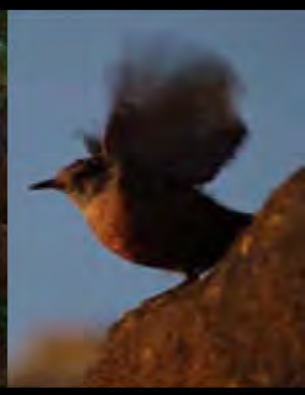


The Vertebrate Fauna of Royal & Heathcote National Parks and Garawarra State Conservation Area

Biodiversity Survey & Assessment Section, Metropolitan Branch
Environment Protection and Regulation Group
Department of Environment, Climate Change & Water (NSW)
March 2011

NSW GOVERNMENT
Environment, Climate Change & Water

THE VERTEBRATE FAUNA OF ROYAL & HEATHCOTE NATIONAL PARKS AND GARAWARRA STATE CONSERVATION AREA

FINAL REPORT Version 1

For enquiries regarding this report please contact Manager, Biodiversity Survey and Assessment Section, Metropolitan Branch, Environment Protection and Regulation Group, Department of Environment, Climate Change and Water, Hurstville. Specialist advice can be sought from Martin Schulz, Daniel Connolly, Elizabeth Magarey or Kylie Madden.

This report should be referenced as follows:
DECCW (2011), *The Vertebrate Fauna of Royal & Heathcote National Parks and Garawarra State Conservation Area*. Department of Environment, Climate Change and Water NSW, Hurstville.

Cover Photos
Front cover
Feature Photo: Early morning light on Bundeena cliffs © M. Schulz
Coastal Sandstone Sheltered Peppermint-Apple Forest © M. Schulz/DECCW
Eastern Pygmy-possum © N. Williams/DECCW
Patch of Cabbage Tree Palms in Royal NP © M. Schulz/DECCW
Rockwarbler at Royal NP cliffs © M. Schulz
Back cover
Common Scaly-foot © M. Schulz
Heathland in Marley Beach area © M. Schulz
Giant Burrowing Frog © E. Magarey/DECCW

Thank you to: Wendy Kinsella, Joe Stammers, Steven Anyon-Smith, Megan Rowlatt, Jessica Zichar and Aaran Coutts-Smith for providing assistance during the field surveys. Thanks to Steve Anyon-Smith for providing information on birds; Anne Carrick for providing information on the birds of the Constables Point area; Richard Jackson for providing information on nocturnal birds; Gary Daly, Ken Griffiths, George Madani and Arthur White for providing information on frogs; Ken Griffiths, John Cann, Andrew Melrose and Henry Cook for providing information on reptiles; Ross Goldingay for providing information on Broad-headed Snakes; Tom Grant and Jason Hughes for providing information on the Platypus and Water Rat; Harry Parnaby and Glen Hoye for providing details on the bat fauna; Ken Allen for providing location details of bat roosts within Royal National Park; Derek Engel and Rose McLaggan for providing general fauna information. Thanks to Richard Jackson, Henry Cook, Narawan Williams, Ray Williams and Colette Harmsen for providing photos used in the report. Thank you to Ross Goldingay and Ken Griffiths for providing comments on the draft version of this report.

Published by:
Department of Environment, Climate Change and Water NSW
43 Bridge St, Hurstville NSW 2220
PO Box 1967, Hurstville NSW 1482
Phone (02) 9995 5000 (switchboard)
www.environment.nsw.gov.au

ISBN 978 1 74293 220 0

DECCW No 2011/0249

March 2011

OVERVIEW

One of the first national parks established in the world, Royal National Park in the south of Sydney is a reserve of outstanding fauna diversity. Together with the adjoining Garawarra and Heathcote reserves, the area currently provides a home or visiting place for 347 native fauna species of which 41 are recognised as threatened species. This ranks amongst the most fauna rich reserve complexes in NSW. Away from the mown picnic areas, car parks and busy roads is another world. One of rustling leaves, lizards basking, the white glistening off the plumage of a White-bellied Sea-Eagle gliding overhead, water trickling across rocks, honeyeaters darting this way and that and the air alive with the sounds of myriad birds and insects. At night for the few that venture forth lies a world of luminescent fungi, the incessant calling of frogs following rain, the heavy wing beats of Flying-foxes passing low overhead, the distant deep throated “ooo...oooo” of a Powerful Owl and rustles in the leaf litter. A walker strolling along one of the many tracks may stroll for hours without coming across another person or rest at a vista that reveals that the reserves lie on the doorstep of the most populated city in the country.

This report provides an overview and detailed discussion of the fauna values of Royal and Heathcote National Parks, Garawarra State Conservation Area and adjacent lands considered to be of high conservation value. It documents the findings of an extensive literature and data review, brings together the observations of many local naturalists who have held a long standing interest in the fauna of the area, and describes and presents the findings of a comprehensive field survey program that has surveyed the full variety of fauna habitats to provide a snapshot of the fauna species present over the 2009 -2010 year.

The reserves are characterised by extensive stands of sandstone forests, heaths and woodlands that provide habitat for a suite of fauna that is typical of the Sydney Basin including species such as the Red-crowned Toadlet that are endemic to the region. However it is the diverse range of habitats, from the beaches and rugged rocky ocean shores, to the mangrove-lined mudflats of Port Hacking, rainforests of the Hacking River valley, extensive heathlands with sweeping vistas and rugged sandstone cliff lines overshadowing the weaving path of the Woronora River, that elevate the species richness to such outstanding levels. The shoreline and wetlands are amongst the most distinct habitat types, supporting a variety of waterbirds that are restricted to the coastal fringe. Similarly the rainforests and adjacent tall wet sclerophyll forests found growing on rich soils in incised gullies support their own unique assemblage of species, some of which are extensions of the more subtropical NSW north-coast.

The results of this study revealed several other interesting findings. Surveys undertaken for this project identified seven species not previously recorded including two threatened species the Eastern Grass Owl and the Australasian Bittern. These are very rare finds in the Sydney area. In contrast, despite Royal NP having been established for over a century, at least 25 species are known or suspected to have been lost from the reserves. At least 15 additional species that once visited the reserves frequently are today only extremely rare visitors or have ceased to visit altogether. The species extinctions, losses and declines have primarily occurred from freshwater wetlands, heathlands, rainforest habitats and shoreline habitats, as well as through loss of grassy woodland habitat from within and proximate to the survey area.

The report provides information to assist park managers’ deal with the complexity of fauna species and habitat management. A profile has been created for each threatened or regionally significant species recorded in the reserves to summarise current distribution and status, while a system has been used to rank species in terms of current conservation management priority, identifying 32 species of high or moderate priority. Habitat profiles are provided to describe the fauna typical of each of the main habitats, and the relative contribution that each of the habitats make to conservation of fauna in the reserves is assessed. Threatening processes to native fauna are identified and ranked, with management recommendations targeted towards reducing threats to the current high and moderate priority fauna species. Key current threats that require management include fire, feral animals, road fatalities, loss of connectivity, hydrological changes, public disturbance and wildlife poaching. Discussion is also made of future survey needs and issues that require consideration for the implementation of monitoring programs.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

1 INTRODUCTION

1.1 PROJECT RATIONALE

Information that describes the type, distribution and status of biodiversity in NSW is required by many arms of the Department of Environment, Climate Change and Water (DECCW) for regulatory, conservation assessment and land management purposes. In the Sydney Basin Bioregion over 60 per cent of extant native vegetation occurs in DECCW reserves making it the largest individual custodian of native flora and fauna in the region. Since 2003, the former Central Branch of the Parks and Wildlife Group has 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. As a result of the first five years of the program, 28 reserves 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 endangered ecological communities and now over 75 per cent of the reserves of the former Central Branch are covered by adequate standards of fauna data and over 60 per cent are covered by adequate vegetation maps.

In 2009 the BSP program was extended for a further five years across an expanded region to include all of the Sydney Basin Bioregion. As part of the extension, a review of progress and priorities was completed. The Royal National Park (NP), Heathcote NP and Garawarra State Conservation Area (SCA) reserve complex and Kamay Botany Bay National Park were identified for systematic fauna survey in 2009/10 as no single comprehensive report detailing the fauna of these reserves currently exists and the reserve Plans of Management are due for revision.

1.2 PROJECT AIMS

The primary objectives of the survey were to:

- Compile and review existing fauna data within the three reserves and identify knowledge gaps for particular fauna species, fauna assemblages, habitats and/or areas of interest.
- Undertake DECCW standard systematic field surveys to provide a baseline data set for all major habitats and fauna groups across the reserves and adjoining lands considered by Royal Area staff to be of high conservation value.
- Undertake targeted survey for threatened and regionally significant species not adequately sampled by systematic survey techniques alone.
- Build an accurate fauna species inventory for the reserves and identify species that represent a conservation priority for park managers.
- Identify broad-scale patterns in fauna habitat use across the survey area and identify habitats of particular conservation significance in a regional context.
- Make an assessment of the contribution that the reserves make towards the protection of vertebrate fauna in the region.
- Identify priorities for conservation and management of fauna in the survey area, including threatened species, regionally significant species and pest species.
- Identify major fauna threatening processes and propose management strategies to maintain or enhance the current biodiversity values.

In this report, vertebrate fauna includes all vertebrate fauna except fish. However, it excludes fish and pelagic fauna that occur with varying frequency in offshore waters that do not use the shoreline for resting, foraging or nesting purposes. Therefore, species such as terns and cormorants which roost on the shoreline, seals that occasionally haul out or Little Penguins that occasionally come ashore to moult are included. Species, such as marine turtles, sea snakes, cetaceans and pelagic seabirds (i.e. storm-petrels Hydrobatidae and Oceanitidae, albatross Diomedeidae, petrels Procellariidae, gannets Sulidae, jaegers Stercorariidae and pelagic terns Laridae, such as the Sooty Tern and various noddy species) are not included even though many of these can be seen close inshore while others have primarily been recorded as beachcast derelicts. For completeness an annotated list of pelagic fauna is provided in Appendix 1, though species have not been assessed to identify conservation status or guide management actions.

1.3 SURVEY AREA

1.3.1 Boundaries of the survey area

The survey area comprises Royal NP (15,068ha), Heathcote NP (2251ha) and Garawarra SCA (900ha) situated on the southern fringe of metropolitan Sydney and north of the northern suburbs of Wollongong, bounded to the east by the south Pacific Ocean and to the west primarily by Holsworthy Military Area and the Woronora Special Area. The coastline sections of the survey area include intertidal zones such as rock platforms, beaches and rocky cliff bases of the ocean shoreline, and the mudflats and mangrove areas bounding parts of Royal NP in Port Hacking, but exclude sub tidal and adjacent inshore waters. These three reserves form the northerly component of a much larger protected area system that extends from Royal National Park in the north to beyond Budderoo and Morton National Parks in the south and Nattai and Blue Mountains National Parks in the west (DECC 2008a).

The current survey also incorporated areas of land adjacent to the reserves that are considered to have high conservation value. These areas of land include: Crown Reserve at Constables Point (also commonly referred to as Deeban Spit) in Port Hacking currently managed by Sutherland Shire Council; Crown Reserve between the F6 Freeway and the old Princes Highway adjacent to the Garrawarra Aged Care Centre (herein referred to as 'Garrawarra Hospital Crown Reserve'); and primarily privately owned bushland in the Otford-Lilyvale-East Helensburgh area (herein referred to as the 'Upper Hacking') (Map 1). The northern portion of the Upper Hacking lands was purchased by DECCW after completion of the field surveys and so is now labelled in Map 1 as a proposed addition to the park.

1.3.2 Regional context

The Sydney Basin Bioregion, in which the survey area is situated, extends from just north of Batemans Bay to Nelson Bay on the central coast of New South Wales, and west toward Mudgee (Thackway and Cresswell 1995). This bioregion covers 3.6 million hectares of land dominated by dissected sandstone and the vegetation is dominated by dry sclerophyllous forests and woodlands that grow on infertile sandy soils. Approximately 40 per cent of the Bioregion is reserved for conservation, largely as National Parks and Nature Reserves (NPWS 2003a).

1.3.3 Geology, geomorphology and elevation

The geology and geomorphology of the area is outlined in detail in the book *Understanding the Scenery* (Young and Young 2006). A brief synopsis is provided here, to give context for understanding fauna distribution patterns.

The area consists of a Triassic Hawkesbury sandstone plateau rising to over 200m in elevation and is deeply dissected by the Hacking River system which drains northward to the Port Hacking estuary and the Woronora River system which drains into the Georges River. The landscape is characterised by steep valleys and ridges, rocky outcrops and streams, many of which are punctuated by waterfalls and pools (NPWS 2000a). In the east, the plateau is characterised by broad, gently sloping ridges and small eastward flowing drainage lines. The coastline is characterised by variable height cliffs cut in the Hawkesbury sandstone north of Curracurrong Creek, while extending to the south the cliffs are formed from the softer Narrabeen group of rocks with small beaches at creek mouths.

There are a number of geomorphological features that vary from the typical Hawkesbury sandstone plateau environment, resulting in the presence of fauna species or assemblages uncommon or absent elsewhere within the survey area. Such features include: the cliff-top dunes of unconsolidated sand in the Jibbon Head and Marley Beach areas of Royal NP formed during periods of higher sea level some 6000 to 10,000 years ago; a system of low beach ridges on the eastern side of Cabbage Tree Basin in Royal NP; patches of laterite on the higher parts of ridges across the area which mark remaining sections of a once more extensive and continuous plateau surface; and the presence of upland swamp areas on low-relief terrain present primarily in parts of Royal NP, a result of sandy sediment entrapment which then acts as a sponge to trap and retain water (NPWS 2000a, Young and Young 2006).

1.3.4 Climate

The area experiences falls within a warm temperate climatic zone with average temperatures ranging from 16 degrees Celsius in winter to 26 degrees Celsius in summer. Rainfall patterns are characterised by wet summers and drier winters (NPWS 2000a). The average rainfall is 1220mm, with maximum rainfall occurring in the south due to the increased elevation and coastal escarpment. During the summer, north-easterly and westerly winds predominate resulting in moist humid conditions, while winter winds are typically from the south and west, resulting in dry to moist conditions (NPWS 2000a).

Map 1: Location of the survey area.

1.3.5 Vegetation

The native vegetation of the survey area has held a long standing interest to botanists. The vegetation has been extensively surveyed over the years with vegetation communities documented by maps and reports including Keith and Tozer (unpublished) and DECCW (2009). The delineation of vegetation communities within the survey area is currently being reviewed for the final version of the Sydney Metropolitan Catchment Management Authority (CMA) area vegetation mapping report, due for release in 2011.

While the reserves are overwhelmingly dominated by Hawkesbury sandstone forests, woodlands and heaths there remains an incredible diversity of different vegetation communities owing to its coastal location, variation in geology and high annual rainfall. These are most easily summarised using the statewide vegetation classification of Keith (2004). Under this classification there are 16 vegetation classes recognised within the survey area. The following lists each of the broader classes and briefly identifies where they occur. Note that Map 2 presents the vegetation communities clumped into 'fauna habitat groups' which relate to, but do not directly align with, the Keith classes listed below. The derivation and description of fauna habitat groups is provided in Section 3.2.1.

1. **Subtropical Rainforests** small areas situated on Hacking River flats in the south of Royal NP.
2. **Northern Warm Temperate Rainforests** found in the southern end of Royal NP in protected Narrabeen sandstone gullies.
3. **Littoral Rainforests** found on protected headlands and escarpment slopes south from Garie.
4. **North Coast Wet Sclerophyll Forests** found in the southern end of Royal NP in protected Narrabeen sandstone gullies.
5. **Northern Hinterland Wet Sclerophyll Forests** form small stands found on residual shale and ironstone caps at Garawarra, Heathcote and Otford.
6. **Maritime Grasslands** form small patches on exposed coastal headlands and along frontal beach sand dunes.
7. **Sydney Coastal Dry Sclerophyll Forests** found on Hawkesbury sandstone ridges and sheltered slopes and gullies and is widespread throughout the survey area.
8. **Coastal Dune Dry Sclerophyll Forests** small headland sand dunes found at Jibbon and near Marley.
9. **Coastal Headland Heaths** small areas along the coastal headlands including headlands and cliffs south of Garie.
10. **Wallum Sand Heaths** small areas found on exposed coastal sand dunes at Jibbon and Marley.
11. **Sydney Coastal Heaths** form extensive areas on skeletal rock sandstone across the survey area.
12. **Coastal Heath Swamps** form isolated patches of sedgelands and heaths on poorly drained sandstone ridgetops and gentle slopes.
13. **Coastal Freshwater Lagoons** are restricted to depressions within the sand dunes between Jibbon and Marley.
14. **Coastal Swamp Forests** are restricted to low-lying coastal flats on the lower Hacking River and Bundeena area.
15. **Mangrove Swamps** are restricted to the estuarine mudflats exposed to tidal inundation on the Lower Hacking to Bundeena.
16. **Saltmarshes** form small patches adjoining Mangrove Swamps.

1.3.6 Fire history

Little is known about traditional Aboriginal and early European burning practices in the area, but there is no doubt that humans have influenced fire regimes and the resulting vegetation composition throughout the area. The *Draft Fire Management Plan for Royal, Heathcote National Parks and Garawarra State Recreation Area* (NPWS 2001c) provides a detailed description of fire history and fire behaviour in the reserves. Two types of fire occur, wildfires and prescribed fires aimed at limiting the incidence and severity of wildfires. In more recent times, extensive high intensity wildfires have burnt through large sections of the reserves. For example, a large proportion of Royal NP has been affected by at least three major wildfires over the last three decades since 1974, while during the same time period Heathcote NP was burnt by a single wildfire in summer 2001/2002 (NPWS 2001c, Tulloch 2003). These fires generally occur between late spring and the end of summer when high temperatures and dry north-westerly winds create conditions conducive to the rapid spread of fire. Arson is a recurring problem in parts of the area with incidents in most summer seasons.

These wildfires inevitably have an impact on the vertebrate fauna of the survey area. The first broad-scale fauna survey work conducted in the area followed the extensive wildfire of January 1994 which burnt more than 90 per cent of Royal NP (Andrew 2001). On adjacent areas of the Woronora Plateau, a separate research project (Biodiversity Survey and Assessment Section, DECCW, Hurstville) is currently investigating the impact of a 2001 wildfire on diurnal birds, arboreal mammals and diurnal reptiles. Initial investigation of the data suggests that arboreal mammals, shrub-frequenting birds and litter-dwelling skinks are the most susceptible fauna groups up to at least seven years following the fire event (DEC 2004, K. Madden DECCW, pers. comm.). Research has also been undertaken on the impacts of fire on the vegetation in Upland Swamps in the Woronora Plateau region (Keith *et al.* 2006). The findings of these studies will have implications for the management of fauna across the region, and should be read in conjunction with this report.

1.3.7 History of European land use

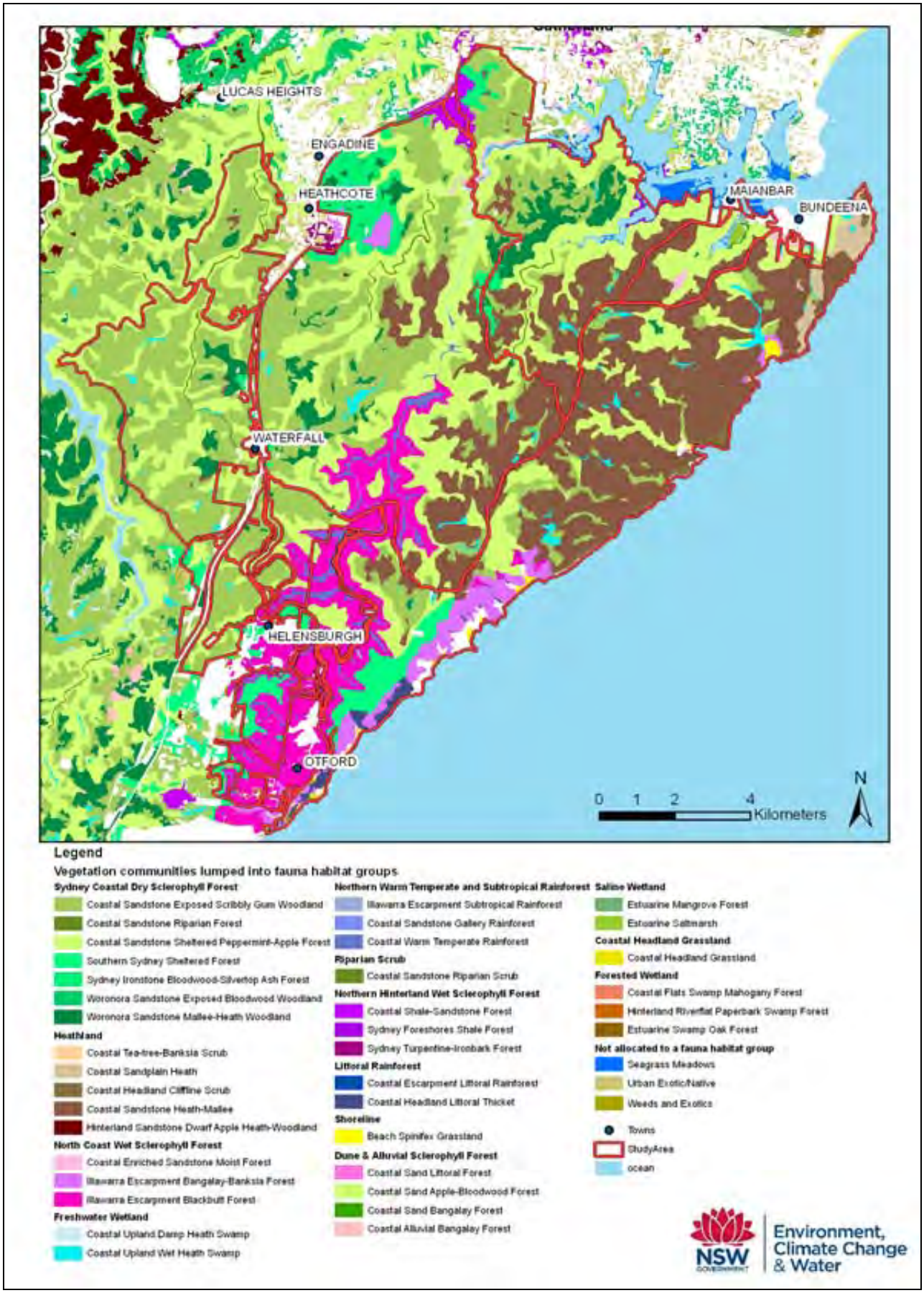
Prior to proclamation of Royal NP in 1879, the area was used primarily for timber getting, particularly along the rivers. Logging operations continued until the 1920s. These operations resulted in a significant reduction of hollow-bearing trees, particularly Blackbutts (*Eucalyptus pilularis*) on high fertility soils, such as in the Hacking River valley. There is also evidence of timber getting in the area that is now Heathcote NP. A range of other land uses have occurred within the survey area including: the presence of houses and associated gardens on parts of the Port Hacking coast and numbers of cabins in various locations along the Royal NP coastline; grazing, particularly on some coastal headlands within Royal NP; military activity, particularly during World War II; the extraction of various materials from a number of quarries for road and rail construction; road construction; the construction of a number of dams within the area or upstream of the survey area on major watercourses such as the Woronora River Dam.

Royal NP was originally managed for the “recreation of the inhabitants of the colony”, which resulted in under scrubbing and clearing of land, construction of buildings, roads, extensive lawns, boat hire facilities and gardens, planting of ornamental trees in the Audley and Lady Carrington Walk area, and establishment of small fenced paddocks and pasture for Horses, Cows and poultry (Trustees 1915). One of the first “improvements” undertaken by the Trustees was the construction of a dam across the Hacking River, changing the river into a “freshwater lake cut off from tidal influence”, followed later by dredging and construction of training walls in the bed of the river below the dam as well as introduction of Trout and Perch (Trustees 1915). The current visitor facilities at Audley are a result of the past recreation focus and today provide habitat for a number of fauna species uncommon or not recorded from other parts of the reserves, such as various waterbird species. A direct result of the recreation focus at Audley by the previous park trustees was the introduction of the Rusa Deer in 1906 for exhibition purposes in a fenced off peninsula called Deer Park. These deer soon escaped and have spread throughout the survey area and into adjacent lands. Additionally, troublesome Sulphur-crested Cockatoos around Audley are considered by some to have originated from caged birds released at Audley (e.g. Seville 2009, B. Sullivan, DECCW, pers. comm.). Yet from the parks early days the Trustees determined to “effectively preserve the flora and fauna committed to their care” thus making it an offence to “discharge firearms or interfere in any way with the birds and animals in the Park” (Trustees 1915).

In contrast to Royal NP, Heathcote NP was originally gazetted (in 1943) as a “primitive area”, a precursor to the current concept of wilderness areas, whose primary objective was the retention of natural conditions (NPWS 2000a). Similarly Garawarra SCA was originally dedicated (in 1934) as a primitive wilderness. These parks are significant as an illustration of the development of the outdoor recreation philosophy and an early stage in the development of the wilderness concept in Australia.

1.4 PROJECT TEAM

This project was carried out by the Biodiversity Survey and Assessment Section in the Metropolitan Branch of the Environment Protection and Regulation Group (EPRG). The project was funded under the Biodiversity Survey Priorities Program, a jointly funded biodiversity survey program between EPRG and the Metro Branch of the Parks and Wildlife Group. Martin Schulz was primarily responsible for the design and management of this project. Martin Schulz ran and undertook most of the field survey including planning, logistics, systematic and targeted surveys, in addition to writing the report. Elizabeth Magarey and Daniel Connolly contributed to writing of the report. Clare O’Brien undertook the fauna gap analysis, initial survey planning, data extraction and maps used in this report. Patsy Ross provided valuable field logistical and communications support. Assistance in the field, primarily for the night and remote components were provided by Debbie Andrew, Meagan Hinds, Clare O’Brien, Patsy Ross, Tim Hager, Kylie McClelland, Mike Fleming and Manu Martinero. Debbie Andrew, Bill Sullivan, Kylie Madden and Josh Madden provided important background information. Kylie Madden and Jennifer Bean provided valuable comments on earlier drafts of the report. Kerry Oakes designed the report cover and formatted the report.



Map 2: The vegetation of Royal and Heathcote NPs, Garawarra SCA and adjoining lands of high conservation value (from DECCW 2009).

Note that delineation of vegetation communities is currently being revised for the final version of the Sydney Metropolitan CMA area vegetation mapping report, due for release in 2011.

2 METHODS USED TO BUILD THE SPECIES INVENTORY

2.1 COMPILATION OF EXISTING FAUNA DATA

The survey area has a long history of interest in its fauna values. There have been a wide variety of formal and informal studies carried out, the results of which are retained in many different formats. Some of this data is recorded in corporate databases such as the Atlas of NSW Wildlife, some in published and unpublished reports and many records remain anecdotal. This project attempted to extract information from as many of these resources as possible.

2.1.1 Systematic fauna survey data

Systematic fauna surveys are those for which the same methods are employed at each site. 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 throughout the park.

Despite the area's proximity to Sydney and Wollongong there have been relatively few systematic fauna surveys within the survey area (D. Andrew DECCW, pers. comm.). Such surveys undertaken include:

- Vertebrate fauna survey of the Upper Hacking River catchment in 1984 and 1991 (Andrew 1985a, b, Smith 1985, NPWS 1985, Whelan *et al*. 1991). The methods employed during these surveys have not been entered into the Atlas of NSW Wildlife (D. Andrew DECCW, pers. comm.) and are not displayed in Table 1.
- Two separate periods of bird surveys have been undertaken by the Royal Australian Ornithologists Union (now known as Birds Australia). The first was undertaken between 1977 and 1981 (Blakers *et al*. 1984) and herein termed Atlas of Australian Birds 1. The second was undertaken between 1998 and 2002 (Barrett *et al*. 2003) and herein termed Atlas of Australian Birds 2. Both data sets are found within the Atlas of NSW Wildlife.

  Atlas of Australian Birds 1 records suggest 128 surveys were completed within the survey area. However, the positions of the sites were based on 10' or 1° grids and hence have very low spatial accuracy. As a result records that appear to fall within the survey area may actually derive from outside the area, including from the nearby Kurnell Peninsula. Consequently records from the Atlas of Australian Birds 1 survey have not been used in this report unless species are also cited in Anyon-Smith (2006).

  Atlas of Australian Birds 2 records suggest 114 surveys fall within the survey area. These records generally have a higher spatial accuracy as they were from point-based surveys using grid references from a GPS. However, the surveys constituted searches for birds within a five kilometre radius of the point locality, such that when these were located near the perimeters of the park some of the records may derive from sightings made outside of the current survey area. Again records were not included unless other supporting evidence was found to confirm their occurrence.
- A post-fire vertebrate fauna survey was undertaken across the entire survey area in January 1996 following the January 1994 wildfire which burnt more than 90 per cent of Royal NP (Andrew 2001). This included an ultrasonic bat survey (Parnaby 2001). These surveys established fifteen two kilometre survey transects comprising 45 sites, with 36 sites in Royal NP and Garawarra SCA and nine sites in Heathcote NP. It included cage, Elliott and pitfall trapping, hair tube sampling, spotlighting, predator scat collection, bird censuses, diurnal herpetofauna searches, frog searches, owl censuses, bat harp trapping, ultrasonic bat call census and interviewing local naturalists, amateur bird watchers, herpetologists and other park users. Data from this survey has been entered into the Atlas of NSW Wildlife.
- The 15 two kilometre survey transects were resampled in January 1997 using the same approach as described above with all data entered in to the Atlas of NSW Wildlife (Andrew 2001). A subset of these sites were surveyed in January 2006 concentrating on heathland communities in Royal NP and a repeat survey of all Heathcote NP sites following the 2001/2002 wildfire (Nolan 2006).
- In late summer/early autumn 1999, nineteen sites were sampled by the Georges River Biodiversity Study in Heathcote NP (NPWS 2000b, c), with all data entered in to the Atlas of NSW Wildlife. Sampling included site-based Anabat ultrasonic detection and harp trap sampling for

bats, bird censuses and diurnal herpetofauna searches using similar methodology to the current survey (see Section 2.4.1). Additionally, transect spotlighting was used, similar to Andrew (2001).

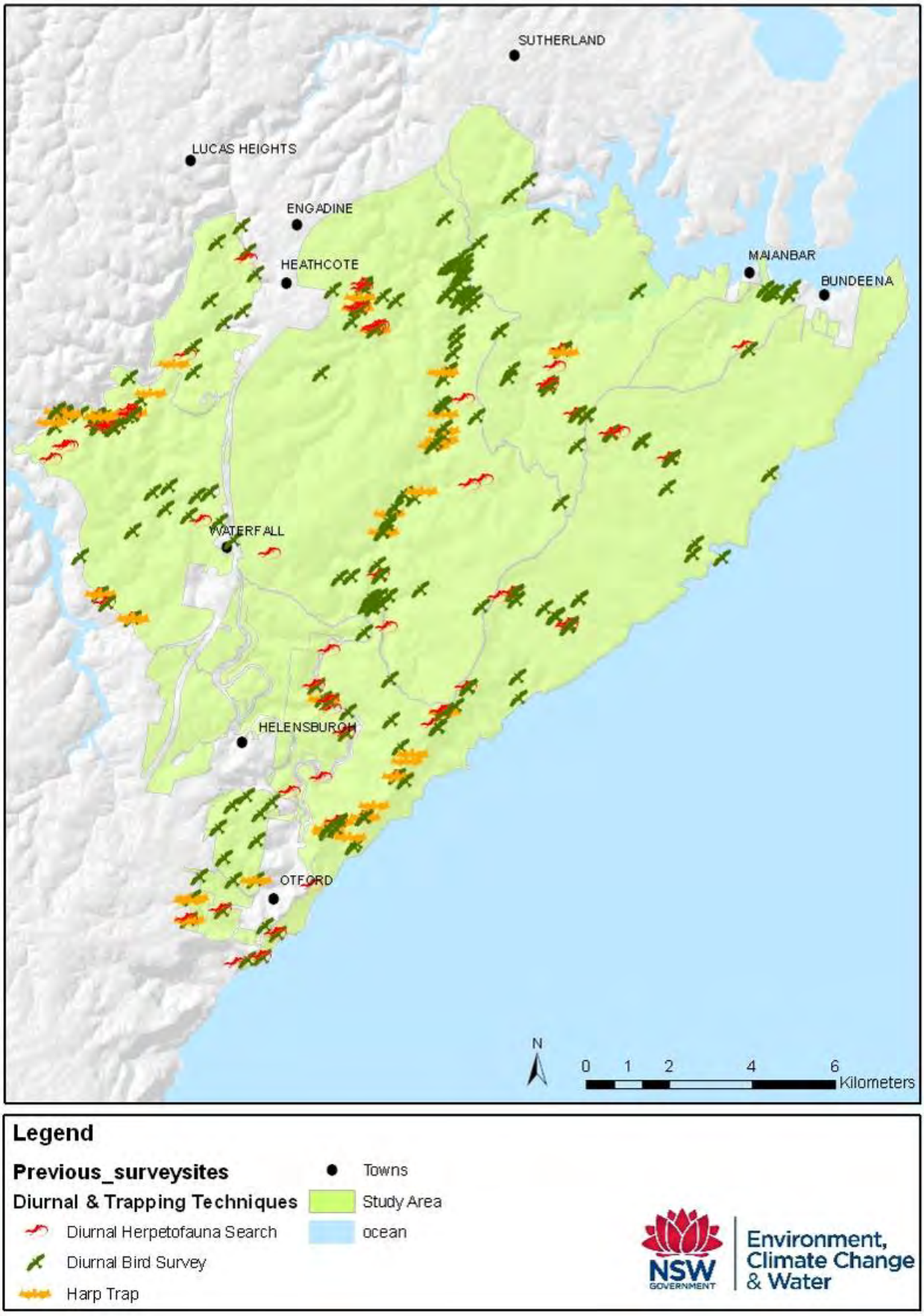
- Four streamside searches were conducted in the Hacking River catchment in January 2000 in search of the Stuttering Frog as part of a statewide *Mixophyes* survey, with all records entered into the Atlas of NSW Wildlife.
- A limited bat survey was undertaken using harp traps at six locations in the Hacking River valley in 2000 as part of a study collecting reference echolocation calls of microbats across NSW, with the data collected entered into the Atlas of NSW Wildlife (Pennay 2000).
- In December 2001, eight sites were sampled in the Hacking River valley as part of a fauna survey of the Illawarra Escarpment, Coastal Plain and Plateau (NPWS 2002), with all data entered in to the Atlas of NSW Wildlife. Sampling included site-based spotlighting, nocturnal streamside searches, diurnal herpetofauna searches, Anabat ultrasonic detection using similar methodology to the current survey (see Section 2.4.1).
- A post-fire study of small mammals following bushfires was conducted in the summer of 2001/2002 within Royal and Heathcote NPs and Garawarra SCA using pitfall traps, Elliott traps and spotlighting at the sites of Andrew (2001), in addition to predator scat collection and analysis (Tulloch 2003).
- Two site-based diurnal herpetofauna searches and one spotlight survey using the systematic techniques outlined in Section 2.4.1 were conducted at two sites in October 2002 and January 2003 respectively as part of the Woronora Plateau post-fire study (DEC 2004).
- Part of a road-based fatality study on major public roads within Royal NP examined road usage, which was assessed at 45 locations adjacent to the road using sand plots and hair tubes between April and August 2003 (Ramp *et al*. 2006). Results from this study have not been entered into the Atlas of NSW Wildlife.
- The Sydney Metropolitan CMA area fauna survey (DECC 2007a) conducted systematic surveys in late summer and autumn of 2007 at 21 sites south of Bulgo in Royal NP and in the proposed national park extension in the Upper Hacking. Additionally, a large number of incidental records were collected in these areas as well as Garawarra SCA and Heathcote NP, with all records entered into the Atlas of NSW Wildlife.

Details of site localities and techniques have been entered into the BSS component of the Atlas of NSW Wildlife for a number of these surveys. Censuses that were undertaken prior to 2009 and entered into BSS are displayed in Maps 3 and 4. As can be seen from these maps and Table 1, the systematic surveys were weighted towards diurnal birds, Elliott trapping and nocturnal call playback and had not adequately systematically sampled microbats, arboreal mammals (using a site-based approach), reptiles and amphibians.

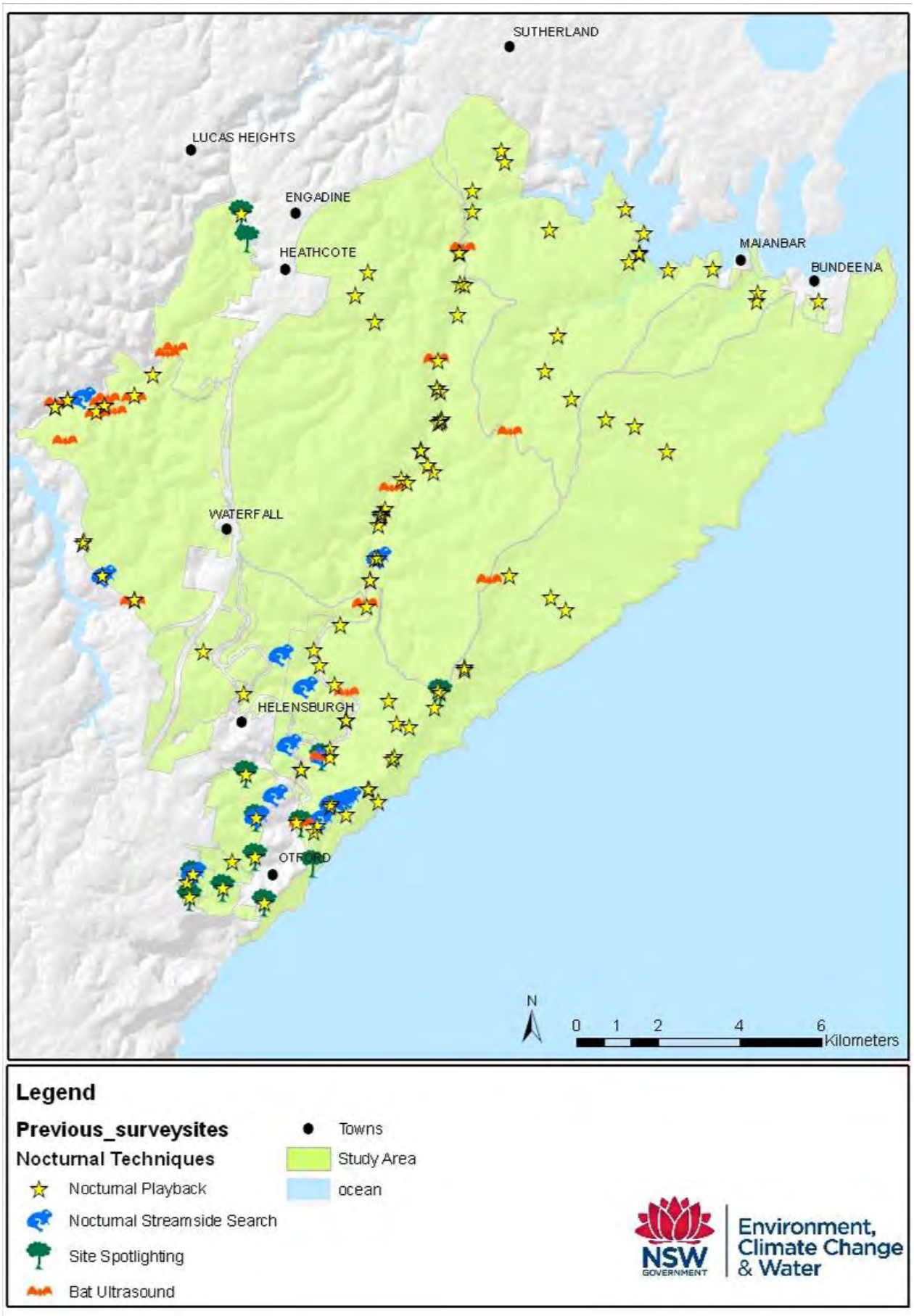
The Spotted Pardalote is a common bird in the forests of the survey area. Photo © M. Schulz

Table 1: Systematic fauna survey effort in the survey area prior to 2009. Where the techniques employed were the same as the systematic methods described in Section 2.4 the number of sites is given.

Project	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Transect spotlighting	Harp trapping	Bat ultrasonic call recording	Nocturnal streamside search	Nocturnal call playback	Cage trapping	Elliott A trapping	Hairtube sampling	Pitfall trapping	Sand plots	Location of sites	Current DECCW standard
Post fire vertebrate fauna monitoring (Andrew 2001)	✓	✓		✓	39	✓	✓	92	✓	✓	✓	✓		Across the survey area.	In part
Pygmy-possum monitoring (Tulloch 2001, 2003)				✓					✓	✓		✓		Across the survey area.	No
Royal NP Biodiversity Survey (Nolan 2006)				✓					✓	✓	✓	✓		Across the survey area.	No
Georges River Biodiversity Study (NPWS 2000c)	9	7		✓	3	4								Woronora River catchment.	Yes
Roadkill Survey (Ramp *et al.* 2006)											✓			Main roads.	No
Mixophyes survey							4							East-flowing creeks into the Hacking River.	Yes
Fauna of the Illawarra Escarpment, Coastal Plain and Plateau (NPWS 2002)		7	3			2	1							Hacking River valley area.	Yes
2003 study of road usage by mammals													45	Park entrance adjacent Sutherland and Bundeena.	Yes
Woronora Post-fire study (DEC 2004)		2	1											Eastern Royal NP.	Yes
Sydney Metropolitan CMA fauna survey (DECC 2008a)	20	4	9		4		2	8						Royal NP south of Bulgo and proposed Park extension in Upper Hacking valley.	Yes
Bat call survey (Parnaby 2001)						✓								Royal and Heathcote National Parks.	No
Study collecting reference echolocation calls of microbats across NSW (Pennay 2000)					6									Hacking River valley.	Yes



Map 3: **The location of previous systematic survey sites using diurnal and trapping techniques in Royal and Heathcote NPs, Garawarra SCA and adjoining lands of high conservation value. This map does not include Atlas of Australian Birds 1 sites due to their spatial inaccuracy.**



Map 4: **The location of previous systematic survey sites using nocturnal techniques in Royal and Heathcote NPs, Garawarra SCA and adjoining lands of high conservation value.**

2.1.2 Other Atlas of NSW Wildlife records

The Atlas of NSW Wildlife (DECCW 2010a) was the primary resource used to access data on the fauna of the survey area. Royal and Heathcote NPs and Garawarra SCA have been visited by numerous fauna enthusiasts and researchers over the decades, resulting in a large number of sightings records. Opportunistic records within the Atlas of NSW Wildlife are derived from observations made by park rangers and field officers, bushwalkers, naturalists, bird watchers, scientific researchers working in the area, neighbours and other visitors to the survey area. These records have various levels of reliability depending on the type of observation, as well as the certainty and identification experience of the observer.

2.1.3 Literature review

Aside from the reports produced from systematic fauna surveys outlined above there have been a number of research theses and published studies from single species research projects undertaken within the survey area. Examples include projects on the Sooty Owl (Chafer and Anderson 1994, Kavanagh and Jackson 1997, Bilney *et al*. 2007), Brown Antechinus (Whelan *et al*. 1996), Eastern Pygmy-possum (Tulloch 2001), Swamp Wallaby (Evans 2000, Ramp and Ben-Ami 2006), and Rusa Deer (Tuck 1971, Giles and McKenzie 1973, Hamilton 1981, Mahood 1981, Moriarty 2004, Keith and Pellow 2005).

General bird records were sourced from published historic visits to Royal NP (e.g. Cayley 1923), old Royal NP bird lists (e.g. Hoskin 1977) and the records of various species cited within the book *Birdwatching in Royal & Heathcote National Parks* by Steve Anyon-Smith (2006). A number of small localised fauna surveys have been conducted along the roads and transport corridors fringing the reserves, such as Kevin Mills and Associates (1995) and LesryK Environmental Consultants (1996, 2005, 2007, 2008, 2010). Additionally unpublished 'grey' literature was accessed by sorting through relevant files in the Royal Area and Hurstville DECCW offices, the Hurstville DECCW library and through discussions with various DECCW staff.

2.1.4 Unpublished information

A limitation of systematic fauna surveys is that they provide a snap shot in time of fauna present within the survey area. Therefore, such surveys do not reflect fauna variation between years, particularly during periods of drought or prolonged wet spells. Similarly, a review of information provided from single-species or single-issue research projects resulted in patchy records and landscape coverage, with some fauna groups poorly represented. Therefore, to provide a more complete overview of fauna present within the survey area information on various fauna groups was obtained by interviewing naturalists, bird observers, park staff, park visitors, and other members of the public. People interviewed for their specialist advice were:

Birds: Steve Anyon-Smith, Richard Jackson, Debbie Andrew.

Bats: Harry Parnaby, Michael Pennay, Bill Sullivan, Peggy Eby.

Other Mammals: Debbie Andrew, Tom Grant, Steve Anyon-Smith, Bill Sullivan, Ross Goldingay.

Reptiles: Ken Griffiths, John Cann, Andrew Melrose, Ross Goldingay, Steve Anyon-Smith.

Amphibians: Arthur White, Gary Daly, Ken Griffiths, Kylie Madden.

Additionally, information was extracted from relevant internet sites, such as birding-aus http://birding-aus.org/ and Birdline NSW http://www.eremaea.com/BirdlineRecentSightings.aspx?Birdline=2

Various queries about specific topics such as reporting Platypus sightings were posted on the Friends of the Royal National Park site on Facebook.

2.1.5 Species habitat models

The survey area is encompassed within a region in which a comprehensive review of the conservation status of terrestrial fauna has been completed. This assessment across greater Southern Sydney (DECC 2007b, c) helps to understand the relative conservation values of fauna in the region. As part of this study some 71 maps of species habitats were produced to help land managers understand the distribution and status of the most significant species in the region. The maps assist in identifying the extent and quality of habitats present in the reserves for a range of priority fauna. Importantly predictive habitat maps of this type also confirm that suitable habitat is present for some species despite no evidence of the species being recorded for many years.

2.1.6 Pest management data

Pest data collated for the purposes of research and management have been used to assist with the identification of distribution patterns of key species including the Rusa Deer. These data are sourced from aerial survey, road-based survey to identify indirect signs of their presence, including locating scats, tracks and browse evidence (DEC 2005, Keith and Pellow 2005, B. Sullivan DECCW, pers. comm.).

2.2 REVIEW OF EXISTING RECORDS

2.2.1 Review of status of existing fauna species records

All compiled information on fauna species recorded in the reserves was reviewed. Each recorded species was allocated to one of the following classes.

1. Species only with unreliable record(s) due to poor locational accuracy. These species were excluded where the locality description did not actually occur within the survey area, or where the methods used to identify the location of the sighting had very low spatial accuracy. Species records were not accepted unless supporting evidence was available from other sources.
2. Species only with unreliable record(s) due to probable misidentification or data entry error. These species were highlighted as they: do not have suitable habitat in the reserve; are outside their known range; and/or have been surveyed for by experts on the species and never confirmed to occur. These species were excluded unless alternative supporting evidence of their occurrence was available from other sources.
3. Introduced and non-local species that do not have established wild populations in the survey area or neighbouring lands, including aviary escapees. These species were excluded from the species inventory.
4. Pelagic Species. These are offshore species that do not use the survey area for resting, foraging or nesting purposes. These are excluded from the species inventory and given a separate discussion in Appendix 1.
6. Included Species. These species are included as suitable habitat occurs *and* they have been reliably and accurately identified either in the past or during recent surveys. This category was then revisited at the end of new survey work to assess the status of all included species.

2.2.2 Identification of species to target during field survey

A list of target species was derived prior to the commencement of field surveys in an effort to ensure adequate survey effort was directed towards these fauna species. Following the review of species records, species classified as confirmed, unconfirmed, or having the potential to occur but not yet recorded were considered for the list. Species were then selected to identify only those that were: threatened under relevant state and/or commonwealth legislation; considered to be locally or regionally significant based on rarity of records, importance of habitat present in the reserves and expert opinion (M. Schulz and D. Andrew); taxa that had recently undergone taxonomic changes leading to uncertainty regarding their presence in the survey area. The list of target species derived is presented in Table 4.

2.3 ANALYSIS OF PREVIOUS SURVEY EFFORT

2.3.1 Gap analysis of standard systematic survey effort

Prior to the commencement of field survey, an analysis was performed to identify gaps in the fauna survey effort previously undertaken within the survey area. This analysis looked at the data in three ways:

- The level of standard systematic survey effort for particular fauna groups.
- The spatial coverage of standard systematic survey effort across the survey area.
- The level of standard systematic survey effort undertaken within each vegetation community.

The analysis resulted in identification of survey effort required in the current survey using standard systematic fauna survey techniques. Standard systematic techniques are herein defined as those described in Section 2.4. A summary of the gap analysis follows.

Frogs

Prior to the current survey, the majority of frog records in the Atlas of NSW Wildlife were observed (191 records), heard (124 records) and trapped individuals (46 records) (DECCW 2010a, Figure 1a). Few standard systematic streamside searches had been conducted (Figure 1c). Survey effort for frogs had

also been implemented using non-standard searches and pitfall trapping efforts established during surveys in 1996 (Andrew 2001) and subsequent DECCW monitoring at the same sites.

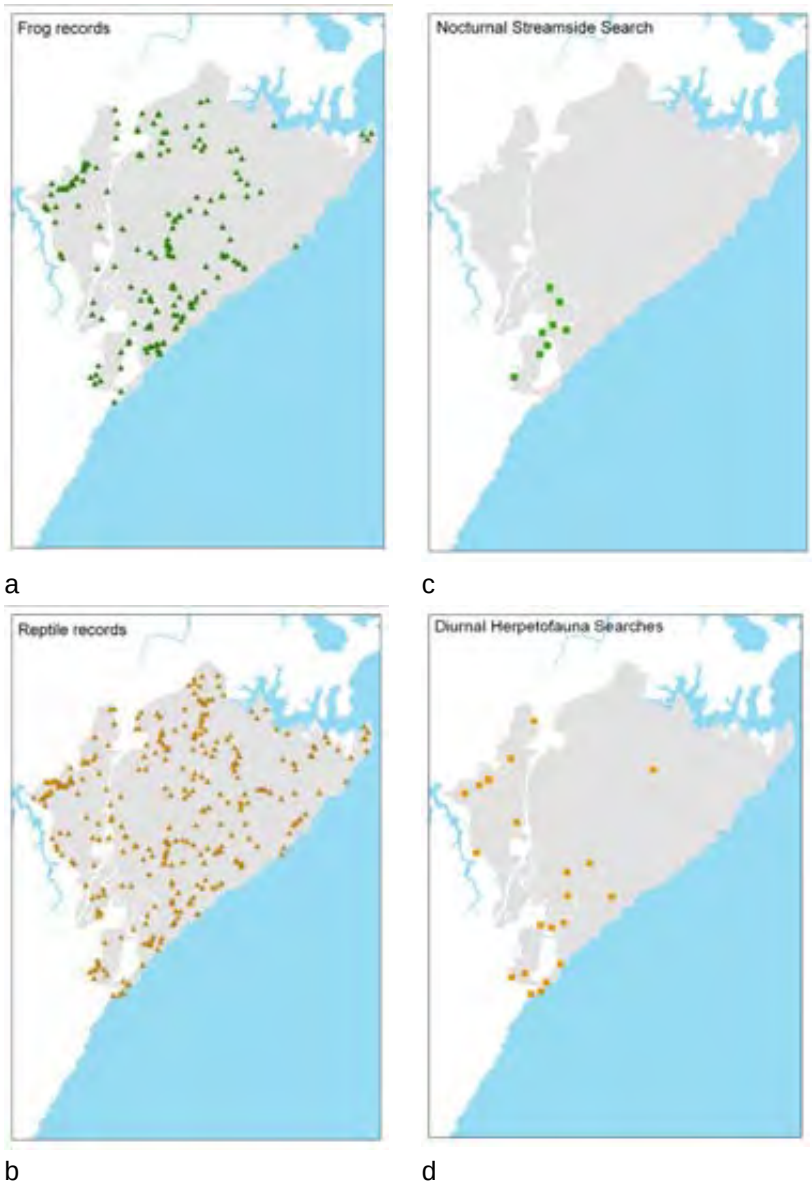
To address gaps in frog data, new survey effort planned to undertaken systematic nocturnal streamside searches throughout the area when conditions were suitable and to obtain incidental records particularly in northern parts of Royal NP. Additional pitfall trapping was considered a low priority due to previous survey effort and hence was not undertaken.

Reptiles

Prior to the current survey reptile records were widespread (Figure 1b) with the majority of reptile records in the Atlas of NSW Wildlife of observed (995 records) or trapped individuals (154 records) (DECCW 2010a). However, despite the number of records only a small number of standard systematic diurnal herpetofauna searches (using the technique described in Section 2.4) had been conducted across the survey area, with large gaps in some sections (Figure 1d). Survey effort for reptiles had also been implemented using different types of systematic searches and pitfall trapping during surveys in 1996 (Andrew 2001) and subsequent DECCW monitoring at the same sites.

To address gaps in reptile data, new survey effort planned to undertake diurnal herpetofauna searches throughout the area when conditions were suitable and to obtain incidental reptile records across the survey area particularly of species infrequently located during systematic searches. Additional pitfall trapping was considered a low priority due to previous survey effort and hence was not undertaken.

Figure 1: Existing frog and reptile records and DECCW systematic survey sites in the Atlas of NSW Wildlife: a) frog records b) reptile records c) standard systematic nocturnal streamside search sites d) standard systematic diurnal herpetofauna search sites.



Diurnal Birds

Prior to the current survey bird records were widespread (Figure 2a) with the majority of records in the Atlas of NSW Wildlife observed (11,758 records) or heard (1278 records) individuals (DECCW 2010a, Figure 2a). Surprisingly, despite the number of records only a small number of standard systematic diurnal bird surveys had been conducted across the survey area, with large gaps in some sections (Figure 2b). Survey effort for diurnal birds had also been implemented using non-standard methods Andrew (2001).

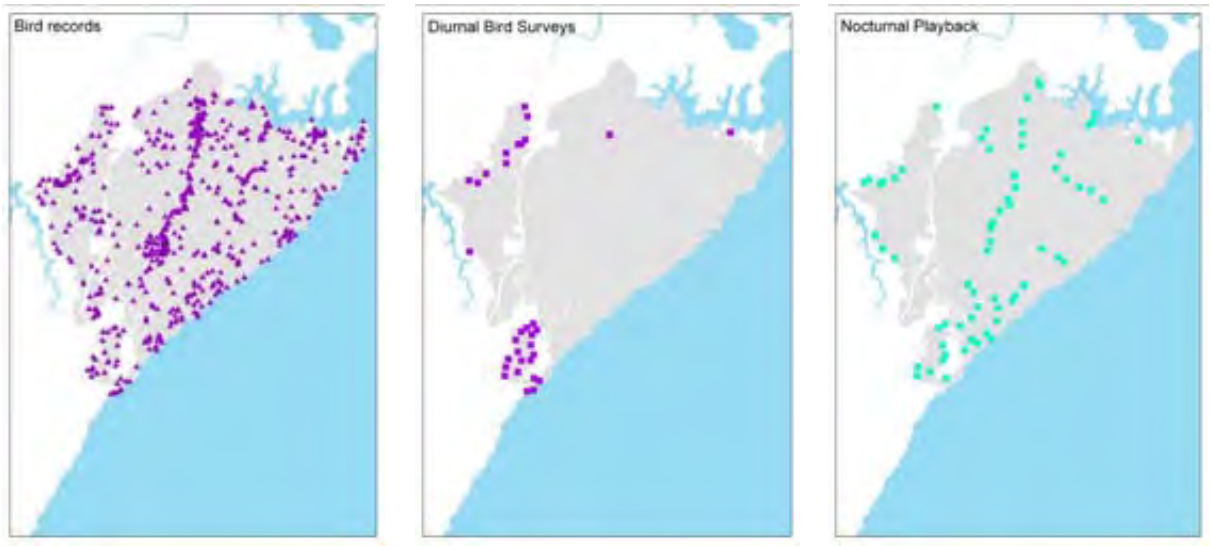
To address gaps in diurnal bird data, new survey effort planned to undertake standard systematic diurnal bird surveys throughout the area when conditions were suitable and to obtain incidental bird records particularly of species infrequently located during systematic searches

Nocturnal Birds

A large number of systematic nocturnal playbacks for threatened forest owl species had been conducted within the survey area (DECCW 2010a, Figure 2c). For example, Andrew (2001) conducted 92 nocturnal call playbacks for threatened forest owls across the survey area, employing a technique equivalent to the current DECCW systematic standard.

Given the extensive existing efforts of nocturnal playback, new survey efforts planned only to use the method to target cryptic nocturnal species not previously addressed including the Grass Owl.

Figure 2: Existing diurnal and nocturnal bird records and DECCW systematic survey sites in the Atlas of NSW Wildlife: a) all diurnal bird records b) standard systematic diurnal bird survey sites c) standard systematic nocturnal call playback sites.



a b c

Microbats

Map 3a shows the distribution of microbat records on the Atlas of NSW Wildlife prior to the current survey. The majority (198 records) derived from trapped or netted animals (see Figure 3b for distribution of systematic harp trapping sites). Other records were 51 calls heard (e.g. White-striped Freetail-bat when spotlighting), 36 observations and 13 miscellaneous records, while few ultrasonic (Anabat) records of microbats had been entered into the Atlas of NSW Wildlife within the survey area (see Figure 3c for distribution of Anabat sites).

New survey work for microbats planned to undertake widespread ultrasonic Anabat survey, additional systematic harp trapping particularly in Royal NP supplemented by additional cave, overhang and tunnel searches.

Figure 3: Existing microbat records and DECCW systematic survey sites in the Atlas of NSW Wildlife: a) all microbat records b) standard systematic harp trapping sites c) standard systematic ultrasonic Anabat sites.

a b c

Other Mammals

Prior to the current survey the records of mammals (excluding microbats) in the Atlas of NSW Wildlife were scattered across the survey area (DECCW 2010a, Figures 4a, b). The majority of mammal records (excluding microbats) comprised 510 trapped records, 459 observed records, 60 roadkill records and 58 heard records. There were few systematic surveys for site-based spotlighting following the technique described in Section 2.4 (Figure 4c) since most of the previous spotlighting surveys had been transect rather than site based (e.g. Andrew 2001). However, trapping techniques had been conducted across the survey area, primarily by Andrew (2001) and subsequent DECCW monitoring at the same sites. These techniques included Elliott trapping, pitfall trapping and hair tubes (Figures 4d, 4e, 4f).

New survey work for terrestrial mammals planned to undertake widespread site-based systematic spotlighting surveys, camera trapping (a technique not previously used in the survey area), location and analysis of predator scats and record incidental observations of all mammal species. Additional Elliott and pitfall trapping and hair tube survey were considered a low priority due to previous survey effort and therefore were not undertaken.

Figure 4: Existing mammal (excluding microbat) records and systematic survey sites in the Atlas of NSW Wildlife: a) ground-dwelling mammal records b) arboreal mammal records c) standard systematic spotlighting survey sites d) Elliott trapping sites e) pitfall trapping sites and f) hair tube sampling sites.

a b c

d

e

f

2.4 CURRENT SURVEY PROGRAM

2.4.1 Systematic fauna survey techniques

The systematic fauna survey methods used are based on those developed by the NPWS Biodiversity Survey Coordination Unit (NPWS 1997a) and are in this document referred to as 'standard systematic 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 survey area. Furthermore, it will allow future comparisons with consistent surveys of environments elsewhere, such as in the adjacent Dharawal SCA and Nature Reserve (DECC 2007a), O'Hares Creek and Woronora Special Areas (DECC 2007d), Sydney Metropolitan CMA area (DECC 2008a) and Kamay Botany Bay National Park (DECCW 2011). These systematic fauna survey methods were used in the current survey and in relevant sites surveyed in DECC (2008a).

The field survey team were supplied with field proformas to facilitate comprehensive, consistent recording of field data and to increase accuracy and efficiency of data entry. The names of observers and recorders were noted on every data sheet to aid data verification and data entry. All systematic surveys undertaken for the current project were entered into the Atlas of NSW Wildlife using the Biodiversity Survey Subsystem (BSS). This database can be queried for systematic survey technique census details and hence locality details are not duplicated here.

Site Selection

The aim of the systematic site selection process was to

1. Ensure that all of the habitat types present within the survey area were systematically sampled in proportion to the land area they each occupy. The primary stratum used as a surrogate for habitat type was vegetation community, using the digital vegetation map produced by DECCW (2009) derived from Keith and Tozer (unpublished). The sampling strategy aimed to sample the mapped vegetation communities proportionately to the mapped area of each community within the reserves and to include repeat sampling within each vegetation community to provide reasonable reliability that potential variations within widespread stratum were captured.

   Such replication of sites served to strengthen the reliability of patterns derived from the collected data. The following rules applied.

   - Vegetation communities occupying less than 0.5 per cent of the survey area were sampled by two systematic survey sites except where limited to one systematic site due to: the majority of patches being smaller than 2ha in size (i.e. the size of a systematic survey site); all patches being significantly modified (e.g. little natural understorey present); patches being separated by less than 0.5km straight-line distance; or only a single patch occurring within the survey area (Table 2).
   - Estuarine Mangrove Forest and Estuarine Saltmarsh were combined due to their intergraded habit with three systematic survey sites selected.
   - Widespread vegetation communities occupying greater than 0.5 per cent of the survey

area had six systematic survey site replicates selected, all separated by a distance of greater than 1km except Coastal Sandplain Heath and Coastal Shale-Sandstone Forest which due to their restricted distribution within the survey area were limited to three selected survey sites (Table 2).

- Three vegetation communities were not sampled: i) seagrass communities as these occurred in the lower intertidal and sub tidal zones; ii) urban/disturbed communities; iii) patches of Hinterland Sandstone Dwarf Apple Heath-Woodland were smaller than 2ha in size and therefore not sampled (Table 2).

2. Fill spatial gaps in standard systematic survey effort, particularly in Heathcote NP and western sections of Royal NP. Additionally, previous systematic survey sites (e.g. Andrew 2001) were targeted with additional survey techniques not conducted during the former surveys. Such gap filling resulted in some widespread vegetation communities having greater than six systematic survey sites sampled.

3. Target high conservation lands that adjoin the reserves where little systematic survey effort had been conducted. One high conservation value area, Constables Point, which is primarily non-vegetated was not included as a local resident (Anne Carrick, Maianbar) undertakes regular wader and waterbird counts at this location.

4. Target sections of Royal NP that are proposed for future prescribed burns.

Systematic sites were initially selected using a Geographic Information System (ArcGIS 9.3) coupled with information from the DECCW (2009) vegetation map, topographic maps, access trails, and knowledge held by DECCW staff and other park users. Wherever possible sites were separated by a straight-line distance of 1km, although due to the limited distribution of a number of vegetation communities (e.g. in the Bundeena area) this was not always achievable. In the latter situation, sites were located greater than 0.5km apart where possible, with the exception of a small number of sites where straight-line distance was between 300m and 500m apart. In these sites, targeted survey techniques and limited systematic survey techniques were undertaken, due to the risk of repeat counting individuals of more mobile fauna groups, particularly birds and larger reptiles and mammals.

Sites were positioned primarily adjacent or close to access trails and walking tracks to maximise the number of sites that could be accessed during the limited survey period. The exceptions to this were sites located in restricted vegetation communities or in spatial fauna information gaps. The placement of harp traps to capture microbats was limited by the availability of suitable fly-ways, such as vegetation constrictions along roads and creek lines.

In the field, the proposed site locations were ground-truthed to ensure that they were representative of the mapped vegetation community, had suffered a minimum amount of disturbance and comprised a single vegetation community. If these criteria were not met, an alternative location was selected for the site. Systematic survey sites were 100m by 200m (2 ha) in area.

Site Attributes

A site attribute form, aiming to characterise fauna habitat, was filled out at every systematic site where one or more survey techniques were conducted. A 20m x 20m quadrat typical of the overall 100m x 200m site was used for the assessment. The site attribute locates and describes the site in a format that is comparable to other sites. Data relating to physio-geographic, disturbance, structural and floristic, microhabitat and stream categories were recorded for each site. 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.

The Swamp Wallaby was one of the most commonly encountered mammals in all habitats across the survey area. Photo © M. Schulz

Table 2: Proposed number of standard systematic fauna survey sites in the different vegetation communities mapped within the survey area.

*-Coastal Escarpment Littoral Rainforest (0.4ha) and Coastal Headland Littoral Thicket (97.2ha) combined; **-Estuarine Mangrove Forest (20.3ha) and Estuarine Saltmarsh (12.3ha) combined.

Vegetation community (after DECCW 2009)	Veg code	Coverage (ha)	Percentage of survey area	Proposed number of systematic survey sites
Coastal Sandstone Exposed Scribbly Gum Woodland	DSF05	5426	26	6
Coastal Sandstone Sheltered Peppermint-Apple Forest	DSF09	5280	25	6
Coastal Sandstone Heath-Mallee	HL08	4539	21	6
Illawarra Escarpment Blackbutt Forest	WSF05	1653	7	6
Woronora Sandstone Mallee-Heath Woodland	DSF16	746	3	6
Sydney Ironstone Bloodwood-Silvertop Ash Forest	DSF14	544	2	6
Illawarra Escarpment Bangalay-Banksia Forest	WSF04	449	2	6
Southern Sydney Sheltered Forest	DSF13	448	2	6
Coastal Warm Temperate Rainforest	RF03	355	1.	6
Coastal Upland Wet Heath Swamp	FrW02	222	1	6
Coastal Sandstone Riparian Scrub	RF09	152	0.7	6
Coastal Sandplain Heath	HL04	151	0.7	3
Coastal Headland Cliffline Scrub	HL07	125	0.6	6
Coastal Shale-Sandstone Forest	WSF06	122	0.5	3
Coastal Headland Littoral Thicket*	RF07/08	97	0.5	6
Beach Spinifex Grassland	GL01	45	0.2	2
Sydney Foreshores Shale Forest	WSF08	38	0.1	2
Coastal Alluvial Bangalay Forest	FoW01	37	0.1	2
Estuarine Mangrove Forest/Estuarine Saltmarsh**	SW01/SW02	32.6	0.1	3
Urban Exotic/Native	-	27	0.1	0
Coastal Enriched Sandstone Moist Forest	WSF02	25	0.1	2
Coastal Sand Apple-Bloodwood Forest	DSF03	24	0.1	1
Coastal Tea-tree-Banksia Scrub	HL02	20	0.1	2
Weeds and Exotics	-	19	0.1	1
Coastal Headland Grassland	GL02	17	0.08	2
Seagrass Meadows	-	12	0.0	0
Coastal Sand Littoral Forest	WSF03	12	0.06	1
Sydney Turpentine-Ironbark Forest	WSF09	10	0.05	1
Coastal Sandstone Gallery Rainforest	RF02	8	0.04	1
Woronora Sandstone Exposed Bloodwood Woodland	DSF15	7	0.03	1
Coastal Sandstone Riparian Forest	DSF08	6	0.03	1
Coastal Sand Bangalay Forest	DSF21	5	0.02	1
Hinterland Riverflat Paperbark Swamp Forest	FoW05	5	0.02	2
Illawarra Escarpment Subtropical Rainforest	RF01	4	0.02	1
Estuarine Swamp Oak Forest	FoW08	3	0.01	1
Coastal Flats Swamp Mahogany Forest	FoW02	1	0.007	1
Hinterland Sandstone Dwarf Apple Heath-Woodland	HL10	1	0.006	0
Coastal Upland Damp Heath Swamp	FrW01	0.6	0.003	1
Total		**20,687.9**		**113**

Diurnal Bird Survey

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

Diurnal Herpetofauna Search

A standard half-hectare area (100m x 50m) was searched for one person-hour at each site (standardised regardless of the number of persons searching). Censuses were restricted to the period between mid-morning and late afternoon, when temperature and insolation were sufficient to ensure maximum reptile activity. Surveying was not conducted on overcast, rainy or extremely windy days.

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, dumped rubbish, rock outcrops and other likely shelter sites. Species identified by shed skin, found during the search, were also recorded on the census sheet. Incidental observations of other fauna were recorded on opportunistic survey forms.

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), captured low-flying species. Sites were selected for their perceived potential to interrupt bats along their flight paths, and were usually positioned on tracks, over watercourses, next to dams or in 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 current surveys some sites were only trapped for one night and others for three nights. This variation to the standard survey effort is recorded in the BSS, but both one, two and three night trapping sites are included together in the summary in Table 3.

Harp trap set on a management track in Royal NP. Photo © M. Schulz/DECCW

Traps were checked during the night and each morning. Captured bats were identified by external morphology, forearm length and body weight, and keyed out where necessary using Parnaby (1992a) and Churchill (1998). Animals were released during the night or on the following night at the point of capture.

Bat Ultrasonic ('Anabat') 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 also record low-flying species in open situations not suited 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 DECCW standard systematic technique for bat ultrasound recording is to leave bat detectors overnight at a site, set to commence detection at dusk and turn off at dawn, thus accounting for variation in species presence (Richards 2001). However, for the current survey the approach taken was to sample all sites in which nocturnal surveys were undertaken. This approach was largely used to minimise the risk of the detector being stolen or vandalised due to the high level of visitor activity in the area at night, as well as maximising the number of sites that could be sampled. An SD1 Anabat detector (Titley Electronics, Ballina, NSW) was deployed at a site for between 15 and 130 minutes, usually for 30 minutes. This variation to the standard survey effort is recorded in the BSS, but all sites where Anabat recording was undertaken are included together in the summary in Table 3. The detector was either: a)

set in locations where bats were expected to fly within a site, such as over waterbodies, in forest openings or along tracks or b) where people were known or perceived to be present the detector was carried while undertaking other survey activities, such as spotlighting.

Ultrasonic calls recorded during the current survey were analysed and identified by Martin Schulz. Only calls that were definite were entered into the Atlas of NSW Wildlife, with the categories of 'probable' and 'possible' used in previous surveys (e.g. DECC 2008b, c) not recorded, due to the risk of later confusion. Reference calls were collected for a number of species in order to document local call patterns and to assist with the identification and verification of non-reference calls.

Site Spotlighting Survey

This census technique comprised searching for arboreal and terrestrial mammals and other active fauna along a 200m transect within a site for half a person hour. In the current survey spotlighting was predominantly confined to habitats with trees greater than 5m in height present. Fifty-watt spotlights were used to scan the vegetation and ground for animals, including searching for reflected eye shine. Surveyors also listened, identified and recorded all fauna calls heard during the survey period. All fauna observed within the census period were recorded, noting whether they were on or off site.

Nocturnal Streamside Search

Streamside searches for frogs were undertaken for half a person hour along a 200m stretch of stream or gully. The searches were primarily conducted on warm, dark, humid and wet nights within two days of rain. All frogs, and other animals, identified visually or by call within the time period were recorded, together with the weather conditions at the time of the survey. Streamside searches were conducted in varying seasons in order to sample different frog species, including in the winter months (for Wallum Froglet), following prolonged rain in October 2009 for spring-breeding species and in April 2010 for autumn-breeding species.

