering et al. 2007, Birds Australia Rarities Committee decisions and case summaries). This record is considered unconfirmed since it was not reviewed by the Birds Australia Rarities Committee.
Wood sandpiper	*Tringa glareola*	*Unconfirmed species* – this species is mentioned as occurring in DECCW (2010a) but no primary reference source could be found. Therefore, the species is considered unconfirmed.
Brown skua	*Stercorarius antarcticus*	*Pelagic species* – Reported by the Australian Littoral Society (1977) but does not come ashore to rest, forage or nest.
Arctic jaeger	*Stercorarius parasiticus*	*Pelagic species* – seen off Towra Spit Island, Towra Beach and the entrance of Quibray Bay, including over shallows exposed at low tide (Australian Littoral Society 1977, M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
Pomarine jaeger	*Stercorarius pomarinus*	*Pelagic species* – seen off Towra Beach (Australian Littoral Society 1977, M. Schulz pers. obs.) but does not come ashore to rest, forage or nest.
White-winged black tern	*Chlidonias leucopterus*	*Unconfirmed species* – Mentioned as occurring in DECCW (2010a) but no primary reference source could be found. Therefore, the species is considered unconfirmed.
Sooty tern	*Onychoprion fuscata*	*Pelagic species* – one individual was found

Common name	Scientific name	Reason for omission from species inventory
		beachwashed on Towra Beach during the February 2013 survey. At that time numerous individuals were reported along the New South Wales coastline, with several beachcast individuals found in various localities (e.g. Birdline NSW 2013). However it does not come ashore to rest, forage or nest.
Cockatiel	*Nymphicus hollandicus*	*Aviary escapee* – there is one record for the Reserve (Australian Littoral Society 1977) but this species is not native to the area and there is no established wild population.
Striated thornbill	*Acanthiza lineata*	*Unconfirmed species* – this species is reported from The Knoll in January 2009 (UBM Ecological Consultants 2009). Other bird surveys have failed to locate this bird in forested areas on the Kurnell Peninsula (Australian Littoral Society 1977, Schulz 2006, DECC 2008a, DECCW 2011a, M. Schulz pers. obs., OEH 2013a). Therefore, given the sedentary nature of this species (Higgins and Peter 2002), this record is considered unconfirmed.
White-cheeked honeyeater	*Phylidonyris niger*	*Unconfirmed species* – this species is mentioned as occurring in DECCW (2010a) but no primary reference source could be found. Therefore, the species is considered unconfirmed.
Varied sittella	*Daphoenositta chrysoptera*	*Unconfirmed species* – this species is reported by the Australian Littoral Society (1977) as "Old records only. Like Phragmites areas. Rare". However, this bird does not occur in reedland habitat, but rather a variety of eucalypt forests and woodlands (Higgins and Peter 2002). Due to the single report and the lack of recent sightings this species is considered unconfirmed.
Pied butcherbird	*Cracticus nigrogularis*	*Unconfirmed species* – this species was reported at one of the high voltage electricity pylons adjacent to Captain Cook Drive in September 2008 (OEH 2013a). However this species is rare in the Sydney region (Hoskin et al. 1991, Higgins et al. 2006) with no other documented records from the Kurnell Peninsula. It is therefore considered a potential error and unconfirmed.
Sugar glider	*Petaurus breviceps*	*Unconfirmed species* – this species was reported from mangrove forest at The Knoll in January 2009 (UBM Ecological Consultants 2009) and at one of the high voltage electricity pylons adjacent to Captain Cook Drive in September 2008 (OEH 2013a). However other nocturnal playback and spotlighting surveys have failed to locate this species in forested areas on the Kurnell Peninsula (Australian Littoral Society 1977, Schulz 2006, DECC 2008a, DECCW 2011a, M. Schulz pers. obs.). Therefore, given the sedentary nature of this species, these records are considered unconfirmed.
Dugong	*Dugong dugon*	*Pelagic species* – one stranded female was recorded on Towra Beach in October 1992 (OEH 2013a) but this species does not come ashore to rest, forage or nest.
Striped dolphin	*Stenella coeruleoalba*	*Pelagic species* – one stranded individual was recorded between Quibray and Weeney Bays in October 1992 (OEH 2013a) but this species does not

Common name	Scientific name	Reason for omission from species inventory
		come ashore to rest, forage or nest.
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	*Pelagic species* – seen off Towra Beach and one lower jawbone has been found amongst mangroves on Pelican Point (Schulz 2006, M. Schulz pers. obs.). However this species does not come ashore to rest, forage or nest.

5.2 Species Not Recorded for Twenty-five Years

Table 8 presents a list of species that have previously been recorded in Towra Point NR, but have not had confirmed sightings for the last 25 years. Some of these species are considered to have been lost from the Reserve. These species are also listed in Appendix A, with the status code NR. As they are not confirmed to currently be resident in or visitors to the Reserve they have been tallied separately in this report.

Twenty-seven previously recorded bird species (including three introduced species) and three mammal species (including one introduced species) have not been confirmed to occur within the Reserve in the last 25 years (Table 8, Appendix A). This includes three species listed under the TSC Act and/or the EPBC Act and one species listed under international migratory bird agreements.

Assessing the reason that these species have not been confirmed in the Reserve in recent years is beyond the scope of this report.

The brown falcon has not been recorded in the last 25 years but is likely to be detected again in the future. Photo © M. Schulz

Table 8: Terrestrial vertebrate fauna species previously recorded in Towra Point Nature Reserve but not confirmed within the last 25 years

Common name	Scientific name	Date and source of last record	Notes
Emerald dove	*Chalcophaps indica*	Record from Weeny Bay in May 1960 (OEH 2013a)	Regularly occurs elsewhere in the Sydney region but vagrant to the Reserve due to lack of suitable habitat.
Australian little bittern	*Ixobrychus dubius*	Australian Littoral Society (1977)	Rare in the Sydney area and highly cryptic.
Collared sparrowhawk	*Accipiter cirrocephalus*	Australian Littoral Society (1977)	Widespread in Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Brown falcon	*Falco berigora*	Australian Littoral Society (1977)	Widespread in Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Eurasian coot	*Fulica atra*	Australian Littoral Society (1977)	Widespread in Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Australian spotted crake	*Porzana fluminea*	Australian Littoral Society (1977)	Widespread in Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Baillon's crake	*Porzana pusilla*	Australian Littoral Society (1977)	Regular visitor to select wetlands in the Sydney area; no longer suitable habitat in the Reserve.
Ruff	*Philomachus pugnax*	Australian Littoral Society (1977)	Vagrant or rare in the Sydney area.

Common name	Scientific name	Date and source of last record	Notes
Wandering tattler	*Tringa incana*	Australian Littoral Society (1977)	Regularly occurs elsewhere in the Sydney region but vagrant to the Reserve due to lack of suitable habitat.
Arctic tern	*Sterna paradisaea*	February 1973 (OEH 2013a)	Vagrant or rare in the Sydney area.
Blue-winged parrot	*Neophema chrysostoma*	February 1986 (OEH 2013a)	Vagrant or rare in the Sydney area.
Red-rumped parrot	*Psephotus haematonotus*	Australian Littoral Society (1977)	Widespread in the Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Pallid cuckoo	*Cacomantis pallidus*	Australian Littoral Society (1977)	Declined in the Sydney area.
Striated fieldwren	*Calamanthus fuliginosus*	1979 (Hoskin et al. 1991)	Vagrant or rare in the Sydney area.
White-throated gerygone	*Gerygone albogularis*	Australian Littoral Society (1977)	Would once have been a breeding summer migrant but has declined in the Sydney area.
Regent honeyeater	*Anthochaera phrygia*	Australian Littoral Society (1977)	Declined in the Sydney region.
Noisy friarbird	*Philemon corniculatus*	Australian Littoral Society (1977)	Widespread in the Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Eastern whipbird	*Psophodes olivaceus*	Australian Littoral Society (1977)	Potentially no longer occurs in the Reserve.
Apostlebird	*Struthidea cinerea*	Australian Littoral Society (1977)	Vagrant or rare in the Sydney area.
Jacky winter	*Microeca fascinans*	Australian Littoral Society (1977)	Declined in the Sydney region.
Scarlet robin	*Petroica boodang*	Australian Littoral Society (1977)	Declined in the Sydney region.
Eurasian skylark	*Alauda arvensis*	Australian Littoral Society (1977)	Likely that individuals occasionally still occur in the Reserve.
Brown songlark	*Cincloramphus cruralis*	Australian Littoral Society (1977)	Declined in the Sydney region.
Tree martin	*Petrochelidon nigricans*	Australian Littoral Society (1977)	Widespread in Sydney area and suitable habitat present in the Reserve; likely to be recorded in the future.
Zebra finch	*Taeniopygia guttata*	Australian Littoral Society (1977)	Rare in the Sydney area with occurrence dependant on conditions inland.
European goldfinch	*Carduelis carduelis*	Australian Littoral Society (1977)	Likely that individuals occasionally still occur in the Reserve.
European greenfinch	*Carduelis chloris*	Australian Littoral Society (1977)	Likely that individuals occasionally still occur in the Reserve.
Eastern grey kangaroo	*Macropus giganteus*	Fox (1972)	Lost from the Reserve.
Swamp rat	*Rattus lutreolus*	Australian Littoral Society (1977)	Likely no longer occurs in the Reserve though possible it may still occur.

Common name	Scientific name	Date and source of last record	Notes
Feral dog	*Canis lupus familiaris*	Australian Littoral Society (1977)	No longer occurs.

5.3 Fauna Species Inventory

A total of 212 native vertebrate fauna species have been accurately recorded in the Reserve within the last 25 years comprising six frog, 15 reptile, 179 native bird and 12 native mammal species (Table 9, Appendix A). In addition, eight introduced bird and six introduced mammal species have been confirmed to occur in the last 25 years.

Table 9: Number of vertebrate fauna species recorded within the last 25 years

Total number native fauna species known to occur	212
Number of species listed as threatened under the TSC Act	21
Number of species listed as threatened under the EPBC Act	4
Number of species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA)	34
Number of introduced mammals	6
Number of introduced birds	8

5.4 Amphibians

Six species of amphibian have been recorded in the Reserve. One species, the green and golden bell frog, is listed as Endangered under the TSC Act and Vulnerable under the EPBC Act (see species profile in section 6.2). The most frequently recorded species is the common eastern froglet, occurring in ephemeral and permanent freshwater wetlands. The brown-striped frog is relatively common in deeper freshwater water bodies while the Peron's tree frog is most frequently encountered in wetlands within tree-ed areas, such as patches of swamp oak fringing sea rush-dominated swampland. The bleating tree frog is common on Towra Point, particularly in Littoral Forests dominated by tall coast banksias and bangalay. Frogs are absent from large parts of the Reserve due to the saline influence, including from Saltmarshes and Mangrove Swamps, from along the shoreline and from offshore islands such as Carters Island and Towra Spit Island.

The eastern dwarf tree frog may have gone undetected in the Resreve. Photo © M. Schulz

The list of amphibian species is likely to be incomplete as all of the main surveys of the Reserve were undertaken during periods of low frog activity (both the Schulz (2006) and the Australian Littoral Society (1977) surveys were undertaken in late autumn and winter, while the 2013 surveys were undertaken in late summer during dry conditions). It is likely that frog species have gone unrecorded within the Reserve, based on information from adjacent areas of the Kurnell Peninsula. Species recorded from adjacent areas that may also occur within the Reserve include the eastern dwarf tree frog (*Litoria fallax*), Jervis Bay tree frog (*L. jervisiensis*), Verreaux's frog (*L. verreauxii*), smooth toadlet (*Uperoleia laevigata*) and the eastern banjo frog (*Limnodynastes dumerilii*) (e.g. from White 2012, OEH 2013a).

The peron's tree frog was frequently encountered in wetland areas with trees. Photo © M. Schulz

5.5 Reptiles

The dark-flecked garden sunskink is the most frequently sighted reptile in the Reserve. Photo © M. Schulz

Fifteen species of reptile have been recorded in the Reserve, comprising one freshwater turtle, nine skinks, one dragon and four snakes. None of the species are species listed under the TSC Act or the EPBC Act. All of the species have been recorded at a number of other localities on the Kurnell Peninsula (e.g. DECCW 2011a, White 2012, OEH 2013a). The most frequently encountered reptile in the Reserve is the dark-flecked garden sunskink which occurs in all habitats including landward sections of Saltmarshes and the terrestrial edge of Mangrove Swamps, in Maritime Grasslands such as behind Towra Beach and within swamplands. It also occurs on some islands, such as Carters Island. Other frequently encountered species in terrestrial habitats such as coastal tea-tree-banksia scrub and bangalay open forest include the jacky lizard and the pale-flecked garden sunskink. The most frequently recorded snake is the black-bellied swamp snake which occurs in a variety of habitats including Coastal Floodplain Wetlands, in sea rushland on the inner margin of Saltmarshes and under timber and other debris in king/storm tidal wrack lines in Saltmarshes. The red-bellied black snake is also widespread, occurring in most habitats including some very large specimens on the landward fringes of Saltmarshes on the east side of Towra Point and west of the Towra Point Track causeway. Species more restricted in distribution include the three-toed skink and the barred-sided skink which were only recorded in Littoral Forests with a dense rainforest subcanopy. During the 2013 surveys the latter species was present in good numbers in rainforest at The Knoll, in addition to bangalay-dominated forest on Towra Point. A number of species have primarily been encountered along the Towra Point Track causeway or on the terrestrial edge of swamplands north of Captain Cook Drive, such as the robust ctenotus, eastern blue-tongue and the black-bellied swamp snake. The eastern snake-necked turtle occurs in a number of freshwater wetlands, including Mirrormere and Weedy Pond on Towra Point. Additionally, this species was recorded in brackish pools amongst sea rushland on the inland edge of Saltmarshes in the Fish Creek area.

The common scaly-foot has not been recorded in the Reserve but is known from elsewhere on the Kurnell Peninsula. Photo © M. Schulz

A number of species have only been recorded once in the Reserve – the eastern water-skink, cream-striped shinning-skink, weasel skink, yellow-faced whip snake and the eastern small-eyed snake. The extent of occurrence of these species in the Reserve is not known.

It is likely that a number of additional species occur within the Reserve, based on records from adjacent areas of the Kurnell Peninsula. Potential species include the common scaly-foot (*Pygopus lepidopodus*), common tree snake (*Dendrelaphis punctulata*) and the eastern brown snake (*Pseudonaja textilis*) (e.g. from White 2012, OEH 2013a).

5.6 Native Birds

Birds are the most obvious form of wildlife in the Reserve. A wide variety of waterbirds frequent the shoreline, while within the forested areas honeyeaters and other species fill the air with a multitude of sounds. Altogether, 179 species of native birds (excluding pelagic species) have been recorded in the last 25 years (Appendix A). This includes 17 species listed under the TSC Act and two species listed under the EPBC Act (refer to species profiles in section 6.2). Waders and other shoreline-frequenting species of the Reserve are well known as a result of the regular monthly counts undertaken by the

NSW Wader Study Group. In contrast terrestrial and freshwater/brackish water wetland species, particularly in forested and dense sedge/rushland areas, are relatively poorly known.

The importance of the Reserve to waterbirds is internationally recognised by the area being listed as a Ramsar wetland (see section 2). Ninety waterbird species (51 per cent of the total bird species) have been recorded within the Reserve in the last 25 years, including a number of vagrants (Appendix A). These vagrant species are predominantly either very rare visitors to the Sydney region (e.g. Hoskin et al. 1991) or occur primarily during periods of drought when many waterbirds move coastwards. Such species include the Australian shelduck, Australasian shoveler, beach stone-curlew, oriental plover, red-kneed dotterel, Australian painted snipe, gull-billed tern and the pacific gull. Other species are regularly recorded within the Reserve but are generally rare in the Sydney area. These species include the little egret, eastern osprey, Lewin's rail, Australian pied oystercatcher, bar-tailed godwit, whimbrel, eastern curlew and the little tern.

The Australian shelduck is a vagrant to the Reserve. Photo © M. Schulz

The Reserve supports one of the few documented white-bellied sea-eagle nests in the Sydney area. Photo © M. Schulz

Most waterbird species utilise the Reserve as non-breeding visitors, including 34 species listed under international migratory bird agreements (see section 6.3). However, the Reserve is significant in supporting the largest little tern breeding colony in the Sydney area and at least seven pairs of the Australian pied oystercatcher, one of the few localities this species nests within the region. Other waterbird species that nest in small numbers within the Reserve include the chestnut teal and the white-faced heron. The Reserve supports one of the few documented white-bellied sea-eagle nests in the Sydney area. This nest is located away from tracks in bangalay-dominated Littoral Forest on Towra Point. The Reserve also supports nesting habitat of the Lewin's rail, a poorly known species within the region with few nesting records. Some species appear to no longer nest within the Reserve, such as the red-capped plover that formerly nested on the edge of pools in saltmarsh areas. Surprisingly there are no colonial waterbird nesting colonies within the Reserve, such as various cormorant species that commonly frequent the subtidal waters around the area.

Cryptic waterbird species that only occur in dense swamplands are very poorly known, with little information available on whether the non-migratory species breed within the Reserve. These species include the Australasian bittern, buff-banded rail, spotless crake and the little grassbird. The Woolooware Shorebird Lagoon has been noted as an important site for freshwater wetland species such as Latham's snipe, various crakes and rails, a variety of ducks and the Australasian bittern (Straw 1996, OEH 2013a, S. Anyon-Smith pers. comm.). However, due to the wetland becoming more brackish, overall numbers of waterbirds observed using this wetland have declined (S. Anyon-Smith pers. comm.). Some migratory bird species that use both salt and freshwater are recorded in the Lagoon, including curlew sandpiper (single birds on three occasions in 2002 (OEH 2013a)) and common greenshank (recorded more often at Woolooware Shorebird Lagoon than anywhere else in Botany Bay (NSW Wader Study Group data)). The Australian pied oystercatcher nests in low numbers on islands in the Lagoon.

The Reserve supports nesting habitat of the Lewin's rail. Photo © M. Schulz

The non-waterbird species that occur within the Reserve are generally common and widespread elsewhere in the Sydney Basin Bioregion. An important exception is the white-fronted chat; the population within the Reserve is currently the last

remaining breeding population within the Sydney area. This population is listed as an Endangered Population under the TSC Act (see species profile in section 6.2). Other species that occur within the Reserve but are patchily distributed or rare within the Sydney area include the southern emu-wren and masked owl (the latter listed as Vulnerable under the TSC Act). The former species is a moderately common breeding resident that is distributed widely across the Reserve. It predominantly frequents Saltmarshes (particularly rushland areas dominated by sea rush), Coastal Floodplain Wetlands with a dense rush or sedge ground layer, Sydney Coastal Heaths and Coastal Freshwater Lagoons with rushes and reeds. A number of species are at or close to their southern range limit within the Reserve, such as the mangrove gerygone and brown honeyeater. Small numbers of the former species are scattered in tall Mangrove Swamps, while the latter species is widespread and common. Interestingly, the mangrove gerygone has expanded its range southwards in New South Wales since the 1940s with it first being recorded in the State at Tweed Heads in 1942, near Harrington at the Manning River mouth in 1955, the Hunter River estuary in 1967 and at Bonna Point in Botany Bay in 1982 (Higgins and Peter 2002).

It is likely that species have gone unrecorded in Towra Point NR, including species that frequent adjacent areas on the Kurnell Peninsula such as Kamay Botany Bay NP (e.g. DECCW 2011a). Such species include the musk lorikeet (*Glossopsitta concinna*), pheasant coucal (*Centropus phasianinus*), eastern grass owl and the dusky woodswallow (*Artamus cyanopterus*).

Approximately one kilometre west of Towra Point NR lies the location of a shorebird community that is listed as Endangered under the TSC Act (listed as The Shorebird Community Occurring on the Relict Tidal Delta Sands at Taren Point). This community extends along the relict marginal shoal of the Georges River between Taren Point and Shell Point on the west side of Woolooware Bay (NSW Scientific Committee 2011). The 20 species listed within this community are the bar-tailed godwit, red knot, great knot, sharp-tailed sandpiper, curlew sandpiper, red-necked stint, common sandpiper, terek sandpiper, Latham's snipe, grey-tailed tattler, grey plover, Pacific golden plover, common greenshank, masked lapwing, marsh sandpiper, ruddy turnstone, Australian pied oystercatcher, sooty oystercatcher, whimbrel and the eastern curlew. All of these species also occur within Towra Point NR, with individuals likely to move between the two areas. However, due to the precise definition of the shorebird community boundaries under the TSC Act, Towra Point NR does not form part of the Endangered community listing.

The brown honeyeater is widespread and common in Towra Point NR. Photo © M. Schulz

Shorebirds roosting at high tide on Towra Spit Island. Photo © J. Bishop

Individuals that occur in the Endangered shorebird community at Taren Point are likely to also use Towra Point NR. However the Reserve is not included in the geographical definition of the community under the TSC Act.
Taren Point shoreline (upper left); disused jetty in the endangered shorebird community – an important high tide shorebird roosting site (upper right); disused barge in the endangered shorebird community with grey-tailed tattler and terek sandpiper roosting (centre left); bar-tailed godwits on the endangered shorebird community shoreline (centre right); endangered shorebird community members (from lower left to right) Pacific golden plover, grey-tailed tattler, ruddy turnstone and sharp-tailed sandpiper. Photos © M. Schulz

There are four further threatened species of bird that have not been recorded in Towra Point NR, but have the potential to occur since potentially suitable habitat is present and there are nearby records on the Kurnell Peninsula. These species are: square-tailed kite (*Lophoictinia isura*, single records in June 1996 from Sir Joseph Banks Drive and from the corner of Captain Cook Drive and Elouera Road (OEH 2013a)); spotted harrier (*Circus assimilis*, documented from near Cronulla High School in November 1989 (OEH 2013a)); swift parrot (*Lathamus discolor*, recorded from near Cronulla Golf Course (OEH 2013a) and may occur in some years when bangalay or swamp mahogany trees are in flower); and eastern grass owl (*Tyto longimembris*, recorded from dense sedgelands in Kamay Botany Bay NP in July 2009 and February 2010 (DECCW 2011a, Schulz and Magarey 2010) and has the potential to occur in wet sedgelands within the Reserve).

5.7 Native Mammals

Twelve species of native mammal have been recorded in Towra Point NR in the last 25 years. Bat species comprise 75 per cent of this total. Three native mammal species listed under the TSC Act are known to occur, being the grey-headed flying-fox, eastern bentwing-bat and the greater broad-nosed

bat (see species profiles in section 6.2). The grey-headed flying-fox is also listed as Vulnerable under the EPBC Act.

Two additional species, the eastern grey kangaroo and swamp rat, have not been recorded in the last 25 years. The former species is considered to have been lost from the Reserve. It is likely that the swamp rat has also been lost, though it is possible that isolated populations may occur in areas of rank vegetation that are rarely traversed and were not sampled during the 2006, 2007 or 2013 fauna surveys. The short-beaked echidna is the only native ground-dwelling mammal that has been recorded in recent times. This is the same as observations made in bushland elsewhere on the Kurnell Peninsula, such as Kamay Botany Bay NP (e.g. UBM Ecological Consultants 2009, DECCW 2011a). The status of the short-beaked echidna is uncertain, however, as no sightings were made during the 2013 survey and the species has not been recorded since the year 2000 in Kamay Botany Bay NP (DECCW 2011a). The single individual that was recorded along Captain Cook Drive could possibly have been a released individual.

The grey-headed flying-fox forages widely across the Reserve, particularly when key feed species are in flower such as the coast banksia, bangalay and the isolated swamp mahogany trees along Captain Cook Drive (see species profile in section 6.2). The Reserve appears to support a high density of insectivorous microbats across a wide range of vegetation communities, including foraging habitat over Saltmarshes and Shorelines. Elsewhere in New South Wales, coastal saltmarsh is known to provide important foraging habitat for a large variety of bats (Gonsalves et al. 2009). The Mangrove Swamps are likely to provide important roosting habitat as the mature mangrove trees and dead standing trees contain an abundance of small hollows.

The many hollows present in tall grey mangrove trees provide roosting opportunities for insectivorous microbats. Photo © M. Schulz

The species most frequently recorded by Anabat were the chocolate wattled bat (34 per cent of positively identified recordings) and the little forest bat (21 per cent of positively identified recordings). The species most commonly captured in harp traps were the little forest bat, lesser long-eared bat and Gould's wattled bat. The chocolate wattled bat was only captured in small numbers in harp traps. The lesser long-eared bat was recorded roosting under exfoliating bark of a swamp oak on Carters Island and on the south side of Fish Creek. Similarly, the chocolate wattled bat was located sheltering under exfoliating bark of a swamp oak on the east side of Towra Point south of Fish Creek. The only other species captured in harp traps was the greater broad-nosed bat, with one individual caught in 2006 along the Towra Point Track in bangalay-dominated Littoral Forests. The presence of this species in the Reserve was unexpected given the absence of records elsewhere on the Kurnell Peninsula. Small numbers (≤one per cent of positively identified ultrasonic calls) of three other bat species were detected in the 2013 survey, the eastern freetail-bat, white-striped freetail-bat and the eastern bentwing-bat. The assemblage of bat fauna is similar to that recorded in nearby Kamay Botany Bay NP, with the exception of the greater broad-nosed bat present in Towra Point NR only and the Gould's long-eared bat present in Kamay Botany Bay NP but not recorded in Towra Point NR.

Two species of arboreal mammal are known to occur in the Reserve, being the common brushtail possum, and the common ringtail possum. The former species is widespread and very common where trees occur, including in Mangrove Swamps. It was the most commonly recorded native mammal species during the 2013 survey, detected by 10 of the 11 infra-red cameras including on Carters Island and in Saltmarshes north of Fish Creek. The common ringtail possum in contrast is largely restricted to Littoral Forests on Towra Point.

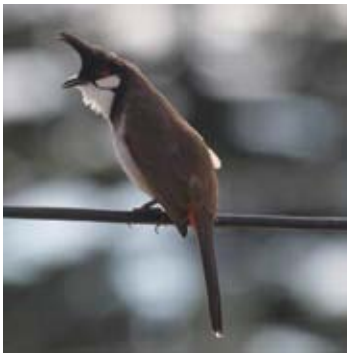
The eastern freetail-bat was only recorded by bat ultrasonic call recording. Photo © M. Schulz

It is likely that additional bat species occur in the Reserve, in particular species that have been recorded elsewhere on the Kurnell Peninsula such as Gould's long-eared bat, east coast freetail-bat (*Mormopterus norfolkensis*), large-footed myotis (*Myotis macropus*)

and the little bentwing-bat (*Miniopterus australis*). Therefore, the compilation of a more exhaustive species inventory for the Reserve would require further bat survey work be undertaken, involving sampling of all vegetation communities (including Estuarine Mangrove Forest) and sheltered waters using bat ultrasonic call recording and harp trapping between mid spring and late summer. Ultrasonic call analysis should be undertaken by an experienced analyser in order to avoid the misidentification of calls.

5.8 Introduced Birds

Eight feral bird species have been recorded in the Reserve in the last 25 years. The most widespread species are the red-whiskered bulbul, spotted dove and the common starling (Map 7). The red-whiskered bulbul is the most widespread of all, occurring in a variety of forested and scrubby habitats including the edge of Mangrove Swamps adjacent to Captain Cook Drive and on Towra Point and Pelican Point. The common starling has been observed on the Shoreline (such as along Towra Beach) and in Saltmarshes, although it is most frequently recorded adjacent to Captain Cook Drive. The spotted dove occurs in various habitats, including the edge of Mangrove Swamps adjacent to Captain Cook Drive and on the edge of Littoral Forests on Towra Point.



The red-whiskered bulbul is the most widespread introduced bird species in the Reserve. Photo © M. Schulz

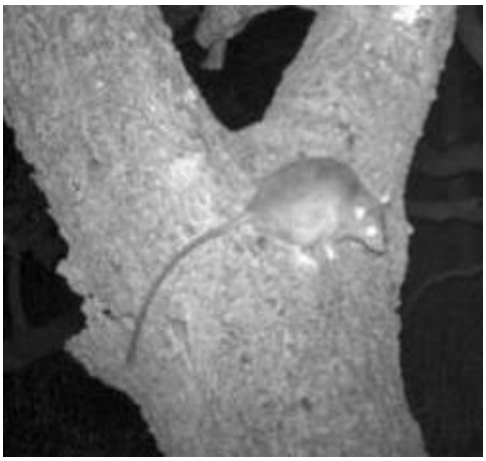
Two feral bird species were confined to disturbed areas and the fringes of the Reserve, the common myna and house sparrow. Others are irregular visitors such as the northern mallard to wetlands adjacent to Captain Cook Drive and the rock dove which was occasionally observed flying over the Reserve or along Captain Cook Drive (Map 7). The Eurasian blackbird has only been recorded once in the last 25 years but is likely to be an occasional visitor to the Reserve.

All of the feral bird species not recorded in the Reserve in the last 25 years (see section 5.2) are likely to occasionally still occur, being the Eurasian skylark, European goldfinch and European greenfinch (see locations of old records in Map 7).

5.9 Introduced Mammals

Six species of introduced mammals have been recorded in Towra Point NR in the last 25 years, three of which are listed as a Key Threatening Process under the TSC Act and/or the EPBC Act. These species are the fox, cat and the rabbit. The feral dog, also listed as a Key Threatening Process, was recorded in the Reserve more than 25 years ago; a pack of wild dogs was reported to have been shot near Towra Point in the 1970s as they were attacking horses and people (Australian Littoral Society 1977). All of these species are profiled in section 6.4 of this report.

One cat was photographed by the infra-red camera traps in 2013, on the Towra Point Track. Photo © M. Schulz



Black rats were photographed at all of the infra-red camera sites in 2013. This one is in a grey mangrove. Photo © OEH

The fox, although formerly widespread within the Reserve and across the Kurnell Peninsula as a whole, was not recorded during the 2013 survey despite the 600 infra-red camera trapping nights. This lack of recent records indicates the success of the current fox control program, both within the Reserve and on adjacent lands. The infra-red camera trapping also indicated the rarity or patchiness of the other two feral species listed as Key Threatening Processes, with no rabbits photographed and only one feral cat photographed (the latter in Littoral Forests on the Towra

Point Track).

A black rat 'highway' occurs on the edge of the western end of Towra Beach within 30 metres of an Australian pied oystercatcher nest. Photo © M. Schulz

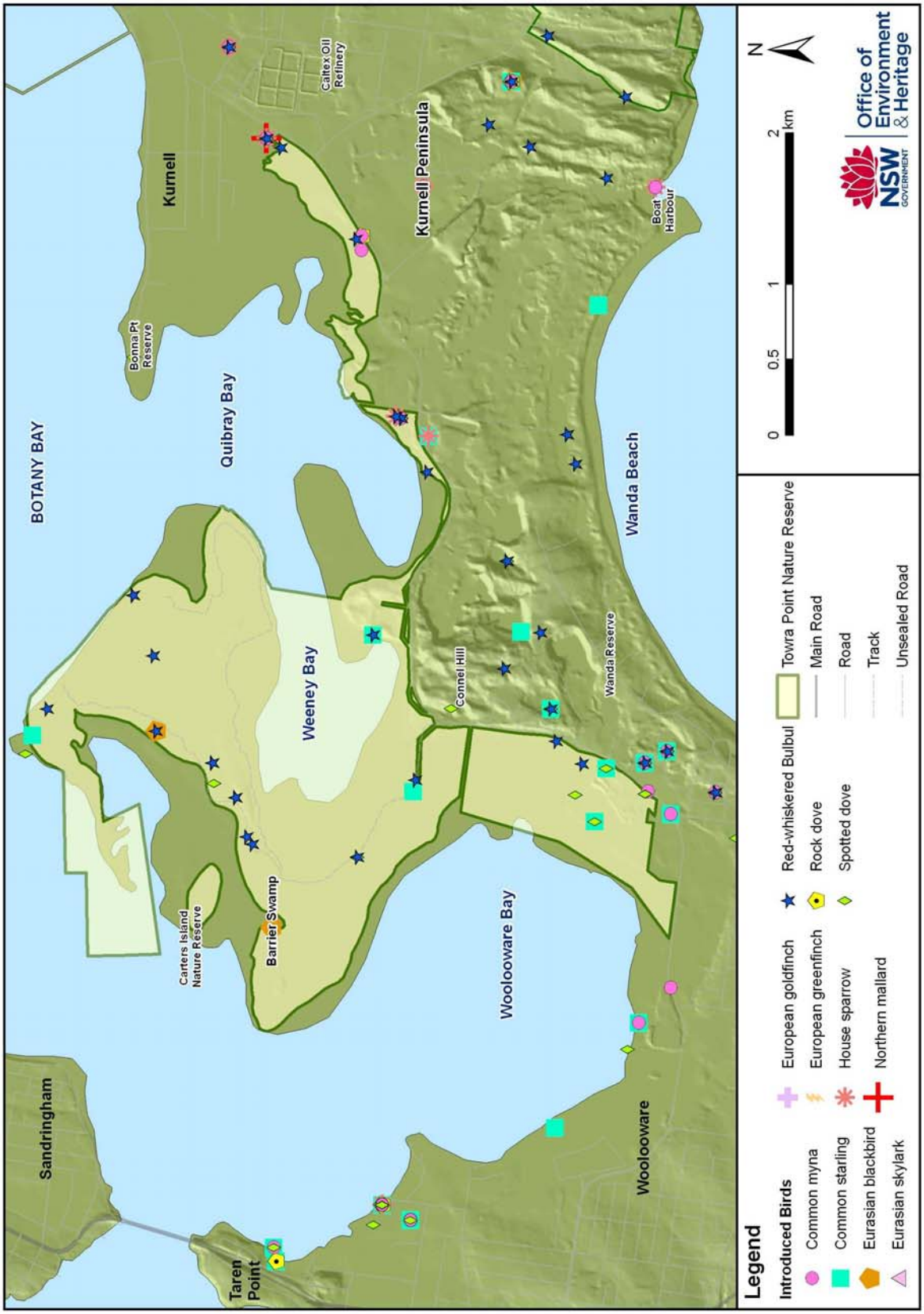
The black rat is widespread across the Reserve, occurring in all vegetation communities including Estuarine Mangrove Forest, Estuarine Saltmarsh, Beach Spinifex Grassland and along the Shoreline. Individuals were observed entering and exiting hollows in mature grey mangrove trees in intertidal areas in 2006 and rat-chewed remains of crabs were found within many hollows of these trees. The species abundance is indicated by it being photographed at all 11 infra-red camera trapping sites during the 2013 survey, including on Carters Island, in freshwater wetlands at Mirrormere and in sea rushland on the inland margin of Saltmarshes in the Fish Creek area. It was also seen during nocturnal site spotlighting surveys in all habitat groups during the 2006 survey. The black rat is listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (Lowe et al. 2004) and is known to negatively impact native fauna on islands. Given the impact on island faunas it is expected that there is at least some impact on native fauna within the Reserve (after Stokes et al. 2009). It is considered that beach-nesting birds such as the little tern may be particularly vulnerable (e.g. Bishop et al. 2009, 2010). The impact of this feral species on other threatened fauna, such as the white-fronted chat is currently unknown. Current management approaches are restricted to Towra Spit Island where a rat baiting program is undertaken prior to and during each little tern breeding season (Bishop 2011a, Bishop et al. 2009, 2010).