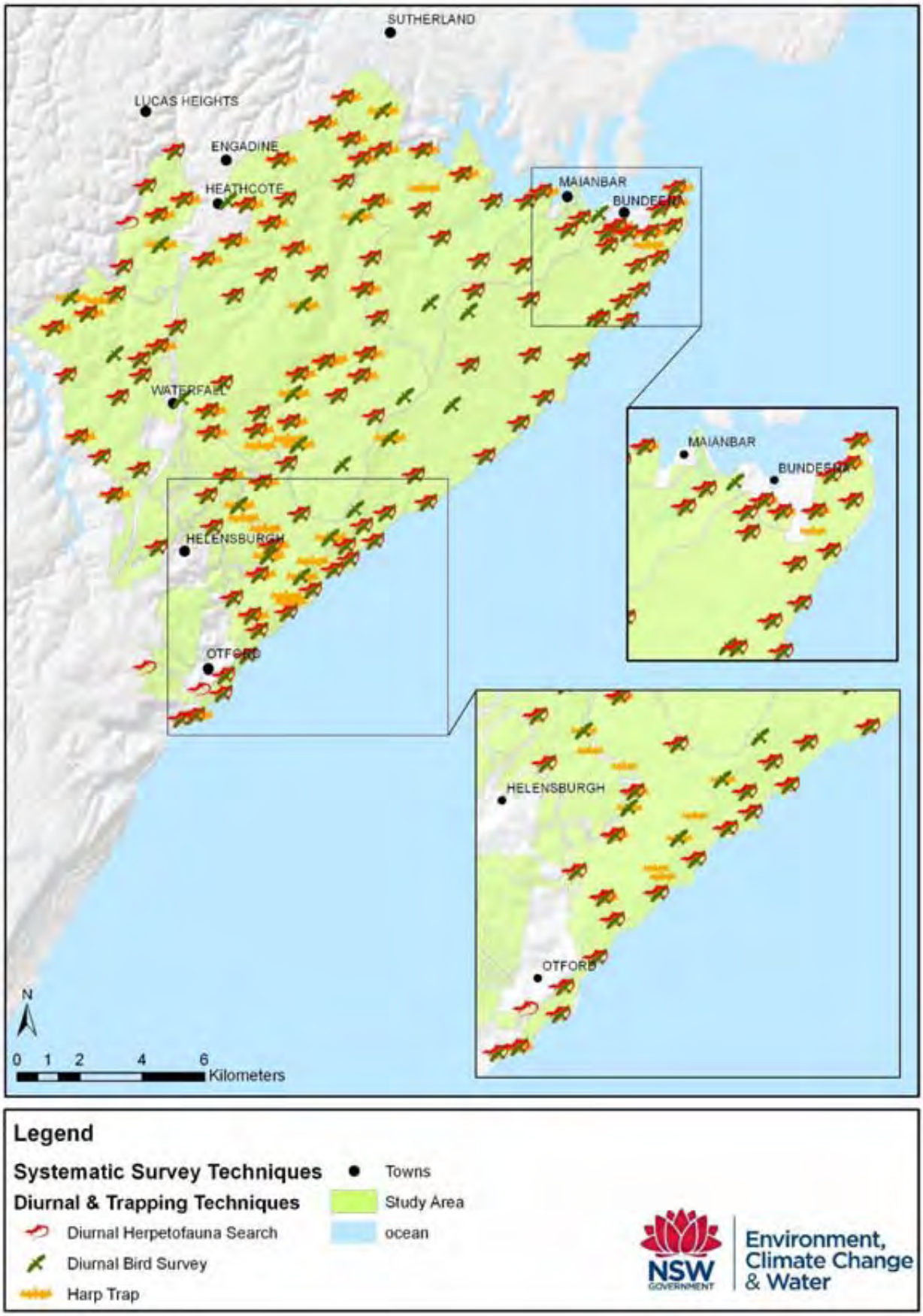
2.4.2 Systematic fauna survey site locations

A total of 151 systematic sites were established and surveyed during the current survey. Site and census details are stored in the BSS of the Atlas of NSW Wildlife. Table 3 summaries the distribution of systematic fauna survey techniques across vegetation communities, while Maps 5 and 6 present the distribution of sites across the survey area.

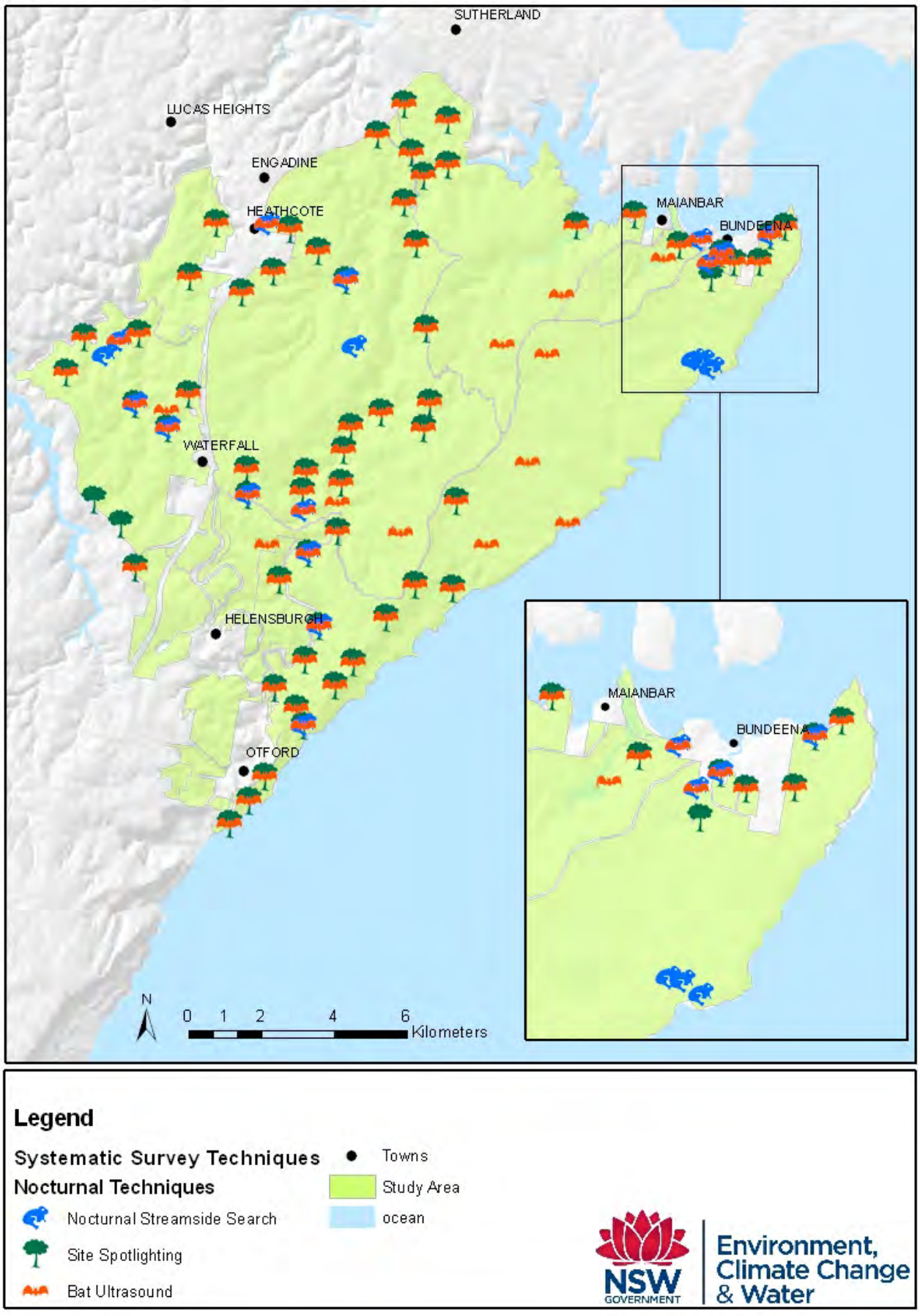
2.4.3 Assessment of survey adequacy for target species

Following the systematic survey gap analysis and the allocation of systematic survey effort to particular vegetation communities and fauna groups, an assessment was made as to whether each of the target fauna species would be adequately sampled by the systematic survey design. This assessment is presented in Table 4. As can be seen in the table, effective survey for some target species required the application of extra systematic searches in suitable habitat. Other target species were assessed to not be adequately sampled by DECCW standard systematic techniques and hence required the design and deployment of targeted survey techniques. The assessment thus led to two aspects of field survey, being standard systematic techniques (Section 2.4.1) and targeted techniques (Section 2.4.4).

The Pacific Gull is now very rarely seen as far north as Sydney. Photo © M. Schulz



Map 5: **The location of systematic survey sites using diurnal and trapping techniques in Royal and Heathcote NPs, Garawarra SCA and adjoining lands of high conservation value in the current survey.**



Map 6: **The location of systematic survey sites using nocturnal techniques in Royal and Heathcote NPs, Garawarra SCA and adjacent high conservation value lands in the current survey.**

Table 3: Vegetation communities within the survey area and corresponding allocation of systematic fauna survey effort during the current fauna survey.

Habitat Group	Vegetation Community	Area (hectares)	Total number of systematic sites	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Harp trapping	Bat ultrasonic call recording	Nocturnal streamside search
Northern Warm Temperate and Subtropical Rainforest	Illawarra Escarpment Subtropical Rainforest	4.3	1	1	1	1	1	1	-
	Coastal Sandstone Gallery Rainforest	8.2	1	1	1	1	1	1	-
	Coastal Warm Temperate Rainforest	355.2	14	10	6	5	11	7	2
Littoral Rainforest	Coastal Headland Littoral Thicket/Coastal Escarpment Littoral Rainforest	97.2	7	5	5	4	2	4	1
Riparian Scrub	Coastal Sandstone Riparian Scrub	152.8	8	7	6	5	3	5	3
North Coast Wet Sclerophyll Forest	Coastal Enriched Sandstone Moist Forest	25.9	2	2	2	1	1	1	-
	Illawarra Escarpment Bangalay-Banksia Forest	449.1	8	7	6	4	2	4	1
	Illawarra Escarpment Blackbutt Forest	1653.5	8	5	6	5	4	6	1
Northern Hinterland Wet Sclerophyll Forest	Coastal Shale-Sandstone Forest	122.4	3	3	3	3	3	3	-
	Sydney Foreshores Shale Forest	38.9	2	2	2	2	1	2	-
	Sydney Turpentine-Ironbark Forest	10.8	1	1	1	1	1	1	-
Sydney Coastal Dry Sclerophyll Forest	Coastal Sandstone Exposed Scribbly Gum Woodland	5426.8	10	9	7	6	5	6	-
	Coastal Sandstone Riparian Forest	6.5	1	1	1	-	-	-	-
	Coastal Sandstone Sheltered Peppermint-Apple Forest	5280.8	14	13	8	6	8	7	4
	Southern Sydney Sheltered Forest	448.2	6	3	2	2	3	5	-
	Sydney Ironstone Bloodwood-Silvertop Ash Forest	544.8	6	6	5	4	4	4	1
	Woronora Sandstone Exposed Bloodwood Woodland	7.1	1	1	1	-	-	-	-
	Woronora Sandstone Mallee-Heath Woodland	746.6	6	6	6	2	3	2	-
Dune and Alluvial Sclerophyll Forest	Coastal Alluvial Bangalay Forest	37.0	2	2	2	2	-	1	-
	Coastal Sand Apple-Bloodwood Forest	24.6	1	1	1	1	1	1	-
	Coastal Sand Littoral Forest	12.5	1	1	1	1	1	1	-
	Coastal Sand Bangalay Forest	5.4	1	1	1	1	-	1	-
Coastal Headland Grassland	Coastal Headland Grassland	17.7	2	2	2	-	-	-	-
	Lomandra-dominated Headlands (not mapped)	N/A	1	1	1	-	-	-	-
Heathland	Coastal Tea-tree-Banksia Scrub	20.1	2	2	2	-	1	-	-

Habitat Group	Vegetation Community	Area (hectares)	Total number of systematic sites	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Harp trapping	Bat ultrasonic call recording	Nocturnal streamside search
	Coastal Sandplain Heath	151.6	3	3	3	-	-	-	-
	Coastal Headland Cliffline Scrub	125.4	7	7	7	-	-	1	-
	Coastal Sandstone Heath-Mallee	4539.0	10	9	9	-	3	1	-
	Hinterland Sandstone Dwarf Apple Heath-Woodland	1.2	-	-	-	-	-	-	-
Freshwater Wetland	Coastal Upland Damp Heath Swamp	0.6	1	1	-	-	-	-	-
	Coastal Upland Wet Heath Swamp	222.1	11	11	7	1	1	5	2
	Coastal Sand Swamp Sedgeland (not mapped)	N/A	-	-	-	-	-	-	-
	Coastal Freshwater Reedland (not mapped)	N/A	-	-	-	-		-	-
Forested Wetland	Coastal Flats Swamp Mahogany Forest	1.5	1	1	1	1	1	1	-
	Hinterland Riverflat Paperbark Swamp Forest	5.0	2	2	2	1	1	2	1
	Estuarine Swamp Oak Forest	3.2	1	1	1	1	1	1	1
Saline Wetland	Estuarine Mangrove Forest/Estuarine Saltmarsh	32.6	3	3	3	1	1	1	-
Shoreline	Beach Spinifex Grassland	45.7	3	3	2	-	-	1	1
Total		20,687.9	151	137	114	62	64	76	18

Table 4: Target species list derived prior to the commencement of the 2009-10 field surveys.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
AMPHIBIANS				
Green and Golden Bell Frog	*Litoria aurea*	Threatened. Formerly occurred at Jibbon Lagoon but has not been recorded recently.	Nocturnal streamside search after spring/summer rain, tadpole searches.	No – requires application of extra systematic nocturnal searches of wetlands after spring rain, particularly Marley and Jibbon lagoons and targeted tadpole surveys.
Littlejohn's Tree Frog	*Litoria littlejohni*	Threatened. Not recorded in survey area but known from adjacent areas on the Woronora Plateau (e.g. DECC2007a, c).	Nocturnal streamside search after spring rain, tadpole searches.	No – requires targeted listening surveys and targeted tadpole surveys.
Freycinet's Frog	*Litoria freycineti*	Regionally Significant (DECC 2008a). Declining in parts of its range in NSW, although Royal NP known to be important its presence is poorly documented.	Nocturnal streamside search after spring and summer rain.	Yes
Lesueur's Frog/Wilcox's Frog	*Litoria lesueurii/wilcoxii*	Recent taxonomic split (Donnellan and Mahony 2004). Distribution of the two species within the survey area unclear.	Nocturnal streamside search after spring and summer rain.	Yes
Narrow-Fringed Frog / Green Stream Frog	*Litoria nudidigita/phyllochroa*	Recent taxonomic split (Donnellan *et al*. 1999). Distribution of the two species within the survey area unclear.	Nocturnal streamside search after spring and summer rain.	Yes
Wallum Froglet	*Crinia tinnula*	Threatened. Not recorded in survey area but known from wetland areas in deep sand on the Kurnell Peninsula (e.g. DECCW 2011).	Diurnal and nocturnal streamside search and listening surveys in swamps after autumn and winter rain.	No – requires application of extra systematic nocturnal searches in potential habitat in winter and application of targeted listening surveys in autumn and winter.
Giant Burrowing Frog	*Heleioporus australiacus*	Threatened.	Nocturnal streamside searches after prolonged rain; site spotlighting; driving roads at night after prolonged rain.	Yes, as well as carefully scanning roads while driving at night especially after prolonged rain.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Stuttering Frog	*Mixophyes balbus*	Threatened. Only recorded once since 1994 wildfires (Andrew 2001). Recommendation of DECC 2007c.	Nocturnal streamside search and tadpole survey in spring and early summer.	No – requires application of extra systematic searches in tributaries of the Hacking River in spring and summer and of targeted tadpole searches.
Red-crowned Toadlet	*Pseudophryne australis*	Threatened.	Nocturnal streamside searches; site spotlighting; driving roads at night after prolonged rain.	No – requires application of extra systematic nocturnal searches in spring particularly in Heathcote NP.
Brown Toadlet	*Pseudophryne bibronii*	Locally Significant. Declining in parts of its range in NSW. Records within Royal NP require confirmation due to potential confusion with the Red-crowned Toadlet where records are based on calls only.	Nocturnal streamside search and listening surveys after autumn rain.	No – requires application of targeted listening surveys in late autumn at ephemeral soaks in the Heathcote East and Garawarra Farm area.
Tyler's Toadlet	*Uperoleia tyleri*	Status uncertain in region. Not recorded in the survey area and few confirmed records in the Sydney area. However, known from similar habitats further south; therefore may potentially occur.	Nocturnal streamside search after spring and summer rain.	Yes
REPTILES				
Rosenberg's Goanna	*Varanus rosenbergi*	Threatened.	Diurnal herpetofauna searches; other site-based activities; opportunistic encounter.	Yes
Bold-striped Cool-skink	*Acritoscincus duperreyi*	Regionally Significant (DECC 2008a). Formerly considered to occur in higher altitude areas it was recently recorded from the Dharawal reserves (DECC 2007a). Therefore although not known from the survey area, may potentially occur.	Diurnal herpetofauna surveys in wet heathland habitats.	Yes
Mainland She-oak Skink	*Cyclodomorphus michaeli*	Regionally Significant (DECC 2008a). Distribution patchy and poorly understood within the region. Not recorded in the survey area (DECCW 2010a).	Diurnal herpetofauna surveys in wet heath and sedgeland habitats.	Yes

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
McCoy's Skink	*Nannoscincus maccoyi (taxonomy revised to Anepischtos maccoyi)*	Northern range limit poorly defined. Recorded further south in the Illawarra and may potentially occur in the survey area.	Diurnal herpetofauna surveys in rainforest and wet sclerophyll forest habitats with a mesic dominated subcanopy.	Yes
Mustard-bellied Snake	*Drysdalia rhodogaster*	Locally Significant. Distribution patchy and poorly understood within the region. Not recorded in the survey area (DECCW 2010a) but recorded from adjacent areas such as Dharawal (DECC2007a).	Diurnal herpetofauna surveys in a variety of habitats.	Yes
Broad-headed Snake	*Hoplocephalus bungaroides*	Threatened.	Diurnal herpetofauna surveys in sandstone outcrop areas in spring and early summer; driving roads for active individuals on warm, humid nights.	Yes, as well as carefully scanning roads while driving at night especially in warm humid conditions.
BIRDS				
King Quail	*Coturnix chinensis*	Regionally significant (DECC 2008a). Suitable habitat present but no confirmed records (Anyon-Smith 2006) although reported sightings on Birdline NSW.	Diurnal bird surveys, diurnal call playback, camera trapping, passive listening and active searching in heathland/sedgeland areas.	No – requires targeted call playback, active searching, and camera trapping.
Emerald Dove	*Chalcophaps indica*	Regionally significant (DECC 2008a). Status uncertain in survey area.	Diurnal bird surveys and opportunistic passive listening in rainforest.	Yes
Superb Fruit-Dove	*Ptilinopus superbus*	Threatened.	Diurnal bird surveys and opportunistic passive listening in rainforest.	Yes
Rose-crowned Fruit-Dove	*Ptilinopus regina*	Threatened.	Diurnal bird surveys and opportunistic passive listening in rainforest.	Yes
Australasian Bittern	*Botaurus poiciloptilus*	Threatened. Suitable habitat but no confirmed records	Passive listening at dusk in wetland areas; daytime searches for roosting birds in sedgelands.	No – requires targeted passive listening and active daytime searching in wet heath and sedgeland.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Black Bittern	*Ixobrychus flavicollis*	Threatened. Status uncertain within the survey area.	Searching upper tidal limits of watercourses; searching sections of non-tidal streams and wetlands.	No – requires targeted riparian dusk watches and listening as well as opportunistic survey when traversing sections of watercourses or Port Hacking shoreline or kayaking.
Osprey	*Pandion haliaetus*	Threatened.	Searching the shoreline of Port Hacking and the lower Hacking River for roosting birds and potential nests.	No – requires scanning of the ocean and Port Hacking shoreline.
Square-tailed Kite	*Lophoictinia isura*	Threatened.	Diurnal bird surveys; incidental observations particularly in spring/early summer.	Yes
Little Eagle	*Hieraaetus morphnoides*	Threatened.	Diurnal bird surveys; incidental observations.	Yes
Peregrine Falcon	*Falco peregrinus*	Regionally significant (DECC 2008a).	Diurnal bird surveys; searching cliff lines for nesting sites.	No – requires scanning of the ocean and Port Hacking shoreline.
Lewin's Rail	*Lewinia pectoralis*	Regionally Significant (DECC 2008a). Status uncertain in survey area.	Diurnal bird surveys; passive listening and active searching in wet heathland/sedgeland areas.	No – requires targeted passive listening and active daytime searching in wet heath and sedgeland. Also infra-red camera trapping.
Spotless Crake	*Porzana tabuensis*	Regionally Significant (DECC 2008a). Status uncertain in survey area.	Diurnal bird surveys; passive listening and active searching in wet heathland/sedgeland areas.	No – requires targeted passive listening and active daytime searching in wet heath and sedgeland. Also infra-red camera trapping.
Pied Oystercatcher	*Haematopus longirostris*	Threatened.	Searching the shoreline of Port Hacking and elsewhere within Royal NP, such as the lower Hacking River for foraging and roosting birds.	No – requires scanning of the ocean and Port Hacking shoreline.
Sooty Oystercatcher	*Haematopus fuliginosus*	Threatened.	Searching the shoreline of Royal NP for foraging and roosting birds.	No – requires scanning of the ocean and Port Hacking shoreline.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Latham's Snipe	*Gallinago hardwickii*	Regionally Significant (DECC 2008a). Status uncertain in survey area.	Diurnal bird surveys; searches for diagnostic probe marks; active searching in wet heathland/sedgeland areas.	No – requires active daytime searching in wet heath and sedgeland.
Migratory Shorebirds		Regionally Significant (DECC 2008a).	Searching the shoreline of Royal NP for foraging and roosting birds.	No – requires scanning of the ocean and Port Hacking shoreline.
Glossy Black-cockatoo	*Calyptorhynchus lathami*	Threatened.	Diurnal bird survey and opportunistic identification of feeding signs.	Yes
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Threatened.	Diurnal bird survey and opportunistic passive listening in dry and wet sclerophyll forest.	Yes
Little Lorikeet	*Glossopsitta pusilla*	Threatened.	Diurnal bird survey; visiting stands of flowering trees, such as Red Bloodwood and Swamp Mahogany.	No – requires additional survey of flowering Swamp Mahogany (autumn)
Swift Parrot	*Lathamus discolor*	Threatened.	Diurnal bird survey; visiting stands of autumn flowering trees, such as Swamp Mahogany.	No – requires additional survey of flowering Swamp Mahogany (autumn)
Eastern Ground Parrot	*Pezoporus wallicus wallicus*	Threatened. Considered locally extinct (Anyon-Smith 2006), however the recent location of this species in the nearby Woronora Special Area suggests that it may occur.	Diurnal bird surveys; diurnal call playback, passive listening, camera traps and active searching in heathland/sedgeland areas.	No – requires targeted call playback and passive listening and active daytime searching in wet heath and sedgeland. Also infra-red camera traps.
Pheasant Coucal	*Centropus phasianinus*	Regionally Significant (DECC 2008a). Status uncertain in survey area.	Diurnal bird surveys; passive listening and active searching in heathland/sedgeland areas.	No – requires targeted passive listening and active daytime searching in wet heath and sedgeland.
Powerful Owl	*Ninox strenua*	Threatened.	Nocturnal call playback; spotlighting.	Yes – adequately surveyed systematically in previous studies so not targeted in 2009-10.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Barking Owl	*Ninox connivens*	Threatened.	Nocturnal call playback.	No – requires targeted nocturnal call playback in drier forest in the Loftus Heights-Heathcote Heights-Waterfall area in summer.
Sooty Owl	*Tyto tenebricosa*	Threatened.	Nocturnal call playback; spotlighting.	Yes – adequately surveyed systematically in previous studies so not targeted in 2009-10.
Masked Owl	*Tyto novaehollandiae*	Threatened.	Nocturnal call playback; spotlighting.	Yes – adequately surveyed systematically in previous studies so not targeted in 2009-10.
Grass Owl	*Tyto capensis*	Threatened. Suitable habitat present but not recorded from the survey area (e.g. Anyon-Smith 2006)	Targeted nocturnal call playback and active searching for roosting birds in heathland/sedgeland areas.	No – requires targeted call playback and passive listening and active daytime searching in wet heath and sedgeland.
Red-browed Treecreeper	*Climacteris erythrops*	Regionally Significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in wet sclerophyll forest.	Yes
Green Catbird	*Ailuroedus crassirostris*	Regionally Significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in rainforest.	Yes
Southern Emu-wren	*Stipiturus malachurus*	Regionally Significant (DECC 2008a)	Diurnal bird surveys and opportunistic passive listening in heathlands.	Yes
Eastern Bristlebird	*Dasyornis brachypterus*	Threatened and possibly locally extinct, but suitable habitat remains. Recommendation of DECC 2007c.	Diurnal call surveys and targeted passive listening in wet heath, sedgelands and heathy woodlands.	No – requires targeted call playback and passive listening in wet heath and sedgeland. Also infra-red camera traps.
Pilotbird	*Pycnoptilus floccosus*	Regionally significant (DECC 2008a). Declining in survey area (S. Anyon-Smith pers. comm.).	Diurnal bird surveys and opportunistic passive listening in predominantly wet sclerophyll forest.	Yes
Rockwarbler	*Origma solitaria*	Regionally significant (DECC 2008a) and endemic to the Sydney Basin Bioregion.	Diurnal bird surveys and opportunistic passive listening in rocky areas in a variety of habitats.	Yes

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Yellow-throated Scrubwren	*Sericornis citreogularis*	Regionally Significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in rainforest and wet sclerophyll forest with a rainforest subcanopy.	Yes
Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*	Regionally significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in heathland and heathy woodland.	Yes
Speckled Warbler	*Chthonicola sagittata*	Threatened. Considered locally extinct by Anyon-Smith (1996).	Diurnal bird surveys and opportunistic listening on the edge of clearings in the western parts of the survey area.	Yes
Mangrove Gerygone	*Gerygone levigaster*	Regionally Significant (DECC 2008a). Status uncertain with few records of this species from mangrove areas within Port Hacking (Anyon-Smith 2006; DECC 2008a). The paucity of records may be associated with much of the habitat being difficult to access except by canoe/kayak.	Diurnal bird surveys and targeted active searching and passive listening in mangrove areas.	No – requires active searching in mangroves.
Buff-rumped Thornbill	*Acanthiza reguloides*	Regionally Significant (DECC 2008a). Status uncertain.	Diurnal bird surveys and opportunistic listening in drier forests in the western part of the survey area.	Yes
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	Threatened.	Diurnal bird survey and opportunistic listening in dry sclerophyll forest in autumn.	Yes
Australian Logrunner	*Orthonyx temminckii*	Regionally Significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in rainforest.	Yes
Varied Sittella	*Daphoenositta chrysoptera*	Threatened.	Diurnal bird survey and opportunistic passive listening in dry and wet sclerophyll forest.	Yes
Scarlet Robin	*Petroica boodang*	Threatened.	Diurnal bird surveys and opportunistic listening in drier forests in the western part of the survey area.	No – requires extra survey in winter months.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Tawny Grassbird	*Megalurus timoriensis*	Regionally Significant (DECC 2008a). Status uncertain within the survey area.	Diurnal bird surveys and targeted passive listening in heathlands, sedgelands and rank grassland areas.	No – requires passive listening and active daytime searching in wet heath and sedgeland.
Diamond Firetail	*Stagonopleura guttata*	Threatened.	Diurnal bird surveys and opportunistic listening on the edge of clearings in the western part of the survey area.	Yes
Beautiful Firetail	*Stagonopleura bella*	Regionally Significant (DECC 2008a).	Diurnal bird surveys and opportunistic passive listening in heathlands.	Yes
MAMMALS				
Platypus	*Ornithorhynchus anatinus*	Regionally Significant (DECC 2008a). Status uncertain within the survey area (Curtis 2001).	Dusk watches along deeper pools of watercourses, burrow searches, camera traps, dusk paddle up navigable sections of the Hacking River and Kangaroo Creek.	No – requires riparian dusk watches, infra-red camera traps and searching of the Port Hacking shoreline and associated estuaries by kayak.
Spotted-tailed Quoll	*Dasyurus maculatus*	Threatened. Old records but no recent confirmed sightings.	Spotlighting; predator scats; camera traps; incidental sightings.	No – requires infra-red camera trapping and reliance on other survey programs.
Dusky Antechinus	*Antechinus swainsonii*	Regionally Significant (DECC 2008a). Old records in the Burning Palms area (D. Andrew, DECCW, pers. comm.) but no recent confirmed records.	Predator scats; and targeted camera trapping.	No – requires infra-red camera trapping and reliance on other survey programs.
Southern Brown Bandicoot	*Isoodon obesulus*	Threatened. Suitable Habitat present	Spotlighting; predator scat analysis; camera traps in heathland and various forest types.	No – requires infra-red camera trapping.
Koala	*Phascolarctos cinereus*	Threatened.	Spotlighting; predator scat analysis; location of scats.	Yes
Common Wombat	*Vombatus ursinus*	Regionally Significant (DECC 2008a).	Spotlighting; predator scat analysis; location of scats.	Yes
Eastern Pygmy-possum	*Cercartetus nanus*	Threatened.	Spotlighting; predator scat analysis; driving roads at night; roadkill search.	No – requires reliance on other survey programs including roadkill search. Also carefully scanning roads while driving at night.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Greater Glider	*Petauroides volans*	Regionally Significant (DECC 2008a). Appears to have recently been lost from the survey area (Andrew 2001; D. Andrew, DECCW, pers. comm.).	Site-based and targeted spotlighting; predator scat analysis.	No – requires active search by extended spotlighting in tall forest.
Mountain Brushtail Possum	*Trichosurus caninus*	Regionally Significant (DECC 2008a).	Spotlighting; driving roads at night; roadkill search; and camera traps.	Yes
Parma Wallaby	*Macropus parma*	Threatened. Formerly occurred in dense forests in the southern part of Royal NP (Robinson 1987, 1988) but presumed locally extinct.	Spotlighting; camera traps; predator scat analysis.	No – requires infra-red camera trapping.
Red-necked Pademelon	*Thylogale thetis*	Threatened. Presumed lost from survey area but rumours of this species persist in Stanwell Park area.	Spotlighting; camera traps; predator scat analysis.	No – requires infra-red camera trapping.
Grey-headed Flying-fox	*Pteropus poliocephalus*	Threatened.	Search for camps; site spotlighting and nocturnal call playback, particularly around flowering Eucalypts and Banksias	Yes
Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	Regionally Significant (DECC 2008a).	Harp trapping; Anabat; searching of caves, tunnels and overhangs for roosts.	No – requires active searching of caves, tunnels, overhangs and culverts.
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Threatened.	Anabat; harp trapping; spotlighting; dusk watches.	Yes
East-coast Freetail-bat	*Mormopterus norfolkensis*	Threatened.	Anabat; harp trapping.	Yes
Little Bentwing-bat	*Miniopterus australis*	Threatened.	Harp trapping; Anabat; searching of caves, tunnels and overhangs for roosts.	No – requires active searching of caves, tunnels, overhangs and culverts.
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	Threatened.	Harp trapping; Anabat; searching of caves, tunnels and overhangs for roosts.	No – requires active searching of caves, tunnels, overhangs and culverts.

Common name	Scientific name	Reason for inclusion as target species	Optimal survey method	Adequately sampled by systematic survey design?
Golden-tipped Bat	*Kerivoula papuensis*	Threatened. Potentially suitable habitat occurs within the survey area (e.g. Schulz and Eyre 2000) but the species has not been recorded.	Harp trapping in rainforest and wet sclerophyll forest with rainforest subcanopy.	No – requires application of extra harp trapping in suitable rainforest habitat such as on tributaries of the Hacking River and along Ridge Trail south of Garawarra Farm. Also requires active searches of Yellow-throated Scrubwren nests.
Large-eared Pied Bat	*Chalinolobus dwyeri*	Threatened.	Harp trapping; Anabat; searching of caves and overhangs for roosts.	No – requires active searching of caves, tunnels, overhangs and culverts.
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Threatened. Status uncertain in region (DECC 2008a).	Harp trapping.	Yes
Large-footed Myotis	*Myotis macropus*	Threatened.	Harp trapping, bat ultrasonic call recording and searching overhangs along and adjacent to major watercourses.	No – requires active searching of caves, tunnels, overhangs and culverts.
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Threatened.	Harp trapping, bat ultrasonic call recording.	Yes
Eastern Cave Bat	*Vespadelus troughtoni*	Threatened.	Harp trapping; searching of caves, tunnels and overhangs for roosts.	No – requires active searching of caves, tunnels, overhangs and culverts.
Water Rat	*Hydromys chrysogaster*	Locally Significant. Status uncertain within the survey area.	Dusk watches along deeper pools of watercourses; burrow searches, searches for feeding signs; predator scats; camera traps; and dusk paddle up navigable sections of the Hacking River and Kangaroo Creek.	No – requires riparian dusk watches, infra-red camera traps, and searching of the Port Hacking shoreline and associated estuaries by kayak.

2.4.4 Targeted fauna survey techniques


Camera trap set in Curra Moors. Photo © M. Schulz/DECCW

A number of the threatened and regionally significant target fauna species are not adequately sampled using standard systematic survey techniques alone. Targeted survey methods were therefore used for these species and are described below. As these targeted surveys differed from the DECCW systematic standard and did not have a census form established within the BSS via which to enter them, the census details could not be entered into the BSS. The location of these targeted surveys is therefore presented here for completeness and future reference. The exception is infra-red camera trapping and targeted nocturnal call playback, which could be, and therefore were, entered into the BSS. All fauna *records* collected during the targeted and opportunistic survey techniques were entered into the Atlas of NSW Wildlife.

All grid references presented in this report use Map Datum AGD66 and are in Zone 56. Targeted survey sites where no systematic survey techniques were undertaken were separated by a minimum straight-line distance of 300m in potentially suitable habitat.

Early Evening Call Playback and Passive Listening in Wet Heath and Sedgeland

Target Species: Grass Owl, Eastern Ground Parrot, King Quail, Australasian Bittern, Lewin's Rail, Spotless Crake, Pheasant Coucal, Tawny Grassbird.

Technique: Areas of potential Grass Owl and Eastern Ground Parrot habitat were identified using aerial photography, primarily wetlands and wet heaths dominated by sedgelands with little tree or shrub cover, including extensive sedgeland areas fringing mangroves (e.g. Cabbage Tree Basin) (Table 5). During a period of approximately one hour prior to dusk an observer sat quietly in a site listening for the calls of the Eastern Ground Parrot and King Quail. This period also incorporated five minutes of Eastern Ground Parrot playback followed by a five minute listening period then a five minute playback of the King Quail call. The other target species were listened for although their calls were not broadcast. In the same evening following dusk, the call of the Grass Owl was broadcast for a five minute period followed by a 10 minute listening period. Windy conditions and evenings with moderate to heavy rain were avoided.

Table 5: Location and timing of early evening call playback and passive listening in wet heath and sedgeland.

Description of location	Easting	Northing	Date	Start	Finish
Uloola Swamp	317549	6222192	14/01/2010	1940	2045
E side of Cabbage Tree Basin	327425	6226334	18/01/2010	1950	2045
Start of Anice Falls FT	324611	6225355	20/01/2010	2000	2045
Curra Moors sedgeland	322541	6218479	27/01/2010	1940	2045
Jibbon Swamp	330346	6226973	1/02/2010	2005	2045
Bundeena Gully	328662	6226222	2/02/2010	2000	2045
Mt Bass Fire Trail	322990	6223989	18/02/2010	1930	2030
Sedgeland N of Big Marley FT	324226	6223714	8/03/2010	1905	2000
Sedgeland E of Shrapnel Hill	324294	6222001	9/03/2010	1000	1200
Sedgeland S of Wattamolla Rd	323698	6220741	9/03/2010	1900	2000
Sedgeland S of Bundeena Drive	324450	6224361	10/03/2010	0910	1130
Sedgeland S of Wallumarra Tk	320190	6218826	10/03/2010	1900	2000
Curra Moors	322541	6218479	28/04/2010	1720	1830
Jibbon Swamp	330346	6226973	29/04/2010	1715	1810

Active Daytime Searching in Wet Heath and Sedgeland

Target Species: Grass Owl, Eastern Ground Parrot, King Quail, Lewin's Rail, Spotless Crake and Australasian Bittern, Latham's Snipe, Pheasant Coucal, Tawny Grassbird.

Technique: Traverses criss-crossing sedgeland areas for roosting or sheltering target species were undertaken at 20 sedgeland/wetland/wet heath/grassland areas (including all identified targeted sites for these species) in January to March 2010 (Table 6). Marley and Jibbon Lagoons, former habitat for the Eastern Ground Parrot, were traversed on three occasions: in October 2009, January and April 2010.

Table 6: Location of active daytime searching in wet heath and sedgeland.

Description of location	Easting	Northing
Sedgeland in Jibbon Lagoon	330346	6226973
Sedgeland in lagoon south of Jibbon Lagoon	330557	6226635
Yarmouth Swamp	328655	6226261
Sedgeland on east edge of Cabbage Tree Basin	327425	6226334
Sedgeland at Marley Lagoon outlet	328733	6223312
Sedgeland north of Mowlee Ridge	324226	6223714
Sedgeland south of Maianbar Road, Bundeena Drive junction	324450	6224361
Wet heathland at start of Anice Falls Fire Trail	324611	6225355
Wet heathland at start of Mt Bass Fire Trail	322990	6223989
Sedgeland east of Shrapnel Hill Fire Trail	324294	6222001
Sedgeland west of Sir Bertram Stevens Drive 37	322188	6221008
Sedgeland south of Wattamolla Road	323698	6220741
Curra Moors sedgeland	322541	6218479
Sedgeland south of Wallumarra Track	320190	6218826
Lomandra-dominated vegetation on Thelma Head	321238	6216380
Sedgeland behind North Era Beach	320729	6216320
Lomandra-dominated vegetation south of Burning Palms	319258	6214812
Lomandra-dominated headland adjacent to Figure Eight Pool	319091	6214471
Headland grassland including ephemeral soaks south of Bulgo	316390	6211533
Uloola Swamp	317549	6222192

Riparian Dusk Watches and Listening

Target Species: Platypus, Water Rat and Black Bittern.

Technique: During a period of approximately one hour prior to dusk an observer sat quietly along a deeper long section of river/creek that provided good visibility of the water watching for active Platypus and Water Rats (following the techniques of Rohweder and Baverstock 1999, Curtis 2001), as well as listening and watching for Black Bittern. This technique was conducted at 24 locations along various watercourses, including the Hacking and Woronora Rivers and a number of smaller creeks (Table 7). Windy conditions and evenings with moderate to heavy rain were avoided.

Table 7: Location and timing of riparian dusk watches.

Date	Description of location	Watercourse	Easting	Northing	Start	Finish
12/10/2009	Red Cedar Flat	Hacking R	317230	6215341	1900	2040
23/11/09	Red Cedar Flat	Hacking River	317363	6215605	1920	2035
20/12/2009	Karloo Pool	Kangaroo Ck	318117	6225719	1935	2025
21/12/2009	Upstream from Bottle Forest Tk crossing	Kangaroo Ck	318686	6225728	1950	2015
21/12/2009	Downstream from Bottle Forest Tk crossing	Kangaroo Ck	318816	6225997	1935	2015
4/01/2010	Engadine Waterhole	-	316525	6227255	1955	2040
5/01/2010	Myuna Pool	Heathcote Ck	312904	6222245	1943	2045
6/01/2010	Friarbird Pool	Woronora River	311495	6224170	1945	2045
7/01/2010	Mirang Pool	Heathcote Ck	314382	6225854	1945	2045
13/01/2010	Upstream from Uloola Falls	Uloola Brook	318927	6223915	1945	2045
28/01/2010	Banya Pool	Heathcote Ck	315124	6227303	1955	2100
28/01/2010	Goburra Pool	Heathcote Ck	315078	6226991	2000	2050
8/02/2010	Weir upstream McKell Ave	Hacking R	318148	6218991	1950	2035
9/02/2010	Upstream from Palm Gully	Hacking R	317284	6216979	1950	2025
10/02/2010	Upstream from Lady Carrington Drive	Bola Ck	318495	6220101	2005	2030
11/02/2010	Downstream from Wallumarra Tk	Bola Ck	318471	6220029	2000	2035
11/02/2010	Upstream from Wallumarra Tk	Bola Ck	318452	6219649	2000	2035
16/02/2010	Downstream from Wallumarra Tk	Bola Ck	318471	6220029	2005	2040
16/02/2010	Downstream from Picnic Area	Bola Ck	318334	6220217	2005	2040
25/02/2010	Opposite boatshed, Audley	Hacking R	320528	6227695	1935	2020
7/03/2010	Upstream from Coast Tk	Curracurrong Ck	324569	6219267	1815	1930
22/03/2010	Pump House adjacent to car park	Coote Ck	325947	6220829	1850	1925
29/03/2010	Lake Eckersley	Woronora River	313164	6225106	1845	1930
15/05/10	Jersey Springs	Hacking River	319957	6225005	1645	1800
14/05/10	Kookaburra Flat	Hacking River	320578	6226639	1640	1750
21/05/10	Upstream of Platypus Brook	Kangaroo Creek	320111	6227770	1700	1745

Infra-red Camera Trapping

Target Species: Dusky Antechinus, Spotted-tailed Quoll, Parma Wallaby, Red-necked Pademelon, Platypus, Water Rat, King Quail, Eastern Ground Parrot, Lewin's Rail, Spotless Crake and Eastern Bristlebird (depending on location).

Technique: The potential presence of these species was investigated by the deployment of camera traps in areas of potential habitat and the collection and analysis of predator scats (see below). Single camera traps were deployed at seventeen locations (site locations entered into BSS of the Atlas of NSW Wildlife). The camera traps (Moultrie Model 160 Digital Game Camera) were attached to saplings or small trees and aimed at a bait station positioned approximately two metres from the camera and

Remote sedgeland near Shrapnel Hill - prime potential habitat for the Eastern Ground Parrot © M. Schulz/DECCW

baited with peanut butter, rolled oats, honey and walnuts. At the end of the period the cameras were collected, the memory cards downloaded and all species that had tripped the camera were identified.

Targeted Nocturnal Call Playback

Target Species: Barking Owl

Technique: Potential habitat for the Barking Owl was selected in the field. At each location after dusk, an observer first listened for five minutes for calls and searched with a spotlight. A pre-recorded compact disc of the Barking Owl call was then broadcast, amplified with a megaphone, for five minutes, followed by a final listening period. After the census the response or presence of any fauna was recorded, together with weather details. Censuses were undertaken in summer. In contrast to the majority of the targeted surveys, the targeted Barking Owl nocturnal call playback technique has the ability to be entered into the BSS of the Atlas of NSW Wildlife, which has been done. Hence the exact location details are not replicated here. In summary, this technique was undertaken at six locations in the following areas: Loftus Heights, Heathcote Heights and Kangaroo Creek in Royal NP and just north of Bondel Rocks in Heathcote NP.

Active Searching of Caves, Tunnels, Overhangs and Culverts

Target Species: Large-eared Pied Bat, Large-footed Myotis, Eastern Bentwing-bat, Little Bentwing-bat and Eastern Horseshoe Bat.

Technique: Various DECCW staff, naturalists and other park users were interviewed about the known or potential location of caves and human-made structures suitable for cave-roosting bats. All caves, overhangs and tunnels identified or encountered during the survey were thoroughly searched with a head torch for cave-roosting bats. Some culverts and bridges of major public roads within the survey area were also investigated for the presence of roosting bats. Additionally, the Otford-Stanwell Park abandoned railway tunnel was visited as sections of this tunnel pass under the survey area. All caves, overhangs and tunnels surveyed were also checked for reptiles, roosting owls and other fauna.

Active Searches of Yellow-throated Scrubwren Nests

Target Species: Golden-tipped Bat.

Technique: The Golden-tipped Bat is known to roost in Yellow-throated Scrubwren nests. Thus, in addition to the extra harp trapping that was undertaken to target the Golden-tipped Bat, all suspended nests of the Yellow-throated Scrubwren that were encountered were checked for the distinctive entrance made by this bat in the base of the nest structure.

Active Searching by Extended Spotlighting in Tall Forest

Target Species: Greater Glider.

Technique: Spotlight searches on foot were undertaken in addition to those conducted within the systematic survey sites to search for the Greater Glider in previously occupied or potentially suitable habitat between January and March 2010. Such searches included: spotlighting the whole of the Forest Island Circuit; spotlighting Lady Carrington Drive between Murrindum Brook south and the junction with Sir Bertram Stevens Drive; spotlighting sections of Lady Wakehurst Drive between Karingal and McKell Drive; spotlighting sections of Sir Bertram Stevens Drive between the junction of Lady Carrington Drive and Upper Toonoum Falls; spotlighting river flats at Audley and the Couranga Track between McKell Drive and where the track starts heading upslope into poorer quality sandstone forest; and spotlighting along the southern escarpment (e.g. Cliff and Werrong Tracks).

Active Searching in Mangroves

Target Species: Mangrove Gerygone.

Technique: In addition to bird counts within the three systematic mangrove sites, all larger mangrove patches in the survey area were checked for calling individuals from the water by kayak at high tide in July and October 2009 and April 2010.

Unsuccessful targeted searches were undertaken for the Wallum Froglet in the Jibbon Head/Bundeena area. Photo © M. Schulz

Active Searching for Traces of Rusa Deer

Target Species: Rusa Deer

Technique: A minimum of 30 minutes was spent scanning for indirect signs in the form of tracks, scats, pads and browse marks in all systematic survey sites while undertaking other daytime systematic survey techniques, especially during the site description and diurnal herpetofauna search techniques.

Amphibian Listening Surveys in Areas of Suitable Habitat

Target Species: Wallum Froglet, Brown Toadlet and Littlejohn's Tree frog

Technique: The potential presence of these species was investigated by: a) Brown Toadlet - undertaking listening surveys in the Goarra Ridge area after prolonged rain events in late autumn at two localities where the species had previously been recorded with a spatial accuracy of 100m or less (AMG 56-318003/6226523 and 317800/6228200) and in the Bottle Forest area; b) Wallum Froglet – undertaking 10 listening surveys in winter 2009 and five listening surveys in autumn 2010 in coastal wetlands and seepages in deep sand at 11 sites in the Bundeena-Jibbon Head-Jibbon Lagoon and Marley Lagoon-Dunes areas (Table 8); c) Littlejohn's Tree Frog – targeted searches were undertaken in spring for calling individuals in wetlands in Heathcote NP.

Table 8: Location of listening surveys for the Wallum Froglet.

Description of location	Easting	Northing
Soak east of Jibbon Fire Trail	330842	6226469
Soak on Jibbon Head north of Jibbon Beach	330599	6227417
Sedgeland in Jibbon Lagoon	330346	6226973
Sedgeland in lagoon south of Jibbon Lagoon	330557	6226635
Yarmouth Swamp	328655	6226261
Bundeena Gully	329358	6226234
Bonnie Vale Lagoon	328403	6226837
Sedgeland on east edge of Cabbage Tree Basin	327425	6226334
Sedgeland at Marley Lagoon outlet	328733	6223312
Ephemeral wetland in Marley Beach dunes	328464	6223501
Marley Lagoon	328254	6223539

Tadpole Surveys in Areas of Suitable Habitat

Target Species: Stuttering Frog, Littlejohn's Tree Frog, Green and Golden Bell Frog

Technique: a) Stuttering Frog – tadpole searches in rainforest and wet sclerophyll forest streamlines in spring and summer at 19 systematic survey sites in the Hacking River valley including Cawleys Creek where this species was last recorded; b) Littlejohn's Tree Frog – tadpole searches in wetlands and pools in headwater streams across the survey area in late spring, summer and autumn; c) Green and Golden Bell Frog – tadpole searches at Jibbon and Marley Lagoons after heavy spring/early summer rain.

Survey of Flowering Swamp Mahogany

Target Species: Little Lorikeet, Swift Parrot and Regent Honeyeater.

Technique: Flowering stands of Swamp Mahogany in the Bundeena area were visited on a number of occasions during the autumn flowering period with the view to locating these target species.

Scanning of the Ocean and Port Hacking Shoreline

Target Species: Osprey, Pied Oystercatcher, Sooty Oystercatcher, Peregrine Falcon, migratory shorebirds, Water Rat, Platypus.

Technique: Ocean and Port Hacking shoreline areas, including beaches and intertidal rock platforms were routinely scanned for birds, including a variety of potentially occurring shorebird species. This was

done in all seasons. In addition, the Port Hacking shoreline and associated estuaries were searched by kayak for presence and signs of Water Rat and Platypus (including burrows, tracks or in the case of Water Rat the chewed remains of molluscs, yabbies and other food items that get deposited on flat rocks, stumps or logs (Triggs 2001)).

Survey for Winter Bird Migrants

The systematic diurnal bird surveys of the current project were all undertaken in spring and summer, meaning that winter migrants would not be detected by this method. In order to address this gap, birds were surveyed on an opportunistic basis in autumn and early winter 2010.

2.4.5 Opportunistic techniques

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

Collection of Predator Scats and Pellets and other Animal Remains or Traces

The large numbers of hairs, and occasionally skeletal remains, in predator scats and pellets results in a high level of confidence in identifications of prey species and is hence an efficient sampling technique for prey animals. In addition, the recording of predator or non-predator scats constitutes records for the species that deposits the scat, providing locality records for species such as the Spotted-tailed Quoll, Fox and Dog. Due to the unknown time delay between prey ingestion and defecation, the location in which the prey animals lived cannot be accurately determined, so this technique is useful only for detecting the species presence within a general area. Lunney *et al.* (2002) showed that on average Dogs and Foxes defecate within a 2km radius of the site of prey ingestion. In addition to predator scats, clumps of hair, skeletal remains or herbivore scats that could not be identified in the field were collected for later analysis.

One hundred and four predator scats were collected, placed in paper envelopes, labelled and sent to specialist Barbara Triggs for analysis. Hair samples were identified using the techniques described by Brunner and Coman (1974). Identifications were classified into three levels of reliability: definite, probable and possible.

Careful Scanning of Roads While Driving at Night

As the primary surveyor for the current project (Martin Schulz) lived in Royal NP during the surveys, hundreds of kilometres of night driving was undertaken during the survey period. This may have involved simply driving home at night from a survey site or driving a longer way between survey sites. Whenever night driving was undertaken, and particularly after prolonged rain or on warm and humid nights, care was taken to scan the road and road verges for animals. In some cases, driving was undertaken with particular species in mind, (such as Giant Burrowing Frog or Red-crowned Toadlet). The date, time, observer, map grid location (usually obtained from a GPS) and microhabitat of any vertebrate animals detected were recorded on an opportunistic survey data sheet.

Traverses

Some extra traverses were undertaken to provide additional incidental records. These included: the length of the Woronora River; Woronora Ridge; various ridgelines in western sections of Royal NP; around Marley Lagoon; on the fringes of mangrove and saltmarsh areas such as on the eastern side of Cabbage Tree Basin, around the entrances of Muddy Creek and in sections of South West Arm.

Incidental Records

Incidental records are point localities of fauna encountered opportunistically during the survey. This mode of recording 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 were recorded on a data sheet.

2.4.6 Survey timing

Field surveys for the current project were undertaken between 27 July 2009 and 16 June 2010. Table 9 summarises the timing of survey techniques and approaches used over this period.

Table 9: Timing of current surveys within Royal and Heathcote National Parks and Garawarra SCA.

Timing	Systematic techniques employed	Targeted techniques employed
27 July - 6 August 2009	Nil	Amphibian listening surveys for Wallum Froglet in the Jibbon Head/Jibbon Lagoon/Bundeena area, active searching in mangroves by kayak.
1 - 15 October 2009	Diurnal bird survey, nocturnal streamside search.	Amphibian listening surveys for spring-breeding species, tadpole surveys, active daytime searching in wet heath and sedgeland, active searching in mangroves by kayak.
17 December 2009 to 31 March 2010	Diurnal bird survey, diurnal herpetofauna search, harp trapping, bat ultrasonic call recording, site spotlighting, nocturnal streamside search, nocturnal call playback.	Riparian dusk watches, active daytime searching in wet heath and sedgeland, early evening call playback and passive listening in wet heath and sedgeland, active searches of caves, tunnels, overhangs and culverts.
12 April to 16 June 2010	Nil	Infra-red camera trapping, survey for winter bird migrants, survey of flowering Swamp Mahogany, riparian dusk watches, active daytime searching in wet heath and sedgeland, early evening call playback and passive listening in wet heath and sedgeland, amphibian listening surveys for Wallum Froglet, active searching in mangroves by kayak.

2.4.7 Survey limitations

At the completion of the systematic and targeted surveys it is considered that all vertebrate fauna groups have been systematically sampled to an adequate level to provide a baseline biodiversity assessment. The low systematic survey effort for frogs was a reflection of the dry, virtually rain-free period between mid-summer and late autumn.

2.5 Review of Patterns of Local Fauna Extinction, Loss and Decline

The review of all known information on fauna of the survey area included compilation of a list of species which were not recorded during the current survey or other recent surveys, but for which evidence exists of their previous occurrence in the reserves. This list includes species that have been documented historically as occurring within the survey area, as well as species that are considered highly likely to have once occurred based on the presence of suitable habitat and the proximity of reliable historic records in nearby areas.

Following compilation of the above list, an assessment of the previous and current status of each species was made in order to determine the likelihood of local extinction. For each species the following was done: the veracity of all historical records was assessed; a judgement of past and present habitat availability and suitability was made; the adequacy of survey effort in preferred habitats was assessed; local naturalists and experts on the species were consulted; and patterns of decline elsewhere in the region as well as current knowledge of the species ecology were considered. The *Threatened Species Conservation Act 1995* (*TSC Act*) considers species to be “presumed extinct in nature” if in the preceding 50 years the species cannot be located despite the searching of known and likely habitats. This definition is aimed at identifying extinction for a species across its entire range in NSW. For the current study, species that have not been recorded within the survey area within the last 50 years but are presumed to have once had established populations are called *locally extinct*. However, this study also aimed to highlight species which have been lost more recently from the survey area. That is, species which were known to occur in the past but have not been detected in recent years despite field survey. These latter species are called *species loss* in this report. For definition and lengthier discussion of these terms and the patterns of species loss and decline see Section 3.1.2, Section 4.2 and species profiles in Section 5.2.

3 METHODS USED TO ASSESS AND PRIORITISE SPECIES, HABITATS AND THREATS

3.1 SPECIES

With a large number of species present in the reserves two separate ranking processes were undertaken to help identify species that deserve additional 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.

3.1.1 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 survey area, as presented in Section 5. A priority species is any fauna species that meets one or more of the following criteria.

1. **Threatened species listed under the *TSC Act* and/or the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) that are listed as 'critically endangered', 'endangered' or 'vulnerable'.** This includes all species that currently occur, are known to have occurred in the past or for which there are unconfirmed or spatially inaccurate records. However, species not included are aviary escapees that do not occur naturally in the region (i.e. Major Mitchell's Cockatoo *Lophochroa leadbeateri*, Superb Parrot *Polytelis swainsonii*, Regent Parrot *P. anthopeplus* and the Budgerigar *Melopsittacus undulatus*) and pelagic species that are seen offshore or have been found beach-washed.
2. **Species that are declining regionally and for which the survey area provides important habitat for a large population compared with most other reserves within the Sydney Basin Bioregion**. Many native animals have declined in the bioregion, therefore species were only included in this category if, based on available data and expert opinion, their numbers or range have been greatly reduced and for which the survey area supports a large population. In particular this includes species with a restricted distribution across the region of which the area forms a significant part and poorly known species with a restricted and greatly declining habitat.
3. **Species that are recognised as pests. These species are introduced terrestrial vertebrates that have a significant negative impact on native species within the survey area, including species listed as Key Threatening Processes under the *TSC Act*.** Not all feral species are included, as some that are confined to urban or modified environments within the area do not have a large impact on native fauna.

3.1.2 Setting management ranking for native priority species

Land managers are faced with an ominous 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 survey area has been ranked into a class according to its level of priority for active conservation management within the reserves. The ranking system is derived from expert knowledge rather than quantitative assessment. It must be noted that, as priority species were defined to include all threatened species reported for the park, whether or not they were accurately recorded or currently exist, there are species classified as priority yet given a 'nil' conservation management priority ranking.

The rankings are defined as follows.

Highest

Highest ranked species are those that are likely to become extinct from the survey area in the short to medium term without action, and for which the survey area is likely to play a crucial role in the regional conservation of the species. These species require management at a site by site level.

High

Species ranked high are those that are at risk of becoming extinct from the region without active management of key habitats and abatement of threats. This category includes species which are rare in the survey area, or for which habitat is limited in extent, but for which the survey area is never-the-less important to regional conservation, as well as species that are better represented in the survey area than in other reserves in the region or species with an uncertain status in the survey area but with little prime habitat present in reserves within the region.

Moderate

Moderate species are those for which the survey area does not support a significant amount of habitat relative to that reserved elsewhere in the region OR species that utilise the area for foraging but are not known to roost/breed within it. Though management of these species is not currently the highest priority for the reserves, an increase of pressure on these species elsewhere in the region, or the delineation of key threats within the survey area, may require more active management in the future.

Low

Species ranked as low are those that currently either: a) occur in low numbers and are well-represented elsewhere in the regional reserve system; b) occur as irregular, rare or extremely rare visitors; or c) only occur as vagrants. These species do not require any specific management in the reserves at this stage, other than ongoing protection of important habitat features e.g. mature hollow-bearing trees.

Nil as Locally Extinct

Species that were accurately identified at the time of sighting but have not been recorded within the survey area for more than 50 years and are now considered locally extinct. If these species were to be rediscovered in the park they would require a reassessment of their status and would most likely be ranked as having *Highest* conservation management priority.

Nil as Suspected Species Loss

Species which have been accurately recorded in the past and are thought to have sustained local populations, yet have not been detected in recent years despite survey being undertaken for them. Local naturalists and park rangers have been consulted about the status of these species. Though it is possible that these species may be rediscovered in the survey area in the future, or occur as extremely rare visitors, at the current time these species are considered to not be established within the survey area and are regarded as species lost from the survey area.

Nil as Peripheral Species Loss

Species which have been accurately recorded in the past, yet probably only ever used the survey area as peripheral or marginal habitat. Loss or modification of higher quality habitat which once adjoined or was proximate to the survey area has resulted in local loss of these species. It is possible that these species may occur as extremely rare visitors in the future, but at the current time they are considered lost from the survey area.

Nil as Inaccurate Record

Species for which only unconfirmed sightings occur, or only have records that are likely to derive from mis-identifications or inaccurate entry into the Atlas of NSW Wildlife, or only have records with low spatial accuracy (e.g. 10km) that are likely to have occurred at known localities in nearby areas.

3.2 FAUNA HABITATS

3.2.1 Definition of fauna habitat groups

The gradient of environmental variables across the survey area leads to distinct changes in the vegetation communities present from east to west and hence variation in the types of fauna habitat available. Much of the fauna habitat is in the form of native vegetation communities. The vegetation communities have been subjectively lumped into broader 'habitat groups' and these are outlined below. Habitat groups bring together vegetation communities that are similar in vegetation structure, habitat features (such as rockiness and hydrology), and average annual rainfall. In addition to the native vegetation there are other unmapped habitat types, such as shorelines and picnic areas. Where appropriate these habitat types have also been allocated a 'habitat group' in this report.

These 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 the survey area 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 thus do not necessary 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 survey area.

The fauna habitat groups are summarised in Table 10 and are derived from groups of vegetation communities described in DECCW (2009). The fauna characteristics of each of the habitat groups have been described in a profile presented in Section 6.

Table 10: Summary of habitat groups and their relation to vegetation communities and statewide formations.

Habitat group	Vegetation community (DECCW 2009)	Statewide vegetation formation (Keith 2004)	Area (hectares) in survey area
Northern Warm Temperate and Subtropical Rainforest	Illawarra Escarpment Subtropical Rainforest	Rainforests	4.3
	Coastal Sandstone Gallery Rainforest		8.2
	Coastal Warm Temperate Rainforest		355.2
Littoral Rainforest	Coastal Escarpment Littoral Rainforest		0.4
	Coastal Headland Littoral Thicket		96.8
Riparian Scrub	Coastal Sandstone Riparian Scrub		152.8
North Coast Wet Sclerophyll Forest	Coastal Enriched Sandstone Moist Forest	Wet Sclerophyll Forests (shrubby subformation)	25.9
	Illawarra Escarpment Bangalay-Banksia Forest		449.1
	Illawarra Escarpment Blackbutt Forest		1653.5
Northern Hinterland Wet Sclerophyll Forest	Coastal Shale-Sandstone Forest	Wet Sclerophyll Forests (grassy subformation)	122.4
	Sydney Foreshores Shale Forest		38.9
	Sydney Turpentine-Ironbark Forest		10.8
Sydney Coastal Dry Sclerophyll Forest	Coastal Sandstone Exposed Scribbly Gum Woodland	Dry Sclerophyll Forests (shrubby subformation)	5426.8
	Coastal Sandstone Riparian Forest		6.5
	Coastal Sandstone Sheltered Peppermint-Apple Forest		5280.8
	Southern Sydney Sheltered Forest		448.2
	Sydney Ironstone Bloodwood-Silvertop Ash Forest		544.8
	Woronora Sandstone Exposed Bloodwood Woodland		7.1
	Woronora Sandstone Mallee-Heath Woodland		746.6
Dune and Alluvial Sclerophyll Forest	Coastal Alluvial Bangalay Forest	Dry Sclerophyll Forests (shrub-grass formation)	37.0
	Coastal Sand Apple-Bloodwood Forest		24.6

Habitat group	Vegetation community (DECCW 2009)	Statewide vegetation formation (Keith 2004)	Area (hectares) in survey area
	Coastal Sand Littoral Forest		12.5
	Coastal Sand Bangalay Forest		5.4
Coastal Headland Grassland	Coastal Headland Grassland	Grasslands	17.7
	Lomandra-dominated Headlands (not mapped)		Not mapped
Heathland	Coastal Tea-tree Banksia Scrub	Heathlands	20.1
	Coastal Sandplain Heath		151.6
	Coastal Headland Cliffline Scrub		125.4
	Coastal Sandstone Heath-Mallee		4539.0
	Hinterland Sandstone Dwarf Apple Heath-Woodland		1.2
Freshwater Wetland	Coastal Upland Damp Heath Swamp	Freshwater Wetlands	0.6
	Coastal Upland Wet Heath Swamp		222.1
	Coastal Sand Swamp Sedgeland		Not mapped
	Coastal Freshwater Reedland		Not mapped
Forested Wetland	Coastal Flats Swamp Mahogany Forest	Forested Wetlands	1.5
	Hinterland Riverflat Paperbark Swamp Forest		5.0
	Estuarine Swamp Oak Forest		3.2
Saline Wetland	Estuarine Mangrove Forest	Saline Wetlands	20.3
	Estuarine Saltmarsh		12.3
Shoreline	Beach Spinifex Grassland	N/A	45.7
Deep Freshwater Habitats	Not Described	N/A	Not mapped
Parklands and other modified lands	Weeds and Exotics	N/A	19.5
	Urban Exotic/Native	N/A	27.9
	Other modified parkland areas	N/A	Not mapped

Northern Warm Temperate and Subtropical Rainforest

This habitat group describes three closed forest communities (or rainforests) comprising less than 10 per cent of the survey area. The warm temperate rainforests are characterised by the canopy being dominated by Coachwood (*Ceratopetalum apetalum*) and emergent species may include Blackbutt (*Eucalyptus pilularis*), Sydney Peppermint (*E. piperita*), Sydney Blue Gum (*E. saligna*) and Turpentine (*Syncarpia glomulifera* subsp. *glomulifera*). Subtropical influenced rainforest is very limited in extent comprising less than five hectares and is restricted to small patches in the Hacking River valley, such as in the Cedar Loop Track area. This rainforest includes a variety of canopy trees including Red Cedar (*Toona ciliata*), Giant Stinging Tree (*Dendrocnide excelsa*), figs (*Ficus* spp.), Coachwood and Laurels (*Cryptocarya* spp.) often without eucalypt emergents.

Littoral Rainforest

This habitat group describes two different types of littoral rainforest communities that together cover less than one per cent of the survey area. Coastal Headland Littoral Thicket occurs on headlands, slopes and gullies along the Royal NP coastline, particularly south of Garie Beach (Map 2). It is characterised by a low, dense canopy of Lilly Pilly (*Acmena smithii*), Red Olive (*Elaeodendron australe* var. *australe)*, Guioa (*Guioa semiglauca*), figs and stands of the Cabbage Tree Palm (*Livistonia australis*). A small patch of a second type of littoral rainforest, Coastal Escarpment Littoral Rainforest (RF07), occurs along a drainage line south of Bonnie Vale comprising less then one hectare. This rainforest is dominated by Lilly Pilly and Cabbage Tree Palm, with occasional emergents, primarily Smooth-barked Apple (*Angophora costata*) and Turpentine.

Riparian Scrub

This habitat group comprises a single vegetation community associated with sandstone stream and creek banks. It is typified by a low scrub, characterised by Water Gums (*Tristaniopsis laurina* and *Tristania neriifolia*), often in combination with wattles, hakeas, grevilleas, tea-trees and casuarinas. It is narrow in places on small streams expanding to wide bands along stream channels and is often interspersed by rock pools, rock pavements and open sandy banks. It occurs in a zone of occasional flooding. It is more commonly found inland such as in Heathcote NP. It is not always identified in maps given its small and patchy distribution.

North Coast Wet Sclerophyll Forest

The north coast wet sclerophyll forests are a diverse assemblage of tall to very tall eucalypt forests which vary with soil fertility, terrain and elevation but typically have rainforest shrubs and vines present (Keith 2004). This habitat group includes three vegetation communities and comprises 10 per cent of the survey area (Map 2). In the survey area these communities are closely associated with shale rich soils of the Narrabeen group within the Hacking River Valley. The canopy is typically dominated by Blackbutt (*Eucalyptus pilularis*), Turpentine, Bangalay (*Eucalyptus botryoides*) and Smooth-barked Apple.

Northern Hinterland Wet Sclerophyll Forest

This habitat group describes wet sclerophyll forests found in less sheltered areas and are characterised by a much lower frequency of mesic shrubs often resulting in a prominent grassy ground cover (Keith 2004). Three vegetation communities were used to define this habitat group. It occupies less than one per cent of the survey area. These eucalypt forests are generally taller than the surrounding sandstone woodlands and feature Bloodwood (*Corymbia gummifera*), Smooth-barked Apple and patches of Blackbutt with an open layer of dry shrubs and a diverse combination of grasses, rushes and herbs providing a continuous ground cover. Dense patches of Spiny-headed Mat-rush (*Lomandra longifolia*) are relatively common.

Sydney Coastal Dry Sclerophyll Forest

This habitat group is by far the most extensive in the reserves. It encompasses a wide range of open forest and woodland communities dominated by eucalypts and dry shrub and heath species. There is considerable variation in vegetation structure depending on topography and soil moisture (Keith 2004) with sheltered sites supporting taller trees and exposed and rocky sites including lower growing mallee and stunted eucalypts. Seven vegetation communities identified by DECCW (2009) were combined and together they cover over 60 per cent of the survey area (see Table 10 and Map 2). Typical eucalypts include Red Bloodwood, Scribbly Gum (*E. haemastoma*/*racemosa*), Silvertop Ash (*Eucalyptus sieberi*) on ridgetops and Sydney Peppermint (*Eucalyptus piperita*) and Smooth-barked Apple on sheltered slopes. Yellow-top Ash (*Eucalyptus luehmanniana*), a tall mallee, occurs on skeletal soils on exposed ridges

Dune and Alluvial Sclerophyll Forest

This habitat group describes coastal eucalypt forests of moderate height associated with sand dunes and sandy alluvium near the coastline. It combines four vegetation communities that occupy less than one per cent of the survey area. These forests have a mix of dry sclerophyll shrubs and a minor component of mesic shrubs found within the littoral zone. Tree species include Bangalay and Swamp Mahogany (*Eucalyptus robusta*) on low lying sites and Smooth-barked Apple, Red Bloodwood and Saw Banksia (*Banksia serrata*) on dune crests.

Coastal Headland Grassland

This group describes a treeless habitat dominated by a dense ground cover of Spiny-headed Mat-rush with patches of Kangaroo Grass (*Themeda australis*). Widely scattered shrubs include Coast Banksia (*Banksia integrifolia*), Coast Beard-heath (*Leucopogon parviflorus*) and Coast Rosemary (*Westringia fruticosa*). It is found on exposed headlands with shale influenced soils. Some areas are likely to be a

result of past clearing, such as on the northern edge of Stanwell Park and in the Bulgo area. It covers less than one per cent of the survey area.

Heathland

Heathland is a widespread habitat group growing on nutrient-poor soils that are characterised by dense stands of low growing shrub and heath species. Low growing eucalypts are sparse to absent. Within the survey area, five heathland vegetation communities identified by DECCW (2009) were combined and together cover around 23 per cent of the survey area (see Table 10 and Map 2). Heaths on old sand dunes feature Scrub She-oak (*Allocasuarina distyla*), Saw Banksia and Coastal Tea-tree. Dunes of a younger age situated to the coastal zone are dominated by Coastal Tea-tree and Coastal Banksia. In contrast heath on Hawkesbury sandstone features dense stands of Heath-leaf Banksia (*Banksia ericifolia*) sometimes with dense clusters of Dwarf Apple (*Angophora hispida*). Hawkesbury Sandstone Headlands support another heath community dominated by Bracelet Honey-myrtle (*Melaleuca armillaris*), Scrub She-oak, Heath-leaved Banksia, Coastal Rosemary and Heath-myrtle (*Baeckea imbricata*). There are frequently extensive open rock plate areas free of vegetation, some of which retain water after rain.

Freshwater Wetland

This habitat group combines four vegetation communities found on poorly drained soils subject to periodic freshwater inundation. Many sites support only a sparse cover of woody vegetation and are more commonly characterised by reeds, rushes and sedges. Some sites include standing water such as lagoons at Marley and Jibbon. The group also includes heath swamps found on impeded sandstone soils and these have a far greater cover of woody plants including Needlebush (*Hakea teretifolia*) and Swamp Banksia (*Banksia robur*). This habitat group covers just over one per cent of the survey area.

Forested Wetland

Forested wetland is a habitat group that includes three vegetation communities associated with alluvial soils that are occasionally subject to flooding. They typically form an open forest dominated by tree species that can tolerate waterlogged soils including eucalypts, paperbarks (*Melaleuca linariifolia*) and Swamp Oak (*Casuarina glauca*). The understorey can include a sparse cover of mesic shrubs above a ground cover of sedges, grasses, moisture loving herbs and rushes. The habitat comprises less than one per cent of the survey area. It is important to note that patches of this habitat group within the survey area do not actually support stands of Swamp Mahogany.

Saline Wetland

The Saline Wetlands habitat group comprises two vegetation communities that occupy the intertidal zone along the Hacking River shoreline. A low closed forest of Grey Mangrove (*Avicennia marina*) occurs on the mudflats with saltmarsh herbfields found on the inland margins. Saltmarshes are typified by species such as Creeping Brookweed (*Samolus repens*) and Glasswort (*Sarcocornia quinqueflora*) and areas of rushes, such as Sea Rush (*Juncus kraussii*) and *Sporobolus virginicus.* This habitat group occupies less than one per cent of the survey area.

Shoreline

This habitat group combines both physical landscape features such as the rocky shoreline, intertidal platforms and beaches, open mudflats and harbour clifflines with beach spinifex found on beach strands. Few of these features are mapped (DECCW 2009) however they comprise a source of important habitat for fauna. This habitat type is narrowly distributed and occupies less than one per cent of the reserves.

Deep Freshwater Habitats

This habitat group is confined to open waterbodies, such as the lower non-tidal reaches of the Hacking River and artificial water storages such as Engadine Waterhole. This habitat group has not been included within the vegetation mapping of DECCW (2009) as it is primarily non-vegetated although some amphibious, emergent and floating plant species may be present and various reeds and sedges may line the banks. However, it has been included in this report as it supports a habitat with a distinct faunal assemblage.

Parkland and Other Modified Habitats

This habitat group encompasses mown parkland with or without some native tree cover such as along the Hacking River at Audley and in various high use picnic areas such as at Wattamolla. Additionally, it includes buildings and associated gardens within the area. This habitat group is not comprehensively mapped but includes the Weeds and Exotics map unit and covers less than one per cent of the survey area.

3.2.2 Assessing the relative conservation significance of fauna habitats

Fauna habitats vary widely in their number of threatened fauna, local and regional spatial extent and level of threat posed on and off reserve. In order to gain an understanding of the role played by each fauna habitat group in the conservation of vertebrate fauna within the survey area and within the region an assessment was made that considered: the number of high and moderate priority fauna species that depend on each habitat group; the extent and level of threat of each habitat group in the reserves and the region; whether the habitat had previously been identified as high priority in the Greater Southern Sydney Region (DECC 2007b) and/or the Sydney Metropolitan CMA area (DECC 2008a). Based on this assessment the contribution that each habitat group makes to the conservation of fauna values in the reserves is discussed.

3.3 THREATS TO FAUNA

3.3.1 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 to these values. This project aimed to identify the threats currently acting on fauna in the survey area, 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 current 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.

3.3.2 Setting priorities for threats

To enable management to be targeted towards threats that pose the greatest risk to native fauna in the survey area, 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 High or Moderate Priority fauna species. Note that no Highest Conservation Priority species were identified. Low Conservation Priority Species were not considered here since they currently occur within the survey area either: a) in low numbers and are well represented elsewhere within the region; b) as irregular, rare or extremely rare visitors; or c) as vagrants. Such species do not require any specific management in the reserves at this stage, other than ongoing protection of important habitat features, such as mature hollow-bearing trees.

Key current threats are prioritised as follows.

Very High: Known or potentially impacting half or more than half of the High and Moderate Priority fauna species.

High: Known or potentially impacting more than three High or Moderate priority fauna species.

Moderate: Known or potentially impacting three or less High or Moderate priority fauna species.

Other Current Threats

Threats that currently have the potential to impact on fauna species not identified as High or Moderate priority species.

Future Threats

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

4 THE SPECIES INVENTORY

4.1 DOUBTFUL, UNCONFIRMED, NOT ESTABLISHED OR SPATIALLY INACCURATE SPECIES RECORDS

In order to make the inventory provided in this report as accurate as possible, species that are only represented by records with high spatial inaccuracy, by unconfirmed sightings, probable mis-identifications or database errors, as well as introduced and non-local species that do not have established wild populations within the survey area have been removed. This includes a large number of waterbird and shorebird species for which spatially inaccurate records exist but that have not been confirmed to occur within the survey area (e.g. Anyon-Smith 2006). Table 11 presents all such species and the reason they have been omitted from the inventories provided in the Appendices of this report.

Table 11: Doubtful, unconfirmed or spatially inaccurate species recorded or non-local species that do not have established wild populations within the survey area.

Common Name	Scientific Name	Reason for omission from species inventory
Rocket Frog	*Litoria nasuta*	Outside generally accepted range (e.g. Griffiths 2006); single record with accuracy ±10,000m.
Robust Ctenotus	*Ctenotus robustus*	Two records from the South West Arm Creek area of Royal NP in 1967 with a spatial accuracy ±10,000m were likely to have been from the Kurnell Peninsula to the north or mis-identifications for the Eastern Water-skink which is common in this area.
Southern Water-skink	*Eulamprus tympanum*	Only one record with a very low spatial accuracy of ten kilometres from the abandoned Grey Mare Gold Mine east of Wises Track in March 1974 is likely to have been a mis-identification of the Eastern Water-skink which is common in this area.
California Quail	*Callipepla californica*	Introduced species. Released into Royal NP in 1883, with no subsequent records (Hoskin *et al*. 1991).
King Quail	*Excalfactoria chinensis*	Single record in Atlas of NSW Wildlife and other reported sightings from Royal NP are considered unconfirmed. Not recorded during current survey despite targeted survey effort.
Indian Peafowl	*Pavo cristatus*	Introduced species. Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy.
Common Pheasant	*Phasianus colchicus*	Introduced species. Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy, with several records in the 1970s (Hoskin *et al.* 1991). There have been no subsequent records, with no feral populations present in the region.
Golden Pheasant	*Chrysolophus pictus*	Introduced species. The only record is of a dead female bird found in Royal NP in 1981 (Hoskin *et al.* 1991). As there are no feral populations within the region this must have been an aviary escapee.
Mute Swan	*Cygnus olor*	Introduced species, with a breeding record and one bird that frequented the Hacking River at Audley between 1950 and 1956 (Hoskin *et al*. 1991). Not recorded since.
Collared Dove	*Streptopelia decaocto*	Introduced species, recorded as being present prior to the 1994 wildfire Andrew (2001) but does not currently have an established population.
Glossy Ibis	*Plegadis falcinellus*	Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy. Not recorded in the survey area (Anyon-Smith 2006); likely to be from wetlands on the Kurnell Peninsula.

Common Name	Scientific Name	Reason for omission from species inventory
Red Goshawk	*Erythrotriorchis radiatus*	A single Atlas record which must be regarded as unconfirmed since there is only one confirmed record from the region; of two specimens collected 'near Sydney' soon after European settlement (Marchant and Higgins 1993). No confirmed sightings have been recorded subsequently (Hoskin *et al.* 1991).
Grey Falcon	*Falco hypoleucos*	Two Atlas records which must be regarded as unconfirmed since this bird is a vagrant east of the Great Dividing Range (Marchant and Higgins 1993), with most sightings in the region confused with the Grey Goshawk.
Grey Plover	*Pluvialis squatarola*	Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy. Not recorded by Anyon-Smith (2006) in the survey area; the record is likely to be from wetlands or shoreline areas on the Kurnell Peninsula.
Lesser Sand-plover	*Charadrius mongolus*	As for the Grey Plover.
Red-kneed Dotterel	*Erythrogonys cinctus*	As for the Glossy Ibis.
Australian Painted Snipe	*Rostratula australis*	As for the Glossy Ibis.
Black-tailed Godwit	*Limosa limosa*	As for the Grey Plover, with one unconfirmed record from Bonnie Vale in November 1998 in the Atlas.
Terek Sandpiper	*Xenus cinereus*	As for the Grey Plover.
Common Greenshank	*Tringa nebularia*	As for the Grey Plover.
Marsh Sandpiper	*Tringa stagnatilis*	As for the Grey Plover.
Great Knot	*Calidris tenuirostris*	As for the Grey Plover.
Red Knot	*Calidris canutus*	As for the Grey Plover.
Red-necked Stint	*Calidris ruficollis*	As for the Grey Plover.
Pectoral Sandpiper	*Calidris melanotus*	As for the Grey Plover.
Curlew Sandpiper	*Calidris ferruginea*	As for the Grey Plover.
Broad-billed Sandpiper	*Limicola falcinellus*	As for the Grey Plover.
Oriental Pratincole	*Glareola maldivarum*	A single Atlas record which must be regarded as unconfirmed since this bird is a vagrant to NSW (Higgins and Davies 1996).
Gull-billed Tern	*Gelochelidon nilotica*	As for the Grey Plover.
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*	Aviary escapee.
Cockatiel	*Nymphicus hollandicus*	Aviary escapee.
Superb Parrot	*Polytelis swainsonii*	Aviary escapee.
Regent Parrot	*Polytelis anthopeplus*	Aviary escapee.
Green Rosella	*Platycercus caledonicus*	Aviary escapee.

Common Name	Scientific Name	Reason for omission from species inventory
Pale-headed (White-cheeked) Rosella	*Platycercus adscitus*	Aviary escapee.
Australian Ringneck	*Barnardius zonarius*	Aviary escapee.
Mallee Ringneck	*Barnardius zonarius barnardi*	Aviary escapee.
Budgerigar	*Melopsittacus undulatus*	Aviary escapee.
Peach-faced Lovebird	*Agapornis roseicollis*	The only record is of a pair of birds in the Maianbar area (Hoskin *et al.* 1991). These birds are likely to have been aviary escapees with no known feral populations present in the region.
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	Not recorded by Anyon-Smith (2006) or in the Atlas. Unconfirmed record in the 2001 Platypus survey by Curtis (2001).
Splendid Fairy-wren	*Malurus splendens*	Assumed error (i.e. from data entry) in the Atlas as this species is not known from east of the Great Dividing Range (Higgins *et al.* 2001).
Striated Fieldwren	*Calamanthus fuliginosus*	Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy. No recent records from the Sydney region (Higgins and Peter 2002) and not recorded in the area (Anyon-Smith 2006).
Weebill	*Smicrornis brevirostris*	Not recorded by Anyon-Smith (2006) in the survey area. An unconfirmed record from the Karloo Pools area in Heathcote NP in December 2000 in the Atlas.
White-fronted Chat	*Epthianura albifrons*	Not recorded by Anyon-Smith (2006). Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy; likely to be from wetlands or shoreline areas on the Kurnell Peninsula. One unconfirmed record from the Palona Picnic Area in February 1991 in the Atlas. The densely forested habitat in this area is highly unusual for this open-space species, therefore it is assumed this record is an error or mis-identification.
White-browed Babbler	*Pomatostomus superciliosus*	Not recorded by Anyon-Smith (2006); one unconfirmed record in unlikely habitat from Bundeena Drive in July 1983 in the Atlas.
Hooded Robin	*Melanodryas cucullata*	An old record from ‘Port Hacking” may have come from the survey area. No records in Anyon-Smith (2006), the Atlas or in the current survey.
Eurasian Skylark	*Alauda arvensis*	Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy; likely to be from the Kurnell Peninsula.
Nutmeg Mannikin	*Lonchura punctulata*	Recorded only during Atlas of Australian Birds 1 at very low spatial accuracy; likely to be from wetlands or scrub areas on the Kurnell Peninsula.
European Goldfinch	*Carduelis carduelis*	Introduced species, recorded being present prior to the 1994 wildfire Andrew (2001), but does not currently have an established population.

Common Name	Scientific Name	Reason for omission from species inventory
Muscovy Duck	*Cairina moschata*	Not recognised as a truly feral species in Australia, with no known wild breeding populations (Christidis and Boles 2008). Individuals seen at Audley and elsewhere are likely to have been dumped by members of the public within the area.
Yellow-footed Antechinus	*Antechinus flavipes*	Not recorded in broad-scale trapping surveys across the area by Andrew (2001); one unconfirmed old record (May 1927) from the Jibbon area in Royal NP in the Atlas. Within the region this species primarily occurs in grassy woodland so this record from heathland habitat seems unlikely and may either be a mis-identification or an incorrect labelling.
Yellow-bellied Glider	*Petaurus australis*	Anecdotal records by Robinson (1988) are considered unconfirmed and require confirmation due to the absence of this species from the Woronora Plateau (DECC 2007c).
Squirrel Glider	*Petaurus norfolcensis*	One record by Robinson (1988) requires confirmation due to the lack of records from the surrounding area (e.g. DECCW 2010a, DECC 2007c).
Short-eared Possum	*Trichosurus caninus*	Recently the Mountain Brushtail Possum was split into two taxa with the survey area being included in the range of the southern form *T. cunninghami* extending from the Sydney area south to Victoria (Lindenmayer *et al*. 2002). The other form, the Short-eared Possum (*Trichosurus caninus*) occurs from the Newcastle area north to south-eastern Queensland. Many records from the survey area within the Atlas are of *T. caninus* before the taxonomic split and should now be referred to as *T. cunninghami*.
Red-necked Wallaby	*Macropus rufogriseus*	No recent records (e.g. Andrew 2001); recent unconfirmed sightings in the Cedar Flat area of Royal NP (B. Sullivan, DECCW, pers. comm.).
Little Freetail-bat	*Mormopterus loriae*	Although there is a record from the survey area in the Atlas of NSW Wildlife, this species is not known from New South Wales (e.g. Parnaby 1992a, van Dyck and Strahan 2008).
East-coast Freetail-bat	*Mormopterus norfolkensis*	No confirmed identifications from within the survey area (e.g. Parnaby 1991), although recorded in adjacent areas (e.g. DECCW 2010a).
Golden-tipped Bat	*Kerivoula papuensis*	Unconfirmed records by ultrasonic call identification in the Atlas in the Helensburgh area on the boundary of the reserves. This species has low call amplitude and therefore can typically be detected at a range of less than 5m and any calls recorded tend to be fragmentary and of poor quality (Schulz 1999). Additionally, calls can be readily confused with the call signals of the Large-footed Myotis and long-eared bats (*Nyctophilus* spp.) (Reinhold *et al*. 2001, Pennay *et al.* 2004), both of which are known to occur in the area.
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	All records within the survey area are from echolocation calls, with none being trapped despite extensive harp trapping occurring. The ultrasonic signals of this bat are readily confused with the Greater Broad-nosed Bat and the Eastern Broad-nosed Bat (Reinhold *et al*. 2001, Pennay *et al.* 2004). Therefore, due to the absence of trapped individuals, the presence of this species within the survey area and elsewhere within coastal areas of the Sydney Basin Bioregion are regarded as unconfirmed (DECC 2007c).

Common Name	Scientific Name	Reason for omission from species inventory
Feral Sheep	*Ovis aries*	This species was either entered incorrectly into the Atlas of NSW Wildlife or scats found along the Sydney Water Pipeline adjacent to Heathcote Road were misidentified since these droppings are far more likely to have originated from the Rusa Deer which occurs in small numbers in this section of Heathcote NP.
Feral Goat	*Capra hircus*	Individuals are infrequently recorded and the few records originate either from dumped individuals or wandering animals from nearby farms. No evidence of an established population.
Red Deer	*Cervus elaphus*	Red Deer were placed in the Deer Park in 1886 and escaped into the bush (Trustees 1915). However, populations do not currently occur in the survey area and the species is only very patchily distributed in the Sydney region (DECC 2007c). The single record from 2001 for Bundeena in the Atlas is far more likely to be a mis-identification and should refer to the Rusa Deer which is commonly seen in this area.
Fallow Deer	*Dama dama*	Fallow Deer were placed in the Deer Park in 1885 (Trustees 1915). The species no longer occurs in the survey area, with the last records from the Red Cedar Flat area at least 15 years ago (B. Sullivan, DECCW, pers. comm.).

4.2 PATTERNS OF LOCAL FAUNA EXTINCTION, LOSS AND DECLINE

4.2.1 Fauna species losses and declines

The completion of the literature review, species review, habitat inventory and field survey components of the current study led to the derivation of two lists of species (in addition to the list of doubtful species records presented above): a) species which have reliable records for the survey area in the past or present and b) species that have never been formally documented in the survey area but given the presence of suitable habitat and the proximity of reliable historic records are considered likely to have occurred in the past or present. From these two lists and the results of recent field survey, interviews with local naturalists and expert knowledge were derived a list of species considered to once have occurred but now undergone severe decline or extinction. Species that have been lost or severely declined tend to fall into three classes, as follows.

1. Species that are thought to have once sustained local populations in the survey area that have been impacted within the area to such an extent that breeding and/or primary habitat use no longer occurs. Suitable habitat remains present for these species. These species are no longer observed except on the rare occasion where they visit from areas outside of the survey area. Where the species has not been confirmed in the survey area for more than 50 years they are called ***locally extinct*****.** Where the species has been recorded within the last 50 years but is considered to no longer have established resident populations today they are termed ***suspected species loss*****.** These species are presented in Table 12.

2. Species which may have used the survey area as peripheral or marginal habitat. Changes to the nature of this marginal habitat on the reserves, together with loss or modification of higher quality habitat which once adjoined or was proximate to the survey area has resulted in declines or local loss of species. Where the species have severely declined across the Sydney Basin Bioregion and/or are considered unlikely to return to the survey area except as extremely rare visitors they are termed ***peripheral species loss***. Where the species are considered to have the potential to return to the survey area either irregularly or in low numbers they are termed ***peripheral species decline*****.** These species are presented in Table 13.

3. Wide ranging and/or nomadic species, which are likely to have once made use of the habitats present in the survey area to varying extents, but have suffered severe impacts across their known range and hence are no longer recorded or are recorded far less frequently. Suitable habitat remains for these species. These are termed ***declining visitors***. These species are presented in Table 14.

The locally extinct, suspected species loss and peripheral species loss animals are not included in the inventory tallies provided in this report. The declining visitor species for which formal records exist for the survey area have been retained within the inventories provided in this report as the species may continue to utilise the reserves to some extent in the future. However the declining visitor species for which no formal records exist have not been added to the current species inventories.

It must be noted that these lists are derived from an assessment of current knowledge and are not definitive. This list is most likely an underestimate as there is little documentation of mammal species present within the survey area at the time of first European settlement or of what waterbird and shorebird species occurred particularly in Port Hacking and associated wetlands.

In addition to the species presented in the tables, the following birds are thought to have declined within the survey area in recent years: Topknot Pigeon, Pilotbird, Rufous Fantail and the Black-faced Monarch (S. Anyon-Smith, pers. comm.).

The stunning Royal NP coastline. Photo © M. Schulz

Table 12: Species considered to have once sustained local populations in the survey area but no longer occur.

Common Name	Scientific Name	Notes on records and decline	Current status
Bush Stone-curlew	*Burhinus grallarius*	Last confirmed record in 1938. Close to extinction in the Sydney Basin Bioregion.	Locally extinct
Eastern Ground Parrot	*Pezoporus wallicus wallicus*	Last confirmed record in 1923 and absent from areas where they were known to have once occurred. A number of unconfirmed sightings in recent decades. Considered close to extinction in the Sydney Basin Bioregion, but recently rediscovered on the Woronora Plateau. May recolonise the survey area if this latter population increases, but at this time considered locally extinct.	Locally extinct
Eastern Bristlebird	*Dasyornis brachypterus*	No confirmed records but suitable habitat is present and species considered to have once occurred. Last closest record is from Mt Kembla in the 1960s.	Locally extinct
Regent Bowerbird	*Sericulus chrysocephalus*	Last reported in the 1920s.	Locally extinct
Parma Wallaby	*Macropus parma*	Common in parts of Royal NP on the mid 1920s. Last recorded sighting in Illawarra region was in 1969.	Locally extinct
Eastern Quoll	*Dasyurus viverrinus*	Was known from survey area but now presumed extinct from the entire Australian mainland (Jones 2008).	Locally extinct
Southern Brown Bandicoot	*Isoodon obesulus*	No formal records but suitable habitat is present and species considered likely to have once occurred.	Locally extinct
Long-nosed Potoroo	*Potorous tridactylus*	No formal records but suitable habitat is present and species considered likely to have once occurred.	Locally extinct
Green and Golden Bell Frog	*Litoria aurea*	Last recorded on Atlas of NSW Wildlife in 1980.	Suspected species loss
Dusky Antechinus	*Antechinus swainsonii*	Recorded inland of Burning Palms below the escarpment in September 1974 but has not been located since, despite extensive mammal trapping and broadscale surveys in the area. Still known further south on the Illawarra Escarpment, and much of the potential habitat in the survey area has not been targeted during mammal trapping. Recent unconfirmed sightings have been made at the DECCW hut south of Burning Palms (D. Andrew, DECCW, pers. comm.). Status in the survey area is uncertain, but at this time it considered to have been lost.	Suspected species loss
Greater Glider	*Petauroides volans*	Last seen one month after the 1994 wildfire (Andrew 2001), with no further sightings despite considerable search effort.	Suspected species loss
Red-necked Pademelon	*Thylogale thetis*	The only Atlas of NSW Wildlife record is from 1974, but a remnant population persisted north of Bald Hill until at least the 1980s (Robinson 1988).	Suspected species loss
Stuttering Frog	*Mixophyes balbus*	Several historic records but only a single record since the 1994 wildfire, of tadpoles. Targeted surveys since that sighting have failed to locate the species.	Suspected species loss

Common Name	Scientific Name	Notes on records and decline	Current status
Spotted-tailed Quoll	*Dasyurus maculatus*	Known from Royal NP in the 1960s and 1970s but not detected since the 1970s (R. Shovelor cited in Andrew 2001) despite extensive cage trapping and the use of hair tubes across the area. Is occasionally recorded in bushland adjoining the survey area. Individuals may be confirmed to occur in the future, particularly wide-ranging animals from outside the survey area, but at this time it considered that the resident population has been lost.	Suspected species loss
Platypus	*Ornithorhynchus anatinus*	Known in the 1960s and 1970s but no recent confirmed sightings despite considerable search effort. Current status of this species in the reserves is highly uncertain. Possible that individuals (or a relict population) may be confirmed to occur in the future, but at this time it considered that the resident population has been lost.	Suspected species loss
Water Rat	*Hydromys chrysogaster*	The only record in the Atlas of NSW Wildlife is of an individual seen at the Audley causeway on the Hacking River in January 1964. No recent confirmed sightings despite considerable search effort. Good habitat remains present and it is possible that individuals may be confirmed to occur in the future, yet given current lack of records it is considered not to occur at this time.	Suspected species loss
Tawny Grassbird	*Megalurus timoriensis*	There may once have been a resident population but the species has not been confirmed in recent years. The survey area is near the southern limit of the species distribution and populations in the Illawarra are known to have declined (Higgins *et al.* 2006). May still turn up on very rare occasions as an extremely rare visitor, but any resident population is considered lost.	Suspected species loss

Table 13: Species considered to have used the survey area as peripheral or marginal habitat but have declined or no longer occur.

Common Name	Scientific Name	Notes on records and decline	Current status
Speckled Warbler	*Chthonicola sagittata*	No confirmed records on Atlas of NSW Wildlife and regarded by Anyon-Smith (2006) as locally extinct.	Peripheral species loss
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	No records on Atlas of NSW Wildlife and listed in Anyon-Smith (2006) as a vagrant with no recent records. Has declined across the Sydney Basin Bioregion.	Peripheral species loss
Painted Honeyeater	*Grantiella picta*	No records on Atlas of NSW Wildlife and listed in Anyon-Smith (2006) as a vagrant not recorded since 1924. Probably extinct in Sydney area.	Peripheral species loss
Restless Flycatcher	*Myiagra inquieta*	Reported by Cayley (1923) and listed in Anyon-Smith (2006) as a rare vagrant not recorded since 1948. Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have been common. Despite lack of recent records it is considered that this species may continue to irregularly visit the area.	Peripheral species decline
White-throated Gerygone	*Gerygone albogularis*	Only Atlas of NSW Wildlife records are from 1905 while Anyon-Smith reports no recent records. Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have been common. Despite lack of recent records it is considered that this species may continue to irregularly visit the area.	Peripheral species decline
Masked Woodswallow	*Artamus personatus*	Reported by Cayley (1923). Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have been common. This species is highly nomadic and hence though it has not been recorded in the small patch of potential habitat in recent years, there is the possibility for it to return.	Peripheral species decline
Blue-faced Honeyeater	*Entomyzon cyanotis*	No records on Atlas of NSW Wildlife while Anyon-Smith reports no records since 1922. Previous extent of use of the reserves not known.	Peripheral species loss
Peaceful Dove	*Geopelia striata*	The only Atlas of NSW Wildlife record is from 1910. Would have largely been confined to the Loftus-East Heathcote sections. Anyon-Smith (2006) reports no recent records.	Peripheral species loss
Jacky Winter	*Microeca fascinans*	Reported as common by Cayley (1923), most likely referring to the Loftus-Engadine area of the reserves. Now considered locally extinct.	Peripheral species loss
Rufous Songlark	*Cincloramphus mathewsi*	Only accurate Atlas of NSW Wildlife records are from 1905 while Anyon-Smith reports no recent records. Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have more commonly visited.	Peripheral species loss
Little Friarbird	*Philemon citreogularis*	Anyon-Smith reports no recent records. Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have more commonly visited.	Peripheral species loss

Common Name	Scientific Name	Notes on records and decline	Current status
White-winged Triller	*Lalage sueurii*	Atlas of NSW Wildlife record from early 1980s while recorded in Anyon-Smith (2006) as a vagrant during summer with no recent records. Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have more commonly visited.	Peripheral species decline
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past where the species may have been common. Now only limited patches of suitable habitat occur. Now probably only occurs as a rare visitor.	Peripheral species decline
White-browed Woodswallow	*Artamus superciliosus*	Amount of potential habitat likely to have been more extensive in Loftus-East Heathcote areas in the past, where the species may have been common. Species does not occur in this part of the survey area today. Single individuals are infrequently sighted elsewhere in Royal NP.	Peripheral species decline
Pallid Cuckoo	*Cacomantis pallidus*	May once have been more common in the Loftus-East Heathcote sections of the survey area. Today only occurs as a rare visitor to the survey area.	Peripheral species decline
Pied Butcherbird	*Cracticus nigrogularis*	May once have been more common in the Loftus-East Heathcote sections of the survey area. Has declined within the Sydney metropolitan area and despite a single recent record it is considered to today only occur as an extremely rare visitor if at all.	Peripheral species loss
Diamond Firetail	*Stagonopleura guttata*	It is likely that a small resident population may have occurred around Farnell Avenue and that suitable habitat once occurred just west of the highway in the Engadine/Loftus areas. These populations appear to have been lost. In addition, the species was more common and widespread on the Cumberland Plain than it is today, meaning birds were more likely to have visited the survey area during times of environmental stress in the past. With the loss of local populations and decline of the species across the region, it is considered to today only occur as an extremely rare visitor (such as the record during the drought in 2002) if at all.	Peripheral species loss
Barking Owl	*Ninox connivens*	Recorded on three occasions since 1975. May once have been more common in the Loftus Heights-Heathcote areas.	Peripheral species decline

Table 14: Species that are wide ranging and/or nomadic and are either no longer recorded in the survey area or are recorded far less frequently.

Common Name	Scientific Name	Notes on records and decline	Current status
Regent Honeyeater	*Xanthomyza phrygia*	Not recorded within the last 25 years.	Declining visitor
Superb Fruit-Dove	*Ptilinopus superbus*	Very rarely recorded and not confirmed for many years, but may once have been a more frequent seasonal visitor.	Declining visitor
Rose-crowned Fruit-Dove	*Ptilinopus regina*	Not recorded in the last 25 years, but may once have been a more frequent seasonal visitor.	Declining visitor
Wompoo Fruit-Dove	*Ptilinopus magnificus*	No formal records but likely to once have been a seasonal visitor.	Declining visitor
Black-necked Stork	*Ephippiorhynchus asiaticus*	No formal records but may have once occurred.	Declining visitor
Magpie Goose	*Anseranas semipalmata*	No formal records but may have once occurred.	Declining visitor
Pacific Gull	*Larus pacificus*	Vary rarely recorded but likely to have once been a frequent visitor.	Declining visitor
Hooded Plover	*Thinornis rubricollis*	No formal records but given it was occasionally recorded on Cronulla beaches as recently as the 1940s it was also likely to have occurred on the less frequented beaches in Royal NP.	Declining visitor
Lesser Sand-plover	*Charadrius mongolus*	No confirmed records but likely that at the turn of last century these species occasionally occurred in Port Hacking as alternate foraging areas to those on the Kurnell Peninsula. Has undergone declines across the eastern seaboard.	Declining visitor
Great Knot	*Calidris tenuirostris*	No confirmed records but likely that at the turn of last century these species occasionally occurred in Port Hacking as alternate foraging areas to those on the Kurnell Peninsula.	Declining visitor
Red-necked Stint	*Calidris ruficollis*	No confirmed records despite suitable habitat on the sand flats of Port Hacking and along the ocean beaches, especially Marley beach estuary. Suspected to have occurred in the past but gone unrecorded.	Declining visitor
Pacific Golden Plover	*Pluvialis fulva*	Not recorded within the last 25 years and now considered an extremely rare visitor.	Declining visitor
Red-capped Plover	*Charadrius ruficapillus*	Still occasionally recorded but probably less frequently than in the past.	Declining visitor
Grey-tailed Tattler	*Tringa brevipes*	Not recorded within the last 25 years and now considered an extremely rare visitor.	Declining visitor
Sharp-tailed Sandpiper	*Calidris acuminata*	Not recorded within the last 25 years and now considered an extremely rare visitor.	Declining visitor

4.2.2 Patterns of loss and decline across habitat groups

Species extinctions, losses and declines have primarily occurred from a small range of habitat associations. The following discussion summarises the pattern of species loss and decline across particular habitat groups.

Freshwater Wetland

Wetlands (including sedgelands) are not extensive in the survey area although they are considered to have been high quality habitat for some species that now no longer occur. Species that have been lost include the Green and Golden Bell Frog and Eastern Ground Parrot. Both these species have declined within the region with the Green and Golden Bell Frog, formerly the most common frog in Sydney, now only known from a small number of localities (McEntee 2005), while the Eastern Ground Parrot was described as "fast disappearing' (Cayley 1923) during his visit to Marley in the early 1920s. It is likely that the Black-necked Stork and Magpie Goose may also have occurred but information regarding the distribution and status of these species at the time of European settlement is limited (DECC 2007b). The reasons for decline of these species within the region are associated with draining of wetlands, clearance of wetland vegetation, hunting of the wetland species, inappropriate fire regimes and introduced predators while the introduction of the Amphibian Chytrid Fungus and feral fish is known to have impacted the Green and Golden Bell Frog (e.g. DECC 2007b). Additionally, Platypus and Water Rat are suspected to have been lost from the survey area as neither has been seen since the 1970s despite considerable search effort.

Heathland

Heathlands occupy large sections of the survey area and are considered to have once been high quality habitat for some species that now no longer occur. Species that have become locally extinct include the Eastern Ground Parrot and Eastern Bristlebird. The former species also occurred in sedgelands within wetland habitats (see above), while the latter species occurred in dense heathlands and was last reported from the region in the 1960s west of Mt Kembla (Chafer *et al*. 1999). Additionally, it is likely that the Southern Brown Bandicoot formerly occurred in heathland and heathy woodland. The Tawny Grassbird is primarily a heathland species and it is possible that a resident population once occurred that has been lost (with individuals that may turn up from time to time being either relicts of that population or wide-ranging visitors from elsewhere). Additionally, the Long-nosed Potoroo would have utilised wet heath in addition to dense gully vegetation.

Rainforest (Northern Warm Temperate and Subtropical Rainforest, Littoral Rainforest and Riparian Scrub)

Rainforest and associated moist eucalypt forest in the survey area represents high quality habitat for several species that now no longer occur. Species that have been lost include the Parma Wallaby (considered locally extinct) and the Stuttering Frog (more recent suspected species loss). Superb Fruit-Dove and Rose-crowned Fruit-Dove are considered to once have been more frequent seasonal visitors but are now only very rarely recorded. Although not documented (e.g. Anyon-Smith 2006), an additional species that was likely to have occurred is the Wompoo Fruit-Dove which was once resident in the Illawarra region but has not been recorded since the 1920s (Chafer *et al.* 1999.). The Fruit-Doves have either become locally extinct or are now very rare visitors across the Illawarra region with all three species being vulnerable to fragmentation and disturbance (Recher *et al*. 1995, Moran *et al*. 2004). The Stuttering Frog has declined in the southern parts of its range from south of Sydney to the Victorian border with intensive surveys indicating it no longer occurs in most of its former haunts within this part of its range (Gillespie 1996). Its disappearance is suspected to be a result of altered water quality and flow characteristics and Amphibian Chytrid Fungus. The Parma Wallaby has severely declined throughout the Illawarra region with the last recorded sighting in 1969 (Robinson 1988). Its decline has been attributed to predation by Foxes, in association with inappropriate fire regimes and habitat fragmentation (DECC 2007c).

Additionally, a number of non-listed threatened species are known or suspected to have been lost from within this habitat including the Regent Bowerbird, Dusky Antechinus, Greater Glider and Red-necked Pademelon. Additionally, the Pilotbird is a moist forest species thought to have declined in the survey area in recent years (S. Anyon-Smith pers. comm.). Within the survey area the Regent Bowerbird was last reported in the 1920s (Anyon-Smith 2006), while the last three species have not been recorded in more recent years, for example the Greater Glider was last seen just after the 1994 wildfire (Andrew 2001) and the Red-necked Pademelon in the 1980s (Robinson 1988). Dusky Antechinus was recorded inland of Burning Palms below the escarpment in September 1974 (DECCW 2010a) but has not been located since, despite extensive mammal trapping (e.g. Andrew 2001, Tulloch 2003) and broadscale surveys in the area (e.g. DECC 2008a, current survey). Recent unconfirmed sightings have been made at the DECCW hut south of Burning Palms (D. Andrew DECCW, pers. comm.). The Greater Glider requires large hollows, with the availability and distribution of suitably sized hollows a limiting factor in its

distribution and abundance (Lindenmayer *et al*. 1990). During this survey it was apparent that many suitable stands of Blackbutt and other wet forest eucalypts had little hollow development as a result of past logging activities in the late 1800s and early 1900s (NPWS 2000a), together with wild fires that have raged through the area. It has been shown that it may take over 200 years for Blackbutt trees to develop large hollows (Mackowski 1984). Therefore it is perhaps not surprising that this species was not recorded during the current surveys and appears to no longer occur. Other recent surveys have also asserted the current absence of Greater Glider from Royal NP (e.g. Maloney 2007). However, it is possible that the Greater Glider may be rediscovered in the future, as it is known to occur in the Stanwell Park area to the south (B. Sullivan DECCW, pers. comm.) although it has become locally extinct in the Coalcliff area on the Illawarra Escarpment (Robinson 1988). Due to time constraints more remote areas away from roads and walking tracks, such as ridges and lower slopes on the east side of the Hacking River, were rarely investigated in previous surveys (e.g. Andrew 2001) and the current survey.

Also occurring within rainforests and associated moist sclerophyll forests, the Rufous Fantail and Black-faced Monarch are thought to have declined within the survey area in recent years (S. Anyon-Smith pers. comm.).

Northern Hinterland Wet Sclerophyll Forest

Northern Hinterland Wet Sclerophyll Forests today comprise only a small portion of the survey area, however extensive stands were once present on ridges and rises around the suburbs of Loftus, Engadine, Sutherland and Heathcote. These forests provided peripheral (though important) habitat for a large number of species that were once more extensively distributed within grassy woodlands found across the drier Cumberland Plain. The Bush Stone-curlew is thought to have once had a population in the survey area that is now locally extinct. Other threatened species that once utilised this habitat and appear to have also been lost include Speckled Warbler, Painted Honeyeater, Black-chinned Honeyeater and resident Diamond Firetail, while the Barking Owl now only occurs as a rare visitor. Threatened species that once visited this habitat and have severely declined include Regent Honeyeater and Swift Parrot. Additionally, a number of other species are known or suspected to have been lost from the reserves or today only occur as rare visitors including the Peaceful Dove, Pallid Cuckoo, White-throated Gerygone, Yellow-rumped Thornbill, Blue-faced Honeyeater, Little Friarbird, White-winged Triller, Pied Butcherbird, Restless Flycatcher, Jacky Winter and the Rufous Songlark. These species would have been largely confined to the Loftus-East Heathcote sections of the survey area. Within these areas some of the species were formerly common. For example, the Jacky Winter in the National Park Station area was reported as “he should be the first bird recorded” (Cayley 1923). Other species in this category from the same general area included the Restless Flycatcher, Yellow-rumped Thornbill, White-throated Gerygone, White-browed and Masked Woodswallows (Cayley 1923). None of these birds occur in this part of the survey area today (e.g. current survey results). The loss of these birds is likely to be associated with the revegetation of the land around this part of the survey area, the loss of similar habitat in adjoining areas to housing development, and the loss and fragmentation of extensive areas of grassy woodland to the west in the Cumberland Plain. The status of the Eastern Bearded Dragon in the survey area is uncertain, but it is another species that would likely have occupied habitats in the Loftus-East Heathcote areas and is now thought to have suffered declines in number or been lost from the wild.

Shoreline

Species that probably once used shoreline habitats within the survey area for breeding, but today only visit in very low numbers, are the Osprey, Pied Oystercatcher and Little Tern. The Osprey was a resident species last century (e.g. Hoskin *et al*. 1991), while the Pied Oystercatcher and Little Tern are likely to have bred in areas such as Constables Point. Several species once visited the shoreline habitats more frequently than they do today including Pacific Golden Plover, Red-capped Plover, Grey-tailed Tattler, Sharp-tailed Sandpiper and Pacific Gull, while others not confidently recorded but also likely to have visited more frequently in the past include Lesser Sand-Plover, Great Knot, Red-necked Stint and Hooded Plover. These species now only occur as extremely rare visitors or no longer visit at all. The decline of several of these species, such as the Pacific Golden Plover (Barrett *et al*. 2003), follows a national trend, while the range of the Pacific Gull has contracted southwards with it being common on the Sydney beaches in the 1920s but now is a rare visitor with most records attributed to mis-identifications of the similar-looking Kelp Gull (Higgins and Davies 1996).

Deep Freshwater Habitats

The status of both of the freshwater aquatic species known from the survey area is uncertain but neither was recorded during the current survey and both are considered to be lost as resident populations. Platypus were last recorded in the Hacking River and Kangaroo Creek catchments in the 1960s and 1970s (I. Morris cited in Andrew 2001), with no recent records reported in a summary of the current occurrence of the species around Sydney (Grant 1998) or in subsequent years (Curtis 2001, T. Grant pers. comm., current survey). Neither the Platypus nor Water Rat has been encountered over a 25-year

period on the lower Hacking River or on the lower reaches of Kangaroo Creek by the operators of the Audley Boatshed (J. Hughes, pers. comm.). Recent unconfirmed sightings of Platypus have been made, including: observations made during the Macarthur University Koala survey (cited in Curtis 2001) from the Hacking River south of the Upper Causeway, on the Hacking River at Calala, Kingfisher Pool on Heathcote Creek and Lake Eckersley on the Woronora River; a number of recent Atlas of NSW sightings including Waratah Rivulet approximately 1km north of Flat Rock crossing in November 2006 and Kangaroo Creek just upstream from the Hacking River confluence in September 2000; as well as just outside the area at Otford Weir and Lake Toolooma on Heathcote Creek. However, fish netting studies in the Hacking and Woronora Rivers (e.g. Bishop 1993, Bruce *et al.* 2001) resulted in no captures or sightings of this species. Similarly, a previous targeted survey using dawn and dusk watches at a number of locations along the Hacking and Woronora Rivers failed to record any definite sightings (Curtis 2001). Caution must be used in interpreting people's sightings who are not familiar with the species, as in poor light a swimming Eastern Water Dragon or even a large fish at the surface from a distance can readily be confused.

Forest Habitat Groups

A few species that are likely to have once occupied a range of forest vegetation communities within the survey area have gone extinct or severely declined. The Eastern Quoll was known from the survey area, but similar to the rest of the Australian mainland has now disappeared (Jones 2008). The status of the Spotted-tailed Quoll in the survey area is less certain but it is considered that the resident population that was known from Royal NP in the 1960s and 1970s has been lost; no confirmed records have been collected in the survey area for many years but given recent sightings on the Woronora Plateau (DECC 2007c), Holsworthy Military Area and in Coledale it is likely that individuals may occasionally wander into the reserves from other surviving populations. A population of Koala occurred in the Helensburgh area in the 1940s and was reported to have become locally extinct in Royal NP in the 1970s (Robinson 1987); a number of recent records of this species exist for the survey area, primarily in Heathcote NP, probably either rehabilitated released individuals (WIRES records) or wide-ranging individuals from the Campbelltown population (Ward and Close 2004) that is common along the Georges River, including in nearby areas of Holsworthy Military Area (DECC 2008a).

4.3 FAUNA SPECIES INVENTORY

Following the review and field survey undertaken for this project it is considered that a total of 347 native vertebrate fauna species currently occur in or visit the survey area (Table 15), comprising 21 frog, 42 reptile, 246 bird and 38 mammal species. Thirty-eight species listed under the *TSC Act* still occur within or visit the survey area, and an additional two have been recorded but are vagrants. Six species listed under the Commonwealth *EPBC Act* as at March 2011 still occur or visit. Finally, nine feral mammal species and eight feral bird species occur that either have established populations or range into the survey area from adjacent urban settlements. A complete species inventory is provided in Appendix 5.

A total of 267 native fauna species were recorded during the 2009-10 fauna survey (see Appendix 5). The surveys resulted in the discovery of seven species that had not previously been recorded in the Atlas of NSW Wildlife for the survey area. These were the Australasian Bittern, Grass Owl, White-plumed Honeyeater, Euro, Lesser Long-eared Bat, Mainland She-oak Skink and Wilcox's Frog. Two of these species are listed under the *TSC Act* demonstrating the value of such a field survey. Additionally, the current survey recorded 50 species not located in previous DECCW surveys within the area, comprising three frog, eight reptile, 36 bird and three mammal species (see Appendix 5). On the completion of the field surveys, approximately 5400 records had been added to the Atlas of NSW Wildlife database.

Table 15: Summary of current numbers of vertebrate fauna in the survey area.

Total number of native fauna species known to occur or visit	347
Number of species listed as threatened under the *TSC Act* (as at March 2011)	38 (plus 2 vagrant species)
Number of species listed as threatened under the *EPBC Act* (as at March 2011)	6
Number of introduced mammals (not including dumped or domestic species that have not established wild breeding populations in or adjacent to the survey area)	9
Number of introduced birds (not including dumped or domestic species that have not established wild breeding populations in or adjacent to the survey area)	8

4.3.1 Amphibians

Twenty-one species of frog are currently known from the survey area. The amphibian surveys undertaken for the current project were during a period when the watertable was low resulting in many ephemeral wetlands and small streams being dry. Additionally, no significant autumn rains fell until late in May when conditions were cool resulting in autumn-breeding amphibian species being poorly surveyed. Therefore, only 16 species of frogs were recorded in the current survey from 18 streamside searches and incidental observations, with three autumn/early winter breeding species known from the area not recorded. These species were the Brown Toadlet, Jervis Bay Tree Frog and Verreaux's Tree Frog.

The Striped Marsh Frog is a common species within the survey area. Photo © M. Schulz

The most common and widespread species within the area during the survey, including in many ephemeral wetlands and soaks, was the Common Eastern Froglet. In deeper, more permanent wetlands or still sections of watercourses with emergent vegetation frequently encountered frogs included the Striped Marsh Frog, Eastern Banjo Frog and the Eastern Dwarf Tree Frog. Along watercourses commonly located species included Lesueur's Frog, Peron's Tree Frog and the Leaf-green Tree Frog.

Tyler's Tree Frog was not recorded in the current survey. Photo © M. Schulz

The current survey located two frog species from within the reserve boundaries that had not previously been recorded in the Atlas of NSW Wildlife. Calling individuals of the Leaf Green River Tree Frog were recorded in grassland adjacent to littoral rainforest on the northern edge of Stanwell Park in January 2010. Targeted searches elsewhere in southern parts of Royal NP (such as along the Werrong Track, behind Werrong Beach and in the Bulgo area) in January 2010 when choruses of this frog were active just south of the survey area (such as along Hargraves Creek in Stanwell Park) failed to locate additional populations of the species. The Leaf Green River Tree Frog has also been recorded in the Camp Gully area at Helensburgh (A. White pers. comm., DECCW 2010a). Secondly Wilcox's Frog was recorded along the Woronora Dam Road and adjacent to the Woronora River.

The survey area is important for two threatened frog species listed under the *TSC Act* which occur in high densities compared to adjacent areas such as Dharawal SCA (DECC 2007a) and elsewhere within the Sydney Metropolitan CMA area (DECC 2008a). These species are the Red-crowned Toadlet and the Giant Burrowing Frog. Additionally, the area supports high densities of the regionally significant Freycinet's Frog which has declined significantly in the northern parts of its range (R. Goldingay, Southern Cross University, pers. comm., H. Hines, Queensland Department of Environment and Resource Management, pers. comm.). All three species were recorded in a number of sites during the current survey (detailed in Section 5.2).

Ephemeral wetland in the Marley dunes. Photo © M. Schulz/DECCW

In addition to Green and Golden Bell Frog and Stuttering Frog, which are considered lost from the survey area, two summer breeding species previously known from the survey area

were not recorded during the current survey: Green Tree Frog and Broad-palmed Frog. The lack of Green Tree Frog records in the current survey may be a reflection of this species' decline in parts of its range, including the Greater Southern Sydney Region (DECC 2007c). Searches for the Broad-palmed Frog were conducted along sections of the Woronora River and lower reaches of Heathcote Creek where the species had previously been recorded (Andrew 2001), but were unsuccessful.

Two additional species, the Spotted Grass Frog (*Limnodynastes tasmaniensis*) and Tyler's Tree Frog (*Litoria tyleri*) have been recorded in the Upper Hacking valley although no records have been entered into the Atlas of NSW Wildlife (Rice 1995). These species were not recorded during the current survey or other recent surveys in the Upper Hacking valley (e.g. DECC 2008a) within the survey area.

4.3.2 Terrestrial reptiles

A total of 40 species of terrestrial reptile are known to occur in the survey area. This total includes four geckoes, two legless lizards, four dragons, two goannas, 13 skinks, and 15 snakes. As discussed below, the status of one reptile within the survey area, the Eastern Bearded Dragon, is considered uncertain, while the presence of other species, such as the Broad-headed Snake, has greatly declined due to various factors including illegal poaching.

The Copper-tailed Skink is one of the most commonly encountered reptiles in heathlands within the area. Photo © M. Schulz

One hundred and fourteen systematic diurnal herpetofauna searches in addition to incidental observations resulted in all of the previously recorded species being recorded in the current survey. This result was in part due to the long warm summer, with many warm, humid nights from January through to March resulting in high levels of reptile activity at night. A number of species were primarily recorded by driving roads at dusk and at night in search of reptiles, including the Thick-tailed Gecko, Burton's Snake-lizard, Brown Tree Snake and the Eastern Bandy-bandy. The most widespread reptile species through a broad range of habitats within the survey area was the Dark-flecked Garden Sunskink, including on the edge of saltmarsh and mangrove areas in Port Hacking. In heathlands and drier forest communities a variety of species were well represented including the Jacky Lashtail, Copper-tailed Skink and White's Rock-skink. In contrast in wetter forest communities commonly encountered species included the Weasel Shadeskink, Three-toed Skink and the Golden-crowned Snake. In rocky areas, species such as the Lesueur's Velvet Gecko, the Broad-tailed Gecko and the Red-throated Skink were patchily distributed. More restricted species included the Cunningham's Skink (which was primarily found in small colonies on deeply joint blocked rock faces between Wattamolla and Garie Beach) and the Common Blue-tongue (which was mostly found in the Bundeena area). A distinct reptile fauna assemblage occurred in drier sections of Heathcote NP, including the Thick-tailed Gecko and Burton's Snake-lizard; with several other species restricted to this area and high broad ridges in the far west of Royal NP, such as the Eastern Stone Gecko and the Red-naped Snake. The Eastern Water Dragon occurs in a number of habitat types, including in the tidal lower reaches of the Hacking River and on intertidal rock platforms in the Bulgo area of Royal NP. In the latter area, large adults were observed in the current survey feeding in pools in the upper intertidal zone.

The Thick-tailed Gecko was only found in Heathcote NP in the current survey. Photo © M. Schulz

Snakes were well represented in the current survey. Two species that are uncommon and patchily distributed in the Sydney Metropolitan CMA area are the Common Tree Snake and the Tiger Snake. The former species was found in five locations in a variety of vegetation types in the lower Hacking River area and between Port Hacking and Bundeena Drive, including a number of roadkills primarily in the Audley area. The Tiger Snake was found in widely separated localities in tall open forest between Cawleys and Wilsons Creeks, upslope of Lady Wakehurst Drive in the Karingal area and in heathland along Marley Track. A surprise result was the location of the typically cryptic and hard-to-find Death Adder in four

The Bandy-bandy is one of the most distinctive snakes present within the survey area. Photo © M. Schulz

localities and some extremely large (around two metres total length) Eastern Brown Snakes between Jibbon Head to inland of Marley Head in Royal NP. Another notable species located was the Brown Tree Snake which was recorded in a cave near Flat Rock Crossing and as a roadkill on Bundeena Drive in Royal NP. This species is near the southern limit of its range in this area (Griffiths 2006).

This survey located one reptile species not previously recorded in the Atlas of NSW Wildlife: the Mainland She-oak Skink. This species was recorded in three localities during the survey: dense sedgeland south of Bundeena Drive; *Juncus kraussii* sedgeland bordering saltmarsh on the eastern side of Cabbage Tree Basin; and in Button Grass (*Gymnoschoenus sphaerocephalus*) sedgeland at Curra Moors. Though not entered into the Atlas of NSW Wildlife, the Mainland She-oak Skink has also been recorded around the Otford area in the past (K. Griffiths pers. comm.).

The observation of an Eastern Bearded Dragon during the current survey on the freeway just east of Loftus holds significance as this species is thought to have suffered declines in the southern suburbs of Sydney in the last few decades. This is only the second sighting of the species in the survey area recorded in the Atlas of NSW Wildlife, with a record from 1969 of a roadkilled animal somewhere in Royal National Park (record has low spatial accuracy). The species was common in the Jannali/Sutherland area in the 1960s (K. Griffiths pers. comm.) and was seen in Engadine, North Engadine and also Heathcote NP more than ten years ago but not since (K. Griffiths pers. comm.). Given the lack of recent sightings, the Eastern Bearded Dragon was suspected to have disappeared from the area (K. Griffiths pers. comm.). It is a possibility that the individual observed during the current study was an escaped or dumped captive animal, as the species is commonly kept as a pet. Given all of these factors the current status of the species in the survey area must be considered uncertain, but if it does persist in the wild it is likely to be confined to the edge of the reserves in the Loftus-Heathcote areas.

The survey area is important for two reptile species listed under the *TSC Act* which occur in high densities compared to most other areas within the Sydney Metropolitan CMA area (DECC 2008a). These species are Rosenberg's Goanna and the Broad-headed Snake. The former species was primarily found in heathland and heathy woodland habitat, with a number of road-killed individuals found. The Broad-headed Snake was found in eight widely spaced localities in Heathcote NP and Royal NP, but could not be located at sites where it previously occurred such as along the coastal cliffs east of Bundeena (R. McLaggan, WIRES and Bundeena resident, pers. comm.).

A number of species not located in the current survey have been recorded from adjacent localities and may potentially occur in the survey area. These species include the Three-lined Skink (*Acritoscincus duperreyi*) which was captured in pitfall traps in Dharawal NR in Button Grass dominated upland swamp (DECC 2007a) and the Mustard-bellied Snake (*Drysdalia rhodogaster*) which has been recorded in the Otford area and further south in the Dharawal NR and SCA area (DECC 2007a). Targeted searches in rainforest and wet sclerophyll forest for an additional species, the cryptic McCoy's Skink, that occurs further south in rainforest along the Illawarra Escarpment as far north as Scarborough (NPWS 2002), were unsuccessful.

The Eastern Snake-necked Turtle is common in the Hacking River at Audley and around Bundeena. Photo © M. Schulz

4.3.3 Freshwater aquatic reptiles

Two freshwater aquatic species have been recorded in the survey area, the Eastern Snake-necked Turtle and the Short-necked Turtle. In the current survey, the former species was primarily recorded from the Hacking River around Audley and in wetlands in the Bundeena area. The identity of the latter species in the Hacking River is uncertain but appears to be a mixture of forms of *Emydura macquarii* not native to the Sydney region and is likely to have originated from released pets (Cann 1998, J. Cann pers. comm.). These Short-necked Turtles are common in the freshwater reaches of the Hacking River in the Audley area.

Other reptiles were also commonly encountered during the survey in and along freshwater streams across the area, frequently seeking water for refuge. These species included the Eastern Water Dragon, Eastern Water Skink and Red-bellied Black Snake.

4.3.4 Terrestrial birds

Birds are the most obvious form of wildlife to most visitors to the survey area, with honeyeaters, lorikeets and other species filling the air with a multitude of sounds. A good overview of the bird fauna occurring in the survey area is presented in the booklet by Anyon-Smith (2006). The current survey recorded 134 species of terrestrial bird, with two additional species recorded to those listed by Anyon-Smith (2006): the Grass Owl and the White-plumed Honeyeater. Species not recorded in the current survey included rare visitors or vagrants from inland areas (such as the Spotted Harrier, Black Falcon, Red-rumped Parrot, Black-eared Cuckoo, Spiny-cheeked Honeyeater, White-winged Triller, Apostlebird and the Diamond Firetail) and rare visitors from northern New South Wales (such as the Superb Fruit-Dove, Forest Kingfisher and the Spectacled Monarch). A number of species either appear to have declined in recent years or are rare residents with few confirmed recent sightings, such White-headed Pigeon, Gang-gang Cockatoo and the Spotted Quail-thrush. Some species are occasionally seen when they pass through the area, such as the Square-tailed Kite, Cattle Egret, Straw-necked Ibis, Satin Flycatcher and the Fairy Martin. Other species are more common in surrounding areas and occasionally range into limited patches of suitable habitat, such as the Mangrove Gerygone, Yellow-rumped Thornbill and the Scarlet Robin. A large amount of potentially suitable habitat for the Glossy Black-Cockatoo and Striated Pardalote is present, but these species were not located during the current survey.


The White-browed Scrubwren is a common and widespread species. Photo © M. Schulz

In the current survey there were a large number of species that were commonly recorded in most habitats across the area and which are typical of the Sydney Basin sandstone environments (e.g. DECC 2007b). These species included the Yellow-tailed Black-Cockatoo, Crimson Rosella, Variegated Fairy-wren, White-browed Scrubwren, Brown Thornbill, Yellow-faced Honeyeater, New Holland Honeyeater, Eastern Spinebill, Pied Currawong and the Silvereye. Other species were largely restricted to heathland and heathy woodland habitats, notably the Southern Emu-wren, Chestnut-rumped Heathwren and the Beautiful Firetail. Yet others were characteristic of tall eucalypt forest, such as the Australian King-Parrot, Superb Lyrebird, White-throated Treecreeper, Golden Whistler and the Rufous Fantail. Some species were confined to specific vegetation types, such as the Australasian Pipit which was limited to open ground with little shrubbery such as along the edge of the sea cliffs. A number of species were restricted to rainforest and adjacent wet sclerophyll forest with a rainforest subcanopy, most notably the Green Catbird and the Australian Logrunner, while others were largely found adjacent to urban areas or in modified parklands within the area, such as the Crested Pigeon, Galah, Little Corella and the Magpie-lark. Others were restricted by location, such as the Bar-shouldered Dove which was only recorded in the Jibbon Beach area, the Buff-rumped Thornbill in dry ridgetop forest north-east of Heathcote Heights and adjacent to the Woronora Dam Road, and the Yellow Thornbill in mangroves and adjacent vegetation along the Port Hacking shoreline.


The Pilotbird is a declining species within the survey area. Photo © M. Schulz

The area supports a diverse nocturnal bird fauna, with 10 species recorded, including five species listed under the *TSC Act*. These species are the Powerful Owl, Barking Owl, Sooty Owl, Masked Owl and the Grass Owl. All nocturnal species listed as occurring within the area were recorded during the current survey, with the exception of the Barking Owl. Targeted playback at six sites in the Loftus-Engadine area failed to locate this species.

Twelve species of threatened diurnal terrestrial birds are included in the current species tally for the survey area, with eight of these being

uncommon to extremely rare visitors (Superb Fruit-Dove, Rose-crowned Fruit-Dove, Square-tailed Kite, Spotted Harrier, Glossy Black-Cockatoo, Swift Parrot, Regent Honeyeater and Scarlet Robin). Others have been recorded regularly in small numbers within the area, such as the Little Eagle, Gang-gang Cockatoo and the Little Lorikeet. The only threatened bird species that was recorded at more than five sites across the area in the current survey was the Varied Sittella. The survey area supports populations of a number of species which have declined in numbers across their national range in recent years (Barrett *et al*. 2003) or within the Sydney Basin Bioregion (e.g. DECC 2007b). These species include the Swamp Harrier, Red-browed Treecreeper, Rockwarbler, Southern Emu-wren, Tawny-crowned Honeyeater, Grey Currawong, Beautiful Firetail and the Australian Pipit.

Some Sulphur-crested Cockatoo are aggressive at Audley. Photo © M. Schulz/DECCW

At least two native species occur as pest species in parts of the survey area. Artificial feeding of Sulphur-crested Cockatoos at Audley has resulted in some individuals becoming bold and aggressive (Seville 2009). Aggressive individuals are removed although population numbers are currently being reduced by a pair of Powerful Owls that frequent the area (B. Sullivan, DECCW, pers. comm.). Populations of the Noisy Miner have increased in some parts of the area, potentially resulting in the marginalisation of some of other bird species such as the Yellow-tufted Honeyeater west of Audley (S. Anyon-Smith pers. comm.). This species is not currently actively managed (B. Sullivan, DECCW, pers. comm.).

It is likely that additional terrestrial bird species will be recorded in the future, particularly inland species as a result of predictions for more frequent, extended drought periods occurring in inland New South Wales as a result of global warming. For example, the recent severe inland drought has resulted in a variety of bird species being recorded from around Sydney that have not previously been recorded, such as the Inland Dotterel (*Charadrius australis*), Crimson Chat (*Epthianura tricolor*) and the Orange Chat (*E. aurifrons*).

4.3.5 Freshwater aquatic and marine birds

Sixty-seven freshwater aquatic and marine birds that use the Royal NP shoreline have been recorded, including a number of extremely rare visitor or vagrant species (Appendix 5). These rare visitor species are primarily restricted to freshwater wetlands, including along still sections of the Hacking River at Audley, and typically occur during periods of drought when many waterbirds move coastwards (Anyon-Smith 2006). Such species include the Freckled Duck, Great Crested Grebe, Australian Little Bittern, Baillon's Crake and the Australian Spotted Crake. Other extremely rare visitors or vagrants occur on the mudflats of Port Hacking and/or along the ocean shoreline, including: a single Beach Stone-curlew that was seen over a period of several months in 1998/99 at Era Beach and in the Bonnie Vale/Constables Point area; the Common Sandpiper which has been recorded on the tidal flats at Bonnie Vale; and the Pacific Gull that was formerly common in the Sydney area but now is considered an extremely rare visitor (Hoskin *et al*. 1991). Also the Black-winged Stilt has been seen at Marley Lagoon and on the shoreline in the Constables Point and Jibbon Beach areas (Anyon-Smith 2006, M. Schulz pers. obs.).

Most waterbird species utilise the survey area as non-breeding visitors, while others breed singly such as various waterbird species in the Audley area. Only one waterbird breeding colony was located during the current surveys. This colony occurred in the trees fringing the lagoon at Bonnie Vale and was comprised of the Little Black Cormorant with smaller numbers of the Little Pied Cormorant and Great Cormorant. The Nankeen Night Heron may also nest in this location, but this has yet to be confirmed. Shorebirds have not been recorded in recent years nesting on beaches and adjoining primary dunes in the area, probably due to the large amount of human disturbance, the presence of a relatively large Australian Raven population, introduced predators such as the Fox and uncontrolled domestic Dogs in some areas (e.g. Constables Point).

The current survey recorded 14 species of freshwater aquatic birds, including the Australasian Bittern that had not previously been recorded (e.g. Anyon-Smith 2006). Single individuals of this species were found in dense sedge thickets in Jibbon Lagoon in July and October 2009. A number of species located are cryptic and therefore their status within the area is uncertain. These species include: the Lewin's Rail which appeared relatively common in some dense wetland areas, such as Bundeena Gully, Jibbon Lagoon (one was caught by hand here while spotlighting), with a single individual also heard at Uloola Swamp; the Spotless Crake with one individual sighted at Engadine Waterhole and around the same time one was heard calling at Marley Lagoon (S. Anyon-Smith pers. comm.); and the Latham's Snipe with

single individuals flushed at Marley Lagoon outlet, behind North Era Beach, in heathland on Jibbon Head, Bundeena Gully and adjacent to a soak in headland grassland south of Bulgo.

Most freshwater wetlands within the area support a low diversity and density of waterbirds, while in contrast the lower sections of the Hacking River at Audley and the lagoon at Bonnie Vale support a wide diversity of species. Common species encountered include the Australian Wood Duck, Purple Swamphen, Dusky Moorhen and the Eurasian Coot. Others are infrequent visitors or occur regularly in small numbers, including the Musk Duck, Australasian Grebe and the White-necked Heron. The Azure Kingfisher is thinly scattered along larger watercourses, while secretive reed/sedge frequenting species are restricted in occurrence. The Little Grassbird was only recorded from Marley Lagoon and the Australian Reed-Warbler was only recorded from Engadine Waterhole and is occasionally recorded along the Hacking River at Audley (Anyon-Smith 2006).

The Lewin's Rail was recorded in a number of wetland areas in the current survey. Photo © M. Schulz

Australian White Ibis resting in Bonnie Vale Lagoon. Photo © M. Schulz/DECCW

Many waterbird species occur both on freshwater wetlands and in marine habitats, particularly in the low energy waters and associated intertidal mudflats of Port Hacking. Twenty-two waterbird species fall into this category within Royal NP, with 21 species recorded in the current survey. Common and widespread species that also frequently occur on freshwater wetlands include the Pacific Black Duck, Little Pied Cormorant, Great Cormorant, Little Black Cormorant and the White-faced Heron. Species that tend to be more common in sheltered coastal areas than inland freshwater wetlands include the Chestnut Teal, Australian Pelican, Pied Cormorant, Eastern Great Egret, Australian White Ibis, Royal Spoonbill, Masked Lapwing and the Silver Gull. Other species tend to occur in small numbers or are infrequent visitors, including the Black Swan, Grey Teal, Australasian Darter, Little Egret, Black-fronted Dotterel and the Caspian Tern. The White-bellied Sea-Eagle is a common sight gliding with wings upswept along the coastal sea cliffs or attempting to catch fish in the sheltered waters of the Hacking River. Two cryptic species occur that are restricted in occurrence and their status is poorly understood within the area. A roost of the Nankeen Night-Heron is present in trees fringing the lagoon at Bonnie Vale while elsewhere it was encountered infrequently as single individuals in the current survey, including at the junction of Wilson's Creek and the Hacking River, Engadine Waterhole and Bundeena Gully. The Black Bittern has rarely been recorded in the area (Anyon-Smith 2006), with one record of a single individual in the current survey from the upper tidal reaches of Cabbage Tree Creek.

A number of waterbird species have only been recorded in marine habitats within the area, with these taxa dominated by marine species that come to roost on the shoreline or species that forage on intertidal mudflats or along the shore. Sixteen waterbird species fall into this category, with 10 species recorded during the current survey. One species that commonly rests along the shoreline but forages in offshore waters is the Crested Tern, while less commonly encountered roosting species include the White-fronted Tern, Common Tern and the Kelp Gull. The Little Penguin occasionally comes ashore to

The Eastern Reef Egret (left) and Sooty Oystercatcher occur in small numbers along the rocky shoreline. Photo © M. Schulz

moult in late summer and autumn, particularly in the Jibbon Head area. Several species are largely confined to the larger intertidal rock platforms on the ocean shoreline and only infrequently occur in Port Hacking, including the Eastern Reef Egret and the Sooty Oystercatcher which primarily occurs in pairs and small groups in the winter months as a non-breeding visitor. A number of shorebird species primarily frequent the intertidal flats of Port Hacking and roost in the Constables Point area at high tide. These species occur in smaller numbers than in nearby Botany Bay and include the Bar-tailed Godwit, Whimbrel, Eastern Curlew and less frequently and becoming increasingly scarce the Pied Oystercatcher. The Striated Heron occurs in very small numbers in mangrove areas and adjacent intertidal flats, while two small shorebirds (the Double-banded Plover and the Red-capped Plover) primarily occur sporadically in the winter months both along ocean beaches such as on Marley Beach and on the intertidal mudflats of Port Hacking. In contrast, the Ruddy Turnstone appears primarily restricted to larger intertidal rock platforms backed by beaches with large amounts of seaweed commonly washed ashore, such as at Bulgo. The Osprey is an occasional visitor, principally to the low energy waters of Port Hacking where it can be seen swooping low and catching fish with its talons or perched in trees at prominent locations overlooking the water.


The Grey-tailed Tattler has not been recorded in recent years. Photo © M. Schulz

Eight species of threatened waterbirds (excluding pelagic species) have been recorded within the area. None of these species are common, with four species occurring as occasional to rare visitors (Osprey, Australian Pied and Sooty Oystercatchers and Little Tern), two as vagrants (Freckled Duck and Beach Stone-curlew) and two species with an uncertain status within the area due to their cryptic nature (Australasian and Black Bitterns).

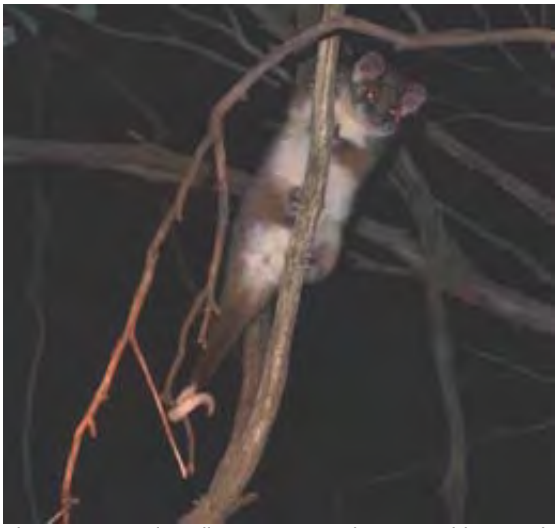
It is likely that additional waterbird species will be recorded in the future, particularly with regular monitoring of intertidal flats at Constables Point in Port Hacking. It is surprising that a number of relatively common shorebird species either have not been recorded from the area or observations only exist in old records (e.g. cited in Anyon-Smith 2006), even though they are regularly recorded on the Kurnell Peninsula and Botany Bay to the north. These species include the Pacific Golden Plover, Grey-tailed Tattler, Red-necked Stint and the Sharp-tailed Sandpiper.

Similar to the cliffs at Maroubra, the sea cliffs of Royal NP make for spectacular viewing of a variety of pelagic seabird species, such as huge rafts of shearwaters, wheeling albatross, diving Australasian Gannets and harassing jaegers. Although pelagic seabirds that do not come to roost on the shoreline are outside the scope of the current study, Appendix 1 outlines the incidence of occurrence of 29 species of pelagic seabirds that have been observed off the sea cliffs east of Bundeena in a three-year period between May 2007 and May 2010 (Schulz in prep. 2).

4.3.6 Arboreal mammals

Sixty-two spotlight searches and incidental observations recorded seven arboreal mammal species in the current survey. The most widespread species, including in tall heathland with little eucalypt overstorey was the Common Ringtail Possum. The Sugar Glider was common and widespread through all vegetation communities with a tree canopy, including rainforest. Two species with a more limited distribution were the Mountain Brushtail Possum (which was restricted to wet forests in the Hacking River valley and littoral rainforest south of Burning Palms) and the Feathertail Glider (encountered in tall open forest along the Hacking River and Kangaroo Creek and on the southern escarpment, including along the Cliff and Werrong Tracks). The Common Brushtail Possum was surprisingly uncommon and was


The Lesser Long-eared Bat had not previously been recorded within the survey area. Photo © M. Schulz



The Common Ringtail Possum was the most widespread arboreal mammal. Photo © M. Schulz

most frequently recorded in the Audley and Bundeena areas. A large number of Common Brushtail Possums have been found roadkilled along Farnell Avenue and the freeway, even though spotlighting searches undertaken in adjacent forest habitat did not locate the species and few hollows occur in adjoining areas. The fact that habitat is not of high quality for this species in these areas leads to the suspicion that many of these roadkills may result from individuals taken from nearby suburbs and released into the park.

The survey area is very important for one threatened arboreal mammal species, the Eastern Pygmy-possum which is listed under the *TSC Act* and occurs in high densities compared to elsewhere within the Sydney Metropolitan CMA area (Tulloch 2003, DECC 2008a). During the survey only a single individual was spotlighted, perhaps due to the fact that tall heathland had low spotlight effort. However, a number of individuals were seen active or found as roadkills on the main roads through Royal NP (see Section 7.1.5) including in warm temperate rainforest in the Hacking River valley. Another threatened arboreal species, the Koala was recorded as a single individual in Girronba Swamp in Heathcote NP. There are a number of records of this species from the area, primarily in Heathcote NP and these individuals probably represent either rehabilitated released individuals (WIRES records) or wide-ranging individuals from the Campbelltown population (Ward and Close 2004), that is common along the Georges River, including in nearby areas of Holsworthy Military Area (DECC 2008a).

It is possible that an eighth arboreal mammal species, the Greater Glider, will be rediscovered in the future, but due to the fact that it was not located during the current or other recent surveys despite considerable targeted search effort, it is currently considered to be lost from the survey area (see Section 4.2.2).

4.3.7 Native terrestrial ground mammals

Ten native terrestrial mammal species are currently known from the survey area, not including the five species considered to have been lost (see Section 4.2). The current survey recorded all terrestrial mammal species that had been recorded in other recent broad-scale surveys (e.g. Andrew 2001, Tulloch 2003, DECC 2008a). Commonly recorded and widespread species found in virtually all vegetation communities were the Short-beaked Echidna and the Swamp Wallaby. Similarly, the Long-nosed Bandicoot was widespread but patchily distributed, with a number of roadkills recorded. Since Elliott and pitfall trapping was not conducted small mammals were mostly recorded by incidental observations, the location of roadkilled individuals and prey items within predator scats. The Brown Antechinus and Bush Rat were widespread, while the Swamp Rat was commonly observed in coastal heaths and wetlands. The Common Dunnart was found in three locations during diurnal herpetofauna searches or incidental log rolling: two sites on Thelma Ridge upslope of Little Garie Beach and one location in the Loftus Trig area. The only New Holland Mouse found during the current survey was roadkilled adjacent to heath on Bundeena Drive. Two mammal species were restricted to limited areas within Heathcote NP: scats and burrows of the Common Wombat were located at a number of sites adjacent to the Woronora Dam Road, while the Euro was only sighted on a rocky slope above the Woronora River downstream of Lake Eckersley. This macropod appears rare in the area; for example it was not recorded by Andrew (2001) and has not been observed by Park rangers (e.g. B. Sullivan, DECCW, pers. comm.). It is likely that individuals range across at times from a known population in the adjoining Holsworthy Military Area (DECC 2008a).