Two other introduced rodents have been recorded but appear uncommon and/or patchily distributed in the Reserve (Map 8). The house mouse has been recorded from scattered localities across the Reserve in a variety of habitats including Saltmarshes, Littoral Forests and Maritime Grasslands. The status of the brown rat is uncertain as it was not detected during the 2013 survey.

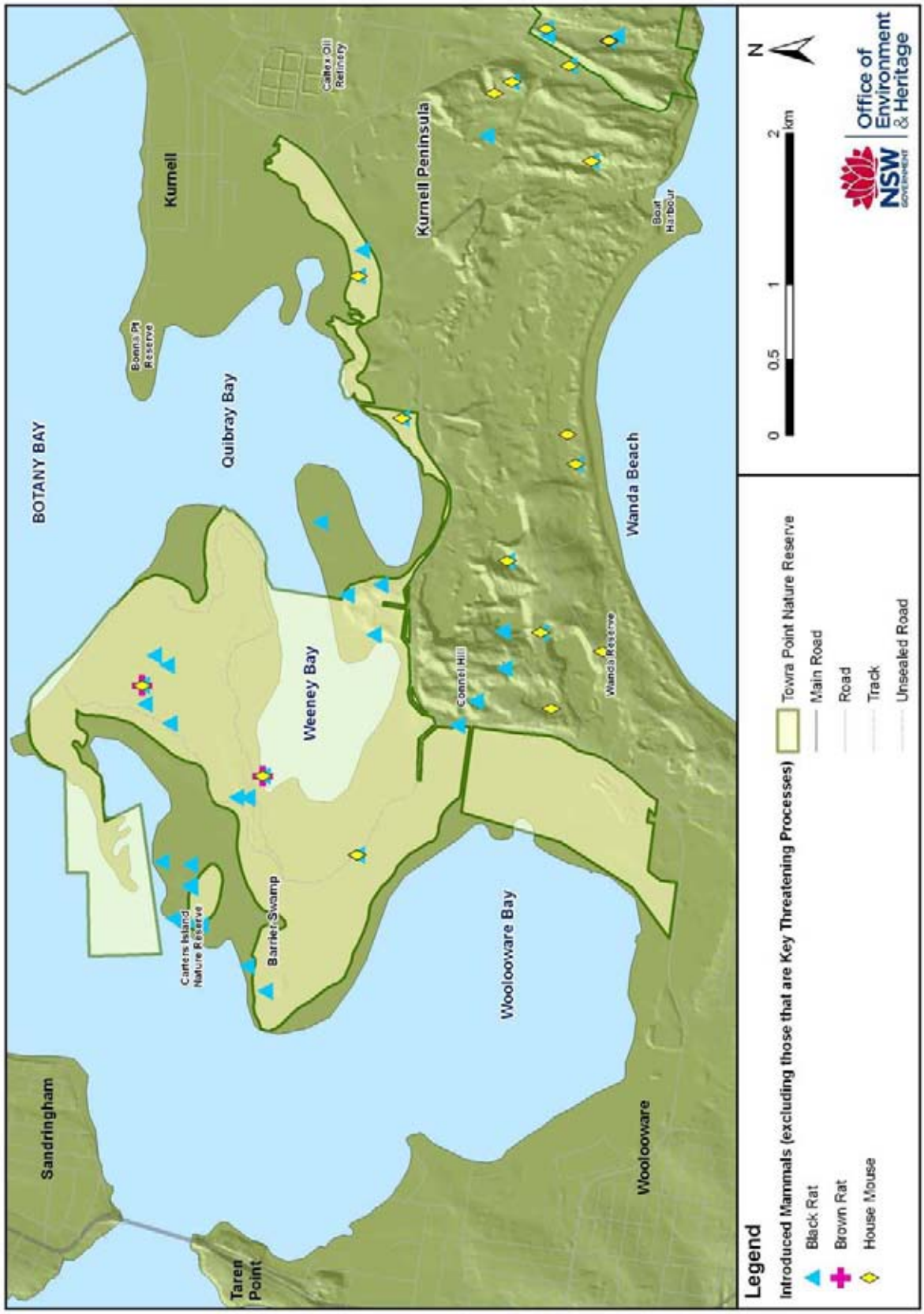
Domestic dogs occasionally occur in the Reserve, either accompanying people landing by boat along the shoreline or accompanying joggers in the Captain Cook Drive area. The incidence of domestic dogs is likely to increase with the increase of residential developments in the vicinity of the Reserve.

This eastern barn owl was photographed by an infra-red camera trap set near Weedy Pond in March 2013. Photo © OEH

Map 7: Distribution of feral bird records in Towra Point Nature Reserve (only includes records from OEH (2013a))



Map 8: Distribution of introduced mammal records in Towra Point Nature Reserve, excluding those listed as a Key Threatening Process



6 Threatened Species

6.1 Format of the Species Profiles

COMMON NAME		*Scientific name*
EPBC Act: Current Listing	**TSC Act: Current Listing**	**Study Area: Management Priority Ranking**

Photo of the species

Occurrence in the Study Area

This section details the species status in Towra Point NR including a summary of existing records and a summary of habitat use and key locations.

Regional Conservation Significance

This section includes an assessment of the significance of the habitat within the Reserve to conservation of the species in the Sydney Basin Bioregion.

Threats within the Study Area

In this section Key Threatening Processes listed under the TSC Act and other threats relevant to the conservation of the species within the Reserve are identified. For species that are vagrants, rare visitors or are unconfirmed in occurrence no threats may be identified.

Management Considerations

A summary of key management considerations are provided. For species that are very rare in occurrence or are unconfirmed no management is identified.

A map of known records of the species in the Reserve is provided. Only spatially accurate records, or records with an accurate place name, are incorporated. Records with a low reliability of identification have not been incorporated on the maps.

6.2 Threatened Species

GREEN AND GOLDEN BELL FROG		*Litoria aurea*
EPBC Act: Vulnerable	**TSC Act: Endangered**	**Study Area: Moderate Priority**

Green and golden bell frog. Photo © M. Schulz

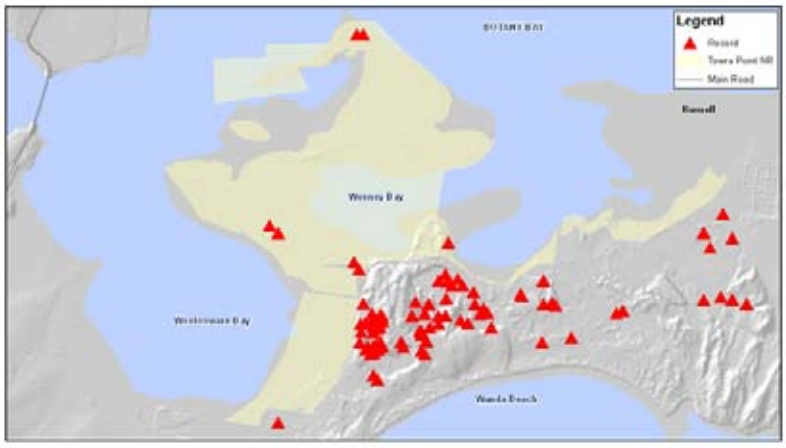
Former locality of the species at Towra Lagoon. Photo © M. Schulz

Occurrence in the Study Area

Status uncertain. The green and golden bell frog was previously known from a number of waterbodies in the Reserve, such as Towra Lagoon (e.g. White 2012). However, it has not been recorded in the Lagoon since seawater intruded during rough sea conditions and erosion on Towra Beach, which resulted from altered currents in Botany Bay generated by the construction of the third runway at Sydney Airport (White 2012). This species has also been recorded in the past at the Towra Point Track causeway on the edge of Saltmarshes (1998, S. Anyon-Smith pers. comm.), in the Stables area (1977), from Captain Cook Drive between Quibray and Weeney bays (1993) (OEH 2013a) and on the eastern edge of The Knoll (DECC 2007c). Potential habitat also occurs at Weedy Pond. However there are no recent records (e.g. from Schulz 2006, Jones 2009, White 2012, this project) and the species is considered to probably be lost from the Reserve (White 2012). Never-the-less the Towra Beach renourishment project, and associated restoration and reclamation works, halted seawater egress into Towra Lagoon (Jones 2009) making it potentially suitable habitat for this frog once again. Few targeted surveys have been conducted in some sections of the Reserve, such as along the fringes of Saltmarshes or at Mirrormere on Towra Point, and it is still possible that the species may be present or occasionally occur. The green and golden bell frog is still known from sites adjacent to the Reserve, including land owned by Australand and Keegans Pond in Cronulla Sewerage Treatment Plant (DECC 2007c, DECC 2008a, White 2012).

Regional Conservation Significance

The green and golden bell frog has declined from a status where it was regarded as one of the most common frog species in the Sydney area to one that now has a fragmented distribution and is absent from at least 90 per cent of its former range (White and Pyke 1996). The decline was first noted in the 1980s (Osborne 1990) and the species is now limited to about 40 fragmented and isolated populations across the State (DEC 2005a). The Kurnell Peninsula population is the second largest in Sydney (DECC 2007c) and is key to the survival of the species in the Sydney Basin Bioregion. However, this population has significantly declined from 22 breeding sites in the 1970s to five sites in 2011, all in the south-west of the Peninsula (DECC 2007c, White 2012). In 2011 sites located in the land owned by Australand were considered the most important, followed by those at Cronulla Sewerage Treatment Plant (A. White pers. comm.). Towra Point NR is not known to currently contribute significantly to the regional conservation of the green and golden bell frog. However, given the proximity to currently occupied sites it is possible that the species may occasionally move into or through the Reserve or may still be present in unsurveyed areas. Hence the species has been given a moderate management priority ranking. The rediscovery of this species within the Reserve



would be of high regional conservation significance.

Threats within the Study Area

The reason for the species decline on the Kurnell Peninsula is considered to be at least in part attributable to chytridiomycosis infection (White 2012). Populations within Towra Point NR have been impacted by saltwater intrusion into Towra Lagoon. Additional threats include: nutrients and other pollutants leaching into the Botany Sands aquifer from industrial and landfill sites; silting up or infilling of waterbodies; weed invasion (e.g. spread of bitou bush and overgrowth of ponds); herbicide spraying; introduced predators such as plague minnow (*Gambusia holbrooki*), fox and feral cat; and the loss of habitat as a result of climate change.

Management Considerations

- Towra Point NR should be managed as if the species does occasionally occur in the Reserve or will be rediscovered in the future. Management should be in accordance with the *Management Plan for the Green and Golden Bell Frog Key Population at Kurnell* (DECC 2007c).
- Conduct targeted late spring/early summer surveys over a number of years in: freshwater wetlands (e.g. Mirrormere and Towra Lagoons on Towra Point); sea rush areas bordering Saltmarshes such as in the Fish Creek area; adjacent to Captain Cook Drive between the Towra Point Track causeway and the Woolooware Shorebird Lagoon (note that this locality is within one kilometre of the known locality at Cronulla Sewerage Treatment Plant); and adjacent to and eastwards of the Stables area north of Captain Cook Drive. Such surveys should be conducted after heavy or prolonged rain episodes following the recommended survey guidelines in DECC (2009). Consider the use of automated audio recorders as part of these surveys, to sample frog calls over a whole spring and summer period in potential habitat areas.
- Ensure all bush regenerator personnel (particularly those working in areas adjacent to Captain Cook Drive and on Towra Point) and OEH staff are aware of the possible occurrence of this species and of the importance of reporting suspected sightings.

Potential habitat at Mirrormere (left) and in sedgeland north of Captain Cook Drive between the Towra Point Track causeway and Woolooware Shorebird Lagoon (right). Photos © M. Schulz

BLUE-BILLED DUCK *Oxyura australis*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Nil as Unconfirmed

Blue-billed ducks. Photos © M. Schulz

Occurrence in the Study Area

Unconfirmed. There is a single record of this species from 'Kurnell Lagoon' in December 1990, but this is actually located south of Captain Cook Drive rather than within the Reserve. It is also mentioned as occurring in DECCW (2010a), but no primary reference source for this species within the Reserve could be found. Little suitable deep freshwater habitat is present within the Reserve. This species is very rare in the Sydney area (Hoskin et al. 1991). Therefore, the blue-billed duck is considered unconfirmed.

Regional Conservation Significance

Towra Point NR does not significantly contribute to the conservation of this species.

Threats within the Study Area

Nil.

Management Considerations

Nil.

AUSTRALASIAN BITTERN *Botaurus poiciloptilus*

EPBC Act: Endangered	TSC Act: Endangered	Study Area: Moderate Priority

Australasian bittern. Photo © T. Shimba/OEH

Occurrence in the Study Area

Status uncertain. Occasional individuals have been recorded from dense reeds and sedges bordering the Woolooware Shorebird Lagoon (OEH 2013a). Potential habitat also exists in wetlands and extensive sedgelands between the interface of Saltmarshes and terrestrial vegetation communities, particularly on Towra Point and adjacent to Captain Cook Drive. The species preferred habitat is shallow vegetated freshwater or brackish swamps dominated by sedges, rushes and/or reeds (Marchant and Higgins 1990). However, targeted nocturnal call playback in February 2013 along Captain Cook Drive and the Towra Point Track causeway did not locate this species, nor did infra-red camera traps set in the Fish Creek area or at Mirrormere. There are however a number of recent records from wetlands adjacent to the Reserve, such as at Keegans Pond in Cronulla Sewerage Treatment Plant (March 2007, DECC 2008a). This species is likely to have been under-recorded due to its nocturnal habits, the fact that it frequents wetland habitats that are difficult to traverse, and due to its probable sporadic occurrence.

Regional Conservation Significance

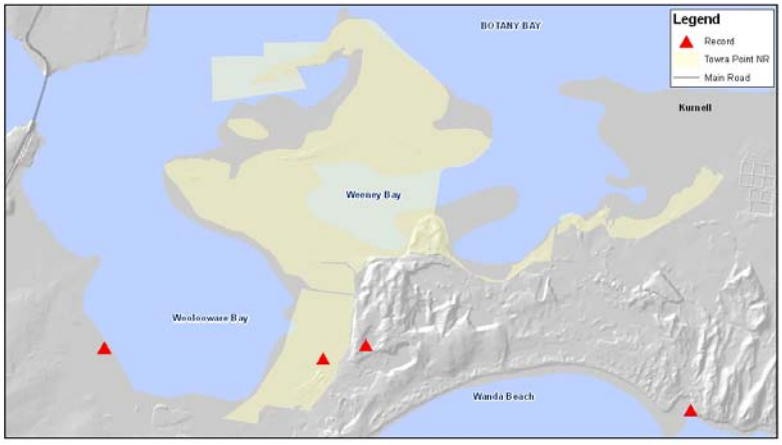
The Australasian bittern's global conservation status is Endangered; the total population in Australia, New Zealand and New Caledonia is estimated at between 1500 and 4000 individuals (BirdLife International 2013). This secretive wetland species is rare and only occasionally recorded within the Sydney Basin Bioregion, with an increase in sightings during severe inland droughts (Hoskin et al. 1991, DECC 2007b). Within New South Wales the overall population has dramatically declined and from surveys in 2009-10 is estimated at a maximum of 162 individuals (Birds Australia 2010). There are no documented breeding records for the region (Chafer et al. 1999). The importance of wetlands within the study area to the conservation of the Australasian bittern is unclear and hence it is a Moderate Conservation Management Priority fauna species.

Threats within the Study Area

Potential threats include: alteration in wetland hydrological characteristics such as saltwater intrusion into Woolooware Shorebird Lagoon and Towra Lagoon; weed infestation particularly of the spiny rush (*Juncus acutus*); predation by the fox; and loss of habitat as a result of climate change (Kingsford 2000, Garnett et al. 2011, OEH 2012). An additional threat is of nutrients and other pollutants leaching into the Botany Sands aquifer from adjacent industrial and landfill sites (DECC 2007c).

Management Considerations

- Conduct targeted surveys over a number of years in spring and early summer using call playback, passive listening at dawn and dusk, and active searching. Recommended areas include extensive sea rush areas bordering Saltmarshes and areas of common reed. Surveys would aim to improve the understanding of species occurrence and distribution and assess breeding status.
- Continue the active fox control program, including baiting around sedgeland fringing Saltmarshes.
- Encourage OEH staff to report any possible sightings.
- Enter all sightings into the Birdlife Australia nationwide Australasian and Australian little bittern project.



EASTERN OSPREY *Pandion cristatus*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Moderate Priority

Eastern osprey. Photo © M. Schulz

Occurrence in the Study Area

Regular visitor. Habitats visited include Shorelines, inshore waters and adjacent Mangrove Swamps including the Woolooware Shorebird Lagoon (e.g. NSW Wader Study Group data, OEH 2013a). A pair of eastern osprey has regularly been observed in the Reserve over the last couple of years including at Pelican Point, Towra Spit Island, Weeney, Quibray and Stinkpot bays; three individuals were observed in July 2011 (Schulz 2006, DECC 2008a, OEH 2013a, D. Andrew pers. comm., Birdline NSW 2013). One individual was observed carrying a stick at Towra Spit Island in December 2010 (NSW Wader Study Group data) indicating the potential for nesting in the area. Morris (1989) classed the eastern osprey as a rare visitor to the nearby Kamay Botany Bay NP, with a single bird recorded in January 1973. However, it is regularly observed in the lower reaches of the Georges River, such as around the junction of the Woronora River (DECC 2008a, D. Andrew pers. comm.) and occasionally to the south in Port Hacking and along the Royal NP ocean shoreline (DECCW 2011b).

Regional Conservation Significance

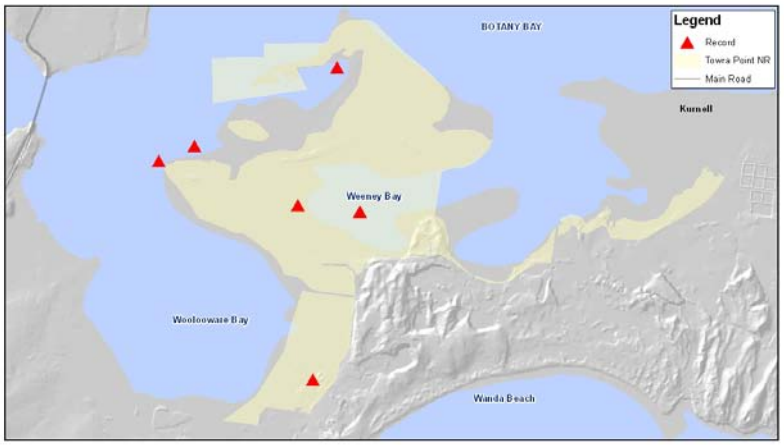
The eastern osprey occurs infrequently in the Sydney Basin Bioregion, mainly as single individuals in coastal estuaries and waterways. There are few nesting records in the region, with the exception of a pair that has nested on a number of occasions in the Narrabeen Lake area (DECC 2008a), and a pair that nested in Illawong in 2013 (D. Andrew pers. comm.). In mid-2013 osprey were observed attempting to build a nest on a yacht mast in Woolooware Bay (J. Dawes pers. comm.). The importance of Towra Point NR to the regional conservation of the species is currently uncertain. However if nesting was confirmed to successfully occur then it would be one of the most southerly nesting locations for the species in the State and would elevate the species management priority rank.

Threats within the Study Area

Potential threats include: disturbance by the public; ingestion of prey items containing pollutants and fish hooks; entanglement with fishing line and other refuse items; pollution of inshore waters, including indirect impacts on prey species; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Investigate the feasibility of establishing one or more predator-proof artificial nest platforms above high water mark in the Fish Creek area, to encourage nesting in the Reserve. Platforms would need to be constructed on poles in open areas more than 10 metres from the nearest tree, enabling birds to have maximum visibility of the surrounding terrain. The nest platform(s) could follow the design used elsewhere in Australia (e.g. Bischoff 2001, Dennis 2007, Howard 2011) or overseas (e.g. Martin et al. 1986, The International Osprey Foundation 2011, New Jersey Division of Fish and Wildlife 2013, The Peregrine Fund 2013).
- Protect roosting habitat, including posts associated with oyster leases.
- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.



BUSH STONE-CURLEW *Burhinus grallarius*

EPBC Act: Not Listed	TSC Act: Endangered	Study Area: Nil as Unconfirmed/Extinct

Bush stone-curlew. Photo © M. Schulz

Occurrence in the Study Area

Unconfirmed record and species locally extinct. The only record for the Reserve in the Atlas of NSW Wildlife is of a single bird recorded at 'Towra Point' in October 1982 (OEH 2013a). However, it is likely that this record is erroneous, possibly deriving from the sighting of a beach stone-curlew which is a rare visitor to the Reserve.

Regional Conservation Significance

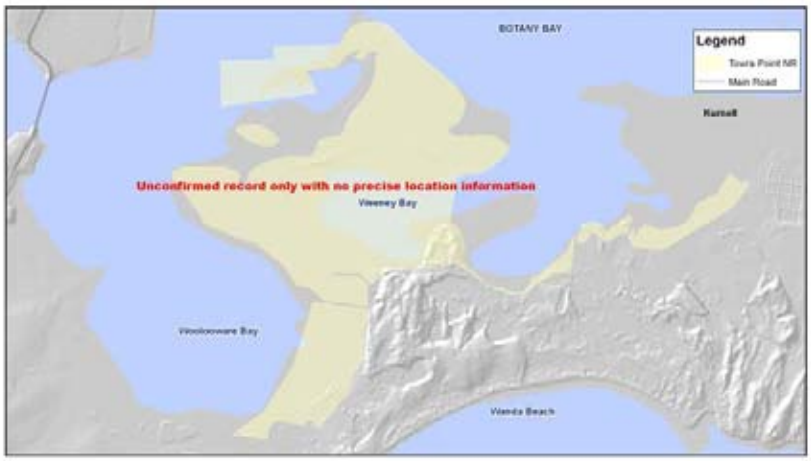
The bush stone-curlew has declined in abundance and distribution in New South Wales, with an overall population estimated at 1000 breeding pairs and declining (DEC 2006). The stronghold of the species in the State is in an area bounded roughly by Albury, Wagga Wagga, Hay and Wentworth (Barrett et al. 2003). The species was formerly widespread in suitable habitat across the Sydney Basin Bioregion, including a pair resident in the Sydney Botanic Gardens (Hoskin et al. 1991, Marchant and Higgins 1993). Today it is close to extinction in the region with small numbers persisting on the Central Coast, particularly around Brisbane Waters, and widely scattered resident individuals in the Pittwater-Avalon area and at Orchard Hills on the Cumberland Plain (DEC 2006, DECC 2007b, 2008a). As the species has not been confirmed in Towra Point NR and is locally extinct, the study area does not make any contribution to the conservation of this species in the Sydney Basin Bioregion.

Threats within the Study Area

Nil.

Management Considerations

Nil.



BEACH STONE-CURLEW *Esacus magnirostris*

EPBC Act: Not Listed	TSC Act: Critically Endangered	Study Area: Low Priority

Beach stone-curlew. Photo © T. Sugiyama/OEH

Occurrence in the Study Area

Rare visitor. Single birds have been recorded at Woolooware Shorebird Lagoon, Pelican Point, Towra Spit Island and Towra Beach (e.g. December 2001, November 2003, January/February 2004, February/November 2010 and November 2011) (Morris 2001, Jones 2004, Birdline NSW 2013, D. Andrew pers. comm., OEH 2013a).

Regional Conservation Significance

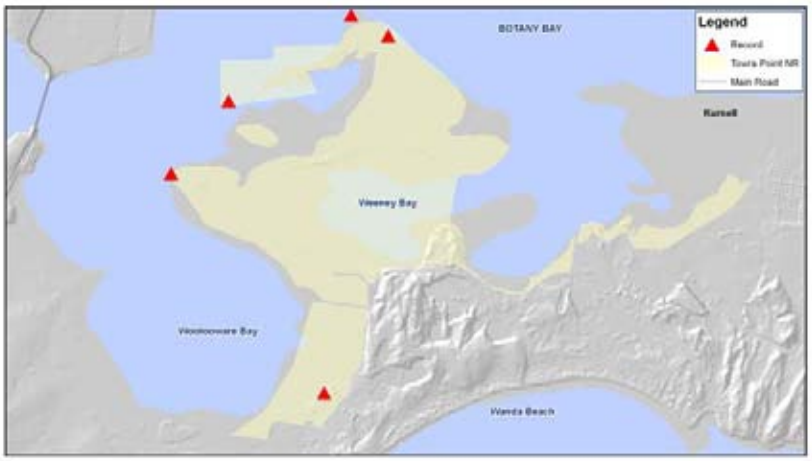
The beach stone-curlew occurs in small numbers on beaches and river entrances in far north-east NSW and is a rare visitor to the Sydney region (Hoskin et al. 1991, Marchant and Higgins 1993). The estimated total population in the State is eight pairs, with some possible interchange with birds in south-eastern Queensland (Rohweder 2003, NSW Scientific Committee 2011b). The single transient birds that are observed at several locations between Sydney and the Victorian border are probably dispersing juveniles (NSW Scientific Committee 2011b). Due to the rarity with which this species visits the Reserve, and the great distance from the species population centres, the Reserve is considered to contribute only a small amount to the regional conservation significance of the beach stone-curlew.

Threats within the Study Area

Potential threats include: disturbance by the public; collection of intertidal invertebrates by fisherman for bait and food; disturbance by domestic dogs; predation at roosts by the fox and feral cat; weed invasion of roosting habitat on Towra Spit Island; hydrological changes to shorelines; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Spit Island, Pelican Point and Towra Beach.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.



AUSTRALIAN PIED OYSTERCATCHER

Haematopus longirostris

EPBC Act: Not Listed	TSC Act: Endangered	Study Priority: Highest

Australian pied oystercatcher. Photo © M. Schulz

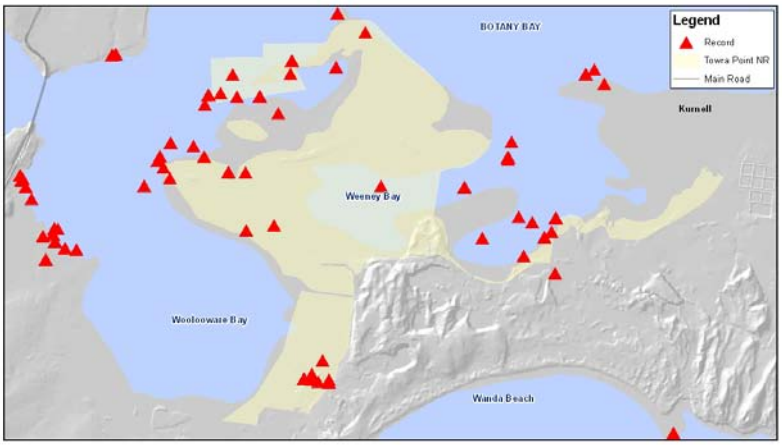
Australian pied oystercatcher nest in oyster post in Quibray Bay just outside the Reserve. Photo © D. Andrew

Occurrence in the Study Area

Breeding resident. This species is widespread along the Shoreline, with roosting concentrations occurring on Towra Spit Island and nearby on old jetties, barges and other infrastructure in the Shell Point area (NSW Wader Study Group data). Numbers peak during the non-breeding season between mid-autumn and mid-winter, with a maximum of 71 individuals recorded roosting in the latter locality in April 2005 (NSW Wader Study Group data). The species is rarely observed around pools in Saltmarshes (M. Schulz pers. obs.). It nests on sand or in spinifex grassland where there is an extensive area of sand above the mean high tide level and the beach is backed by Maritime Grasslands on low primary dunes (D. Andrew pers. comm., J. Bishop pers. comm., M. Schulz pers. obs.). Nesting areas include: Towra Spit Island (up to two pairs on the west end and one pair on the east end), Towra Beach (usually one pair on the Elephant's Trunk and irregularly one pair on Towra Point itself) and Pelican Point (typically one pair). Additionally up to two pairs have been recorded nesting on islands in Woolooware Shorebird Lagoon (J. Bishop pers. comm., H. Watson pers. comm., Birdline NSW 2013), one pair has been recorded nesting on oyster lease posts in Towra Point Aquatic Reserve south-west of Carters Shoals (D. Andrew pers. comm.) and another pair on posts in Quibray Bay (D. Andrew pers. comm.). It is not known if chicks were successfully fledged from the oyster lease post sites. No recent nesting records have been documented from adjacent areas on the Kurnell Peninsula (e.g. DECC 2008a, DECCW 2011a), although it is suspected to nest on private land in lagoons on the south side of Captain Cook Drive (D. Andrew pers. comm.).

Regional Conservation Significance

The Australian pied oystercatcher occurs at beaches and embayments along the New South Wales coastline. The total population was estimated at 250 individuals in 1991 (Smith 1991), 232 in 1998 (Owner and Rohweder 2003) and fewer than 200 breeding pairs in the State in 2008 (NSW Scientific Committee 2008c). The species disappeared from beaches around Sydney at the turn of the century, but recolonised Botany Bay in 1973 (Hindwood and McGill 1958, Rogers 1974, Hoskin et al. 1991, Straw 1996). Numbers observed in Botany Bay increased dramatically during monitoring undertaken between 1972 and 1996, with several sightings of individuals that had been colour-banded in Victoria (Straw 1996). In Botany Bay numbers peak between mid-autumn and mid-winter with a maximum of 71 individuals counted (NSW Wader Study Group data). Most of these birds are non-breeding, but some individuals regularly nest in the Bay, predominantly within Towra Point NR. The breeding population in the Reserve comprises a significant component of the New South Wales population and consequently is of very high regional and State conservation significance.