The Red-necked Pademelon is presumed extinct within the survey area. Photo © M. Schulz

The Southern Brown Bandicoot has recently been recorded in the Woronora Special Area and therefore could potentially be discovered

Leopard Seal hauled out on Jibbon Beach. Photo © M. Schulz

within the survey area. However, broadscale cage trapping and the use of hair tubes in past surveys has failed to locate this species (e.g. Andrew 2001). In the current survey this species was not detected in 104 predator scats collected. Although macropod species such as the Eastern Grey Kangaroo (*Macropus giganteus*) and Red-necked Wallaby (*M. rufogriseus*) were not recorded in the current survey, it is likely that they may range into the survey area after fires when the terrain is more open. Rangers undertaking night shoots for the Rusa Deer in southern parts of Royal NP have not reported sightings of small macropods (other than the Swamp Wallaby), with the exception of fleeting glimpses of a possible Red-necked Wallaby in the Red Cedar Flat area (e.g. B. Sullivan, DECCW, pers. comm.).

4.3.8 Bats

Seventeen species of bats have been recorded in the survey area, with one species, the Yellow-bellied Sheathtail-bat only known from a single dead specimen prior to the January 1994 wildfires (T. Rose cited in Andrew 2001). The occurrence of this species in the Sydney region is poorly understood and it is regarded as an extremely rare visitor/vagrant to the Sydney Metropolitan CMA area (DECC 2007c, 2008a).

In the current survey, the Grey-headed Flying-fox was observed across the area feeding on a range of canopy and subcanopy species, particularly figs, Red Bloodwood, Swamp Mahogany and the Heath-leaved Banksia during different seasons. No camps were located, although single individuals were encountered roosting in forest on the edge of Bundeena. Fifteen species of microbats were located from 64 sites sampled using harp traps and 76 sites sampled with Anabat ultrasonic detection. The most widespread species were the Gould's Wattled Bat and the Little Forest Bat, including in open heathland habitats without a eucalypt overstorey. Other species were patchily distributed across the area in a range of vegetation communities, such as the Gould's Long-eared Bat, the Eastern Freetail-bat and the Chocolate Wattled Bat. Species that had a more limited distribution included: the White-striped Freetail-bat which was scattered across Royal NP, with most records in or adjacent to the Hacking River valley, the Bulgo area and around Bundeena; the Large Forest Bat which was recorded in tall open forests and rainforest in the Hacking River valley and along the southern escarpment in Royal NP and adjacent to Friarbird Pool in Heathcote NP; and the Eastern Broad-nosed Bat which was recorded behind Werrong Beach, on the southern escarpment edge along the Cliff Track and along Bola and Kangaroo Creeks. The Eastern Horseshoe Bat occurred patchily in a wide range of forest types, with a maternity roost located in the Bola Creek area (S. Anyon-Smith, pers. comm., H. Parnaby, DECCW, pers. comm.). Other roosts located included Dingo Tunnel and a deep rock fissure adjacent to the Woronora River one and a half kilometres upstream of Heathcote Creek confluence in Heathcote NP and various locations in Royal NP including in caves west of Yenabilli Point, adjacent to Flat Rock Creek crossing and in a culvert underneath Lady Wakehurst Drive at the Palm Gully crossing.

The Gould's Wattled Bat is one of the most widespread bats in the survey area. © M. Schulz

The current survey located one species not previously recorded on the Atlas of NSW Wildlife, the Lesser Long-eared Bat. It was only trapped in Coastal Sand Apple-Bloodwood Forest at the beginning of Jibbon Fire Trail close to the eastern edge of Bundeena. It occurs in similar habitat in Kamay Botany Bay NP to the north (DECCW 2010a, 2011).

In addition to the Grey-headed Flying-fox the survey area is important for five threatened microbat species listed under the *TSC Act*, being the Little Bentwing-bat, Eastern Bentwing-bat, Large-eared Pied Bat, Large-footed Myotis and the Greater Broad-nosed Bat. No roosts of the Large-eared Pied Bat were located during the survey, however, it was captured in harp traps along the Hacking River downstream of Calala and along the Cliff Track south of Garawarra Farm. It was also recorded ultrasonically along Wises Track on a ridge above the

Hacking River. The Large-footed Myotis was trapped at five sites and recorded ultrasonically at an additional two sites, primarily along the Hacking River and Kangaroo Creek in Royal NP and at Mirang Pool on Heathcote Creek in Heathcote NP. No roosts were located of this species, but it has been recorded roosting in a nearby abandoned railway tunnel and an underground aqueduct in the Helensburgh area (DECC 2008a). In contrast, the Eastern Bentwing-bat was surprisingly uncommon given that roosts are similarly known to occur in underground aqueducts and railway and mine tunnels in the Helensburgh area/Stanwell Park area (DECC 2008a). It was trapped on the escarpment edge south of Garawarra Farm, adjacent to Bola Creek and in a gully adjacent to Red Cedar Flat South, while small roosts of this species were located in deep overhangs west of Yenabilli Point and in the abandoned Stanwell Park-Otford railway tunnel just south of the area. Similarly, the Greater Broad-nosed Bat appeared uncommon, with single individuals trapped along the Cliff Track south of Garawarra Farm in Royal NP and adjacent to Friarbird Pool on the Woronora River in Heathcote NP. This species was also recorded ultrasonically and spotlighted just after dusk on Wises Track in Royal NP. The Little Bentwing-bat was not recorded during the current survey. However, it is known to roost in the abandoned Stanwell Tops-Otford railway tunnel representing the most southerly known roost of this species (DECC 2008a). No individuals were located in the tunnel in March and May 2010 in the current survey. This species has also been identified from ultrasonic recordings along the Woronora Dam Road in March 2005 (DECCW 2010a). Although the records of the threatened East-coast Freetail-bat from the survey area are unconfirmed (Parnaby 2001), and therefore the species has not been included in the species inventory provided in this report, potential habitat does exist within the survey area and it is possible that further survey would confirm the bat's occurrence.

4.3.9 Freshwater aquatic and marine mammals

Neither of the freshwater aquatic species (Platypus and Water Rat) that have previously been recorded in the survey area is today confirmed to occur (see Section 4.2).

Various species of seals are occasionally found hauled out on the shoreline of Royal NP. An infrequently used haul out of the Australian Fur-seal is located on the rock platforms below Marley Head with rarely more than a single individual present, usually a large adult male. Fur-seals are regularly observed throughout the year (see Appendix 1) close inshore either feeding or floating on the surface with flippers extended into the air. The identity of these Fur-seals is unknown as Fur-seal species are difficult, if not impossible, to distinguish at sea (Shirihai 2007). The New Zealand Fur-seal has also been recorded hauled out in the survey area. The Subantarctic Fur-seal is recorded from nearby Wanda Beach in Bate Bay (DECCW 2010a) and may also occasionally occur in the survey area though it is not currently on the record. Very occasionally 'true' seals (Phocidae) from Antarctic and subantarctic waters come ashore to rest and are typically in poor condition. The most frequently recorded species is the Leopard Seal with one juvenile ashore during the survey period on Marley Beach on 10 July 2009 and probably the same individual at Jibbon Beach on 12 July 2009. Other seals recorded ashore in the area included a young male Southern Elephant Seal in September 1980 and from nearby beaches an adult female Crabeater Seal (*Lobodon carcinophagus*) came ashore at Dolans Bay opposite Maianbar in Port Hacking in July 1982 (DECCW 2010a).

Many visitors to Royal NP make for the sea cliffs to view the northward and southward migration of the Humpback Whale. Similar to the cliffs at Cape Solander in Kamay Botany Bay NP, the sea cliffs of Royal NP make for spectacular viewing of this species and others, such as occasional Southern Right Whales just off the rocks and pods of Short-beaked Common Dolphins heading north or south. Off the shoreline of Port Hacking, Indo-Pacific Bottlenose Dolphins are occasionally seen and there are several sight records of the Dugong, such as in September 1992 and April 1993 (DECCW 2010a). Although cetaceans are outside the scope of the current study, Appendix 1 outlines the incidence of occurrence of nine species of cetaceans that have been observed off the sea cliffs east of Bundeena in a three-year period between May 2007 and May 2010 (Schulz in prep. 1). Occasional cetaceans have been found washed ashore on the coastline of Royal NP and adjacent areas, including the Humpback Whale, Dwarf Minke Whale, Pygmy Sperm Whale, Dwarf Sperm Whale and the Indo-Pacific Bottlenose Dolphin (Appendix 1, DECCW 2010a, Robinson 1984, R. Haering, DECCW, pers. comm., M. Schulz, DECCW, pers. obs.).

The current status of the Platypus within the survey area is uncertain but at this stage the resident population appears to have been lost. Photo © M. Schulz

4.3.10 Introduced species

Introduced Birds

Eight species of introduced bird have been recorded that either have established populations within the survey area or range into the area from populations in adjacent urban settlements. None of these species are regarded as a significant threat to native wildlife in the area (Andrew 2001, DECCW 2010a). Neither the Rock Dove, Eurasian Blackbird nor Common Starling was observed during the current survey. Individual Rock Doves are occasionally recorded in the survey area, with occasional flights of racing pigeons observed overhead and very rarely as banded roadkilled individuals (Schulz and Madden in prep.). Rock Doves have not been recorded nesting in the sea cliffs (current survey, B. Sullivan, DECCW, pers. comm.) unlike in areas to the north such as in Kamay Botany Bay NP, and do not appear to be resident in the reserves. The Eurasian Blackbird is sporadically recorded, such as single birds along the Hacking River and in the Wattle Forest area at Audley in 2000 and 2001 (B. Sullivan, DECCW, pers. comm., DECCW 2010a). The Common Starling is restricted to urban fringe areas, with no colonies recorded nesting in the sea cliffs, also unlike in Kamay Botany Bay NP (DECCW 2011).

The Blackbird is a sporadic visitor but has the potential to become established in the moist forests of the Hacking River valley. Photo © M. Schulz

The remaining five species were recorded during the current survey, with most of these species restricted to the fringe of the reserves. In the current survey the House Sparrow was recorded in the camping area at Bonnie Vale and on the edge of Hinterland Riverflat Paperbark Swamp Forest in Bundeena Gully. The Common Myna was restricted to the fringe of forest habitat adjoining Heathcote Heights, Bonnie Vale, Bundeena, Stanwell Park and adjacent to Engadine Waterhole, while occasional individuals are seen elsewhere such as at Constables Point and Garie Beach (DECC 2008a, B. Sullivan, DECCW, pers. comm.). The Spotted Dove, although primarily restricted to bushland adjacent to urban areas such as Engadine and Helensburgh was recorded more than half a kilometre from the nearest dwelling in the Maianbar area, such as adjacent to Costens Point Fire Trail and in the Bundeena area such as on Jibbon Head. The Northern Mallard and Northern Mallard X Pacific Black Duck hybrids occasionally occur on the lower Hacking River and Kangaroo Creek at Audley and the lagoon at Bonnie Vale. The most widespread introduced bird species is the Red-whiskered Bulbul which in the current survey was recorded as occurring patchily along coastal sections of the area away from urban edges, such as behind Marley Beach, Curracurrang Gully, behind Little Garie, Era and Burning Palms Beaches, and in the Bulgo-Bald Hill area.

Introduced Mammals

Eleven species of feral mammals have been recorded in the survey area, with eight species included under the *TSC Act* as Key Threatening Processes. These species are the Fox, feral Cat, Rabbit, Rusa Deer, feral Dog, feral Pig, feral Goat, and Fallow Deer. However, Fallow Deer no longer occur in the area, and feral Goat only occur as dumped or escaped individuals with no evidence of an established population, such that both species have been removed from the species inventory provided in Appendix 5. The feral Dog has primarily been recorded from Heathcote NP (e.g. DECCW 2010a) mostly from the edge of urban areas. In the current survey the Dog was only recorded from scats and these may actually have originated from domestic Dogs. Feral Dogs are thus not likely to currently be having a significant impact on native fauna within the reserves. A small population of the feral Pig may occur in the Marley Swamp area, with one individual recently hit by a vehicle on Bundeena Drive (B. Sullivan, DECCW, pers. comm.). There is also a record of an animal sighted on the Coast Track in the Palm Jungle area in 1999 (DECCW 2010a). Given the restricted distribution and small number of records it is also considered unlikely that the Pig is having a significant impact on native fauna at this time.

The remaining four species are discussed in further detail in Section 5.3 of this report. The Rabbit also has a restricted distribution within the area, with most individuals in the current survey sighted along the edge of the Pacific Highway in the Loftus Oval area. After the 1994 wildfires, Rabbits were common in open areas on the coast south of Burning Palms (S. Anyon-Smith pers. comm.) and occasional individuals are still sighted in open treeless habitats south of South Era, including below Bald Hill (B. Sullivan, DECCW, pers. comm.). Additional localities in which this species has been recorded include along the powerline easement running through eastern Heathcote NP and on the Uloola Track (S. Anyon-Smith pers. comm., DECCW 2010a). The other three species: Fox, Cat and Rusa Deer are widespread

across the area, with only small numbers of Rusa Deer present in Heathcote NP. The feral Cat, judging by footprints located in sandy areas and the results from a roadkill study (Schulz and Madden in prep.), is thinly scattered across the area. Also encountered on a number of occasions were wide-ranging domestic Cats, including one individual with collar and bell attached observed hunting lizards west of Yenabilli Point over 300m from the closest dwelling on the outskirts of Maianbar.

Two feral mammal species not listed as Key Threatening Processes have been recorded in the area, the House Mouse and the Black Rat. These species have been recorded from scattered localities across the area, including in the current survey. Most records of both species were from the edge of urban areas or adjacent to disturbed areas, such as the tip off Sir Bertram Stevens Drive in Royal NP, along the powerline easement adjacent to eastern Heathcote NP and under dumped rubbish in the Garrawarra Hospital Reserve. An additional species, the Brown Rat (*Rattus norvegicus*) has been recorded in the Upper Hacking along the Hacking River upstream near Otford (DECCW 2010a) and is likely to occur within the survey area along the Hacking River and potentially on parts of the Port Hacking shoreline.

5 PRIORITY FAUNA SPECIES

5.1 FORMAT OF THE SPECIES PROFILES

Colour of the heading correlates to that used for animal groups in DECC (2007a) being amphibians, reptiles, diurnal birds, nocturnal birds, terrestrial mammals, arboreal mammals, bats and introduced species. Marine mammals are coloured differently as they are not included in DECC (2007a).

COMMON NAME		*Scientific name*
***EPBC Act*: Current listing**	***TSC Act*: Current listing**	**Survey Area: Management priority ranking**

Photo of the species and other relevant photographs.

Occurrence in the Survey area

This section details the species status in the survey area, the findings of the current survey, a summary of other 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 survey area to the regional conservation of the species.

Threats within the Survey area

In this section key threatening processes listed under the *TSC Act* and other threats relevant to the conservation of the species within the survey area are identified. For species that are rare visitors or are unconfirmed in occurrence no threats are identified.

Management Considerations

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

A map of known records of the species in the survey area, from the Atlas of NSW Wildlife, is provided; with only records having spatial accuracy of less than 100m incorporated. Records with a low reliability of identification and all records from the Birds Australia Atlas 1 with an accuracy of 10km and from the Birds Australia Atlas 2 with an accuracy of 1km or more have not been incorporated on the maps.

5.2 NATIVE SPECIES

GREEN AND GOLDEN BELL FROG		*Litoria aurea*
***EPBC Act*: Vulnerable**	***TSC Act*: Endangered**	**Priority in Area: Nil as suspected species loss**

Green and Golden Bell Frog. Photo © M. Schulz

Occurrence in the Survey Area

Suitable habitat occurs in small areas within the reserves. This species formerly occurred at Jibbon Lagoon, Marley Lagoon and on private lands in the vicinity of Helensburgh (McEntee 2005, DECCW 2010a). There have been no confirmed recent records since 1980 (DECCW 2010a). Similarly, this species was not located in the current survey despite targeting potential habitat in the Jibbon and Marley Lagoon areas after heavy rain in October and during the summer. This species has been proposed for re-introduction into Marley Lagoon (McEntee 2005).

Regional Conservation Significance

The Green and Golden Bell Frog was formerly widespread in the Sydney Basin Bioregion and was one of the most common frogs in Sydney (DECC 2007c, White and Pyke 1996). Today it is restricted to a small number of localities, many in areas outside of conservation reserves (McEntee 2005). The species' decline was first noted in the 1980s (Osborne 1990) and currently is limited to about 40 fragmented and isolated populations across the state (McEntee 2005). The survey area does not currently contribute significantly to the regional conservation of this species.

Threats in the Survey Area

Introduction of the Amphibian Chytrid Fungus; predation by feral Plague Minnow; and changes in water quality.

Management Considerations

- DECCW rangers and other staff to report any possible sightings or calls.
- Conduct further spring and summer surveys at Jibbon and Marley Lagoons after heavy rain, including the installation of automated voice recorders to sample frog calls nightly for a whole spring and summer period.

FREYCINET'S FROG *Litoria freycineti*

EPBC Act: Not Listed	*TSC Act*: Not Listed	Priority in Area: High

Freycinet's Frog. Photo © M. Schulz

Occurrence in the Survey Area

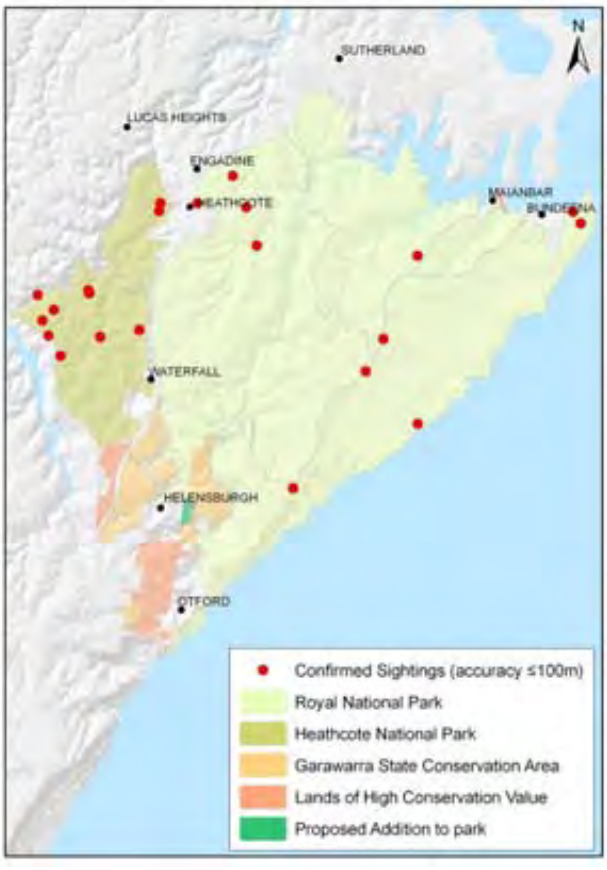
Common breeding resident, with suitable habitat throughout the reserves. Atlas of NSW Wildlife records several localities from across the survey area. In the current survey, this species was probably under-recorded due to the dry conditions and the low water table present during the course of the survey. It was detected at 15 locations within both Heathcote and Royal NP, with the species dominating frog choruses in some localities. This frog was predominantly recorded from Riparian Scrub, Heathland and Sydney Coastal Dry Sclerophyll Forest with a smaller number of records from Freshwater Wetland. Although no records were collected from Forested Wetland and Dune and Alluvial Sclerophyll Forest in the current survey it has been located in this community in previous years (e.g. M. Schulz pers. obs.).

Regional Conservation Significance

Freycinet's Frog is not listed as a threatened species under the *TSC Act* however it has been identified as a regionally significant species in this study. The reason for this priority listing is that it has significantly declined in northern parts of its range in north-eastern New South Wales and south-eastern Queensland (R. Goldingay, Southern Cross University, pers. comm., H. Hines, Queensland Dept of Environment and Resource Management, pers. comm.). Currently its population status within the Sydney Basin Bioregion is unclear, with it being considered common (Griffiths 2006); although in the Sydney Metropolitan CMA area it has a patchy distribution and was absent from a number of sites that appeared to support prime habitat (DECC 2008a). Due to the decline of this species elsewhere in the state and its poorly understood population trend within the bioregion, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Introduction of the Amphibian Chytrid Fungus; predation by the feral Plague Minnow; changes in water quality and hydrological regimes; habitat fragmentation; trampling of wetland vegetation by Rusa Deer; and predation by Foxes and Cats.



Management Considerations

- Ensure the current hydrological regime of wetlands, heath and seepages is maintained.
- Maintain and improve water quality of streams, including larger streams such as Heathcote and Kangaroo Creeks.
- Any DECCW works in remote wetlands that are rarely accessed to observe frog hygiene protocols to avoid the transmission of the Amphibian Chytrid Fungus (NPWS 2001a).
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Control wide-ranging domestic Cats adjoining urban areas.

GIANT BURROWING FROG *Heleioporus australiacus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Giant Burrowing Frog. Photo © M. Schulz

Giant Burrowing Frog. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon localised resident. The reserves include high quality habitat for this species. All records extracted from the Atlas of NSW Wildlife are situated in Royal NP, with the exception of an individual found on the edge of Girronba Swamp in Heathcote NP. In the current survey this species was under-recorded due to the dry conditions and the low water table present during the course of the survey. It was detected at 16 locations within Royal NP. No individuals were located in Heathcote NP despite targeted searches. In the current survey this frog was predominantly recorded from Sydney Coastal Dry Sclerophyll Forest and Heathland. It has also been encountered in Freshwater Wetlands, such as Uloola Swamp (e.g. M. Schulz pers. obs.). The Giant Burrowing Frog is occasionally roadkilled as is reflected in a three-year study between 2007 and 2010 in which five individuals were found (Schulz and Madden in prep.). The species was most frequently killed in January and February, accounting for 80 per cent of all records with all records from Sydney Coastal Dry Sclerophyll Forest and Heathland on Sir Bertram Stevens Drive and one on Farnell Avenue downslope from the regional DECCW office.

Regional Conservation Significance

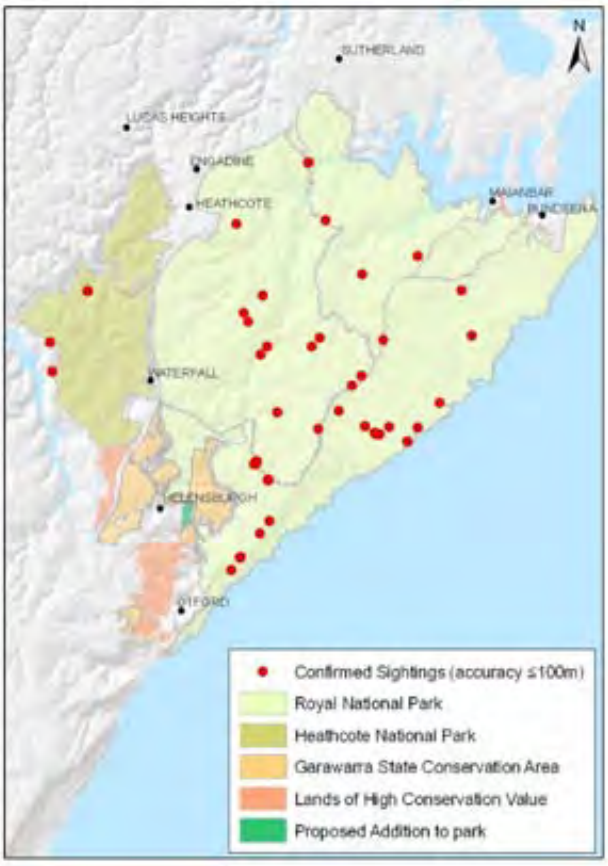
The Giant Burrowing Frog occurs patchily in sandstone areas across the Sydney Basin Bioregion, with the survey area supporting one of the highest densities in the region based on records in the Atlas of NSW Wildlife (DECC 2007c). Within this region the species is associated with Upland Swamps that contain pools of fish-free water and areas of deep sandy soil. Due to the survey area being a recognised hotspot, it contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Road/management trail construction and maintenance; introduction of the Amphibian Chytrid Fungus; changes in water quality and hydrological regimes; high fire frequency; habitat fragmentation; trampling of habitat by Rusa Deer; and predation by Foxes and Cats.

Management Considerations

- Ensure road and management trail works in the area will not impact this species.
- Protect the hydrological regime and water quality of streams, wetlands, heaths and seepages.
- Observe frog hygiene protocols (NPWS 2001a) during any DECCW works in known habitat.
- Protect areas of known habitat from high frequency fire where possible.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).



STUTTERING FROG		*Mixophyes balbus*
***EPBC Act*: Vulnerable**	***TSC Act*: Endangered**	**Priority in Area: Nil as suspected species loss**

Stuttering Frog. Photo © M. Schulz

Occurrence in the Survey Area

Considered to no longer occur although suitable habitat still exists in Royal NP. Several historic records are included in the Atlas of NSW Wildlife which note observations made in March 1954 and February 1963. It has not been recorded in recent surveys within the survey area (e.g. Andrew 1985b, 2001, Nolan 2006, DECC 2008a). Similarly in the Upper Hacking-Helensburgh area it was not recorded by White (1994), Astondoa (1995) and DECC (2008a). The only record since the 1994 wildfire was of tadpoles in Cawleys Creek in the Hacking River valley (Rice 1995) which were grown to metamorphlings. Subsequent visits to this location and other potential sites have failed to relocate the species (*Mixophyes* survey, A. White, K. Griffiths and G. Daly, pers. comm., DECC 2008a). In the current survey this species was targeted in a number of rainforest creeks, including Cawleys Creek by spotlighting and searching for tadpoles in January and February 2010. Similar to other recent surveys, no individuals were located.

Regional Conservation Significance

The disappearance of the Stuttering Frog from the survey area mirrors its dramatic decline in the southern portion of its range (Hunter and Gillespie 2006). This species is close to extinction in the wetter forests and rainforests of the Blue Mountains and Illawarra Escarpment (G. Daly cited in DECC 2007c). For example, an intensive search for this species in 1999-2000 in rainforest creeks along the Illawarra Escarpment from the Upper Hacking to Macquarie Pass only located the species in Macquarie Pass NP (NPWS 2002). Elsewhere within the bioregion it is principally known from the Watagan Mountains area on the Central Coast. It primarily occurs in creeklines with dense canopy cover. Due to the absence of recent records, the survey area does not contribute significantly to the regional conservation of this species. However, if this species is relocated, as with all other known localities within the Bioregion it would be of the highest conservation priority.

Threats in the Survey Area

Changes in water quality and hydrological regimes; introduction of the Amphibian Chytrid Fungus; loss of moist forest habitat through inappropriate fire regimes; and predation by Foxes and Cats.

Management Considerations

- Maintain and improve water quality and flow characteristics of rainforest streams.
- DECCW rangers and other staff to become familiar with this species and report any possible sightings.
- Conduct further summer surveys at Cawleys Ck and adjacent creeks in January-March.
- Protect Northern Warm Temperate Rainforest and Littoral Rainforest from fire.
- Observe frog hygiene protocols (NPWS 2001a) during any DECCW works in rainforest streams.
- Conduct Fox control in rainforest and adjacent wet sclerophyll forest.

RED-CROWNED TOADLET		*Pseudophryne australis*
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Red-crowned Toadlet. Photo © M. Schulz

Occurrence in the Survey Area

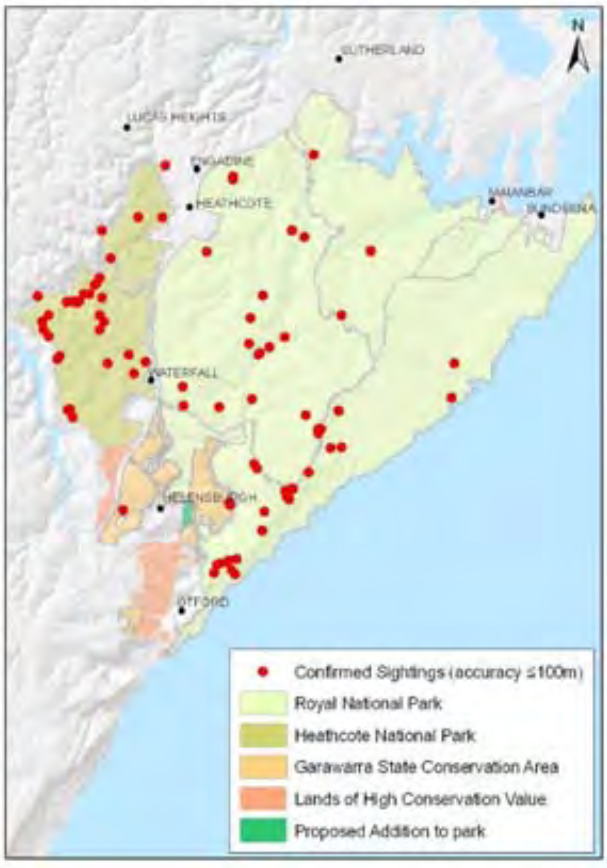
Uncommon localised resident. Large areas of suitable habitat. The species is known from all of the reserves in the survey area. In the current survey this species was probably under-recorded due to the dry conditions and the low water table present during the course of the survey resulting in little calling activity particularly during autumn. It was detected at 30 locations across the survey area, with 18 localities recorded in Heathcote NP. In the current survey this frog was predominantly recorded from Sydney Coastal Dry Sclerophyll Forest and Heathland, with a small number of records from Riparian Scrub, Dune and Alluvial Sclerophyll Forest and Littoral Rainforest patches on Lomandra-dominated headlands south of Burning Palms. This species frequently uses drains and runoffs on the edge of roads and management trails across the area e.g. a number of locations on Sir Bertram Stevens Drive and beneath the water pipeline on the Pipeline Track.

Regional Conservation Significance

The Red-crowned Toadlet is endemic to the Sydney Basin Bioregion, with recognised core areas on the Woronora Plateau, the current survey area and the Blue Mountains between Glenbrook and Blackheath (DECC 2007c). It favours sandstone areas with low soil fertility and a cover of Heath-leaved Banksia. This species has undergone declines in the region in the last 20 years, particularly in northern Sydney (Wells 2002). Within the area it is reported to have declined, notably in Heathcote NP (R. Wells pers. comm.). Due to the survey area being a recognised hotspot, it contributes significantly to its regional conservation.

Threats in the Survey Area

Low dispersal ability and high rates of reproductive failure (Thumm and Mahony 2002) make this species vulnerable to local extinction. Major threats: are road/trail/walking track construction and maintenance; habitat alteration due to high frequency fires; introduction of the Amphibian Chytrid Fungus; changes in water quality and hydrological regimes within Heathlands and Sydney Coastal Dry Sclerophyll Forest; trampling of seepage areas by Rusa Deer; predation by Fox and Cat; habitat fragmentation; disturbance of loose rock and bushrock removal.



Management Considerations

- Take measures to ensure that road, walking track and management trail works, including slashing, do not impact on this species.
- Ensure the current hydrological regime and water quality of seepages in heath and dry sclerophyll forest is maintained.
- Protect areas of known habitat from high frequency fire where possible.
- Observe frog hygiene protocols (NPWS 2001a) during any DECCW works in remote seepage areas.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Take measures to reduce the incidence of disturbance and destruction of loose rock as well as prevent removal of bush rock.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.

ROSENBERG'S GOANNA *Varanus rosenbergi*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Rosenberg's Goanna. Photo © M. Schulz

The Rosenberg's Goanna freezes when danger approaches. Photo © M. Schulz

Occurrence in the Survey Area

Large areas of suitable habitat. Unlike its close relative the Lace Monitor, this species does not scavenge for food at Bonnie Vale camping area or in picnic grounds. In the current survey this species was recorded from 14 locations, with the majority of records from Royal NP. It is likely to have been under-recorded as it is a shy species that is readily overlooked. It was recorded almost exclusively from Sydney Coastal Dry Sclerophyll Forest and Heathland. One sighting was made of an individual feeding on ripe fig fruits that had fallen on to the ground in Littoral Rainforest in Palm Jungle at least 200m straight-line distance from more open habitats. The presence of this species in such a habitat is unusual and suggests that it may at times utilise the full range of habitats across the survey area. The Rosenberg's Goanna freezes when approached by a perceived threat unlike the Lace Monitor which tends to run for the closest tree. As a result this species is frequently roadkilled as is reflected in a three-year study between 2007 and 2010 in which 12 individuals were found roadkilled, making it the second most commonly killed species listed under the *TSC Act* (Schulz and Madden in prep., Section 7.1.5). The species was most frequently killed in November and December, accounting for 67 per cent of all records with the majority of records in heathland sections of Bundeena and Sir Bertram Stevens Drives.

Regional Conservation Significance

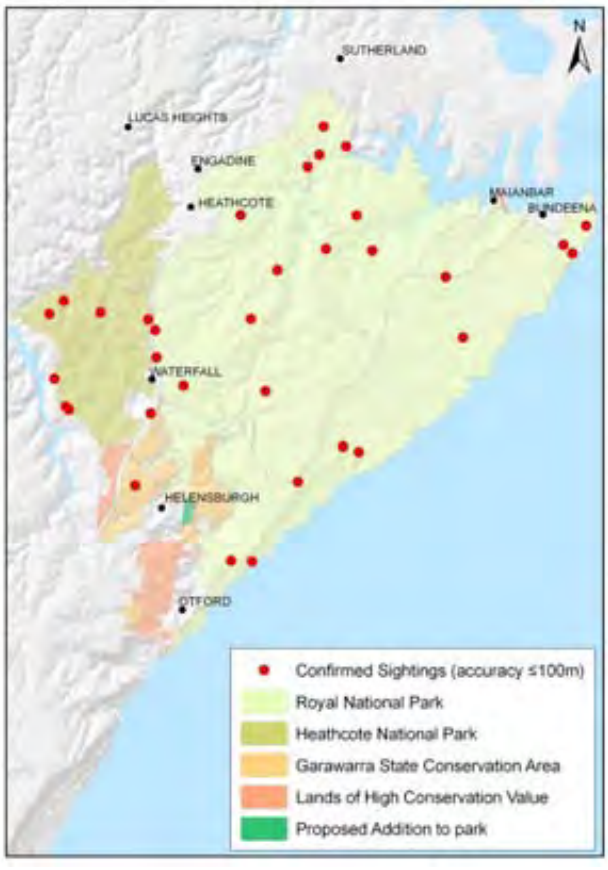
Royal NP and the Woronora Plateau form one of the most important population centres for the Rosenberg's Goanna in NSW (DECC 2007c). A predictive species habitat model (DECC 2007c) indicates a preference for ridgetops with high levels of rock and shrubs on flat ground. Due to its abundance and it being a recognised hotspot, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Road fatality; predation by feral and domestic predators; habitat fragmentation; consumption of Fox baits; removal of dead trees and fallen logs; potentially poaching activities; potentially secondary poisoning from Rabbit baiting.

Management Considerations

- Work with road traffic authorities to help reduce roadkills on major thoroughfares through the reserves.
- Minimise bait takes by this species by following Fox baiting protocols.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Avoid the removal of dead trees and fallen timber.
- Minimise the impact of domestic Dogs through regular patrols.
- If Rabbit baiting is considered, take steps to minimise impacts on Rosenberg's Goanna.
- Support research into the ecology of and threats to this species within the survey area.



BROAD-HEADED SNAKE *Hoplocephalus bungaroides*

***EPBC Act*: Vulnerable**	***TSC Act*: Endangered**	**Priority in Area: High**

Broad-headed Snake on the road in Royal NP. Photo © M. Schulz

Occurrence in the Survey Area

Patchy distribution of high quality habitat. This species was formerly locally common within the survey area, but today has disappeared from a number of localities e.g. along the top of the Bundeena sea cliffs (R. McLaggan, WIRES, pers. comm.). Due to pressure from illegal poachers no precise locations in which this species has been identified will be discussed. In the current survey this species was recorded from eight locations, with the majority of records from Royal NP. In the current survey it was recorded almost exclusively from Sydney Coastal Dry Sclerophyll Forest and Heathland, with additional records from Riparian Scrub. It is occasionally roadkilled during the summer months with two individuals found in summer on warm humid nights in a three-year study between 2007 and 2010 (Schulz and Madden in prep., Section 7.1.5).

Regional Conservation Significance

The Broad-headed Snake is endemic to the Sydney Basin Bioregion, with Royal NP and the Woronora Plateau recognised as hotspots (DECC 2007c). Important habitat elements within this region are sandstone outcrops, tree hollows and gullies (Webb and Shine 1997), with its distribution limited by its highly specific diurnal retreat sites (Pringle *et al*. 2003). Due to the area being recognised as a hotspot and the species' entire distribution being confined to the Sydney Basin Bioregion, the survey area contributes significantly to the regional and national conservation of this species.

Threats in the Survey Area

Illegal collection of the Broad-headed Snake and key prey species (Lesueur's Velvet Gecko and Copper-tailed Skink) and associated disturbance including displacement and/or destruction of rocks; inappropriate fire regimes (e.g. high frequency fires); the removal of hollow-bearing and dead trees; road fatality; night-time mountain biking; bush rock removal; habitat fragmentation and predation from introduced predators.

Management Considerations

- Maintain current public exclusion in sections of western Royal NP.
- Conduct regular patrols for illegal poaching activities including disturbance of rock.
- Encourage the public to report reptile-collecting or rock disturbance activities.
- Glean intelligence on poaching activities from reptile groups.
- Minimise high frequency fires.
- Avoid the removal of hollow-bearing and dead standing trees.
- Work with road traffic authorities to help reduce roadkills on major thoroughfares through the reserves.
- Restrict night-time mountain biking to tracks away from known localities.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.

FRECKLED DUCK *Stictonetta naevosa*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

The Freckled Duck is commonly found swimming amongst other waterfowl, frequently at long distances from the observer. Photo © M. Schulz

Marley Lagoon, the only locality the Freckled Duck has been recorded in the survey area. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

Vagrant. Small areas of suitable habitat. Not recorded during the current survey. The only documented record is of two individuals seen at Marley Lagoon during the 2002-2003 drought (Anyon-Smith 2006). These are not shown in the map below as they are not included in the Atlas of NSW Wildlife.

Regional Conservation Significance

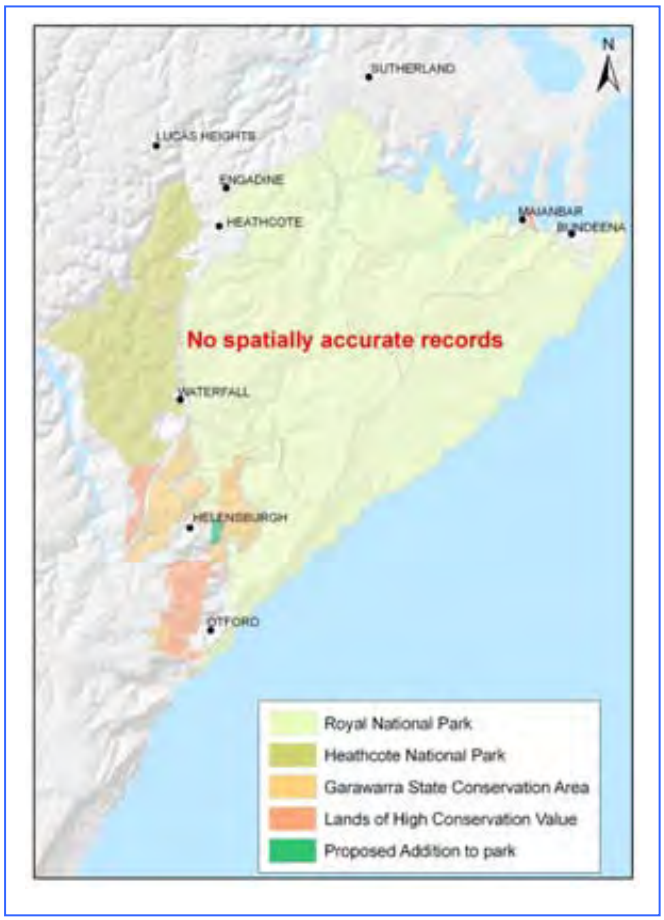
This species is a very rare visitor to the region, during periodic or severe drought in inland Australia. Its occurrence in the region is extremely sporadic. For example in the Sydney area it was recorded in 1897 and then not again until 1958 (Marchant and Higgins 1990, Hoskin *et al*. 1991). During the 2002-2003 drought there were a number of sightings of this species in the Illawarra area (Chafer 2004). At such times it opportunistically makes use of suitable habitat wherever it may find it. The survey area does not contribute significantly to the regional conservation of this species.

Threats in the Survey Area

Alteration in wetland hydrological characteristics.

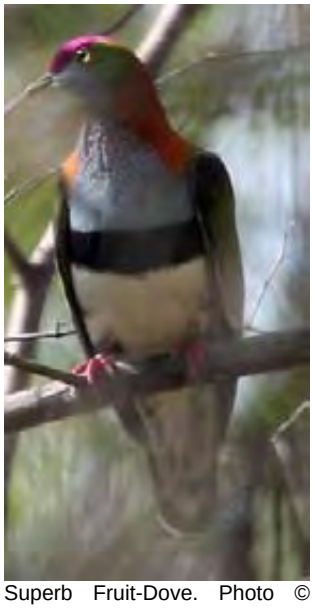
Management Considerations

- Maintain hydrological regime of Marley Lagoon and other coastal wetlands.



SUPERB FRUIT-DOVE *Ptilinopus superbus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**



Superb Fruit-Dove. Photo © DECCW

Occurrence in the Survey Area

Suspected that the species may once have been a more frequent seasonal visitor. Very rarely recorded and not confirmed for many years. Suitable habitat is present in the reserves within warm-temperate rainforest and wet sclerophyll forests. Not recorded during the current survey. The only documented record is of one individual recorded at Wattle Forest on the edge of the Hacking River in Royal NP in 2002 (Anyon-Smith 2006). This has not been mapped below as the record is not included within the Atlas of NSW Wildlife. Additionally, there is a record from close to the survey area at Fairview Avenue, Engadine in April 1995 (DECCW 2010a). Unless calling, this species is easily overlooked as it typically feeds in the canopy and its plumage makes it well camouflaged. Therefore, this species may occur more frequently than the lack of records suggests.

Regional Conservation Significance

This rainforest-dependent pigeon primarily occurs sporadically on the far north coast of New South Wales, with occasional records from urban areas on the coastal strip between Newcastle and southern Sydney. Many of the records from Sydney are of individuals that have flown into windows (Hoskin 1991, Chafer *et al.* 1999). This species is primarily sedentary or locally nomadic, with irregular irruptions (Recher *et al.* 1995) during which time individuals are most likely to turn up within the survey area. There are very few sightings of this species outside urban areas within this region. The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

Loss of moist forest habitat through inappropriate fire regimes.

Management Considerations

- Protect Northern Warm Temperate Rainforest and Littoral Rainforest from fire.

ROSE-CROWNED FRUIT-DOVE *Ptilinopus regina*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Low

Adult male Rose-crowned Fruit-Dove. Photo © M. Schulz

Occurrence in the Survey Area

Suspected that the species may once have been a more frequent seasonal visitor. Very rarely recorded and not confirmed for many years. Suitable habitat is present in the reserves within warm-temperate rainforest and wet sclerophyll forests. Not recorded during the current survey. Although no recent records were reported in Anyon-Smith (2006) a single record from the Atlas of NSW Wildlife at Lady Carrington Bower area along the Hacking River in Royal NP in May 1982. This record was spatially inaccurate and hence not included in the map. Unless calling this species is easily overlooked as it typically feeds in the canopy and its plumage makes it well camouflaged. Therefore, this species may occur more frequently than the lack of records suggests.

Regional Conservation Significance

This rainforest-dependent pigeon primarily occurs in north-eastern New South Wales, with only occasional records in the Sydney Basin Bioregion such as the northern suburbs of Wollongong (DECC 2007c). The majority of records in the region are between May and October (Chafer *et al*. 1999). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

Loss of moist forest habitat through inappropriate fire regimes.

Management Considerations

- Protect Northern Warm Temperate Rainforest and Littoral Rainforest from fire.

AUSTRALASIAN BITTERN	*Botaurus poiciloptilus*	
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Australasian Bittern. Photo © T.Shimba/DECCW

Jibbon Lagoon, the only locality the Australasian Bittern has been recorded in the survey area. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

The species was first recorded in the survey area during the current survey, with two records of single individuals flushed from Jibbon Lagoon in July and October 2009. After this period, Jibbon Lagoon completely dried up and during visits in December, January, February, April and May no further records were obtained. As a result it is uncertain as to whether the species is a visitor or resident of the area. No previous records are known from either Anyon-Smith (2006) or the Atlas of NSW Wildlife. This species is likely to have been overlooked prior to the current survey due to its nocturnal habits, frequenting wetland habitats that are difficult and unpleasant to traverse, and its probable sporadic occurrence. Care must be taken in identification of this species as it is commonly confused with the immature Nankeen Night Heron

Regional Conservation Significance

This secretive wetland species is rare and only occasionally recorded within the Sydney Basin Bioregion, with an increase in sightings during severe inland droughts (DECC 2007c). There are no documented breeding records for the region (Chafer *et al*. 1999). The majority of records adjacent to the survey area are to the north from the Kurnell Peninsula, including Towra Point Nature Reserve (DECC 2008a). Coastal wetlands are key habitat for the species. Within the bioregion these ecosystems are amongst the most heavily degraded. While the contribution the small areas present in the reserves makes toward the protection of the species is not well understood, it has been recommended that all known habitat in the region be considered sites of high conservation significance (DECCW 2007c).

Threats in the Survey Area

Alteration in wetland hydrological characteristics; predation of eggs and young by the Fox; inappropriate fire regimes; and grazing and trampling of vegetation by Rusa Deer (NPWS 1999, Garnett and Crowley 2000).

Management Considerations

- Aim to exclude Rusa Deer from Jibbon Lagoon.
- Maintain the current hydrological regime of Jibbon Lagoon.
- Undertake Fox control around Coastal Upland Swamps such as Jibbon Lagoon.
- Conduct targeted searches to increase understanding of occupation rates and habitat usage within the survey area.

BLACK BITTERN		*Ixobrychus flavicollis*
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Black Bittern. Photo © A. Taylor

Cabbage Tree Creek, the only locality the Black Bittern has been recently recorded in the survey area. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

The local status of this bird is uncertain as observations of this species are very rare. It is regarded as a vagrant by Anyon-Smith (2006), but the survey area is within the accepted distribution of the species. Small areas of suitable habitat are present in Royal NP. A single individual was recorded during the current survey, flushed from the tidal limits of Cabbage Tree Creek in Royal NP in January 2010. A nearby record was of a single individual at the junction of Forbes and Loftus Creeks in the Woronora River catchment in May 2007 (DECC 2008a). This species is likely to have been under-recorded prior to the current survey due to: a) its flighty nature, often disappearing before an observer makes a positive identification or simply being overlooked when other birds are present; b) commonly frequenting upper tidal and freshwater sections of watercourses that are typically not navigable by watercraft making the chance of encounter low; and c) its probable sporadic occurrence.

Regional Conservation Significance

This secretive wetland species is an uncommon and patchily distributed breeding visitor in the region, with the most regular sightings in Sydney region in the Deep Creek-Narrabeen Lake area (DECC 2008a). In the Illawarra the regional population is estimated at around 20 individuals, with most records from watercourses or adjacent lagoons lined with Swamp Oak or River Oak (*Casuarina cunninghamiana*) (Chafer *et al*. 1999). Coastal wetlands are key habitat for the species. Within the bioregion these ecosystems are amongst the most heavily degraded. While the contribution the small areas present in the reserves makes toward the protection of the species is not well understood, it has been recommended that all known habitat in the region be considered sites of high conservation significance (DECCW 2007c).

Threats in the Survey Area

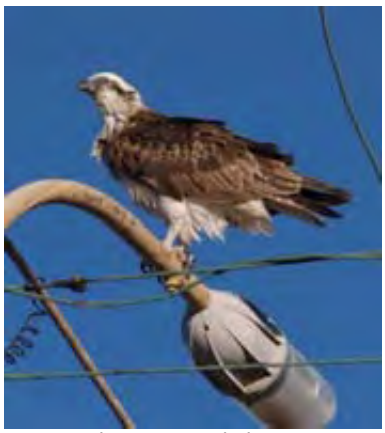
Habitat destruction, including the clearing of riparian vegetation; alteration in watercourse quality and flow characteristics; alteration in water quality and hydrological characteristics of lagoons associated with watercourses; predation of eggs and young by the Fox; the trampling of watercourse margins by Rusa Deer; and public disturbance, particularly in navigable sections of watercourses (Garnett and Crowley 2000).

Management Considerations

- Consider and ameliorate any potential negative impacts on water quality in the lower and mid reaches of streams flowing into Port Hacking.
- Avoid clearing of riparian vegetation in these streams.
- Conduct Rusa Deer control along these streams.
- Maintain current hydrological characteristics of watercourses and associated lagoons.
- Conduct targeted searches to increase the understanding of occupation rates and habitat usage, including in lower to mid freshwater sections of these streams.

OSPREY *Pandion haliaetus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**



Osprey. Photo © M. Schulz

The Osprey is occasionally observed in the Constable's Point area of Port Hacking. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

Rare visitor. Prior to 1900 a few pairs frequented Port Hacking (Hoskin *et al*. 1991). Currently, this species is typically encountered as single individuals in Port Hacking, with occasional sightings along the tidal lower reaches of the Hacking River (e.g. Anyon-Smith 2006, DECC 2008a). It is infrequently sighted, principally during calm conditions along the ocean shoreline of Royal NP, such as along the Bundeena sea cliffs, Marley and Wattamolla Beaches (DECCW 2010a, M. Schulz pers. obs.). In the current survey single individuals were observed along the Port Hacking shoreline west of Yenabilli Point in January 2010 and at Red Jacks Point in March 2010. This species is regularly observed in the lower reaches of the Georges River to the north, such as around the junction of the Woronora River (DECC 2008a, D. Andrew, DECCW, pers. comm.). A colour banded individual in this area was banded as a chick on the Clarence River, near Grafton (D. Andrew, DECCW, pers. comm.). The individuals occasionally observed in the survey area may be the same individuals as those regularly seen in the lower Georges River.

Regional Conservation Significance

This distinctive raptor occurs infrequently mainly as single individuals or pairs scattered primarily in coastal estuaries and waterways within the Sydney Basin Bioregion. There are few nesting records, with the exception of a pair that has nested on a number of occasions in the Narrabeen Lake area (DECC 2008a).

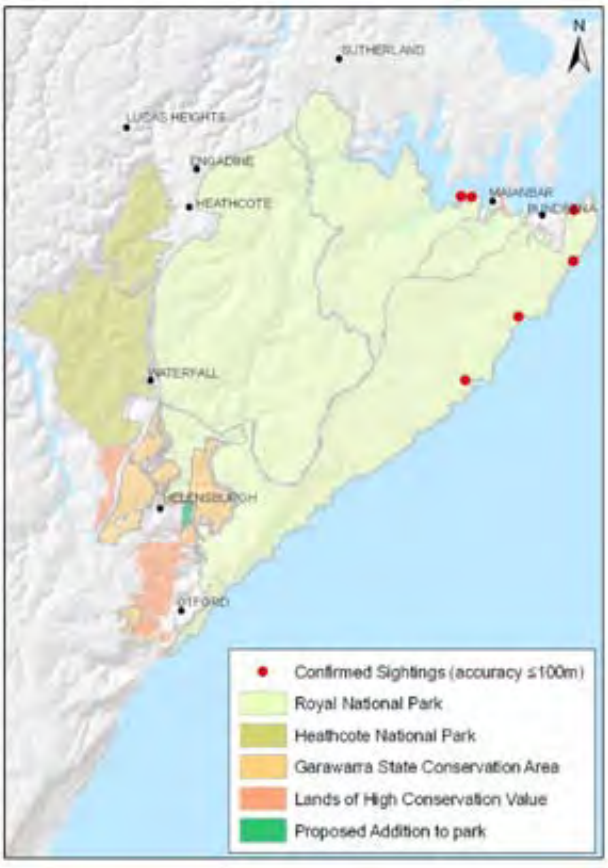
The survey area does not contribute significantly to the regional conservation of this species.

Threats in the Survey Area

Disturbance by the public to roosting birds, both in trees lining the Port Hacking foreshore and on Constables Point; and domestic Dogs, particularly at Constables Point.

Management Considerations

- Investigate ways to reduce disturbance by the public on Constables Point at high tide.
- Regular enforcement to reduce Dog disturbance in the Constables Point area.



SQUARE-TAILED KITE *Lophoictinia isura*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Low

Square-tailed Kite. Photo © T. Tarrant

The Square-tailed Kite has been seen flying over Northern Hinterland Wet Sclerophyll Forest in the Loftus Trig area. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

Rare visitor to forests within the area, with the most recent record along Farnell Avenue near the Regional Office in Royal NP (Anyon-Smith 2006, S. Anyon-Smith pers. comm.). Not recorded during the current survey. There are also several records from adjacent areas such as south of Helensburgh, the Woronora Special Area and the western section of Holsworthy Military Area (DECC 2008a, DECCW 2010a). There are no records with high spatial accuracy from within the survey area in the Atlas of NSW Wildlife. As a result species locality can not be plotted on the map below.

Regional Conservation Significance

There are only scattered records of this species from the Greater Southern Sydney Region (DECC 2007c) and the Sydney Metropolitan CMA area (DECC 2008a). This species is regarded as a very rare straggler to the Sydney region (Hoskin *et al*. 1991), although sightings have increased in recent years (DECC 2008a). Since this species can readily be confused with some other medium-sized raptors such as the Little Eagle it is possible it has been under-recorded within the survey area. The survey area does not contribute significantly to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

SPOTTED HARRIER *Circus assimilis*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Spotted Harrier. Photo © M. Schulz

A Spotted Harrier hunting over heathland inland of Providential Head, Royal NP. Photo © M. Schulz

Occurrence in the Survey Area

Rare visitor, with recent records from Royal NP along Wises Track, near Wattamolla, heathland inland of Providential Head, Jibbon Lagoon and on Bundeena Drive (Anyon-Smith 2006, M. Schulz pers. obs.). Not recorded during the current survey. There are very few records from adjoining areas (e.g. DECCW 2010a).

Regional Conservation Significance

Prior to 1900 the Spotted Harrier was recorded as “not uncommon” in marshy areas around Sydney (Hoskin *et al*. 1991). Today there are only scattered records of the Spotted Harrier from the Sydney Basin Bioregion, with occasional influxes particularly in late summer or autumn (Marchant and Higgins 1993). There was a 47 per cent decrease in the reporting rate of this bird between 1984 and 2002 across the nation (Barrett *et al*. 2003). The number of sightings within Royal NP has led to a suggestion that this species may be resident (Anyon-Smith 2006). However, the paucity of recent sightings, such as in the current survey strongly suggests this species is not resident. The species can be confused with the much more common Swamp Harrier and all sight records require confirmation. The survey area does not contribute significantly to the regional conservation of this species.

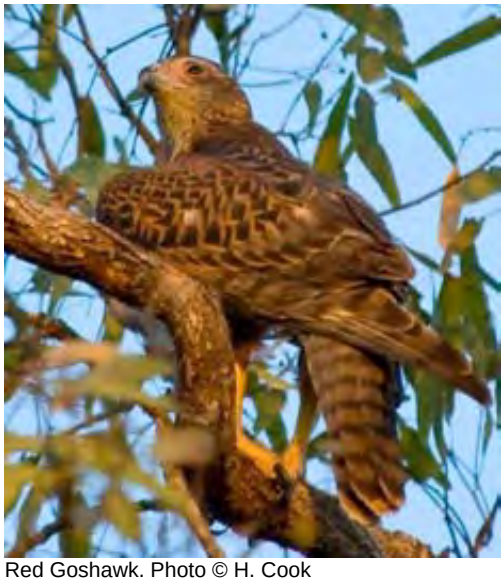
Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

RED GOSHAWK	*Erythrotriorchis radiatus*	
***EPBC Act*: Vulnerable**	***TSC Act*: Critically Endangered**	**Priority in Area: Nil as inaccurate record**



Red Goshawk. Photo © H. Cook

Occurrence in the Survey Area

Only noted by a single unconfirmed record from Wattamolla in Royal NP held in the Atlas of NSW Wildlife. Not recorded during the current survey or by Anyon-Smith (2006). There are no confirmed records from adjoining areas.

Regional Conservation Significance

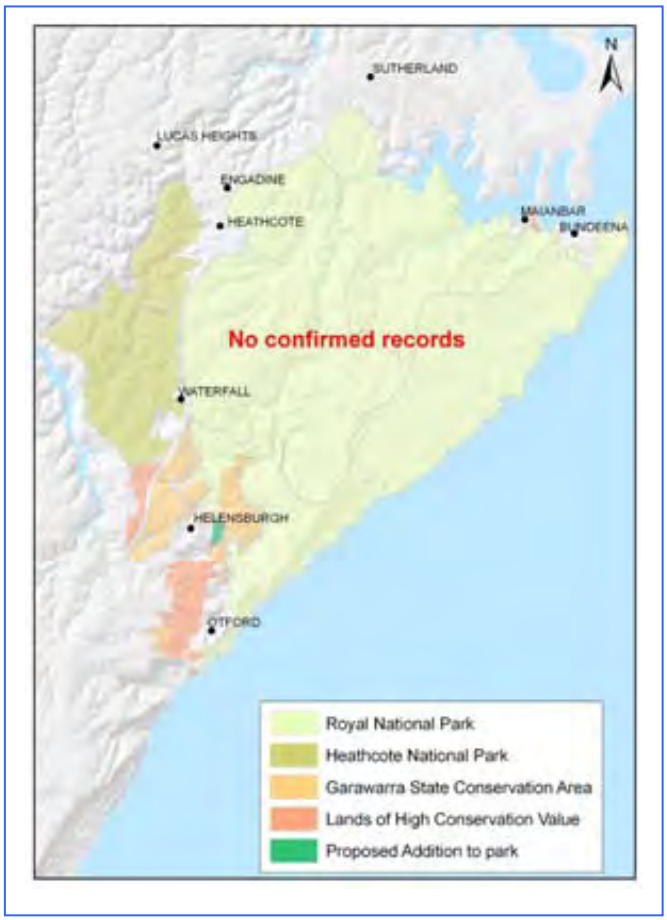
There is only one confirmed record from the region, being of two specimens collected 'near Sydney' soon after European settlement (Hoskin *et al*. 1991, Marchant and Higgins 1993). Since this species is virtually unknown from the region and can readily confused by inexperienced observers with other raptors such as the Swamp Harrier, Little Eagle, Square-tailed Kite and Brown Falcon any sightings must be submitted for review by the Birds Australia Rarities Committee (BARC) (http://www.tonypalliser.com/barc/barc-home.html) before being accepted as occurring within the survey area. The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

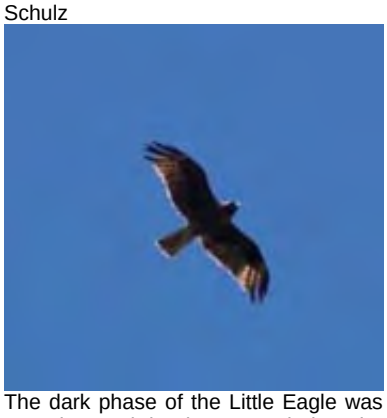
No management required.



LITTLE EAGLE *Hieraaetus morphnoides*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Moderate

Light phase Little Eagle. Photo © M. Schulz



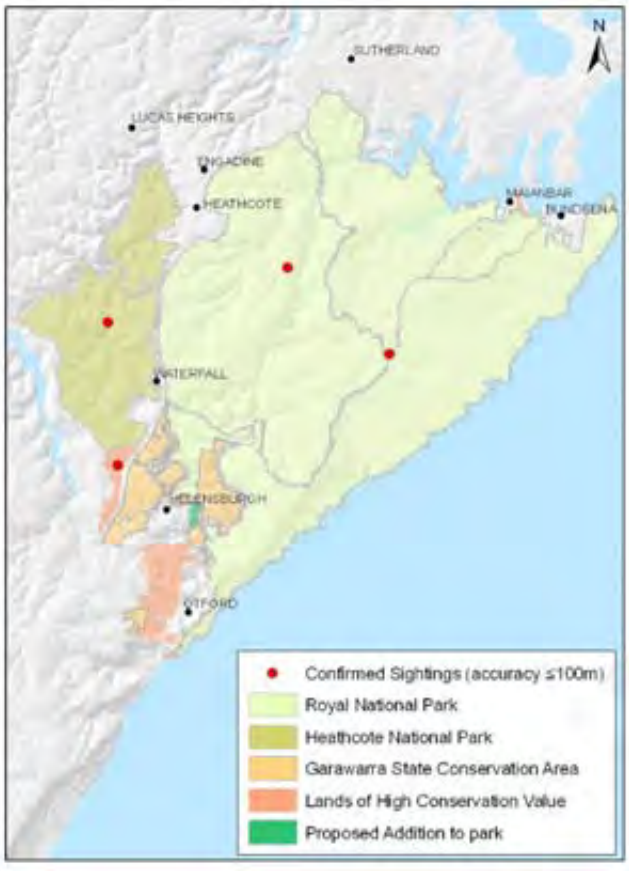
The dark phase of the Little Eagle was not observed in the area during the current survey. Photo © M. Schulz

Occurrence in the Survey Area

Rare breeding resident. The species was formerly a rare visitor but after the 1994 wildfires became a breeding resident with successful nesting near Jersey Spring in Royal NP in 2005 (Anyon-Smith 2006). During the current survey single light phase individuals were observed at the lookout on Bullawaring Track in Heathcote NP, adjacent to the freeway in Garawarra SCA, and two locations in Royal NP, Gurrumboola Ridge west of Uloola Track and adjacent to Bundeena Drive. All records were either from Sydney Coastal Dry Sclerophyll Forest or Heathland. This species may have been under-recorded in the past due to the difficulty many observers have in separating it from the more common Whistling Kite (*Haliastur sphenurus*).

Regional Conservation Significance

The range of this species has been suggested to have extended in south-eastern Australia following the introduction and expansion of the Rabbit (Marchant and Higgins 1993). However, there was a 14 per cent decrease in the reporting rate of this bird between 1984 and 2002 across the nation (Barrett *et al*. 2003). This species is scattered across the Sydney Basin Bioregion in small numbers, with the majority of sightings in woodlands often adjacent to open areas on near-coastal plains and foothills. Due to the small number present (i.e. possibly a resident pair with occasional additional individuals ranging across the area) the survey area does not significantly contribute to the regional conservation of this species. Since the predominant dietary item is the Rabbit (Marchant and Higgins 1993), this species is likely to be more prevalent within the survey area for a period of years following wildfire and other disturbance events when Rabbit numbers are higher and then gradually diminish in numbers as Rabbit populations decline. The species is frequently mistaken for the more common Whistling Kite (Hoskin *et al*. 1991).



Threats in the Survey Area

Habitat destruction, including the removal of nest trees which may be used in successive or subsequent years (Marchant and Higgins 1993); the loss of nest trees through fire; and secondary poisoning from Rabbit baiting.

Management Considerations

- Protect known nest trees, including during hazard reduction burning operations.
- If Rabbit baiting is to be considered, assess and take steps to minimise impacts on Little Eagle.

GREY FALCON		*Falco hypoleucos*
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Grey Falcon. Photo © M. Schulz

Occurrence in the Survey Area

Two unconfirmed records from Gurrumboola Ridge and Era Beach areas in February 2001 (DECCW 2010a). Not recorded during the current survey or by Anyon-Smith (2006). There is one unconfirmed record from north-west of Helensburgh outside the survey area in May 2007 (e.g. DECCW 2010a). It is considered that these records either represent mis-identifications for the much more common grey phase of the Grey Goshawk or the records were incorrectly coded when entered into the Atlas of NSW Wildlife.

Since this species can readily confused by inexperienced observers with other raptors such as the grey morph of the Grey Goshawk, caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

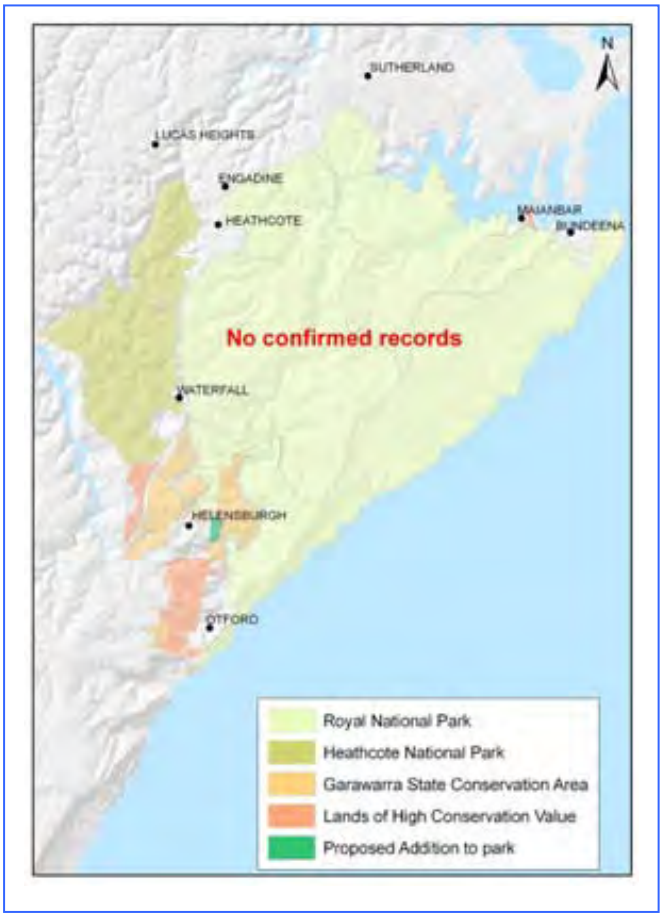
The Grey Falcon is a species of semi-arid and arid areas and is a vagrant east of the Great Dividing Range, including the County of Cumberland (Hoskin *et al*. 1991). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



BUSH STONE-CURLEW *Burhinus grallarius*

***EPBC Act*: Not Listed**	***TSC Act*: Endangered**	**Priority in Area: Nil as locally extinct**

Bush Stone-curlew. Photo © M. Schulz

Occurrence in the Survey Area

Locally extinct in the survey area, with the last confirmed record in 1938 (Anyon-Smith 2006). Small areas of suitable habitat remains present.

There is one unconfirmed record on the Atlas of NSW Wildlife from the Bonnie Vale in May 1998. This is suspected to be a data entry error probably arising from observations of the closely named Beach Stone-curlew, an unusual visitor in 1998.

Regional Conservation Significance

The Bush Stone-curlew has declined in abundance and reduction in range across New South Wales. This 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 Water, and scattered resident individuals at Careel Bay on Pittwater and at Orchard Hills on the Cumberland Plain (DECC 2007c, 2008a). The reserves do not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

BEACH STONE-CURLEW *Esacus neglectus*

***EPBC Act*: Not Listed**	***TSC Act*: Critically Endangered**	**Priority in Area: Low**

Beach Stone-curlew. Photo © T. Sugiyama/DECCW

Occurrence in the Survey Area

Vagrant. One individual observed at Era Beach and tidal flats adjacent to Bonnie Vale and Constable Point over a number of months in 1998 (Anyon-Smith 2006, DECCW 2010a).

Regional Conservation Significance

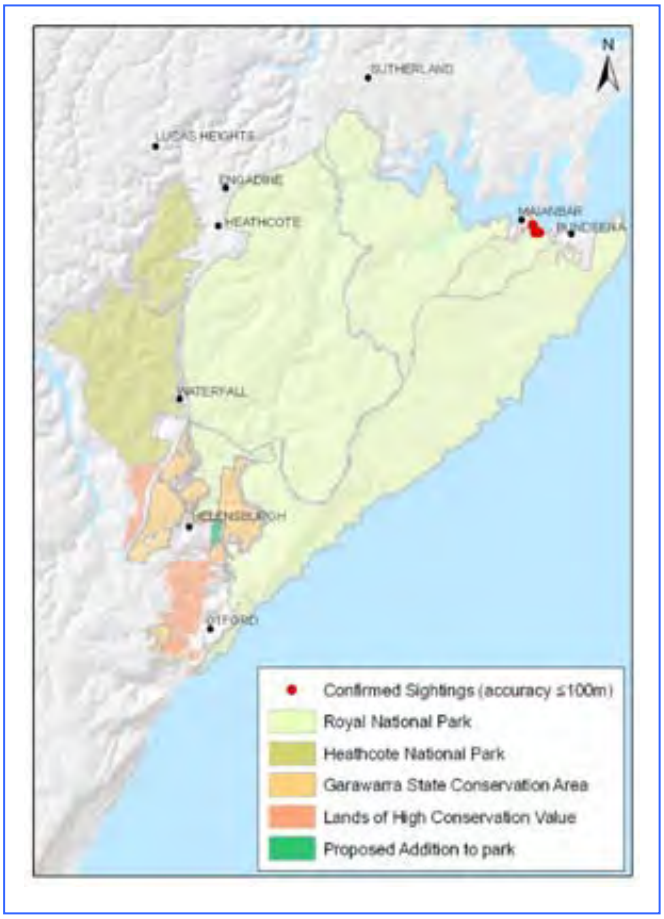
The Beach Stone-curlew occurs in small numbers on beaches and river entrances in far north-eastern New South Wales and is a vagrant to the Sydney region (Marchant and Higgins 1993). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



PIED OYSTERCATCHER *Haematopus longirostris*

***EPBC Act*: Not Listed**	***TSC Act*: Endangered**	**Priority in Area: Moderate**

Pied Oystercatcher. Photo © M. Schulz

Occurrence in the Survey Area

Irregular visitor. This species is irregularly observed resting on Constables Point and feeding on adjacent intertidal flats off Maianbar and in the Cabbage Tree Basin area of Port Hacking (Anyon-Smith 2006, DECC 2008a, A. Carrick, pers. comm.). In this area, it is normally seen in groups of one to three individuals, with a maximum of six individuals seen in 2007 and 2009 (DECC 2008a, A. Carrick, pers. comm.). It is very rarely seen at Jibbon Beach and is a rare visitor to the ocean beaches within Royal NP (e.g. M. Schulz pers. obs., DECCW 2010a). This species was not recorded during the current survey, although no systematic surveys were undertaken in the Constables Point-Maianbar area. Numbers of this species are monitored as a component of the Botany Bay Wader Monitoring Program by the New South Wales Wader Study Group and on national count days as part of Birds Australia National Shorebirds 2020 Monitoring Program. There are no recent nesting records, although suitable habitat exists in the Constables Point area and on ocean beaches backed by sparsely vegetated primary sand dunes, such as at Marley Beach. It is likely that nesting no longer occurs due to the high levels of public visitation to such areas, in addition to trampling of nests by Rusa Deer and predation of eggs and chicks by various predators. In the advent of reduced disturbance on Constables Point it is possible that individuals may take up residence.

Regional Conservation Significance

The Pied Oystercatcher is confined to beaches and embayments along the entire New South Wales coastline. However, it has declined through much of this range, probably as a result of human disturbance. Within the region it occurs in small numbers, with a small breeding population present in Botany Bay where it has been recorded nesting in a number of locations, such as Towra Spit Island (DECC 2008a). In Botany Bay, numbers peak between mid-autumn and mid-winter with a maximum of 71 individuals counted (NSW Wader Study Group count data). The Constable Point HCV lands provide important habitat for this species, and thus though sighting numbers are currently low in the survey area it is considered to contribute to the regional conservation of the species.

Threats in the Survey Area

Disturbance by the public and domestic Dogs, particularly at Constables Point when roosting at high tide with no alternative roosts; and predation by the Fox.

Management Considerations

- Encourage and work with local government to find ways to reduce disturbance by the public at high tide roost on Constables Point, including regular enforcement to reduce domestic Dog disturbance.
- In the event of nesting follow the best-practice guidelines of managing threatened beach-nesting shorebirds in NSW (DECC 2008d).
- Support continued monthly monitoring of waders in the Constables Point-Bonnie Vale area.

SOOTY OYSTERCATCHER *Haematopus fuliginosus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Moderate**

Sooty Oystercatcher. Photo © M. Schulz

Occurrence in the Survey Area

Regular visitor. This species occurs regularly in small numbers, principally in the non-breeding season between mid-autumn and late winter on intertidal rock platforms and occasionally adjacent ocean beaches along the Royal NP coastline. Occasionally it occurs as single individuals or pairs on the rocky shoreline in the Jibbon Beach area and on the intertidal flats at Bonnie Vale (Anyon-Smith 2006, M. Schulz pers. obs.). Maximum numbers recorded were of 11 individuals on exposed rock platforms in the Little Marley Beach area in August 2010 and 12 individuals on the rock platform at Bulgo in June 2007 (both sightings M. Schulz pers. obs.). This species has not been recorded nesting within the survey area (e.g. Anyon-Smith 2006, M. Schulz pers. obs.). During the current survey this species was recorded as single individuals or pairs at Jibbon Beach, Jibbon Head, Boy Martin Point and the reef platform at Bulgo. This species occurs in larger numbers on the north side of Bate Bay in the Merries Reef/Boat Harbour area, with a maximum of 23 individuals recorded (NSW Wader Study Group count data) and on reef platforms adjacent to the northern suburbs of Wollongong with up to 32 individuals recorded (M. Schulz pers. obs.). Numbers of this species are monitored as a component of the Botany Bay Wader Monitoring Program by the New South Wales Wader Study Group and on national count days as part of Birds Australia National Shorebirds 2020 Monitoring Program. However, these counts do not cover intertidal rock platform areas seldom used by other species of waders, such as along the Royal NP coastline, resulting in local population trends of this species being poorly understood.

Regional Conservation Significance

The Sooty Oystercatcher is confined to rocky shorelines and adjacent beaches and embayments along the entire New South Wales coastline. Within the region it occurs in small numbers, principally as a non-breeding visitor (e.g. Chafer *et al*. 1999). The closest nesting location is on the Five Islands south of Wollongong. Currently suitable habitats within the survey area are regularly used by a small number of non-breeding birds. As a result Royal NP is moderately important to the regional conservation of this species.

Threats in the Survey Area

Disturbance by the public, particularly rock fishermen; disturbance by domestic Dogs, when individuals occur on parts of the Port Hacking shoreline; and hydrological changes to shorelines.

Management Considerations

- Erect wildlife awareness signs at key foraging/resting sites, in particular the rock platform at Bulgo and in the Jibbon Head/Shelly Beach area.
- Regular enforcement to reduce Dog disturbance in the Jibbon Beach/Jibbon Head area.
- Support continued monthly monitoring of shorebirds in the Constables Point-Bonnie Vale area.

LESSER SAND-PLOVER *Charadrius mongolus*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Nil as inaccurate record

Lesser Sand-plover. Photo © T. Sugiyama/DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006) and has not been recorded in regular shorebird counts in the Constables Point-Maianbar area (A. Carrick, pers. comm.). The only records in the Atlas of NSW Wildlife are from the Birds Australia Atlas 1 with records of 10km accuracy. It is considered that these records were actually from the Boat Harbour/Merries Reef area on the north side of Bate Bay where this species is an occasional summer visitor with a maximum recent number of 38 individuals recorded in March 1992 (DECC 2008a).

It is likely that the species once utilised the survey area but no longer does. Potential habitat is present on the sand flats in the Deeban Spit area, off Maianbar and Bonnie Vale. It is likely that at the turn of last century these species occasionally occurred in Port Hacking as alternate foraging areas to those on the Kurnell Peninsula. However, due to the very high level of disturbance in Port Hacking small to medium-sized waders are now exceptionally rare if seen at all. Due to the marked decline in this species across the eastern seaboard it is highly unlikely that these species would occur today even though potential habitat is present.

Regional Conservation Significance

The Lesser Sand-plover principally occurs in littoral and estuarine environments in scattered localities along the New South Wales coastline. It is uncommon in the region and numbers appear to have declined in recent decades, similar to other localities such as in the Newcastle region. There was a greater than 20 per cent decrease in the reporting rate of this bird between 1984 and 2002 in this bioregion and 37 per cent nationally (Barrett *et al*. 2003). The survey area does not contribute to the regional conservation of this species. This species can readily be confused with the more common Double-banded Plover that occurs in small numbers on Constables Point and occasionally on ocean beaches, particularly Marley Beach.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

AUSTRALIAN PAINTED SNIPE *Rostratula australis*

***EPBC Act*: Vulnerable**	***TSC Act*: Endangered**	**Priority in Area: Nil as inaccurate record**

Australian Painted Snipe. Photo © T. Shimba /DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006). The only records in the Atlas of NSW Wildlife are from the Birds Australia Atlas 1 with records of 10km accuracy. It is considered that these records were actually from the Kurnell Peninsula where the species has been recorded in Towra Point NR (Hoskin *et al.* 1991).

Snipe generally flush from dense cover surprising the observer and resulting in typically only brief glimpses as the bird flies rapidly out of sight. Under such circumstances this species can be readily confused with the more common Latham's Snipe which occurs in small numbers in swampy situations within the survey area. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

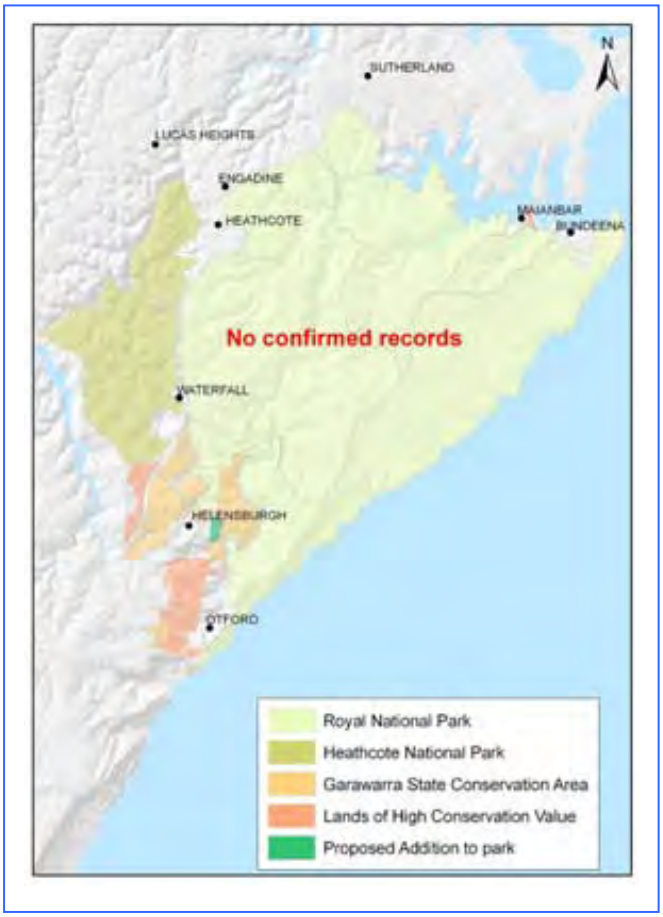
The Australian Painted Snipe is an extremely rare visitor to the Sydney Basin Bioregion (Hoskin *et al*. 1991, Chafer *et al*. 1999). It primarily occurs in freshwater wetlands with dense vegetative cover and exposed mud flats. The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



BLACK-TAILED GODWIT *Limosa limosa*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Nil as inaccurate record

Black-tailed Godwit. Photo © R. Bennett/DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006) and has not been recorded in regular shorebird counts in the Constables Point-Maianbar area (A. Carrick, pers. comm.). There is one unconfirmed record from Bonnie Vale in November 1998 (DECCW 2010a). Additionally, there are two records in the Atlas of NSW Wildlife from the Birds Australia Atlas 1 with records of 10km accuracy. It is considered that these records were actually from the Kurnell Peninsula, such as Towra Point NR where this bird is a rare visitor (DECC 2008a).

This species can readily be confused with the more common Bar-tailed Godwit that occurs regularly in small numbers on Constables Point and adjacent intertidal flats. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

The Black-tailed Godwit principally occurs in sheltered bays, estuaries and lagoons in scattered localities in coastal New South Wales. It is a rare summer migrant across the state and within the region it is a rare visitor (e.g. Chafer *et al*. 1999). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

TEREK SANDPIPER *Xenus cinereus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Terek Sandpiper. Photo © T. Sugiyama/ DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006) and has not been recorded in regular shorebird counts in the Constables Point-Maianbar area (A. Carrick, pers. comm.). There is one unconfirmed record from the Hacking River valley upstream of Jersey Spring in January 1983 (DECCW 2010a). Since this species almost exclusively occurs on intertidal mudflats the location of this record is questionable. This record has an accuracy of 1km and is either the result of data entry error, mis-identification or originated from the Kurnell Peninsula, where the species is an uncommon visitor (DECC 2008a).

Regional Conservation Significance

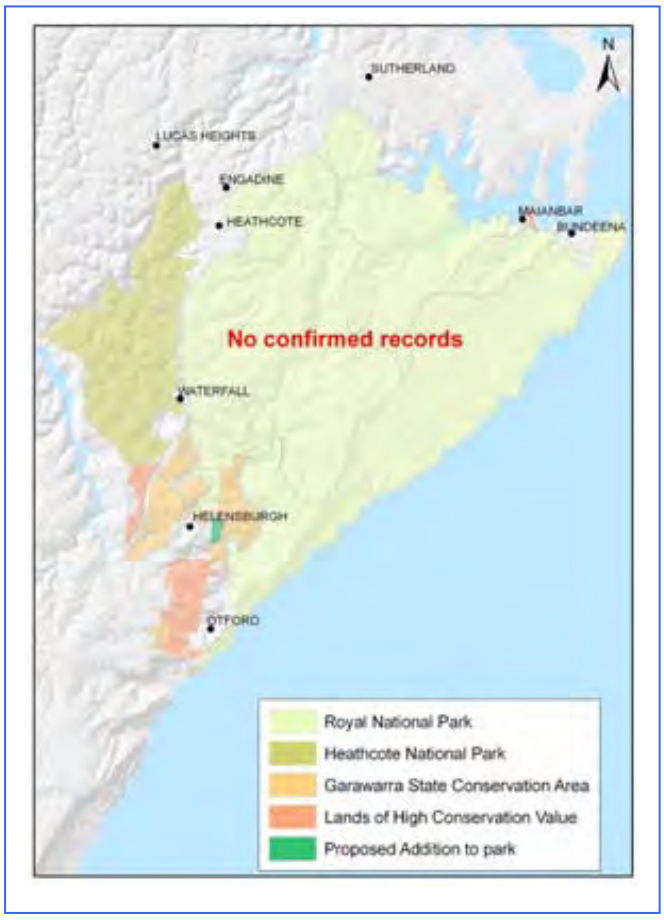
The Terek Sandpiper principally occurs on intertidal mudflats in sheltered bays, estuaries and lagoons in scattered localities in coastal New South Wales. It is an uncommon summer migrant principally to north-eastern New South Wales and within the region it is an uncommon to rare visitor (e.g. Chafer *et al*. 1999. DECC 2008a). Regular shorebird counts in Botany Bay indicate that this species is declining (NSW Wader Study Group count data). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



GREAT KNOT *Calidris tenuirostris*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Great Knot. Photo © T. Shimba/DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006) and has not been recorded in regular shorebird counts in the Constables Point-Maianbar area (A. Carrick, pers. comm.). The only records in the Atlas of NSW Wildlife are from the Birds Australia Atlas 1 with records of 10km accuracy. It is considered that these records were actually from the Boat Harbour/Merries Reef area on the north side of Bate Bay where this species is a rare visitor or from Towra Spit Island in Botany Bay where this species occurs irregularly in small numbers (DECC 2008a).

It is likely that the species once utilised the survey area but no longer does. Potential habitat is present on the sand flats in the Deeban Spit area, off Maianbar and Bonnie Vale. It is likely that at the turn of last century these species occasionally occurred in Port Hacking as alternate foraging areas to those on the Kurnell Peninsula. However, due to the very high level of disturbance in Port Hacking small to medium-sized waders of any species are now exceptionally rare if seen at all.

This species can readily be confused with the more common Red Knot (*Calidris canutus*) that occurs in small numbers in Botany Bay and occasionally at Boat Harbour. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as currently occurring within the survey area.

Regional Conservation Significance

The Great Knot principally occurs in littoral and estuarine environments in scattered localities along the New South Wales coastline. It is uncommon in the region, with the majority of records from Botany Bay (DECC 2008a). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

BROAD-BILLED SANDPIPER *Limicola falcinellus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Broad-billed Sandpiper. Photo © T. Sugiyama/DECCW

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006) and has not been recorded in regular shorebird counts in the Constables Point-Maianbar area (A. Carrick, pers. comm.). There are three unconfirmed records from the Era Beach area in January 1983 (DECCW 2010a). These records have an accuracy of 1km. Since this species almost exclusively occurs on intertidal mudflats the location of this record is questionable. We therefore consider that all three records are either a result of data entry error, mis-identification or originated from Merries Reef or Botany Bay where the species is a rare visitor (DECC 2008a).

This species can readily be confused with a number of other small sandpipers, such as the Red-necked Stint (*Calidris ruficollis*). Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

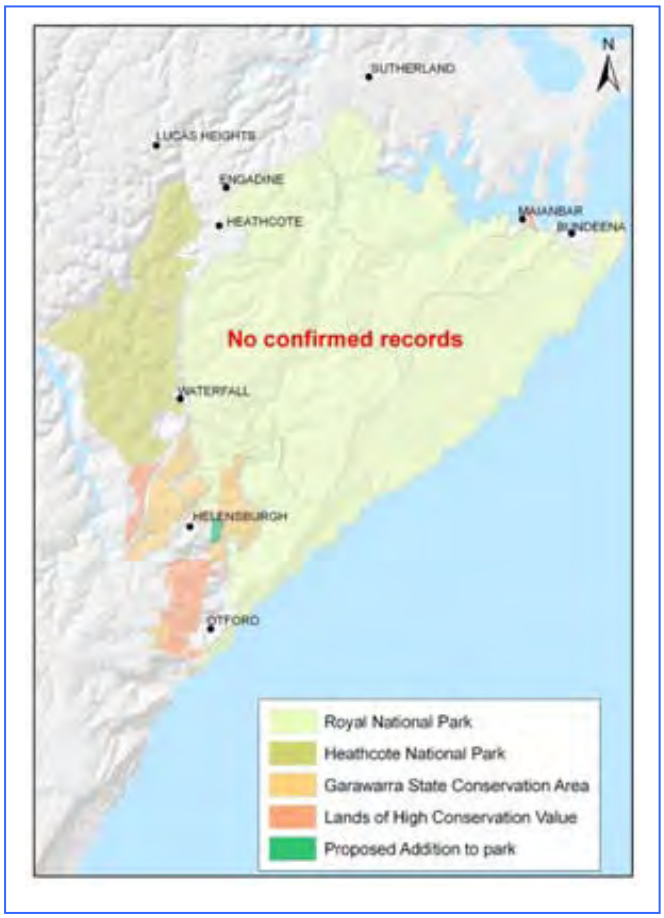
The Broad-billed Sandpiper principally occurs in littoral and estuarine environments in scattered localities along the New South Wales coastline. It is uncommon in the region and has declined in Botany Bay with no recent records (NSW Wader Study Group count data). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



LITTLE TERN *Sternula albifrons*

EPBC Act: Not Listed	*TSC Act*: Endangered	Priority in Area: Low

Little Tern. Photo © DECCW

Occurrence in the Survey Area

Rare visitor. This species is occasionally seen foraging along the Port Hacking foreshore and close inshore off Jibbon Head, and less frequently off the Bundeena sea cliffs (Anyon-Smith 2006, Appendix 1). This species is very rarely encountered resting on the shoreline of the survey area, for example in regular waterbird counts at Constables Point this species has not been observed (A. Carrick, pers. comm.) and in regular surveys over a three-year period of ocean beaches in the survey area, including Jibbon Beach, this species has not been seen (M. Schulz, DECCW, pers. obs.). During the current survey the only record was of a single individual fishing just off the rocks off the Bundeena sea cliffs in January 2010. There are no nesting records, although suitable habitat exists on the Constables Point sand spit and potentially at the Marley Lagoon outlet on Marley Beach. However, nesting is unlikely due to the high levels of public visitation to such areas, in addition to unleashed Dogs in the Constables Point area, trampling of nests by Rusa Deer and predation of eggs and chicks by various predators including the Fox, Silver Gull and the Australian Raven.

Regional Conservation Significance

The Little Tern principally occurs in sheltered coastal environments in scattered localities along the entire New South Wales coastline. However, it has declined through much of this range, probably as a result of human-related disturbance. Within the region it occurs in small numbers, with a small breeding population present in Botany Bay where it has been recorded nesting at several locations, such as Towra Spit Island (DECC 2008a). It formerly nested at Boat Harbour on the north side of Bate Bay with up to five pairs present in the late 1950s (O'Sullivan *et al*. 2001). Currently due to the infrequency of birds resting on the shoreline the survey area does not significantly contribute to the regional conservation of this species. However, in the advent of reduced disturbance on Constables Point individuals may attempt to nest as has occurred at Penrhyn Inlet on Botany Bay in 2003 and 2006 (DECC 2008a). Any nesting activity would make this area of high conservation significance to the species.

Threats in the Survey Area

Disturbance by the public and domestic Dogs, particularly at Constables Point and Jibbon Beach. Feral predators are known to have severe impact on nesting sites, although these are known present in the survey area at present.

Management Considerations

- Reduce disturbance by the public on Constables Point at high tide.
- Regular enforcement to reduce Dog disturbance in the Constables Point area.
- Support continued monthly monitoring of shorebirds in the Constables Point-Bonnie Vale area.
- In the advent of a nesting attempt follow the strategies outlined in the Little Tern recovery plan (NPWS 2003c) and follow the best-practice guidelines of managing threatened beach-nesting shorebirds in NSW (DECC 2008d). Such a strategy resulted in the successful fledging of a number of chicks at Penrhyn Bay; an area that was heavily used by the public.

GLOSSY BLACK-COCKATOO *Calyptorhynchus lathami*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Glossy Black-Cockatoo. Photo © N. Williams/ DECCW

Chewed *Allocasuarina* cones are telltale evidence of this species. Photo © M. Schulz

Occurrence in the Survey Area

Rare visitor to forests and woodlands of the reserves with the most recent records from East Heathcote in July 2000 and behind Little Marley Beach in Royal NP in November 2000 (Anyon-Smith 2006, DECCW 2010a). This species was not recorded in the current survey despite extensive surveys throughout the park. There was no evidence of either their distinctive call or the telltale chewed cones littering the ground beneath stands of *Allocasuarina* (see photo below).

Regional Conservation Significance

The Glossy Black-Cockatoo is relatively common in the sandstone reserves west of the Cumberland Plain, including Nattai and Blue Mountains NP (DECC 2007c). It is very rare on the Woronora Plateau (e.g. Chafer *et al*. 1999), although numbers increased after extensive wildfires to the west of this area in 2001 (DECC 2007c). The scarcity of this species in the survey area despite suitable food trees being present is a reflection of this species' scarcity on the Woronora Plateau. In the future this species might be expected to occur more frequently if fire frequency increases in the Blue Mountains and results in diminished food resources. Currently habitats in the reserves are rarely visited and as a result they do not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

Loss of food trees (*Allocasuarina* spp.) through inappropriate burning regimes (e.g. high frequency fires); impeded regeneration of food trees by Rusa Deer and the Rabbit; and infection by Psittacine Circoviral (Beak and feather) Disease.

Management Considerations

- Maintain current Rusa Deer control measures across the survey area following the Deer Management Plan (DEC 2005).
- Maintain current Rabbit management strategies.

GANG-GANG COCKATOO *Callocephalon fimbriatum*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Gang-gang Cockatoo. Photo © M. Schulz

Occurrence in the Survey Area

Rare visitor to tall open forest, sandstone gully forest and woodland across the survey area (Anyon-Smith 2006). The only site where this species has been regularly reported is around Garawarra Farm and adjacent areas of Garawarra Fire Trail, although it has not been seen for the last few years (S. Anyon-Smith, pers. comm., B. Sullivan, DECCW, pers. comm.). There are few records elsewhere within the survey area, with most sightings from Heathcote NP. For example, sightings in the Atlas of NSW Wildlife were reported from the Pipeline Road in May 1992, east of Lake Toolooma in June 1995 and Scouters Mountain in June 1995. The only sighting reported in the Atlas of NSW Wildlife in areas away from Garawarra Farm in Royal NP was in tall forest along McKell Drive in November 1993. This species was not recorded in the current survey.

Regional Conservation Significance

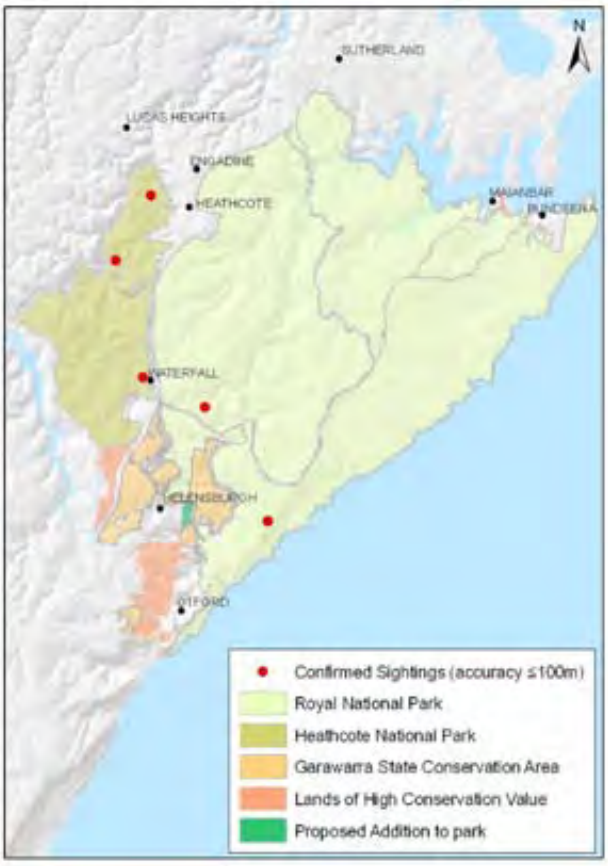
The Gang-gang Cockatoo is widely distributed across the region, particularly in the elevated areas of Warragamba and Metropolitan Special Areas and Kanangra-Boyd NP (DECC 2007c). It is uncommon on the Woronora Plateau, particularly in northern sections, although it was recorded in a number of locations in recent fauna surveys in the Dharawal SCA and NR (DECC 2007a). The scarcity of this species in the survey area is a reflection of this species' scarcity in northern parts of the Woronora Plateau. The habitats of the survey area are irregularly used and as a result they do not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

Infection by Psittacine Circoviral (Beak and feather) Disease.

Management Considerations

No management required.



LITTLE LORIKEET *Glossopsitta pusilla*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Moderate

Little Lorikeet. Photo © H. Cook

The Red Bloodwood is an important food resource. Photo © M. Schulz

Occurrence in the Survey Area

Regular visitor. Present in small numbers, particularly when the Blackbutts are flowering in the southern parts of Royal NP, such as along the Garawarra Fire Trail (Anyon-Smith 2006). In the current survey this species was recorded along the Cliff Track south of Garawarra Farm, adjacent to Sir Bertram Stevens Drive west of the Garie Beach turnoff and on the edge of Bundeena. On all occasions individuals were feeding in flowering Red Bloodwoods in Sydney Coastal Dry Sclerophyll Forest, Dune and Alluvial Sclerophyll Forest and Heathland with scattered trees present. The only documented record from Heathcote NP is from Spion Kop on Mirang Road in March 1999 (DECCW 2010a). This species is occasionally observed in Bundeena, particularly when the Swamp Mahoganies are in flower (M. Schulz pers. obs.). It is likely that some of these individuals also feed in similar species of trees in adjacent parts of Royal NP, such as in Bundeena Gully and in the Bonnie Vale area.

Regional Conservation Significance

The Little Lorikeet is a relatively common although declining species across the region, including in the sandstone reserves west of the Cumberland Plain, such as Nattai and Blue Mountains NPs (Hoskin *et al*. 1991, DECC 2007c). In this region the Little Lorikeet primarily feeds in the canopy of flowering eucalypts and avoids profusely flowering Banksias (Higgins 1999). Movements of the species are irregular, the number of individuals present varying between years depending on the prevalence of key flowering trees. Important flowering trees within the survey area include Red Bloodwood, Blackbutt and Swamp Mahogany (from Higgins 1999). Due to the relatively few records and the widespread distribution of suitable habitat (in particular the Red Bloodwood) the survey area is considered to contribute moderately to the regional conservation of the species.

Threats in the Survey Area

Loss of key flowering trees, particularly Red Bloodwood, Blackbutt and Swamp Mahogany through inappropriate burning regimes (e.g. high frequency fires) or in the case of Swamp Mahogany through altered soil hydrology, including from adjacent properties; impeded regeneration of food trees by Rusa Deer and the Rabbit; removal of dead trees and fallen timber; and infection by Psittacine Circoviral (Beak and feather) Disease.

Management Considerations

- In fire management planning, ensure key feeding habitat (i.e. Red Bloodwood) is maintained in dry sclerophyll forest.
- Ensure that stands of Swamp Mahogany within the survey area are not compromised, for example by altered hydrology.
- Maintain current Rusa Deer control measures, with increased control measures undertaken in vegetation communities supporting Swamp Mahogany.

SWIFT PARROT *Lathamus discolor*

***EPBC Act*: Endangered**	***TSC Act*: Endangered**	**Priority in Area: High**

Swift Parrot. Photo © H. Cook

Occurrence in the Survey Area

Rare visitor. Small areas of suitable habitat present. Visits flowering Swamp Mahogany and Bangalay within the survey area (Anyon-Smith 2006). This species was recorded feeding in Bangalay near Burning Palms Beach in August 2002 (Anyon-Smith 2006). The majority of recent records are from the Bundeena area, including of two individuals feeding in flowering Swamp Mahoganies in Dune and Alluvial Sclerophyll Forest adjacent to Bundeena Oval in May 2009 (M. Schulz pers. obs.). This species was not recorded in the current survey, despite regular checks of flowering Swamp Mahoganies in the Bundeena Gully and Bonnie Vale areas in April and May 2010.

Regional Conservation Significance

The Swift Parrot is relatively rare and patchily distributed in the Sydney Basin Bioregion, with important areas including the Illawarra Coastal Plain, the Cumberland Plain, Burragorang Valley and Narrabeen Lakes-Warriewood areas (DEC 2007c, 2008a). It is a non-breeding visitor from Tasmania arriving in April and departing in early September. In this region the Swift Parrot primarily feeds in the canopy of flowering eucalypts (Higgins 1999), with the winter-flowering Coast Banksia also reported as an important food source in southern coastal New South Wales (Mills 2004). Movements of this species are highly nomadic due to the variable nature of the flowering of its favoured food trees, sometimes not returning to the same locality for a number of years. The most important food tree within the survey area is the Swamp Mahogany (taken from Higgins 1999). Although there are few recent records due to the rarity of this declining species, the survey area does significantly contribute to the regional conservation of this species in some years.

Threats in the Survey Area

Loss of the Swamp Mahogany and Bangalay through inappropriate burning regimes (e.g. high frequency fires) or altered soil hydrology, including in the case of the latter species adjacent to coastal cabin areas; impeded regeneration of food trees by Rusa Deer and the Rabbit; aggressive honeyeaters such as the Noisy Miner; and infection by Psittacine Circoviral (Beak and feather) Disease.

Management Considerations

- Follow relevant management recommendations outlined in the national recovery plan (Swift Parrot Recovery Team 2001).
- Survey all areas of Swamp Mahogany and accessible Bangalay areas during the Birds Australia annual Swift Parrot census.
- Ensure that stands of Swamp Mahogany within the survey area are not compromised, for example by altered hydrology.
- Protect Bangalay stands from encroachment and incremental loss around coastal cabin areas (e.g. at Burning Palms).
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005) and target Swamp Mahogany stands.

EASTERN GROUND PARROT	*Pezoporus wallicus wallicus*	
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as locally extinct**

Eastern Ground Parrot. Photo © M. Schulz

Occurrence in the Survey Area

Small areas of suitable habitat are known from the reserves. This species formerly occurred in moorland fringing Marley Lagoon (Cayley 1923) but now is considered either rare or locally extinct (Anyon-Smith 2006). There is an unconfirmed sighting in the Atlas of NSW Wildlife from the Curra Moors area in April 1996. The species was recently rediscovered in nearby wet heathlands in the Woronora Special Area (DECCW 2010a). However, the species was not recorded in the current survey despite an intensive targeted survey effort.

Regional Conservation Significance

Until recently, the Eastern Ground Parrot was considered to be no longer present in the Sydney Basin Bioregion, with the upland swamps on the Woronora Plateau a former stronghold of the species (DECC 2007a). Its disappearance from this area was attributed to a period of frequent burning after the extensive 1968 wildfires (DECC 2007c). However, it has recently been rediscovered in the region with records from the Woronora Special Area and an individual found at Malabar (DECCW 2010a, DEC 2008a). Its rediscovery in the Woronora Special Area may suggest recolonisation following the frequent fires in the late 1960s. It is possible that in the absence of inappropriate burning regimes as this population increases individuals may colonise suitable habitat within the survey area. Currently due to the absence of confirmed records the survey area does not significantly contribute to the regional conservation of this species. However, in the advent of recolonisation by this species, the survey area will be considered of highest conservation significance to the species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the Eastern Ground Parrot requiring a mosaic of different age classes to ensure the presence of refugia during wildfire, colonisation of habitat that has recovered after fire and recovery of habitat that has become unsuitable through being unburnt for too long (Meredith 1984, McFarland 1991). In the advent of colonisation it is susceptible to predation by Foxes and Cats; and vegetation trampling by Rusa Deer.

Management Considerations

- Conduct regular aural monitoring using automated electronic acoustic monitoring devices every three years at all the sites listed in Table 5.
- Investigate the feasibility of control burning a subset of Coastal Upland Swamps that have not burnt since the 1994 wildfire.
- Ensure a mosaic of age classes of Coastal Upland Swamps across the survey area.
- Maintain current Rusa Deer control measures targeting Coastal Upland Swamps.

POWERFUL OWL *Ninox strenua*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Low

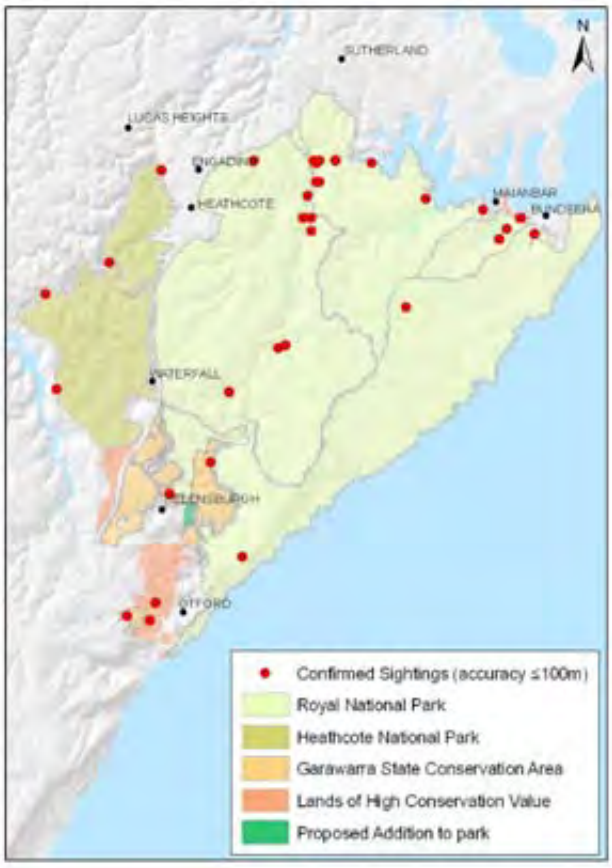
Powerful Owl with prey of the Common Ringtail Possum. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon breeding resident. There are a large number of records from Royal NP in the Atlas of NSW Wildlife, centred in four locations: Audley-Reids Flat area; southern Lady Carrington Drive including Forest Island; Bonnie Vale area; and Bundeena Gully. Single records occur from Marley Track, south of Garawarra Farm and Warumbul Picnic Area. In the current survey this species was not targeted due to the amount of previous systematic call playback conducted within the survey area. Incidental records in the current survey were from Reids Flat, east of Muddy Creek on the edge of Port Hacking, southern Lady Carrington Drive and in Heathcote NP at Lake Eckersley. The cluster of records from the Atlas and current survey suggests that at least seven pairs may be present, excluding the adjoining lands of high conservation value: around Audley, southern Lady Carrington Drive, Bonnie Vale, Bundeena Gully, south of Garawarra Farm, Warumbul-Muddy Creek area and at Lake Eckersley in Heathcote NP. The majority of records in the current survey were from Sydney Coastal Dry Sclerophyll Forest with a smaller proportion of records from Northern Warm Temperate Rainforest and North Coast Wet Sclerophyll Forest. However, this species is also present and nests in Dune and Alluvial Sclerophyll Forest in the Bundeena area (M. Schulz pers. obs.). The species is relatively common in the gullies and slopes of the Engadine area, with a number of records close to the northern edge of Heathcote NP, such as along the Woronora River and Prestons Gully (DECC 2008a). In the Forbes and Loftus Creek valleys a number of nests have been located in hollows of the Smooth-barked Apple (R. Jackson, pers. comm.). One immature Powerful Owl was found road killed in Audley in February 2011 (Schulz and Madden in prep.), while road killed animals have been observed on Princes Highway Heathcote in mid 2010 (R. Goldingay, pers. comm.) and in February 2011 (E. Magarey, pers. comm.).

Regional Conservation Significance

The Powerful Owl is common and widespread in the Sydney Basin Bioregion (DECC 2007a). Due to the presence of a small breeding population in the survey area, and its widespread occurrence across the region, the survey area does not significantly contribute to the regional conservation of this species.



Threats in the Survey Area

Loss of gully roosting habitat and hollow-bearing trees through inappropriate fire regimes; loss of hollow-bearing and dead trees through reserve management practices, such as adjacent to roads; disturbance at known roosts; overuse of call playback at known localities for the species; predation of fledglings by the Fox; road mortality.

Management Considerations

- Follow relevant management recommendations in the statewide recovery plan (DEC 2006a).
- Protect rainforest and adjacent wet sclerophyll forest from fire.
- Protect known nest trees and avoid felling hollow-bearing and dead trees.
- Discourage the use of call playback by birdwatchers.

BARKING OWL *Ninox connivens*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Low

Barking Owl. Photo © M. Schulz

Occurrence in the Survey Area

Very rare visitor. The only records are from 1975 (Anyon-Smith 2006) and one Atlas of NSW Wildlife record on the east side of Deer Pool in Royal NP. Additionally there is one confirmed record from Engadine, not mapped here (R. Jackson, pers. comm.). This species was not recorded in the current survey despite undertaking call playback at six sites in the Loftus Heights-Heathcote areas, where the species was probably once more common.

Regional Conservation Significance

The Barking Owl occurs in widely scattered localities within the Sydney Basin Bioregion, with a small number of recent records from the Sydney Metropolitan CMA area (e.g. DECC 2008a). Currently due to the paucity of records the survey area does not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

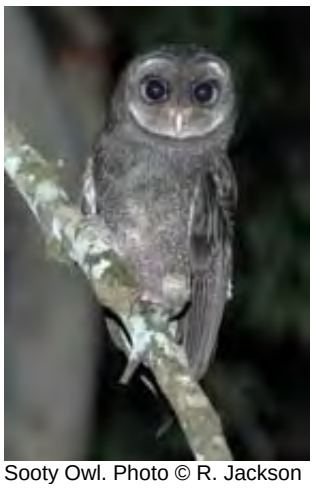
No threats identified.

Management Considerations

- In the advent of individuals becoming resident follow relevant management recommendations outlined in the statewide recovery plan (NPWS 2003b).

SOOTY OWL *Tyto tenebricosa*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Moderate



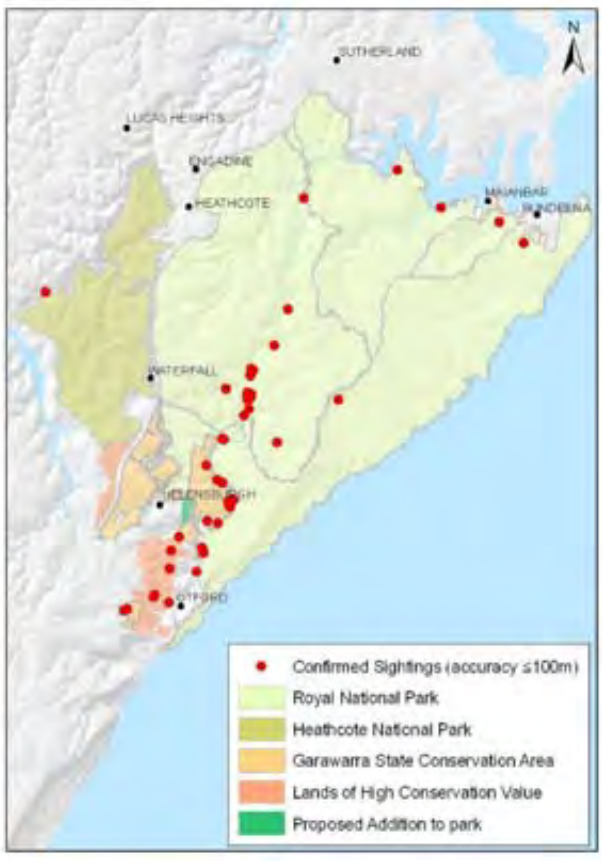
Sooty Owl. Photo © R. Jackson

Occurrence in the Survey Area

Uncommon breeding resident. Records of this species are scattered through most moist forest communities across the survey area with most concentrated in the upper to mid Hacking River valley (DECCW 2010a). A radio-tagged individual that roosted near Audley regularly flew west to the Woronora River and foraged along the northern shoreline of Port Hacking (Kavanagh and Jackson 1997). Records outside the Hacking River valley include from Costens Point and Bonnie Vale in Royal NP, Kelly Falls in Garawarra SCA and along the Woronora River Track in Heathcote NP (DECCW 2010a). It has been suggested that as many as eight pairs are present within the survey area, excluding the Upper Hacking proposed reserve extensions (DECC 2007c). In the current survey this species was not targeted with call playback due to the amount of previous systematic call playback conducted within the survey area (refer to Section 2.3.1). Incidental records in the current survey were principally from the Hacking River valley, with one bird flushed from an overhang adjacent to Yarmouth Swamp in Royal NP. The majority of records in the current survey were from Northern Warm Temperate Rainforest with a smaller number of records from North Coast Wet Sclerophyll Forest and Dune and Alluvial Sclerophyll Forest (Section 3.2.1). The diet of this species is comparatively well known in Royal NP with mammalian prey species comprising the Brown Antechinus, Long-nosed Bandicoot, Eastern Pygmy-possum, Sugar and Feathertail Gliders, Common Ringtail Possum, Bush and Swamp Rats and the Black Rat (Kavanagh and Jackson 1997. Bilney *et al*. 2007).

Regional Conservation Significance

The Sooty Owl is considered relatively common in suitable habitat within the Sydney Basin Bioregion with small numbers present in larger tracts of forest supporting moist forest with a mesic understorey (DECC 2007c). Due to the presence of a small population in the survey area and its widespread occurrence within the region, the survey area contributes moderately to the regional conservation of this species.



Threats in the Survey Area

Loss of moist forest habitat through high frequency or high intensity fires; the loss of hollow-bearing trees; lack of connectivity in the reserve system to important populations along the Illawarra Escarpment; disturbance of known roosts; secondary poisoning from rodenticides; potentially poaching of eggs from nests; and uncontrolled use of call playback by birdwatchers.

Management Considerations

- Follow relevant management recommendations outlined in the statewide recovery plan (DEC 2006a).
- Protect Northern Warm Temperate Rainforest from fire.
- Avoid felling hollow-bearing trees in moist forests as these are a scarce resource due to past land management practices.
- Maintain and improve connectivity with the moist forests of the reserves and those along the Illawarra Escarpment.
- Discourage the use of call playback by birdwatchers.

MASKED OWL *Tyto novaehollandiae*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: High

Masked Owl. Photo © R. Jackson

Occurrence in the Survey Area

Likely that this species is a rare visitor and a very uncommon resident. This species was recorded along Lady Carrington Drive in November 2000 and on the Curra Moors Management Trail in November 2003 (Anyon-Smith 2006). There are a number of records in the Atlas of NSW Wildlife from the Lady Carrington Drive section of the Hacking River valley, with other records from Royal NP adjacent to Heathcote East on several occasions in 1991. In the current survey this species was not targeted with call playback due to the amount of previous systematic call playback conducted within the survey area (refer to Section 2.3.1). Incidental records in the current survey were principally from the Hacking River valley, with one bird observed on the edge of McKell Drive west of National Falls. The majority of records in the current survey were from Sydney Coastal Dry Sclerophyll Forest with a smaller proportion of records from Northern Warm Temperate Rainforest and North Coast Wet Sclerophyll Forest (Section 3.2.1). This bird is occasionally seen in residential parts of Bundeena and therefore is likely to occur in adjacent vegetation communities (M. Schulz pers. obs.).

Regional Conservation Significance

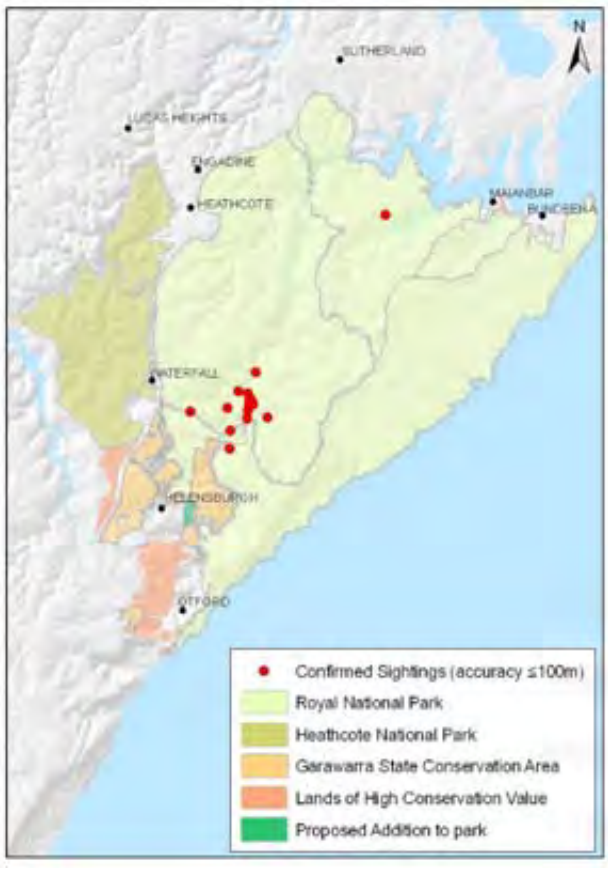
The Masked Owl is scattered in distribution across the Sydney Basin Bioregion with small numbers recorded irregularly in dry open forest and woodlands on soils of mid to high fertility (DECC 2007c). Within the region, the open woodlands of the coastal plains between Wyong and Port Stephens support the highest numbers of this species, though this area is currently under considerable threat from development (DECC 2008c). Due to the number of records in the reserves in contrast to the species' scattered occurrence within the region, the reserves contribute significantly to the regional conservation of this species.

Threats in the Survey Area

Loss of dry forest habitat on mid to high fertility soils through inappropriate fire regimes (e.g. high frequency fires); the loss of hollow-bearing and dead trees; the repeated and uncontrolled use of call playback at known localities for the species by birdwatchers; potentially poaching of eggs from nests; road mortality; and the use of rodenticides, in particular around urban areas.

Management Considerations

- Follow relevant management recommendations outlined in the statewide recovery plan (DEC 2006a).
- Ensure a mosaic of post-fire age classes of dry forest on mid to high fertility soils through strategic prescribed burns.
- Avoid felling hollow-bearing and dead trees in moist and dry forests.
- Maintain and improve connectivity with the moist forests of the reserves and those along the Illawarra Escarpment.
- Discourage the use of call playback by birdwatchers.
- Keep use of rodenticides within the reserves to an absolute minimum necessary.



GRASS OWL *Tyto capensis*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: High

Grass Owl. Photo © J. Winter/DECCW

The Grass Owl site. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

Status uncertain. First recorded in the reserves during the current survey, with no previous records documented. Suitable habitat is confined in the reserves to coastal swamps and swamp heath. Despite intensive targeted survey only a single observation was made from a densely vegetated Coastal Upland Swamp in a drainage line south of Bundeena Drive.

Around the same time this species was recorded from Coastal Sand Swamp Sedgeland inland of Cape Baily in Kamay Botany Bay NP (DECCW 2011). No pellets were located where the flushed bird emerged. In Kamay Botany Bay NP prey remains from nine pellets comprised the Black Rat, House Mouse and one Brown Quail (DECCW 2011). This species is likely to have been overlooked prior to the current survey due to its nocturnal habits, frequenting wetland habitats that are difficult and unpleasant to traverse, and its probable highly sporadic occurrence.

Regional Conservation Significance

The Grass Owl is considered very rare in the Sydney Basin Bioregion with records from Homebush Bay and St Albans (Higgins 1999). Within the Sydney area records are attributed to coastal dispersal from inland areas (Schodde and Mason 1980), wide-ranging vagrants from northern New South Wales (Hobcroft and James 1997) and the location of an undocumented population (discounted by Hobcroft and James 1997). In north-eastern New South Wales where this species is locally common it primarily occurs in rank pastureland, in addition to wet heathlands, sedgelands on sandy infertile soils, reedbeds and saltmarsh (Debus *et al.* 2001, Higgins 1999). The species can be irruptive in habit moving into areas following influxes of quail and rodents. Due to the lack of records, the possibility of a previously undocumented population and the species uncertain status in the region, this single record may indicate that the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Alteration in wetland hydrological characteristics; predation of eggs and young by the Fox; inappropriate fire regimes (e.g. high frequency fires); road mortality; grazing and trampling of vegetation and nests by Rusa Deer; and the use of rodenticides.

Management Considerations

- Conduct further targeted searches to increase understanding of occupation rates and habitat usage within the survey area.
- Ensure the current hydrological regime of Coastal Upland Swamps is maintained.
- Ensure a mosaic of time since fire age classes of Coastal Upland Swamps across the survey area.
- Maintain current Rusa Deer control measures.
- Keep use of rodenticides within the reserves to an absolute minimum necessary.
- In the advent of nesting conduct targeted Fox control.

BROWN TREECREEPER (EASTERN SUBSPECIES)

Climacteris picumnus victoriae

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Brown Treecreeper. Photo © M. Schulz

Occurrence in the Survey Area

Habitat is unsuitable for this species and as a result the existing records are probable misidentification or data entry error. This species was not recorded within the survey area by Anyon-Smith (2006) or during the current survey. There are no records in the Atlas of NSW Wildlife. However there are several unconfirmed records for the area, such as at three undescribed localities in the 2001 Platypus survey (Curtis 2001).

This species can readily be confused with treecreeper species. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

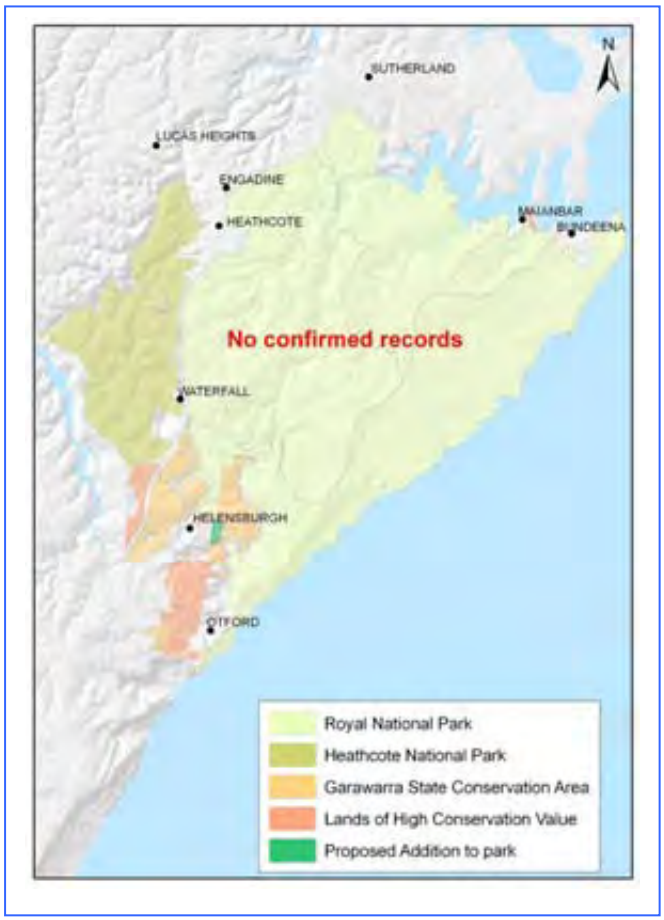
The Brown Treecreeper has severely declined in the Sydney region with a recent survey in the Cumberland Plain confirming the species is close to extinction in this area (DEC 2006b). The rarity of this species on the Cumberland Plain and the lack of suitable habitat makes the presence of this species in the survey area unlikely. The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.



GREEN CATBIRD	*Ailuroedus crassirostris*	
***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

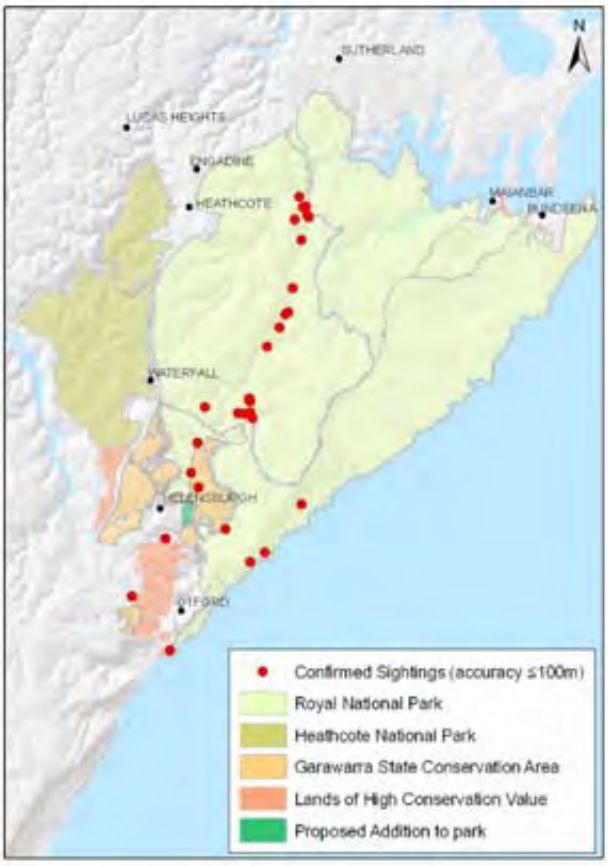
Green Catbird. Photo © M. Schulz

Occurrence in the Survey Area

Common breeding resident. This species is scattered through most rainforest and wet sclerophyll forest with a mesic subcanopy in Royal NP and Garawarra SCA, with records concentrated: in the upper to mid Hacking River valley, such as around Red Cedar Flat; along Lady Carrington Drive, including Forest Island and Bola Creek; in the Wattle Forest area at Audley; along Camp Creek; and in the Kelly Falls area (DECCW 2010a, S. Anyon-Smith pers. comm.). It also occurs in adjoining private lands in the Upper Hacking (DECC 2008a). Locations outside the Hacking River valley include Lost World at the foot of the escarpment south of Burning Palms (S. Anyon-Smith pers. comm.). In the current survey this species was principally recorded from the Hacking River valley, including along Cawleys and Wilsons Creeks and in Frews Gully. Additionally, the species was located in a number of sites below the southern escarpment in Royal NP, such as in Cutty Gully behind Mid Era, south of Burning Palms, Palm Jungle and below Bald Hill. The majority of records in the current survey were from Northern Warm Temperate Rainforest and Littoral Rainforest with a smaller proportion of records from North Coast Wet Sclerophyll Forest with a mesic subcanopy (Section 3.2.1).

Regional Conservation Significance

The Green Catbird is not listed as a threatened species under the *TSC Act*, however it was identified as a species of conservation priority due to its regional significance. It has a restricted distribution across the Sydney Basin Bioregion of which Royal NP and Garawarra comprise a significant proportion of its preferred habitat. These reserves include the northern extension of the Illawarra population. The Green Catbird is near the southern limits of its range in the survey area and is considered scarce south of the Shoalhaven River (Chafer *et al*. 1999). Within the region the majority of records are from the Illawarra and the Watagans region of the Central Coast. Due to the status of this species in the area close to the southern extremity of the species' range and its limited habitat within the region, the survey area contributes significantly to the regional conservation of this species.



Threats in the Survey Area

Loss of moist forest habitat through inappropriate fire regimes; and the lack of connectivity in the reserve system to important populations further south along the Illawarra Escarpment.

Management Considerations

- Protect Northern Warm Temperate Rainforest and Littoral Rainforest from fire.
- Maintain and improve connectivity with the moist forests of the reserves to those along the Illawarra Escarpment.

SOUTHERN EMU-WREN		*Stipiturus malachurus*
***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Southern Emu-wren. Photo © H. Cook

Occurrence in the Survey Area

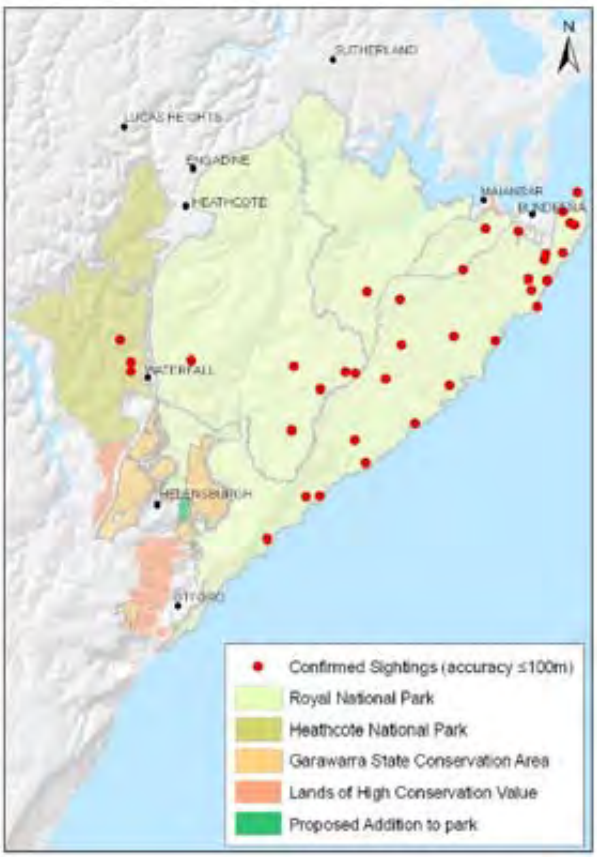
Very common breeding resident (Anyon-Smith 2006), with a large number of records extracted from the Atlas of NSW Wildlife. In the current survey this species was recorded at 32 localities from Royal NP and Heathcote NP. It was recorded from most habitat groups with a large percentage of records from Heathland (49 per cent of records collected during current survey) and Freshwater Wetlands (24 per cent of records collected during current survey). The species was more prevalent in Royal NP with scattered records in Heathcote NP. No individuals were recorded in Northern Warm Temperate and Littoral Rainforests, Northern Hinterland Wet Sclerophyll Forest, Shoreline, Deep Freshwater Wetland or Parkland (Section 3.2.1). No nests were located in the current survey, although dependent young were observed in Heathland and Freshwater Wetland.

Regional Conservation Significance

The Southern Emu-wren is not listed as a threatened species under the *TSC Act*. However it is recognised as a regionally significant species in this and other studies (including DECC 2007c). A 20 per cent decrease in the reporting rate of this bird has been recorded between 1984 and 2002 across the nation (Barrett *et al*. 2003). In addition it has a patchy distribution across the Sydney Basin Bioregion, with Upland Swamps and coastal heathlands supporting the largest populations (DECC 2007c). For this reason the survey area together with elsewhere on the Woronora Plateau supports one of the largest populations in the region. Within the region the species prefers flat areas with low levels of grass (DECC 2007c), although it is relatively common in extensive sedgelands in some lagoons (e.g. Jibbon Lagoon) and adjoining saltmarsh and mangrove areas (e.g. eastern side of Cabbage Tree Basin). Due to the abundant status of this species in the area compared to most other localities within the region, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes, with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire and rapid colonisation of habitat that has recovered after fire; alteration in wetland and heathland hydrological characteristics; habitat fragmentation; predation by Fox, Cat and Black Rat; grazing and trampling of vegetation by Rusa Deer; potentially grazing of vegetation by Rabbit; and road mortality.



Management Considerations

- Maintain a mosaic of time since fire classes in Heathland and Coastal Upland Swamps.
- Maintain the current hydrological regimes of Coastal Upland Swamps.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Undertake Fox control around Coastal Upland Swamps and Heathlands.
- Control wide-ranging domestic Cats.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Work with road traffic authorities to help reduce roadkills on major thoroughfares through the reserves.

EASTERN BRISTLEBIRD *Dasyornis brachypterus*

***EPBC Act*: Endangered**	***TSC Act*: Endangered**	**Priority in Area: Nil as locally extinct**

Eastern Bristlebird. Photo © M. Schulz

Occurrence in the Survey Area

There are no confirmed recent records of this species in the survey area (e.g. Andrew 2001, Anyon-Smith 2006, DECC 2008c, current survey, DECCW 2010a, M. Schulz, DECCW, pers. obs.). There are a number of recent suggested sightings, such as in the Curra Moors area (Anyon-Smith 2006). However no evidence of the species presence was made during the current surveys. This is despite considerable effort including the use of call playback, aural dusk listening and camera traps in the Curra Moors area, which all failed to locate this bird. It is considered that the bird no longer occurs within the survey area and is regarded as locally extinct although suitable habitat remains present.

This species is typically shy and therefore commonly affords only brief glimpses making it easy to confuse with other skulking heathland species. Similarly the call can be confused with species such as the Chestnut-rumped Heathwren that is widespread within the survey area. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as currently occurring within the survey area.

Regional Conservation Significance

The Eastern Bristlebird is considered locally extinct along the Illawarra Escarpment with the last record west of Mt Kembla in the 1960s (Chafer *et al.* 1999). While suitable habitats (i.e. Upland Swamps, heaths and dense woodlands) still exist in the area extensive surveys, including on the Woronora Plateau and in Royal NP, have failed to locate any evidence of an extant population (DECC 2007c). The nearest known populations are in the vicinity of Barren Grounds NR and in the Jervis Bay area (Chafer *et al*. 1999). The survey area does not currently contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

ROCKWARBLER		*Origma solitaria*
***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Rockwarbler. Photo © M. Schulz

Occurrence in the Survey Area

Common breeding resident (Anyon-Smith 2006). A large number of records are known from across the reserves. In the current survey this species was recorded at 29 localities from Royal NP, Garawarra SCA and Heathcote NP entered into the Atlas of NSW Wildlife. It was recorded from most habitat groups wherever large rock outcrops were present. This bird was most frequently sighted in Sydney Coastal Dry Sclerophyll Forest, Heathland and Riparian Scrub. No individuals were recorded in Northern Warm Temperate and Littoral Rainforest, Dune and Alluvial Sclerophyll Forest, Freshwater and Forested Wetlands, Saline and Deep Freshwater Wetlands or Parkland (Section 3.2.1). The Rockwarbler was frequently observed foraging amongst boulders in the high tideline at the base of cliffs, particularly south of Burning Palms. Numerous nests were located in rock overhangs across the survey area, including upslope of some rocky shorelines.

Regional Conservation Significance

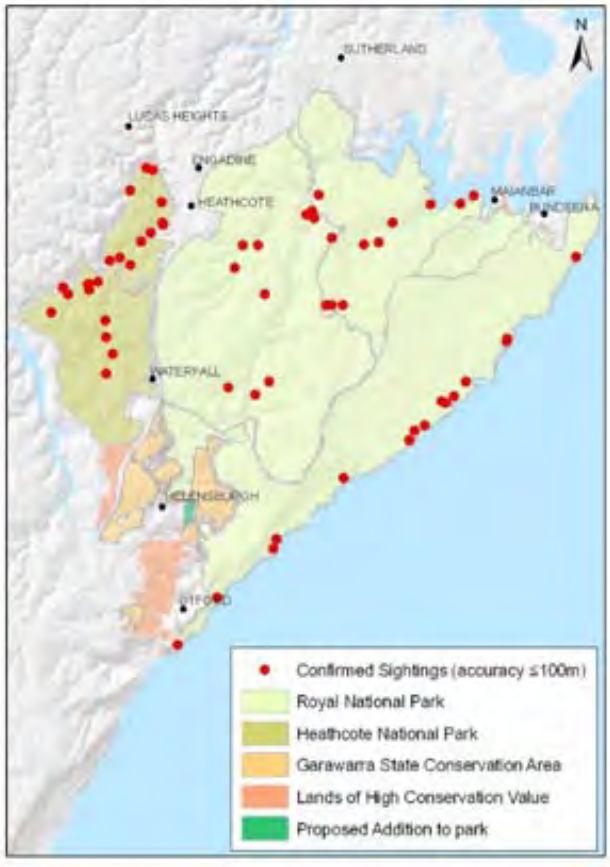
The Rockwarbler is not listed as a threatened species under the *TSC Act*, however it was identified as a priority regionally significant species. The reason for this priority listing is that it is endemic to New South Wales being confined principally to the Sydney Basin Bioregion. Within the region many populations in coastal areas have severely declined or become locally extinct, such as in remnant habitat fringing the coastline of Sydney (DECC 2008a). Therefore the population along the Royal NP coastline is regionally significant as the survey area supports one of the largest coastal populations of this species in the region. The species' preferred habitat is rugged sandstone environments at low elevations (DECC 2007c). Due to the common status of this species in the survey area particularly along the coastal fringe compared to most other localities within the region, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires); habitat fragmentation; disturbance of nesting birds by members of the public and Rusa Deer in some accessible rock overhangs; and predation by Foxes, Black Rats and both feral and domestic Cats.

Management Considerations

- Ensure a mosaic of time since fire age classes of Sydney Coastal Dry Sclerophyll Forest across the survey area.
- Control wide-ranging domestic Cats adjoining urban areas.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.



CHESTNUT-RUMPED HEATHWREN *Hylacola pyrrhopygia*

***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Chestnut-rumped Heathwren.
Photo © M. Schulz

Occurrence in the Survey Area

Common breeding resident (Anyon-Smith 2006), with a large number of records present across the reserves. In the current survey this species was recorded at numerous locations with 38 localities from Royal NP, Garawarra SCA and Heathcote NP. It was recorded from a number of habitat groups with a large percentage of records from Sydney Coastal Dry Sclerophyll Forest and Heathland (Section 3.2.1). A smaller number of sightings were made in Riparian Scrub, North Coast Wet Sclerophyll Forest, Dune and Alluvial Sclerophyll Forest. No nests were located in the current survey, although dependent young were observed in Sydney Coastal Dry Sclerophyll Forest and Heathland. This species is occasionally roadkilled, with two individuals found in Royal NP between May 2007 and May 2009 (Schulz and Madden in prep.).

Regional Conservation Significance

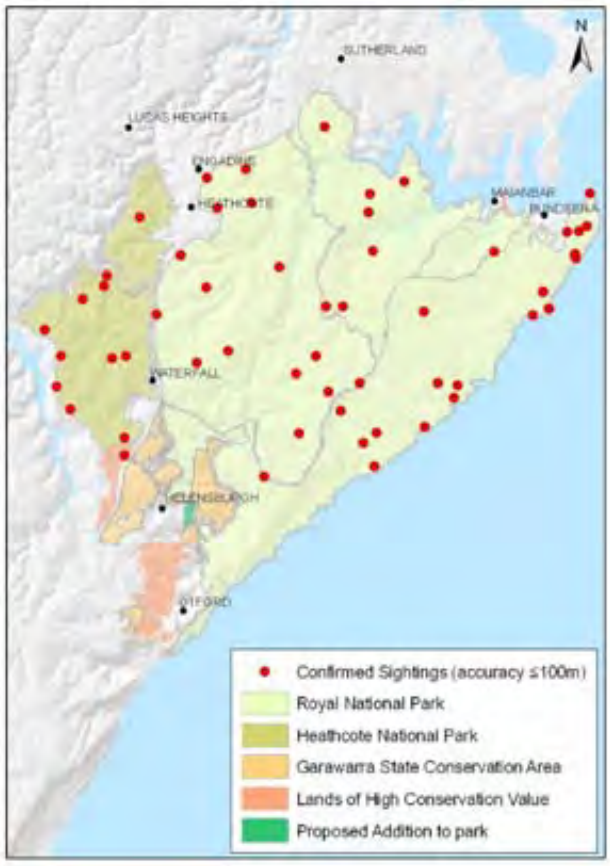
The Chestnut-rumped Heathwren is not listed as a threatened species under the *TSC Act* however it was identified for this study as a regionally significant species. It has a patchy distribution across the Sydney Basin Bioregion, with few populations remaining within the Sydney Metropolitan CMA area and other coastal areas. Due to the common status of this species in the reserves, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire and rapid colonisation of habitat that has recovered after fire; habitat fragmentation; predation by Foxes, Black Rats and both feral and domestic Cats; grazing and trampling of vegetation by Rusa Deer; and road mortality.

Management Considerations

- Ensure a mosaic of time since fire age classes of Sydney Coastal Dry Sclerophyll Forest and Heathland across the survey area.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Control wide-ranging domestic Cats adjoining urban areas.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Undertake Fox control in Heathlands.



STRIATED FIELDWREN	*Calamanthus fuliginosus*	
***EPBC Act*: Not Listed**	***TSC Act*: Endangered**	**Priority in Area: Nil as inaccurate record**

Striated Fieldwren. Photo © M. Schulz

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006), Andrew (2001) or during the current survey. There is one record in the Atlas of NSW Wildlife from the Atlas of Australian Birds 1 with a spatial accuracy of 10km. It is considered that this record was from the Kurnell Peninsula where the species has been recorded in Towra Point NR (DECC 2008a).

This species can readily be confused with other small wren-like species by inexperienced observers. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

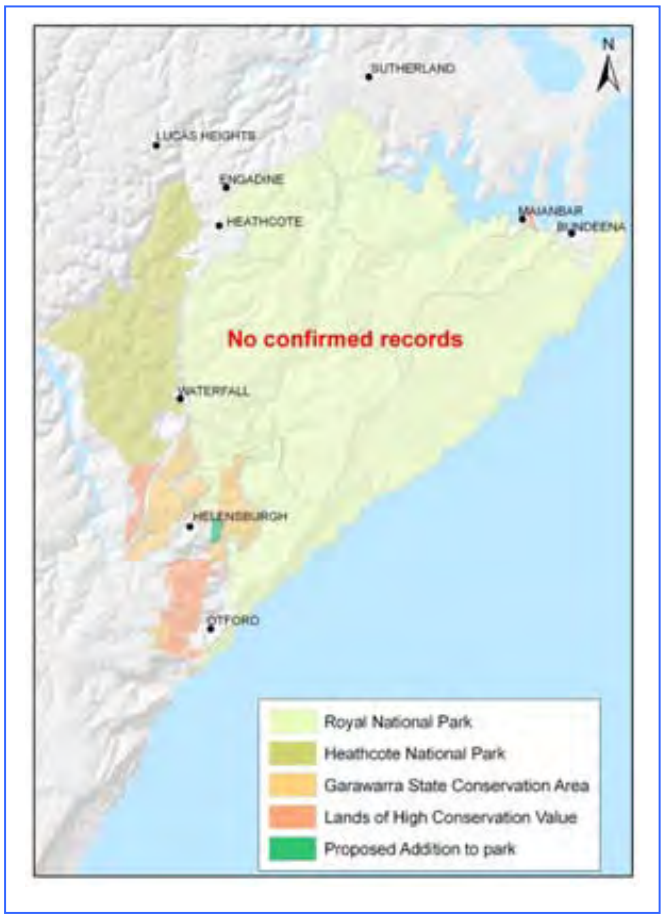
The Striated Fieldwren has only been recorded in the 1970s from the Towra Point NR within the Sydney Basin Bioregion (Hoskin *et al*. 1991, Chafer *et al*. 1999, DECC 2007c). The survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

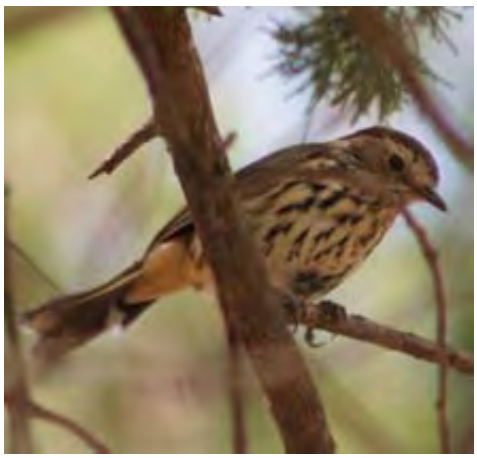
Management Considerations

No management required.



SPECKLED WARBLER *Chthonicola sagittata*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as peripheral species loss**



Speckled Warbler. Photo © M. Schulz

Occurrence in the Survey Area

This species was not recorded within the survey area during the current survey and is regarded by Anyon-Smith (2006) as locally extinct. There is a record in the Atlas of NSW Wildlife from the Mt Bass Fire Trail in Royal NP in September 1998, however the location is in dense dry sclerophyll forest which is an unlikely habitat for this species, and therefore it is considered this record is either a mis-identification or a data entry error.

In the region the species' preferred habitat is box woodland with low to moderate rainfall. Habitat most closely resembling this is the Coastal Shale-Sandstone Forest (Northern Hinterland Wet Sclerophyll Forest habitat group) in the Loftus Trig area, however it is of marginal quality for the species today. Targeted searches in this area failed to locate this species during the current survey.