Threats within the Study Area

Threats include: disturbance by the public, particularly around nesting locations; collection of intertidal invertebrates by fisherman for bait and food; disturbance and predation by domestic dogs; predation of eggs and/or chicks by the Australian

raven, silver gull, fox and feral cat; potential predation of eggs by introduced rats; shoreline changes including beach erosion; pollution of inshore waters, including indirect impacts on intertidal invertebrates; weed invasion (such as sea spurge (*Euphorbia paralias*)) of nesting habitat in Beach Spinifex Grassland; entanglement or ingestion of anthropogenic debris, particularly entanglement of runners after hatching; alteration in structure of Saltmarshes and loss of Saltmarshes due to mangrove invasion; loss of oyster lease and other posts as nesting and high tide roosting sites; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- At nesting locations such as Towra Spit Island follow the best-practice guidelines for managing threatened beach-nesting shorebirds in New South Wales (DECC 2008b).
- Continue the active shorebird nest management program on Towra Spit Island (see profile for little tern) which includes: removal of encroaching vegetation; removal of flotsam and jetsam; removal of weed species; regular patrols; baiting for foxes, rats and ants; and removal of problematic Australian ravens and silver gulls.
- Undertake regular patrols to enforce the restriction of public access to parts of Towra Beach and Pelican Point. This could include extension of the patrols undertaken during the little tern breeding season to the sand areas on the far west end of Towra Beach at the entrance to Towra Bay.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Erect signs near known nesting locations, particularly at locations with restricted public access on Towra Beach, to educate the public about the high environmental sensitivity and conservation significance of the area.
- Continue the existing monitoring of the Australian pied oystercatcher in the Reserve, including monitoring fledgling success on Towra Spit Island and monitoring the location of nests elsewhere in the Reserve (i.e. Towra Beach, Pelican Point, the islands in Woolooware Shorebird Lagoon) and on oyster posts within the adjoining Aquatic Reserve.
- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Consider expanding the rat baiting program to include Pelican Point and the west end of Towra Beach before and during the nesting season.
- Consider expanding the removal of flotsam and jetsam to include Towra Point and Pelican Point prior to and during the Australian pied oystercatcher nesting season.
- Support the program of monitoring and replacement of old oyster lease posts.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.

Black rat tracks within 30 metres of Australian pied oystercatcher nest at the Elephant's Trunk (left) Photo © M. Schulz. Australian pied oystercatchers roosting at high tide amongst migratory shorebirds on Towra Spit Island (right) Photo © J. Bishop.

SOOTY OYSTERCATCHER *Haematopus fuliginosus*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Low Priority

Sooty oystercatcher. Photo © M. Schulz

Occurrence in the Study Area

Occasional visitor to shoreline areas including Towra Beach, Elephant's Trunk, Woolooware Shorebird Lagoon, Towra Spit Island and Carters Island in very small numbers (predominantly in ones and twos) with no documented nesting (e.g. NSW Wader Study Group data). The sooty oystercatcher regularly occurs elsewhere on the Kurnell Peninsula as a non-breeding visitor to rocky intertidal areas and occasionally adjacent ocean beaches (e.g. DECCW 2011a). It is most commonly seen in the Boat Harbour/Merries Reef area, with up to 23 individuals recorded at this location (DECC 2008a, D. Andrew pers. comm.). The closest nesting location is on the Five Islands south of Wollongong (Chafer et al. 1999).

Regional Conservation Significance

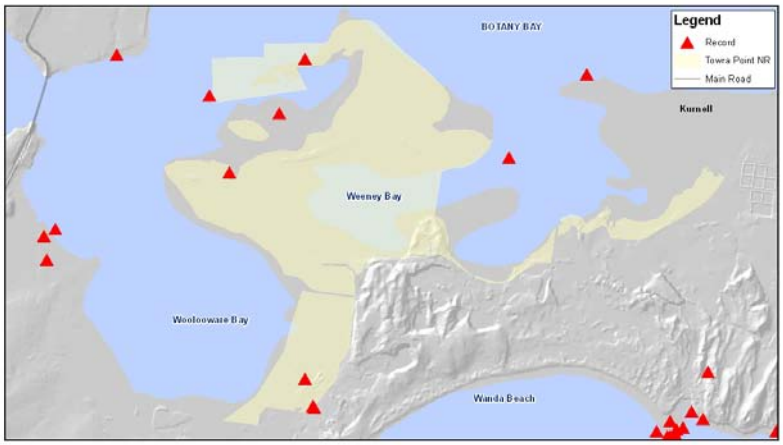
The sooty oystercatcher occurs on rocky shorelines and adjacent beaches and embayments along the New South Wales coastline. The total population was estimated at 200 individuals in 1991 (Smith 1991) and between 173 and 240 birds in 1996-2000 (NSW Scientific Committee 2008d). Within the Sydney area it occurs in small numbers as a non-breeding visitor (e.g. Hoskin et al. 1991, Chafer et al. 1999). This species was first documented in the Botany Bay area in 1953 (Hindwood 1955 cited in Straw 1996) and the Botany Bay-Bate Bay area is now critical to the conservation of the species in the Sydney Basin Bioregion. However Towra Point NR itself does not include rocky intertidal areas and only supports occasional visits of low numbers of this species. Therefore it is considered of low regional conservation significance to this species.

Threats within the Study Area

Disturbance by the public; collection of intertidal invertebrates by fisherman for bait and food; disturbance by domestic dogs; entanglement or ingestion of anthropogenic debris; predation by the fox and feral cat at roosts; weed invasion of roosting habitat on Towra Spit Island; hydrological changes to shorelines; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Continue the active management program on Towra Spit Island (see profile for little tern) which includes: removal of weed species, regular patrols, baiting for foxes.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.



LESSER SAND PLOVER *Charadrius mongolus*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: Low Priority

Lesser sand plover. Photo © T. Sugiyama/OEH

Occurrence in the Study Area

Rare and declining summer migrant. This species was last recorded in the Reserve in Quibray Bay in 1975 (OEH 2013a). However given that it is irregularly recorded at Boat Harbour, the species is likely to occur on more occasions in Towra Point NR than has been recorded, particularly on Towra Spit Island at high tide. Morris (1989) and Straw (1996) both noted numbers of the lesser sand plover to be declining in the Botany Bay area. The numbers recently seen at Boat Harbour and Merries Reef during the NSW Wader Study Group surveys are low (1 to 3 individuals) compared to observations in the late 1980s and early 1990s (19 to 26 individuals), This decline corresponds to declines elsewhere within New South Wales (e.g. Herbert 2007). Two subspecies of the lesser sand plover occur in New South Wales: *C. m. mongolus* and *C. m. stegmanni*. The subspecies that occurs in Towra Point NR is not known.

Regional Conservation Significance

The lesser sand plover principally occurs in littoral and estuarine environments, in scattered localities along the New South Wales coastline. Both subspecies are listed by Garnett et al. (2011) as Endangered. In 1991 there was an estimated total mid-summer population of 800 individuals in New South Wales (Smith 1991). Numbers in the Sydney area have declined in recent decades, similar to other localities such as the Hunter River estuary (Herbert 2007) and Shoalhaven estuary (Chafer et al. 1999). In the Hunter River estuary the species is now considered 'effectively locally extinct' (Herbert 2007). Botany Bay is listed as a site of national significance to the species with counts of over 200 birds in the past (Watkins 2003). However, numbers have gradually declined due to the loss of habitat, such as the old Cooks River estuary (Hoskin et al. 1991). The small numbers that now visit the Bay roost at Penrhyn Inlet and Boat Harbour and feed on intertidal flats in the northern part of the Bay (Straw 1996). The shoreline of Towra Point NR provides potential supporting habitat to the Botany Bay population. However, given that the lesser sand plover appears to be a very rare visitor, the contribution this habitat makes to the regional conservation of the species is considered low.

Threats within the Study Area

Potential threats within the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; hydrological changes to shorelines; and the pollution of inshore waters, including indirect impacts on intertidal invertebrates.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.

GREATER SAND PLOVER *Charadrius leschenaultii*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: Low Priority

Greater sand plovers. Photo © M. Schulz

Occurrence in the Study Area

Rare visitor to sandy beaches within the Reserve, with few recent documented records. Recent records include two individuals on Towra Beach in February 2002 and a single individual on Towra Beach in April 1987 (NSW Wader Study Group data, OEH 2013a). The greater sand plover is also a rare visitor to nearby Boat Harbour and Merries Reef (Blanchflower 2004, Morris 1989, OEH 2013a). This species can readily be confused with the lesser sand plover.

Regional Conservation Significance

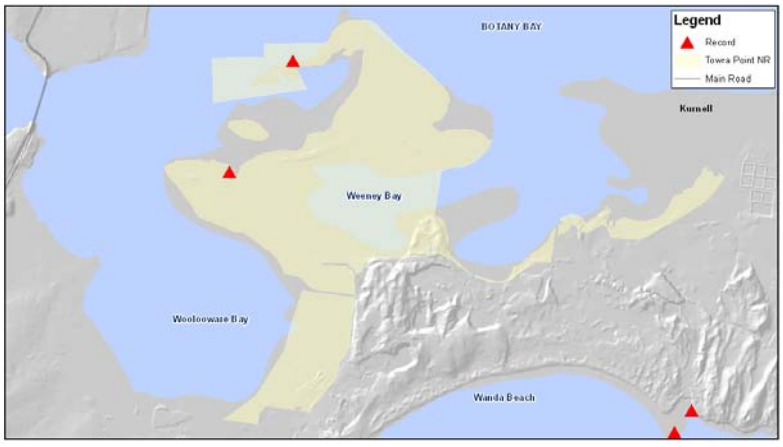
Three quarters of the East Asian-Australasian Flyway population of the greater sand plover (subspecies *C. l. leschenaultii*) occurs in Australia in the non-breeding period (Bamford et al. 2008). This species is listed by Garnett et al. (2011) as Vulnerable. The primary occurrence is in northern Australia, with areas of international importance in Queensland, Northern Territory and Western Australia (Watkins 1993, Bamford et al. 2008). In New South Wales the species occurs in littoral and estuarine environments in scattered localities along the coastline; in 1991 there was an estimated total mid-summer population of 80 individuals (Smith 1991, Marchant and Higgins 1993). It is rare in the Sydney Basin Bioregion. The incidence of sightings to the north of Sydney has declined in recent decades, such as in the Hunter River estuary (Herbert 2007). Within Botany Bay this species has primarily been observed at Boat Harbour or feeding on sand flats in the north (Straw 1996). Towra Point NR is considered of low regional conservation priority to the greater sand plover.

Threats within the Study Area

The primary threats facing this species occur at the migratory staging sites (Garnett et al. 2011). In the Reserve potential threats include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion of Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.



AUSTRALIAN PAINTED SNIPE *Rostratula australis*

EPBC Act: Endangered, CAMBA (as *R. benghalensis*)	**TSC Act: Endangered**	**Study Area: Low Priority**

Occurrence in the Study Area

Rare visitor. One male was observed foraging amongst reeds on the edge of Towra Lagoon on 15 February 2013 during surveys for the BSP project. Additionally, this species was stated as occurring at Towra Point by UBM Ecological Consultants (2009) citing Hoskin et al. (1991). However, Hoskin et al. (1991) actually refer to this species occurring at 'Woolooware Bay', the location of which may or may not have been within the current boundary of Towra Point NR. This species may have been under-recorded in the Reserve due to the fact that it occurs in wetland habitats that are difficult to traverse and its probable highly irregular occurrence.

Regional Conservation Significance

The Australian painted snipe was recently distinguished as a separate species from the greater painted snipe (*R. benghalensis*) which occurs in Africa and Asia (Lane and Rogers 2000, Christidis and Boles 2008). It is rare nationwide, with the total population estimated between 1000 and 1500 individuals and experiencing a decline of greater than an estimated 30 per cent in the past 26 years (Department of Sustainability, Environment, Water, Population and Communities 2011b). It is a rare visitor to the Sydney Basin Bioregion during periods of drought in inland areas (Marchant and Higgins 1990, Hoskin et al. 1991). In 2011-2013 there have been a number of reports in the Sydney and Illawarra areas (Birdline NSW 2013) as a result of several wet years inland followed by a drying period. The closest documented localities in which this species has been recorded during this period include Richmond, Pitt Town, Hawkesbury, Riverstone, Warriewood Wetlands and Sydney Olympic Park (Birdline NSW 2013). The Australian painted snipe is considered of low conservation management priority in Towra Point NR.

Threats within the Study Area

The decline of this species is principally attributed to loss and degradation of shallow ephemeral wetlands, replacement of native wetland vegetation with invasive weeds, and the grazing and trampling of wetlands (Rogers et al. 2005, Garnett et al. 2011). However no threats are specifically identified within Towra Point NR.

Management Considerations

Nil.

BLACK-TAILED GODWIT *Limosa limosa*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: Low Priority

Black-tailed godwit. Photo © R. Bennett/OEH

Occurrence in the Study Area

Rare visitor to shorelines within the Reserve, with few documented records. Single individuals were recorded in Quibray Bay in March 2007 and Woolooware Shorebird Lagoon in June 2002 and October 2006 (OEH 2013a). The species was also seen adjacent to the Reserve on oyster lease posts at the entrance to Quibray Bay in February 2003 (OEH 2013a). There are a few documented records for other parts of the Kurnell Peninsula, such as at Boat Harbour and Merries Reef (DECC 2008a, OEH 2013a). This species can readily be confused with the more common bar-tailed godwit.

Regional Conservation Significance

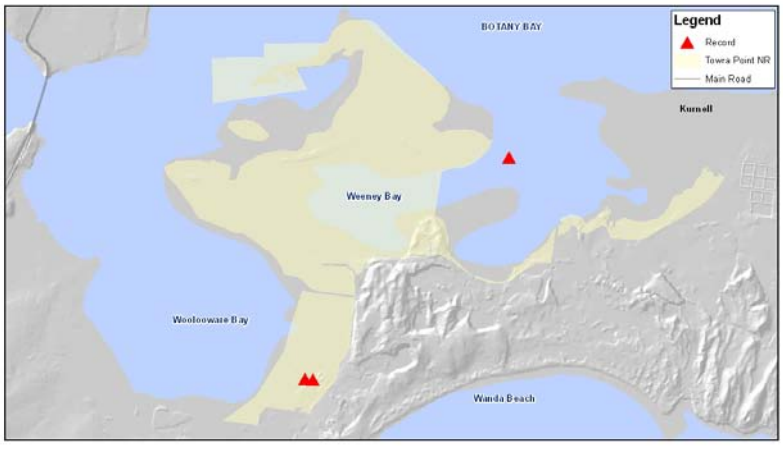
The majority of the East Asian-Australasian Flyway population of this species occurs in Australia in the non-breeding period (Bamford et al. 2008). In Australia there has been a decline of 20-29 per cent over the last 26 years (Garnett et al. 2011). The occurrence is concentrated on the northern coast between Darwin and Weipa, with the most important site being in south-east Gulf of Carpentaria (Watkins 1993). Smaller numbers occur at other coastal and inland wetlands across Australia (Blakers et al. 1984, Geering et al. 2007). In New South Wales the black-tailed godwit principally occurs in sheltered bays, estuaries and lagoons in scattered coastal localities, with the Hunter River estuary listed as a site of international importance (Bamford et al. 2008). Numbers have declined in the Hunter River estuary, dropping from between 400 and 800 individuals in the 1970s and 1980s to less than 200 individuals in 2006/2007 (Herbert 2007). The species is a rare visitor to the Sydney region, including the Botany Bay area (e.g. Hoskin et al. 1991, Straw 1996, Chafer et al. 1999, Higgins and Davies 1996). Towra Point NR is considered of low regional conservation priority to the black-tailed godwit.

Threats within the Study Area

The primary threats facing this species occur at the migratory staging sites (Garnett *et al.* 2011). In the Reserve potential threats include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.



TEREK SANDPIPER *Xenus cinereus*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: High Priority

Terek sandpiper. Photo © T. Sugiyama/OEH

Occurrence in the Study Area

Uncommon visitor. Small numbers are regularly observed in the Reserve, including at Towra Spit Island, Pelican Point and Woolooware Shorebird Lagoon. This species may have been under-recorded due to its cryptic habit of roosting in mangroves (as reported in the Hunter River estuary and elsewhere (Higgins and Davies 1996, Herbert 2007)). Most records in Botany Bay are of more visible roosting individuals, seen at high tide on the barges and other derelict infrastructure in the Shell Point area of Woolooware Bay (NSW Wader Study Group data). The Reserve includes important supporting habitat for birds that use the Shell Point area. There are a few documented records for other parts of the Kurnell Peninsula such as Boat Harbour and Merries Reef (DECC 2008a, OEH 2013a).

Regional Conservation Significance

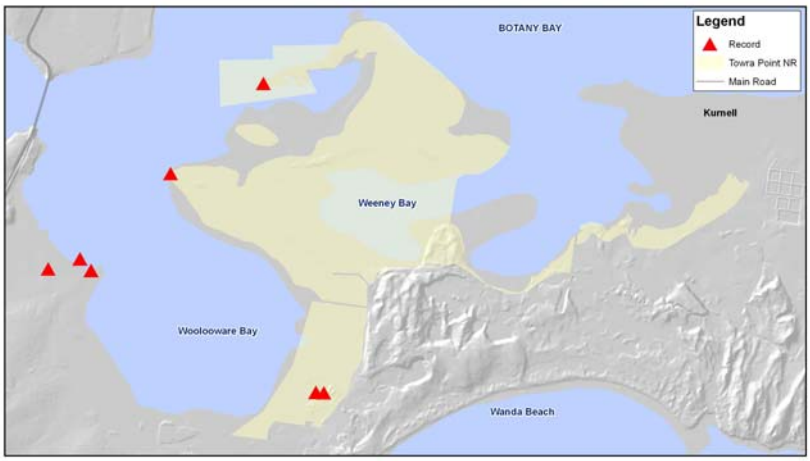
Less than half of the East Asian-Australasian Flyway population of the terek sandpiper occurs on the mudflats of northern Australia (Watkins 2003, Bamford et al. 2008). In New South Wales it principally occurs on intertidal mudflats in sheltered bays, estuaries and lagoons; the Hunter River estuary is listed as a site of international importance (Bamford et al. 2008). The terek sandpiper is a rare summer migrant in the Sydney area (e.g. Hoskin et al. 1991), with few records in Botany Bay prior to the mid 1970s (Straw 1996). Shorebird counts in Botany Bay indicate that this species has been declining in recent years (NSW Wader Study Group data). The primary known roosting area within Botany Bay is in the Shell Point area, while individuals forage on the intertidal flats between Taren Point and Woolooware Bay (Straw 1996, NSW Wader Study Group data). The Reserve provides supporting habitat to this important Shell Point area.

Threats within the Study Area

Potential threats in the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Conduct targeted surveys at high tide in summer by canoe/kayak in shallow mangrove areas to determine whether the species uses the mangroves.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates.
- Remove invasive plants from Towra Spit Island.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.



GREAT KNOT *Calidris tenuirostris*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: High Priority

Great knot. Photo © T. Shimba/OEH

Occurrence in the Study Area

Uncommon. Small numbers (less than 10 individuals) are infrequently observed on shorelines in the Reserve, principally on Towra Spit Island and also on adjacent sand shoals just outside the boundary (NSW Wader Study Group data, D. Andrew pers. comm.). Observations are primarily in the summer months (NSW Wader Study Group data). This species has also been recorded from Woolooware Shorebird Lagoon (OEH 2013a). There are a few documented records from Boat Harbour and Merries Reef, but the majority of records are from adjacent areas in Botany Bay, particularly from Shell Point and the oyster leases off Pelican Point (Morris 1989, NSW Wader Study Group data). Quibray and Weeney bays have been described as important feeding areas for this species (Straw 1996). The great knot can be confused with the more common red knot.

Regional Conservation Significance

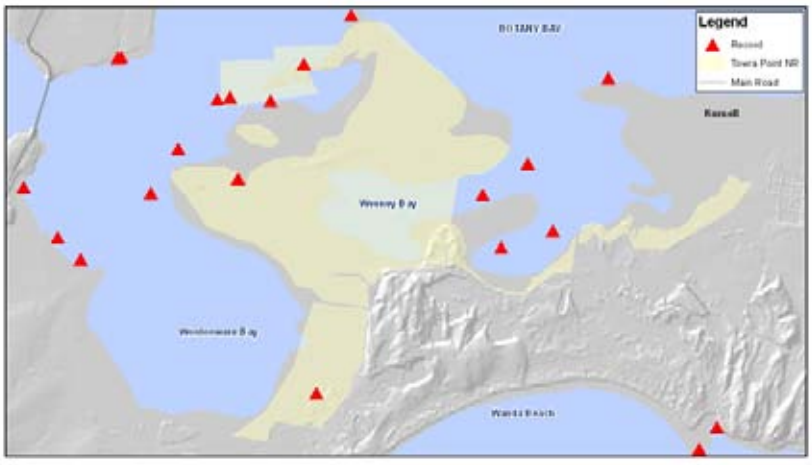
The great knot is restricted to the East Asian-Australasian Flyway, with Australia supporting 95 per cent of the total population in the non-breeding season (Bamford et al. 2008). This species declined by 34 per cent across 49 Australian sites between 1983 and 2007, principally attributed to the reclamation of tidal flats at Saemangeum in the South Korean Yellow Sea (Moores et al. 2008, Garnett et al. 2011). The species is principally concentrated on the coastal mudflats of north-west Australia, the Northern Territory and the Gulf of Carpentaria (Watkins 2003). In New South Wales, it primarily occurs in littoral and estuarine environments, with a total mid-summer population estimated at 50 individuals in 1991 (Smith 1991, Higgins and Davies 1996). It is rare in the Sydney area, with the majority of records from Botany Bay (Hoskin et al. 1991, Straw 1996, DECC 2008a) including Towra Point NR, Shell Point and the oyster leases off Pelican Point. Due to the fact that few sites regularly support this species in the Sydney Basin Bioregion, the Reserve is considered of high regional conservation priority.

Threats within the Study Area

The primary threats facing this species occur at the migratory staging sites (Garnett et al. 2011). In the Reserve potential threats include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Remove invasive plants from Towra Spit Island.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.



SANDERLING *Calidris alba*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: Low Priority

Sanderlings. Photo © M. Schulz

Occurrence in the Study Area

Very rare visitor. The only documented recent sighting was of a single bird in the Towra Spit Island/Carters Shoals area in December 2007 (NSW Wader Study Group data). The report by the Australian Littoral Society (1977) also lists this species as occurring within the Reserve. It is a declining occasional summer visitor to nearby Boat Harbour and Merries Reef. On that section of the Kurnell Peninsula shoreline it was regularly recorded in larger numbers prior to 1970 (Morris 1989, DECC 2008a, OEH 2013a). The sanderling may occur more frequently in Towra Point NR than gets recorded, particularly on Towra Spit Island and Towra Beach at high tide. This species can be confused with the more common but smaller red-necked stint.

Regional Conservation Significance

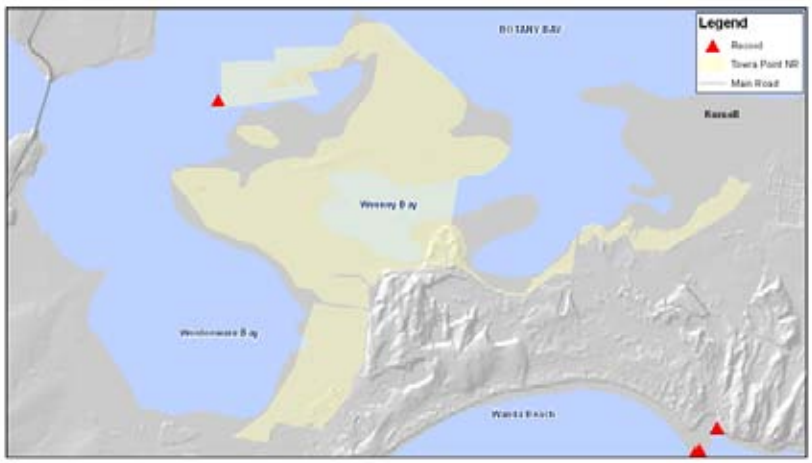
Nearly half of the East Asian-Australasian Flyway population occurs in Australia in the non-breeding season (Bamford et al. 2008). The species is widely scattered on sandy beaches around Australia, with no sites of international or national significance identified within New South Wales (Watkins 2003, Bamford et al. 2008). In New South Wales it principally occurs on ocean beaches and less commonly intertidal mud and sandflats, with a total mid-summer population estimated at 60 individuals in 1991 (Smith 1991, Higgins and Davies 1996, Geering et al. 2007). It is rare in the Sydney area and numbers have declined in recent decades (Morris 1989, Hoskin et al. 1991, Straw 1996, OEH 2013a). Towra Point NR is considered of low regional conservation priority to the sanderling.

Threats within the Study Area

Potential threats in the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.



CURLEW SANDPIPER		*Calidris ferruginea*
EPBC Act: CAMBA, JAMBA, ROKAMBA	**TSC Act: Endangered**	**Study Area: High Priority**

Occurrence in the Study Area

Very rare visitor. The only documented records are of single birds at Woolooware Shorebird Lagoon in September and October 2002, the Towra Spit Island area in October 2007 and 'Towra Point' in July 1983 (NSW Wader Study Group data, OEH 2013a). The report by the Australian Littoral Society (1977) also recorded this species in the Reserve. The Woolooware Shorebird Lagoon has been described as an important feeding area for this species (Straw 1996). However most records in the southern section of Botany Bay are of individuals roosting at high tide on barges and other derelict infrastructure in the Shell Point area of Woolooware Bay (NSW Wader Study Group data). The curlew sandpiper may occur more frequently in Towra Point NR than gets recorded, including potentially in areas of Saltmarshes.

Regional Conservation Significance

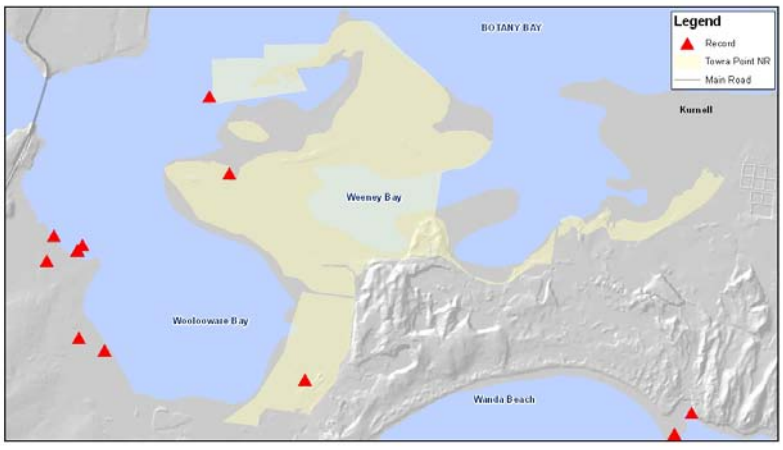
Over three quarters of the East Asian-Australasian Flyway population (Watkins 2003, Bamford et al. 2008) occurs in scattered localities across Australia. This species declined by 82 per cent across 49 Australian sites between 1983 and 2007, principally attributed to wetland degradation at migration staging areas in east Asia (Garnett et al. 2011). In New South Wales it principally occurs on intertidal mudflats in sheltered bays, estuaries and lagoons. Data collected by the Australian Wader Study Group indicates a 94 per cent decline in maximum annual counts of the New South Wales population between 1982 and 2010 (Herbert 2007). The Hunter River estuary is listed as a site of international importance (Watkins 2003, Bamford et al. 2008), however numbers have declined from 4000 individuals in the 1970s to 276 in 2006/2007 (Herbert 2007). The curlew sandpiper is an uncommon but regular summer migrant in the Sydney area (e.g. Hoskin et al. 1991, Chafer et al. 1999, DECC 2008a). It was relatively common in Botany Bay prior to 1986, when annual counts of between 300 and 700 individuals were made, but the species has significantly declined in subsequent years (Straw 1996). Given the national, state and regional declines of this species, the fact that Towra Point NR provides supporting habitat to the important Shell Point area, and the important feeding habitat in Woolooware Shorebird Lagoon (Straw 1996), the Reserve is considered to be of high regional conservation priority to the curlew sandpiper.

Threats within the Study Area

The primary threats facing this species occur at the migratory staging sites (Garnett et al. 2011). In the Reserve potential threats include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; hydrological changes to shorelines; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; alteration in saltmarsh structure; loss of saltmarsh due to mangrove invasion; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Remove invasive plants from Towra Spit Island.



BROAD-BILLED SANDPIPER *Limicola falcinellus*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Vulnerable	Study Area: Low Priority

Broad-billed sandpiper. Photo © T. Sugiyama/OEH

Occurrence in the Study Area

Very rare and declining visitor. There are no recent documented sightings within the Reserve, but the species is listed in the report by the Australian Littoral Society (1977). Most records in the southern section of Botany Bay are of individuals roosting at high tide in the Shell Point area of Woolooware Bay (OEH 2013a). There are a few documented records from Boat Harbour and Merries Reef, with three individuals recorded in January 1950 (OEH 2013a).

Regional Conservation Significance

Over one quarter of the East Asian-Australasian Flyway population of the broad-billed sandpiper occurs on mudflats of the north coast of Australia (Watkins 2003, Bamford et al. 2008). In New South Wales it principally occurs in littoral and estuarine environments, with a total mid-summer population estimated at 10 individuals in 1991 (Smith 1991, Higgins and Davies 1996). It is a rare visitor to the Sydney area (Hoskin et al. 1991), with most documented records from the northern shores of Botany Bay (Straw 1996). Towra Point NR is considered of low regional conservation priority to the broad-billed sandpiper.

Threats within the Study Area

Potential threats within the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; weed invasion on Towra Spit Island; entanglement or ingestion of anthropogenic debris; hydrological changes to shorelines; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Beach and Towra Spit Island.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.

LITTLE TERN *Sternula albifrons*

EPBC Act: CAMBA, JAMBA, ROKAMBA	TSC Act: Endangered	Study Area: Highest Priority

Little tern. Photo © OEH

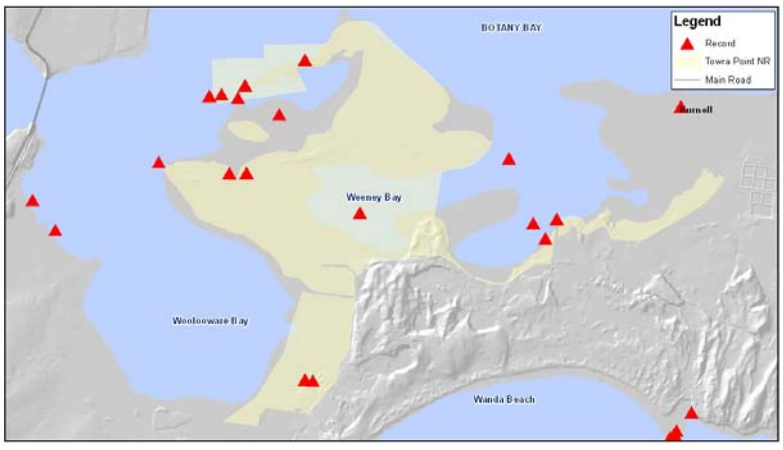
Little tern chick at Towra Spit Island. Photo © J. Bishop

Occurrence in the Study Area

Regular summer migrant. The little tern uses the shoreline and inshore habitats and has regularly nested on Towra Spit Island after relocation from Sydney Airport due to construction of the third runway (Priddel and Ross 1996). The number of nests and successful fledging of chicks varies greatly between years. For example, in the 2002-03 season 101 nests were recorded and 43 chicks fledged (Ross et al. 2003); in the 2008-09 season 50 nests were located and 50 chicks fledged; in the 2009-10 season no nesting was observed; while in the 2010-11 season 52 nests were located and 72 chicks fledged (Bishop 2011a, Bishop et al. 2009, 2010). In the two most recent seasons 2011-12 had 72 nests located with 85 chicks fledged, while in 2012-13 only 14 nests were located and 22 chicks fledged (Bishop 2012, 2013). In the latter season the terns nested very early with the last clutch laid in the first week of November. The presence of a peregrine falcon in 1994 resulted in complete nest abandonment (Priddel and Ross 1996); this may have been the reason that no nesting was observed in 2009-10 (Bishop et al. 2010). The little tern has also been recorded nesting at the far west end of Towra Beach at the entrance to Towra Bay, where two pairs bred in 1986-87 (A. Morris cited in Smith 1990), and at the entrance to Stinkpot Bay in the 2012-13 season (D. Andrew pers. comm.). It commonly forages over shallow inshore waters in Towra Point Aquatic Reserve and occasionally roosts on Towra Beach and the old oyster lease posts in Quibray Bay, where up to 60 individuals were observed in the 2009-10 nesting season (Bishop et al. 2010). Elsewhere on the Kurnell Peninsula, the species formerly nested in low numbers on the sand spit at Boat Harbour (with up to five pairs present in the late 1950s) but this has not occurred for over 50 years (NPWS 2003, O'Sullivan et al. 2001). Nesting was suspected to have occurred in the sandmining area south of Captain Cook Drive in the 2009-10 nesting season as adults were observed flying in that direction carrying fish (Bishop et al. 2010).