Regional Conservation Significance

The Speckled Warbler has severely declined in the Sydney region with a recent survey on the Cumberland Plain confirming the species to be very rare and extremely localised in occurrence (DEC 2006b). The most secure population occurs in the Burragorang Valley (DECC 2007b). As no confirmed population remains in the survey area or adjacent areas, and habitat is only of marginal quality, it is considered to not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

REGENT HONEYEATER		*Anthochaera phrygia*
***EPBC Act*: Endangered**	***TSC Act*: Critically Endangered**	**Priority in Area: Low**

Regent Honeyeater. Photo © DECCW

Occurrence in the Survey Area

Rare visitor with no recent records (Anyon-Smith 2006). Only small areas of suitable habitat are present. This species was not recorded within the reserves by Andrew (2001), DECC (2008a) or during the current survey. There is an unconfirmed record in the Atlas of NSW Wildlife from the Mt Bass Fire Trail in Royal NP in May 1991. The location for this record was in heathland/heathy low woodland, an unlikely habitat for this species. Therefore it is considered this record is either a result of mis-identification or a mistake made during data entry into the Atlas. Additionally there is a record from March 1977 in the Atlas of NSW Wildlife from the Atlas of Australian Birds 1 with a spatial accuracy of 10km. It is not known whether this record was made within the survey area or in the Cronulla area to the north. Targeted searches for this species conducted in stands of flowering Swamp Mahogany in the Bundeena-Bonnie Vale area during the current survey and over the last three year period (M. Schulz pers. obs.) have been unsuccessful.

Regional Conservation Significance

The Regent Honeyeater has severely declined in abundance across its range, including within the Sydney Basin Bioregion. Within the region the species is principally recorded in the lower Hunter, Burragorang and Capertee Valleys with occasional sightings elsewhere (DECC 2007c, 2008b). 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. Key eucalypt food trees present within the region (i.e. Mugga Ironbark *Eucalyptus sideroxlyon* and White Box *E. albens*) do not occur within the survey area (adapted from Higgins *et al*. 2001). However, less frequently used species are either widespread (e.g. Smooth-barked Apple) or restricted in distribution (Swamp Mahogany) within the survey area. Therefore as a result of the absence of recent sightings, the survey area does not contribute significantly to the regional conservation of this species. However, the presence of key flowering trees, such as the Swamp Mahogany and Smooth-barked Apple within the survey area may serve to act as a food supply for the species when primary key eucalypt species have failed in flowering elsewhere within the region, such as during times of drought.

Threats in the Survey Area

Loss of the Swamp Mahogany through inappropriate burning regimes (e.g. high frequency fires) or altered soil hydrology, including from adjacent properties.

Management Considerations

- Follow relevant management recommendations outlined in the national recovery plan (Menkhorst *et al.* 1999).
- Survey all areas of flowering Swamp Mahogany during the Birds Australia annual Regent Honeyeater census.
- Maintain stands of Swamp Mahogany within the survey area and minimise the impacts by fire, Deer and public disturbance.

WHITE-FRONTED CHAT *Epthianura albifrons*

EPBC Act: Not Listed	*TSC Act*: Vulnerable; Endangered Population in the Sydney Metropolitan Catchment Management Authority area	Priority in Area: Nil as inaccurate record

White-fronted Chat. Photo © M. Schulz

Occurrence in the Survey Area

This species was not recorded within the survey area by Anyon-Smith (2006), Andrew (2001) or during the current survey. There is one record in the Atlas of NSW Wildlife from Palona Brook in Royal NP in February 1991. Given this species prefers open habitats such as grassland and saltmarsh (e.g. Higgins *et al*. 2001) rather than wet sclerophyll forest it is considered this record is either a result of mis-identification or a mistake made during data entry into the Atlas. In addition there are a large number of records from the Atlas of Australian Birds 1 with a spatial accuracy of 10km. It is considered that these record were from Towra Point NR area on the Kurnell Peninsula, which supports one of the only remaining populations present in the Sydney metropolitan area (DECC 2008a).

This species is easily identified but due to its current status caution should be exercised, and any suspected sightings verified, before being accepted as occurring within the survey area.

Regional Conservation Significance

The White-fronted Chat has severely declined in the Sydney region with remnant populations at Towra Point NR and Homebush Bay (DECC 2008a). The decline in the Sydney region is a reflection of 36 per cent decrease in the reporting rate of this bird between 1984 and 2002 in the Sydney Basin Bioregion and greater than 20 per cent across the nation (Barrett *et al*. 2003). In the Sydney region it primarily occurs in saltmarsh and associated vegetation communities. However, targeted searches of all larger tracts of saltmarsh and associated vegetation within the survey area, such as on the eastern side of Cabbage Tree Basin failed to locate this bird. Therefore as a result of no confirmed population being present, the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

TAWNY-CROWNED HONEYEATER	*Gliciphila melanops*	
***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Tawny-crowned Honeyeater. Photo © M.

Occurrence in the Survey Area

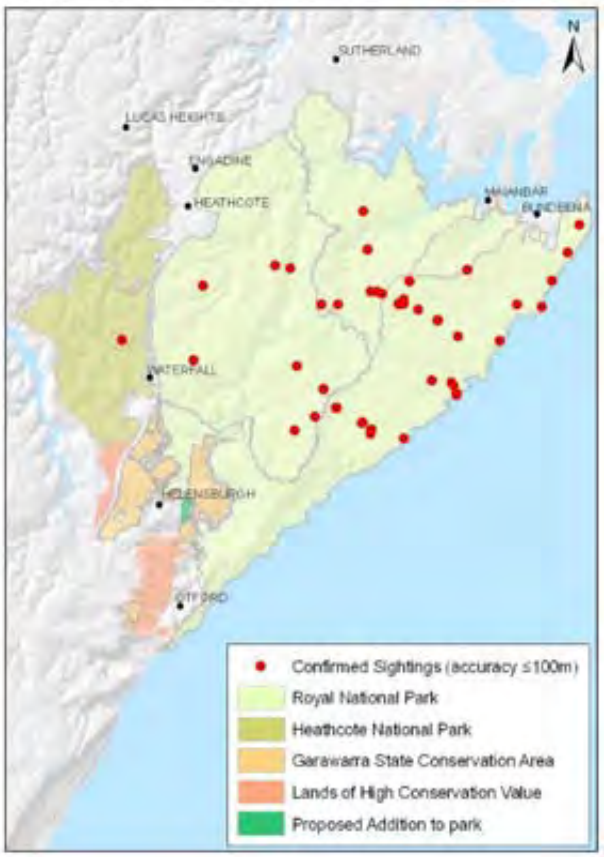
Common breeding resident (Anyon-Smith 2006), with a large number of records from the survey area. In the current survey this species was recorded at 21 localities. The majority of records were from Royal NP, with only a small number from Heathcote NP. This species was primarily recorded from Heathland habitat (58 per cent of records from current survey) with a smaller number of records in Sydney Coastal Dry Sclerophyll Forest and Freshwater Wetland. Within the Heathland habitat it was most prevalent on low coastal heathlands near seacliffs. In Sydney Coastal Dry Sclerophyll Forest habitat it was associated with a low and patchy stunted tree cover or locations bordering heathland. No nests were located in the current survey, although dependent young were observed in Heathland and Freshwater Wetland.

Regional Conservation Significance

The Tawny-crowned Honeyeater is not listed as a threatened species under the *TSC Act*, however it was identified in this study as a regionally significant species. It has a patchy distribution across the Sydney Basin Bioregion, with Upland Swamps and coastal heathlands supporting the largest remaining populations (DECC 2007c). Much of its former habitat has been cleared for urban development, particularly along the Sydney coastline. Royal NP supports one of the largest populations in the region. Its conservation status has also been recognised elsewhere, where it has been identified as a species that had a decreased reporting rate between 1984 and 2002 (Barrett *et al*. 2003). Within the region the species prefers habitat that supports the Heath-leaved Banksia although the height of the vegetation and time since fire are likely to be important determinants influencing its distribution. For example in areas supporting tall dense Heath-leaved Banksia it was rarely recorded while in low heathland, including on the edge of sea cliffs it was well represented. Royal NP contributes significantly to the regional conservation of this species as it retains higher numbers of records than other localities in the region.

Threats in the Survey Area

Inappropriate fire regimes, with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire, rapid colonisation of habitat that has recovered after fire and recovery of habitat that has become unsuitable through being unburnt for too long; alteration in wetland and heathland hydrological characteristics; habitat fragmentation; predation by Fox, Black Rat and Cat; grazing and trampling of vegetation by Rusa Deer and potentially Rabbit.



Management Considerations

- Maintain a mosaic of time since fire classes of Heathland and Coastal Upland Swamps.
- Maintain the current hydrological regimes of Coastal Upland Swamps.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Undertake Fox control around Coastal Upland Swamps and Heathlands.
- Control wide-ranging domestic Cats.
- Aim to improve habitat connectivity between Heathcote and Royal NPs.
- Work with road traffic authorities to help reduce roadkills on major thoroughfares through the reserves.

BLACK-CHINNED HONEYEATER (EASTERN SUBSPECIES)

Melithreptus gularis gularis

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Nil as peripheral species loss

Black-chinned Honeyeater (eastern subspecies). Photo © T. Shimba/DECCW

Occurrence in the Survey Area

There are no records of this species from the survey area in the Atlas of NSW Wildlife and it was not recorded by Andrew (2001), DECC (2008a) or during the current survey. The species is listed in Anyon-Smith (2006) as a vagrant with no recent records. The survey area is within the accepted distribution of the species, however, and so does not meet the definition of the term 'vagrant' that is used in this report; instead it is considered that the bird was once an irregular to rare visitor, but due to declines across the region, coupled within habitat changes in the Loftus-Engadine-East Heathcote areas, now no longer visits the survey area.

In the Sydney region the species' preferred habitat is low elevation grassy woodlands. This habitat type is not currently present within the survey area, with key flowering tree species absent (adapted from Higgins *et al*. 2001).

Regional Conservation Significance

The Black-chinned Honeyeater (eastern subspecies) is rarely recorded within the region, with most records from the Burragorang and lower Hunter valleys (DECC 2007c, 2008b). There are a small number of records on the edge of the Cumberland Plain to the west of the survey area, such as along the Georges River and Myrtle Creek in the Minto Heights area (DEC 2006b, DECC 2007a). As there have not been any recent records within the survey area, and habitat suitability is marginal, the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

PAINTED HONEYEATER *Grantiella picta*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Nil as peripheral species loss

Painted Honeyeater. Photo © H. Cook

Occurrence in the Survey Area

There are no records of this species from the survey area in the Atlas of NSW Wildlife and it was not recorded by Andrew (2001), DECC (2008a) or during the current survey. Anyon-Smith (2006) notes the species as a vagrant with no records since 1924 (Anyon-Smith 2006). The survey area was at least once within the accepted distribution of the species, however, and so does not meet the definition of the term 'vagrant' that is used in this report; instead it is considered that the bird was once a rare visitor, but due to decline across the region now no longer visits the survey area.

This species is unusual in that it primarily feeds on the fruit of various mistletoe species (Higgins *et al*. 2001). The Painted Honeyeater was formerly an uncommon breeding visitor to County of Cumberland, occurring most regularly in shale areas with plentiful mistletoe. Little suitable habitat is currently present in the survey area.

Regional Conservation Significance

The Painted Honeyeater is probably extinct within the Sydney area with the last confirmed record at Castlereagh on the Cumberland Plain in 1960 (DECC 2007c). As there have been no recent records and little suitable habitat is present, the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

AUSTRALIAN LOGRUNNER *Orthonyx temminckii*

***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Australian Logrunner. Photo © G. Barnett

Occurrence in the Survey Area

Rare resident with a recent breeding record from Lady Carrington Drive (Anyon-Smith 2006). Records are closely associated with warm temperate rainforest and wet sclerophyll forests along the Hacking River valley. This includes private lands in the upper Hacking near Peabody Colliery and Stuarts Gully (DECC 2008a). In the current survey, all records of this species were from the mid-Hacking River valley: south of Red Cedar Flat, Wilsons' Creek, Palm Gully and Walker's Garden along Lady Carrington Drive. All records were in Warm Temperate Rainforest, with the exception of the Walker's Garden location which was located in North Coast Wet Sclerophyll Forest with a mesic subcanopy (Section 3.2.1). Surprisingly no observations were made in Littoral Rainforest, despite bird censuses and six widely separated locations where camera traps were set for 13 consecutive days. However, there are old records from Palm Jungle and the Garie Beach area (Hoskin *et al*. 1991).

Regional Conservation Significance

The Australian Logrunner is not listed as a threatened species under the *TSC Act*, however it was identified as a priority regionally significant species. The reason for this priority listing is that it has a restricted distribution across the Sydney Basin Bioregion of which the survey area forms the northern limits of the isolated Illawarra population. This population forms the southern limits of its total distribution. It is geographically isolated from other populations which occur in the Watagan Mountains and north of the Hunter River (Higgins and Peter 2002). The Illawarra population prefers rainforest or wet sclerophyll forest with a mesic subcanopy (DEC 2003). Due to the population being a component of the Illawarra isolated population, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Loss of moist forest habitat through inappropriate fire regimes; lack of connectivity in the reserve system to important populations further south along the Illawarra Escarpment; predation by Foxes and both feral and domestic Cats; and grazing and trampling of vegetation by Rusa Deer.

Management Considerations

- Protect Northern Warm Temperate Rainforest and adjacent wet sclerophyll forest from fire.
- Maintain and improve connectivity with the moist forests of the reserves to those along the Illawarra Escarpment.
- Investigate approaches to protect populations of this species outside reserves in the Upper Hacking.
- Undertake Fox control in rainforest and adjacent wet sclerophyll forest, particularly known locations of the Logrunner.

VARIED SITTELLA *Daphoenositta chrysoptera*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Moderate**

Varied Sittella. Photo © M. Schulz

Occurrence in the Survey Area

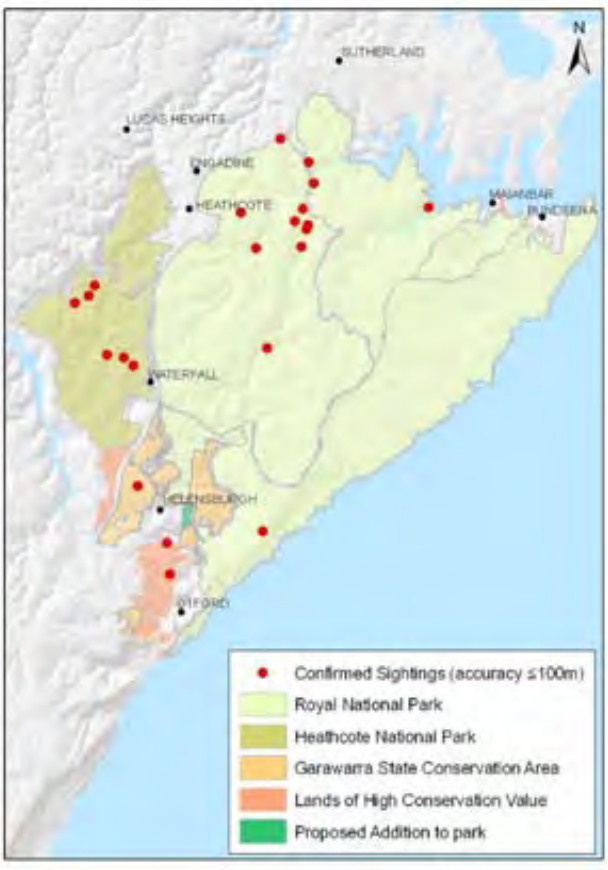
Uncommon breeding resident, with a number of records from Royal NP, Garawarra SCA and Heathcote NP. In March 2007 this species was recorded from two sites in the proposed reserve extension in the Upper Hacking: adjacent to Camp Creek and Gardiner's Creek north of Otford Road (DECC 2008a). In the current survey this species was uncommon and was only recorded at six locations: Grahams Point on South West Arm, Kangaroo Creek, south of Garawarra Farm, Loftus Trig, Hacking River upstream of Currawong Flat and in Heathcote NP at Bondel Pool on Heathcote Creek. It was principally recorded in Sydney Coastal Dry Sclerophyll Forest with a smaller number of records in North Coast Wet Sclerophyll Forest and Northern Hinterland Wet Sclerophyll Forest (Section 3.2.1). Although not recorded in the current survey this species also regularly occurs along the lower reaches of Kangaroo Creek upstream of Audley in alluvial forests dominated by Bangalay trees (M. Schulz pers. obs.). No nests were located in the current survey, although dependent young were observed in Sydney Coastal Dry Sclerophyll Forest and North Coast Wet Sclerophyll Forest.

Regional Conservation Significance

The Varied Sittella is widespread in small numbers across the Sydney Basin Bioregion. 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 2007c). Due to the small population in the survey area compared to other reserves within the region, the survey area contributes moderately to the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire and rapid colonisation of habitat that has recovered after fire; the removal of dead standing trees; and predation by Black Rats and both feral and domestic Cats.

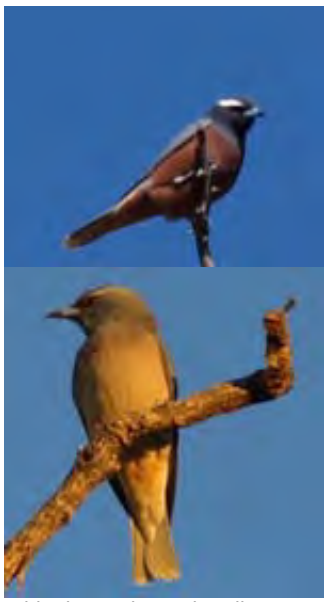


Management Considerations

- Ensure a mosaic of age classes in Sydney Coastal Dry Sclerophyll Forest across the survey area.
- Avoid felling dead trees in moist and dry forests as these are a scarce resource.
- Control wide-ranging domestic Cats adjoining urban areas.

WHITE-BROWED WOODSWALLOW *Artamus superciliosus*

***EPBC Act*: Not Listed**	***TSC Act*: Not listed**	**Priority in Area: Low**



White-browed Woodswallow male (above), female (below). Photo © M. Schulz

Occurrence in the Survey Area

Rare non-breeding visitor. Small numbers were observed over heathland in Royal NP during the 2002-2003 drought (Anyon-Smith 2006). The only other record was during the current survey of a pair of birds perched and hawking for insects in sand dune forest on the edge of heathland at the start of the Coast Track just east of Bundeena in October 2009. There are a number of records of this species from the nearby Woronora Special Area in spring 2002 (DECCW 2010a).

Regional Conservation Significance

The White-browed Woodswallow occurs sporadically in the Sydney Basin Bioregion, primarily during coastward irruptions probably influenced by conditions inland (Higgins *et al.* 2006). At these times large numbers of individuals may occur in a wide range of habitats across the region, including in urban areas of Sydney. However, overall there was a 38 per cent decrease in the reporting rate of this bird between 1984 and 2002 within this region (Barrett *et al*. 2003). Due to the small number of records, the survey area does little to contribute toward the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

SCARLET ROBIN		*Petroica boodang*
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Scarlet Robin female. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon to rare winter visitor (Anyon-Smith 2006), with the only spatially accurate record known from the Woronora Dam Road in Heathcote NP in September 2007. No individuals were recorded in the current survey, which is primarily due to the majority of fieldwork being conducted between early summer and mid-autumn when this species was unlikely to have been present. There are a number of records of this species from the nearby Woronora Special Area in September 2003 (DECCW 2010a).

Regional Conservation Significance

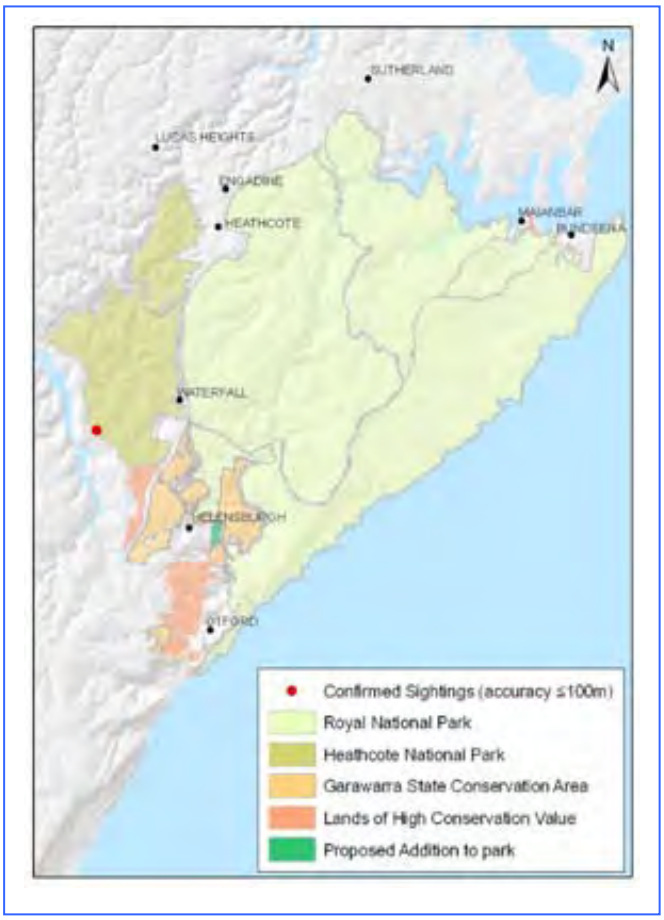
The Scarlet Robin is widespread in small numbers across much of the Sydney Basin Bioregion. There was a greater than 20 per cent decrease in the reporting rate of this bird between 1984 and 2002 within the bioregion and 31 per cent across the nation (Barrett *et al*. 2003). Due to the small number of records, the survey area does little to contribute toward the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the species requiring a mosaic of different age classes of Sydney Coastal Dry Sclerophyll Forest, with a preference for drier forest types with reduced shrub cover (Higgins *et al*. 2006); the removal of fallen timber and dead standing trees; and predation by Black Rats and both feral and domestic Cats.

Management Considerations

- Ensure a mosaic of age classes of Sydney Coastal Dry Sclerophyll Forest, particularly in Heathcote NP.
- Avoid the removal of fallen timber.
- Avoid felling dead and hollow-bearing trees in dry forests as these are a scarce resource.
- Control wide-ranging domestic Cats adjoining urban areas.



HOODED ROBIN *Melanodryas cucullata cucullata*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Hooded Robin. Photo © M. Schulz

Occurrence in the Survey Area

Suspected spatially inaccurate historic record from 'Port Hacking' in the 1800s. This species was not recorded by Anyon-Smith (2006), Andrew (2001), DECC (2008a) or during the current survey.

Due to the rarity of this species within the Greater Sydney region caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

The Hooded Robin was formerly widespread in the Cumberland Plain region of the County of Cumberland (Hoskin *et al.* 1991), however today there are very few records from this area (DEC 2006b). Elsewhere within the Sydney Basin Bioregion the species is now mostly restricted to the Hunter, Capertee and Burragorang Valleys (DECC 2007c). The decline in the County of Cumberland is a reflection of the greater than 20 per cent decrease in the reporting rate of this bird between 1984 and 2002 in this bioregion (Barrett *et al*. 2003). This species favours grassy box woodlands with low rainfall, although non-breeding birds may disperse into other habitats (DECC 2007c, Higgins and Peter 2002). Since none of its favoured habitat occurs within the survey area and there have been no recent records the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

DIAMOND FIRETAIL		*Stagonopleura guttata*
***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Diamond Firetail. Photo © H. Fallow/DECCW

Occurrence in the Survey Area

Rare visitor with the most recent record on the edge of Wattamolla Road in November 2002 (Anyon-Smith 2006). This observation coincided with an inland drought and wildfires on the Woronora Plateau including Heathcote NP in December 2001 and January 2002. This species was not recorded by Andrew (2001), DECC (2008a) or during the current survey. There are a number of old spatially inaccurate records in the Atlas of NSW Wildlife from Heathcote suburb in 1907 and Helensburgh in 1913 and 1916. It is possible that some of these records originated from within the survey area.

Due to the rarity of this species within the Greater Sydney region caution should be exercised, and any suspected sightings verified if possible, before being accepted as occurring within the survey area.

Regional Conservation Significance

The Diamond Firetail is rare throughout much of the Sydney Basin Bioregion, having disappeared from the Cumberland Plain and the Illawarra Coastal Plain (Hoskin *et al.* 1991, Chafer *et al.* 1999). Overall 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 stronghold within the region is in the Burragorang, Capertee and Hunter Valleys (DECC 2007c). In the region this species favours grassy box woodlands on high fertility soils (DECC 2007c). Since none of its favoured habitat occurs within the survey area and there has been only one recent record, the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

BEAUTIFUL FIRETAIL *Stagonopleura bella*

EPBC Act: Not Listed	*TSC Act*: Not Listed	Priority in Area: High

Beautiful Firetails. Photo © M. Schulz

Occurrence in the Survey Area

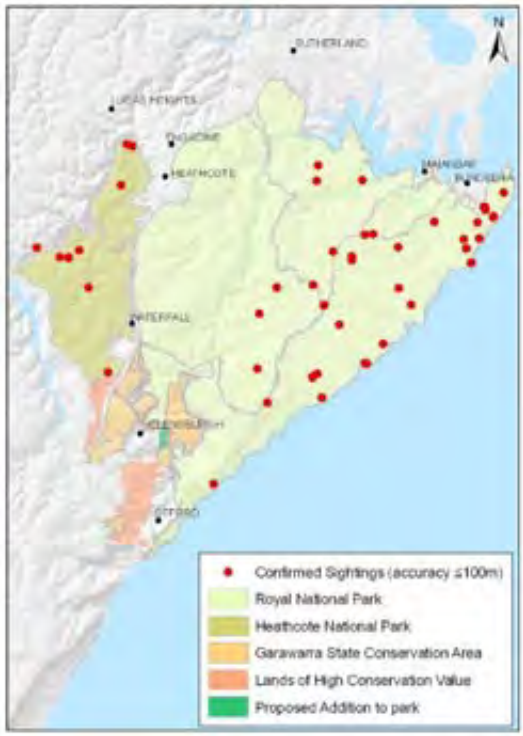
Common breeding resident, with a large number of records present in the Atlas of NSW Wildlife. This species declined after the extensive 1994 wildfire but is slowly increasing in numbers (Anyon-Smith 2006). In the current survey this species was recorded at numerous locations with 24 localities from Royal NP and four locations in Heathcote NP. It was predominantly recorded from Heathland (62 per cent of records from current survey) with a smaller number of records from Freshwater Wetland (19 per cent of records from current survey), Sydney Coastal Dry Sclerophyll Forest, North Coast Wet Sclerophyll Forest, Riparian Scrub and Coastal Headland Grassland (Section 3.2.1). It is present in coastal dune forests east of Bundeena (M. Schulz pers. obs.). No nests were located in the current survey, although juveniles were observed in Heathland and Freshwater Wetland. This species is regularly roadkilled, with 13 individuals recorded between May 2007 and May 2010 (Schulz and Madden in prep.).

Regional Conservation Significance

The Beautiful Firetail is not listed as a threatened species under the *TSC Act*, however it was identified as a priority regionally significant species. It has been reported to have decreased by at least 20 per cent within the region between 1984 and 2002 (Barrett *et al*. 2003). Additionally, the reason for this priority listing is that it has a restricted distribution across the Sydney Basin Bioregion, with few coastal records north of Royal NP (DECC 2007c). In the bioregion the main areas of occurrence are in Royal and Heathcote NPs, on the Woronora Plateau and Upland Swamps in the Blue Mountains. Within the region the species prefers high rainfall areas with low vegetation. Due to the survey area being identified as one of three principal primary areas in which this species occurs within the bioregion, being on the edge of its northern coastal range limit and its abundance compared to other hotspots within the region, the survey area contributes significantly to the regional conservation of this species.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire and rapid colonisation of habitat that has recovered after fire; alteration in wetland and heathland hydrological characteristics; habitat fragmentation; predation by Foxes and both feral and domestic Cats; grazing and trampling of vegetation by Rusa Deer; and road mortality.



Management Considerations

- Ensure a mosaic of age classes of Heathland and Coastal Upland Swamps across the area.
- Ensure the current hydrological regime of Coastal Upland Swamps is maintained.
- Aim to improve habitat connectivity between Heathcote and Royal NPs for fauna with limited dispersal ability.
- Undertake Fox control in Heathland and Coastal Upland Swamps.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Control wide-ranging domestic Cats.
- Work together with road and traffic authorities to raise awareness of the impact of wildlife road deaths on major thoroughfares within and adjoining the reserves.
- Consider supporting research into quantifying the impact of road fatality on this species at a population level.

SPOTTED-TAILED QUOLL *Dasyurus maculatus*

EPBC Act: Endangered	*TSC Act*: Vulnerable	Priority in Area: Nil as suspected species loss

Spotted-tailed Quoll resting. Photo © C. Harmsen

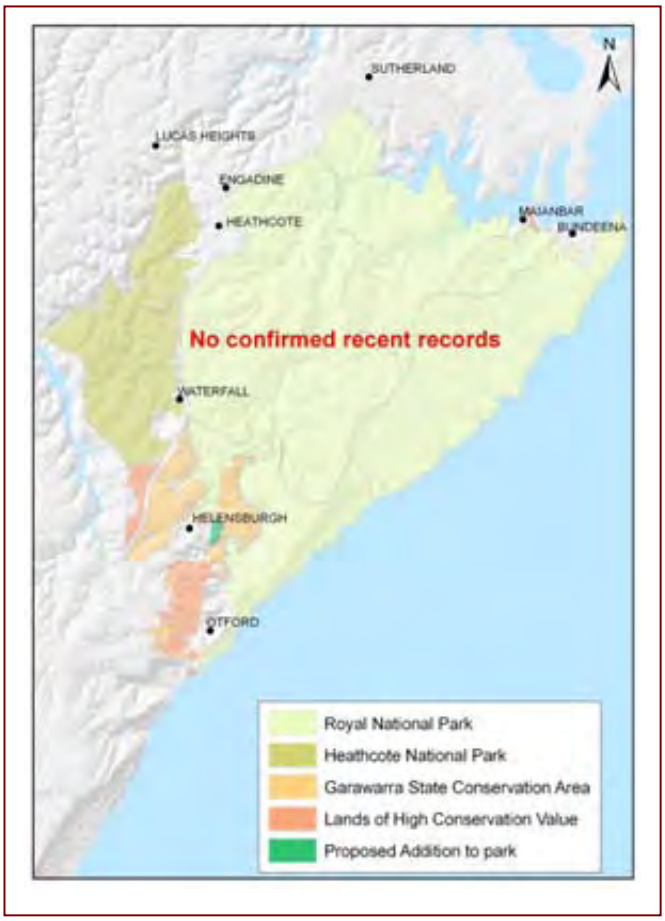
Spotted-tailed Quoll scats are readily confused with Fox scats. Photo © M. Schulz

Occurrence in the Survey Area

Not recorded for over 25 years although suitable habitat exists and very occasional observations are made in adjoining areas. The Spotted-tailed Quoll was recorded in Royal NP in the late 1960s and 1970s (Robinson 1987, R. Shovelor cited in Andrew 2001) and specimens were collected from Otford and Helensburgh in the 1800s (Australian Museum specimens). There is a single unconfirmed recent record within the survey area from Farnell Avenue in Royal NP in March 2007 (DECCW 2010a). The species was not located in Royal and Heathcote NPs despite 600 cage trap nights and 4200 hair tube nights by Andrew (2001) or in subsequent surveys within the survey area (e.g. Tulloch 2003) or in the Upper Hacking proposed reserve extension (DECC 2008a). Similarly the species was not recorded in the current survey despite the analysis of 104 predator scats and the sampling of 17 sites by camera traps. Additionally, this species has not been encountered by DECCW staff who undertake large amount of night patrols while hunting Rusa Deer (B. Sullivan, DECCW, pers. comm.) or naturalists that have spent a great deal of time over many years wandering around the survey area (e.g. S. Anyon-Smith pers. comm.). However, the species is known from adjoining areas, such as Holsworthy Military Area (DECC 2008a), Dharawal SCA area (DEC 2007a), the Metropolitan Special Area (DECC 2007c) and recently an individual was sighted on the upslope edge of Coledale (G. Daly, pers. comm.).

Regional Conservation Significance

There are scattered records of the Spotted-tailed Quoll across the Sydney Basin Bioregion, with the closest stronghold located in the Barren Grounds NR area (DECC 2007c). In the past this species was not uncommon on the Illawarra Escarpment, although locals reported this species declining in the 1980s (Robinson 1988). Since there has been only one record since the 1970s the survey area does not currently contribute to its regional conservation. However, since males may move up to 8km in one night (e.g. Belcher and Darrant 2004) it is likely that occasional animals may range into the survey area from adjoining areas.



Threats in the Survey Area

Road mortality; competition with the Fox; poisoning through incorrect Fox baiting; and habitat fragmentation.

Management Considerations

- Maintain and improve connectivity with the moist forests of the reserves to those along the Illawarra Escarpment, particularly between Helensburgh and Stanwell Park.
- Bury all Fox baits below 10cm at bait stations to reduce the incidence of bycatch poisoning.

EASTERN QUOLL *Dasyurus viverrinus*

***EPBC Act*: Not Listed**	***TSC Act*: Endangered**	**Priority in Area: Nil as locally extinct**

Eastern Quoll. Photo © R. Williams

Occurrence in the Survey Area

Extinct on the Australian mainland (Jones 2008). This species was once widely distributed across the region, being reasonably common until the late 1920s or early 1930s (Robinson 1988). The last records from the survey area were of occasional individuals around Lilyvale in the Upper Hacking in the 1960s (Robinson 1988).

Regional Conservation Significance

The Eastern Quoll is extinct within the Sydney Basin Bioregion (DECC 2007c, Jones 2008).

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

KOALA *Phascolarctos cinereus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Koala. Photo © P. Madden

A number of Koalas have been killed on Heathcote Road. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon non breeding visitor. Koalas are known principally from Heathcote NP or adjacent urban areas, such as Helensburgh, Heathcote and Waterfall. In the current survey this species was only recorded from one location: an individual was heard calling from the edge of Girronba Swamp in Heathcote NP on the edge of Coastal Upland Swamp in Sydney Coastal Dry Sclerophyll Forest. Individuals recorded within the survey area may represent a small remnant from the Woronora catchment population that was prevalent until the 1940s (Robinson 1987); rehabilitated released individuals (WIRES records); or wide-ranging individuals from the Campbelltown population that has been increasing since the 1980s (Ward and Close 2004, DECC 2007c). The Campbelltown population is found along the Georges River, including in adjoining areas of Holsworthy Military Area (DECC 2008a). This Koala is occasionally hit by vehicles on Heathcote Road to the west of the survey area (R. McLaggan, WIRES, pers. comm.).

Regional Conservation Significance

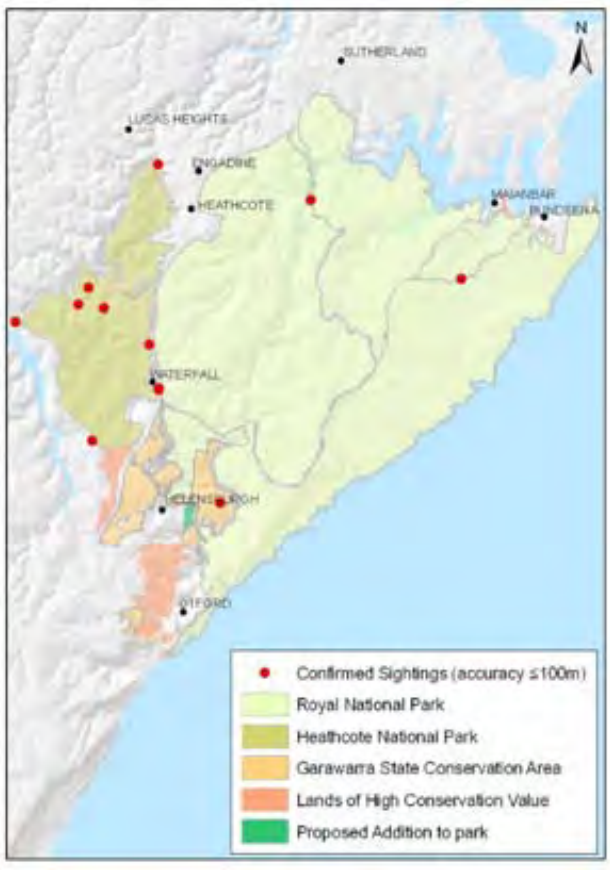
The Koala has a number of well known populations within the Sydney Basin Bioregion, including near Campbelltown, in the Avon/Upper Nepean catchments of the Metropolitan Special Area, Glenbrook and in southern Nattai NP (DECC 2007c). The survey area does not contribute significantly to the regional conservation of this species as observations are infrequent and sparse compared to areas around breeding populations elsewhere on the Woronora Plateau. However, over time this may change if Koalas colonise the survey area from the nearby Campbelltown population or elsewhere.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires); habitat fragmentation; predation by Foxes and Dogs; road mortality; and infection by Chlamydia which causes keratoconjunctivitis (an infection of the eyes) and infertility (DECC 2008e).

Management Considerations

- Follow relevant management recommendations outlined in the statewide recovery plan (DECC 2008e).
- Minimise high frequency fires.
- Aim to improve habitat connectivity between Heathcote and Royal NPs.
- Control wide-ranging domestic Dogs, especially in Heathcote NP.
- Work together with road and traffic authorities to raise awareness of the impact of wildlife road deaths on major thoroughfares within and adjoining the reserves.



EASTERN PYGMY-POSSUM *Cercartetus nanus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Eastern Pygmy-possum. Photo © N. Williams

Occurrence in the Survey Area

Common resident with large areas of high quality habitat. It is more frequently encountered in the survey area than anywhere else in the region. Most records are from pitfall and Elliott trapping (e.g. Ward 1994, Andrew 2001, Tulloch 2001, 2003, Nolan 2006). Unlike other possums this species is difficult to spotlight; for example in the current survey only two individuals were spotlighted incidentally at two locations in Heathcote NP. Its prevalence in Royal NP is reflected in a study between 2007 and 2011 in which 65 individuals were found road killed, making it the most commonly killed threatened species and the second-most commonly killed mammal after the Swamp Wallaby (Schulz and Madden in prep.). In the current survey this species was not targeted with trapping due to the amount of previous work conducted. This species was recorded incidentally from 16 locations, with 88 per cent of these records of active live or dead individuals on the public roads traversing Royal NP. This species was most commonly located in Heathland and Sydney Coastal Dry Sclerophyll Forest, and recorded less frequently from Northern Warm Temperate Rainforest and North Coast Wet Sclerophyll Forest. Additionally this species is known from sand dune forests east of Bundeena (M. Schulz pers. obs.). The species shelters in a variety of situations, such as tree hollows and rotting stumps in forest, while in heath it shelters in long-leaved grassy species such as Grass Trees, abandoned bird nests or underground (Tulloch 2001). Trapping results have shown that this species is most prevalent in habitats that are long unburnt (e.g. Andrew 2001, Tulloch 2003). However, small numbers have been recorded in recently burnt habitats (Tulloch 2003) or in unburnt patches within recently burnt (i.e. <1 year) heath (Ward 1994).

Regional Conservation Significance

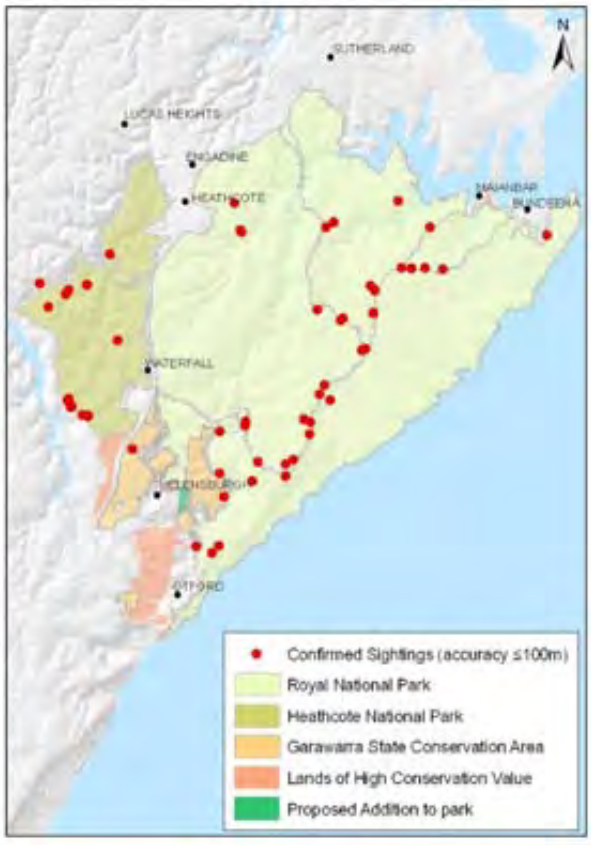
The survey area is a known 'hotspot' for the species within the Sydney Basin Bioregion (DECC 2007c), supporting one of the most important populations of the species in NSW (Bowen and Goldingay 2000). The survey area contributes significantly to its regional conservation.

Threats in the Survey Area

Inappropriate fire regimes (e.g. high frequency fires), with the species requiring a mosaic of different age classes to ensure the presence of refugia in times of wildfire and rapid colonisation of habitat that has recovered after fire; alteration in wetland and heathland hydrological characteristics; habitat fragmentation; predation by Foxes, Cats and Black Rats; grazing and trampling of vegetation by Rusa Deer; removal of hollow-bearing and dead trees and fallen timber; and road mortality.

Management Considerations

- Maintain a mosaic of time since fire classes of Heathland and Coastal Upland Swamps.
- Maintain the current hydrological regimes of Coastal Upland Swamps.
- Aim to improve habitat connectivity between Heathcote and Royal NPs.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Control wide-ranging domestic Cats.
- Undertake Fox control in Heathlands.
- Retain fallen logs and hollow-bearing trees.
- Consider supporting research into quantifying the impact of road fatality on this species.



YELLOW-BELLIED GLIDER *Petaurus australis*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Yellow-bellied Glider. Photo © R. Williams

Old Yellow-bellied Glider feedmarks in a Grey Gum. Photo © M. Schulz/DECCW

Occurrence in the Survey Area

Suspected mis-identification. This species was not recorded by Andrew (1985a, 2001), Tulloch (2003), Nolan (2006), DECC (2008a) or during the current survey. Additionally, there are no records from the survey area in the Atlas of NSW Wildlife. The only records are of several anecdotal reports in the 1960s and one heard in 1970 from the Hacking River valley (Robinson 1988). Since the records are all anecdotal the presence of the species within the survey area is considered unconfirmed.

Due to the apparent absence of this species from the Woronora Plateau area and the difficulty in distinguishing this species from other gliders such as the Greater Glider any suspected sightings should be verified before being accepted as currently occurring within the survey area. Any suspected feed marks in trees such as the Grey Gum should be photographed or shown to an expert, as feed marks can also be produced by other animals such as cockatoos and the Sugar Glider.

Regional Conservation Significance

The Yellow-bellied Glider is widespread in many parts of the Sydney Basin Bioregion, although the few records from the Woronora Plateau area have low reliability (DECC 2007c). Therefore the records from the Hacking River valley must be considered unconfirmed unless more than anecdotal evidence is located. Therefore the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

SQUIRREL GLIDER *Petaurus norfolcensis*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Squirrel Glider. Photo © N. Williams

Occurrence in the Survey Area

Suspected mis-identification. This species was not recorded by Andrew (1985a, 2001), Tulloch (2003), Nolan (2006), DECC (2008a) or during the current survey. Additionally, there are no records from the survey area in the Atlas of NSW Wildlife. The only record is of a sighting from 'Royal National Park' with no further details provided by Robinson (1987). As a result of the lack of details regarding this sighting and the absence of other documented records the presence of this species is considered unconfirmed.

Due to the rarity of this species within the Greater Sydney region and the difficulty in distinguishing this species from the common Sugar Glider caution should be exercised, and any suspected sightings verified, before being accepted as occurring within the survey area.

Regional Conservation Significance

The Squirrel Glider is scattered through the Sydney Basin Bioregion, with the majority of records from dry woodlands of the Central Coast and lower Hunter Valley. These areas are a stronghold for the species, though few records are from within conservation reserves (Smith and Murray 2003). Since there have been no recent records despite extensive spotlighting the survey area does not contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

No management required.

PARMA WALLABY *Macropus parma*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as locally extinct**

Parma Wallaby. Photo © DECCW

Occurrence in the Survey Area

Presumed extinct in the region. In the mid-1920s this species was common in Royal NP from west of Garie Beach south to the Hell Hole behind Werrong Beach in low thick scrub with rainforest elements (Robinson 1988). Additionally, there is a museum specimen from Red Cedar Flat. In the current survey this species was targeted by the placement of camera traps in littoral rainforest and adjoining wet sclerophyll forest at eight sites between Burning Palms and Stanwell Park, including one in the Hell Hole for a period of 12 sampling nights and two sites adjacent to Red Cedar Flat for 14 nights. Additionally Fox scats were collected in and adjacent to these areas. The only macropod species recorded using these two techniques was the Swamp Wallaby.

The Parma Wallaby can readily be confused with other macropods, particularly as good views are rarely obtained. Hence caution should be exercised, and any suspected sightings verified if possible, before being accepted as currently occurring within the survey area.

Regional Conservation Significance

The Parma Wallaby was once widespread across the Illawarra region being reasonably common in the 1920s but today is presumed extinct. There have been no records since 1969 when two groups were observed in the Cataract Dam catchment following the 1968 fires (Robinson 1988, DECC 2007c).

Threats in the Survey Area

No threats identified.

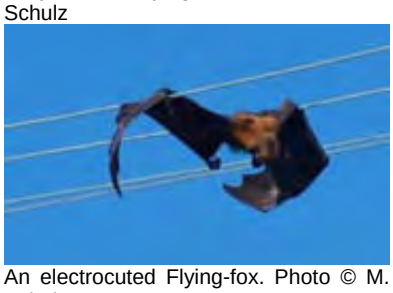
Management Considerations

- Several sightings of macropods that were presumed to be the Red-necked Wallaby in the Red Cedar Flat area require identification to confirm that they are not actually the Parma Wallaby as this was once a known locality for the species (e.g. Robinson 1988). Any DECCW staff working in this area should take photographs of these macropods wherever possible irrespective of image quality and pass these on to experts for identification.

GREY-HEADED FLYING-FOX *Pteropus poliocephalus*

***EPBC Act*: Vulnerable**	***TSC Act*: Vulnerable**	**Priority in Area: High**

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



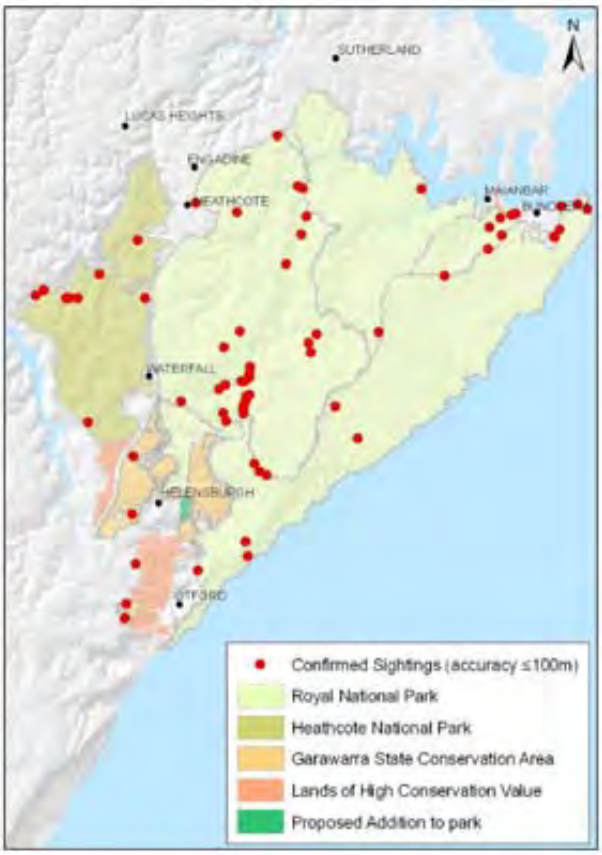
An electrocuted Flying-fox. Photo © M. Schulz

Occurrence in the Survey Area

Common seasonal visitor with a large number of records present across the survey area. There are no camps known within the survey area. Individuals are likely to commute from camps on the Kurnell Peninsula (although use of the desalination site is unknown) and from camps at Kareela and possibly from irregularly used camps at Mt Kembla and Bulli Pass and the large permanent camp at Cabramatta. Occasional single individuals are encountered roosting during the day in the Bundeena-Bonnie Vale area. The survey area is an important food resource for the species, particularly when key plants are in flower such as the Red Bloodwood, Blackbutt, Smooth-barked Apple, Heath-leaved Banksia and Swamp Mahogany, in addition to various fruiting rainforest canopy and subcanopy trees. In the current survey this species was recorded at numerous locations with 22 localities. It was predominantly recorded from Sydney Coastal Dry Sclerophyll Forest, Heathland and Dune and Alluvial Sclerophyll Forest with smaller number of records in all other habitat groups with the exception of Northern Warm Temperate Rainforest, Coastal Headland Grassland, Forested and Saline Wetlands and Shoreline. However, in other years this species has been observed feeding in figs in Warm Temperate and Subtropical Rainforest adjacent to Red Cedar Flat and in scattered Coast Banksias in Coastal Headland Grassland within the survey area (M. Schulz pers. obs.). Twelve individuals were found roadkilled between May 2007 and March 2011, with 89 per cent of these found in April and May 2010 when the species was feeding close to the ground in flowering Heath-leaved Banksia along Bundeena Drive (Schulz and Madden in prep.).

Regional Conservation Significance

The Grey-headed Flying-fox is widespread across the Sydney Basin Bioregion, with approximately 16 camps present (Eby *et al*. 1999). The fact that the area supports large tracts of unfragmented habitat supporting key flowering species (e.g. Red Bloodwood and Heath-leaved Banksia) indicates that it significantly contributes to the regional conservation of this species.



Threats in the Survey Area

Inappropriate fire regime; road mortality; predation by the Fox at roosts; entanglement in barbwire fences; hydrological changes in streams, wetlands and heath; loss of key flowering trees; and electrocution on powerlines in adjacent areas.

Management Considerations

- Avoid using barbwire fencing, particularly on the top strand of fences within the survey area, including on reserve boundaries.
- Encourage DECCW staff and members of the public to record and report road deaths of this species in the survey area.
- Consider installation of road kill awareness signage and distribution of information brochures.

EASTERN HORSESHOE BAT *Rhinolophus megaphyllus*

***EPBC Act*: Not Listed**	***TSC Act*: Not Listed**	**Priority in Area: High**

Eastern Horseshoe Bat. Photo © M. Schulz

Occurrence in the Survey Area

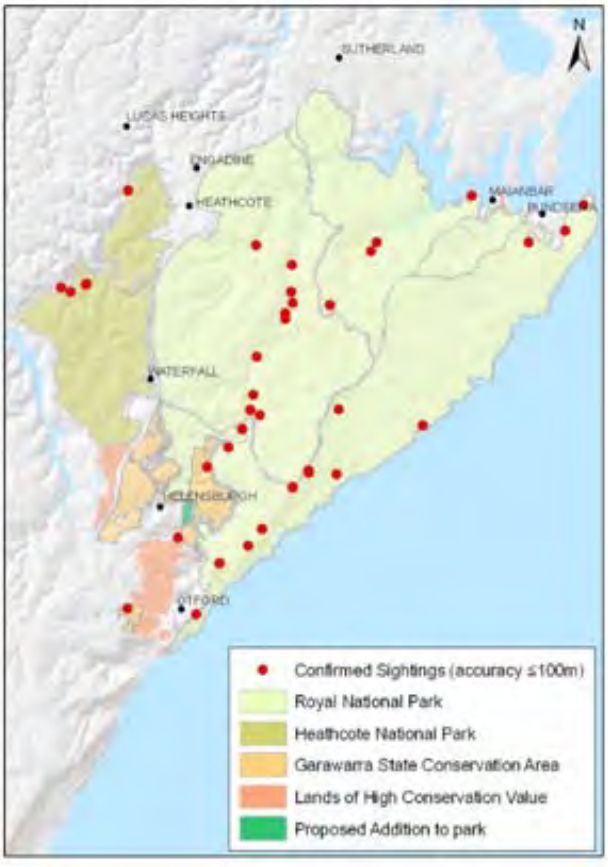
Common breeding resident with a large number of records from across the survey area. In the current survey this species was recorded at numerous locations, with 22 localities from across the survey area. It was recorded in all forested habitat groups with the largest number of records in Sydney Coastal Dry Sclerophyll Forest. Additionally it was also recorded in Heathland some distance from adjoining forested areas. Two roadkilled animals have been recorded in the survey area by Schulz and Madden (in prep.). This species was recorded roosting in a number of artificial structures, including Dingo Tunnel in Heathcote NP and under bridges along the Hacking River valley and in road culverts along the Garie Beach Road. Additionally individuals were located roosting in a deep rock fissure adjacent to the Woronora River 1.5km upstream of Heathcote Creek confluence in Heathcote NP and various locations in Royal NP including in caves west of Yenabilli Point and adjacent to Flat Rock Creek crossing. Additionally it has been recorded roosting in a number of artificial structures in the Upper Hacking, including disused railway tunnels (DECC 2008a). A maternity roost is located in the Bola Creek area with approximately 100 individuals present five years ago (S. Anyon-Smith, pers. comm., H. Parnaby, DECCW, pers. comm.).

Regional Conservation Significance

The Eastern Horseshoe Bat is not listed as a threatened species under the *TSC Act*, however it was identified as a priority regionally significant species. The survey area supports one of the only known maternity sites within the Sydney Basin Bioregion (H. Parnaby, DECCW pers. comm.).

Threats in the Survey Area

Disturbance by the public at the maternity roost, particularly in the breeding season; disturbance by the public at non-breeding roosts; predation by the Fox and both feral and domestic Cats; sealing up or incorrect gating of old mines and tunnels; and road mortality.



Management Considerations

- Do not publicise the presence of the maternity roost.
- Limit the development of walking tracks and other infrastructure in the Bola Creek area.
- Control wide-ranging domestic Cats.

YELLOW-BELLIED SHEATHTAIL-BAT *Saccolaimus flaviventris*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Yellow-bellied Sheathtail-bat. Photo © H. Cook

Occurrence in the Survey Area

The status of this species in the survey area is uncertain, but it likely either an extremely rare visitor or vagrant. Habitat suitability is unknown. This species was not recorded by Pennay (2000), Andrew (2001), Parnaby (2001), DECC (2008a) or during the current survey. Additionally, there are no records from the survey area in the Atlas of NSW Wildlife. The only records are of a dead individual found by T. Rose (cited in Andrew 2001) and of a low quality call recorded by an Anabat detector in the Tall Timbers area of Bundeena Drive (Engel 2010).

Regional Conservation Significance

The status of the Yellow-bellied Sheathtail-bat in the Sydney Basin Bioregion is poorly understood with a small number of Australian Museum specimens collected, no capture records and a number of Anabat records, with some of uncertain quality (DECC 2007c). The species is readily distinguished by spotlight but no records have been documented using this technique. Due to the absence of confirmed records it is assumed that the survey area does not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

- Due to the uncertain status of this species within the survey area it is recommended that any provisionally identified Anabat recordings be sent to a bat call expert for confirmation.

EAST-COAST FREETAIL-BAT *Mormopterus norfolkensis*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Nil as inaccurate record

East-coast Freetail-bat. Photo © N. Williams

Occurrence in the Survey Area

Signals detected by Anabat at Jersey Springs along the Hacking River could not be distinguished between this species or *Mormopterus* "Species 2" (Parnaby 2001) and there are no confirmed records within the survey area. Anabat recordings have been identified from adjacent land in the Helensburgh area to the west of the survey area (DECCW 2010a). In the current survey 64 harp trap sites and 76 sites sampled by Anabat across the area failed to detect East-coast Freetail-bat.

Potential habitat for the species does exist within the survey area and it is possible that further survey will confirm the bat's occurrence.

Regional Conservation Significance

The majority of East-coast Freetail-bat records in the Sydney Basin Bioregion are from coastal plains and larger incised fertile valleys, such as the Burragorang, Cumberland, Hunter and Wollondilly Valleys (DECC 2007c). Its preferred habitat is grassy box woodlands on fertile soils in flatter terrain. Due to the absence of confirmed records the survey area does not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

- Due to the uncertain status of this species within the survey area; any provisionally identified Anabat recordings are to be sent to a bat call expert for confirmation.

LITTLE BENTWING-BAT *Miniopterus australis*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Moderate

Little Bentwing-bat. Photo © M. Schulz

Occurrence in the Survey Area

Status uncertain. No individuals of this species have been captured in harp traps within the survey area (Pennay 2000, Andrew 2001, Nolan 2006, DECC 2008a and the current survey). The majority of records within the area are from Anabat signal identification; for example, along the Woronora Dam Road in March 2005 (DECCW 2010a) and at an unreported location in Royal NP (Engel 2010). Additionally a small aggregation of 20+ individuals of this species was recorded roosting in the disused Otford-Stanwell Park railway tunnel in March 2007 (DECC 2008a). Sections of this tunnel pass under the survey area. The entrance of this tunnel was trapped using a harp trap and the tunnel searched for roosting individuals during the current survey in March and May 2010 with no individuals located.

Regional Conservation Significance

The Little Bentwing-bat roost in the abandoned Stanwell Park-Otford railway tunnel represents the most southerly documented roost for this species (DECC 2008a). The closest documented roost is in a concrete-lined underground section of Brookvale Creek in Brookvale on the Northern Beaches (DECC 2008a). Due to fact that the abandoned Stanwell Park-Otford railway tunnel passes under a section of the area, the species is at its southern range limit and that the species forages within the area indicates that the survey area significantly contributes to the regional conservation of this species.

Threats in the Survey Area

Disturbance by the public in the abandoned Stanwell Park-Otford railway tunnel; and incorrect gating that will result in roost abandonment.

Management Considerations

- Any new gating in the abandoned Stanwell Park-Otford railway tunnel to follow guidelines in 'The Australian Handbook for conservation of bats in mines and artificial cave-bat habitats' (Thomson 2002) and to be done in consultation with bat experts.
- Old railway tunnels that have recently become managed by DECCW be considered for management that will encourage the roosting of cave-dwelling bats, particularly species sensitive to entrance gating. Any works to be done in consultation with bat experts.
- Consider reopening old tunnels and shafts to offer alternative habitats for roosting on reserves.

EASTERN BENTWING-BAT *Miniopterus schreibersii oceanensis*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: Moderate

Eastern Bent-winged Bat. Photo © N. Williams

Occurrence in the Survey Area

Uncommon non-breeding visitor. This species has been infrequently recorded across the survey area, principally in the Hacking River valley (e.g. Pennay 2000, Parnaby 2001, DECC 2008a). In the current survey the Eastern Bentwing-bat was surprisingly uncommon given that roosts are known to occur in underground aqueducts, railway and mine tunnels in the Helensburgh-Stanwell Park area (DECC 2008a). It was captured in harp traps on the Cliff Track south of Garawarra Farm, Bola Creek and a gully south west of Red Cedar Flat. No confirmed signals were identified using Anabat due to the difficulty in separating signals from the Large Forest Bat (Pennay *et al*. 2004), which occurs sympatrically in southern parts of Royal NP. Small roosts of this species were located in deep overhangs west of Yenabilli Point and in the abandoned Stanwell Park-Otford railway tunnel just south of the area. In the current survey the species was recorded in Northern Warm Temperate Rainforest, North Coast Wet Sclerophyll Forest Northern Hinterland Wet Sclerophyll Forest and Sydney Coastal Dry Sclerophyll Forest. An individual roadkill was recorded in Heathland on Bundeena Drive by Schulz and Madden (in prep.).

Regional Conservation Significance

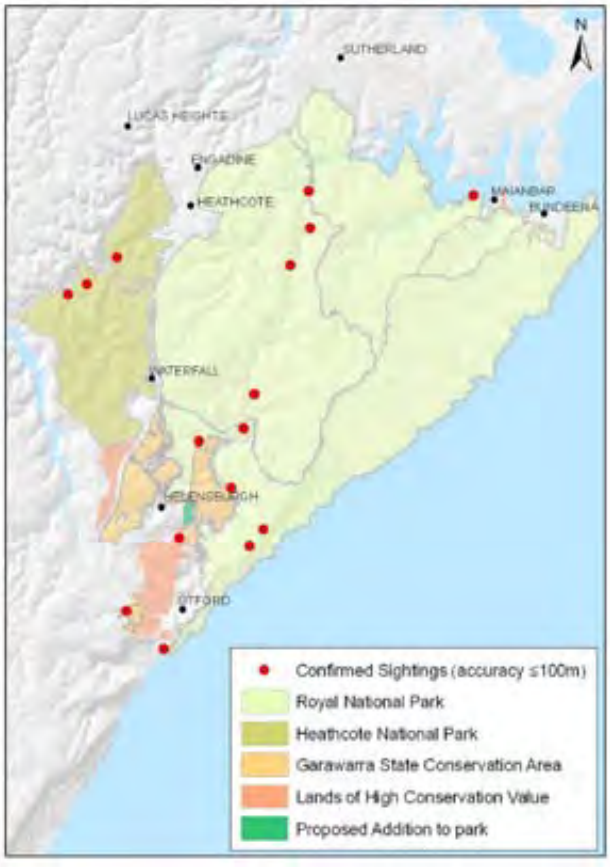
Although the Eastern Bentwing-bat is widespread across the Sydney Basin Bioregion, occurring in a range of habitats, including in urban areas there are no confirmed maternity caves from this bioregion (DECC 2007c, 2008a). The survey area significantly contributes to the regional conservation of this species due to it supporting several known roosts, the further likelihood of a number of undocumented roosts and the likelihood of individuals ranging into the area to forage from known roosts in the Helensburgh-Stanwell Park area.

Threats in the Survey Area

Disturbance by the public in roosts; incorrect gating of artificial structures that support roosting colonies will result in roost abandonment (this species is particularly sensitive to entrance gating and it is very difficult to install gates that will not result in abandonment; L. Lumsden, Victorian Dept of Sustainability and Environment); and road mortality.

Management Considerations

- Any new gating in the abandoned Stanwell Park-Otford railway tunnel to follow guidelines in 'The Australian Handbook for conservation of bats in mines and artificial cave-bat habitats' (Thomson 2002) and to be done in consultation with bat experts.
- Old railway tunnels that have recently become managed by DECCW be considered for management that will encourage the roosting of cave-dwelling bats, particularly species sensitive to entrance gating. Any works to be done in consultation with bat experts.
- Consider reopening old tunnels and shafts to offer alternative habitats for roosting on reserves.



GOLDEN-TIPPED BAT *Kerivoula papuensis*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Golden-tipped Bat. Photo © M. Murphy

Yellow-throated Scrubwren nests are used as roosts by the Golden-tipped Bat. Photo © M. Schulz

Occurrence in the Survey Area

The Golden-tipped Bat has not previously been captured in harp traps within the survey area (e.g. Pennay 2000, Andrew 2001, Nolan 2006, DECC 2008a). The only records are from Anabat recordings at Helensburgh on the boundary of the survey area. These identifications must be considered unconfirmed since this species' ultrasonic call is rarely recorded. The reason for the signals being rarely recorded is that it emits short, quiet, high frequency wide band echolocation signals which travel only a few metres and so are rarely picked up with bat detectors (Reinhold *et al.* 2001).

The Golden-tipped Bat occurs in rainforest and adjacent wet forest habitats north of Sydney in the Watagan Mountains area and south of Sydney, such as state forests inland of Batemans Bay. As potentially suitable habitat occurs within the survey area (e.g. Schulz and Eyre 2000), for example, the rainforests of the intervening area, such as along the Illawarra Escarpment (e.g. DEC 2003), the species was targeted during the current survey. Targeted harp trapping was undertaken in 24 rainforest or adjacent wet sclerophyll forest sites but resulted in no individuals being captured. The Golden-tipped Bat primarily roosts in the suspended nests of the Yellow-throated Scrubwren (Schulz 2000a, b, c). These nests are modified to provide access through a basal hole rather than through the side entrance constructed by the bird (Schulz 2000a). Such modifications are diagnostic and therefore during the current survey all accessible Yellow-throated Scrubwren nests encountered were checked for roosting individuals or the presence of basal holes. Approximately 40 nests were checked in Northern Warm Temperate and Littoral Rainforests without any roosting bats or evidence of basal holes found.

Regional Conservation Significance

Although the Golden-tipped Bats distribution is from far south-eastern NSW to Cape York Peninsula there is a gap in its distribution in the Illawarra and Sydney areas (e.g. DECC 2007c). Within this region including in Royal NP, prime habitat attributes identified by Schulz and Eyre (2000) are present. These attributes were identified as closed forest with multiple tree layers and numerous vines at elevations of 50 to 150m above sea level in terrain with high relief and slope, close spacing between streams on slopes near the ecotone with adjacent more open forest. Currently the ultrasonic records must be regarded as unconfirmed and therefore the survey area does not significantly contribute to this bat's regional conservation.

Threats in the Survey Area

No threats identified.

Management Considerations

- Any provisionally identified Anabat recordings are to be sent to a bat call expert for confirmation.

LARGE-EARED PIED BAT *Chalinolobus dwyeri*

***EPBC Act*: Vulnerable**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Large-eared Pied Bat. Photo © M. Schulz

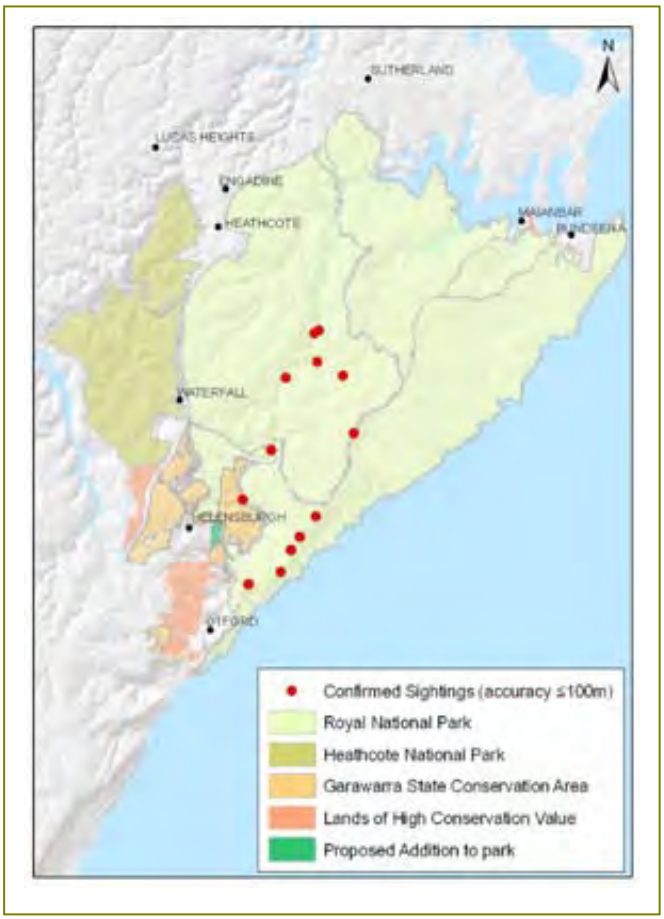
An individual disappearing into a roost in a rock crevice. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon localised resident. This species has been infrequently recorded in previous surveys with all records from Royal NP (e.g. Pennay 2000, Parnaby 2001). In these surveys it was principally recorded from the Hacking River valley, with additional records from the south of Garawarra Farm and the start of the Curra Moors Fire Trail. In trapping within the proposed reserve extensions in the Upper Hacking no individuals were captured (DECC 2008a). In the current survey the Large-eared Pied Bat was recorded from similar localities to the previous surveys, with no records from Heathcote NP. It was principally captured in harp traps along the southern escarpment edge on the Cliff Track between Garawarra Farm and the Coast Track junction, with one capture along the Hacking River in a gully south of Calala. An additional ultrasonic recording was identified from Wises Track on the ridge above the Hacking River valley. In the current survey the species was principally recorded from North Coast Wet Sclerophyll Forest with single records from Littoral Rainforest and Sydney Coastal Dry Sclerophyll Forest. Andrew (2001) also recorded this species from Heathland and Northern Warm Temperate Rainforest. No roosts of this species have previously been documented. In the current survey despite searching parts of the escarpment from south of Garawarra Farm to Bulgo Hill no roosts were located. It is likely this species roosts in small crevices and is difficult to find.

Regional Conservation Significance

Although the Large-eared Pied Bat occurs from Bungonia north to central Queensland, the Sydney Basin Bioregion represents critical habitat for this species with a large proportion of all known records originating from this region. The prime habitat for the species within the region includes areas of moderately tall trees and vegetated watercourses on fertile soils (DECC 2007c). There are few documented roosts recorded within the region, with no maternity sites known. Due to the region supporting critical habitat for this species, with much prime habitat cleared in the Sydney region (e.g. Cumberland Plain), the survey area significantly contributes to the regional conservation of this species.



Threats in the Survey Area

Loss of rainforest and wet sclerophyll forest as a result of high frequency fires.

Management Considerations

- Protect North Coast Wet Sclerophyll Forest and rainforest from fire.

EASTERN FALSE PIPISTRELLE *Falsistrellus tasmaniensis*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Nil as inaccurate record**

Eastern False Pipistrelle. Photo © M. Schulz

Occurrence in the Survey Area

Suspected inaccurate record. This species has only been identified from ultrasonic signals recorded in Heathcote NP along the Woronora Dam Road and in Royal NP along the Hacking River and at Flat Rock Crossing on South West Arm Creek (Parnaby 2001). No individuals have been captured during surveys conducted within the survey area (e.g. Pennay 2000, Andrew 2001, Nolan 2006, DECC 2008a). In the current survey no individuals were captured in harp traps located at 64 sites across the area. Given that this species is relatively trappable when present and that the ultrasonic signals of this bat are readily confused with the Greater Broad-nosed Bat, Gould's Wattled Bat and the Eastern Broad-nosed Bat (Reinhold *et al*. 2001, Pennay *et al.* 2004) the presence of this species within the area is currently considered unconfirmed. This approach is similar to that adopted elsewhere within the coastal part of the bioregion (e.g. DECC 2007c, 2008a).

Regional Conservation Significance

The majority of Eastern False Pipistrelle records based on trapped individuals within the Sydney Basin Bioregion are from high elevation areas in the western part of the region, such as Boyd and Newnes Plateaus in the western Blue Mountains. In contrast records from around Sydney are based on ultrasonic call identification with no captured individuals recorded despite intensive trapping effort in localities where call identifications have been made (DECC 2007c). Given the difficulty of readily distinguishing this species from a number of other bat species that are widespread across the Sydney area (see above) these records have all been discounted and not incorporated within habitat modelling for the Eastern False Pipistrelle across the region (DECC 2007c). Therefore, due to the absence of confirmed records based on trapped individuals the survey area is not considered to significantly contribute to the regional conservation of this species.

Threats in the Survey Area

No threats identified.

Management Considerations

- Due to the uncertain status of this species within the survey area it is recommended that any provisionally identified Anabat recordings be sent to a bat call expert for confirmation.