Regional Conservation Significance

The little tern principally occurs in sheltered coastal environments in scattered localities along the New South Wales coastline. It has declined through much of this range, probably as a result of human-related disturbance. Little terns of the subspecies *sinensis* (from eastern Australia and south-eastern Asia) migrate southwards to New South Wales, arriving between September and November, nesting from October through to February and then leaving from March to May (NPWS 2003). Winter records are very rare (NPWS 2003). Botany Bay (i.e. Towra Spit Island in most years) supports one of the largest and most successful breeding colonies of the eastern Australian population of little tern remaining in New South Wales and is listed as a priority site for the Sydney region (NPWS 2003). Original nesting sites in Botany Bay have been lost due to various developments, for example the entrance to Cooks River was destroyed during the construction of the Kingsford Smith Airport and a nesting site at Shell Point was destroyed for a housing development (Smith 1990). For these reasons the little tern nesting site is considered of highest management priority within the Reserve.



Threats within the Study Area

Threats within the Reserve include: hydrological changes to the shoreline resulting in loss of nesting habitat, exposure to inundation or connection of Towra Spit Island to the mainland; disturbance by the public and domestic dogs on Towra Spit Island; encroachment of vegetation and the growth of weed species such as coast pennywort resulting in unsuitable nesting habitat; predation of eggs and chicks by the fox, cat and introduced rats; loss of eggs by ant attack; loss of eggs by ghost crab predation; desertion of colony due to the presence of the peregrine falcon; predation of eggs and chicks by the Australian raven; predation of eggs and chicks by the silver gull, in addition to stealing of food from adults who are carrying food for chicks; entanglement or ingestion of anthropogenic debris, particularly by runner little terns; pollution of inshore waters, including indirect impacts on key fish species; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

Breeding productivity of the little tern at Towra Point NR has been assisted by intensive on-ground management. It is recommended that the current on-ground active management be continued in order to maintain and where possible increase breeding productivity within Towra Point NR. The management program includes strategies outlined in the little tern recovery plan (NPWS 2003) and follows the best-practice guidelines of managing threatened beach-nesting shorebirds in NSW (DECC 2008b). Measures undertaken at Towra Spit Island include (e.g. Priddel and Ross 1996, Ross and Jarman 2001, Ross et al. 2003, Bishop et al. 2009, J. Bishop pers. comm.):

- Redistribution of sand to reduce exposure to tidal flooding and prevent inundation using light engineering and sand-bagging techniques.
- Potentially nest relocation to higher ground to avoid inundation (following NPWS 2003).
- Preparation of an attractive nesting substrate prior to the nesting season (undertaken by OEH staff and volunteers). Measures include removal of encroaching vegetation such as hairy spinifex and weeds (particularly coast pennywort), removal of beachcast dead seagrass, removal of flotsam and jetsam, and raking of the sand surface in August or September to form areas of flat clear sand prior to the tern's arrival.
- A warden program to reduce human disturbance (in some years).
- Increase of patrols to three or four times a week during the nesting season and erection of signs in strategic locations to minimise public disturbance.
- Baiting of foxes (using 1080) on the island, in strategic locations elsewhere within the Reserve (following Bishop 2011b), and off-reserve elsewhere on the Kurnell Peninsula, with baiting increasing in intensity prior to and during the breeding season.
- Baiting of black rats on the Island prior to and during the breeding season.
- Baiting of ants on the Island prior to and during the breeding season.
- Monitoring of nests for potential predation by ghost crab (*Ocypode cordimana*) and active management where required (such as the placement of sheets of plywood under nests where crab burrowing is evident).
- Active management of problematic Australian ravens and silver gulls.
- A community education program.
- In August 2012 a backhoe and bobcat were used on Towra Spit Island to push sand into mounds and remove invading vegetation such as coast wattle, coast pennywort, sea rocket (*Cakile maritima*) and fleabane (*Conyza* spp.) resulting in an increase of nesting habitat by up to 50 metres square (J. Bishop and B. Hodgson pers. comm.).

Additional management considerations include:

- Ongoing funding of a warden program to minimise public disturbance to nesting birds every breeding season.
- Ensuring that Towra Spit Island remains isolated from the mainland to prevent access by foxes. This includes dredging where required, as undertaken in 2004 (DECCW 2010a).
- Further reducing public disturbance through extension of patrols during the nest establishment period to the sand areas on the far west end of Towra Beach at the entrance to Towra Bay. Note that the Australian pied oystercatcher currently nests within this area and would also benefit from reduced public disturbance.
- Assessment each season of whether nesting is occurring at suitable shoreline habitat in Quibray Bay and the far west end of Towra Beach.
- Continued support for monitoring of shorebirds (including little terns) in Botany Bay by the NSW Wader Study Group.

- Monitoring the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.

Little tern runners at water's edge, Towra Spit Island (top left). Photo © J. Bishop; little tern nesting habitat following site preparation, Towra Spit Island (top right). Photo © J. Bishop; signage on Towra Spit Island aimed at reducing public disturbance (middle left). Photo © J. Bishop; little tern eggs (middle right). Photo © J. Bishop; removal of invasive vegetation on Towra Spit Island (bottom left). Photo © J. Bishop; creation of prime nesting habitat for the little tern on Towra Spit Island, August 2012 (bottom right). Photo © J. Bishop.

MASKED OWL *Tyto novaehollandiae*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Low Priority

Masked owl. Photo © R. Jackson

Occurrence in the Study Area

Status uncertain. The only recorded occurrence of masked owl in the Reserve is of one bird responding to nocturnal call playback on a number of nights in May 2006 (Schulz 2006). The response was heard in bangalay and coast banksia-dominated Littoral Forests on Towra Point and at one stage the individual followed the observers into adjacent Estuarine Swamp Oak Forest. At the time of the observation there were a large number of black rats present in the area. The masked owl has not previously or subsequently been recorded in the Reserve nor elsewhere on the Kurnell Peninsula.

Regional Conservation Significance

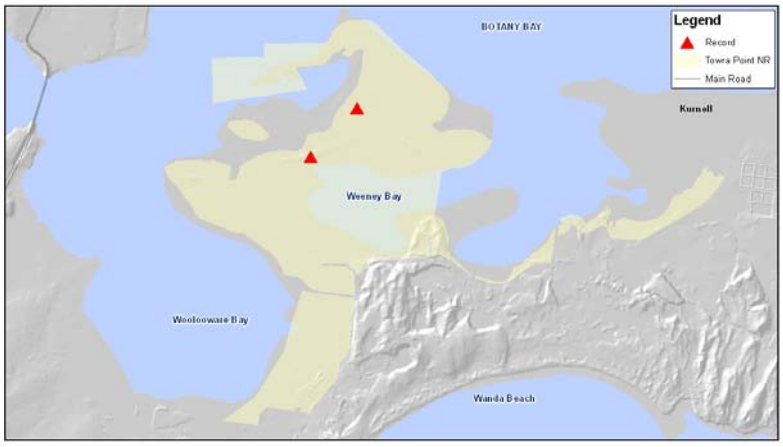
The masked owl is scattered in distribution across the Sydney Basin Bioregion with small numbers recorded irregularly in dry open forest and woodlands on soils of moderate to high fertility (DECC 2007b). Within the region, the open woodlands of the coastal plains between Wyong and Port Stephens support the highest numbers of the masked owl (OEH 2013a). Due to the fact that the masked owl has only been recorded once within the Reserve and that the patch of potential habitat is small in relation to habitat elsewhere in the region, the species is currently considered of low management priority. If a resident breeding pair was found to be present in the Reserve the management priority will require re-assessment.

Threats within the Study Area

Potential threats within the Reserve include: loss of hollow-bearing living and dead standing trees; hollow competition with the feral honeybee (*Apis mellifera*); difficulty in foraging due to the dense coverage of lantana, vines and other weed species in the understorey on Towra Point; and secondary poisoning from rodenticides.

Management Considerations

- Follow relevant management recommendations outlined in the statewide recovery plan (DEC 2006b).
- Avoid removal of hollow-bearing living and dead standing trees, and remove any honeybee colonies encountered in tree hollows.
- Continue the bush regeneration program in Littoral Forests on Towra Point.
- Avoid use of rodenticides within forested sections of the Reserve.



STRIATED FIELDWREN *Calamanthus fuliginosus*

EPBC Act: Not Listed	TSC Act: Endangered	Study Area: Nil as Unconfirmed/Extinct

Striated fieldwren. Photo © M. Schulz

Occurrence in the Study Area

Locally extinct. The striated fieldwren was last recorded in Saltmarshes in 1979 (Hoskin et al. 1991). There are no recent confirmed records despite targeted searching for the species (e.g. Morris 2002, Schulz 2006, DECC 2008a) and the detailed studies of the white-fronted chat population between 2008 and 2011 which has included mist netting in potential habitat areas (R. Major pers. comm.).

Regional Conservation Significance

The striated fieldwren is not known from elsewhere in the Sydney area, with the closest populations occurring in south-east Morton NP and in the Ulladulla region. The largest known populations occur between Eden and the Victorian border, particularly in Nadgee NR (Hoskin et al. 1991, Higgins and Peter 2002, DECC 2007b). Towra Point NR does not currently contribute to the regional conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.

REGENT HONEYEATER *Anthochaera phrygia*

EPBC Act: Endangered	TSC Act: Critically Endangered	Study Area: Low Priority

Regent honeyeater. Photo © OEH

Occurrence in the Study Area

Probably locally extinct. The regent honeyeater was last recorded by the Australian Littoral Society (1977) as a rare nomadic visitor. There are no records within the last 25 years. The species has not been recorded elsewhere on the Kurnell Peninsula in recent years, with the last records for Kamay Botany Bay NP in 1973 and 1974 (OEH 2013a). Given the decline of the species across its range and the lack of recent records from the southern Sydney area, it is very unlikely that the regent honeyeater continues to visit the Reserve. The primary feed tree relevant to the regent honeyeater in the Reserve is the swamp mahogany.

Regional Conservation Significance

The regent honeyeater has severely declined in abundance across its range, including within the Sydney Basin Bioregion. Within the bioregion the species is principally recorded in the Capertee, lower Hunter and Burragorang valleys and Central Coast with occasional sightings elsewhere (DECC 2007b, 2008a). It is a sporadic visitor to the region with its occurrence dependent on the concentration of flowering of key tree species, and the absence of flowering elsewhere within its range. Due to the lack of sightings of the regent honeyeater from the Reserve and neighbouring areas for several decades it is concluded that the study area does not contribute to the regional conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.

WHITE-FRONTED CHAT *Epthianura albifrons*

EPBC Act: Not Listed	TSC Act: Vulnerable, Endangered Population in the Sydney Metropolitan Catchment Management Authority Area	Study Area: Highest Priority

White-fronted chat. Photo © H. Cook

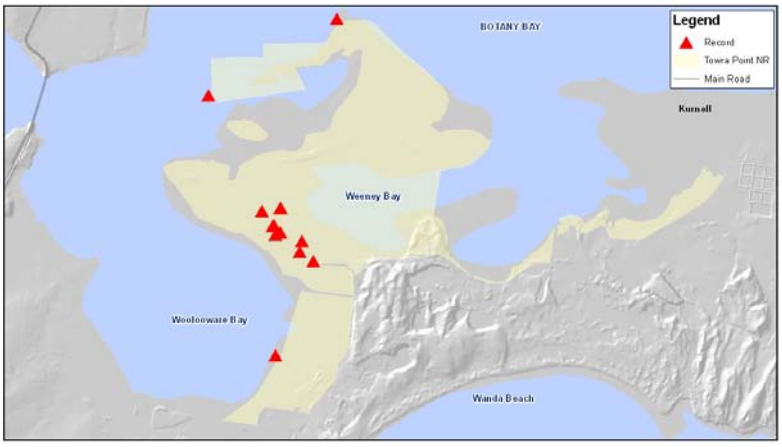
White-fronted chat habitat in Towra Point NR – extensive saltmarsh adjacent to the Towra Point Track causeway. Photo © M. Schulz

Occurrence in the Study Area

Rare resident. The white-fronted chat has been the subject of scientific research in Towra Point NR, particularly by the Australian Museum. Based on colour-banding studies the maximum population size of white-fronted chat in Towra Point NR was estimated to be around 24 individuals in 2010 and 16 birds in 2012 (R. Major pers. comm.). The population is primarily restricted to Saltmarshes, principally adjacent to the Towra Point Track causeway. No sightings have been made in Saltmarshes elsewhere in the Reserve such as on the east side of Towra Point (Schulz 2006, R. Major pers. comm.). Foraging primarily occurs in Saltmarshes dominated by beaded glasswort (K. Lindsay pers. comm.). Nesting occurs on the edges of areas dominated by sea rush and in sea blite. Nest success is variable; approximately half of the 12 nests located in 2010 fledged at least one young but only 20 per cent of nests fledged young in 2011. This fledging success is possibly higher than in studies conducted elsewhere (R. Major pers. comm.). Radio-tracking studies located one night-roost in Mangrove Swamps adjacent to Saltmarshes near the Towra Point Track causeway (R. Major pers. comm.). Radiotracking studies have shown the species to be relatively sedentary, however due to the limited battery life of the transmitters (around 14 days) movement information is limited. In winter 2011, colour-banded birds were found foraging in short-cropped exotic grasses on privately owned land to the south of Captain Cook Drive (R. Major pers. comm.). This area has subsequently been built out by the Greenhills Beach housing estate. Individuals are also occasionally reported from Towra Spit Island (e.g. NSW Wader Study Group data). There are recent reports of chats from the Boat Harbour area, however these sightings have not been confirmed and it is not known whether they are the same individuals as those regularly seen in the Reserve.

Regional Conservation Significance

The white-fronted chat has severely declined in the Sydney area, with remnant populations restricted to Towra Point NR and Homebush Bay (DECC 2008a). This decline is a reflection of a 36 per cent decrease in the reporting rate between 1984 and 2002 in the Sydney Basin Bioregion, and a greater than 20 per cent decrease across the nation over the same period (Barrett et al. 2003). The Homebush Bay population has dramatically declined, with only two males (both colour-banded) remaining in 2013 (R. Major pers. comm.). This makes the population at Towra Point NR the only remaining breeding population within the Sydney area. Consequently the Reserve contributes extremely significantly to the regional conservation of the white-fronted chat. The closest other known populations are from Shoalhaven Heads to the south and the Kooragang Island area of the Hunter River estuary to the north (R. Major pers. comm., Herbert 2007). Genetic studies indicate that the Towra Point population is isolated from these other populations (R. Major pers.



comm.). Interestingly, gene profiling has detected two migrant white-fronted chats at Towra Point NR; one of these individuals has bred on three occasions but two nests were depredated and the only young to reach independence was not recorded beyond two months.

Threats within the Study Area

Recent genetic evidence suggests that inbreeding is likely to be a serious threat to the small population in the Reserve (R. Major pers. comm.). Other threats include: the impact of climate change on key habitats; vulnerability of the small population to stochastic events (such as targeted predation by single individual avian predators such as has been observed with the Australian hobby (R. Major pers. comm.); loss of Saltmarshes due to mangrove invasion (a 62 per cent loss of Estuarine Saltmarsh has occurred between 1956 and 1999) (Wilton 2002, DECCW 2010a); nest predation from super-abundant Australian ravens, feral cats, foxes, rodents and other native predators; public disturbance; loss of secondary foraging habitat outside of the Reserve; and alteration in structure of Saltmarshes, including invasion by the spiny rush (a noxious weed).

Management Considerations

- As a matter of urgency, and in consultation/partnership with scientific researchers studying the population (such as the Australian Museum), conduct a study into the appropriateness and feasibility of introducing individuals into the white-fronted chat population. Such a study must take into account all current published and unpublished research on the population within the Reserve and on the species elsewhere in the region.
- In consultation/partnership with scientific researchers studying the population (such the Australian Museum), investigate the feasibility of protecting nests by nest caging.
- Investigate the feasibility of removal of troublesome Australian ravens.
- Support ongoing research and monitoring of the Towra Point white-fronted chat population.
- Instigate a community awareness program across the Kurnell Peninsula to raise awareness of the high conservation value of this species and its habitat in the Reserve and surrounding areas. A key aim of this program would be to enable surrounding landholders and members of the public to identify this species and encourage them to report sightings to the NPWS Area office, the Atlas of NSW Wildlife, and/or the Australian Museum together with accurate location information. Over time this would provide a better understanding of the occurrence of the white-fronted chat outside of the Reserve.
- Remove seedling mangroves from Saltmarshes where adult mangrove trees do not occur.
- Undertake regular searches for outbreaks of the spiny rush. Include management of spiny rush as a priority in the Reserve weed management strategy.
- Slash the exotic vegetation growing along sections of the Towra Point Track causeway, to encourage the growth of short-cropped grass and hence provide additional foraging resources.
- Ensure the current hydrological regimes of Saltmarshes are maintained.
- Undertake regular patrols to enforce the restriction of public access to the Towra Point Track causeway area and hence minimise potential public disturbance.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- In consultation with scientific researchers studying the population (such as the Australian Museum) consider expanding the rat baiting program to include sea rushland areas adjacent to the Towra Point Track causeway before and during the nesting season.
- Continue support for the development of wildlife corridors as part of the Kurnell 2020 project.
- In consultation/partnership with scientific researchers studying the population in the Reserve and the species elsewhere in New South Wales, investigate the feasibility of expanding the current extent of Saltmarshes in the Reserve, such as behind Quibray Bay adjoining the Stables area (currently heavily infested with exotic weed species).

Mangrove encroachment into Saltmarshes is a key threat to the white-fronted chat population at Towra Point (left). Photo © M. Schulz; white-fronted chats use mangroves for perching (right). Photo © M. Schulz

VARIED SITTELLA *Daphoenositta chrysoptera*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Nil as Unconfirmed

Varied sittella. Photo © M. Schulz

Occurrence in the Study Area

The varied sittella was reported by the Australian Littoral Society (1977) as "Old records only. Like Phragmites areas. Rare". However, this species does not occur in reedland habitat, but rather a variety of eucalypt forests and woodlands (Higgins and Peter 2002). Due to the fact that there is only a single record and there are no recent sightings, this species is considered unconfirmed in the Reserve.

Regional Conservation Significance

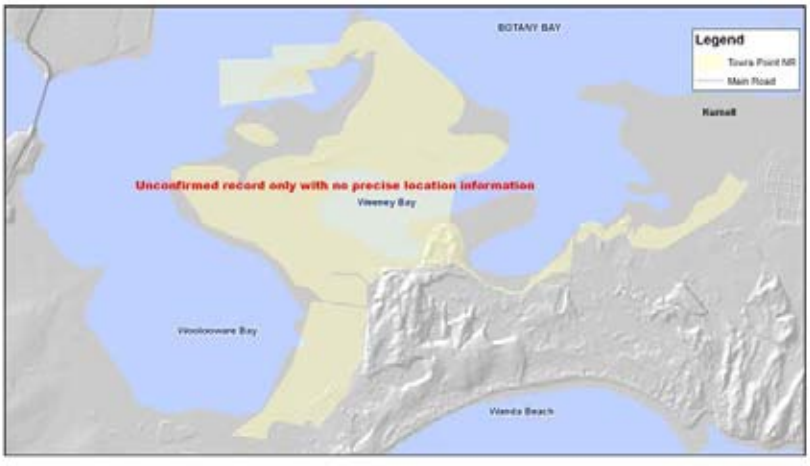
The varied sittella is widespread in small numbers across the Sydney Basin Bioregion (DECC 2007). However, there was a greater than 20 per cent decrease in the reporting rate of this bird between 1984 and 2002 in this Bioregion (Barrett et al. 2003). Its preferred habitat is flatter environments with moderately tall trees, particularly in dry box woodland and forests on more fertile soils (DECC 2007). In the Sydney area it is more commonly encountered in larger forest remnants in the Cumberland Plain such as at Bents Basin State Conservation Area, Shanes Park and in the Riverstone area (Birdline NSW). As this species is not confirmed to occur in Towra Point NR, the Reserve does not contribute to the conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.



SCARLET ROBIN *Petroica boodang*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Low Priority

Scarlet robin. Photo © M. Schulz

Occurrence in the Study Area

Probably locally extinct. The scarlet robin was last recorded by the Australian Littoral Society (1977) as a winter migrant. There are no records within the last 25 years, nor elsewhere on the Kurnell Peninsula (OEH 2013a).

Regional Conservation Significance

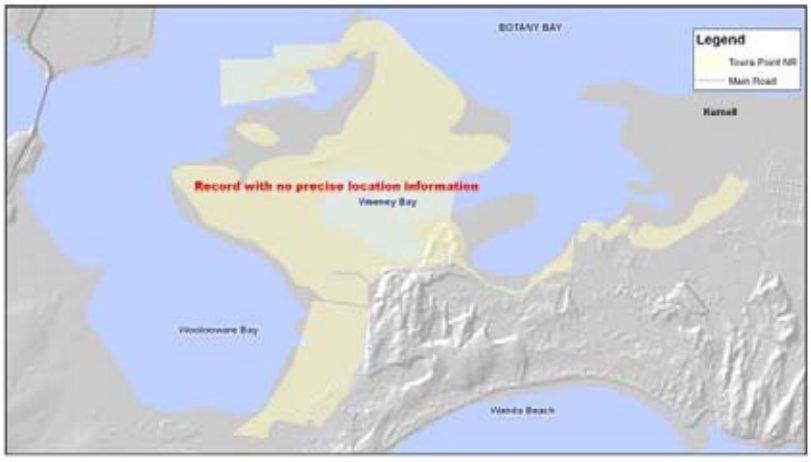
The scarlet robin is widespread in small numbers across much of the Sydney Basin Bioregion. There was a greater than 20 per cent decrease in the reporting rate of this species between 1984 and 2002 within the Bioregion and 31 per cent across the nation (Barrett et al. 2003). However due to the lack of sightings of the scarlet robin from the Reserve and neighbouring areas for several decades it is concluded that the study area does not contribute to the regional conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.



GREY-HEADED FLYING-FOX *Pteropus poliocephalus*

EPBC Act: Vulnerable	TSC Act: Vulnerable	Study Area: Moderate Priority

Grey-headed flying-fox. Photo © M. Schulz

Occurrence in the Study Area

Regular visitor. The grey-headed flying-fox visits Towra Point NR when key plants are in flower, particularly coast banksia and bangalay and to a lesser extent swamp mahogany. The predominant foraging habitats are Littoral Forests (Coastal Dune Littoral Rainforest, Coastal Sand Littoral Forest and Coastal Tea-tree-Banksia Scrub). The fruits of various species are also an important food source, including species in mesic forest on Towra Point, in The Knoll area and also adjacent to Captain Cook Drive. Elsewhere the grey-headed flying-fox has also been observed feeding on mangrove flowers (E. Magarey pers. obs.). No camps are present within the Reserve (J. Bishop pers. comm., S. Callaghan pers. comm. and observations of the 2006 and 2013 surveys). Individuals formerly commuted from the camp at the Desalination Plant site (Schulz 2006) and currently commute from the camp at Kareela and possibly from other camps. Individuals seen flying south across Botany Bay on or after sunset (observed during the 2006 survey) may come from the former Royal Botanic Gardens site.

Regional Conservation Significance

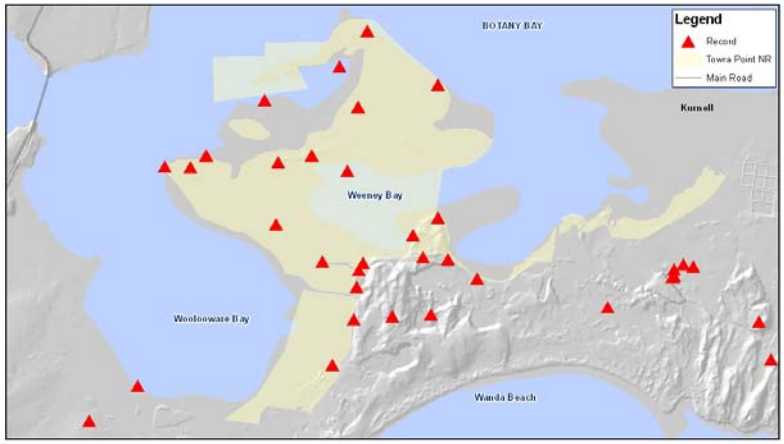
The grey-headed flying-fox is widespread across the Sydney Basin Bioregion. The significance of foraging habitat within Towra Point NR in a regional context is unknown, but it may make an important contribution when there are food shortages at particular times of the year elsewhere in the region or the State.

Threats within the Study Area

Potential threats within the Reserve include: the loss of important feed trees, particularly the swamp mahogany and coast banksia along Captain Cook Drive; electrocution on powerlines; and road mortality along Captain Cook Drive.

Management Considerations

- Follow relevant management recommendations in the draft national recovery plan (DECC 2009b).
- Ensure that all existing coast banksia, bangalay and swamp mahogany trees are retained, including those adjacent to Captain Cook Drive.
- Check electrocuted individuals for the presence of young (which can survive for a time even if the mother has been electrocuted) and seek help from wildlife carers as necessary.
- Encourage OEH staff and park users to report electrocutions and then compile this information to identify problem areas. If problem areas are identified work with power supply companies to deploy measures to reduce the incidence of electrocution in these areas.



EASTERN BENTWING-BAT

Miniopterus schreibersii oceanensis

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Low Priority

Eastern bentwing-bat. Photo © M. Schulz

The closest documented roost is in the decommissioned gunnery emplacements on Henry Head in Kamay Botany Bay NP. Photo © M. Schulz

Occurrence in the Study Area

Uncommon visitor. The eastern bentwing-bat has only been recorded once in the Reserve when one individual was detected by its ultrasonic call as it flew over Mangrove Swamps and Saltmarshes west of the Towra Point Track causeway in February 2013. It is likely that occasional wide-ranging foraging individuals forage in airspace over a wide variety of habitats in the Reserve. There are no documented roosts within the Reserve or adjacent areas. The closest known roost is in the decommissioned gunnery emplacements approximately eight kilometres to the north-east at Henry Head and Cape Banks in Kamay Botany Bay NP (White 2007, DECCW 2011a). Other undocumented roosts are likely to occur within commuting distance for this species.

Regional Conservation Significance

The eastern bentwing-bat is widespread across the Sydney Basin Bioregion, occurring in a wide range of habitats including in urban areas (DECC 2007b, 2008a). There are no confirmed locations of maternity roost sites in the Bioregion. Due to the small number of records and the lack of a roost or roosting habitat the Reserve is considered to be of low significance to regional conservation of this species.

Threats within the Study Area

Nil.

Management Considerations

Nil.

.

GREATER BROAD-NOSED BAT *Scoteanax rueppellii*

EPBC Act: Not Listed	TSC Act: Vulnerable	Study Area: Moderate Priority

Greater broad-nosed bat. Photo © M. Schulz

Feral honeybees that occupy hollows in Littoral Forests may pose a threat to the greater broad-nosed bat on Towra Point. Photo © M. Schulz

Occurrence in the Study Area

Status uncertain. The greater broad-nosed bat has only been recorded once in the Reserve when one individual was captured in a harp trap in Coastal Sand Littoral Forest on Towra Point south-west of Mirrormere in May 2006 (Schulz 2006). This site was re-sampled in 2013, but no individuals were detected there or in any other harp traps or *Anabats* set within the Reserve. It is likely that this species forages over a variety of habitat types, such as Coastal Tea-tree-Banksia Scrub and nearby Saltmarshes and possibly Mangrove Swamps. There are no confirmed records of this species elsewhere in forested areas on the Kurnell Peninsula (DECC 2008a, DECCW 2011a, OEH 2013a).

Regional Conservation Significance

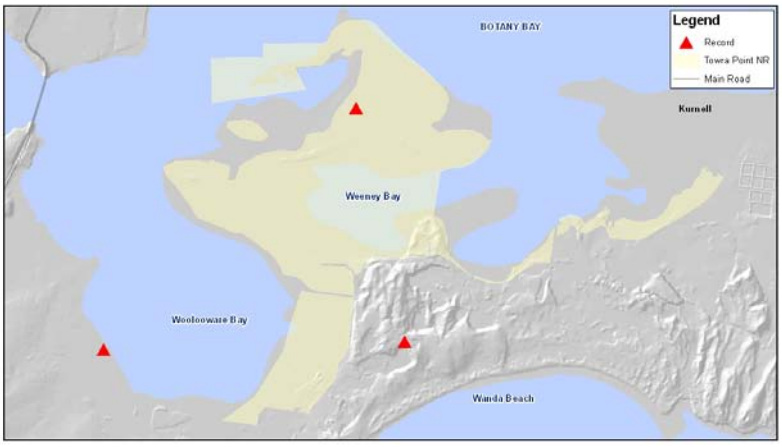
Within the Sydney Basin Bioregion the greater broad-nosed bat primarily occurs in forested lowland environments, preferring taller forests on fertile soils (DECC 2007b). Based on capture records, the greater broad-nosed bat is rarely recorded in the greater southern Sydney region (DECC 2007b). The contribution that Towra Point NR makes to the regional conservation of this species is not currently known. Due to the rarity of the species in surrounding areas it is considered of Moderate Conservation Management Priority until further information is gained.

Threats within the Study Area

Potential threats within the Reserve include: loss of hollow-bearing living and dead standing trees; hollow competition with the feral honeybee, particularly in Littoral Forests; pesticide and herbicide usage which may reduce the availability of insects for food or result in the accumulation of toxic residues; and possibly predation by the black rat.

Management Considerations

- Conduct targeted surveys over a number of years across forested sections of the Reserve in order to gain an understanding of species occurrence.
- Ensure retention of hollow-bearing living and dead standing trees, as these are a scarce resource due to past land management practices.
- Remove any honeybee colonies encountered in tree hollows on Towra Point, particularly in live bangalay trees.
- Follow best practice when applying herbicides on Towra Point, and avoid broad-scale application where other techniques are viable.



6.3 Non-threatened Species Covered by International Migratory Bird Agreements

FORK-TAILED SWIFT *Apus pacificus*

EPBC Act: CAMBA, JAMBA, ROKAMBA	Study Area: Low Priority

Occurrence in the Study Area

The fork-tailed swift is a rare non-breeding visitor to the Reserve, only recorded on one occasion (M. Schulz pers. obs.). It is an aerial species that may occur above all habitats in the Reserve.

Regional Conservation Significance

The fork-tailed swift is a summer migrant to Australia. Records are widely distributed across the Sydney Basin Bioregion. Towra Point NR contributes little to the conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.

WHITE-THROATED NEEDLETAIL *Hirundapus caudacutus*

EPBC Act: CAMBA, JAMBA, ROKAMBA	Study Area: Low Priority

White-throated needletail. Photo © M. Schulz

Occurrence in the Study Area

This swift is regularly observed foraging over the Reserve, often ahead of storms or cold fronts in the summer and early autumn months. It forages over the airspace above all vegetation communities, and at times very low over water surfaces of adjacent bays such as Stinkpot Bay (D. Andrew pers. comm.).

Regional Conservation Significance

The white-throated needletail is widespread and common over the Sydney Basin Bioregion feeding over a wide variety of natural and disturbed habitats. Towra Point NR contributes little to the conservation of this species.

Threats in the Study Area

Nil.

Management Considerations

Nil.

LARGE WADING BIRDS

EPBC Act: CAMBA, JAMBA (eastern great egret, cattle egret); CAMBA (eastern reef egret, glossy ibis)	Study Area: Eastern great egret – Low Priority Cattle egret – Low Priority Eastern reef egret – Low Priority (Vagrant) Glossy ibis – Low Priority

Eastern great egret. Photo © M. Schulz

Occurrence in the Study Area

Two species of large wading birds listed under international migratory bird agreements are irregularly recorded in the Reserve. The eastern great egret occurs as a non-breeding visitor that is predominantly encountered as single individuals foraging on intertidal flats in sheltered embayments as well as at Woolooware Shorebird Lagoon and occasionally at other wetlands within the Reserve. The cattle egret occurs irregularly in small numbers in the winter months on passage, with most records from Saltmarshes and wetland habitats.

The eastern reef egret is a rare visitor/vagrant to the Reserve, only recorded once in the Atlas of NSW Wildlife (OEH 2013a). Similarly the glossy ibis has only been recorded three times in the Atlas of NSW Wildlife, twice at Woolooware Shorebird Lagoon and once adjacent to the remains of oyster sheds at Weeney Bay (OEH 2013a).

Regional Conservation Significance

Both the eastern great egret and the cattle egret occur widely across the Sydney Basin Bioregion. Since no nesting has been recorded in the Reserve, and the species are widespread in the region, neither species is considered of high management priority for Towra Point NR. The eastern reef egret and glossy ibis are also considered of low management priority.

Threats in the Study Area

Potential threats in the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; entanglement or ingestion of anthropogenic debris; hydrological changes to shorelines; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.

MIGRATORY SHOREBIRDS

EPBC Act: Variously CAMBA, JAMBA, ROKAMBA (see Appendix A)	**Study Area: Bar-tailed godwit – High Priority** **Eastern curlew – High Priority** **Red-necked stint – High Priority** **Whimbrel – High Priority** **Pacific golden plover – Low Priority** **Grey plover – Low Priority** **Common sandpiper – Low Priority** **Ruddy turnstone – Low Priority** **Red knot – Low Priority** **Sharp-tailed sandpiper – Low Priority** **Common greenshank – Low Priority** **Latham's snipe – Low Priority** **Grey-tailed tattler – Low Priority** **Little curlew – Low Priority** **Oriental plover – Low Priority (Vagrant)**

Bar-tailed godwit. Photo © M. Schulz

Occurrence in the Study Area

There are twelve species of migratory shorebird listed under international migratory bird agreements that regularly to occasionally occur within the Reserve, principally at high tide on Towra Spit Island and at low tide on exposed intertidal flats principally in the adjacent Aquatic Reserve. The species most frequently recorded roosting on Towra Spit Island are the bar-tailed godwit, eastern curlew and the red-necked stint. The whimbrel frequently roosts in Mangrove Swamps lining protected embayments, such as in Stinkpot Bay. Species which occur less frequently and in smaller numbers, principally on Towra Spit Island, are: the pacific golden plover, grey plover, common sandpiper, ruddy turnstone, red knot and the sharp-tailed sandpiper. Many of these species are more regularly recorded in the nearby Taren Point area which comprises The Shorebird Community Occurring on the Relict Tidal Delta Sands at Taren Point, an Endangered Ecological Community under the TSC Act. Many of these species are also or instead more regularly recorded in the Boat Harbour area.

Latham's snipe. Photo © M. Schulz

The common greenshank is primarily recorded at the Woolooware Shorebird Lagoon usually in numbers of less than ten (NSW Wader Study Group data, OEH 2013a). The Latham's snipe is infrequently seen, but is likely to be under-recorded due to its cryptic nature. It occupies dense sedgeland/rushland areas bordering wetlands, which are not covered by the NSW Wader Study Group monthly counts and are rarely traversed by other birdwatchers. During the BSP survey and in 2011 it was recorded near the edge of Saltmarshes in the Fish Creek area, while previously it was recorded from the Woolooware Shorebird Lagoon (OEH 2013a). The grey-tailed tattler is rarely recorded in the Reserve, with only two records in the Atlas of NSW Wildlife. However it is regularly recorded in adjacent areas and may forage within the Reserve (D. Andrew pers. comm.). The species has also been recorded in Quibray/Weeney bay in Mangrove Swamps (D. Andrew pers. comm. reporting sighting of P. Straw).

Regional Conservation Significance

Towra Spit Island is an important shorebird high tide roost which at times supports all or a large percentage of the entire Botany Bay population of the eastern curlew (mean number over five years = 171±19 (SD)), the bar-tailed godwit (mean number over five years = 306±51 (SD)), the whimbrel (mean number over five years = 49±9 (SD)) and the red-necked stint (mean number over five years = 168±41 (SD)) (DECCW 2010a). Additionally, the Reserve was considered to support greater than one

per cent of global population of the eastern curlew, although this has now been revised to less than one per cent as a result of more accurate global population estimates (Li Zuo Wei and Mundkur 2007). The Reserve is considered to hold high regional conservation significance for these four species.

The remaining species included in this profile are considered of low management priority.

Threats in the Study Area

Potential threats in the Reserve include: disturbance by the public and domestic dogs; collection of intertidal invertebrates by fisherman for bait and food; predation by the fox and feral cat; entanglement or ingestion of anthropogenic debris; hydrological changes to shorelines; loss of oyster lease and other posts as high tide roosting sites; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.
- Undertake regular patrols to enforce the restriction of public access and the incidence of disturbance by domestic dogs to Towra Spit Island, Pelican Point and parts of Towra Beach.
- Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.
- Continue the active shorebird nest management program on Towra Spit Island.
- Continue the Reserve-wide and off-park baiting of the fox.
- Instigate a feral cat control program.
- Remove invasive plants from Towra Spit Island.
- Support the program of monitoring and replacement of old oyster lease posts.
- Maintain existing and erect new signs on Towra Spit Island to educate the public about the high environmental sensitivity and conservation significance of the area. Ensure signs are visible from the water and include multiple languages.
- Monitor the nature of Towra Spit Island with respect to the expansion of the Port Botany shipping facility and other proposed developments within Botany Bay that may impact current flow regimes.

WHITE-BELLIED SEA-EAGLE *Haliaeetus leucogaster*

EPBC Act: CAMBA	**Study Area: High Priority**

White-bellied sea-eagle. Photo © M. Schulz

Occurrence in the Study Area

This raptor occurs across the entire Reserve. One pair is known to nest in Littoral Forests on the east side of Towra Point.

Regional Conservation Significance

Given that at least one pair nests annually in the Park, and that there are few nesting sites within urban Sydney, this species has been given a High Conservation Management Priority ranking.

Threats in the Study Area

Potential threats include: disturbance around the nest site; hydrological changes to shorelines; water pollution, including indirect impacts on intertidal invertebrates; and entanglement or ingestion of anthropogenic debris.

Management Considerations

- Undertake regular patrols to enforce the restriction of public access.

TERNS

EPBC Act: CAMBA, JAMBA (caspian tern); CAMBA, JAMBA, ROKAMBA (common tern)	**Study Area: Caspian tern – Low Priority Common tern – Low Priority**

Caspian tern. Photo © M. Schulz

Occurrence in the Study Area

The caspian tern regularly roosts on Towra Spit Island and forages over inshore waters of the Reserve and the adjacent Aquatic Reserve. It is principally recorded in small numbers.

The common tern is a rare visitor to the Reserve, with just three records from Towra Spit Island and the Elephants Trunk (OEH 2013a). It regularly forages over adjacent waters in Botany Bay in summer (D. Andrew pers. comm.).

Regional Conservation Significance

Both the common tern and the caspian tern occur widely along the coast of the Sydney Basin Bioregion. Neither species is considered of high management priority for Towra Point NR.

Threats in the Study Area

Potential threats in the Reserve include: disturbance by the public and domestic dogs; predation by the fox and feral cat; entanglement or ingestion of anthropogenic debris; pollution of inshore waters, including indirect impacts on intertidal invertebrates; and the loss of suitable habitat as a result of sea level rise associated with climate change.

Management Considerations

- Continue to support the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group.

SPECIES UNCONFIRMED OR NOT RECORDED FOR 25 YEARS

EPBC Act: CAMBA, JAMBA, ROKAMBA	**Study Area: Wood sandpiper – Nil as Unconfirmed White-winged black turn – Nil as Unconfirmed Ruff – Low Priority (Not Recorded for 25 Years) Wandering Tattler – Low Priority (Not Recorded for 25 Years)**

Occurrence in the Study Area

The wood sandpiper and white-winged black tern are mentioned in DECCW (2010a), but no primary reference source is known. These species are therefore considered unconfirmed.

One record of the ruff is reported in the study by the Australian Littoral Society (1977), but the species has not been documented since. The wandering tattler is reported in the same study as “rare prefers rocky shores” (Australian Littoral Society 1977) but similarly has not been documented in the Reserve since.

Regional Conservation Significance

Towra Point NR does not contribute to the conservation of these species.

Threats in the Study Area

Nil.

Management Considerations

Nil.

6.4 Feral Species

DOG	*Canis lupus familiaris*
EPBC Act: Not Listed	TSC Act: Key Threatening Process

Dog. Photo © M. Schulz

Occurrence in the Study Area

The feral dog has not been recorded in the Reserve for over 25 years. A pack of wild dogs was reported to have been shot near Towra Point in the 1970s, as they were attacking horses and people (Australian Littoral Society 1977).

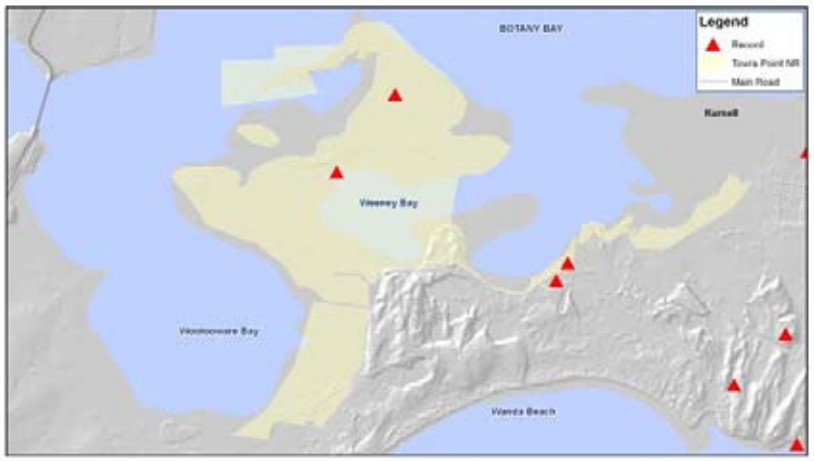
Domestic dogs occasionally occur in the Reserve, either accompanying people landing by boat along the shoreline or accompanying joggers and walkers in the Captain Cook Drive area.

Impacts in the Study Area

Predation and hybridisation by feral dogs is listed as a Key Threatening Process under the TSC Act. Since feral dogs are not known to currently occur in Towra Point NR, this threat is not currently relevant to the study area. Domestic dogs illegally brought into the Reserve by humans do pose a threat to native fauna, primarily through disturbance that causes waders and other waterbirds resting at high tide to take flight and potentially destruction of nests. Threatened species within the Reserve that are particularly at risk from disturbance by domestic dogs include the Australian pied oystercatcher, little tern, terek sandpiper, great knot and curlew sandpiper. Particularly sensitive locations include Towra Beach, Towra Spit Island and Pelican Point. Dogs accompanying members of the public also occasionally occur along the shores of Woolooware Shorebird Lagoon and the Towra Point Track causeway. The incidence of unaccompanied domestic dogs in the Reserve, and whether they hunt native fauna, is not known.

Management Considerations

- Undertake regular patrols to enforce the restriction of public access to Towra Spit Island, parts of Towra Beach and Pelican Point.
- Continue the increased patrols (three to four times per week) of Towra Spit Island during the nesting season of the little tern, particularly during spring and summer holiday periods.
- Extend the increased patrols undertaken on Towra Spit Island during the little tern breeding season to include other Australian pied oystercatcher nesting habitat areas including the sand areas on the far west end of Towra Beach at the entrance to Towra Bay.
- Erect signs near known nesting locations of little tern and Australian pied oystercatcher, particularly at locations with restricted public access on Towra Beach, to educate the public about the high environmental sensitivity and conservation significance of the area and the prohibition of domestic dogs. Ensure signs are visible from the water and include multiple languages.
- Increase signage around the Woolooware Shorebird Lagoon and along Captain Cook Drive to inform members of the public of the environmental sensitivity of the area and that dogs are prohibited.



Fox *Vulpes vulpes*

EPBC Act: Key Threatening Process	TSC Act: Key Threatening Process

Fox. Photo © M. Schulz

Occurrence in the Study Area

The fox is widespread in all habitats, including the landward edge of Mangrove Swamps and along Shorelines. However, the success of the current fox control program in the Reserve and adjacent lands is demonstrated by the fact that no individuals were photographed by the infra-red cameras set across the area in early 2013. Dredging was undertaken in 2004 to separate Towra Spit Island from other parts of the Reserve and hence stop fox access to the little tern colony, nesting Australian pied oystercatchers and the high tide roost for migratory shorebirds.

Impacts in the Study Area

Predation by the fox is listed as a Key Threatening Process under both the EPBC Act and TSC Act due to the major threat posed to the survival of native Australian fauna, with non-flying mammals weighing between 35 and 5500 grams and ground-nesting birds at the greatest risk (e.g. NSW Scientific Committee 2008a). Reptiles and amphibians are also preyed upon, although the impact of this predation within the Reserve is unknown. Threatened species within the Reserve that are particularly at risk include the little tern and Australian pied oystercatcher which both nest on the ground. The species' impact on the white-fronted chat population is unknown.

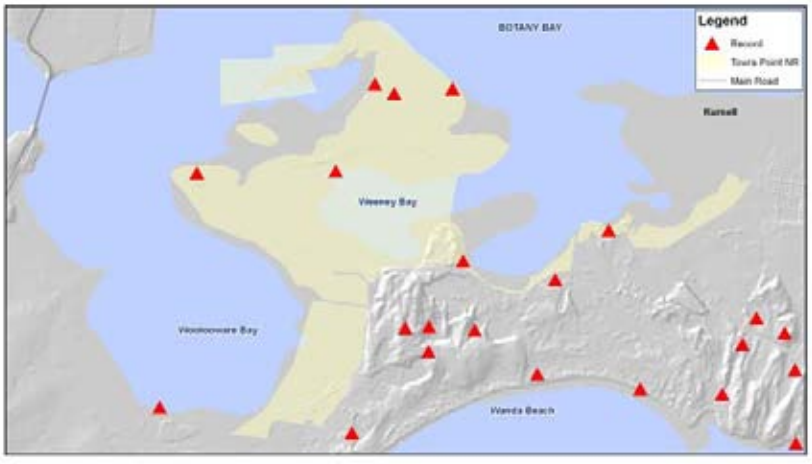
Management Considerations

An active fox control program is currently undertaken in the Reserve and co-operatively with surrounding landholders on the Kurnell Peninsula. The program is conducted in accordance with the NSW Predation by the Red Fox Threat Abatement Plan (TAP) (NPWS 2001b, Bishop 2011b), under which the Reserve is a high priority site for fox control and for monitoring the impacts of fox control. The off-reserve control program is co-ordinated by OEH and Sutherland Shire Council and performed by a Council contractor. The control program has been a great success in terms of controlling fox numbers and increasing public awareness (Bishop 2011b). Current management actions include:

- Reserve-wide baiting (using 1080) at strategic locations (Map 9), with intensity increasing prior to and during the little tern nesting season (Bishop 2011b, J. Bishop pers. comm.).
- Collaborative off-reserve fox control in conjunction with Sutherland Shire Council and various private landholders, with intensity increasing prior to and during the little tern nesting season.

Additional management considerations include:

- Undertake feral cat control in concert with the fox baiting programs, particularly in late winter.
- Undertake rabbit control on Towra Beach in concert with the fox baiting programs, and also in other parts of the Reserve if rabbit numbers or distributions are observed to increase.
- Investigate sources of funding to undertake dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve to form a barrier which stops foxes accessing the important avifauna sites on the Island.



Map 9: Strategic reserve-wide fox baiting stations in Towra Point Nature Reserve (from Bishop 2011b)

FERAL CAT *Felis catus*

EPBC Act: Key Threatening Process	TSC Act: Key Threatening Process

Feral cat. Photo © M. Schulz

Occurrence in the Study Area

The cat is uncommon but widespread across the Reserve. Few individuals were encountered during the 2006 and 2013 surveys, with most records deriving from tracks left on soft substrate such as sand. The species has been recorded in a variety of habitat groups. For example, in August 2011 tracks were found along the shoreline and in Maritime Grassland along Towra Beach, in Saltmarshes adjacent to the Towra Point Track causeway, and in Littoral Forests along Towra Point Track (M. Schulz pers. obs.). One individual was photographed by the infra-red cameras set in the Reserve in early 2013, in bangalay-dominated open forest along the Towra Point Track.

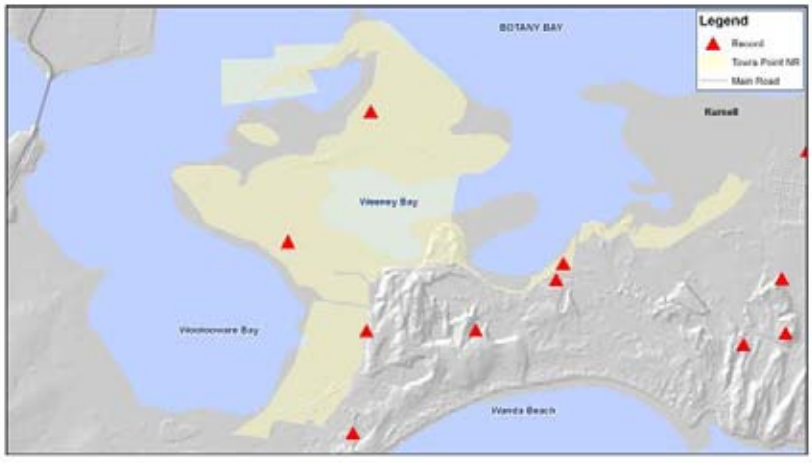
Impacts in the Study Area

The feral cat is listed as a Key Threatening Process under the EPBC Act and by the World Conservation Union as among 100 of the 'World's Worst Invaders' (Lowe et al. 2004). In New South Wales, predation by the feral cat is listed as a Key Threatening Process since it has been implicated in the extinction and decline of many species of mammals and birds in Australia and other parts of the world (NSW Scientific Committee 2008b). The impact of feral cats on birds, frogs, reptiles and small mammals within the Reserve is currently unknown. Threatened species potentially at risk include Australian pied oystercatcher, white-fronted chat, little tern, curlew sandpiper, terek sandpiper and great knot.

Management Considerations

The current management approach primarily consists of shooting or trapping individuals that are encountered (J. Bishop pers. comm.). It is recommended that control also be expanded to include the following.

- Instigate a strategic trapping and shooting program in concert with the fox baiting program both on the Reserve and elsewhere across the Kurnell Peninsula, particularly during late winter. Include Towra and Pelican points in the control program.
- Encourage reserve visitors, such as researchers and bush regenerators, to report cat sightings made within the Reserve. Follow up these sightings with trapping to remove individual cats.
- Investigate sources of funding to undertake dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve to form a barrier which stops foxes and cats accessing the important avifauna sites on the Island.



RABBIT *Oryctolagus cuniculus*

EPBC Act: Key Threatening Process	TSC Act: Key Threatening Process

Rabbit. Photo © M. Schulz

Rabbit tracks on Towra Beach. Photo © M. Schulz

Rabbit droppings in Maritime Grasslands behind Towra Beach. Photo © M. Schulz

Occurrence in the Study Area

The rabbit is patchily distributed within Towra Point NR, with most recent records from adjacent to Captain Cook Drive, the Towra Point Track causeway, on Towra Point Track and Towra Beach (OEH 2013a, M. Schulz pers. obs.). The species has primarily been recorded from disturbed vegetation, such as along the Towra Point Track causeway or in Maritime Grasslands and Sydney Coastal Heaths behind Towra Beach. No individuals were photographed by the infra-red cameras deployed in early 2013.

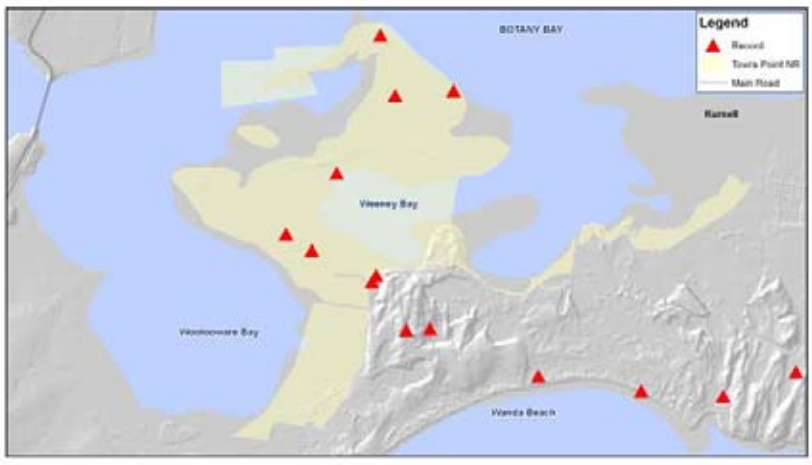
Impacts in the Reserve

Competition and grazing by the feral rabbit is listed as a Key Threatening Process and the species is also listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (Lowe et al. 2004). Potential threats posed in the Reserve include: altering the structure and composition of vegetation communities through removing plant biomass, preventing plant regeneration and ring-barking of trees and shrubs; soil and sand erosion through burrowing; and the elevation of feral predator numbers resulting in increased pressure on native fauna when sharp declines in rabbit numbers occur. Rabbit occurrence in the Reserve is currently restricted in extent and the species does not appear to be posing a direct threat to any threatened fauna species. However the impact of this species on nesting Australian pied oystercatchers in Maritime Grasslands at Towra Point is unknown.

Management Considerations

The current management approach includes intermittent shooting (particularly on Towra Beach) and trapping (such as along the Towra Point Track causeway) (J. Bishop pers. comm.). The following is also noted.

- Conduct the shooting on Towra Beach during or soon after the fox baiting program.
- If rabbit numbers or distributions are observed to increase in other parts of the Reserve, consider shooting or trapping in other sections, such as in Saltmarshes adjacent to the Towra Point Track causeway and Captain Cook Drive, in concert with fox control.
- Similar to the Peninsula-wide fox control program, encourage a collaborative cross-tenure approach to rabbit control.



7 Fauna Habitats

7.1 Format of the Habitat Group Profiles

Colour of the heading conforms to the colouration of Keith (2004) formations used in DECCW (2011c).

HABITAT GROUP LABEL

EPBC Act: Whether the vegetation communities currently conform to any Commonwealth TEC	TSC Act: Whether the vegetation communities currently conform to any State TEC	Study Area: Whether the habitat group has been designated as a Priority Fauna Habitat for the Reserve

This section provides a brief description of the structure, location and disturbance history of the habitat group.

The species lists in the habitat profiles are primarily derived from a quantitative assessment of records collected during the systematic and targeted fauna survey techniques undertaken in 2006, 2007 and 2013. This information was augmented by a qualitative assessment of all fauna records for the Reserve and expert knowledge of likely habitat preferences.

Photographs of vegetation communities within the habitat group.

Commonly Observed Herpetofauna

This section provides a list of frogs and reptiles that were commonly encountered in the habitat group.

Commonly Observed Birds

This section provides a list of diurnal and nocturnal birds that were commonly encountered in the habitat group.

Commonly Observed Mammals

This section provides a list of native and introduced mammals that were commonly encountered in the habitat group.

Potential Threats to Native Fauna

This section provides a list of current potential threats to native fauna that utilise the habitat group and to the integrity of the habitat itself.

Priority Species for Which Habitat Is Provided

This section provides a list of native priority fauna species that have been recorded within the last 25 years for which the habitat group provides known or potential habitat.

Note: the white-throated needletail and fork-tailed swift are not listed under any habitat group since being aerial insectivores they have the potential to occur over all habitats within the Reserve but would not be expected to land in any habitats present in the area (after Higgins 1999).

Species	Relative importance of this habitat group
	Predominant – species more closely associated with one to three habitat groups than with the other habitats available in the Reserve.
	General – species that are wide ranging and use or potentially use this habitat to a similar extent as several other habitats.
	Infrequent – species that have been (or have the potential to be) recorded in this habitat type but only infrequently and are not considered to depend on features located therein.

7.2 Habitat Group Profiles

LITTORAL FORESTS

EPBC Act: Coast Dune Littoral Rainforest is part of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	TSC Act: Coast Dune Littoral Rainforest is part of Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions; Coastal Sand Littoral Forest is part of Kurnell Dune Forest; Coastal Tea-Tree Banksia Scrub shares many species with the Kurnell Dune Forest TEC	Study Area: Not a Priority Fauna Habitat

Littoral Forests includes three forested vegetation communities occurring on sand with or without rainforest trees, eucalypts and/or coast banksia: Coast Dune Littoral Rainforest, Coastal Sand Littoral Forest and Coastal Tea-Tree-Banksia Scrub (after DECCW 2011c). These three communities grade into one another on Towra Point and elsewhere in the Reserve. Much of this habitat group is heavily infested with weeds, particularly lantana, bitou bush and African olive. Some bush regeneration work has been undertaken in recent years along Captain Cook Drive and on Towra Point.

Coastal Dune Littoral Rainforest. Photo © OEH

Coastal Sand Littoral Forest (dominated by bangalay). Photo © M. Schulz

Coastal Tea-Tree-Banksia Scrub (heavily infested with lantana). Photo © M. Schulz

Commonly Observed Herpetofauna

Bleating tree frog, dark-flecked garden sunskink and three-toed skink.

Commonly Observed Birds

Crimson rosella, fan-tailed cuckoo, superb fairy-wren, variegated fairy-wren, white-browed scrubwren, brown gerygone, yellow thornbill, spotted pardalote, little wattlebird, Lewin's honeyeater, eastern yellow robin, golden whistler (winter), black-faced cuckoo-shrike, pied currawong, grey fantail, Australian raven and silvereye. The introduced red-whiskered bulbul is also common, particularly along Captain Cook Drive and adjacent to Towra Beach.

Commonly Observed Mammals

Common brushtail possum, grey-headed flying-fox, chocolate wattled bat, lesser long-eared bat and little forest bat. The black rat is common, while the fox and feral cat were found at a small number of sites.

Potential Threats to Native Fauna

Weed infestation (including exotic vines); predation by feral predators; loss of hollow-bearing living and dead standing trees; hollow competition with the feral honeybee; hollow competition with feral birds along Captain Cook Drive, particularly the common myna and common starling; road mortality along Captain Cook Drive; and infection of frogs by amphibian Chytrid fungus.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
White-bellied sea-eagle	Predominant (nesting)
Masked owl	Predominant
Regent honeyeater	Predominant, but probably locally extinct
Grey-headed flying-fox	Predominant
Greater broad-nosed bat	Predominant
Eastern bentwing-bat	General (above canopy)

MARITIME GRASSLANDS

EPBC Act: Not Listed	TSC Act: Not Listed	Study Area: Priority Fauna Habitat

Maritime Grasslands occur on sections of primary sand dune behind sandy beaches. The single vegetation community that comprises this habitat group in the Reserve (Beach Spinifex Grassland) has an open cover of grasses and herbs.

Commonly Observed Herpetofauna

Dark-flecked garden sunskink and jacky lizard.

Commonly Observed Birds

White-faced heron, silver gull, superb fairy-wren, Australian magpie, willie wagtail, Australian raven, welcome swallow and Australian pipit.

Commonly Observed Mammals

Chocolate wattled bat, lesser long-eared bat, little forest bat. Frequently recorded introduced species are the black rat, house mouse (Towra Beach) and rabbit (Towra Beach).

Potential Threats to Native Fauna

Industrial development in the north of Botany Bay has reflected wave energy onto Towra Point, accelerating natural erosive beach processes and resulting in significant erosion of Towra Beach; this is reducing the sandy foredune habitat for this community in the Reserve (DECCW 2011c). Other potential threats include: high levels of public visitation and disturbance (in places); disturbance and predation by domestic dogs; predation by feral predators and by over-abundant native birds such as the Australian raven and silver gull; weed invasion; pollution of inshore waters; entanglement or ingestion of anthropogenic debris; and rising sea level associated with climate change.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Australian pied oystercatcher	Predominant (nesting)
Eastern bentwing-bat	General (above canopy)

Beach Spinifex Grassland at Towra Beach. Photo © M. Schulz

Beach erosion resulting in the loss of Beach Spinifex Grassland. Photo © M. Schulz

Beach Spinifex Grassland on Towra Spit Island with shorebirds roosting on the beach below the grassland. Photo © M. Schulz

SYDNEY COASTAL HEATHS

EPBC Act: Not Listed	TSC Act: Not Listed	Study Area: Not a Priority Fauna Habitat

Sydney Coastal Heaths comprise one scrubland vegetation community in the Reserve: Coastal Foredune Wattle Scrub. This community primarily occurs behind beaches, particularly on Towra Spit Island and behind western sections of Towra Beach. It is a dense low scrub dominated by coast tea-tree and coastal wattle that has been pruned by the wind. In the Reserve the scrubs have been subject to recent changes as a result of modified wave refraction following the construction of Sydney airport and more recently Botany Bay port (DECCW 2011c). Many patches are infested with weeds such as lantana.

Coastal Foredune Wattle Scrub above eroding Towra Beach. Photo © M. Schulz

Coastal Foredune Wattle Scrub on Towra Spit Island. Photo © M. Schulz

Commonly Observed Herpetofauna

Dark-flecked garden sunskink.

Commonly Observed Birds

Superb fairy-wren, white-browed scrubwren, New Holland honeyeater, brown honeyeater and silvereye. The introduced red-whiskered bulbul is also common.

Commonly Observed Mammals

Chocolate wattled bat and little forest bat. Frequently recorded introduced species are the black rat, house mouse (Towra Beach) and rabbit (Towra Beach).

Potential Threats to Native Fauna

Sections of this community are threatened by erosion as a result of wave action and altered currents within Botany Bay. Other threats include weed infestation, predation by feral predators, and disturbance by the public.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Eastern bentwing-bat	General (above canopy)

COASTAL FRESHWATER LAGOONS

EPBC Act: Not Listed	TSC Act: Coastal Freshwater Reedland, Coastal Sand Swamp Paperbark Scrub and Coastal Freshwater Swamp Forest form part of the Sydney Freshwater Wetlands TEC. Coastal Freshwater Reedland occurring on coastal floodplains forms a component of the Freshwater Wetlands On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions TEC.	Study Area: Priority Fauna Habitat

Coastal Freshwater Lagoons includes four vegetation communities: Estuarine Reedland, Coastal Freshwater Reedland, Coastal Sand Swamp Paperbark Scrub and Coastal Freshwater Swamp Forest. Additionally, this habitat group includes areas of open freshwater, such as deeper parts of Towra Lagoon.

Commonly Observed Herpetofauna

Common eastern froglet, striped marsh frog, Peron's tree frog, eastern snake-necked turtle, dark-flecked garden sunskink and red-bellied black snake.

Commonly Observed Birds

Chestnut teal, Pacific black duck, little pied cormorant, white-faced heron, nankeen night heron, Australian white ibis, swamp harrier, nankeen kestrel, superb fairy-wren, southern emu-wren, white-browed scrubwren, Australian raven, golden-headed cisticola and welcome swallow.

Commonly Observed Mammals

Common brushtail possum (on the margins), chocolate wattled bat and little forest bat. The introduced black rat is also common.

Potential Threats to Native Fauna

Changes to water quality; silting up or infilling of waterbodies; weed invasion (including by the spiny rush); saltwater intrusion as a result of increased wave action and altered currents in Botany Bay; predation by feral predators including the plague minnow; infection of frogs by amphibian Chytrid fungus; and rising sea level associated with climate change.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Green and golden bell frog	Predominant, but probably locally extinct
Australasian bittern	Predominant
Eastern osprey	Infrequent
Australian painted snipe	Predominant
Glossy ibis	Predominant
Latham's snipe	Predominant
Eastern bentwing-bat	General (above canopy)

Estuarine Reedland. Photo © M. Schulz

Coastal Freshwater Reedland at Weedy Pond. Photo © M. Schulz

Coastal Freshwater Reedland at Towra Lagoon. Photo © M. Schulz

COASTAL FLOODPLAIN WETLANDS

EPBC Act: Not Listed	TSC Act: Estuarine Swamp Oak Forest is part of the Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions TEC	Study Area: Priority Fauna Habitat

This habitat group comprises a single vegetation community: Estuarine Swamp Oak Forest. In the vegetation succession inland of Mangrove Swamps and Saltmarshes it is the first community above tidal influence. The community is still inundated for periods of time during king tides or following large rain events. The canopy is dominated by swamp oak and the shrub layer is low-growing and sparse comprising a mix of terrestrial species and others more typical of wetlands. Extensive bush regeneration works have been conducted in sections of this habitat adjacent to Captain Cook Drive.

Estuarine Swamp Oak Forest. Photo © M. Schulz

Estuarine Swamp Oak Forest fringing sedgeland. Photo © M. Schulz

Estuarine Swamp Oak Forest subject to erosion on Towra Beach. Photo © M. Schulz

Commonly Observed Herpetofauna

Common eastern froglet, striped marsh frog, Peron's tree frog, dark-flecked garden sunskink and black-bellied swamp snake.

Commonly Observed Birds

Brown goshawk, Australian white ibis, crimson rosella, sacred kingfisher, superb fairy-wren, southern emu-wren, white-browed scrubwren, brown gerygone (winter), yellow thornbill, little wattlebird, brown honeyeater, black-faced cuckoo-shrike, pied currawong, Australian raven, grey fantail, silvereye and red-browed finch. The introduced red-whiskered bulbul is also common.

Commonly Observed Mammals

Common brushtail possum, grey-headed flying-fox, chocolate wattled bat, lesser long-eared bat and little forest bat. The introduced black rat is also common.