LARGE-FOOTED MYOTIS *Myotis macropus*

EPBC Act: Not Listed	*TSC Act*: Vulnerable	Priority in Area: High

Large-footed Myotis. Photo © M. Schulz

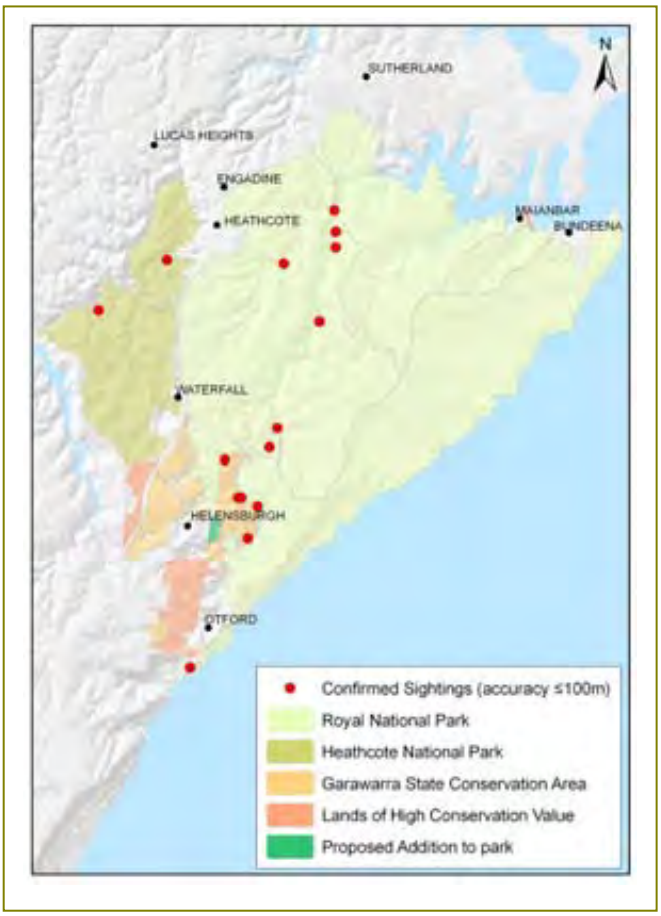
Large feet of this species used for raking prey up from the water surface. Photo © M. Schulz

Occurrence in the Survey Area

Moderately common localised resident. This species has been infrequently recorded in previous surveys with the majority of records from along the Hacking River valley (e.g. Pennay 2000, Andrew 2001, Parnaby 2001, DECC 2008a). In the current survey the Large-footed Myotis was recorded from five localities within the Hacking River valley, with additional records from Kangaroo Creek at the Bottle Forest Track crossing and in Heathcote NP at Mirang Pool on Heathcote Creek. All records were along deeper sections of larger watercourses, with the exception of a gully south of Red Cedar Flat which had little water present and no deep pools. In the current survey the species was principally recorded from Northern Warm Temperate Rainforest (50 per cent of records from current survey) and Riparian Scrub (25 per cent of records from current survey), with a small number of records from North Coast Wet Sclerophyll Forest and Deep Freshwater Habitats. No observations were made from intertidal habitats along the Port Hacking shoreline. No roosts have been documented within the survey area, although it is likely to use both deep rock overhangs and hollows in trees and dead stags. Several roosts are known from the Upper Hacking, including 30+ individuals located in an underground water aqueduct at the Peabody Colliery adjacent to Camp Creek and 20+ present in the abandoned Stanwell Park-Otford railway tunnel (DECC 2008a).

Regional Conservation Significance

The Large-footed Myotis primarily occurs in scattered localities along the watercourses within the Sydney Basin Bioregion. Due to the relatively high numbers recorded and the continuous riparian habitat present, the reserves significantly contribute to the conservation of the species in the region.



Threats in the Survey Area

Loss of hollow-bearing and dead standing trees; public disturbance at roosts; sealing up or incorrect gating of old mines and tunnels; water quality and flow changes in streams; and public disturbance at roost sites.

Management Considerations

- Protect hollow-bearing and dead standing trees adjacent to major watercourses.
- Ensure high water quality of watercourses.
- Any new gating in the abandoned Stanwell Park-Otford railway tunnel to follow guidelines in 'The Australian Handbook for conservation of bats in mines and artificial cave-bat habitats' (Thomson 2002) and to be done in consultation with bat experts.
- Explore the feasibility of creating bat roosting habitat under bridges along Lady Carrington Drive.

GREATER BROAD-NOSED BAT *Scoteanax rueppellii*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: High**

Greater Broad-nosed Bat. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon localised resident. This species is likely to be more common than the few records suggest due to the difficulty of distinguishing its ultrasonic signal from the Eastern False Pipistrelle and Eastern Broad-nosed Bat (Pennay *et al*. 2004). The only records prior to the current survey were from the Upper Causeway on the Hacking River (Parnaby 2001), with no captured individuals recorded (e.g. Pennay 2000, Andrew 2001, Nolan 2006, DECC 2008a). In the current survey the Greater Broad-nosed Bat was recorded as single individuals captured in harp traps at two localities: on the Cliff Track north of the Lilyvale Track junction in Royal NP and at Friarbird Pool on the Woronora River in Heathcote NP. Additionally an individual was spotlighted and recorded ultrasonically on dusk adjacent to Wises Track 1.5km south of Sir Bertram Stevens Drive in Royal NP. The species is likely to have been under-recorded with a number of ultrasonic signals that could not be definitely differentiated from similar species such as the Eastern Broad-nosed Bat and the Eastern False Pipistrelle. In the current survey the species was principally recorded from Riparian Scrub-North Coast Wet Sclerophyll Forest interface in Heathcote NP and Sydney Coastal Dry Sclerophyll Forest in Royal NP. No roosts have been documented within the survey area, although it is likely to use hollows in trees and dead stags.

Regional Conservation Significance

The Greater Broad-nosed Bat primarily occurs in forested lowland environments within the Sydney Basin Bioregion; preferring taller forests on fertile soils (DECC 2007c). Due to the rarity of this species in the Sydney region (based on capture records), the survey area significantly contributes to the regional conservation of this species.

Threats in the Survey Area

Loss of hollow-bearing and dead standing trees through inappropriate fire regimes (e.g. high frequency fires); and the loss of hollow-bearing and dead trees through reserve management practices, such as adjacent to roads and picnic areas.

Management Considerations

- Avoid felling hollow-bearing and dead trees as these are a scarce resource due to past land management practices within tall eucalypt forests.

NEW HOLLAND MOUSE		*Pseudomys novaehollandiae*
***EPBC Act*: Vulnerable**	***TSC Act*: Not Listed**	**Priority in Area: High**

New Holland Mouse. Photo © N. Williams

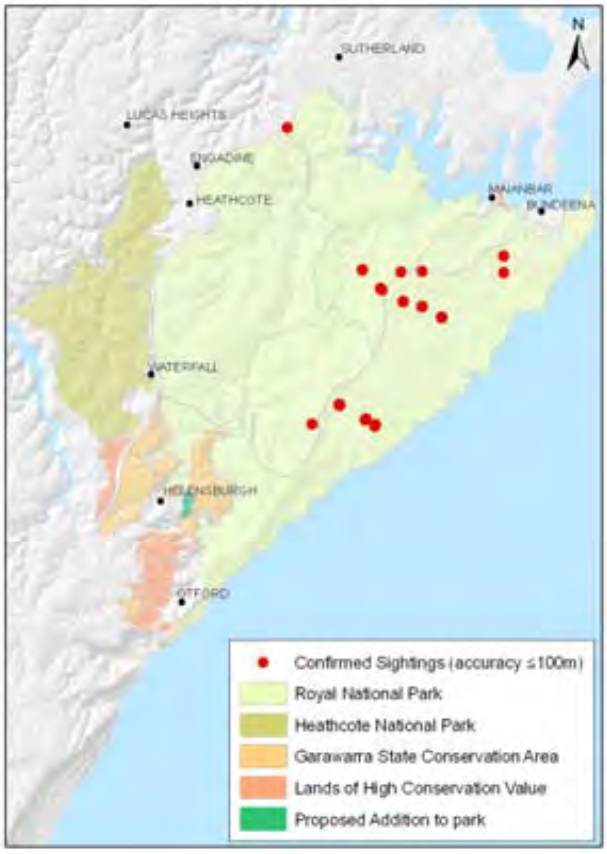
Occurrence in the Survey Area

Locally common resident. The species was not targeted during the current survey due to the amount of previous trapping work conducted within the survey area (e.g. Andrew 2001). The majority of sightings in the Atlas of NSW Wildlife are from pitfall and Elliott trapping, with records between 1996 and 2006 as well as a couple in the early 1970s. Several other observations were made on the Marley Track in the 1970s, as well as one in 1998 on the Curra Moors Track. Three individuals have been found dead on the road within the survey area, including one on Bundeena Drive during the current survey, plus one on Bundeena Drive and one on Farnell Avenue by Schulz and Madden (in prep. see Appendix 2). The New Holland Mouse is primarily confined to the Heathlands habitat group in the eastern part of Royal NP (see map), with the large majority of trapped individuals located in areas of deeper sand where there is no tall tree canopy (D. Andrew pers. comm.). Animals do occur through other parts of the park, as evidenced by the road kill found 40m from the highway on Farnell Avenue, though their density and distribution is not clear.

This species is easily overlooked and can readily be confused with other small mammals such as House Mouse, or in the case of road kills even Black Rat. Hence care should be taken when identifying specimens.

Regional Conservation Significance

The New Holland Mouse is patchily distributed across the Sydney Basin Bioregion, and though records are scattered through the sandstone reserves of the greater Blue Mountains the greatest densities of records occur closer to the coast (DECCW 2010a). Clusters of records occur in Royal NP, Garigal NP-Ku-ring-gai Chase NP, Munmorah SRA and the Tomago Sandbeds (DECCW 2010a). While across its range it occurs from heathland to woodland or swamp and on sandy, loamy or rocky soils, coastal populations have a marked preference for sandy substrates and a heathy understorey (Kemper and Wilson 2008). Due to ongoing threats to coastal populations of the species and the concentration of records within the survey area, the survey area is considered to contribute significantly to the regional conservation of this species.



Threats in the Survey Area

Predation from introduced predators; inappropriate fire regimes which do not provide habitat patches of suitable successional age, size and distribution; habitat fragmentation and loss of connectivity; grazing and trampling of vegetation by Rusa Deer; and road mortality.

Management Considerations

- Maintain a mosaic of time since fire classes in Heathland in Royal NP.
- Maintain current Rusa Deer control measures following the Deer Management Plan (DEC 2005).
- Control wide-ranging domestic Cats.
- Undertake Fox control in Heathlands.
- Work together with road and traffic authorities to help reduce roadkills on major thoroughfares through the reserves.

AUSTRALIAN FUR-SEAL *Arctocephalus pusillus*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

Australian Fur-seal. Photo © M. Schulz

Unidentified Fur-seals are regularly observed loafing close inshore off the sea cliffs. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon visitor. There are no records in the Atlas of NSW Wildlife of this species hauled out along the Royal NP shoreline. However, single individuals are occasionally observed resting on a rock platform below Marley Head (M. Schulz pers. obs.). This species was reported from Little Garie Beach in August 2002 and one was found entangled in a shark net off Wattamolla Beach in March 2008 (R. Haering, DECCW, pers. comm.). This species was not recorded during the current survey. Unidentified fur seals are regularly seen loafing in the water just off the rocks of the sea cliffs (Appendix 1). At times unidentified immatures have been observed for several hours resting in the water against a vertical rock face rising and falling with the swell (M. Schulz pers. obs.).

This species can readily be confused with the New Zealand Fur Seal and Subantarctic Fur Seal (*Arctocephalus tropicalis*) that may also haul out along the Royal NP coastline. Therefore, any sightings would benefit from photographs to document the presence of this species within the survey area.

Regional Conservation Significance

The Australian Fur Seal is a non-breeding visitor to coastal waters of the Sydney Basin Bioregion. Due to the rarity of this species hauling out, the survey area does not significantly contribute to the regional conservation of this species. This species can readily be confused with the New Zealand Fur Seal and Subantarctic Fur Seal that may also haul out along the Royal NP coastline. Therefore, any sightings will benefit from photographs to document the presence of this species within the survey area.

Threats in the Survey Area

Public disturbance while ashore.

Management Considerations

- Follow the DECCW *Standard Operating Procedures for Pinniped Haul Outs* (DECCW 2010b).

NEW ZEALAND FUR-SEAL *Arctocephalus forsteri*

***EPBC Act*: Not Listed**	***TSC Act*: Vulnerable**	**Priority in Area: Low**

New Zealand Fur-seals. Photo © M. Schulz

Immature Fur-seals are occasionally observed playing just off the sea cliffs. Photo © M. Schulz

The Subantarctic Fur -seal has been found at Wanda Beach and may turn up on the Royal NP coast. Photo © M. Schulz

Occurrence in the Survey Area

Uncommon visitor. This species was not recorded during the current survey. The New Zealand Fur Seal has been recorded hauled out on Jibbon and Garie Beaches in Royal NP (DECCW 2010a). Additionally, unidentified fur seals are regularly seen loafing in the water just off the rocks of the sea cliffs (Appendix 1). At times unidentified immatures have been observed for several hours resting in the water against a vertical rock face rising and falling with the swell (M. Schulz pers. obs.).

This species can readily be confused with the Australian Fur Seal and Subantarctic Fur Seal that may also haul out along the Royal NP coastline. Therefore, any sightings will benefit from photographs to document the presence of this species within the survey area.

Regional Conservation Significance

The New Zealand Fur Seal is a non-breeding visitor to coastal waters of the Sydney Basin Bioregion. Due to the rarity of this species hauling out, the survey area does not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

Public disturbance while ashore.

Management Considerations

- Follow the DECCW *Standard Operating Procedures for Pinniped Haul Outs* (DECCW 2010b).

SOUTHERN ELEPHANT SEAL *Mirounga leonina*

***EPBC Act*: Vulnerable**	***TSC Act*: Not Listed**	**Priority in Area: Low**

Southern Elephant Seal. Photo © M. Schulz

Occurrence in the Survey Area

Vagrant. The only record in the Atlas of NSW Wildlife was of a young male found ashore on Garie Beach in October 1980. It lived for only one week following its initial discovery and died of a tapeworm infection.

Regional Conservation Significance

The Southern Elephant Seal is a rare vagrant to New South Wales waters. Therefore, the survey area does not significantly contribute to the regional conservation of this species.

Threats in the Survey Area

Public disturbance while ashore.

Management Considerations

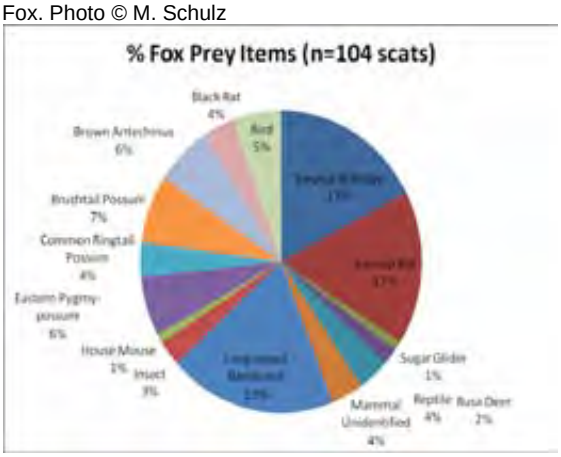
- Follow the DECCW *Standard Operating Procedures for Pinniped Haul Outs* (DECCW 2010b).

5.3 INTRODUCED SPECIES

This section provides profiles on priority introduced pest species that are both listed as Key Threatening Processes under the *TSC Act* and are known or likely to have a serious impact on native fauna or ecosystems within the survey area.

A number of other feral species have been recorded within the survey area in the last decade, but profiles were not provided if there were very few records and/or they were considered to have minimal impacts on native fauna or ecosystems at the present time.

Fox. Photo © M. Schulz



Prey items analysed from 104 Fox scats collected during the survey across the area.

Occurrence in the Survey Area

Listed as a Key Threatening Process under the *TSC Act* and *EPBC Act*. Common and widespread. In the current survey this species was recorded from all habitat groups with the exception of Deep Freshwater habitats, although individuals were observed patrolling the margins of this habitat. The tracks of the Fox were observed along all beaches visited and scats and tracks were located on the inland edge of Saline Wetlands. Individuals were regularly observed in Parkland with one animal observed being fed on dusk by visitors at Wattmolla. Results from six camera traps set in Littoral Rainforest indicated that 67 per cent of the cameras photographed Foxes during a 12 night period. Given this result it is perhaps not surprising that species such as the Red-necked Pademelon appear to have been lost from the reserves. The analysis of 104 scats revealed the most common prey species to be the Long-nosed Bandicoot, Swamp Wallaby and Swamp Rat (refer to graph). The listed Eastern Pygmy-possum accounted for six per cent of prey items. A surprise was the absence of the Bush Rat as a prey species within the scats analysed.

Regional Occurrence

The Fox is common and widespread across the Sydney Basin Bioregion (DECC 2007c).

Impacts in the Survey Area

Predation of a wide variety of mammal, bird and reptile species; and spreading of some weeds.

Management Considerations

Maintain current Fox management strategy and that outlined in the Fox TAP (NPWS 2001b) *but target* habitats that support ground-dwelling priority species which are likely to be highly impacted, in particular:

a) Coastal Upland Swamps, such as Jibbon Lagoon that support the Australasian Bittern and rails.

b) Coastal heathlands that support a diverse array of priority species including the Eastern Pygmy-possum, Southern Emu-wren, Chestnut-rumped Heathwren and Beautiful Firetail.

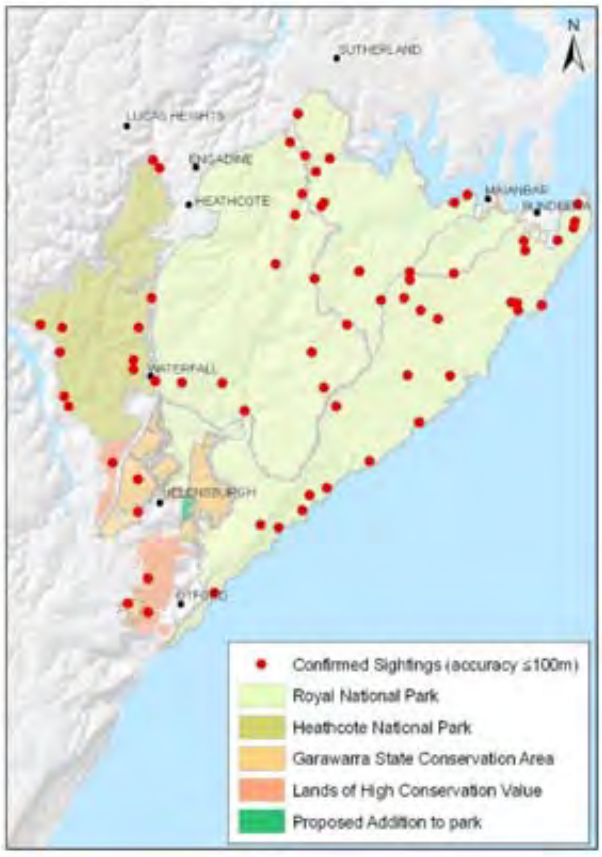
c) Known localities of the Stuttering Frog, Australian Logrunner and the vicinity of Powerful Owl nests.

e) Adjacent to the entrance of bat roosts.

f) Constables Point-Bonnie Vale area to protect roosting shorebirds and other waterbirds.

Note: 1) Any baiting to follow protocols that minimise the take of non-target species, especially the Spotted-tailed Quoll and Rosenberg's Goanna.

2) Any baiting to be followed up by Cat control.



FERAL CAT *Felis catus*

Feral Cat. Photo © M. Schulz

Feral Cat tracks. Photo © M. Schulz

Occurrence in the Survey Area

Listed as a Key Threatening Process under the *TSC Act* and the *EPBC Act*. Additionally this species has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Uncommon but widespread across the survey area. In the current survey few individuals were encountered, with most records from tracks left on soft substrates such as sand. This species was recorded in a variety of habitat groups, including along the shoreline at Era and Marley Beaches and in Sydney Coastal Dry Sclerophyll Forest adjacent to Kingfisher Pool in Heathcote NP. Unlike the Fox, no individuals were photographed at the 14 sites where cameras were set for mammals. Due to the feral Cat's habitat of burying its droppings, no scats were located for analysis in the current survey.

One dumped Cat was observed in a picnic ground at Audley, while a number of wide-ranging domestic Cats were encountered during the current survey. For example, an animal was observed hunting lizards west of Yenabilli Point over 300m from the closest dwelling on the edge of Maianbar while another was observed stalking fairy-wrens about 100m from the reserve edge at East Heathcote. Domestic Cats have been recorded bringing in a range of native mammals from Royal NP adjacent to East Heathcote, such as the Feathertail and Sugar Gliders (R. McLaggan, WIRES, pers. comm.).

Regional Occurrence

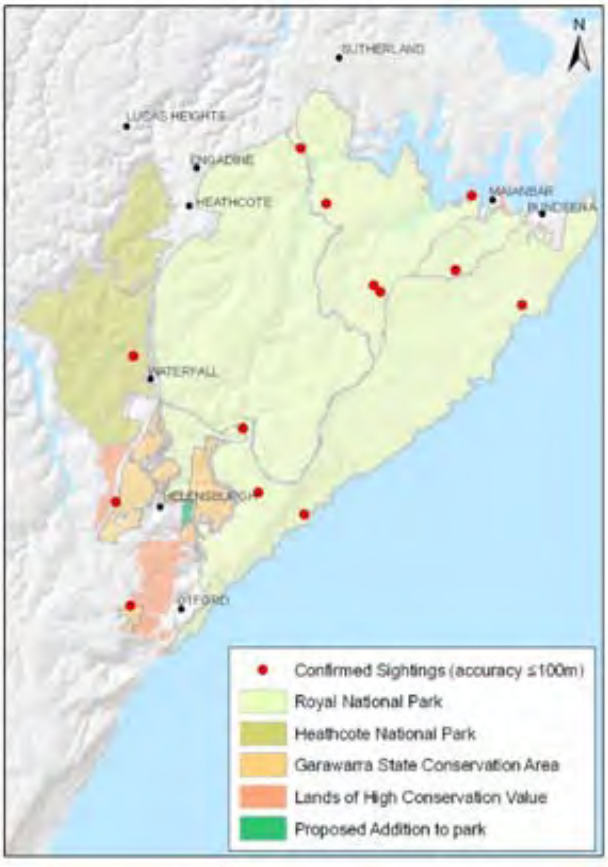
The feral Cat is widespread across the Sydney Basin Bioregion (DECC 2007c).

Impacts in the Survey Area

Predation of a wide variety of mammals, bird and reptile species.

Management Considerations

- Maintain current feral Cat management strategy.
- After Fox baiting undertake regular patrols to remove feral Cats that may have moved in or bred up since the removal of Foxes frequently results in the competitive release of this species and an increase in numbers (Glen and Dickman 2005). Such Patrols to be undertaken in conjunction with Rusa Deer culls
- Encourage members of the public to report Cat sightings across the survey area.
- Remove wide-ranging domestic Cats that use the reserve for the hunting and taking of native fauna.



Rabbit. Photo © M. Schulz

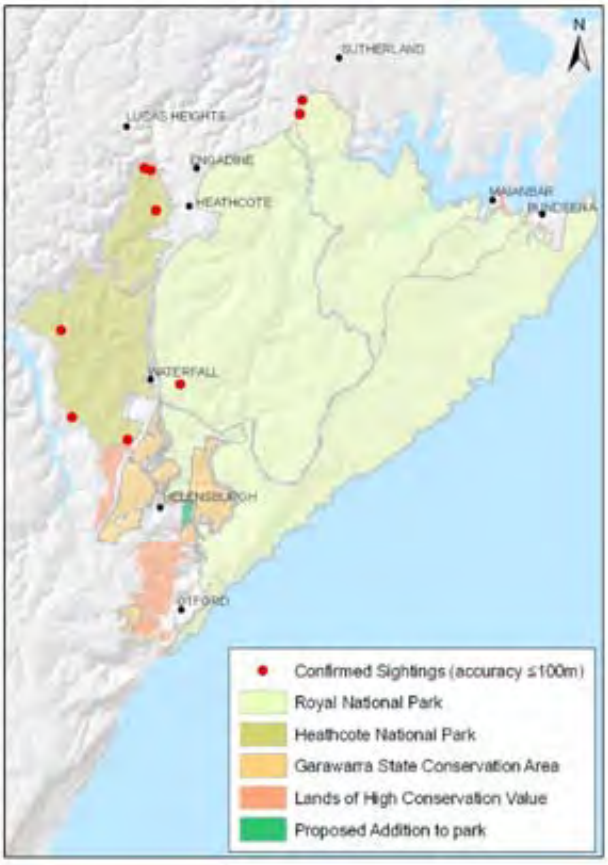
Rabbit tracks. Photo © M. Schulz

Occurrence in the Survey Area

Listed as a Key Threatening Process under the *TSC Act* and the *EPBC Act*. Additionally this species has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). After the 1994 wildfire this species was common along the coast south of Garie Beach in Royal NP to below Bald Hill (S. Anyon-Smith pers. comm.). Currently only irregular sightings are made in this section of the area, with regular sightings made along the Easement Track in Heathcote NP and from the edge of the highway adjacent to Loftus Oval in Royal NP on shale enriched soils (S. Anyon-Smith pers. comm., B. Sullivan pers. comm.). At this site many of the individuals are black and ginger-coloured animals indicating they are from dumped stock. In the current survey this species was recorded from the forest edge adjacent to the highway in the Loftus Oval area, Garawarra SCA at Helensburgh and as far north as the Temptation Creek Fire Trail junction with the highway. The localised distribution of this species is indicated by the lack of remains found in Fox scats collected across the survey area.

Regional Occurrence

The Rabbit occurs patchily across the Sydney Basin Bioregion, being most abundant in areas of high fertility and deep soils, such as the Cumberland and Illawarra Coastal Plains (DECC 2007c). It prefers grassy woodlands or forests, with little shrubbery and some of level of disturbance. Therefore, much of the survey area is not prime habitat for the species.



Impacts in the Survey Area

Land degradation by altering the structure and composition of vegetation communities; removing plant biomass; preventing plant regeneration; ring-barking of trees and shrubs; competition with native fauna; burrows can result in soil erosion; and populations may maintain feral predator numbers at an elevated level resulting in increased impacts on native fauna when sharp declines in Rabbit population numbers occur.

Management Considerations

- Maintain current Rabbit management protocols
- Monitor Rabbit numbers and undertake more targeted approaches where numbers increase as a result of disturbance events, such as fires, including even small-scale hazard reduction burns.

Rusa Deer male. Photo © M. Schulz

Rusa Deer trampling. Photo © M. Schulz

Rusa Deer wetland degradation, Jibbon Lagoon. Photo © M. Schulz

Occurrence in the Survey Area

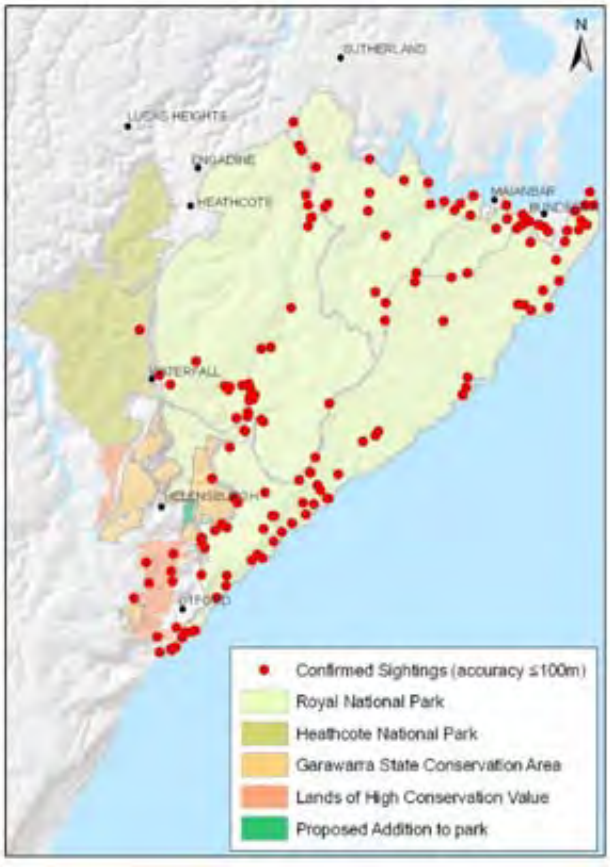
Listed as a Key Threatening Process under the *TSC Act*. Common and widespread, particularly in Royal NP. During the current survey this species was recorded from 78 sites, with only single records from Heathcote NP and Garawarra SCA. The species also occurs in the Upper Hacking and Constables Point adjoining lands of high conservation value (DECC 2008a, DECCW 2010a). In the current survey this species was recorded from all habitat groups with the exception of Deep Freshwater habitats, although individuals were observed on the margins of this habitat. The tracks of the Rusa Deer were observed along all beaches visited and scats and tracks were located on the inland edge of Saline Wetlands. This species was commonly present in a number of restricted habitats that support a range of priority native fauna species, such as Dune and Alluvial Sclerophyll Forest, Freshwater Wetlands and Forested Wetlands.

Regional Occurrence

The Rusa Deer primarily occurs within the survey area in the Sydney Basin Bioregion, with other populations occurring on the Woronora Plateau, the northern shore of Port Hacking, along the Illawarra Escarpment, edges of suburban Wollongong, Holsworthy Military Area and parts of the Cumberland Plain along the Nepean River (DECC 2007c).

Impacts in the Survey Area

Degradation of vegetation through grazing; trampling of fragile habitats, including the creation of well-defined pads in wetlands that Foxes can then use for access; loss of viability of plant populations through the curtailment of seed production and seedling recruitment (Keith and Pellow 2005).



Management Considerations

Maintain current Rusa Deer management strategy (DEC 2005) *but* incorporating the targeting of habitats of significant ground- and shrub-dwelling priority species which are likely to be highly impacted, in particular:

- Coastal swamps, such as Jibbon Lagoon that support the Australasian Bittern and rails.
- Coastal heathlands that support a diverse array of priority species including the Eastern Pygmy-possum, Southern Emu-wren, Chestnut-rumped Heathwren and Beautiful Firetail.
- Forested Wetland and Dune and Alluvial Sclerophyll Forest adjacent to Bundeena.
- Littoral Rainforest, Northern Warm Temperate and Subtropical Rainforest and adjoining wet sclerophyll forest that supports rainforest species with limited distribution, in particular the Australian Logrunner.

6 FAUNA HABITATS

6.1 FORMAT OF THE HABITAT GROUP PROFILES

Colour of the heading conforms to the colouration of Keith (2004) formations used in DECCW (2009).

HABITAT GROUP LABEL

This section provides a brief description of the extent, location and status of the habitat group.

A photo of typical habitat for the group

To ensure fauna records originated from the correct habitat group only records collected during the current survey were used to generate the species lists provided herein. It is important to note that a limitation of the species listed in each habitat group is that they derive primarily from the summer months, since the majority of survey work was conducted between December 2009 and March 2010.

The lists provided in the next three paragraphs incorporate species that were found in more than 50 per cent of systematic sites, irrespective of the number of sites surveyed. Species for which few individuals were encountered in systematic sites, but there were a large number of incidental records were also included as commonly encountered species.

Commonly Observed Herpetofauna

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

Commonly Observed Birds

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

Commonly Observed Mammals

This section provides a list of native and introduced terrestrial and arboreal mammals and bats that are commonly encountered in the habitat group.

Priority Species For Which Habitat Is Provided

This section provides a list of Priority fauna species known to still occur in the survey area for which the habitat group provides potential habitat. This list and the 'Relative Importance of this Habitat Group' categories are based upon a calculation of the percentage of records of each Priority species in each habitat group (using only records with a high degree of spatial accuracy collected during the current surveys) and augmented by other sightings, knowledge of species habitat preferences, and assessment of potential habitat usage for species not recorded during the recent surveys.

Common name	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 survey area
	General – species that are wide ranging and 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 closely associated with habitat features therein.

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.

6.2 HABITAT GROUP PROFILES

NORTHERN WARM TEMPERATE & SUBTROPICAL RAINFOREST

Northern Warm Temperate and Subtropical Rainforest includes three vegetation communities that comprise 1.7 per cent of the survey area in the Hacking River valley, including in the south-west of Royal NP, in the eastern and southern blocks of Garawarra SCA and in the Upper Hacking lands. This habitat group was identified as being a priority fauna habitat in the Sydney Metropolitan CMA area (DECC 2008a).

Commonly Observed Herpetofauna

Leaf-green Tree Frog, Eastern Water Skink, Dark-flecked Garden Sunskink, Weasel Shadeskink and Yellow-bellied Three-toed Skink.

Commonly Observed Birds

Crimson Rosella, Superb Lyrebird, Rufous Fantail, Black-faced Monarch, Eastern Yellow Robin, Golden Whistler, Eastern Whipbird, Brown Gerygone, Brown Thornbill, White-browed Scrubwren, Yellow-throated Scrubwren, Large-billed Scrubwren, White-throated Treecreeper, Silvereye, Eastern Spinebill, Lewin's Honeyeater and Pied Currawong.

Commonly Observed Mammals

Sugar Glider, Swamp Wallaby, Eastern Horseshoe Bat, Gould's Long-eared Bat, Large-footed Myotis, Chocolate Wattled Bat and Little Forest Bat.

Northern Warm Temperate Rainforest. Photo © M. Schulz/DECCW

Subtropical Rainforest. Photo © M. Schulz/DECCW

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Australian Logrunner	Predominant
Sooty Owl	Predominant
Green Catbird	Predominant
Superb Fruit-Dove	Predominant
Rose-crowned Fruit-Dove	Predominant
Large-footed Myotis	Predominant
Powerful Owl	General
Masked Owl	General
Eastern Bentwing-bat	General
Eastern Horseshoe Bat	General
Grey-headed Flying-fox	General
Eastern Pygmy-possum	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Habitat loss through high intensity fire events; weed invasion, such as along some creeklines downstream of the Illawarra Railway or adjacent to disturbed areas; changes to water quality of some streams flowing through this habitat, in particular from the Helensburgh area; predation by feral predators; grazing and trampling by the Rusa Deer; road mortality, principally along Lady Wakehurst Drive; potential infection of frogs by Amphibian Chytrid Fungus; and feral fish populations, particularly the Mosquito Fish.

LITTORAL RAINFOREST

Littoral Rainforest includes two vegetation communities that comprise 0.5 per cent of the survey area on the headlands, slopes and gullies along the southern coastline of Royal NP and the far south-eastern block of the Upper Hacking lands, with a small patch in the Bonnie Vale area. This habitat group was identified as being a priority fauna habitat in the Sydney Metropolitan CMA area (DECC 2008a).

Commonly Observed Herpetofauna

Leaf-green Tree Frog, Eastern Water Dragon, Eastern Water Skink, Dark-flecked Garden Sunskink, Yellow-bellied Three-toed Skink, Diamond Python and Golden-crowned Snake.

Commonly Observed Birds

Crimson Rosella, Superb Lyrebird, Rufous Fantail, Black-faced Monarch, Eastern Yellow Robin, Golden Whistler, Eastern Whipbird, Brown Gerygone, Brown Thornbill, White-browed Scrubwren, Yellow-throated Scrubwren, Silvereye, Eastern Spinebill, Lewin's Honeyeater, Satin Bowerbird and Pied Currawong.

Commonly Observed Mammals

Long-nosed Bandicoot, Gould's Wattled Bat, Chocolate Wattled Bat, Large Forest Bat and Little Forest Bat.

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Green Catbird	Predominant
Grey-headed Flying-fox	General
Eastern Horseshoe Bat	General
Red-crowned Toadlet	Infrequent
Rosenberg's Goanna	Infrequent
Australian Logrunner	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Habitat loss through high intensity fire events; weed invasion; localised disturbance through high levels of public usage, such as behind Werrong Beach; localised impact around and accessing some shack areas, particularly Bulgo; erosion; predation by feral predators; grazing and trampling by the Rusa Deer; and potential infection of frogs by Amphibian Chytrid Fungus.

RIPARIAN SCRUB

Riparian Scrub incorporates a single vegetation community that comprises more than 0.7 per cent of the survey area along the channels of larger watercourses in inland sections, including Kangaroo Creek and South West Arm Creek in Royal NP and Heathcote Creek in Heathcote NP. It has not been identified as a priority fauna habitat in the region (e.g. DECC 2007b 2008a).

Commonly Observed Herpetofauna

Common Eastern Froglet, Freycinet's Frog, Leaf-green Tree Frog, Eastern Water Dragon, Eastern Water Skink and Dark-flecked Garden Sunskink.

Commonly Observed Birds

Australian Owlet-nightjar, Grey Fantail, Leaden Flycatcher, Eastern Yellow Robin, Golden Whistler, Rufous Whistler, Grey Shrike-thrush, Striated Thornbill, White-browed Scrubwren, Rockwarbler, Variegated Fairy-wren, White-throated Treecreeper, Mistletoebird, Spotted Pardalote, Little Wattlebird, Eastern Spinebill, Yellow-faced Honeyeater, Yellow-tufted Honeyeater, New Holland Honeyeater, Pied Currawong and Australian Raven.

Commonly Observed Mammals

Swamp Wallaby, Eastern Horseshoe Bat, Gould's Long-eared Bat, Gould's Wattled Bat and Little Forest Bat.

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Large-footed Myotis	Predominant
Freycinet's Frog	General
Rockwarbler	General
Greater Broad-nosed Bat	General
Eastern Bentwing-bat	General
Eastern Horseshoe Bat	General
Black Bittern	General
Red-crowned Toadlet	Infrequent
Broad-headed Snake	Infrequent
Southern Emu-wren	Infrequent
Chestnut-rumped Heathwren	Infrequent
Beautiful Firetail	Infrequent
Grey-headed Flying-fox	Infrequent

Potential Threats To Native Fauna

Habitat loss through high intensity fire events; weed invasion, such as downstream of urban areas; altered flow regimes and water quality of some streams flowing through this habitat; predation by feral predators; potential infection of frogs by Amphibian Chytrid Fungus; and feral fish populations, particularly the Mosquito Fish.

North Coast Wet Sclerophyll Forest

North Coast Wet Sclerophyll Forest includes three vegetation communities that comprise 10.3 per cent of the survey area, primarily in southern parts of the survey area including: along the southern escarpment of Royal NP; and in the Hacking River valley in southern Royal NP, the eastern and southern blocks of Garawarra SCA, and through much of the Upper Hacking lands.


Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Leaf-green Tree Frog, Eastern Water Skink, Dark-flecked Garden Sunskink and Yellow-bellied Three-toed Skink.

Commonly Observed Birds

Sulphur-crested Cockatoo, Rainbow Lorikeet, Crimson Rosella, Superb Lyrebird, Grey Fantail, Rufous Fantail, Black-faced Monarch, Eastern Yellow Robin, Golden Whistler, Eastern Whipbird, Brown Gerygone, Striated Thornbill, Brown Thornbill, White-browed Scrubwren, White-throated Treecreeper, Spotted Pardalote, Silvereye, Eastern Spinebill, Lewin's Honeyeater, Yellow-faced Honeyeater, New Holland Honeyeater and Pied Currawong.

Commonly Observed Mammals

Long-nosed Bandicoot, Sugar Glider, Swamp Wallaby, Gould's Wattled Bat and Little Forest Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Large-eared Pied Bat	Predominant
Little Lorikeet	General
Green Catbird	General
Australian Logrunner	General
Swift Parrot	General
Powerful Owl	General
Masked Owl	General
Sooty Owl	General
Varied Sittella	General
Regent Honeyeater	General
Grey-headed Flying-fox	General
Eastern Horseshoe Bat	General
Greater Broad-nosed Bat	General
Eastern Bentwing-bat	General
Gang-gang Cockatoo	General
Rockwarbler	Infrequent
Southern Emu-wren	Infrequent
Beautiful Firetail	Infrequent
Chestnut-rumped Heathwren	Infrequent
Superb Fruit-Dove	Infrequent
Rose-crowned Fruit-Dove	Infrequent
Eastern Pygmy-possum	Infrequent
Large-footed Myotis	Infrequent

Potential Threats To Native Fauna

Habitat loss through frequent or high intensity fire events; weed invasion; Rusa Deer impacts including grazing and trampling; loss of remaining trees supporting hollows; changes to water quality of some streams flowing through this habitat; predation by feral predators; and road mortality, principally along Lady Wakehurst Drive.

NORTHERN HINTERLAND WET SCLEROPHYLL FOREST

Northern Hinterland Wet Sclerophyll Forest includes three vegetation communities that comprise 0.8 per cent of the survey area, primarily on shale enriched soils in the Loftus and East Heathcote areas and patchily on sandstone scarps overlooking Port Hacking. There are no occurences in Heathcote NP or Garawarra SCA. Two vegetation communities within this habitat group, Sydney Foreshores Shale Forest and Sydney Turpentine-Ironbark Forest, are included within Sydney Turpentine-Ironbark Forest, an Endangered Ecological Community listed under Schedule 1 in the *TSC Act* (DECC 2009).

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Broad-tailed Gecko, Jacky Lashtail, Lace Monitor, Barred-sided Skink, Dark-flecked Garden Sunskink, Weasel Shadeskink and Yellow-bellied Three-toed Skink.

Commonly Observed Birds

Sulphur-crested Cockatoo, Rainbow Lorikeet, Australian Owlet-nightjar, Eastern Koel, Laughing Kookaburra, Grey Fantail, Eastern Yellow Robin, Rufous Whistler, Black-faced Cuckoo-shrike, Brown Thornbill, White-browed Scrubwren, Variegated Fairy-wren, Silvereye, Eastern Spinebill, Little Wattlebird, Red Wattlebird, Noisy Miner, New Holland Honeyeater, Olive-backed Oriole, Pied Currawong, Grey Butcherbird, Australian Magpie and Australian Raven.

Commonly Observed Mammals

Short-beaked Echidna, Common Ringtail Possum, Sugar Glider, Swamp Wallaby, Gould's Wattled Bat and Little Forest Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Little Lorikeet	General
Varied Sittella	General
Regent Honeyeater	General
Grey-headed Flying-fox	General
Eastern Bentwing-bat	General
Eastern Horseshoe Bat	General
Rockwarbler	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Habitat loss through frequent or high intensity fire events; weed invasion; grazing and trampling by the Rusa Deer; loss of remaining trees supporting hollows, particularly bordering urban areas; predation by feral predators; predation by domestic Cats in patches adjacent to urban areas; disturbance and predation by domestic Dogs in areas adjacent to urban areas; disturbance from feral birds bordering urban areas, such as the Common Myna; and disturbance from recreational activities such as adjacent to picnic areas and popular boat landing sites on Port Hacking and from mountain bikes, including night time riding in the Heathcote Heights-Loftus areas.

SYDNEY COASTAL DRY SCLEROPHYLL FOREST

Sydney Coastal Dry Sclerophyll Forest includes seven vegetation communities that comprise 60.2 per cent of the survey area, forming the most widely distributed habitat group. This habitat group comprises almost the entire area of Heathcote NP, as well as the western block of Garawarra SCA, much of the western half of Royal NP, most of the Garrawarra Hospital lands and western parts of the Upper Hacking lands. The Sydney Ironstone Bloodwood-Silvertop Ash Forest which is a component of the Duffys Forest Ecological Community and Southern Sydney Sheltered Forest are listed as Endangered Ecological Communities under the *TSC Act* (DECC 2009).

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Common Eastern Froglet, Red-crowned Toadlet, Copper-tailed Skink and Dark-flecked Garden Sunskink.

Commonly Observed Birds

Grey Fantail, Grey Shrike-thrush, Eastern Whipbird, Brown Thornbill, White-browed Scrubwren, White-throated Treecreeper, Spotted Pardalote, Eastern Spinebill, Little Wattlebird, Yellow-faced Honeyeater, White-eared Honeyeater, New Holland Honeyeater and Pied Currawong.

Commonly Observed Mammals

Short-beaked Echidna, Sugar Glider, Swamp Wallaby, Gould's Wattled Bat and Little Forest Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Red-crowned Toadlet	Predominant
Giant Burrowing Frog	Predominant
Rosenberg's Goanna	Predominant
Broad-headed Snake	Predominant
Little Eagle	Predominant
Powerful Owl	Predominant
Masked Owl	Predominant
Chestnut-rumped Heathwren	Predominant
Glossy Black-cockatoo	Predominant
Eastern Pygmy-possum	Predominant
Freycinet's Frog	General
Little Lorikeet	General
Rockwarbler	General
Tawny-crowned Honeyeater	General
Regent Honeyeater	General
Varied Sittella	General
Koala	General
Grey-headed Flying-fox	General
Greater Broad-nosed Bat	General
Eastern Horseshoe Bat	General
Eastern Bentwing-bat	General
Beautiful Firetail	Infrequent
Southern Emu-wren	Infrequent
Large-eared Pied Bat	Infrequent
New Holland Mouse	Infrequent

Potential Threats To Native Fauna

Habitat loss through frequent or high intensity fire events; poaching of reptiles, particularly the Broad-headed Snake; displacement and destruction of loose rock; weed infestation adjacent to urban areas and disturbed ground; predation by feral predators; changes to water quality of some streams flowing through this habitat; predation by domestic Cats in patches adjacent to urban areas; disturbance and predation by domestic Dogs in areas adjacent to urban areas; disturbance from feral birds bordering urban areas, such as the Common Myna; disturbance from recreational activities such as trail erosion, particularly from illegal trail bike riding and mountain bikes, including night time riding in the Heathcote Heights-Loftus areas; grazing and trampling by the Rusa Deer; feral fish populations in larger streams, particularly the Mosquito Fish; impacts from past quarrying activities in some areas; and potential infection of frogs by Amphibian Chytrid Fungus.

Dry Sclerophyll Forest. Photo © M. Schulz/DECCW

DUNE AND ALLUVIAL SCLEROPHYLL FOREST

Dune and Alluvial Sclerophyll Forest includes four vegetation communities that comprise 0.4 per cent of the survey area. It occurs on deep sands or alluvial deposits in Royal NP, primarily in the Bundeena/Bonnie Vale but also near Audley on the flats of the Hacking River and Kangaroo Creek. Three of the vegetation communities within this habitat group form components of Endangered Ecological Communities listed under the *TSC Act*.


Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Dark-flecked Garden Sunskink, Weasel Shadeskink and Yellow-bellied Three-toed Skink.

Commonly Observed Birds

Sulphur-crested Cockatoo, Rainbow Lorikeet, Southern Boobook, Laughing Kookaburra, Eastern Koel, Eastern Yellow Robin, Grey Shrike-thrush, Eastern Whipbird, Variegated Fairy-wren, White-browed Scrubwren, Spotted Pardalote, Silvereye, Little Wattlebird, Eastern Spinebill, Lewin's Honeyeater, New Holland Honeyeater, Pied Currawong, Grey Butcherbird and Australian Raven.

Commonly Observed Mammals

Common Ringtail Possum, Sugar Glider, Swamp Wallaby and Gould's Wattled Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Swift Parrot	Predominant
Freycinet's Frog	General
White-browed Woodswallow	General
Little Lorikeet	General
Sooty Owl	General
Grey-headed Flying-fox	General
Eastern Horseshoe Bat	General
Powerful Owl	General
Masked Owl	General
Regent Honeyeater	General
Varied Sittella	General
Eastern Bentwing-bat	General
Greater Broad-nosed Bat	General
Red-crowned Toadlet	Infrequent
Black Bittern	Infrequent
Southern Emu-wren	Infrequent
Chestnut-rumped Heathwren	Infrequent
Beautiful Firetail	Infrequent
Eastern Pygmy-possum	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Habitat loss through frequent or high intensity fire events; weed infestation; changes to water quality and alteration of hydrology of alluvial vegetation communities; predation by feral predators; predation by domestic Cats adjacent to urban areas; disturbance and predation by domestic Dogs adjacent to urban areas; competition and disturbance from feral birds bordering urban areas; grazing and trampling by Rusa Deer; impacts from past sand mining activities; and infection of frogs by Amphibian Chytrid Fungus.

COASTAL HEADLAND GRASSLAND

Coastal Headland Grassland includes one natural vegetation community that comprises 0.09 per cent of the survey area; in the Bulgo-Stanwell Park area. This habitat group includes a modified habitat resulting from past clearing, that has few trees and is dominated by Spiny-headed Mat-rush on headlands south of Little Garie Beach. Coastal Headland Grassland forms a component of the Themeda Grassland on sea cliffs and coastal headlands and is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009).

Coastal Headland Grassland. Photo © M. Schulz

Spiny-headed Mat-rush headland. Photo © M. Schulz

Commonly Observed Herpetofauna

Common Eastern Froglet, Striped Marsh Frog, Jacky Lashtail and Dark-flecked Garden Sunskink.

Commonly Observed Birds

Nankeen Kestrel, Crimson Rosella, Welcome Swallow, Variegated Fairy-wren, Southern Emu-wren, Silvereye, Little Wattlebird, Eastern Spinebill, New Holland Honeyeater, Australian Magpie and Australian Raven. Additionally, many birds from adjacent vegetation communities range into this habitat, particularly where there are scattered Coast Banksias or shrub patches, such as the White-browed Scrubwren and Lewin's Honeyeater.

Commonly Observed Mammals

The most commonly encountered mammals were the Gould's Wattled Bat and Swamp Rat. Additionally, other mammals from adjacent vegetation communities range into this habitat, particularly where there are scattered Coast Banksias or shrub patches, such as the Swamp Wallaby and a variety of bats forage over the open habitat adjacent to forested vegetation communities.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Southern Emu-wren	Infrequent
Rockwarbler	Infrequent
Beautiful Firetail	Infrequent
Grey-headed Flying-fox	Infrequent

Potential Threats To Native Fauna

Woody vegetation regeneration; weed invasion; grazing and trampling by the Rusa Deer; disturbance of areas adjacent to shacks, such as Bulgo; predation by feral predators; predation by domestic Cats in patches adjacent to urban areas; disturbance and predation by domestic Dogs in areas adjacent to urban areas; and erosion.

HEATHLAND

Heathland includes five vegetation communities that comprise 23.4 per cent of the survey area, forming the second most widely distributed habitat group. The great majority occurs in Royal NP, primarily east of the Hacking River and north of the road to Garie Beach. Very small patches are mapped through the eastern half of Heathcote NP and the far south of Royal NP. This habitat group was identified as being a priority fauna habitat in the Sydney Metropolitan CMA area (DECC 2008a).

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Common Eastern Froglet, Jacky Lashtail, Copper-tailed Skink, Eastern Water-skink, White's Rock-skink and Dark-flecked Garden Sunskink.

Commonly Observed Birds

Horsfield's Bronze-Cuckoo, Welcome Swallow, Eastern Whipbird, White-browed Scrubwren, Chestnut-rumped Heathwren, Variegated Fairy-wren, Southern Emu-wren, Little Wattlebird, New Holland Honeyeater, Tawny-crowned Honeyeater, Beautiful Firetail and Australian Raven. The migration of hundreds of Yellow-faced Honeyeaters in late autumn and early to mid spring is a feature of the heathlands of coastal sections of Royal NP.

Commonly Observed Mammals

The most commonly encountered mammals were the Short-beaked Echidna, Swamp Wallaby and Gould's Wattled Bat. Additionally, other mammals from adjacent vegetation communities range into this habitat, for example a variety of bats forage adjacent to forested vegetation communities.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Red-crowned Toadlet	Predominant
Broad-headed Snake	Predominant
Rosenberg's Goanna	Predominant
Beautiful Firetail	Predominant
Tawny-crowned Honeyeater	Predominant
Southern Emu-wren	Predominant
Chestnut-rumped Heathwren	Predominant
Eastern Pygmy-possum	Predominant
New Holland Mouse	Predominant
Giant Burrowing Frog	General
Freycinet's Frog	General
Little Eagle	General
Little Lorikeet	General
White-browed Woodswallow	General
Rockwarbler	General
Grey-headed Flying-fox	General
Eastern Bentwing-bat	General
Eastern Horseshoe Bat	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Habitat loss through frequent fire events; poaching of reptiles; displacement and destruction of loose rock; weed infestation; grazing and trampling by the Rusa Deer; changes to water quality of creeks; alteration of drainage and water flow patterns; predation by feral predators; predation by domestic Cats and Dogs adjacent to urban areas; impacts from recreation; and potential infection of frogs by Amphibian Chytrid Fungus.

FRESHWATER WETLAND

This habitat group includes four vegetation communities and is scattered across the area, particularly in Royal NP. Small patches are also mapped in Heathcote NP, one small patch in Garawarra SCA and a couple of patches in Garrawarra Hospital Crown Reserve. Part of the habitat group forms a component of Sydney Freshwater Wetlands which is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009). This habitat group was identified as priority fauna habitat in the Greater Southern Sydney Region and in the Sydney Metroplitan Catchment Authority Area (DECC 2007b, 2008a).

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

The most commonly encountered herpetofauna were the Common Eastern Froglet and Dark-flecked Garden Sunskink. It is likely that other amphibian species are more common than indicated due to the dry conditions experienced in the current survey. In wetlands with more permanent water, additional species commonly encountered included the Striped Marsh Frog and Eastern Dwarf Tree Frog.

Commonly Observed Birds

The most commonly encountered birds were the Welcome Swallow, White-browed Scrubwren, Eastern Whipbird, Southern Emu-wren and Variegated Fairy-wren. Additionally, many birds from adjacent vegetation communities range into the wetlands particularly where there are patches of shrubbery, such as the Crimson Rosella, Little Wattlebird, New Holland Honeyeater and Grey Fantail. In wetlands with more permanent water, additional species commonly encountered included the Pacific Black Duck and White-faced Heron. Two additional species that are cryptic and likely to be more common than the records indicate are the Lewin's Rail and possibly the Spotless Crake.

Commonly Observed Mammals

The most commonly encountered mammals were the Short-beaked Echidna, Swamp Wallaby, Gould's Wattled Bat and Swamp Rat. However, individuals from adjacent vegetation communities range into wetlands particularly where there is no surface water, such as the Long-nosed Bandicoot and a number of microbats species that forage over the open habitat, such as the White-striped Freetail-bat and the Little Forest Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Australasian Bittern	Predominant
Grass Owl	Predominant
Southern Emu-wren	Predominant
Tawny-crowned Honeyeater	Predominant
Beautiful Firetail	Predominant
Freycinet's Frog	General
Giant Burrowing Frog	General
Black Bittern	General
Rosenberg's Goanna	Infrequent
Eastern Pygmy-possum	Infrequent
Grey-headed Flying-fox	Infrequent

Potential Threats To Native Fauna

Changes to water quality; alteration of drainage and water flow patterns; habitat loss through frequent fire events; weed infestation; grazing and trampling by the Rusa Deer; predation by feral predators; potential infection of frogs by Amphibian Chytrid Fungus; and feral fish populations, particularly the Mosquito Fish.

FORESTED WETLAND

Forested wetland includes three vegetation communities that comprises 0.05 per cent of the survey area. It is restricted to small patches in the Bundeena area and along the lower tidal reaches of the Hacking River in Royal NP. One vegetation community within this habitat group, Hinterland Riverflat Paperbark Swamp Forest, forms a component of the Swamp Sclerophyll Forest on Coastal Floodplains of NSW and is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009). Another community, Estuarine Swamp Oak Forest, forms a component of the Swamp Oak Floodplain Forest that is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009). A third community, Coastal Flats Swamp Mahogany Forest, forms a component of Swamp Sclerophyll Forest on Coastal Floodplains that is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009). This habitat group was identified as priority fauna habitat in the Greater Southern Sydney Region and in the Sydney Metroplitan Catchment Authority Area (DECC 2007b, 2008a).

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Common Eastern Froglet, Striped Marsh Frog, Eastern Dwarf Tree Frog, Peron's Tree Frog, Leaf-green Tree Frog, Eastern Water Skink, Dark-flecked Garden Sunskink and Red-bellied Black Snake.

Commonly Observed Birds

Purple Swamphen, Pacific Black Duck, Sulphur-crested Cockatoo, Australian Owlet-nightjar, Dollarbird, Sacred Kingfisher, Willie Wagtail, Eastern Yellow Robin, Golden Whistler, Grey Shrike-thrush, Eastern Whipbird, Brown Thornbill, White-browed Scrubwren, Silvereye, Little Wattlebird, Lewin's Honeyeater, New Holland Honeyeater and Pied Currawong.

Commonly Observed Mammals

Swamp Wallaby, Gould's Wattled Bat and Little Forest Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Swift Parrot	General
Freycinet's Frog	General
Eastern Bentwing-bat	General
Greater Broad-nosed Bat	General
Eastern Horseshoe Bat	General
Southern Emu-wren	Infrequent
Large-eared Pied Bat	Infrequent

Potential Threats To Native Fauna

Changes to water quality; alteration of drainage and water flow patterns; weed infestation; grazing and trampling by the Rusa Deer; impacts from recreation; predation by feral predators; potential infection of frogs by Amphibian Chytrid Fungus; feral fish populations, particularly the Mosquito Fish; and habitat loss through frequent fire events.

SALINE WETLAND

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Saline wetland includes two vegetation communities that comprise 0.2 per cent of the survey area. These communities are restricted to small patches along the Port Hacking shoreline in Royal NP. One vegetation community within this habitat group, Estuarine Saltmarsh, forms a component of the Coastal Saltmarsh of NSW and is listed as an Endangered Ecological Community under the *TSC Act* (DECC 2009). This habitat group was identified as priority fauna habitat in the Greater Southern Sydney Region and in the Sydney Metroplitan Catchment Authority Area (DECC 2007b, 2008a).

Commonly Observed Herpetofauna

The Dark-flecked Garden Sunskink was the only commonly observed herpetofauna species in this habitat. It was found mostly on higher ground, but some individuals were encountered basking on logs within tidal mangrove areas (e.g. South West Arm).

Commonly Observed Birds

Australian White Ibis, White-faced Heron, Whistling Kite, Welcome Swallow, Yellow Thornbill, Silvereye, Yellow-faced Honeyeater and Australian Raven. Depending on tide levels and the amount of disturbance elsewhere within Port Hacking numbers of waterbirds can be found either roosting and/or foraging in the mangroves or in wetlands in saltmarsh/sedgeland behind the mangroves, such as various cormorants, the Chestnut Teal and the Eastern Great Egret. Additionally, many birds from adjacent vegetation communities range into this habitat, such as the Sacred Kingfisher, Superb Fairy-wren, Willie Wagtail and Australian Magpie.

Commonly Observed Mammals

The most commonly encountered mammals were the Swamp Wallaby and Little Forest Bat. Species from adjacent vegetation communities range into this habitat; in particular a number of microbats species such as the White-striped Freetail-bat and the Gould's Wattled Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Southern Emu-wren	Infrequent

Potential Threats To Native Fauna

Changes to water quality; weed invasion; impacts from recreation; predation by feral predators; and grazing and trampling by the Rusa Deer.

SHORELINE

Shoreline includes one vegetation community, Beach Spinifex Grassland, that comprises 0.2 per cent of the survey area. It is restricted to small patches in primary dunes behind ocean beaches in Royal NP. This habitat group also includes rocky shoreline, intertidal platforms and beaches on the ocean coastline, in addition to beaches, rocky shoreline and intertidal mudflats lacking Estuarine Mangrove Forest on the Port Hacking shoreline, including tidal streams.

Photo © M. Schulz

Commonly Observed Herpetofauna

No reptiles are commonly encountered in this habitat group. However, individuals from adjacent vegetation communities range on to the shoreline, most notably the Eastern Water Dragon that forages in intertidal pools on some parts of the coast and the Lace Monitor that occasionally scavenges along the high tideline. Infrequent marine reptiles are washed ashore.

Commonly Observed Birds

Along the ocean shoreline regularly encountered species include the Great Cormorant, Crested Tern, Silver Gull, Sooty Oystercatcher, Eastern Reef Egret, White-bellied Sea-Eagle, Peregrine Falcon and Welcome Swallow. Marine seabirds are regularly washed ashore with the most frequently encountered species being the Short-tailed Shearwater, Wedge-tailed Shearwater and Australasian Gannet. Along the calmer waters of the Hacking shoreline regularly seen species include the Great Cormorant, Little Black Cormorant, Pied Cormorant, Little Pied Cormorant, Australian Pelican, Crested Tern Silver Gull, Masked Lapwing, Eastern Curlew, Australian White Ibis, Great Egret, White-faced Heron, Chestnut Teal, White-bellied Sea-Eagle and Welcome Swallow. Occasional marine seabirds are washed ashore, including the Short-tailed and Wedge-tailed Shearwaters. Additionally, many birds from adjacent vegetation communities range on to the shoreline, such as the Sacred Kingfisher, Superb Fairy-wren, Willie Wagtail, Australian Magpie and Australian Raven. The Rockwarbler commonly feeds amongst rocks in the upper parts of the shoreline at the base of cliffs south of Burning Palms.

Commonly Observed Mammals

No mammals are confined to this habitat; with infrequent seals hauling out, particularly the Australian Fur Seal and very occasional cetaceans are beach cast. However, individuals from adjacent vegetation communities range on to the shoreline, most notably the Swamp Wallaby that is commonly seen on the water's edge and a number of microbats species that forage over the shoreline, in particular the Gould's Wattled Bat and Little Forest Bat. Other mammals that range on to the inland margin of the shoreline in places include the Long-nosed Bandicoot and Swamp Rat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Osprey	Predominant
Pied Oystercatcher	Predominant
Sooty Oystercatcher	Predominant
Little Tern	Predominant
Australian Fur-seal	Predominant
New Zealand Fur-seal	Predominant
Rockwarbler	General
Black Bittern	Infrequent

Potential Threats To Native Fauna

Impacts from recreation; grazing and trampling by the Rusa Deer; predation by feral predators; erosion; and weed invasion.

DEEP FRESHWATER HABITATS

Deep freshwater habitats do not include any vegetation communities listed in DECCW (2009). Instead this habitat group comprises open waterbodies, such as the lower non-tidal reaches of the lower Hacking River above the Audley causeway and artificial water storages such as Engadine Waterhole. This habitat group was identified as priority fauna habitat in the Sydney Metroplitan Catchment Authority Area (DECC 2008a).

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Frequently observed reptile species away from the edges of this habitat are the Eastern Snake-necked Turtle and Short-necked Turtle (*Emydura* spp.). A number of species are common on the edges of this habitat including the Eastern Dwarf Tree Frog, Peron's Tree Frog, Eastern Water Dragon, Eastern Water-skink, Dark-flecked Garden Sunskink and Red-bellied Black Snake.

Commonly Observed Birds

Dusky Moorhen, Purple Swamphen, Eurasian Coot, Great Cormorant, Little Black Cormorant, Little Pied Cormorant, White-faced Heron, Australian Wood Duck, Pacific Black Duck, Chestnut Teal, Azure Kingfisher and Welcome Swallow. Additionally, many birds from adjacent vegetation communities hawk for insects over the open water, such as the White-throated Nightjar, Sacred Kingfisher and Dollarbird; while others feed or come in to drink along the edges, such as the Variegated Fairy-wren, White-browed Scrubwren and Red-browed Finch.

Commonly Observed Mammals

No commonly observed mammal species away from the edges of this habitat were encountered. A number of species are frequently seen on the edges of this habitat including the Swamp Wallaby. At certain times of the year Grey-headed Flying-foxes can be observed after dusk to glide down and scoop up water to drink, while many microbats commonly forage over this habitat, such as the Large-footed Myotis and Gould's Wattled Bat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Large-footed Myotis	Predominant
Grey-headed Flying-fox	General
Greater Broad-nosed Bat	General

Potential Threats To Native Fauna

Changes to water quality; weed invasion; impacts from recreation; potential infection of frogs by Amphibian Chytrid Fungus; feral fish populations, particularly the Mosquito Fish; hybridizing of the Mallard with the native Pacific Black Duck; predation by feral predators; and trampling of the edges by the Rusa Deer.

PARKLAND AND MODIFIED HABITATS

Parkland and other modified habitats do not include any vegetation communities listed in DECCW (2009). Instead this habitat group comprises mown parkland with or without some native tree cover such as at Audley and Bonnie Vale and in high use picnic areas such as at Wattamola.

Photo © M. Schulz/DECCW

Photo © M. Schulz/DECCW

Commonly Observed Herpetofauna

Frequently observed reptile species away from the edges of this habitat are the Lace Monitor, Eastern Water-skink and Dark-flecked Garden Sunskink. A number of species are common on the edges of this habitat (depending on the location) including the Common Eastern Froglet, Peron's Tree Frog and Eastern Water Dragon.

Commonly Observed Birds

A number of species are primarily found in this habitat within the survey area, particularly away from urban edges. These species include the Crested Pigeon, Little Corella, Long-billed Corella, Galah, Eastern Rosella and Magpie Lark. Other species that are commonly present include the Rainbow Lorikeet, Sulphur-crested Cockatoo, Crimson Rosella, Laughing Kookaburra, Eastern Koel, Welcome Swallow, Willie Wagtail, Black-faced Cuckoo-shrike, Superb Fairy-wren, Spotted Pardalote, Noisy Miner, Red Wattlebird, Little Wattlebird, New Holland Honeyeater, Red-browed Finch, Pied Currawong, Grey Butcherbird, Australian Magpie and Australian Raven. Additionally, depending on the location, a variety of other species range into this habitat from adjacent vegetation communities, principally to forage.

Commonly Observed Mammals

No mammals are confined to this habitat, with individuals of various species ranging into this modified habitat from adjacent vegetation communities, most notably the Common Brushtail Possum, Swamp Wallaby, Grey-headed Flying-fox and a number of microbats species that forage over the open habitat.

Priority Species For Which Habitat Is Provided

Common name	Relative importance of this habitat group
Grey-headed Flying-fox	Infrequent

Potential Threats To Native Fauna

Impacts from recreation; predation by feral predators; and trampling by the Rusa Deer.

6.3 RELATIVE CONSERVATION PRIORITY OF FAUNA HABITATS

Table 16 presents a summary of the relative importance of each habitat group to high and moderate priority fauna species, together with the percentage of the survey area each habitat group occupies, whether the group has previously been identified as priority fauna habitat and some regional context.

The **Northern Warm Temperate and Subtropical Rainforests** support a suite of species largely restricted to this habitat group, including four high or moderate priority species. Several additional high or moderate priority species also utilise this habitat group as part of a broader mosaic of habitats. Furthermore, Northern Warm Temperate and Subtropical Rainforests are key habitat for several species that have suffered severe declines in the region, some of which are now considered lost from the survey area, including Stuttering Frog, Superb Fruit-Dove, Rose-crowned Fruit-Dove, Spotted-tailed Quoll and Parma Wallaby. The rainforest is restricted in extent in both the survey area and the Sydney Basin Bioregion, with the small patches contributing significantly to the species richness of the reserves. This habitat group is therefore considered a **priority fauna habitat**. The other rainforest groups (**Littoral Rainforest and Riparian Scrub**) each support a slightly different mix of fauna species, with less that are restricted to those habitat types. Never-the-less as they too fall into the classification of Rainforests that were identified as Priority Fauna Habitat in the Sydney Metropolitan CMA area (DECC 2008a), these two habitat groups also are considered **priority fauna habitat** for the survey area.

Wet Sclerophyll Forest is not identified as Priority Fauna Habitat in either the Greater Southern Sydney Region (DECC 2007b) or the Sydney Metropolitan CMA area (DECC 2008a). North Coast Wet Sclerophyll Forest is the predominant habitat for just one high priority fauna species, but is part of a mosaic of habitats for eleven further high or moderate priority species. Importantly, North Coast Wet Sclerophyll Forest has strong rainforest influence in the subcanopy, leading to the presence of rainforest species such as Australian Logrunner and Green Catbird. This habitat group often adjoins the Northern Warm Temperate and Subtropical Rainforest habitat group, providing important supporting, linking and buffering habitat to the rainforest. These wet sclerophyll forests require management to support their rainforest elements and the neighbouring patches of rainforest itself, and for all these reasons is identified as **priority fauna habitat,** though of a lower priority than rainforest, freshwater wetlands, heathlands and shoreline.

Northern Hinterland Wet Sclerophyll Forest is not currently the predominant habitat for any high or moderate priority fauna species. It is worth noting, however, that in the past the vegetation communities that comprise this group would have provided peripheral habitat for a suite of species typically occurring in grassy woodlands, including Speckled Warbler, Black-chinned Honeyeater, Painted Honeyeater, Restless Flycatcher, Jacky Winter, Peaceful Dove, Pallid Cuckoo, White-throated Gerygone and Diamond Firetail. It is thought that past land management practices in the Loftus Trig area may have favoured these species, which prefer more open grassy forests with a sparse shrub cover. This area appears to only have ever provided peripheral habitat for these species, however. With reservation came dense regrowth of shrub and understorey species which, together with the urban development of neighbouring lands and other true grassy woodland patches, mean that these fauna species no longer occur in the reserve or are now only very rare visitors. The habitat modelling undertaken across the southern Sydney region did not predict any current high quality habitat in the survey area for Speckled Warbler, Black-chinned Honeyeater or Diamond Firetail (DECC 2007c, see Appendix 3). Therefore, although an important but limited peripheral habitat in the past Northern Hinterland Wet Sclerophyll Forest today is not considered priority fauna habitat.

As can be seen in Table 16, **Sydney Coastal Dry Sclerophyll Forest** supports a large number of high and moderate priority fauna species, of which eight predominantly occur in this habitat group. In contrast to the rainforests, however, this habitat is extensive not only within the survey area but within the bioregion, and is very well represented within the regional reserve system. Hence, though this habitat group must also be considered priority fauna habitat, it does not warrant an equivalent degree of targeted fauna management as do the more restricted habitat groups, and hence is given a **lower priority fauna habitat** status. Dry Sclerophyll Forest and Woodland is not nominated as Priority Fauna Habitat in the Sydney Metropolitan CMA area (DECC 2008a).

Dune and Alluvial Sclerophyll Forest comprises a mix of vegetation types on deep sand, the alluvial portions of which could be included in the Alluvial Forests and Woodlands Priority Fauna Habitat of DECC (2007b) and DECC (2008a). However, the majority of high and moderate priority fauna species that use this habitat within the survey area do so as part of a mix of several habitat groups. The Swift Parrot is the only species for which this habitat group is predominant, the key habitat feature being the presence of Swamp Mahogany and Bangalay. Hence only the portions of this habitat groups that support **Swamp Mahogany or Bangalay** (i.e. sections mapped as Coastal Alluvial Bangalay Forest, Coastal Sand Littoral Forest and Coastal Sand Bangalay Forest) are considered **priority fauna habitat**.

Nine high or moderate priority fauna species predominantly occur in the **Heathland** habitat group while a further seven species frequently use the habitat. Though Heathlands comprise over twenty per cent of the survey area, coastal heaths have a restricted distribution within the Sydney Basin Bioregion with Royal NP contributing significantly to the conservation of this habitat on a regional scale. The survey area supports some of the largest populations of heath-dependent species in the region, including Chestnut-rumped Heathwren, Southern Emu-wren, Beautiful Firetail and Tawny-crowned Honeyeater. Heathlands are key habitat for several species that have been lost from the reserves, including Tawny Grassbird, Ground Parrot and Eastern Bristlebird. This latter fact demonstrates the vulnerability of heathland fauna and suggests that more species may be lost in the future without active management of threats. Heathlands were identified as Priority Fauna Habitat in the Sydney Metropolitan CMA area (DECC 2008a) and are considered **highest priority fauna habitat** for the survey area.