Potential Threats to Native Fauna

Sections of this community are threatened by erosion as a result of wave action and altered currents within Botany Bay. Other potential threats include: changes to water quality; weed invasion; predation by feral predators including the plague minnow; infection of frogs by amphibian Chytrid fungus; rising sea level associated with climate change; loss of hollow-bearing living and dead standing trees; hollow competition with the feral honeybee; and rubbish dumping.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Green and golden bell frog	Infrequent, but probably locally extinct
Masked owl	Infrequent (where bordering Littoral Forest on Towra Point)
White-fronted chat	Predominant (roosts and perches in clumps or stands bordering Saltmarshes)
Eastern reef egret	Infrequent
Latham's snipe	Infrequent
Grey-headed flying-fox	General
Eastern bentwing-bat	General
Greater broad-nosed bat	Infrequent (where bordering Littoral Forest on Towra Point)

MANGROVE SWAMPS

EPBC Act: Not Listed	TSC Act: Not Listed Mangroves are protected under the NSW *Fisheries Act 1994*	Study Area: Priority Fauna Habitat

Towra Point supports an extensive area of Estuarine Mangrove Forest. The Mangrove Swamps are dominated by the grey mangrove and range from a tall forest structure (mostly on the seaward margin with some trees exceeding 12 metres in height) to a stunted structure (on the terrestial margin). The community is flooded twice daily by tidal waters. Many Mangrove Swamps within the Reserve are backed by Saltmarshes and aerial photographs indicate that mangroves have been invading into the Saltmarshes, as seen elsewhere in the State. This encroachment is considered either to be in response to climate change and/or increased sedimentation following development in the Georges River catchment (Mitchell and Adam 1989, Pickthall et al. 2004).

Estuarine Mangrove Forest opposite Towra Spit Island. Photo © M. Schulz

Estuarine Mangrove Forest on the east side of Towra Point. Photo © M. Schulz

Grey mangroves invading Estuarine Saltmarsh adjacent to the Towra Point Track causeway. Photo © M. Schulz

Commonly Observed Herpetofauna

Nil.

Commonly Observed Birds

Chestnut teal, little pied cormorant, great cormorant, pied cormorant, little black cormorant, Australian pelican, white-faced heron, Australian white ibis, white-bellied sea-eagle, crimson rosella, Horsfield's bronze-cuckoo, sacred kingfisher, superb fairy-wren, brown gerygone (winter), mangrove gerygone, yellow thornbill, brown honeyeater, grey fantail, Australian raven, silvereye and welcome swallow.

Commonly Observed Mammals

Chocolate wattled bat, Gould's wattled bat, lesser long-eared bat and little forest bat. The introduced black rat is also common.

Potential Threats to Native Fauna

Changes to water quality; pollution of inshore waters; entanglement or ingestion of anthropogenic debris; collection of intertidal invertebrates by fishermen for bait and food; trampling of pneumatophores; and rising sea level associated with climate change.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Eastern osprey	Predominant (roosting)
White-bellied sea-eagle	General (perching)
Terek sandpiper	Predominant (roosting)
Eastern curlew	Infrequent
Whimbrel	Predominant (roosting)
White-fronted chat	Predominant (communal night roosting and day perching on edge of Saltmarshes)
Common greenshank	Infrequent
Grey-headed flying-fox	General
Eastern bentwing-bat	General
Greater broad-nosed bat	Infrequent

SALTMARSHES

EPBC Act: Not Listed	TSC Act: Included in the Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions TEC	Study Area: Priority Fauna Habitat

Towra Point supports one of the most extensive stands of Estuarine Saltmarsh in the Sydney region, accounting for 60 per cent of the region's total saltmarsh area (DECCW 2010a). The seaward margin and tidal channels support colonising grey mangrove and the more elevated areas such as the terrestrial margin support extensive patches of sea rush. Aerial photographs indicate that mangroves have been invading into the Saltmarshes, as seen elsewhere in the State. This encroachment is considered either to be in response to climate change and/or increased sedimentation following development in the Georges River catchment (Mitchell and Adam 1989, Pickthall et al. 2004).

Saltmarshes dominated by beaded glasswort adjacent to the Towra Point Track causeway. Photo © M. Schulz

Patches dominated by sea rush are included within this habitat group. Photo © M. Schulz

Commonly Observed Herpetofauna

Eastern snake-necked turtle (brackish pools on inland margins), dark-flecked garden sunskink, eastern bluetongue, black-bellied swamp snake and red-bellied black snake (primarily on the terrestrial fringe).

Commonly Observed Birds

White-faced heron, Australian white ibis, swamp harrier, nankeen kestrel, superb fairy-wren, southern emu-wren, Australian magpie, willie wagtail, Australian raven, welcome swallow and Australian pipit.

Commonly Observed Mammals

Chocolate wattled bat, Gould's wattled bat and little forest bat. The introduced black rat and house mouse are also common.

Potential Threats to Native Fauna

Changes to water quality; invasion by mangroves; rising sea level associated with climate change; weed invasion (including by the spiny rush); pollution of inshore waters; entanglement or ingestion of anthropogenic debris; and habitat isolation.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Green and golden bell frog	Infrequent, but probably locally extinct
Australasian bittern	Infrequent (fringing sedgeland areas)
Eastern osprey	General
White-bellied sea-eagle	Infrequent
Curlew sandpiper	Infrequent
Eastern curlew	Infrequent
Bar-tailed godwit	Infrequent
Whimbrel	Infrequent
Red-necked stint	Infrequent
Australian pied oystercatcher	Infrequent
Cattle egret	Predominant
White-fronted chat	Predominant
Latham's snipe	Infrequent (fringing sedgeland areas)
Common greenshank	Infrequent
Eastern bentwing-bat	General
Greater broad-nosed bat	Infrequent

SHORELINES

EPBC Act: Not Listed	TSC Act: Not Listed Note: Seagrass Meadows are protected under the NSW *Fisheries Act 1994*	Study Area: Priority Fauna Habitat

This habitat group includes sandy beaches, intertidal mudflats that lack vegetation, and subtidal areas (including patches of Seagrass Meadows that may or may not be exposed at low tide). It incorporates posts and other decaying wooden infrastructure that remain in subtidal and intertidal areas from previous oyster leases. It also includes Woolooware Shorebird Lagoon (since it is tidally influenced) but excludes areas of dense common reed and other brackish water that abut the Lagoon margin. A large amount of beach sand has been lost or altered within the Reserve due to beach erosion events over the last three decades.

Towra Spit Island. Photo © M. Schulz

Towra Beach. Photo © M. Schulz

Commonly Observed Herpetofauna

Nil.

Commonly Observed Birds

Chestnut teal, little pied cormorant, great cormorant, pied cormorant, little black cormorant, Australian pelican, white-faced heron, Australian white ibis, white-bellied sea-eagle, whimbrel, eastern curlew, crested tern, silver gull, sacred kingfisher, Australian magpie, willie wagtail, Australian raven and welcome swallow.

Commonly Observed Mammals

Gould's wattled bat, little forest bat and black rat.

Potential Threats to Native Fauna

Habitat loss as a result of beach erosion and altered water movements in Botany Bay; disturbance by members of the public and accompanying domestic dogs, particularly on Towra Spit Island; predation by feral predators; predation by over-abundant native birds such as the Australian raven and silver gull; sediment movement resulting in the connection of Towra Spit Island to the mainland; water quality including sedimentation and nutrient-enriched water that can impact on seagrass meadows; pollution of inshore waters; entanglement in anthropogenic debris washed ashore; illegal collection of intertidal invertebrates; weed invasion especially of little tern nesting sites on Towra Spit Island; loss of posts associated with former oyster leases resulting in a loss of secure roosting habitat; impact of boating on seagrass meadows; and rising sea level associated with climate change.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Eastern osprey	Predominant
Beach stone-curlew	Predominant
Australian pied oystercatcher	Predominant
Sooty oystercatcher	Predominant
Lesser sand plover	Predominant
Greater sand plover	Predominant
Black-tailed godwit	Predominant
Terek sandpiper	Predominant

Common name	Relative importance of this habitat group
Great knot	Predominant
Sanderling	Predominant
Curlew sandpiper	Predominant
Broad-billed sandpiper	Predominant
Little tern	Predominant
White-fronted chat	Infrequent (Towra Spit Island)
White-bellied sea-eagle	Predominant
Eastern curlew	Predominant
Bar-tailed godwit	Predominant
Whimbrel	Predominant
Red-necked stint	Predominant
Eastern great egret	Predominant
Cattle egret	Predominant
Eastern reef egret	Predominant (vagrant)
Glossy ibis	Predominant
Pacific golden plover	Predominant
Grey plover	Predominant
Common sandpiper	Predominant
Ruddy turnstone	Predominant
Red knot	Predominant
Sharp-tailed sandpiper	Predominant
Little curlew	Predominant
Oriental plover	Predominant (vagrant)
Common greenshank	Predominant
Grey-tailed tattler	Predominant
Caspian tern	Predominant
Common tern	Predominant

7.3 Relative Conservation Priority of Fauna Habitats

A set of 'priority fauna habitats' were derived for the Sydney area by DECC (2008a) as part of the rapid fauna habitat assessment of the Sydney Metropolitan Catchment Management Authority (SMCMA) area. These priority habitats were compared to the fauna habitat groups profiled in section 7.2. Table 10 shows the fauna habitat groups in Towra Point NR that have been aligned to 'priority fauna habitats' of DECC (2008a) along with the highest, high and moderate conservation management priority native species for which the habitat group forms the most important habitat available in the Reserve.

The fauna habitat groups in Towra Point NR are listed below in order of the number of highest, high and moderate priority species for which habitat is provided, together with notes on species occurrence. Notes on the representation of the corresponding statewide vegetation class(es) in reserves in the Sydney Basin Bioregion are also made.

Shorelines support nesting habitat for two of the most significant threatened species occurring in the Reserve – the little tern and the Australian pied oystercatcher. Shorelines also provide important roosting, and known or potential foraging, habitat for the Australian pied oystercatcher, terek sandpiper, great knot, curlew sandpiper, eastern curlew, bar-tailed godwit, whimbrel and red-necked stint. Additionally this habitat group provides feeding and roosting habitat for the eastern osprey. Shoreline habitats are not well represented within reserves of the Sydney basin, though are present around the edge of Royal and Kamay Botany Bay national parks for example. Shoreline is the highest priority fauna habitat group.

Saltmarshes support critical feeding and nesting habitat for the endangered population of the white-fronted chat. Saltmarshes also provide potential habitat for the Australian pied oystercatcher, eastern osprey, white-bellied sea-eagle, curlew sandpiper, eastern curlew, bar-tailed godwit, whimbrel, red-necked stint and potential foraging habitat for the greater broad-nosed bat. Extensive sea rush areas are also likely to be utilised by the Australasian bittern on occasions. Additionally the green and golden bell frog has been recorded on the fringes of this habitat in the past. Saltmarshes are restricted in size and area in New South Wales, with as much as half of their original area in the State destroyed for clearing or landfill (Keith 2004).

Mangrove Swamps provide roosting habitat for the white-fronted chat, eastern osprey, whimbrel and terek sandpiper as well as potentially the eastern curlew. They provide perching habitat for the white-bellied sea-eagle and foraging habitat for the grey-headed flying-fox and potentially the greater broad-nosed bat. There is limited representation of Mangrove Swamps in coastal reserves in the Sydney basin, such as in Newington NR, Ku-ring-gai Chase NP and Royal NP.

Coastal Floodplain Wetlands provide roosting and perching habitat for the white-fronted chat, particularly where swamp oaks occur in clumps within extensive Saltmarshes. The group provides general habitat for the grey-headed flying-fox and potentially for the greater broad-nosed bat where it borders Littoral Forests on Towra Point. This group may have provided supporting habitat for the green and golden bell frog, though it is currently probably locally extinct. Coastal Floodplain Wetlands are degraded across the State, with little area protected in reserves (Keith 2004).

Maritime Grasslands provide important nesting habitat for the Australian pied oystercatcher on Towra Beach and Pelican Point. Maritime Grasslands occupy small areas of coastal national parks in the Sydney basin, such as Royal NP.

Coastal Freshwater Lagoons are a key habitat utilised by the Australasian bittern. The green and golden bell frog has been recorded in this habitat in the past. The eastern osprey may also infrequently utilise Coastal Freshwater Lagoons.

Littoral Forests provide a foraging resource for the grey-headed flying-fox when key plant species are in flower and is likely to provide foraging and roosting habitat for the greater broad-nosed bat. A pair of white-bellied sea-eagles is known to nest in Littoral Forests on the east side of Towra Point.

Sydney Coastal Heaths do not provide predominant habitat for any highest, high or moderate conservation management priority fauna species currently known to be present in the Reserve.

Table 10: Comparison of fauna habitat groups to 'priority fauna habitats' previously identified in the SMCMA area (DECC 2008a)

Towra Point NR fauna habitat group	Corresponding 'priority fauna habitat' (from DECC 2008a)	Predominant habitat in Towra Point NR for highest, high and moderate conservation priority species	Priority fauna habitat for Towra Point NR?
Shorelines	Coastal shoreline	Australian pied oystercatcher, little tern, terek sandpiper, great knot, curlew sandpiper, eastern osprey, white-bellied sea-eagle, eastern curlew, bar-tailed godwit, whimbrel, red-necked stint	Yes
Saltmarshes	Saltwater wetland	White-fronted chat	Yes
Mangrove Swamps	Saltwater wetland	White-fronted chat, eastern osprey, terek sandpiper, whimbrel	Yes
Coastal Floodplain Wetlands	Forested wetland	White-fronted chat	Yes
Maritime Grasslands	Coastal shoreline	Australian pied oystercatcher	Yes
Coastal Freshwater Lagoons	Freshwater wetland	Australasian bittern, green and golden bell frog	Yes
Littoral Forests	Rainforest and heathland	Grey-headed flying-fox, greater broad-nosed bat, white-bellied sea-eagle	No
Sydney Coastal Heaths	Heathland	Nil	No

8 Threats to Native Fauna

8.1 Key Current Threats

8.1.1 Public disturbance

Rationale: Public access is not permitted across much of the Reserve and consequently public disturbance levels are relatively low. However, sensitive areas that provide important nesting habitat for two of the Highest Conservation Management Priority fauna species, the little tern and Australian pied oystercatcher, are subject to occasional disturbance by people visiting the Reserve. Public access to these areas is principally by boat. The areas include Towra Spit Island, the Elephants Trunk and Towra Point. Towra Spit Island also provides an important high tide roosting habitat for waders, terns and other waterbirds, as well as occasional feeding habitat for the white-fronted chat. In the adjoining Aquatic Reserve foraging shorebirds are subject to some disturbance on the intertidal flats between Towra Spit Island and Pelican Point and in the Quibray Bay area. Birds are subject to some public disturbance in the Woolooware Shorebird Lagoon.

Priority species threatened: Three Highest Conservation Management Priority fauna species, eight High Conservation Management Priority fauna species and two Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on many Low Conservation Management Priority bird species.

8.1.2 Weed invasion

Rationale: Much of the vegetation in the Reserve has been highly modified since European settlement. For example, most of the native vegetation on Towra Point was cleared for timber extraction, grazing and other pursuits as early as the 1830s and 1840s (Australian Littoral Society 1977, Salt 2000). Elsewhere, terrestrial vegetation communities have been subject to widespread clearing for grazing, agriculture and other pursuits, resulting in heavy weed infestation. Much of the vegetation on Towra Point is infested by lantana, while buffalo grass is widespread in more heavily disturbed sites including within and adjoining freshwater wetland communities, within Estuarine Swamp Oak Forest and on the inland margins of Saltmarshes. Other problematic areas include: the invasion of spiny rush (*Juncus acutus*) into Saltmarshes and fringing reed/rushlands; weed invasion of Beach Spinifex Grassland (e.g. by sea spurge (*Euphorbia paralias*)); weed invasion of shorebird roosting habitat on Towra Spit Island; and encroachment of vegetation and weed species such as coast pennywort into little tern nesting habitat on Towra Spit Island. At least eight of the weed species in Towra Point NR are listed under the NSW *Noxious Weeds Act 1993* including lantana, bitou bush, blackberry (*Rubus* spp.), prickly pear (*Opuntia stricta*), pampas grass (*Cortaderia selloana*), African olive (*Olea africana*), African boxthorn (*Lycium ferocissimum*) and asparagus fern (*Asparagus sprengeri*) (J. Bishop pers. comm.). Invasion and establishment of exotic vines and scramblers is listed as a Key Threatening Process under the TSC Act. As a result of the high levels of weed infestation a weed management strategy has been prepared (West of the Divide Environmental Consultants (WODEC) 2007).

Priority species threatened: Three Highest Conservation Management Priority fauna species, three High Conservation Management Priority fauna species and two Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.3 Predation by the fox

Rationale: The fox is widespread across the Reserve and adjacent areas on the Kurnell Peninsula. However it is currently present in very low numbers in the Reserve, as suggested by the fact that none were photographed at any of the 11 infra-red camera traps that were set over a two month period in early 2013. However the fox is unlikely to ever be completely eradicated and continues to pose a significant threat to fauna within the Reserve. Particularly susceptible are ground-dwelling and semi-arboreal mammals and ground-frequenting birds (Dickman 1996, DECC 2007). The fox can also aid the spread of some weed species, such as bitou bush and blackberry, through the deposition of seeds in faeces.

Priority species threatened: Three Highest Conservation Management Priority fauna species, seven High Conservation Management Priority fauna species and two Moderate Conservation Management

Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

People ashore on Towra Beach (left); dense lantana in Littoral Forests on Towra Point (right). Photos © M. Schulz

8.1.4 Predation by the feral cat

Rationale: The feral cat appears rare within the Reserve, as suggested by the fact that none were photographed at any of the 11 infra-red camera traps that were set over a two month period in early 2013. In New South Wales, predation by the feral cat is listed as a Key Threatening Process since it has been implicated in the extinction and decline of many species of mammals and birds in Australia and other parts of the world (NSW Scientific Committee 2008b). Its impact in the Reserve on ground-nesting birds, waders and other waterbirds at high tide roosts, other avifauna, small mammals and herpetofauna is unknown.

Priority species threatened: Three Highest Conservation Management Priority fauna species, seven High Conservation Management Priority fauna species and one Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.5 Disturbance and predation by over-abundant native species

Rationale: Two native bird species are present in elevated numbers within the Reserve, partly as a result of its proximity to the Kurnell Waste Disposal and Recycling Centre which is located on the south side of Captain Cook Drive. These species are the silver gull and the Australian raven. Both species have been implicated in nest failure of the little tern and the silver gull has been observed taking food that has been collected by terns. It is likely that both species also impact on the nesting success of the Australian pied oystercatcher. Elsewhere the silver gull has been recorded predating on the eggs and chicks of the little tern and a variety of other terns and shorebird species (Higgins and Davies 1996) and stealing food from a variety of terns and also the Australin pied oystercatcher (Higgins and Davies 1996). It has also been reported elsewhere stealing food from cormorants, the little egret, eastern curlew, bar-tailed godwit, curlew sandpiper and other shorebirds (Higgins and Davies 1996). The Australian raven is adept at finding nests of other birds and eating eggs and chicks (Higgins et al. 2006), including the white-fronted chat (R. Major pers. comm.). The Australian raven has also been observed harassing eastern ospreys, particularly in the Weeney Bay area. Constant harassment of these birds may prevent breeding attempts within the Reserve, even with the erection of artificial nest platform structures.

Priority species threatened: Three Highest Conservation Management Priority fauna species and one Moderate Conservation Management Priority fauna species (Table 11) with potential impacts on three High Conservation Management Priority fauna species (eastern curlew, bar-tailed godwit and curlew sandpiper) as well as Low Conservation Management Priority shorebirds.

8.1.6 Predation by the black rat

Rationale: The black rat is abundant across the Reserve in all vegetation communities, including on some islands. Its abundance was demonstrated by the fact that it was photographed at all 11 infra-red camera traps set across the Reserve in early 2013, including on Carters Island. Elsewhere the species

has had a significant impact on island fauna; for example on Lord Howe Island six bird species became extinct after the black rat became established following a shipwreck in 1918 (Garnett and Crowley 2000, DECC 2005b). It is considered that beach-nesting birds such as the little tern and Australian pied oystercatcher may be particularly vulnerable (e.g. Bishop et al. 2009, 2010). Given the presence of the black rat in sea rushland, it is likely that the nests of the white-fronted chat (which occur in clumps of sea rush surrounding by sea blite and on the edges of big patches of sea rush) are also vulnerable to predation. The impact of the black rat on other threatened and non-threatened fauna in the Reserve is unknown.

Priority species threatened: Three Highest Conservation Management Priority species (Table 11).

Australian raven (left); Towra Beach erosion occuring as a result of increased wave action (right). Photos © M. Schulz

8.1.7 Entanglement or ingestion of anthropogenic debris

Rationale: A large amount of plastics, discarded fishing line and other tackle, and other anthropogenic materials are deposited along the shorelines of the Reserve. Such waste also gets deposited behind Mangrove Swamps and in Saltmarshes after king tides or storm events. This anthropogenic material has the potential to entangle, or be ingested by, a variety of birds and other fauna that use the shoreline and tidal-influenced wetlands. Species at risk include a variety of shorebirds, eastern osprey, little tern and other species listed under international migratory bird agreements.

Priority species threatened: Two Highest Conservation Management Priority fauna species, eight High Conservation Management Priority fauna species and one Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.8 Pollution of inshore waters

Rationale: Towra Point NR is situated in a catchment that has large amounts of industry and urban development. Runoff that reaches the Reserve frequently exceeds guidelines for ammonia, total nitrogen, suspended solids, copper and lead (Sutherland Shire Council 2004). Excessive nutrients and chemicals in runoff increase the risk of algal blooms, eutrophication, and poisoning by heavy metals. Fish kills are occasionally reported, with the source sometimes attributed to chemical spills, such as from a cyanide leak in the Cooks River in 1973 (DECCW 2010a). Additionally, the Reserve is situated close to large vessel berthing facilities, with the associated risk of chemical and oil spills or the introduction of pest species into the bay. Also a one kilometre long wharf is situated at Silver Beach to the east of the Reserve; this facility was constructed for the transportation of crude oil from ships to the Caltex oil refinery and the transportation of airline fuel via an underground pipeline to Sydney airport. There were 31 spills of more than one barrel documented between 1957 and 1988, with the largest being of 95 kilolitres in 1979 (McGuinness 1988). Water pollution can have indirect impacts on terrestrial fauna through impacting on fish and intertidal invertebrate prey.

Priority species threatened: Two Highest Conservation Management Priority fauna species, eight High Conservation Management Priority fauna species and one Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.9 Shoreline changes, including saltwater intrusion into lagoons

Rationale: The natural accretion and erosion processes are for tide and wave action to move sediment from Quibray Bay around Towra Point and towards the Elephants Trunk while sediment flowing from the Georges River settles in low-energy areas such as Woolooware and Weeney bays (Australian Littoral Society 1977). Changes to the bathymetry and shorelines of Botany Bay, such as through the development of Sydney Airport and Sydney Port and associated dredging in Botany Bay, have altered sand movement from a south-easterly to a westerly direction (Australian Littoral Society 1977, Roy and Crawford 1979). This has resulted in ongoing erosion of the east section of Towra Beach, saltwater intrusion into Towra Lagoon, the formation of Towra Spit Island after this section separated from the Elephants Trunk, and increased accretion rate of the Elephant's Trunk (URS Australia 2003). The sediment load and deposition rate is also likely to have increased as a result of urban expansion throughout the Botany Bay catchment. The saltwater intrusion into Towra Lagoon has been implicated in the loss of the green and golden bell frog from the Lagoon (White 2012). Erosion of Towra Beach threatens nesting habitat of the Australian pied oystercatcher. The increased accretion rate of the Elephants Trunk has resulted in the creation of a land bridge between Towra Spit Island and Carters Island, thereby providing access to Towra Spit Island for predators such as the fox and black rat. The dynamics of the area suggest that Towra Spit Island will continue to migrate in a south-west direction (for example it moved at a rate of 25 metres per year between 1995 and 1999) and Towra Beach will continue to be eroded. The Towra Beach renourishment project, and associated restoration and reclamation works, halted seawater egress into Towra Lagoon (Jones 2009), however erosion of the Beach is predicted to continue which may result in further saltwater intrusion into Towra Lagoon (Connell Wagner 2001, DECCW 2010a) and further loss of Maritime Grasslands backing sections of Towra Beach.

Priority species threatened: Two Highest Conservation Management Priority fauna species, seven High Conservation Management Priority fauna species and two Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.10 Disturbance and predation by domestic dogs

Rationale: Domestic dogs occasionally accompany visitors to sensitive areas of the Reserve such as Towra Spit Island and Towra Beach. Such visits have the potential to cause destruction of nests of the little tern and Australian pied oystercatcher, and to cause waders and other waterbirds resting at high tide to take flight. Members of the public collecting intertidal invertebrates for bait or human consumption are sometimes accompanied by domestic dogs, which may result in increased disturbance to foraging birds. Dogs also occasionally accompany members of the public along the shores of Woolooware Shorebird Lagoon and the Towra Point Track causeway.

Priority species threatened: Two Highest Conservation Management Priority fauna species and seven High Conservation Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

Flotsam and jetsam deposited by high tides behind mangroves on Carters Island (left); mangrove encroachment into Saltmarshes near the Towra Point Track casuseway (right). Photos © M. Schulz

8.1.11 Saltmarsh alteration

Rationale: The extent of Saltmarshes in the Reserve has declined as a result of mangrove encroachment, with a decrease of 62 per cent reported between 1956 and 1999 (Wilton 2002). The mangrove encroachment has been attributed to a combination of sea level rise, soil subsidence, and increased nutrient and sediment loads (Saintilan and Williams 2000). Such mangrove encroachment is typical of more modified urban and industrial catchments. The mangrove encroachment will have a profound effect on the endangered population of the white-fronted chat, which principally feeds in Saltmarshes. Invasion by the spiny rush also has the potential to alter the structure of Saltmarshes (see section 8.1.2).

Priority species threatened: Two Highest Conservation Management Priority fauna species and one High Conservation Management Priority fauna species (Table 11).

8.1.12 Predation by raptors

Rationale: The presence of a peregrine falcon around Towra Spit Island in 1994 resulted in complete little tern nest abandonment (Priddel and Ross 1996) and may have been the reason that no little tern nesting was observed in 2009-10. White-fronted chats are also potential prey for peregrine falcon and Australian hobby.

Priority species threatened: Two Highest Conservation Management Priority fauna species (Table 11).

8.1.13 Collection of intertidal invertebrates for bait and food

Rationale: On occasions members of the public collect intertidal invertebrates for bait or human consumption from flats in the Aquatic Reserve, such as within Quibray Bay and between Towra Spit Island and Pelican Point. This may impact on waders and other waterbirds within the Reserve by depleting or altering the available food resources and causing localised disturbance to foraging birds. Bait collectors are sometimes accompanied by domestic dogs, which may result in increased disturbance to foraging birds (see section 8.1.10).

Priority species threatened: One Highest Conservation Management Priority fauna species and seven High Management Priority fauna species (Table 11). Also potentially impacts on several Low Conservation Management Priority fauna species.

8.1.14 Loss of oyster lease posts and other roosting infrastructure

Rationale: The old oyster lease posts that are principally located in the Aquatic Reserve provide roosting habitat for a variety of waterbirds, including the Australian pied oystercatcher and shorebirds listed under international migratory bird agreements (in particular the bar-tailed godwit). The little tern occasionally rests on posts in Quibray Bay. Additionally, the Australian pied oystercatcher has been recorded nesting on oyster lease posts in the Aquatic Reserve south-west of Carters Shoals and in Quibray Bay (D. Andrew pers. comm.). Many posts are in a state of disrepair and are in danger of falling over. This would result in a loss of important roosting and nesting habitat that is not accessible to introduced predators.

Priority species threatened: One Highest Conservation Management Priority fauna species and one High Conservation Management Priority fauna species (Table 11).

Oyster posts in the Aquatic Reserve in Quibray Bay (left); Quibray Bay overshadowed by the Kurnell waste disposal facility on the centre right of the photo (right). Photos © M. Schulz

8.1.15 Ant attack

Rationale: Little tern nest failure on Towra Spit Island has been caused by ant attack of eggs and recently hatched chicks (Ross and Jarman 2001, Bishop et al. 2009, 2010). It is not known whether the Australian pied oystercatcher nests are similarly vulnerable.

Priority species threatened: One Highest Conservation Management Priority fauna species (Table 11).

8.1.16 In-breeding/small population size

Rationale: Recent genetic evidence suggests that inbreeding is likely to be a serious threat to the small population of the white-fronted chat in the Reserve (R. Major pers. comm.).

Priority species threatened: One Highest Conservation Management Priority fauna species (Table 11).

8.1.17 Ghost crab predation

Rationale: Little tern nest failure on Towra Spit Island has been caused by the ghost crab taking eggs and recently hatched chicks (Bishop et al. 2009, 2010). It is not known whether the Australian pied oystercatcher nests are similarly vulnerable.

Priority species threatened: One Highest Conservation Management Priority fauna species (Table 11).

8.1.18 Alteration of wetland characteristics

Rationale: Ground water in the southern zone of the Botany Sands aquifer flows in a north-west direction from the Kurnell Peninsula and discharges into the Towra Point wetlands and Botany Bay (URS Australia 2004). Leaks from heavy industry, seepage from the Kurnell Waste Disposal and Recycling Centre and runoff from industrial sites and roads have the potential to contaminate this groundwater (URS Australia 2004, DECCW 2010a).

Priority species threatened: Two Moderate Conservation Management Priority fauna species (see Table 11).

8.1.19 Herbicide spraying

Rationale: The application of herbicides has been identified as a threat to the green and golden bell frog (DECC 2007c). Herbicide spraying may also impact the greater broad-nosed bat.

Priority species threatened: Two Moderate Conservation Management Priority species (Table 11).

8.1.20 Loss of hollow-bearing and standing dead trees

Rationale: A number of fauna species require tree hollows in living trees or dead standing trees for nesting and/or roosting purposes. Such species that are listed as threatened include the masked owl and greater broad-nosed bat. The removal of hollow-bearing trees during maintenance works may result in the loss of breeding and sheltering sites for these species. The white-bellied sea-eagle also utilises large standing trees for nesting, though they do not nest within hollows.

Priority species threatened: One High Conservation Management Priority fauna species and one Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on one Low Conservation Management Priority fauna species.

8.1.21 Loss of key feed trees

Rationale: The swamp mahogany and coast banksia are key flowering feed trees for the grey-headed flying-fox, as well as other threatened species that have the potential to occur such as the little lorikeet (*Glossopsitta pusilla*) and the swift parrot. Swamp mahogany has a limited distribution in the Reserve, predominantly occurring along Captain Cook Drive in the Woolooware Shorebird Lagoon area.

Priority species threatened: One Moderate Conservation Management Priority species (see Table 11).

8.1.22 Competition with the feral honeybee

Rationale: Hollow-dependent species may be impacted by the competition with the feral honeybee for hollows. A number of bee-occupied hollows were found in tall bangalays and coast banksias on Towra Point during the 2007 surveys. Species at risk include the masked owl and a variety of microbats.

Priority species threatened: One Moderate Conservation Management Priority fauna species (Table 11). Also potentially impacts on one Low Conservation Management Priority fauna species.

8.1.23 Electrocution on powerlines

Rationale: The grey-headed flying-fox is susceptible to electrocution on powerlines adjoining the Reserve, particularly when these are sited in close proximity to flowering trees such as the coast banksia and swamp mahogany.

Priority species threatened: One Moderate Conservation Management Priority species (see Table 11).

8.1.24 Road mortality

Rationale: Grey-headed flying-foxes have occasionally been found road-killed along Captain Cook Drive, particularly when coast banksias and swamp mahoganies abutting the road are in flower.

Priority species threatened: One Moderate Conservation Management Priority species (Table 11).

8.1.25 Infection of frog species by amphibian Chytrid fungus

Rationale: The decline of the green and golden bell frog on the Kurnell Peninsula is considered to be at least in part due to chytridiomycosis. Swabs taken of green and golden bell frogs on land owned by Australand showed that Chytrid pathogen was present at low levels, indicating that the population has been previously exposed to the disease (White 2012).

Priority species threatened: One Moderate Conservation Management Priority species (see Table 11).

8.1.26 Predation of tadpoles by the plague minnow (Gambusia holbrooki)

Rationale: The plague minnow (or mosquito fish) preys on the eggs, tadpoles and adults of a variety of frog species, including the green and golden bell frog (DECC 2007c). The plague minnow is present in most permanent waterbodies inhabited by the green and golden bell frog on the Kurnell Peninsula (DECC 2007c).

Priority species threatened: One Moderate Conservation Management Priority species (see Table 11).

8.2 Other Current Threats

There are a number of additional threats that have the potential to impact on fauna species not currently identified as highest, high or moderate conservation management priority, as follows:

- Competition from introduced bird species, particularly the common starling and common myna.
- Impacts of grazing by the rabbit (listed as a Key Threatening Process).
- Rubbish dumping including the dumping of garden clippings and the dumping and burning of motor vehicles.

Exotic vine in a swamp oak (left); rubbish dumped at the entrance to Woolooware Shorebird lagoon (right). Photos © M. Schulz

8.3 Future Threats

- Invasion of the cane toad (listed as a Key Threatening Process) into wetlands within the Reserve has the potential to impact on native fauna species. In 2010 over 200 cane toads were collected in the Sutherland Shire with a concentration around Taren Point industrial area (J. Bishop pers. comm.). A cane toad action group has been established, with the aim of eradicating this frog from the area. In some of 2010 and 2011 monthly amphibian surveys were undertaken in Towra Point NR by the community using spotlights and auditory equipment. A cane toad sniffer dog has also been used, but neither survey technique located any cane toads (SMCMA 2011). Wetlands in the Reserve (e.g. Mirrormere, Weedy Pond and Towra Lagoon) were checked four times during 2012 by a cane toad sniffer dog and OEH staff, with no cane toads located (J. Bishop pers. comm.). However, if the outbreak at Taren Point becomes established it has the potential to spread to reserves on the Kurnell Peninsula including Towra Point NR. In 2010 a few individuals had been sighted on the Kurnell Peninsula, meaning they had expanded from Taren Point (A. Goeth pers. comm.). Cane toad populations can reach very high densities and there is currently no efficient method for significantly reducing established populations (NSW Scientific Committee 2008e).
- Human-induced climate change (listed as a Key Threatening Process) resulting in sea level rise, increased air temperatures, changes to precipitation patterns, increased carbon dioxide in the seawater and ocean acidification is likely to have significant impacts on fauna species occurring within the Reserve. For example, hydrology is a key driver for the ecological character of the Reserve; a sea level rise would alter tidal levels which in turn would result in changes to the distribution of vegetation communities. Some communities such as Saltmarshes may be lost, while low-lying landforms such as Towra Spit Island may no longer provide suitable nesting habitat for the little tern and Australian pied oystercatcher nor roosting habitat for shorebirds at high tide. A rise in temperature coupled with a rise in sea level would be expected to result in an increase in the distribution of Mangrove Swamps at the expense of Saltmarshes (Saintilan et al. 2009).
- Spread of the rusa deer (listed as a Key Threatening Process) into Towra Point NR would likely impact directly and indirectly on native fauna. A population of the rusa deer is not currently established on the Kurnell Peninsula. However, deer have been sighted in Kamay Botany Bay NP (DECCW 2011a), are reported by members of the public elsewhere on the Kurnell Peninsula and near Miranda, and are known from Loftus and Grays Point (DEC 2008a, DECCW 2011a). A population has also recently been discovered in Georges River NP (OEH 2013b). Rusa deer that occur on the Kurnell Peninsula would derive from the well-established wild population centred in Royal National Park, with individuals moving north through Gymea, Caringbah and Cronulla possibly via Grays Point. The establishment of rusa deer in Towra Point NR could result in: degradation of vegetation by grazing; trampling of fragile habitats including the creation of well-defined pads in wetlands that introduced predators could use for access; trampling of muddy/sandy wetlands edges that would impact on foraging areas for shorebirds and some large wading birds such as egrets and bitterns; trampling of the nests of ground-breeding fauna; and loss of viability of plant populations through the curtailment of seed production and seedling recruitment (Keith and Pellow 2005, DECCW 2011b).
- Caulerpa (*Caulerpa taxifolia*) is a seagrass native to warm, tropical waters which has recently been found in Botany Bay. It is known to occur in waters surrounding Towra Point (DECCW 2010a). This species forms dense meadows and has the potential to out-compete other seagrasses under low-light conditions (Street 2007). The potential impact of invasion by this seagrass on fauna within the Reserve is unknown.

8.4 Relative Priority of Threats

Table 11 displays the priority ranking of the Key Current Threats according to the number of Highest, High and Moderate Priority fauna species they potentially impact. The majority of the threats (17) were identified as Very High Threats due to their known or potential impacts on the three Highest Conservation Management Priority fauna species (i.e. Australian pied oystercatcher, little tern and white-fronted chat).

It is important to note that the threat ranking may significantly change if the green and golden bell frog is relocated in the Reserve, which would result in its conservation management priority being raised from moderate to highest.

The Other Current Threats identified above have a lower priority for management than the Key Current Threats, while the Future Threats should be assessed for management priority as they emerge.

Table 11: Prioritisation of key current threats to highest, high and moderate conservation management priority fauna species occurring within the Reserve

Threat Priority Ranking	Very High																	Moderate								
Key Current Threat	Public disturbance	Weed invasion	Predation by the fox	Predation by the feral cat	Disturbance & predation by over-abundant native species	Predation by the black rat	Entanglement or ingestion of anthropogenic debris	Pollution of inshore waters	Shoreline changes, including saltwater intrusion into lagoons	Disturbance and predation by domestic dogs	Saltmarsh alteration	Predation by raptors	Collection of intertidal invertebrates for bait and food	Loss of oyster lease posts and other roosting infrastructure	Ant attack	Inbreeding/small population size	Ghost crab predation	Alteration of wetland characteristics	Herbicide spraying	Loss of hollow-bearing and standing dead trees	Loss of key feed trees	Competition with the feral honeybee	Electrocution on powerlines	Road mortality	Infection of frog species by Chytrid fungus	Predation of tadpoles by the plague minnow
Key Threatening Process		X	X	X			X											X			X	X				
Threatens Priority Fauna Habitat	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X		X	X				
Highest Priority Species																										
Australian pied oystercatcher	X	X	X	X	X	X	X	X	X	X	X		X	X												
Little tern	X	X	X	X	X	X	X	X	X	X		X			X		X									
White-fronted chat	X	X	X	X	X	X					X	X				X										

Threat Priority Ranking	Very High																	Moderate								
Key Current Threat	Public disturbance	Weed invasion	Predation by the fox	Predation by the feral cat	Disturbance & predation by over-abundant native species	Predation by the black rat	Entanglement or ingestion of anthropogenic debris	Pollution of inshore waters	Shoreline changes, including saltwater intrusion into lagoons	Disturbance and predation by domestic dogs	Saltmarsh alteration	Predation by raptors	Collection of intertidal invertebrates for bait and food	Loss of oyster lease posts and other roosting infrastructure	Ant attack	Inbreeding/small population size	Ghost crab predation	Alteration of wetland characteristics	Herbicide spraying	Loss of hollow-bearing and standing dead trees	Loss of key feed trees	Competition with the feral honeybee	Electrocution on powerlines	Road mortality	Infection of frog species by Chytrid fungus	Predation of tadpoles by the plague minnow
High Priority Species																										
Curlew sandpiper	X	X	X	X			X	X	X	X	X		X													
Terek sandpiper	X	X	X	X			X	X	X	X			X													
Great knot	X	X	X	X			X	X	X	X			X													
White-bellied sea-eagle	X						X	X																		
Eastern curlew	X		X	X			X	X	X	X			X													
Bar-tailed godwit	X		X	X			X	X	X	X			X	X												
Whimbrel	X		X	X			X	X	X	X			X													
Red-necked stint	X		X	X			X	X	X	X			X													

Threat Priority Ranking	Very High																	Moderate								
Key Current Threat	Public disturbance	Weed invasion	Predation by the fox	Predation by the feral cat	Disturbance & predation by over-abundant native species	Predation by the black rat	Entanglement or ingestion of anthropogenic debris	Pollution of inshore waters	Shoreline changes, including saltwater intrusion into lagoons	Disturbance and predation by domestic dogs	Saltmarsh alteration	Predation by raptors	Collection of intertidal invertebrates for bait and food	Loss of oyster lease posts and other roosting infrastructure	Ant attack	Inbreeding/small population size	Ghost crab predation	Alteration of wetland characteristics	Herbicide spraying	Loss of hollow-bearing and standing dead trees	Loss of key feed trees	Competition with the feral honeybee	Electrocution on powerlines	Road mortality	Infection of frog species by Chytrid fungus	Predation of tadpoles by the plague minnow
Moderate Priority Species																										
Green and golden bell frog		X	X	X					X									X	X						X	X
Australasian bittern	X	X	X						X									X								
Eastern osprey	X				X		X	X																		
Grey-headed flying-fox																					X		X	X		
Greater broad-nosed bat																			X	X		X				

9 Recommendations for Fauna Management

9.1 Management of Very High Threats

Table 12: Recommendations for management of Very High Threats

Threat	Management response	Target areas or habitats	Key species issues
Public disturbance	Maintain current restriction of public access.	Across the Reserve.	Little tern, shorebirds and other waterbirds.
	Undertake regular patrols to enforce the restriction of public access to sensitive areas.	Towra Spit Island, Towra Beach, Pelican Point, Towra Point Track causeway.	Little tern and Australian pied oystercatcher nesting sites, wader and other waterbird high tide roosts, white-fronted chat habitat.
	Continue with increased patrols (three to four times a week) during the little tern nesting season and holiday periods during the warmer months of the year and extend the patrols to include sand areas on the far west end of Towra Beach.	Towra Spit Island, west end of Towra Beach.	Little tern and Australian pied oystercatcher nesting sites.
	Maintain existing and erect new signs near known nesting locations of little tern and Australian pied oystercatcher, and shorebird roost areas, to educate the public about the high environmental sensitivity and conservation significance of the areas. Ensure signs are visible from the water and include multiple languages.	Towra Spit Island, Towra Beach, Pelican Point.	Little tern and Australian pied oystercatcher nesting sites, wader and other waterbird high tide roosts.
	Increase signage around Woolooware Shorebird Lagoon and along Captain Cook Drive to inform members of the public of the environmental sensitivity of the area and that dogs are prohibited.	Woolooware Shorebird Lagoon, along Captain Cook Drive.	Waterbirds including the Australasian bittern, curlew sandpiper, Australian pied oystercatcher and other waterbirds and waders.
Weed invasion	Review the 2007 weed management strategy and incorporate species, habitat and threat priorities presented in this report.	Across the Reserve.	
	Encourage an integrated weed management strategy for the entire Kurnell Peninsula.		
	Continue to remove vegetation encroaching on nesting areas on Towra Spit Island, including native species such as hairy spinifex and weeds such as coast pennywort.	Towra Spit Island.	Little tern and Australian pied oystercatcher nesting sites, wader and other waterbird high tide roosts.
	Consider the removal of weeds from Beach Spinifex Grassland.	Behind Towra Point, west end of Towra Beach.	Australian pied oystercatcher nesting sites.

Threat	Management response	Target areas or habitats	Key species issues
	Undertake regular searches for outbreaks of the spiny rush. Include management of spiny rush as a priority in the Reserve weed management strategy.	Saltmarshes and wetland areas particularly adjacent to the Towra Point Track causeway.	White-fronted chat and Australasian bittern habitat.
	Slash the exotic vegetation growing along sections of the Towra Point Track causeway, to encourage the growth of short-cropped grass and hence provide additional foraging resources.	Towra Point Track causeway.	White-fronted chat foraging habitat.
	Continue ongoing weed management across the Reserve, including of species listed under the NSW *Noxious Weeds Act 1993* (including lantana, bitou bush, blackberry, prickly pear, pampas grass, African olive, African box-thorn and asparagus fern) and of exotic vines and scramblers.	Across the Reserve.	Maintain/restore integrity of habitat.
	Continue to support bush regeneration programs.	Along Captain Cook Drive, in The Knoll area and on Towra Point.	Maintain/restore integrity of habitat.
	Avoid spraying of herbicide within 50 metres of freshwater wetlands and other water bodies.	All water bodies and wetlands.	Frog and waterbird species.
Predation by the fox	Continue the Reserve-wide baiting program at strategic locations with intensity increasing prior to and during the little tern nesting season.	Across the Reserve with particular focus on Towra Point, Towra Beach, the Elephants Trunk and Towra Spit Island.	Wide variety of species including little tern and Australian pied oystercatcher.
	Continue collaborative off-reserve fox control in conjunction with Sutherland Shire Council and private landholders, with intensity increasing prior to and during the little tern nesting season.	Across the Kurnell Peninsula.	Wide variety of species including little tern and Australian pied oystercatcher.
	Following assessment of the feasibility of undertaking dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve, investigate funding sources to undertake such operations. This is likely to require approval under the NSW *Environmental Planning and Assessment Act 1979*.	Towra Spit Island channel.	Little tern and Australian pied oystercatcher nesting sites.
Predation by the feral cat	Continue the current management of shooting or trapping individuals that are encountered.	Across the Reserve.	Wide variety of species including Australian pied oystercatcher, white-fronted chat, little tern, curlew sandpiper, terek sandpiper and great knot.

Threat	Management response	Target areas or habitats	Key species issues
	Instigate a strategic trapping and shooting program in concert with the fox baiting program both on the Reserve and elsewhere across the Kurnell Peninsula, particularly during late winter.	Across the Reserve with particular focus on Towra Point, Towra Beach and Pelican Point.	As above.
	Encourage reserve visitors, such as researchers and bush regenerators, to report cat sightings made within the Reserve. Follow up these sightings with trapping to remove individual cats.	Across the Reserve.	As above.
	Following assessment of the feasibility of undertaking dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve, investigate funding sources to undertake such operations. This is likely to require approval under the NSW *Environmental Planning and Assessment Act 1979*.	Towra Spit Island channel.	Little tern and Australian pied oystercatcher nesting sites.
Disturbance and predation by over-abundant native species	Continue the active management of silver gulls and Australian ravens.	Towra Spit Island.	Little tern and Australian pied oystercatcher nesting sites.
	Investigate the feasibility of the removal of troublesome Australian ravens.	Saltmarshes adjacent to the Towra Point Track causeway.	White-fronted chat nesting sites.
Predation by the black rat	Continue the current program of rat baiting before and during the little tern nesting season.	Towra Spit Island.	Little tern and Australian pied oystercatcher nesting sites.
	Consider expanding the rat baiting program to other areas prior to and during the nesting season of Australian pied oystercatcher.	Adjacent to the beach on Pelican Point, Towra Point, far west end of Towra Beach.	Australian pied oystercatcher nesting sites.
	In consultation with R. Major from the Australian Museum, consider expanding the rat baiting program to other areas prior to and during the nesting season of the white-fronted chat. First undertake a trapping program to ensure that no native swamp rats are present.	Sea rushland adjacent to the Towra Point Track causeway.	White-fronted chat nesting sites.
	Following assessment of the feasibility of undertaking dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve, investigate funding sources to undertake such operations. This is likely to require approval under the NSW *Environmental Planning and Assessment Act 1979*.	Towra Spit Island channel.	Little tern and Australian pied oystercatcher nesting sites.
	Avoid use of rodenticides within forested sections of the Reserve.	Littoral Forests.	Avoid potential secondary poisoning of the masked owl.

Threat	Management response	Target areas or habitats	Key species issues
Entanglement or ingestion of anthropogenic debris	Continue removal of flotsam and jetsam from strategic locations prior to and during the little tern nesting season.	Towra Spit Island.	Little tern, Australian pied oystercatcher, waders and other waterbirds.
	Expand removal of flotsam and jetsam to additional strategic locations prior to and during the Australian pied oystercatcher nesting season.	Towra Point, Pelican Point.	Australian pied oystercatcher, waders and other waterbirds.
Pollution of inshore waters	The Sydney Ports Corporation is responsible for responding to chemical and oil spills in Botany Bay. Work with the Corporation to ensure a coordinated response to spill incidents and that the Nature Reserve and Aquatic Reserve are protected as far as practicable.	Shoreline and inshore waters.	Little tern, Australian pied oystercatcher, waders and other waterbirds.
Shoreline changes, including saltwater intrusion into lagoons	Following assessment of the feasibility of undertaking dredging operations to maintain a tidal channel separating Towra Spit Island from other parts of the Reserve, investigate funding sources to undertake such operations. This is likely to require approval under the NSW *Environmental Planning and Assessment Act 1979*.	Towra Spit Island channel.	Little tern and Australian pied oystercatcher nesting sites.
	Following assessment of the feasibility of undertaking renourishment of Towra Beach, investigate sources of funding to undertake operations at the same time as dredging the tidal channel at Towra Spit Island.	Towra Beach to prevent saltwater intrusion into Towra Lagoon and protect nesting habitat at Towra Beach and Towra Point.	Towra Lagoon: green and golden bell frog, Australasian bittern and other species such as the Australian painted snipe. Towra Beach/Towra Point: Australian pied oystercatcher nesting sites.
	Continue active management of Towra Spit Island before and during the little tern nesting season.	Towra Spit Island.	Little tern nesting sites.
Disturbance and predation by domestic dogs	Undertake regular patrols in sensitive areas to enforce the prohibition of domestic dogs.	Towra Spit Island, Towra Beach, Pelican Point.	Little tern and Australian pied oystercatcher nesting sites, wader and other waterbird high tide roosts.
	Continue with increased patrols (three to four times a week) during the little tern nesting season and holiday periods during the warmer months of the year and extend the patrols to include sand areas on the far west end of Towra Beach.	Towra Spit Island, west end of Towra Beach.	Little tern and Australian pied oystercatcher nesting sites.
	Maintain existing and erect new signs near known nesting locations of little tern and Australian pied oystercatcher, and shorebird roost areas, to highlight the prohibition of domestic dogs. Ensure signs are visible from the water.	Towra Spit Island, Towra Beach, Pelican Point.	Little tern and Australian pied oystercatcher nesting sites, wader and other waterbird high tide roosts.

Threat	Management response	Target areas or habitats	Key species issues
	Increase signage around Woolooware Shorebird Lagoon and along Captain Cook Drive to inform members of the public that dogs are prohibited.	Woolooware Shorebird Lagoon, along Captain Cook Drive.	Waterbirds including the Australasian bittern, curlew sandpiper, Australian pied oystercatcher and other waterbirds and waders.
Saltmarsh alteration	Remove seedling mangroves from Saltmarshes where adult mangrove trees do not occur. This project will require a Review of Environmental Factors (REF) and approval from the Department of Primary Industries (DPI) as mangroves are protected under the NSW *Fisheries Act 1994*.	Saltmarshes adjacent to the Towra Point Track causeway.	White-fronted chat foraging habitat; occasional Australian pied oystercatcher and shorebird foraging habitat.
	Undertake regular searches for outbreaks of the spiny rush. Include management of spiny rush as a priority in the Reserve weed management strategy.	Saltmarshes adjacent to the Towra Point Track causeway.	White-fronted chat habitat.
Predation by raptors	None recommended.		
Collection of intertidal invertebrates for bait and food	Undertake regular patrols to enforce the prohibition of the collection of intertidal invertebrates from the Nature Reserve and the adjoining Aquatic Reserve.	Intertidal flats in Weeney Bay and in the Aquatic Reserve.	Waders and other waterbirds foraging habitat.
	Continue with increased patrols during holiday periods.	As above.	As above.
	Maintain signs to educate the public about the high environmental sensitivity and conservation significance of the areas. Ensure signs are visible from the water.	Towra Spit Island, Towra Beach, Pelican Point, Weeney Bay, Quibray Bay.	Waders and other waterbirds foraging habitat.
Loss of oyster lease posts and other roosting infrastructure	Support the current monitoring of bird usage of replacement artificial structures that have been installed.	The Aquatic Reserve off Pelican Point and in Quibray Bay.	Australian pied oystercatcher roosting and nesting habitat, occasional little tern resting habitat, and roosting habitat for a variety of other waterbirds and waders including the bar-tailed godwit.
	If the replacement structures currently installed continue to be used by priority bird species then support the replacement of other fallen old posts with additional artificial structures.	As above.	As above.
	Support investigation into the feasibility of erecting other artificial structures such as tyres to replace/replicate the roosting habitat provided by barges.	As above.	Roosting habitat for a variety of waterbirds and waders such as terek sandpiper.
Ant attack	Continue the current program of ant baiting before and during the little tern nesting season.	Towra Spit Island.	Little tern and Australian pied oystercatcher nesting sites.

Threat	Management response	Target areas or habitats	Key species issues
Inbreeding/small population size	In consultation/partnership with scientific researchers studying the endangered population of white-fronted chats, conduct a study into the appropriateness and feasibility of introducing individuals into the population.	Principally adjacent to the Towra Point Track causeway, as well as other areas used by the population.	White-fronted chat.
Ghost crab predation	Continue monitoring of little tern nests during the nesting season and undertaking active management to reduce the risk of ghost crab predation as required.	Towra Spit Island.	Little tern nesting sites.

9.2 Management of Moderate Threats

Table 13: Recommendations for management of moderate threats

Threat	Management response	Target areas or habitats	Key species issues
Alteration of wetland characteristics	Liaise with landholders on the Kurnell Peninsula to advocate the importance of effluent, seepage and runoff management to minimise groundwater pollution.		Frog and waterbird species including the Australasian bittern.
Herbicide spraying	Avoid spraying of herbicide within 50 metres of freshwater wetlands and other water bodies.	All water bodies and wetlands.	Frog and waterbird species.
	Avoid broad-scale application of herbicides where other techniques are viable.	Littoral Forests on Towra Point.	Microbats including the greater broad-nosed bat.
Loss of hollow-bearing and standing dead trees	Avoid removal of hollow-bearing and dead standing trees and fallen timber during OEH works.	Across the Reserve.	Greater broad-nosed bat, masked owl and other hollow-dependant species.
Loss of key feed trees	Retain swamp mahogany trees wherever they occur.	Adjacent to Captain Cook Drive in the Woolooware Shorebird Lagoon area.	Grey-headed flying-fox foraging habitat as well as foraging habitat for nectarivorous birds.
	Consider strategic planting of swamp mahogany trees in line with the mapped vegetation community (as mapped in DECCW 2011c).	Adjacent to Captain Cook Drive in the Woolooware Shorebird Lagoon area and potentially in degraded areas elsewhere in the Reserve.	As above.
	Assist natural regeneration of swamp mahogany stands, where necessary by bush regeneration.	Adjacent to Captain Cook Drive in the Woolooware Shorebird Lagoon area.	As above.
Competition from feral honeybees	Remove feral honeybees that establish in hollows within the Reserve.	Littoral Forests.	Greater broad-nosed bat, masked owl and other hollow-dependant species.
Electrocution on powerlines	Check electrocuted individuals found in the local area for the presence of young (which can survive for a time even if the mother has been electrocuted) and seek help from wildlife carers as necessary.	Powerlines adjacent to the Reserve.	Grey-headed flying-fox.

Threat	Management response	Target areas or habitats	Key species issues
	Commence a program encouraging all OEH staff as well as members of the public, bush regenerators and naturalists to report bat electrocutions in the neighbourhood with accurate location information. Compile this information on a data base/GIS and look for patterns to identify problem areas.	As above.	As above.
	If problem areas are identified, work together with power supply companies to reduce the incidence of electrocution in these areas for example by increasing the visibility of powerlines or bundling cables (DECC 2008e).	As above.	As above.
Road mortality	Liaise with road authorities to design and implement a plan to minimise wildlife road mortality on Captain Cook Drive. Elements could include a speed camera on Captain Cook Drive.	Captain Cook Drive between Woolooware Shorebird Lagoon and the junction of Towra Point Track.	Grey-headed flying-fox and other native species.
Infection of frog species by Chytrid fungus	Ensure that staff, contractors and bush regeneration teams follow the *Hygiene protocol for the control of disease in frogs* (NPWS 2001).	Across the Reserve.	Frog species including the green and golden bell frog if rediscovered.
Predation of tadpoles by the plague minnow	If the green and golden bell frog is rediscovered survey habitat for plague minnow, with reference to the Gambusia Threat Abatement Plan and where possible remove plague minnow from sites occupied by the green and golden bell frog (DECC 2007c).	Any areas where green and golden bell frog is rediscovered.	The green and golden bell frog if rediscovered.

Sign providing information about the bush regeneration project on Towra Point. Photo © M. Schulz

9.3 Management of Other Fauna Threats

Additional strategies to reduce the impact of other threats to native fauna include the following.

- Continue the current approach to management of the rabbit and also consider conducting control during or soon after fox baiting. If rabbit numbers are observed to increase in parts of the Reserve where they are not currently controlled, then expand control to these areas.
- Destroy nests of common starling and common myna where they are noticed in tree hollows within the Park.
- Work with community groups to conduct cleanup days within sections of the Reserve, such as near the Woolooware Shorebird Lagoon and along shorelines.

9.4 Potential Discovery of New or Presumed Lost Species

This report documents the most accurate possible current inventory of fauna species for Towra Point NR. New species may arrive or be discovered over time, or species that are suspected to have been lost may return or be rediscovered. When additional species are reported it is important that reliable supporting evidence is sourced so that an accurate inventory can be maintained. When confirmed, a new species should be reviewed to identify its relative conservation management priority so that resources are continually directed toward those species currently most in need.

Annual checks of the species recorded in the Atlas of NSW Wildlife is recommended by comparing the species list outputs with those generated for this report. Recent records of species not discussed in this report, or not confirmed in recent years, should be verified and reviewed. A reordering of species conservation priorities may be warranted depending on the conservation status of newly discovered species.

9.5 Maintaining Wildlife Data Systems

Surveys such as those undertaken in 2006 and 2013 are restricted in terms of providing only a 'snapshot in time' with respect to the fauna present and fauna patterns during different annual cycles, such as drought and above-average rainfall years. The following recommendations are therefore provided with the aim of gaining a better understanding of the fauna present within the Reserve.

- Strongly encourage all researchers and fauna consultants to contribute their records (e.g. trapping effort and results) to the Atlas of NSW Wildlife. These records should be submitted on a regular basis rather than after the study has been completed. It would be highly advantageous for accompanying photographs or ultrasound recording files of rare species or species that have not previously been confirmed to occur in the area to also be submitted with records.
- Strongly encourage OEH staff and contractors to enter sightings into the Atlas of NSW Wildlife, where possible with accompanying photographs if the species is rare or has not been previously recorded.

The red-capped plover formerly nested around pools in Saltmarshes within the Reserve. Photo © M. Schulz

10 Recommendations for Monitoring, Further Survey and Research

10.1 Fauna Monitoring

Discussion of fauna monitoring is important as it is increasingly included as a key corporate environmental management objective for park managers. It is a complex and difficult issue because questions about what to monitor are often poorly described and projects are rarely funded for sufficient time periods to generate meaningful results. The purpose of this section is to discuss the current overarching monitoring strategies in New South Wales, the reasons why monitoring programs often fail and to suggest monitoring projects that are relevant to fauna within the Reserve that is the focus of this report.

Part of the complexity of fauna monitoring lies in the different sorts of monitoring questions there are to choose from. The NSW Monitoring and Evaluation Strategy (NSW NRE CEO Cluster Group 2006) describes two different types of monitoring program that attempt to answer completely different questions.

1. **Resource Condition Monitoring** follows trends in particular aspects of a natural resource to understand whether the overall health of the resource is changing. We would use Resource Condition monitoring to answer questions like 'What is the condition of fauna in Georges River NP?" and "Is the health declining, improving or staying the same?" To answer these questions it is imperative to develop good indicators of the condition or health of fauna diversity so that it can be measured periodically over a long time period. Resource condition monitoring allows us to observe the **net effect of all active threats and management actions**, but it does not explain the cause of the observed trend.

2. **Performance monitoring** on the other hand can inform us about what is causing an observed trend, and can be used to assess whether management actions are resulting in improved health. Performance monitoring can be split into two components (1) identifying the cause of an observed trend, and (2) measuring the effectiveness of a management action to eliminate that causal factor.

   Performance monitoring often relies on more detailed research, and requires a carefully planned experiment if causal factors are to be identified (NSW NRE CEO Cluster Group 2006). Once the causal factors for a change are understood then a performance monitoring program may be implemented to track the success of any management actions. For example, fox predation has been identified as a major factor in the decline of medium sized ground-dwelling mammals. A monitoring program can be set up to measure the success of management actions carried out to ameliorate this threat (e.g. increase in abundance of ground-dwelling mammals following a fox-baiting program).

NPWS (part of OEH) recently initiated a program called ParkIQ to improve the strategic approach to coordinating survey, monitoring, evaluation and research work on reserves across the State. The program has three main components: development of a Monitoring and Evaluation Guide (MEG, DECCW 2010); compilation of a Monitoring, Survey and Research Inventory (MSR inventory); and the Park IQ Strategy (PIQS). The key biodiversity component of the PIQS is an initiative known as WildCount which seeks to provide a single unifying framework for vertebrate fauna monitoring across the NSW reserve system.

The completion of this report and survey program, together with the Australian Littoral Society study in 1977, is actually a key step towards the development of a monitoring program for the Reserve. They provide data against which future trends can be gleaned by adopting the same systematic methods employed in 2006 and 2013. The results of the work help answer questions not only about the state of fauna in Towra Point NR but also about the contribution the area makes toward the persistence of species in the region and within the State. This is particularly the case for threatened and migratory species.

10.1.1 Implementing a fauna monitoring program

There are two broad components of a monitoring program. The first is the scientific design and the second is the administration of the project. Monitoring projects commonly fail as a result of the latter.

Fauna monitoring is expensive and requires a long term commitment to generate reliable data. New surveys generate data all of which needs to be entered into a database and analysed periodically to assess results. Consider that for many fauna it may be at least 5-10 years to observe a trend. Unless there is clear support for such a program the long term viability will be tenuous and may become a one-off study that is not maintained over time. A well constructed monitoring program should link with other monitoring projects occurring within OEH to ensure that projects can as far as possible satisfy multiple monitoring objectives. This includes threatened species management, state of the parks reporting and scientific services research. Consultation with the relevant staff greatly increases the chances of implementing an integrated project that garners support for its continuation over time.

The scientific issues to consider before setting up a monitoring program are also complex. Table 14 presents a summary of the issues that confront fauna monitoring programs.

Table 14: Scientific issues to consider In relation to monitoring programs

Issue	Description
Have clear, simple goals and test well defined hypotheses	Monitoring programs that have very broad aims, or vague hypotheses, or are too ambitious in terms of the number of questions they try to answer, often fail. It is important to keep things simple.
Develop reliable and useful indicators	Choosing the right indicators requires careful thought to ensure they will provide information that clearly relates to the issue that you want to monitor. For example monitoring a hard to find fauna species to inform of the health of fauna overall will be more resource intensive than using a common species.
Have a well thought out survey design that uses appropriate stratification	Again, a simple design that is limited to a particular species, or a few or perhaps limiting the subject of the monitoring to one suite of species, will give the monitoring project a better chance of success
Have enough sites and therefore enough statistical power to detect change	A simple calculation can be done *a priori* to determine the minimum sample size needed to have sufficient power. Too few survey sites will guarantee that a monitoring program will either fail to detect change, or give an unreliable or misleading result.
Clearly define the type of data the monitoring program sets out to collect	For example, presence/absence of species at the site scale which can be regionally summarised as species x was present at 10 out of 18 sites in the region; OR breeding success of a species per year, OR number of individuals of a species per unit effort
Employ appropriate survey methods for the desired data type	For example you might choose one method to generate presence/absence data, but another to obtain abundance estimates. This needs to be thought about and planned for at the concept stage of planning.
Be undertaken at an appropriate temporal scale, and most importantly have on-going commitment for the long-term	Most monitoring projects need at least 5 years worth of data to detect change, whereas many will need much longer than that (IUCN red list criteria suggest that 10 years (or 3 x generation length) of data is the minimum amount needed to adequately assess trends over time see http://www.iucnredlist.org/technical-documents/categories-and-criteria for more detail). The number of years needed for monitoring will depend on the frequency of monitoring, the methods used and the biology, in particular the life history of the species or suite of species being monitored. Monitoring anything for less than 5 years is a waste of time and resources, as statistically, you will likely need many more than 5 data points to confidently interpret any observed trend.

Issue	Description
Set limits of acceptable change	This is an important aspect of monitoring that many programs omit. It is easy at the conclusion of a monitoring program to say, "Species x declined by 60% over 30 years", however it is often too late to use this information and the population has changed beyond recovery. Information that a decline is occurring at present is much more useful, so that something can be done to halt or reverse the decline. Hence, there must be a limit of acceptable change set for all monitoring programs. This will define a point of "worry", and help to facilitate a feedback loop for adaptive management. There will always be a small amount of change due to natural fluctuations, e.g. drought, however this amount of expected natural fluctuation needs to be estimated and a sensible limit of acceptable change determined. For example, you might set an acceptable limit of change for the abundance of a certain species to be +/- 8% annually (this translates into the species being at risk of extinction within 20 years), and for the first 3 years, the population has shown a 2% increase, then a 2% decline, then a 4% decline, then in the 4th year, the population drops by 9%. Because we have set 8% as the "worry" point, we know that we need to act to halt or reverse this decline. The relevant land managers should be made aware and act accordingly, maybe stepping up predator control, or investigating other threats.

10.1.2 Suggested monitoring programs

As discussed above, the design of monitoring programs is a complex issue requiring extensive planning and consultation. Once running, monitoring programs require ongoing funding and resource commitment to ensure their success and value in the long term. There are a number of monitoring programs already established in Towra Point NR; these are highly valuable as they have run over many years and provide sufficient sampling effort to undertake trend analyses. Ongoing commitment to these existing monitoring programs is considered high priority. These programs are listed below.

- Regular monthly counts of shorebirds and other waterbirds by the NSW Wader Study Group, including threatened and migratory shorebird species. This survey is of particular value as it has been conducted monthly for almost 20 years, thereby providing a large amount of data that can be used to investigate the population trends of waders and other waterbirds. The counts have been conducted systematically and frequently by the same observers. These monthly counts provide a regional context as they have been conducted during the same high tide period in adjacent parts of Botany Bay and at Boat Harbour. It is highly recommended that these surveys continue to be supported.
- Annual monitoring of little tern nesting on Towra Spit Island and elsewhere in Botany Bay, including documenting fledgling success, nest failure rates and the causes of nest failures. This monitoring is embedded in the recovery plan for the species (NPWS 2003) and is listed as an action in the species priority action statement (PAS).
- Monitoring and research of the white-fronted chat. Towra Point NR plays a crucial role in the conservation of the endangered population of white-fronted chat in the Sydney metropolitan area. Research and monitoring is currently led by the Australian Museum. Annual monitoring and population analysis are listed as actions in the species priority action statement (PAS). It is vital to the conservation of this species in the Reserve that ongoing research, monitoring and active management be supported.
- Annual monitoring of the Australian pied oystercatcher including monitoring fledgling success on Towra Spit Island and monitoring the location of nests elsewhere in the Reserve (i.e. Towra Beach, Pelican Point, the islands in Woolooware Shorebird Lagoon) and on oyster posts within the adjoining Aquatic Reserve. Annual survey and monitoring is listed as an action in the species priority action statement (PAS).

In addition to the above there are two monitoring/survey programs already established in the Sydney region and nationwide which are applicable to Towra Point NR, as follows.

- Birdlife Australia annual census for regent honeyeater and swift parrot. Surveys are undertaken when key eucalypt feed trees are in flower; for Towra Point NR the key flowering species is the swamp mahogany.
- Birdlife Australia survey for Australia's bitterns (Birdlife Australia 2010). It is recommended that surveys be undertaken over a number of years in spring and early summer using call playback,

passive listening at dawn and dusk, and active searching. Recommended areas include extensive sea rush areas bordering Saltmarshes and areas of common reed.

10.2 Further Fauna Survey

At the completion of the 2013 survey it is considered that all vertebrate fauna groups except amphibians have been systematically sampled to an adequate level to provide a baseline understanding of terrestrial vertebrate fauna in Towra Point NR and enable the setting of conservation management priorities. The species inventory in Appendix A presents the current list of vertebrate fauna for the Reserve, however this list would surely be expanded upon with additional survey. The high priority for further fauna survey is systematic amphibian survey, as follows.

- Conduct systematic amphibian surveys after heavy or prolonged rain in late spring/early summer over a number of years, aiming to sample all frog species while targeting the green and golden bell frog and cane toad. Suggested regular survey sites include Mirrormere, Towra Lagoon, Weedy Pond and the radar shed area on the Towra Point Track causeway, building on surveys that have been undertaken in these areas in the past. Additional recommended sites are: sea rush areas bordering Saltmarshes such as in the Fish Creek area; adjacent to Captain Cook Drive between the Towra Point Track causeway and the Woolooware Shorebird Lagoon; and adjacent to and eastwards of the Stables area north of Captain Cook Drive. Local green and golden bell frog experts and relevant OEH threatened species personnel should be consulted during survey design and implementation to ensure that the surveys complement monitoring and species recovery work undertaken elsewhere on the Kurnell Peninsula. Survey techniques should follow the recommended survey guidelines for green and golden bell frogs in DECC (2009), and be deployed consistently each survey period. Consider involving the community in the surveys. Also consider the use of automated audio recorders to augment the on-ground surveys, in order to sample frog calls over a whole spring and summer period in potential green and golden bell frog or cane toad habitat areas. As a matter of priority, ensure that all survey effort and survey results are entered into the fauna module of the Atlas of NSW Wildlife.
- Continue the current program of using cane toad sniffer dogs to periodically search wetlands in the Reserve, for as long as invasion by the cane toad remains a threat.
- Compilation of a more exhaustive species inventory for the Reserve over time would require: additional reptile surveys between late spring and mid-summer; additional insectivorous bat surveys between late spring and mid-summer using harp traps and bat ultrasonic call recorders; and regular bird surveys in bushland areas over a number of years, in addition to the monitoring/survey programs suggested in section 10.1.2 above.

10.3 Research

10.2.1 Ongoing research on the white fronted chat to inform conservation management

Ongoing research and monitoring of the Towra Point white-fronted chat population is of very high conservation management priority and should continue to be supported. Some areas of study to consider incorporating into the research program include: investigating the feasibility and appropriateness of introducing individuals into the population; investigating the feasibility of protecting nests by nest caging; considering expansion of the Reserve's rat baiting program to include sea rushland areas adjacent to Towra Point Track causeway and monitoring the impact on the rat population and the white-fronted chats; investigating the feasibility of expanding the current extent of Saltmarshes in the Reserve, such as behind Quibray Bay adjoining the Stables area; ongoing research into appropriate amelioration of other threats to the population.

10.2.2 Low tide, foraging and roosting habitats of shorebirds in Botany Bay

All surveys undertaken for the monitoring of shorebirds in Botany Bay by the NSW Wader Study Group are timed at high tide, leading to a good understanding of high tide habitat use in the Bay. Information is more scattered, however, on the pattern of shorebird habitat use at low tide, the importance of various intertidal foraging areas, and the roosting habitats of many species. The full range of habitats within the Botany Bay area that are used by The Shorebird Community Occurring on Relict Tidal Delta Sands at Taren Point Endangered Ecological Community is not fully documented,

nor is the extent to which individuals move between the EEC area and Towra Point NR and consequently the relative importance of the Reserve to the EEC and its component species.

A program is warranted to bring together all existing information on low tide and roosting habits and habitats of the shorebirds in Botany Bay, and generate new data where information is found lacking. Such a program should include consultation with local shorebird experts and the NSW Wader Study Group; where new survey work is necessary this should be designed and implemented with input from these groups. The program would seek to answer the following questions.

- What is the relative importance of habitats and localities used by shorebird species in Botany Bay at low tide?
- What is the importance of intertidal areas within the Reserve as foraging habitat for shorebird species, in particular the Australian pied oystercatcher, terek sandpiper, curlew sandpiper and broad-billed sandpiper that predominantly roost at high tide in the nearby Shell Point area.
- What is the extent of use of mangroves in the Reserve by shorebird species, in particular as roosting habitat for the terek sandpiper and other mangrove-roosting species? Answering this question would involve conducting targeted surveys at high tide in summer by canoe or kayak in shallow difficult-to-access mangrove areas.

10.2.3 Installation of artificial nest platforms for eastern osprey

There are few nesting records of eastern osprey in the Sydney Basin Bioregion. A pair of eastern osprey has regularly been observed in the Reserve over the last couple of years and in December 2010 one individual was observed carrying a stick at Towra Spit Island (NSW Wader Study Group data) indicating the potential for nesting in the area. If nesting successfully occurred in the Reserve then it would be one of the most southerly nesting locations for the species in New South Wales. The extent of quality habitat within and surrounding Towra Point NR, together with the relatively low degree of public disturbance, presents an opportunity to encourage nesting of eastern osprey. A research project could investigate the feasibility of, and trial, establishing artificial nest platforms within the Reserve. The platforms should be predator-proof and located above high tide in Saltmarshes in parts of the Reserve infrequently visited by humans such as the Fish Creek area. Platforms would need to be constructed on poles in open areas more than 10 metres from the nearest tree, enabling birds to have maximum visibility of the surrounding terrain. The nest platform(s) could follow the design used elsewhere in Australia (e.g. Bischoff 2001, Dennis 2007, Howard 2011) or overseas (e.g. Martin et al. 1986, The International Osprey Foundation 2011, New Jersey Division of Fish and Wildlife 2013, The Peregrine Fund 2013).

10.2.4 Alternative methods of reducing the population of black rats

In recent years, research has been undertaken elsewhere in the Sydney region investigating whether the reintroduction of native bush rats (*Rattus fuscipes*) after a reduction in black rat numbers will lead to establishment of bush rat population(s) that maintain the numbers of black rats at a low level. Consideration could be given to volunteering Towra Point NR to be part of this research.

Towra Spit Island. © M. Schulz

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Yellow-tailed black-cockatoos perched in a swamp oak on the Towra Point Track causeway. Photo © M. Schulz

APPENDIX A: VERTEBRATE FAUNA OF TOWRA POINT NATURE RESERVE

This appendix provides a list of vertebrate fauna (excluding fish) that currently or previously occurred within Towra Point NR (Table 15). The list is primarily based on records from the Atlas of NSW Wildlife, with additional records from Schulz (2006), White (2012), the Australian Littoral Society (1977) and various consultancy reports. Following a review of records conducted for this project a number of species are not included in this list and these are detailed in Table 7.

In this list the species order for amphibians and reptiles follows Cogger (1996), for birds Christidis and Boles (2008) and for mammals Van Dyck and Strahan (2008). All recent taxonomic changes have been incorporated (as of May 2013).

The following columns have been included for each species:

NSW Legal Status = Current listing under the TSC Act (as of June 2013). Codes used are CE=Critically Endangered, E=Endangered, EP=Endangered Population, V=Vulnerable, P=Protected, U=Feral species.

Federal Legal Status = Current listing under the Commonwealth EPBC Act (as of June 2013).

Migratory Bird Listing = Species listed under C – CAMBA (Commonwealth of Australia 1995a), J – JAMBA (Commonwealth of Australia 1995b) and R – ROKAMBA (Commonwealth of Australia 2006).

Current Status = Status of species (adapted from Australian Littoral Society 1977, Schulz 2006). Species regarded as locally extinct or no confirmed sightings within the last 25 years = **NR** (in bold); species that have uncertain status within the Reserve, including species with less than five records that are likely to have been under-recorded as a result of their cryptic behaviour or specialised habitat requirement = SU. SM = predominantly a summer migrant; WM = predominantly a winter migrant; RE = Resident (regularly recorded, but may not breed in the Reserve); IV = Irregular visitor; and VA = Vagrant bird species with less than two documented records in Atlas of NSW Wildlife and/or by M. Schulz (unpublished records) and/or classed as rare in Australian Littoral Society (1977).

Record Source = 1 – Atlas of NSW Wildlife, including the survey records of the BSP survey, Schulz (2006), DECC (2008a) and NSW Wader Study Group monthly count records. If no records in this source then: *2* – Arthur White, Biosphere Environmental Consultants pers. comm. and White (2012); 3 – records from various observers on the Birding Aus website; 4 – Fox (1972); 5 – Priddel and Ross (1996); 6 – Australian Littoral Society (1977); 7 – M. Schulz (2011, unpublished records); 8 – Lindsay (2011); 9 – Jones (2009); 10 – J. Bishop pers. comm. (reporting a call heard by M. Greenaway). Where an Atlas record is considered unconfirmed an additional record source is provided.

Table 15: Fauna species accurately recorded in Towra Point Nature Reserve

Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Frogs							
Myobatrachidae	*Crinia signifera*	Common eastern froglet	P			RE	1
Myobatrachidae	*Limnodynastes peronii*	Brown-striped frog	P			RE	1
Hylidae	*Litoria aurea*	Green and golden bell frog	E	V		SU	1,2
Hylidae	*Litoria dentata*	Bleating tree frog	P			RE	1
Hylidae	*Litoria jervisiensis*	Jervis Bay tree frog	P			RE	1
Hylidae	*Litoria peronii*	Peron's tree frog	P			RE	1
Reptiles							
Chelidae	*Chelodina longicollis*	Eastern snake-necked turtle	P			RE	1
Scincidae	*Ctenotus robustus*	Robust ctenotus	P			RE	1
Scincidae	*Cryptoblepharus pulcher*	Cream-striped shinning-skink	P			SU	7
Scincidae	*Eulamprus quoyii*	Eastern water-skink	P			SU	1
Scincidae	*Eulamprus tenuis*	Barred-sided skink	P			RE	1
Scincidae	*Lampropholis delicata*	Dark-flecked garden sunskink	P			RE	1
Scincidae	*Lampropholis guichenoti*	Pale-flecked garden sunskink	P			RE	1
Scincidae	*Saiphos equalis*	Three-toed skink	P			RE	1
Scincidae	*Saproscincus mustelinus*	Weasel skink	P			SU	1
Scincidae	*Tiliqua scincoides*	Eastern blue-tongue	P			RE	1
Agamidae	*Amphibolurus muricatus*	Jacky lizard	P			RE	1
Elapidae	*Cryptophis nigrescens*	Eastern small-eyed snake	P			SU	1
Elapidae	*Demansia psammophis*	Yellow-faced whip snake	P			SU	7
Elapidae	*Hemiaspis signata*	Black-bellied swamp snake	P			RE	1
Elapidae	*Pseudechis porphyriacus*	Red-bellied black snake	P			RE	1
Birds							
Phasianidae	*Coturnix pectoralis*	Stubble quail	P			SU	1
Phasianidae	*Coturnix ypsilophora*	Brown quail	P			IV	1,9
Anatidae	*Anas castanea*	Chestnut teal	P			RE	1
Anatidae	*Anas gracilis*	Grey teal	P			IV	1
Anatidae	*Anas platyrhynchos*	Northern mallard	U			VA	1
Anatidae	*Anas rhynchotis*	Australasian shoveler	P			VA	1
Anatidae	*Anas superciliosa*	Pacific black duck	P			IV	1
Anatidae	*Aythya australis*	Hardhead	P			IV	6
Anatidae	*Biziura lobata*	Musk duck	P			IV	1
Anatidae	*Chenonetta jubata*	Australian wood duck	P			IV	1
Anatidae	*Cygnus atratus*	Black swan	P			IV	1

Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Anatidae	*Tadorna tadornoides*	Australian shelduck	P			VA	1
Podicipedidae	*Podiceps cristatus*	Great crested grebe	P			IV	1
Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed grebe	P			IV	1
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe	P			IV	1
Columbidae	*Chalcophaps indica*	Emerald dove	P			**NR**	1
Columbidae	*Columba leucomela*	White-headed pigeon	P			VA	1
Columbidae	*Columba livia*	Rock dove	U			IV	7
Columbidae	*Geopelia humeralis*	Bar-shouldered dove	P			IV	1
Columbidae	*Lopholaimus antarcticus*	Topknot pigeon	P			VA	3
Columbidae	*Ocyphaps lophotes*	Crested pigeon	P			IV	1
Columbidae	*Streptopelia chinensis*	Spotted dove	U			RE	1
Podargidae	*Podargus strigoides*	Tawny frogmouth	P			SU	1
Apodidae	*Apus pacificus*	Fork-tailed swift	P		C, J, R	SM	7
Apodidae	*Hirundapus caudacutus*	White-throated needletail	P		C, J, R	SM	6,7
Anhingidae	*Anhinga novaehollandiae*	Australasian darter	P			IV	1
Phalacrocoracidae	*Microcarbo melanoleucos*	Little pied cormorant	P			RE	1
Phalacrocoracidae	*Phalacrocorax carbo*	Great cormorant	P			RE	1
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little black cormorant	P			RE	1
Phalacrocoracidae	*Phalacrocorax varius*	Pied cormorant	P			RE	1
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican	P			RE	1
Ardeidae	*Ardea ibis*	Cattle egret	P		C, J	IV	1
Ardeidae	*Ardea intermedia*	Intermediate egret	P			IV	1
Ardeidae	*Ardea modesta*	Eastern great egret	P		C, J	RE	1
Ardeidae	*Ardea pacifica*	White-necked heron	P			VA	1
Ardeidae	*Botaurus poilciloptilus*	Australasian bittern	E	E		SU	1
Ardeidae	*Butorides striata*	Striated heron	P			RE	1
Ardeidae	*Egretta garzetta*	Little egret	P			IV	1
Ardeidae	*Egretta novaehollandiae*	White-faced heron	P			RE	1
Ardeidae	*Egretta sacra*	Eastern reef egret	P		C	VA	1
Ardeidae	*Ixobrychus dubius*	Australian little bittern	P			**NR**	6
Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron	P			RE	1
Threskiornithidae	*Platalea flavipes*	Yellow-billed spoonbill	P			VA	6
Threskiornithidae	*Platalea regia*	Royal spoonbill	P			RE	1
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	P		C	IV	1
Threskiornithidae	*Threskiornis molucca*	Australian white ibis	P			RE	1
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked ibis	P			VA	6
Accipitridae	*Accipiter cirrocephalus*	Collared sparrowhawk	P			**NR**	6
Accipitridae	*Accipiter fasciatus*	Brown goshawk	P			RE	1
Accipitridae	*Accipiter*	Grey goshawk	P			IV	1

Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
	novaehollandiae						
Accipitridae	*Aquila audax*	Wedge-tailed eagle	P			VA	5
Accipitridae	*Circus approximans*	Swamp harrier	P			RE	1
Accipitridae	*Elanus axillaris*	Black-shouldered kite	P			IV	1
Accipitridae	*Haliaeetus leucogaster*	White-bellied sea-eagle	P		C	RE	1
Accipitridae	*Haliastur sphenurus*	Whistling kite	P			IV	1
Accipitridae	*Pandion cristatus*	Eastern osprey	V			IV	1
Falconidae	*Falco berigora*	Brown falcon	P			**NR**	6
Falconidae	*Falco cenchroides*	Nankeen kestrel	P			RE	1
Falconidae	*Falco longipennis*	Australian hobby	P			IV	1
Falconidae	*Falco peregrinus*	Peregrine falcon	P			IV	1
Falconidae	*Falco subniger*	Black falcon	P			VA	1
Rallidae	*Fulica atra*	Eurasian coot	P			**NR**	6
Rallidae	*Gallinula tenebrosa*	Dusky moorhen	P			VA	1
Rallidae	*Gallirallus philippensis*	Buff-banded rail	P			RE	1
Rallidae	*Lewinia pectoralis*	Lewin's rail	P			RE	1
Rallidae	*Porphyrio porphyria*	Purple swamphen	P			RE	1
Rallidae	*Porzana fluminea*	Australian spotted crake	P			**NR**	6
Rallidae	*Porzana pusilla*	Baillon’s crake	P			**NR**	6
Rallidae	*Porzana tabuensis*	Spotless crake	P			IV	1
Burhinidae	*Esacus magnirostris*	Beach stone-curlew	CE			VA	1
Haematopodidae	*Haematopus fuliginosus*	Sooty oystercatcher	V			IV	1
Haematopodidae	*Haematopus longirostris*	Australian pied oystercatcher	E			RE	1
Recurvirostridae	*Himantopus himantopus*	Black-winged stilt	P			IV	1
Charadriidae	*Charadrius bicinctus*	Double-banded plover	P			WM	1
Charadriidae	*Charadrius leschenaultii*	Greater sand plover	V		C, J, R	SM	1
Charadriidae	*Charadrius mongolus*	Lesser sand plover	V		C, J, R	SM	1
Charadriidae	*Charadrius ruficapillus*	Red-capped plover	P			IV	1
Charadriidae	*Charadrius veredus*	Oriental plover	P		J, R	VA	1
Charadriidae	*Elseyornis melanops*	Black-fronted dotterel	P			IV	1
Charadriidae	*Erythrogonys cinctus*	Red-kneed dotterel	P			VA	1
Charadriidae	*Pluvialis fulva*	Pacific golden plover	P		C, J, R	SM	1
Charadriidae	*Pluvialis squatarola*	Grey plover	P		C, J, R	SM	1
Charadriidae	*Vanellus miles*	Masked lapwing	P			RE	1
Rostratulidae	*Rostratula australis*	Australian painted snipe	E	E	C	VA	1
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	P		C, J, R	SM	1
Scolopacidae	*Arenaria interpres*	Ruddy turnstone	P		C, J, R	SM	1
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	P		C, J, R	SM	1
Scolopacidae	*Calidris alba*	Sanderling	V		C, J, R	SM	1,6
Scolopacidae	*Calidris canutus*	Red knot	P		C, J, R	SM	1
Scolopacidae	*Calidris ferruginea*	Curlew sandpiper	E		C, J, R	SM	1
Scolopacidae	*Calidris ruficollis*	Red-necked stint	P		C, J, R	SM	1

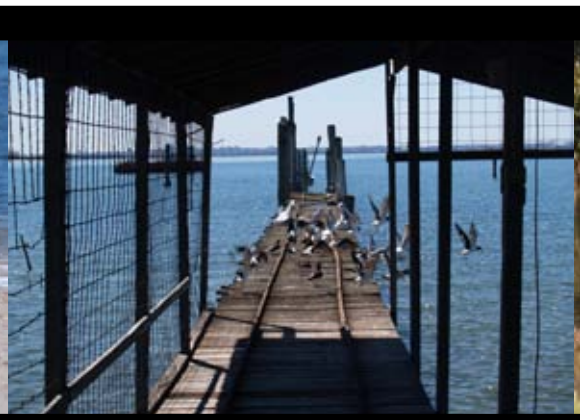
Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Scolopacidae	*Calidris tenuirostris*	Great knot	V		C, J, R	SM	1
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	P		C, J, R	SM	1
Scolopacidae	*Limicola falcinellus*	Broad-billed sandpiper	V		C, J, R	SM	6
Scolopacidae	*Limosa lapponica*	Bar-tailed godwit	P		C, J, R	SM	1
Scolopacidae	*Limosa limosa*	Black-tailed godwit	V		C, J, R	SM	1
Scolopacidae	*Numenius madagascariensis*	Eastern curlew	P		C, J, R	SM	1
Scolopacidae	*Numenius minutus*	Little curlew	P		C, J, R	SM	1
Scolopacidae	*Numenius phaeopus*	Whimbrel	P		C, J, R	SM	1
Scolopacidae	*Philomachus pugnax*	Ruff	P		C, J, R	**NR**	6
Scolopacidae	*Tringa brevipes*	Grey-tailed tattler	P		C, J, R	SM	1
Scolopacidae	*Tringa incana*	Wandering tattler	P		C, J	**NR**	6
Scolopacidae	*Tringa nebularia*	Common greenshank	P		C, J, R	SM	1
Scolopacidae	*Xenus cinereus*	Terek sandpiper	V		C, J, R	SM	1
Turnicidae	*Turnix varius*	Painted button-quail	P			SU	1
Laridae	*Chlidonias hybrid*	Whiskered tern	P			IV	1
Laridae	*Chroicocephalus novaehollandiae*	Silver gull	P			RE	1
Laridae	*Gelochelidon nilotica*	Gull-billed tern	P			VA	1
Laridae	*Hydroprogne caspia*	Caspian tern	P		C, J	IV	1
Laridae	*Larus dominicanus*	Kelp gull	P			IV	1
Laridae	*Larus pacificus*	Pacific gull	P			VA	1
Laridae	*Sterna hirundo*	Common tern	P		C, J, R	SM	1
Laridae	*Sterna paradisaea*	Arctic tern	P			**NR**	1
Laridae	*Sterna striata*	White-fronted tern	P			WM	6
Laridae	*Sternula albifrons*	Little tern	E		C, J, R	SM	1
Laridae	*Sternula nereis*	Fairy tern	P			VA	1
Laridae	*Thalasseus bergii*	Crested tern	P			RE	1
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	P			IV	1
Cacatuidae	*Cacatua sanguinea*	Little corella	P			IV	1
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed black-cockatoo	P			IV	1
Cacatuidae	*Eolophus roseicapillus*	Galah	P			IV	1
Psittacidae	*Neophema chrysostoma*	Blue-winged parrot	P			**NR**	1
Psittacidae	*Platycercus elegans*	Crimson rosella	P			RE	1
Psittacidae	*Platycercus eximius*	Eastern rosella	P			IV	1
Psittacidae	*Psephotus haematonotus*	Red-rumped parrot	P			**NR**	6
Psittacidae	*Trichoglossus haematodus*	Rainbow lorikeet	P			IV	1
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed cuckoo	P			RE	1
Cuculidae	*Cacomantis pallidus*	Pallid cuckoo	P			**NR**	6
Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo	P			SM	1

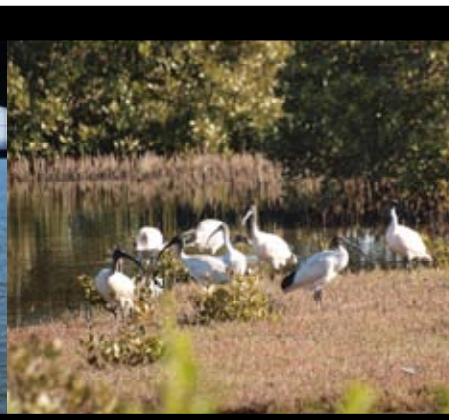
Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Cuculidae	*Chalcites lucidus*	Shining bronze-cuckoo	P			SM	1
Cuculidae	*Eudynamys orientalis*	Eastern koel	P			SM	1
Cuculidae	*Scythrops novaehollandiae*	Channel-billed cuckoo	P			SM	1
Strigidae	*Ninox novaeseelandiae*	Southern boobook	P			RE	1
Tytonidae	*Tyto javanica*	Eastern barn owl	P			SU	1
Tytonidae	*Tyto novaehollandiae*	Masked owl	V			SU	1
Alcedinidae	*Ceyx azureus*	Azure kingfisher	P			IV	8
Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra	P			RE	1
Halcyonidae	*Todiramphus sanctus*	Sacred kingfisher	P			SM	1
Coraciidae	*Eurystomus orientalis*	Dollarbird	P			SM	1
Pittidae	*Pitta versicolor*	Noisy Pitta	P			SU	10
Climacteridae	*Cormobates leucophaea*	White-throated treecreeper	P			SU	1
Maluridae	*Malurus cyaneus*	Superb fairy-wren	P			RE	1
Maluridae	*Malurus lamberti*	Variegated fairy-wren	P			RE	1
Maluridae	*Stipiturus malachurus*	Southern emu-wren	P			RE	1
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped thornbill	P			SU	1
Acanthizidae	*Acanthiza nana*	Yellow thornbill	P			RE	1
Acanthizidae	*Acanthiza pusilla*	Brown thornbill	P			RE	1
Acanthizidae	*Calamanthus fuliginosus*	Striated fieldwren	E			**NR**	1
Acanthizidae	*Gerygone albogularis*	White-throated gerygone	P			**NR**	6
Acanthizidae	*Gerygone levigaster*	Mangrove gerygone	P			RE	1
Acanthizidae	*Gerygone mouki*	Brown gerygone	P			RE	1
Acanthizidae	*Hylacola pyrrhopygia*	Chestnut-rumped heathwren	P			SU	1
Acanthizidae	*Sericornis frontalis*	White-browed scrubwren	P			RE	1
Pardalotidae	*Pardalotus punctatus*	Spotted pardalote	P			RE	1
Pardalotidae	*Pardalotus striatus*	Striated pardalote	P			IV	7,8
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked honeyeater	P			VA	3,6
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern spinebill	P			RE	1
Meliphagidae	*Anthochaera carunculata*	Red wattlebird	P			IV	1
Meliphagidae	*Anthochaera chrysoptera*	Little wattlebird	P			RE	1
Meliphagidae	*Anthochaera phrygia*	Regent honeyeater	CE	E		**NR**	6
Meliphagidae	*Epthianura albifrons*	White-fronted chat	V, EP			RE	1
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced honeyeater	P			IV	1
Meliphagidae	*Lichmera indistincta*	Brown honeyeater	P			RE	1
Meliphagidae	*Manorina melanocephala*	Noisy miner	P			IV	1
Meliphagidae	*Meliphaga lewinii*	Lewin's honeyeater	P			RE	1

Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Meliphagidae	*Melithreptus lunatus*	White-naped honeyeater	P			IV	1
Meliphagidae	*Myzomela sanguinolenta*	Scarlet honeyeater	P			IV	1
Meliphagidae	*Philemon corniculatus*	Noisy friarbird	P			**NR**	6
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland honeyeater	P			RE	1
Psophodidae	*Psophodes olivaceus*	Eastern whipbird	P			**NR**	6
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	P			RE	1
Campephagidae	*Lalage sueurii*	White-winged triller	P			VA	1
Pachycephalidae	*Colluricincla harmonica*	Grey shrike-thrush	P			RE	1
Pachycephalidae	*Pachycephala pectoralis*	Golden whistler	P			WM	1
Pachycephalidae	*Pachycephala rufiventris*	Rufous whistler	P			SM	1
Oriolidae	*Oriolus sagittatus*	Olive-backed oriole	P			IV	1
Artamidae	*Cracticus tibicen*	Australian magpie	P			RE	1
Artamidae	*Cracticus torquatus*	Grey butcherbird	P			RE	1
Artamidae	*Strepera graculina*	Pied currawong	P			IV	1
Dicruridae	*Dicrurus bracteatus*	Spangled drongo	P			WM	1
Rhipiduridae	*Rhipidura albiscapa*	Grey fantail	P			RE	1
Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	P			RE	1
Rhipiduridae	*Rhipidura rufifrons*	Rufous fantail	P			SM	1
Corvidae	*Corvus coronoides*	Australian raven	P			RE	1
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	P			RE	1
Monarchidae	*Myiagra inquieta*	Restless flycatcher	P			VA	1
Monarchidae	*Myiagra rubecula*	Leaden flycatcher	P			SM	1
Corcoracidae	*Struthidea cinerea*	Apostlebird	P			**NR**	6
Petroicidae	*Eopsaltria australis*	Eastern yellow robin	P			RE	1
Petroicidae	*Microeca fascinans*	Jacky winter	P			**NR**	6
Petroicidae	*Petroica boodang*	Scarlet robin	V			**NR**	6
Petroicidae	*Petroica rosea*	Rose robin	P			WM	1
Alaudidae	*Alauda arvensis*	Eurasian skylark	U			**NR**	6
Cisticolidae	*Cisticola exilis*	Golden-headed cisticola	P			RE	1
Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler	P			SM	1
Megaluridae	*Cincloramphus cruralis*	Brown songlark	P			**NR**	6
Megaluridae	*Megalurus gramineus*	Little grassbird	P			SU	1
Megaluridae	*Megalurus timoriensis*	Tawny grassbird	P			SU	1
Timaliidae	*Zosterops lateralis*	Silvereye	P			RE	1
Hirundinidae	*Hirundo neoxena*	Welcome swallow	P			RE	1
Hirundinidae	*Petrochelidon ariel*	Fairy martin	P			IV	1
Hirundinidae	*Petrochelidon nigricans*	Tree martin	P			**NR**	6
Pycnonotidae	*Pycnonotus jocosus*	Red-whiskered bulbul	U			RE	1
Turdidae	*Turdus merula*	Eurasian blackbird	U			IV	1

Family	Scientific name	Common name	NSW legal status	Federal legal status	Migratory Bird Listing	Current Status	Record Source
Sturnidae	*Sturnus tristis*	Common myna	U			RE	1
Sturnidae	*Sturnus vulgaris*	Common starling	U			RE	1
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird	P			IV	1
Estrildidae	*Neochmia temporalis*	Red-browed finch	P			RE	1
Estrildidae	*Taeniopygia bichenovii*	Double-barred finch	P			VA	1
Estrildidae	*Taeniopygia guttata*	Zebra finch	P			**NR**	6
Passeridae	*Passer domesticus*	House sparrow	U			IV	1
Motacillidae	*Anthus novaeseelandiae*	Australasian pipit	P			RE	1
Fringillidae	*Carduelis carduelis*	European goldfinch	U			**NR**	6
Fringillidae	*Carduelis chloris*	European greenfinch	U			**NR**	6
Mammals							
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	P			SU	1
Pseudocheiridae	*Pseudocheirus peregrinus*	Common ringtail possum	P			RE	1
Phalangeridae	*Trichosurus vulpecula*	Common brushtail possum	P			RE	1
Macropodidae	*Macropus giganteus*	Eastern grey kangaroo	P			**NR**	4
Pteropodidae	*Pteropus poliocephalus*	Grey-headed flying-fox	V	V		IR	1
Molossidae	*Mormopterus* “species 2”	Eastern freetail-bat	P			RE	1
Molossidae	*Tadarida australis*	White-striped freetail-bat	P			SU	7
Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat	P			RE	1
Vespertilionidae	*Chalinolobus morio*	Chocolate wattled bat	P			RE	1
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern bentwing-bat	V			IV	1
Vespertilionidae	*Nyctophilus geoffroyi*	Lesser long-eared bat	P			RE	1
Vespertilionidae	*Scoteanax rueppellii*	Greater broad-nosed bat	V			SU	1
Vespertilionidae	*Vespadelus vulturnus*	Little forest bat	P			RE	1
Muridae	*Mus musculus*	House mouse	U			RE	1
Muridae	*Rattus lutreolus*	Swamp rat	P			**NR**	1
Muridae	*Rattus norvegicus*	Brown rat	U			RE	1,9
Muridae	*Rattus rattus*	Black rat	U			RE	1
Canidae	*Canis lupus familiaris*	Feral dog	U			**NR**	1
Canidae	*Vulpes vulpes*	Fox	U			RE	1
Felidae	*Felis catus*	Feral cat	U			RE	1
Leporidae	*Oryctolagus cuniculus*	Rabbit	U			RE	1

Woolooware Shorebird Lagoon. Photo © M. Schulz





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