Though **Freshwater Wetlands** are very limited in extent they support a disproportionately high number of high or moderate priority fauna species, five of which predominately occur in this habitat type. Coastal freshwater wetlands also have a highly restricted distribution within the Sydney Basin Bioregion, with Royal NP contributing significantly to the conservation of this habitat on a regional scale. Freshwater Wetland is identified as Priority Fauna Habitat in the Sydney Metropolitan CMA area (DECC 2008a) as they are poorly protected and subject to ongoing threats even where they are reserved. Freshwater Wetlands are considered **highest priority fauna habitat** for the survey area.

Forested Wetlands occupy only a tiny proportion of the survey area of which only half supports Bangalay, a feed tree for the Swift Parrot. None of the patches of this habitat group within the survey area support Swamp Mahogany, a key feed tree for Swift Parrot, Regent Honeyeater and Little Lorikeet. The habitat modelling undertaken across the southern Sydney region did not predict any high quality habitat in the survey area for Swift Parrot or Regent Honeyeater (DECC 2007c, see Appendix 3). Hence, the habitat group is not considered priority fauna habitat. Similarly Saline Wetland has not been identified as priority fauna habitat for the survey area as it is not important habitat for any high or moderate priority fauna species.

Shoreline habitats are currently key to only three high or moderate priority fauna species. However, the shoreline provides the only habitat for several additional threatened species and migratory species, thereby significantly elevating the species richness of the survey area. Coastal Shoreline is identified as Priority Fauna Habitat in the Sydney Metropolitan CMA area (DECC 2008a) as it is poorly protected with even reserved patches subject to ongoing threats. The Shoreline habitat group is thus also considered **priority fauna habitat** for the survey area.

Deep Freshwater Habitats are not here identified as priority fauna habitat as though restricted in extent they are widespread in the region and also only provide habitat for three moderate or high priority fauna species, all of which are wide ranging and would utilise similar habitats outside of the survey area also. The Parkland and other modified habitats group is not priority fauna habitat for the survey area as it is not the predominant habitat for any high or moderate priority fauna species.

In addition to the Habitat Groups described in this report it is important to remember the role played by other non vegetative habitat features including caves, rock crevices, rock overhangs and artificial structures including road culverts, bridges, underground aqueducts, railway and mine tunnels. These habitat features, both within the survey area and in adjacent lands, are key to the occurrence of some species in the survey area, most notably the microbats Eastern Horseshoe Bat, Large-footed Myotis, Eastern Bentwing-bat and Little Bentwing-bat. The maternity roost site of the Eastern Horseshoe Bat in the Bola Creek area has particular conservation significance, as does the abandoned Stanwell Park-Otford railway tunnel just south of the survey area.

Table 16: Assessment of relative conservation priority of fauna habitat groups

Habitat group	**% of survey area**	**Bioregion context**	**Predominant** or general **habitat in the survey area for high and moderate priority fauna species**	**Corresponding 'Priority Fauna Habitat' (from DECC 2007b and 2008a)**	**Priority Fauna Habitat for the survey area?**
Northern Warm Temperate and Subtropical Rainforest	1.7	Naturally restricted in extent.	**Australian Logrunner, Sooty Owl, Green Catbird, Large-footed Myotis,** Masked Owl, Eastern Bentwing-bat, Eastern Horseshoe Bat, Grey-headed Flying-fox	Rainforest (DECC 2008a)	Yes
Littoral Rainforest	0.5	Restricted in extent and threatened by development.	**Green Catbird,** Grey-headed Flying-fox, Eastern Horseshoe Bat	Rainforest (DECC 2008a)	Yes
Riparian Scrub	0.7	Restricted in extent but widespread in region and well reserved.	**Large-footed Myotis,** Freycinet's Frog, Rockwarbler, Greater Broad-nosed Bat, Eastern Bentwing-bat, Eastern Horseshoe Bat, Black Bittern	Rainforest (DECC 2008a)	Yes
North Coast Wet Sclerophyll Forest	10.3	This Keith class is widely distributed in the bioregion although Royal NP supports a large proportion of the individual vegetation communities themselves and importantly has strong rainforest elements in the sub canopy.	**Large-eared Pied Bat,** Little Lorikeet, Green Catbird, Australian Logrunner, Swift Parrot, Masked Owl, Sooty Owl, Varied Sittella, Grey-headed Flying-fox, Eastern Horseshoe Bat, Greater Broad-nosed Bat, Eastern Bentwing-bat		Yes – Lower Priority
Northern Hinterland Wet Sclerophyll Forest	0.8	Restricted in extent and threatened by development.	Little Lorikeet, Varied Sittella, Grey-headed Flying-fox, Eastern Bentwing-bat, Eastern Horseshoe Bat		No
Sydney Coastal Dry Sclerophyll Forest	60.2	Extensive and well reserved in the bioregion.	**Red-crowned Toadlet, Giant Burrowing Frog, Rosenberg's Goanna, Broad-headed Snake, Little Eagle, Masked Owl, Chestnut-rumped Heathwren, Eastern Pygmy-possum,** Freycinet's Frog, Little Lorikeet, Rockwarbler, Tawny-crowned Honeyeater, Varied Sittella, Grey-headed Flying-fox, Greater Broad-nosed Bat, Eastern Horseshoe Bat, Eastern Bentwing-bat		Yes – Lower Priority
Dune and Alluvial Sclerophyll Forest	0.4	Restricted in extent and subject to ongoing threats.	**Swift Parrot,** Freycinet's Frog, Little Lorikeet, Sooty Owl, Grey-headed Flying-fox, Eastern Horseshoe Bat, Masked Owl, Varied Sittella, Eastern Bentwing-bat, Greater Broad-nosed Bat	Alluvial Forests and Woodlands (DECC 2007b, DECC 2008a)	Yes where Swamp Mahogany and Bangalay occur.

Habitat group	**% of survey area**	**Bioregion context**	**Predominant** or general **habitat in the survey area for high and moderate priority fauna species**	**Corresponding 'Priority Fauna Habitat' (from DECC 2007b and 2008a)**	**Priority Fauna Habitat for the survey area?**
Coastal Headland Grassland	Restricted	Restricted and subject to ongoing threats.			No
Heathland	23.38	Coastal heaths of the type present in the survey area are patchily distributed in the bioregion and threatened by clearing and development.	**Red-crowned Toadlet, Broad-headed Snake, Rosenberg's Goanna, Beautiful Firetail, Tawny-crowned Honeyeater, Southern Emu-wren, Chestnut-rumped Heathwren, Eastern Pygmy-possum, New Holland Mouse,** Giant Burrowing Frog, Freycinet's Frog, Little Eagle, Little Lorikeet, Rockwarbler, Grey-headed Flying-fox, Eastern Bentwing-bat	Heathland (DECC 2008a)	Yes – Highest Priority
Freshwater Wetland	1.1	Restricted in extent and subject to ongoing threats.	**Australasian Bittern, Grass Owl, Southern Emu-wren, Tawny-crowned Honeyeater, Beautiful Firetail,** Freycinet's Frog, Giant Burrowing Frog, Black Bittern	Freshwater Wetland (DECC 2008a) and partly Upland Swamp (DECC 2007b) and Coastal Wetlands (DECC 2007b	Yes – Highest Priority
Forested Wetland	0.05	Restricted in extent, but patches within the survey area are not the best representatives of this habitat.	Swift Parrot, Freycinet's Frog, Eastern Bentwing-bat, Greater Broad-nosed Bat, Eastern Horseshoe Bat	Forested Wetland (DECC 2008a)	No
Saline Wetland	0.2	Restricted in extent, but those within the survey area are not the best representatives of this habitat.		Saltwater Wetland (DECC 2008a) and Saltmarsh (2007b)	No
Shoreline		Restricted in extent and that within the survey area is a good representation of this habitat.	**Pied Oystercatcher, Sooty Oystercatcher,** Rockwarbler	Coastal Shoreline (DECC 2008a)	Yes
Deep Freshwater Habitats		Restricted in extent but widespread in region.	**Large-footed Myotis**, Grey-headed Flying-fox, Greater Broad-nosed Bat	Components conform to Freshwater Wetland (DECC 2008a)	No
Parkland and other modified habitats		n/a			No

7 THREATS TO NATIVE FAUNA

7.1 KEY CURRENT THREATS

7.1.1 High frequency fire including wild fire and prescribed burns

The ecological consequences of high frequency fires have been listed as a Key Threatening Process under the *TSC Act*. Fire is identified as a major factor having a significant impact on fauna in the survey area. On the Woronora Plateau it has been attributed as a major contributing factor in the local extinction of the Eastern Bristlebird and the near-extinction of the Eastern Ground Parrot (DECC 2007c). Major impacts of wildfire are associated with: the broadscale burning of large areas of the survey area; burning of rainforest and adjoining wet sclerophyll forest with a mesic understorey; loss of hollow-bearing trees; loss of fallen logs and dead standing trees; and potential impacts on species using overhangs and shallow caves. Additionally, prescribed burns may also impact on fauna, particularly where they burn remaining unburnt refugia left following extensive wildfire, penetrate into rainforest, burn extensive areas of a single habitat without retaining refugia, are conducted at a time of year that is likely to have maximum impact on fauna (such as during the main breeding season, see Table 17), result in the loss of hollow-bearing and standing dead trees and/or are conducted at frequent intervals that results in a reduction in the diversity of habitats and hence biodiversity.

There are few studies that afford insight into the impacts of fire on fauna in sandstone forests, woodlands heaths and swamps. One relevant study by DECCW (DEC 2004) in the water catchments on the Woronora Plateau examined the one-off impacts of an extensive wildfire in 2001/2, including in habitats that are similar to some of those present in Royal, Heathcote and Garawarra reserves. The study examined the composition and abundance of several fauna groups across a number of typical sandstone habitats in burnt and unburnt states and then charted the recovery over several seasons. It suggests that arboreal mammals, shrub frequenting birds and litter dwelling skinks are particularly susceptible to high intensity fires. Although most species recover quickly, the study highlighted the importance of unburnt refugia in the recolonisation of burnt areas. Unburnt refugia remain important for many years (at least 7-10 years) after the fire. They provide a population source for depleted areas and provide augmentary food and habitat for animals occupying burnt areas.

The DEC (2004) study, however, was restricted to relatively few monitoring seasons. Opportunities exist to extend this study to assist in understanding just how long it takes for faunal diversity to return to pre-wildfire levels. However, such a project is clearly a monitoring program, and any work should be designed and conducted in combination with the overarching statewide and regional MER program (see discussion in Section 9.1).

There is also a need to develop a better understanding of the impacts of repeated low intensity fires that are likely to occur in areas of the reserves that require asset protection and public safety interests to be prioritised. This requires a specially designed study that differs from the impacts of a single large scale wildfire event examined by DEC (2004b). Such issues are broader reaching than just the current survey area and again any study should be linked with a broader regional program that ensures a commitment to long term monitoring and reporting.

Priority Species Impacted: At least 18 High Management Priority Species and four Moderate Management Priority Species (Table 19), with unknown impacts on additional species such as Rosenberg's Goanna and cave-dwelling bats.

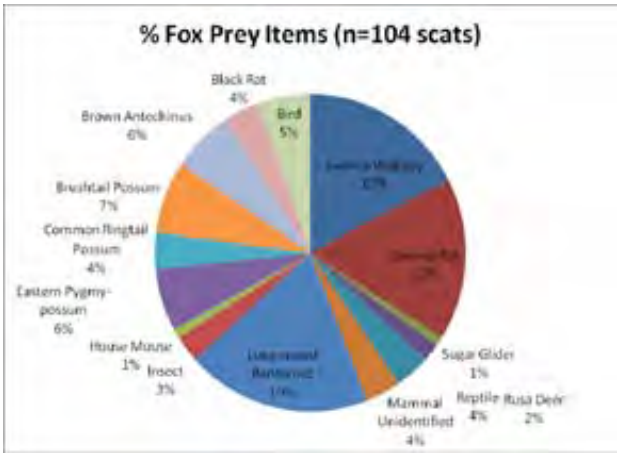
7.1.2 Predation by the Fox

Predation by the Fox is listed as a Key Threatening Process under the *TSC Act* and the Commonwealth *EPBC Act*. The Fox is widespread across the survey area (e.g. see species profile map), including habitats that are generally regarded as not supporting this species, such as steep Littoral Rainforest.

Table 17: Main breeding season of priority bird and mammal species known or potentially likely to breed within the survey area.

Species	Breeding Period	Source
Australasian Bittern	October-February	Marchant and Higgins 1990
Black Bittern	September-January	Marchant and Higgins 1990
Little Eagle	August-October	Marchant and Higgins 1993
Square-tailed Kite	July-February	Marchant and Higgins 1993
Little Lorikeet	June-January	Higgins 1999
Eastern Ground Parrot	September-January	Higgins 1999
Powerful Owl	May-February	Higgins 1999
Sooty Owl	Throughout year	Higgins 1999
Masked Owl	Throughout year	Higgins 1999
Grass Owl	Throughout year	Higgins 1999
Green Catbird	September-February	Higgins *et al.* 2006
Southern Emu-wren	August-February	Higgins *et al.* 2001
Rockwarbler	August-January	Higgins and Peter 2002
Chestnut-rumped Heathwren	June-December	Higgins and Peter 2002
Tawny-crowned Honeyeater	July-February	Higgins *et al*. 2001
Australian Logrunner	August-February	Higgins and Peter 2002
Varied Sittella	August-February	Higgins and Peter 2002
Beautiful Firetail	September-January	Higgins *et al.* 2006
Koala	Throughout the year	Martin *et al*. 2008
Eastern Pygmy-possum	Late spring-early autumn	Ward and Turner 2008
Hollow-dependant bats	Spring-mid summer	M. Schulz pers. obs.

Figure 5: Analysis of prey items in Fox scats collected during current survey



The Fox impacts on a range of native species by preying on them or competing with them for food or other resources, in particular ground-dwelling and semi-arboreal mammals, ground-frequenting birds and turtles (Dickman 1996, DECC 2007c). In the current survey the Fox was recorded preying on nine native mammal species, including the Eastern Pygmy-possum which comprised six per cent of mammalian prey remains identified (Figure 5). Additionally, this species can be responsible for the spread of some weed species, through the deposition of seeds in faeces (e.g. Bitou Bush and Blackberry).

Priority Species Impacted: At least 18 High Management Priority Species and one Moderate Management Priority Species (Table 19).

7.1.3 Herbivory and environmental degradation caused by Rusa Deer

Herbivory and environmental degradation caused by the Rusa Deer has been listed as a Key Threatening Process under the *TSC Act*. Rusa Deer are widespread across the survey area (e.g. see species profile map) and impact on native fauna both directly and indirectly through: a) the degradation of vegetation by grazing; b) trampling of fragile habitats, including the creation of well-defined pads in wetlands that Foxes can then use for access; c) trampling of mud/sand edges of wetlands that impact on foraging areas for shorebirds and some large wading birds such as egrets and bitterns; d) the trampling of the nests of

ground-breeding fauna; e) the potential interference of bat roosts in cave overhangs; f) the loss of viability of plant populations through the curtailment of seed production and seedling recruitment (Hamilton 1981, Keith and Pellow 2005) and g) resulting soil erosion that impacts on the integrity and water quality of wetlands and stream banks.

Priority Species Impacted: At least 15 High Management Priority Species and one Moderate Management Priority Species (Table 19).

7.1.4 Predation by the feral Cat and domestic Cat

Preadtion by the feral Cat is listed as a Key Threatening Process under the *TSC Act* and the Commonwealth *EPBC Act*. Additionally this species has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). The impact of the feral Cat is poorly known due to the difficulty in locating faeces, but in NSW has been implicated in the extinction of 13 mammal species and four birds species (DECC 2007c). Similarly, within the survey area the impact of this species is unknown due to its low population size and the difficulty in locating faeces. Additionally, wide-ranging domestic Cats are likely to have significant impacts on fauna, particularly in restricted vegetation communities adjacent to urban areas, such as in the Bundeena, Maianbar and East Heathcote areas. For example, domestic Cats have been recorded bringing in a range of native mammals from Royal NP adjacent to East Heathcote, such as Feathertail and Sugar Gliders (R. McLaggan, WIRES, pers. comm.).

Priority Species Impacted: At least 13 High Management Priority Species and one Moderate Management Priority Species (Table 19), with unknown impacts on additional species such as the Broad-headed Snake and cave-dwelling bats.

7.1.5 Road fatalities

The diversity and number of animals killed on the sealed roads within Royal NP has been documented in several studies. In a five-month period between April and August 2003, two reptile, 13 bird and seven roadkilled mammal species were located, including two priority species Grey-headed Flying-fox and Beautiful Firetail (Ramp *et al.* 2006). In a study between May 2007 and March 2011 five amphibian, 23 reptile, 44 bird and 16 mammal species were located roadkilled, including 11 priority species (Schulz and Madden in prep., Table 18 and Appendix 2). Although Ramp *et al*. (2006) suggested the presence of roadkill 'hotspots', the location of roadkills recorded by Schulz and Madden (in prep.) does not indicate localised 'hotspot' areas (refer to Appendix 2 Maps 7 and 8). The majority of roadkills of priority mammal species occurred along the length of Bundeena Drive for the Grey-headed Flying-fox, and for the Eastern Pygmy-possum the same length of Bundeena Drive and along Sir Bertram Stevens Drive between Warumbul Road and Curra Moors Management Trail (Appendix 2 Map 7). Priority amphibian, reptile and bird species roadkills were largely confined to Bundeena Drive and Sir Bertram Stevens Drive between Audley and McKell Drive junction (Appendix 2 Map 8). The impact that road mortality in Royal NP has on particular priority species at a population is largely unknown. Indeed, worldwide, adverse impacts of roads on wildlife populations are frequently implicated but not well demonstrated (Taylor and Goldingay 2010). Aside from priority species, Ramp and Ben-Ami (2006) suggested that as a result of the number of roadkilled individuals, the Swamp Wallaby may potentially become extinct. The impact on other non-priority species is unknown but may be significant for species such as the Short-beaked Echidna that has little opportunity for immigration from surrounding areas due to barriers such as the Illawarra Railway and the Freeway corridor.

Due to the long stretches of road along which wildlife deaths occur, strategies commonly advocated to mitigate fatalities around identified 'hotspots', such as fencing and the creation of overpasses or underpasses (e.g. Clevenger *et al.* 2001, Goosem *et al.* 2001, Jaeger and Fahrig 2004, Hayes and Goldingay 2009), may not be appropriate for Royal NP, particularly when weighed against the high cost of installation and maintenance. Certainly quantification of the current road mortality rates on particular priority species, to forecast impacts at the population level, is required before the need for such a measure can be determined and before it could be implemented effectively. Research addressing this question for particular priority species within the survey area is recommended in Section 9. Shorter term management recommendations are presented in Table 21.

Priority Species Impacted: At least 13 High Management Priority Species and one Moderate Management Priority Species (Tables 18 and 19).

Table 18: Priority species recorded as roadkill in Schulz and Madden (in prep) between May 2007 and March 2011.

Species	Number of individuals found dead on the road (Schulz and Madden in prep.)
Freycinet's Frog	6
Giant Burrowing Frog	5
Rosenberg's Goanna	14
Broad-headed Snake	2
Powerful Owl	1
Southern Emu-wren	6
Chestnut-rumped Heathwren	3
Beautiful Firetail	17
Eastern Pygmy-possum	65
Grey-headed Flying-fox	12
Eastern Horseshoe Bat	2
Eastern Bentwing-bat	1
New Holland Mouse	2

7.1.6 Loss of connectivity

In the Sydney metropolitan area context, the Royal, Heathcote, Garawarra reserve complex is one of the better connected reserves as it remains proximate to extensive areas of native vegetation. However, there are two major issues which threaten connectivity for animals between the western parts of the sandstone plateau and the coast, as well as north and south along the wet forests of the Illawarra. The first of these is the major transport corridor of the freeway and railway which interrupts vegetated links between the Royal/Garawarra and Heathcote reserves and the Woronora Special Area. The second is the mosaic of cleared and vegetated land between Helensburgh and Stanwell Park. These lands are currently a mix of tenures supporting a number of urban and semi rural land uses. They are not currently managed for nature conservation and may be vulnerable to increased urbanisation, leading to isolation of Royal NP from the Illawarra escarpment. The effects of breaks in native vegetation such as these are most critically felt during catastrophic events such as extensive and severe wildfire. Impacts on species with low dispersal ability are particularly acute including frogs, most reptiles and most non-flying mammals. The effects of isolation are generally gradual resulting in a slow decline in species diversity over several generations. Ground moving or low flying species are also very vulnerable to the loss of connectivity as they are most likely to suffer from increased mortality from collision with vehicles and occasional collisions with trains. It is estimated that 7000 animals are killed on NSW roads each day (WIRES 2006) and numbers of animals are regularly found roadkilled on freeways and beside rail lines, although the incidence of road fatalities along these corridors has not been formally documented. Studies such as Schulz and Madden (in prep, Appendix 2) indicate the extent of road collisions even on minor, less travelled roads.

Priority Species Impacted: At least 13 High Management Priority Species and one Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.7 Hydrological changes to wetlands, heath and seepages

Hydrological changes (e.g. alteration in water table and drainage characteristics) in wetlands, Heath, Dune and Alluvial Sclerophyll Forest and seepages within other habitats are likely to impact on a number of species. These changes can either be direct through the loss of seepages or regular flooding events in low-lying habitats or indirect such as through the loss of the Swamp Mahogany (a key flowering tree for the Swift Parrot and Little Lorikeet) that requires a specific hydrological regime. Such hydrological changes may result from local disturbance due to road/management trail construction or management. However, changes are more likely to originate from sources outside the survey area, such as from altered drainage as a result of developments in adjoining urban areas and longwall mining associated with the Peabody Colliery in Garawarra SCA.

Priority Species Impacted: At least 12 High Management Priority Species and one Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.8 Public disturbance

The survey area is a high public usage area and therefore some public disturbance is to be expected. However, public disturbance can have significant impact on some species that are either restricted in distribution or susceptible during a particular stage within the daily or annual cycle. These disturbances include: a) the disturbance of waders and other waterbirds resting on Constables Point at high tide with no secondary roosts present that the birds can readily moved to when harassed; b) disturbance of resting and foraging Sooty Oystercatchers on extensive reef platforms, such as at Bulgo and Semi Detached Point; c) disturbance of cave-dwelling bat roosts in old tunnels, particularly through noise, the lighting of fires and fumes from cigarettes and spray paint; d) disturbance of nesting Rockwarblers and roosting cave-dwelling bats in deep overhangs and caves in sandstone outcrops; e) uncontrolled playback of territorial night birds in parts of Royal NP; and f) disturbance and interference of seals hauled out on the shoreline.

a  b 

a) Off-leash Dogs are a major disturbance issue on Constables Point and adjacent intertidal flats; b) Public disturbance is a major issue for waterbirds in Port Hacking. Photos © M. Schulz

Priority Species Impacted: At least five High Management Priority Species and five Moderate Management Priority Species (Table 19). This category also includes all seals that haul out on the shoreline.

7.1.9 Removal of dead trees and fallen timber

This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. Dead standing trees and fallen timber provide important shelter and breeding habitat for a range of species within the survey area, including the endangered Broad-headed Snake. Removal of such habitat during DECCW maintenance and fire control works may result in the loss of breeding and sheltering sites of these species.

Priority Species Impacted: At least six High Management Priority Species and three Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

a  b 

a) Hollow-bearing trees are a scarce resource within the survey area; b) This massive standing Blackbutt stag is a very rare sight within the Hacking River valley. Photos © M. Schulz

7.1.10 Predation by the Black Rat

There is little evidence that the Black Rat threatens fauna values on the Australian mainland, although dietary studies are limited (Dickman and Watts 2008). However, this species has had a significant impact on island faunas, 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 2007e). Such an impact has been recognised through this species being listed on Lord Howe Island as a Key Threatening Process under the *TSC Act*. Therefore, given the impact on island faunas and the lack of dietary studies in natural bushland it is expected that there is some impact on fauna within the survey area, particularly given the arboreal nature of this species compared to native rat species that may occur in sympatry (Stokes *et al*. 2009). However, within the survey area, the distribution of this species appears to be in close proximity to urban areas, buildings and other modified habitats. It would be near impossible to eradicate Black Rat from the park and use of rodenticide itself would constitute a threat to native predators. Hence it is not recommended that removal of the Black Rat be attempted at this stage.

Priority Species Impacted: At least six High Management Priority Species and one Moderate Management Priority Species (Table 19), although these impacts are likely to be restricted to the edge of urban areas and in and adjacent to modified habitats.

7.1.11 Water quality and flow changes in streams

This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. Alterations in water quality and flow changes within streams in the survey area may result in the loss of a number of species. Changes in stream characteristics are likely to originate from sources outside the survey area, such as runoff from the Peabody Colliery, Helensburgh tip, stormwater runoff from fringing urban areas, the Illawarra Railway and the Princes Highway. For example, it is suspected that the loss of Platypus populations was the result of a chemical spill on the highway that washed into streams in Royal NP (D. Andrew, DECCW, pers. comm.).

Priority Species Impacted: At least six High Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.12 Loss of hollow-bearing trees

Rationale: This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. Hollow-bearing trees provide important shelter and breeding habitat for a range of species within the survey area, including the endangered Broad-headed Snake (Webb and Shine 1997). Removal of such trees during DECCW maintenance and fire control works may result in the loss of breeding and sheltering sites of these species. For example, the removal of hollow-bearing trees along Lady Carrington Drive due to public safety concerns is suggested to be a factor resulting in the loss of the Greater Glider from the survey area (Andrew 2001).

Priority Species Impacted: At least five High Management Priority Species and one Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.13 Poaching activities and associated destruction of rocky habitat

Various reptile and amphibian species that use rock for sheltering are threatened by disturbance to rocky habitat. Disturbance may consist of displacement of rocks, which alters the microhabitat characteristics of the site for sheltering fauna, or complete destruction of rock outcrops. An experimental investigation into the extent of this issue in Royal NP found 36 per cent of monitored sites to be disturbed by people over a 15 month period, including up to 450m from a walking track or road (Goldingay and Newell 2000). Such disturbance may sometimes be undertaken by hikers and vandals, but reptile poachers pose the greatest threat to both the animals and their habitat. In the current survey over 75 per cent of diurnal herpetofauna searches conducted in sites with surface rock had evidence of previous reptile searching activities, including large rocks having been crowbarred and smaller rocks flipped over or smashed. Such disturbance was observed in remote areas far from walking tracks. Illegal collection of the Broad-headed Snake endangers the viability of the species ((Webb *et al.* 2002). Poaching of its key prey species, Lesueur's Velvet Gecko and the Copper-tailed Skink, is also a major threat to this snake. The species no longer occurs in some parts of the area, such as along the sea cliffs east of Bundeena (R. McLaggan, WIRES, pers. comm.). Local Bundeena residents are also aware of the poaching of other reptiles, such as the Bandy-bandy, and various bird species (R. McLaggan, WIRES, pers. comm.). In the current survey, bird seed was found laid out along parts of the Coast Track east of Bundeena, which may have been part of an attempt to capture Beautiful Firetails that occur in the vicinity. Other species possibly poached include Giant Burrowing Frog, Rosenberg's Goanna and eggs of various owl species. Given the

potential for catastrophic direct and indirect impacts on a high number of threatened and non-threatened species, poaching is considered a major threat within the survey area.

Priority Species Impacted: Definite impacts on one High Management Priority Species, with possible impacts on additional species including at least six High and Moderate Management Priority Species (Table 19).

7.1.14 Sealing up or incorrect gating of the entrances of old mines/tunnels

The sealing up of the entrances of caves/old mines/ tunnels due to public safety issues is likely to have a deleterious impact on a number of cave-dwelling bats that occur in the survey area. Although only one species is known to occupy a maternity cave within the survey area, there is also evidence that the Large-footed Myotis likely breeds within the area. It appears that the two bent-winged bat species are non-breeding visitors, however artificial structures may form important hibernation or transit roosts for these two species. The gating of old mines and tunnels is commonly seen as a solution to meet public safety requirements. However, a number of species of cave-dwelling bats will abandon roosts, including maternity sites where the gating has been applied without consideration for the bat species present. The most sensitive bat species present within the survey area is the Eastern Bentwing-bat which will typically abandon tunnels/caves/old mines that have been gated (L. Lumsden, DSE, pers. comm.).

Priority Species Impacted: Two High Management Priority Species and two Medium Management Priority Species (Table 19).

7.1.15 Grazing by the Rabbit

The Rabbit is listed as a Key Threatening Process under the *TSC Act* and the Commonwealth *EPBC Act*. Additionally this species has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). After the 1994 wildfire this species was common along the coast south of Garie Beach in Royal NP to below Bald Hill (S. Anyon-Smith pers. comm.). Currently only irregular sightings are made in this section of the area, with regular sightings made along the Easement Track in Heathcote NP and from the edge of the highway adjacent to Loftus Oval in Royal NP on shale enriched soils (S. Anyon-Smith pers. comm., B. Sullivan pers. comm.). The Rabbit indirectly adversely affects fauna values by land degradation through altering the structure and composition of vegetation communities; removing plant biomass; preventing plant regeneration; the ring-barking of trees and shrubs; competition with native fauna; burrows can result in soil erosion; and populations may maintain feral predator numbers at an elevated level resulting in increased impacts on native fauna when sharp declines in population numbers occur (DECC 2007c). The impact on native fauna at current population levels is very low and localised. However, after catastrophic events such as extensive wildfire or localised events such as prescribed burns populations may increase and have a more significant impact on native fauna.

Priority Species Impacted: Indirectly at least three High Management Priority Species and one Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.16 Road /management trail/walking track construction and maintenance

A number of priority frog species may be impacted by road/management trail/walking track construction and maintenance through direct impacts on breeding sites or as a result of localised impacts on drainage and water quality of adjacent streams or seepages, particularly where bridgeworks are undertaken. For example, recent bridgeworks works in 2010 on the Curra Moors Management Trail resulted in the apparent loss of Giant Burrowing Frog tadpoles from pools adjacent to the site (current survey results). Similarly, populations of the Red-crowned Toadlet that have colonised ditches can be severely impacted by the upgrading of these ditches with back hoeing machinery resulting in the destruction of adults and their nests (Thumm 1997). Mowing/Slashing of management trails and walking tracks is likely to change evaporation levels and ambient temperature resulting in the potential loss of Red-crowned Toadlets and their eggs (Thumm 1997).

Priority Species Impacted: Three High Management Priority Species (Table 19).

7.1.17 Disturbance by domestic Dogs

Domestic Dogs are currently banned by the Sutherland Shire Council from the Maianbar-Constables Point shoreline. Despite this ban, domestic Dogs are a major disturbance threat to waders and other waterbirds resting on Constables Point at high tide (Carrick 2009). Many of these Dogs come from boats that have landed on Constables Point. Additionally, Sooty Oystercatchers foraging or resting on rocks on the edge of Jibbon Beach are typically disturbed by off-leash Dogs (M. Schulz pers. obs.). The impact of domestic Dogs elsewhere is poorly known, such as adjacent to urban areas, walking tracks in the

Maianbar-Bundeena area and in the East Heathcote-Helensburgh-Waterfall areas. During the survey off-leash Dogs were commonly encountered, often more than 1km from the edge of urban areas, including in more remote localities such as Marley Beach and along the Pipeline Road in Heathcote NP. Unaccompanied Dogs were not encountered in the current survey but are likely to roam into the survey area from adjacent urban settlements.

Priority Species Impacted: One High Management Priority Species and two Moderate Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.18 Amphibian Chytrid Fungus

This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. Research has implicated Amphibian Chytrid Fungus as a major factor responsible for the decline of many frog species both in Australia and elsewhere (Berger *et al.* 1998). It is likely to be a primary factor in the suspected loss of the Green and Golden Bell Frog and Stuttering Frog from the survey area.

Priority Species Impacted: Three High Management Priority Species (Table 19), with unknown impacts on additional species; in addition to two species that are suspected to have been lost from the survey area.

7.1.19 Secondary poisoning from rodenticides

Some owl species that prey on small- to medium-sized mammals are susceptible to secondary poisoning in areas where rodenticides baits have been laid, including the Masked and Grass Owls (Higgins 1999, Garnett and Crowley 2000).

Priority Species Impacted: Two High Management Priority Species and one Medium Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.20 Loss of key flowering trees

The Swamp Mahogany is a key flowering tree, including for threatened species such as the Swift Parrot, Little Lorikeet, Regent Honeyeater and Grey-headed Flying-fox. This tree has an extremely limited distribution within the survey area, primarily restricted to the Bundeena/Bonnie Vale area, with most patches on the edge of the reserve or in high public usage modified parkland landscapes. It is important that all adult trees be retained and planting of additional stands be undertaken.

Priority Species Impacted: Two High Management Priority Species and one Medium Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.21 Bushrock removal

This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. Various reptile and amphibian species that use bushrock as shelter sites are threatened by the removal of this habitat, including the endangered Broad-headed Snake (Shine and Fitzgerald 1989). This threat is currently limited within the survey area due to the gating of all management trails leading into the reserve sections.

Priority Species Impacted: Two High Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.22 Beak and feather disease

Psittacine Circoviral (Beak and Feather) Disease is listed as a Key Threatening Process under the *TSC Act*. It affects parrots by killing the cells of the feather and beak, in addition to the cells of the immune system exposing infected birds to bacterial and other infections. This disease has been recorded in a number of priority parrot species that occur in the area including the Swift Parrot and Little Lorikeet. Beak and Feather Disease is prevalent in common parrots within the area, such as the Rainbow Lorikeet and Sulphur-crested Cockatoo (R. McLaggan, WIRES, pers. comm.).

Priority Species Impacted: One High Management Priority Species and one Medium Management Priority Species (Table 19), with unknown impacts on additional parrot species.

7.1.23 Predation by the Plague Minnow

This fauna threat has been listed as a Key Threatening Process under the *TSC Act*. The Plague Minnow preys on the eggs, tadpoles and adults of a variety of frog species, including threatened species such as the Green and Golden Bell Frog (NPWS 2003d).

Priority Species Impacted: One High Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.24 Taking of Fox baits

Various scavenging species may be impacted by the taking of inappropriately laid Fox baits, including the Rosenberg's Goanna. Additionally, if Spotted-tailed Quolls were to range into or recolonise the survey area they may also be adversely affected by taking inappropriately laid baits (Belcher 2004, Claridge *et al*. 2006).

Priority Species Impacted: One High Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.25 Night-time mountain bike riding

Night-time mountain bike riding is a common activity along management trails and other undesignated tracks in western parts of Royal NP and to a lesser extent in Heathcote NP and Garawarra SCA. Mountain bikers tend to ride fast and often ride as groups, making the probability of accidentally running over nocturnal reptiles, including the endangered Broad-headed Snake very high.

Priority Species Impacted: One High Management Priority Species (Table 19), with unknown impacts on additional species.

7.1.26 Removal of nest trees

Some raptor species use the same nest tree in consecutive years, including the Little Eagle, Wedge-tailed Eagle and White-bellied Sea-Eagle (e.g. Marchant and Higgins 1993). Therefore these structures require protection from DECCW prescribed burns and other management activities.

Priority Species Impacted: One Medium Management Priority Species (Table 19).

7.2 OTHER CURRENT THREATS

A number of other threats may locally impact on fauna within the survey area or become important in the future. Such threats include:

- Public disturbance of hauled out seals on the shoreline (follow procedural guidelines, DECCW 2010b).
- The potential of oiled marine life washing from spills or shipping incidences (follow procedural guidelines, NPWS 2003e).
- The potential of live single or mass cetacean strandings on the shoreline of Royal NP, including the Port Hacking coastline (follow procedural guidelines DECCW 2010c, NPWS 1997b).
- Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments (listed as a Key Threatening Process).
- Infection of native plants by root-rot fungus (Phytophthora cinnamomi) (listed as a Key Threatening Process).
- Invasion, establishment and spread of Lantana (Lantana camara) (listed as a Key Threatening Process).
- Invasion of native plant communities by Bitou Bush and Boneseed (*Chrysanthemoides monilifera*) (listed as a Key Threatening Process).
- Invasion and establishment of exotic vines and scramblers (listed as a Key Threatening Process).
- Invasion of native plant communities by exotic perennial grasses (listed as a Key Threatening Process).
- Competition from feral Honeybees (*Apis mellifera*) (listed as a Key Threatening Process).
- Alteration to habitat following subsidence due to longwall mining (listed as a Key Threatening Process).
- Invasion and spread of weeds along gullies downslope from urban areas and developments such as the upgrade of the Illawarra Railway.
- Invasion of Sea Spurge (*Euphorbia paralias*) in primary dunes and ephemeral wetlands within dunes along the Royal NP coastline. This weed has been identified as a threat to dune-nesting shorebirds and may impact on frogs frequenting ephemeral wetlands in dunes, including in the past the Green and Golden Bell Frog.

- Boundary fences with barbed wire top strands may result in mortality of a number of mammals and birds, including threatened species listed under the TSC Act, such as the Grey-headed Flying-fox, Yellow-bellied Sheathtail-bat, Koala, Masked Owl and Grass Owl (Booth 2006).
- Infection of native plants in the Myrtaceae family by Myrtle Rust (*Uredo rangelii*) potentially resulting in plant death.
- Illegal motorbikes, particularly in Heathcote NP and Garawarra SCA lead to erosion and possible road mortality.
- Illegal hunting, particularly in parts of Royal NP has an unknown impact on non-target wildlife.
- Powerline easements, particularly in Heathcote NP, result in habitat fragmentation and roads within the easements provide access to the Fox and people exercising Dogs.
- The incidence of the disease Chlamydia in Koalas within the survey area is unknown. However, it is likely that only old or sick individuals would succumb.

7.3 FUTURE THREATS

- Human-induced climate change (listed as a Key Threatening Process), including sea level rise and other hydrological changes to the Port Hacking shoreline (e.g. impacting on the Constables Point high tide roost and the intertidal flats supporting foraging waterbirds between Cabbage Tree Basin and South West Arm) and associated streams; in addition to the coastline of Royal NP.
- Introduction of the Red-eared Slider Turtle (*Trachemys scripta elegans*) into rivers and wetlands within the survey area. This pest species may carry pathogens and diseases that can kill native turtles and other aquatic wildlife and it aggressively competes with native species for food resources. Although it is illegal to keep, sell or release this species it is commonly dumped in the wild as adults are capable of inflicting painful bites (Department of Primary Industries and Fisheries 2007).
- Introduction of the Cane Toad (*Bufo marinus*), listed as a Key Threatening Process under the TSC Act, which may spread into the area from a possible population present in the Taren Point/Caringbah area to the north.
- Spread of the Yabby (*Cherax destructor*) into the survey area (see Coughran *et al*. 2009).
- The Little Eagle and possibly additional species are susceptible to secondary poisoning from Rabbit baiting. Although Rabbit baiting is not currently undertaken, in the advent of a significant population increase of this pest species (e.g. after extensive wildfire) this threat may become important.

7.4 RELATIVE PRIORITY OF FAUNA THREATS

Section 3.3.2 of this report defined several classes and ranks of threats posed to native fauna within the reserves. In Table 19 the threats identified as Key Current Threats are ranked according to these definitions, relating to the number of High and Moderate Priority fauna species they potentially affect. The Very High and High threats are ordered from highest to lowest left to right in terms of the number of priority species known or potentially impacted.

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

Table 19: Prioritisation of major identified threats impacting high and moderate priority fauna species within the survey area.

Threat Priority	**Very High**			**High**												**Moderate**										
Major Identified Threats	**High frequency fire including wild fire and prescribed burns**	**Predation by the Fox**	**Herbivory and environmental degradation by Rusa Deer**	**Predation by the feral and domestic Cat**	**Road fatalities**	**Loss of connectivity**	**Hydrological changes in wetlands, heath & seepages**	**Public disturbance**	**Removal of dead trees and fallen timber**	**Predation by the Black Rat**	**Water quality and flow changes in streams**	**Loss of hollow-bearing trees**	**Poaching activities and associated destruction of rocky habitat**	**Sealing up or incorrect gating of the entrances of old mines/tunnels**	**Grazing by the Rabbit**	**Road/track construction and maintenance**	**Disturbance by domestic Dogs**	**Amphibian Chytrid Fungus**	**Secondary poisoning from rodenticides**	**Loss of key flowering trees**	**Bushrock removal**	**Beak and Feather Disease**	**Predation by the Plague Minnow**	**Taking of Fox baits**	**Night time mountain bike riding**	**Removal of nest trees**
Threat listed as Key Threatening Process (*TSC Act*)	X	X	X	X	-	-	-	-	X	-	X	X	-	-	X	-	-	X	-	-	X	X	X	-	-	-
High Priority Species																										
Freycinet's Frog		X	X	X	X	X	X				X					X		X					X			
Giant Burrowing Frog	X	X	X	X	X	X	X				X		X			X		X								
Red-crowned Toadlet	X	X	X	X		X	X						X			X		X			X					
Rosenberg's Goanna		X		X	X	X			X				X				X							X		
Broad-headed Snake	X	X			X	X			X			X	X								X				X	
Australasian Bittern	X	X	X				X																			
Black Bittern		X	X				X	X			X															
Swift Parrot	X		X				X								X					X		X				
Masked Owl	X							X	X			X	X						X							

Threat Priority	Very High			High											Moderate										
Major Identified Threats	High frequency fire including wild fire and prescribed burns	Predation by the Fox	Herbivory and environmental degradation by Rusa Deer	Predation by the feral and domestic Cat	Road fatalities	Loss of connectivity	Hydrological changes in wetlands, heath & seepages	Public disturbance	Removal of dead trees and fallen timber	Predation by the Black Rat	Water quality and flow changes in streams	Loss of hollow-bearing trees	Poaching activities and associated destruction of rocky habitat	Sealing up or incorrect gating of the entrances of old mines/tunnels	Grazing by the Rabbit	Road/track construction and maintenance	Disturbance by domestic Dogs	Amphibian Chytrid Fungus	Secondary poisoning from rodenticides	Loss of key flowering trees	Bushrock removal	Beak and Feather Disease	Predation by the Plague Minnow	Taking of Fox baits	Night time mountain bike riding	Removal of nest trees
Grass Owl	X	X	X		X		X				X								X							
Green Catbird	X					X																				
Southern Emu-wren	X	X	X	X	X	X	X			X					X											
Rockwarbler	X	X	X	X		X		X		X																
Chestnut-rumped Heathwren	X	X	X	X	X	X				X																
Tawny-crowned Honeyeater	X	X	X	X			X			X					X											
Australian Logrunner	X	X	X	X	X	X																				
Beautiful Firetail	X	X	X	X	X	X	X			X			X													
Eastern Pygmy-possum	X	X	X	X	X	X	X		X	X		X														
Grey-headed Flying-fox	X	X			X		X				X									X						
Eastern Horseshoe Bat		X		X	X			X						X												
Large-eared Pied Bat	X																									
Large-footed Myotis								X	X		X	X		X												
Greater Broad-nosed Bat	X								X			X														

Threat Priority	Very High			High												Moderate										
Major Identified Threats	High frequency fire including wild fire and prescribed burns	Predation by the Fox	Herbivory and environmental degradation by Rusa Deer	Predation by the feral and domestic Cat	Road fatalities	Loss of connectivity	Hydrological changes in wetlands, heath & seepages	Public disturbance	Removal of dead trees and fallen timber	Predation by the Black Rat	Water quality and flow changes in streams	Loss of hollow-bearing trees	Poaching activities and associated destruction of rocky habitat	Sealing up or incorrect gating of the entrances of old mines/tunnels	Grazing by the Rabbit	Road/track construction and maintenance	Disturbance by domestic Dogs	Amphibian Chytrid Fungus	Secondary poisoning from rodenticides	Loss of key flowering trees	Bushrock removal	Beak and Feather Disease	Predation by the Plague Minnow	Taking of Fox baits	Night time mountain bike riding	Removal of nest trees
New Holland Mouse		X	X	X	X	X																				
Medium Priority Species																										
Little Eagle	X																									X
Pied Oystercatcher		X						X									X									
Sooty Oystercatcher								X									X									
Little Lorikeet	X		X				X		X						X					X		X				
Sooty Owl	X					X		X	X			X	X						X							
Varied Sittella	X			X					X	X																
Little Bentwing-bat								X						X												
Eastern Bentwing-bat					X			X						X												

8 MANAGEMENT RECOMMENDATIONS

8.1 MANAGEMENT OF VERY HIGH THREATS

Table 20: Recommendations for management of very high threats

Threat	Management Response	Target Areas or Habitats	Key Species Issues
High Frequency Fire Including Wild Fire and Prescribed Burns	Protect unburnt refugia from fire for more than 10 years following extensive wildfire, including exclusion of planned burns from remaining unburnt patches.	Sandstone Coastal Dry Sclerophyll Forest, Heathland, Freshwater Wetland and Northern Hinterland Wet Sclerophyll Forest	Protect source populations to facilitate recolonisation of burnt areas for species with smaller dispersal ability including reptiles, frogs and small mammals.
	Prevent fire from penetrating rainforests and wet sclerophyll forests.	Northern Warm Temperate Rainforest, Subtropical Rainforest, Littoral Rainforest, North Coast Wet Sclerophyll Forest	High numbers of priority fauna including Australian Logrunner.
	Maintain a mosaic of time since fire classes for all habitats except rainforests and wet sclerophyll forests.	All	All terrestrial species.
	Maintain long unburnt areas within each habitat group.	All	All terrestrial species.
	Where planned burns are necessary, conduct them in autumn to minimise overlap with breeding times for priority fauna species.	All	See Table 17
	Planned burns should exclude fire near known owl roost and nest sites. Consult with local naturalists and owl experts regarding the current location of roost and nest sites, as they are usually not entered into the Atlas of NSW Wildlife.	Commonly rainforests and wet sclerophyll forests	Sooty Owl, Powerful Owl, Masked Owl, Grass Owl.
	Planned burns should avoid burning of forests when Swamp Mahogany, Blackbutt, Bangalay, Red Bloodwood or Smooth-barked Apple is flowering; also avoid planned burning of heathlands dominated by flowering Heath-leaved Banksia.	All forests and heathlands	Feeding resources for nectarivorous threatened species such as the Swift Parrot, Little Lorikeet, Regent Honeyeater and Grey-headed Flying-fox (Higgins 1999, Higgins *et al*. 2001, current survey).
	Avoid felling or damage to hollow-bearing or standing dead trees during fire operations.	All	Protection of arboreal fauna dependent on hollows including threatened owls, bats, arboreal mammals and birds.
	Avoid undertaking prescribed burns in conditions which may result in flare-ups resulting in the loss of large hollow-bearing trees and standing dead trees.	All	Protection of arboreal fauna dependent on hollows including threatened owls, bats, arboreal mammals and birds.
	Planned burns should exclude fire near known raptor nest sites. Consult with local naturalists and raptor experts regarding the current location of nest sites, as they are usually not entered into the Atlas of NSW Wildlife.	All	Raptor nests are commonly re-used over consecutive years. Species affected include Little Eagle and White-bellied Sea-Eagle

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	Hazard reduction burn plans should make use of habitat profiles presented in this report to assess which priority species have the potential to be impacted.	All	See Section 6.2.
	Hazard reduction burn plans should make use of species-habitat models to assess which priority species have the potential to be impacted.	All	See Appendix 3.
	Encourage the implementation and awareness of frog hygiene protocols in planned operations near frog habitats.	Forested Wetlands, Freshwater Wetlands, Dune and Alluvial Sclerophyll Forests, Riparian Scrub, Rainforests	Red-crowned Toadlet, Giant Burrowing Frog.
	Ensure fire regime around coastal cabin areas does not lead to incremental loss of Bangalay stands.	Burning Palms and Little Garie Beach in particular.	Swift Parrot.
	Ensure that surfactants (wetting and foaming agents) are not used within 50m of rainforest, water courses, dams and swamps (as per DECC 2009).	Rainforest, water courses, dams and swamps	Frog species.
	Incorporate the findings of this report, including the habitat group profiles, into writing, updating and implementing park management plans, fire plans and other management documents.	All	All terrestrial species.
	Support a coordinated program between local, regional and statewide DECCW resources and the Sydney Catchment Authority, together with leading fire and fauna experts, to progress long term fire and fauna impact studies and address the need for specific management recommendations.	All	All terrestrial species.
Predation by the Fox	Continue implementing current Fox management strategy and the Fox Threat Abatement Program (NPWS 2001b) but target the priority fauna species and habitats identified here.	Prioritise areas around Coastal Upland Swamps, such as Jibbon Lagoon.	Australasian Bittern and rails.
		Prioritise Heathlands.	Eastern Pygmy-possum, New Holland Mouse, Southern Emu-wren, Chestnut-rumped Heathwren and Beautiful Firetail.
		Prioritise rainforest and adjacent wet sclerophyll forest, particularly known locations of Australian Logrunner.	Australian Logrunner (as well as Stuttering Frog habitat).
		Prioritise around the vicinity of Powerful Owl nests.	Powerful Owl.
		Prioritise the areas adjacent to the entrance of bat roosts.	Cave roosting bat species.
		Prioritise the Constables Point-Bonnie Vale-Cabbage Tree Basin area.	Protect roosting shorebirds and other waterbirds.
	Promote baiting protocols that minimise the take of non-target species including threatened species.	All.	Reduce bait take by Rosenberg's Goanna, Lace Monitor, Little Eagle and if they were to use the area Spotted-tailed Quoll.

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	After Fox baiting undertake a control program for feral Cats that may have moved in or bred up. The removal of Foxes frequently results in the competitive release of Cats and an increase in numbers (Glen and Dickman 2005). Areas baited for Foxes should also target Cats by implementing the Rusa Deer cull program in the area and removing Cats when seen. Baited areas should also assess for the presence of Cat tracks.	Areas where Fox baiting is being undertaken.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
Herbivory and Environmental Degradation Caused by the Rusa Deer	Continue implementing Rusa Deer management strategy (DEC 2005) but target the priority fauna species and habitats identified here.	Prioritise areas around Coastal Upland Swamps, such as Jibbon Lagoon and surrounding habitats.	Australasian Bittern and rails.
		Prioritise Heathlands.	Eastern Pygmy-possum, New Holland Mouse, Southern Emu-wren, Chestnut-rumped Heathwren and Beautiful Firetail.
		Prioritise rainforest and adjacent wet sclerophyll forest.	Australian Logrunner (as well as Stuttering Frog habitat).
		Prioritise areas that support Swamp Mahogany, particularly the Bundeena and Bonnie Vale areas.	Little Lorikeet, Swift Parrot and Regent Honeyeater.
		Prioritise lower and mid reaches of streams flowing into Port Hacking.	Black Bittern
	The use of 1080 baiting (as outlined in DEC 2005) is recommended against due to the potential impacts of poisoning as a result of bait take.	All.	Stop bait take by Rosenberg's Goanna, Lace Monitor, Little Eagle, other raptor species, and if they were to use the area Spotted-tailed Quoll.

8.2 MANAGEMENT OF HIGH THREATS

Table 21: Recommendations for management of high threats

Threat	Management Response	Target Areas or Habitats	Key Species Issues
Predation by the feral Cat and domestic Cat	Continue to implement current control program for feral and domestic Cats.	All.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
	Conduct more intensive trapping in areas where high densities of sightings or indirect signs are evident and the current control program is unsuccessful.	Any area where high densities of sightings or indirect signs are evident.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
	After Fox baiting undertake a trapping program targeting feral Cats that may have moved in or bred up, as outlined in Section 8.1.	Areas where Fox baiting is being undertaken.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
	Work with local government to raise public awareness of the impact that free roaming domestic Cats have on native fauna and encourage neighbours to always keep their Cats inside at night.	All.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
	Encourage members of the public to report Cat sightings on reserve.	All.	Reduce predation pressure on High Priority and other frog, reptile, bird and mammal species.
	Encourage a cross tenure approach to feral Cat management through cooperation and integration of programmes with neighbouring landholders and land managers, such as the Sydney Catchment Authority and the Holsworthy Military Area.		
Road Fatalities	Work with road management authorities and police to encourage enforcement of road speed limits on all sealed roads, particularly between late spring and autumn.	All roads as no recognised 'hot spots'.	Minimise road deaths of a wide range of species including Eastern Pygmy-possum, Giant Burrowing Frog, Freycinet's Frog, Broad-headed Snake, Rosenberg's Goanna.
	Work with road management authorities to encourage use of temporary motorist speed control measures between September and December.	Along stretches of Heathland on Sir Bertram Stevens Drive and Bundeena Drive.	Minimise road deaths of Rosenberg's Goanna.
	Consider installation of temporary road kill awareness signage between October and December in key areas for Rosenberg's Goanna.	Curra Moors track parking area, start of Farnell Avenue, just south of the junction of Maianbar Road and Bundeena Drive, and in heathland on Sir Bertram Stevens Drive.	Minimise road deaths of Rosenberg's Goanna.
	If the pattern of use of heathlands for foraging by Grey-headed Flying-fox in April and May 2010 is found to be repeated in subsequent years, consider installation of temporary road kill awareness signage in autumn in key areas.	Bundeena Drive between Maianbar Road and Sir Bertram Stevens Drive.	Minimise road deaths of Grey-headed Flying-fox.

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	Consider the installation of permanent high visual impact road kill awareness signage in key areas similar to that used for Long-nosed Bandicoots at North Head.	All park entrances plus at the park boundary on main roads leaving Bundeena and Maianbar	Minimise road deaths of a wide range of species including Eastern Pygmy-possum, Giant Burrowing Frog, Freycinet's Frog, Broad-headed Snake, Rosenberg's Goanna.
	Work with local government and community groups in the production of a brochure for existing and new residents of Bundeena and Maianbar to increase awareness of road kills and potential impact on important wildlife.	All	Minimise road deaths of a wide range of species including Eastern Pygmy-possum, Giant Burrowing Frog, Freycinet's Frog, Broad-headed Snake, Rosenberg's Goanna.
	Consider the production a wildlife road fatality brochure to accompany day visitors' park use entry payments.	Park entrances	Minimise road deaths of a wide range of species including Eastern Pygmy-possum, Giant Burrowing Frog, Freycinet's Frog, Broad-headed Snake, Rosenberg's Goanna, Koala.
	Consider supporting research into quantifying the impact of road barriers on certain priority species. See Section 9 of this report.	All	Gain an understanding of the impact of road barriers on populations of priority fauna including Eastern Pygmy-possum, Beautiful Firetail and Rosenberg's Goanna.
Loss of Connectivity	Encourage land use practices on adjoining tenures that are sympathetic to the conservation of native fauna. This includes maintaining and improving corridors of native vegetation along the Illawarra Escarpment into the Hacking River valley as well as linkages west into the Sydney Catchment Lands.	See high conservation value lands in Map 1.	Moist forest species and species of low mobility.
	Consider the purchase of land to facilitate the improvement of wildlife corridors as opportunities arise.	Upper Hacking, Bald Hill and Stanwell Park escarpments.	Moist forest species.
	Work together with local government to ensure no further loss of native vegetation at Bald Hill from clearing.	Bald Hill.	Maintain the integrity of the only continuous linkage between Royal NP and the Illawarra Escarpment for moist forest species.
	Work together with road and rail management authorities to investigate strategies to provide for immigration and exchange of wildlife access across major easements.	F6 Freeway and Rail line.	Low mobility species including heathland birds, Eastern Pygmy-possum, New Holland Mouse, Rosenberg's Goanna and other reptiles and frogs.
Hydrological Changes in Wetlands, Swamp-Heath and Seepages	Minimise permanent and temporary hydrological changes during road, management trail and walking track construction and maintenance.	All wetlands, swamps, wet heath and seepages.	Maintain integrity of species that utilise habitats that are supported by elevated water tables including freshwater wetlands, forested wetlands. Species include Southern Emu-wren, Tawny-crowned Honeyeater, Grass Owl, Swift Parrot, Grey Flying-fox, Little Lorikeet, Black Bittern.

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	Report any incidents of urban storm water and industrial runoff from adjoining lands impacting on wetlands.	Bundeena, Lower Hacking and Waterfall-Heathcote Areas	As above.
Public Disturbance	Together with local government establish wildlife awareness signs to minimise public disturbance in key areas within and adjoining the reserves. Use a technique on the top edge of the signs to deter the perching of bird predators on these signs.	Constables Point and reef platforms at Bulgo, Semi Detached Point, Jibbon Head/Shelly Beach area and Little Marley.	Sooty Oystercatcher, Pied Oystercatcher, other waders and waterbirds.
	For hauled out seals situated in sections of shoreline used by the public follow the DECCW *Standard Operating Procedures for Pinniped Haul Outs* (DECCW 2010b).	Shoreline.	Various seal species.
	Discourage the use of owl playback area where resident owls are regularly disturbed by call playback.	Bola Creek/Lady Carrington Drive	Large forest owls
	Restrict public access on old tunnel and mine shafts by closing road access and constructing physical barriers in consultation with bat experts.	Old tunnels and mine shafts	Cave-roosting bats
Removal of Dead Trees and Fallen Timber and Loss of Hollow-bearing Trees	Avoid the removal of dead standing trees during DECCW works.	Riparian and moist forest habitats where few hollows remain due to previous disturbance such as timber harvesting.	Priority and other species that use hollows including owls, bats, arboreal mammals and the Broad-headed Snake.
	Avoid the removal of large logs and other fallen timber in areas where these resources are scarce.	All forested habitats.	Species that use timber for shelter or feeding including Rosenberg's Goanna and Broad-headed Snake.
	Ensure relevant fauna impact assessment methods are implemented prior to felling large dead standing trees or live hollow-bearing standing trees. Such an assessment is to include stag watches over a number of nights from prior to dusk to two hours after darkness by experienced fauna personnel, using an Anabat detector and night scope to ascertain species emergence.	All forested habitats.	Priority and other species that use hollows including owls, bats, arboreal mammals and the Broad-headed Snake.
Predation by the Black Rat	No ameliorative strategies recommended at this stage for the reasons outlined in Section 7.1.10 of this report.		
Water Quality and Flow Changes in Streams	Continue the current monitoring of stream water quality and flow characteristics as part of the Streamwatch program.	Existing monitoring sites.	Quality of habitat for Black Bittern, Large-footed Myotis and other riparian species.
Poaching activities and associated destruction of rocky habitat	Maintain current public exclusion in sections of Royal NP.	Sections of western Royal NP.	Various species particularly Broad-headed Snake.
	During patrols maintain vigilance for poaching activities, including catching people in the act of rock disturbance, looking for signs of habitat disturbance including rock displacement or destruction, looking for other signs such as scattering of bird seed.	All.	Various reptiles, amphibians and birds including Broad-headed Snake and Beautiful Firetail.

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	Encourage members of the public to report suspicious reptile, amphibian and bird collecting activity.	All.	Various reptiles, amphibians and birds including Broad-headed Snake and Beautiful Firetail.
	Continue to support and promote campaigns to raise public awareness of the impacts associated with disturbance of loose rock.	All.	Various species particularly Broad-headed Snake.
	Develop and maintain good working relationships with frog, reptile and bird aviarist groups.	All	Various reptiles, amphibians and birds including Broad-headed Snake and Beautiful Firetail.
Sealing Up or Incorrect Gating of the Entrances of Old Mines/Tunnels	Investigate cost-effective alternative solutions prior to entrance closing proposals.	Old tunnels and mine shafts.	Cave-roosting bats.
	Assess for the presence of microbats across all seasons prior to sealing or gating any mine or tunnel entrances. Ensure relevant experts are used during impact assessment process.	Old tunnels and mine shafts.	Cave-roosting bats.
	If gating (or other public access restrictions) are to be considered for structures used by microbats, closely consult with bat experts before proceeding to ensure the most appropriate strategy is used. Include reference to 'The Australian Handbook for conservation of bats in mines and artificial cave-bat habitats' (Thomson 2002).	Old tunnels and mine shafts.	Cave-roosting bats.
	Map disused tunnels and mine shaft locations for ongoing management of roosting resources.	Old tunnels and mine shafts.	Cave-roosting bats.
	Consider reopening old tunnels and shafts to offer alternative habitats for roosting on reserves.	Old tunnels and mine shafts.	Cave-roosting bats.
Grazing by the Rabbit	Maintain current Rabbit management strategies.	Areas with open grass cover in disturbed environments such as the Easement Track Heathcote NP and Loftus Oval Royal NP. Maintain vigilance in areas recently disturbed where vegetation becomes more open. Control can occur following fire or other disturbance.	Species affected by suppressed regeneration of key flowering trees such as Swift Parrot and Little Lorikeet.
	Where Rabbit populations are observed to increase and baiting is to be considered, assess and take steps to minimise impacts on non-target species.	All.	Little Eagle, Rosenberg's Goanna

8.3 MANAGEMENT OF MODERATE THREATS

Table 22: Recommendations for management of moderate threats

Threat	Management Response	Target Areas or Habitats	Key Species Issues
Road/Management Trail/Walking Track Construction and Maintenance	Ensure relevant fauna impact assessment is implemented for new track construction or realignments. Where frog habitat is proximate, such assessment needs to include survey following rain during the core calling periods for these frog species (from Lemckert and Mahoney 2008): Freycinet's Frog (October to February), Giant Burrowing Frog (November to April) and the Red-crowned Toadlet (July to March).	All.	All terrestrial species including priority species in relevant habitats.
	Make use of fauna habitat profiles generated for this report to identify species that may be impacted by proposed construction or realignment works.	All.	All terrestrial species including priority species in relevant habitats.
	Make use of fauna habitat models where relevant to guide impact assessment requirements for priority species for construction or realignment works.	All.	See Appendix 3.
	Conduct surveys for the Red-crowned Toadlet in peak calling periods to locate populations alongside management trails, walking tracks and roads. Include survey in areas identified as high quality habitat for this species by DECC (2007c). Incorporate locations found during current study and produce a map of populations.	Roads, management trails and walking tracks through high quality Red-crowned Toadlet habitat.	Red-crowned Toadlet.
	Retain unmown/undisturbed habitat in road depressions where frog populations have been identified.	Roads, management trails and walking tracks through frog habitat areas.	Primarily Red-crowned Toadlet, as well as Giant Burrowing Frog, Freycinet's Frog.
	Maximise opportunities for road slashing, mowing and widening to be carried out during the non-breeding season for key frogs (April to July).	Roads, management trails and walking tracks through frog habitat areas.	Red-crowned Toadlet, Giant Burrowing Frog, Freycinet's Frog.
Disturbance by Domestic Dogs	Undertake joint Dog control operations with local government.	Constable Point particularly at high tide on weekends and public holidays.	Reduce disturbance to waders and waterbirds
	Increase frequency of Dog patrols in early mornings and dusk.	In the Jibbon Beach and Jibbon head area and along firetrails within 1km of urban settlements.	Reduce disturbance to waders and water birds and reduce predation pressure on ground mammals, birds, reptiles and frogs.
	During patrols throughout the park maintain vigilance for Dogs and ensure enforcement of park bans.	All.	Reduce predation pressure on ground mammals, birds, reptiles and frogs.
Amphibian Chytrid Fungus	Ensure that staff, contractors and bush regeneration teams follow the DECCW hygiene protocols for the control of Amphibian Chytrid Fungus (NPWS 2001a), particularly when staff are working in remote sections of the survey area.	Freshwater Wetlands, Forested Wetlands, Riparian Scrub, Rainforest.	Priority and other frog species.

Threat	Management Response	Target Areas or Habitats	Key Species Issues
	Determine the extent of Amphibian Chytrid Fungus in the survey area. This fungus is considered to have contributed to the loss or decline of several frog species yet remains poorly understood in the survey area. Testing should be undertaken by an experienced herpetologist, utilising the latest collection and pathology techniques.	Wetland habitats.	Priority and other frog species.
Secondary Poisoning from Rodenticides	Minimise the laying of rodenticide baits within DECCW estate by restricting use to the vicinity of built structures such as cabins.	All.	Masked Owl, Grass Owl and Sooty Owl
Loss of Key Flowering Trees	Retain all existing stands and individual Swamp Mahogany trees throughout the reserves, including in parkland landscapes.	Primarily Bundeena-Bonnie Vale areas.	Swift Parrot, Little Lorikeet, Regent Honeyeater and Grey-headed Flying-fox.
	Encourage the protection of Swamp Mahogany on reserves, adjoining private and council lands.	All areas of Swamp Mahogany.	Swift Parrot, Little Lorikeet, Regent Honeyeater and Grey-headed Flying-fox.
	Encourage the replanting and regeneration of Swamp Mahogany in areas from which it has been cleared including parkland landscapes.	Bundeena-Bonnie Vale areas for example.	Swift Parrot, Little Lorikeet, Regent Honeyeater and Grey-headed Flying-fox.
Bushrock Removal	Ensure all entrance gates to management trails are securely locked to prevent illegal entry of bushrock removal vehicles.	Sandstone areas adjacent to tracks.	Broad-headed Snake and prey species as well as other herpetofauna.
Beak and Feather Disease	Remove all aviary escapee Parrots.	Bonnie Vale and Audley parklands.	Prevent spread of disease to wild native parrots including Swift Parrot.
	Remove all Sulphur-crested Cockatoos with Beak and Feather Disease.	Audley Parklands.	Prevent spread of disease to wild native parrots including Swift Parrot.
Predation by the Plague Minnow	No action recommended unless reintroductions of Green and Golden Bell Frog are planned.	Jibbon and Marley Lagoons.	Green and Golden Bell Frog if reintroduction is considered.
Taking of Fox Baits	Ensure all baits are buried 10cm below the surface following the recommendations of research into decreasing the number of baits taken by the Spotted-tailed Quoll (Glen and Dickman 2003) and other species, such as Rosenberg's Goanna.	All.	Minimise any impacts on Rosenberg's Goanna and if they were to recolonise the area Spotted-tailed Quoll
Night-time Mountain Bike Riding	Close management trails to night time bike riding where they traverse known Broad-headed Snake localities. Consult with relevant experts to identify areas that should be avoided.	Western section of Royal NP.	Broad-headed Snake, other nocturnal reptiles and some priority frog species such as Giant Burrowing Frog.
Removal of Nest Trees	Ensure assessment of presence of owl and raptor nests is undertaken during standard REF procedures for on-park works.	All.	Little Eagle, White-bellied Sea Eagle, Powerful Owl and other owl and raptor species.
	Protect all large raptor nests from DECCW prescribed burn and other management activities.	All.	Little Eagle, White-bellied Sea Eagle, Powerful Owl and other owl and raptor species.

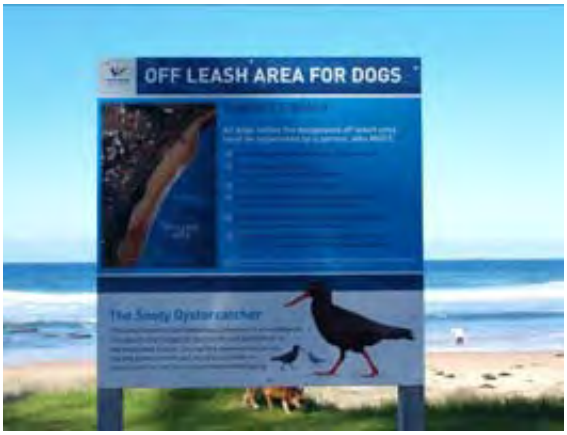
8.4 FAUNA VALUES OF ADJOINING HIGH CONSERVATION VALUE LANDS

The current survey investigated three areas of conservation value that adjoin the reserves. The location of these areas are detailed in Section 1.3.1 and illustrated on Map 1. A list of the fauna recorded within each of these adjoining lands is provided in Appendix 4.

8.4.1 Constables Point Crown Reserve

Constables Point Crown Reserve is currently managed by Sutherland Shire Council. The area contains records of two high or moderate priority fauna species (Pied Oystercatcher and Grey-headed Flying-fox), habitat for a further three high or moderate priority species (Sooty Oystercatcher, Little Tern and Black Bittern), and records for the threatened but lower priority Osprey and Beach-stone Curlew. It contains Shoreline which is identified as priority fauna habitat in this report. More specifically, this area supports the only high tide roosting site of migratory shorebirds within the survey area. Other shorebirds and a variety of waterbirds also make use of the area. Many of these species forage at low tide in Cabbage Tree Basin and on intertidal flats off Bonnie Vale and between Maianbar and South West Arm. The Constables Point Crown Reserve is considered to have **very high conservation value** for native fauna.

a



b

Examples of shorebird signs that could be modified for use in a) Port Hacking and b) on intertidal ocean reef platforms for the Sooty Oystercatcher. Photos © M. Schulz

The birds of this area are currently subjected to very high levels of disturbance by members of the public and domestic Dogs (which are banned from the area by Sutherland Shire Council, although policing is rare, A. Carrick pers. comm.). Importantly, unlike areas on the Kurnell Peninsula such as Boat Harbour, there are no secondary high tide roosts to which the birds can move when disturbance is continuous. The importance of this area could be significantly increased by enforcing the Dog ban (including Dogs that come from boats landing on the shoreline) and decreasing public disturbance, particularly at high tide. It is likely that with significantly reduced levels of disturbance that shorebird species which frequently occur at Boat Harbour and Merries Reef on the north side of Bate Bay may also frequent this area, including a variety of species that have not been recorded in recent years (e.g. Anyon-Smith 2006).

a

b

a) Birds roosting on Constables Point at high tide; b) Recommended coastal habitat link connecting Royal NP with the Illawarra below Bald Hill. Photos © M. Schulz

8.4.2 Upper Hacking

The Upper Hacking area assessed in the current study contains records for nine high or moderate priority fauna species, habitat for a further two high or moderate priority species. It also has records of three threatened but lower priority species and habitat for a further four. It contains Northern Warm Temperate and Subtropical Rainforest habitat group which is identified as priority fauna habitat in this report. This area provides a link between the rainforest and moist forests of the Illawarra Escarpment and those in the southern parts of Royal NP and Garawarra SCA. Such a link has long been recognised and considered of high importance (e.g. Robinson 1977, Andrew 1985a, b, DECC 2008a). Without such a link it is likely that over time further moist forest species would be lost from the survey area, for example species with low dispersal ability and current population sizes such as the Australian Logrunner. The Upper Hacking area is considered to have **very high conservation value** for native fauna, and its protection would greatly support conservation of native fauna on the reserves. Note that since completion of the field surveys the northern portion of the Upper Hacking lands was purchased by DECCW (parcel labelled as proposed addition to park in Map 1) with intention for inclusion in Royal NP.

The most important potential habitat link is below Bald Hill and extending to the northern outskirts of Stanwell Park. This area supports a roost of the Little Bentwing-bat (the most southerly known roost in Australia) and habitat for unusual rainforest species, such as the Noisy Pitta. This land is currently owned by the Department of Planning, with a corridor owned by State Rail.

8.4.3 Garrawarra Hospital Crown Reserve

This area contains records for five high or moderate priority fauna species and habitat for a further nine high or moderate priority species and three threatened but low priority species. The area supports vegetation communities that are widespread in adjacent areas of Garawarra SCA and Heathcote NP, including Sydney Coastal Dry Sclerophyll Forest which is identified in this report as lower priority fauna habitat. One of the most important features of the reserve is that it provides a link between Garawarra SCA with the Woronora Special Area and Holsworthy. This would be an important link if species recently rediscovered on the Woronora Plateau were to expand towards the reserves, namely Eastern Ground Parrot and Southern Brown Bandicoot. Given these features the Garrawarra Hospital Crown Reserve is considered to have **high conservation value** for native fauna.

Currently the common uses of this land are rubbish dumping, horse riding and trail bike riding. Although this area provides a habitat link between the Garawarra SCA and the Woronora Special Area its value is restricted due to the presence of the Freeway reserve effectively isolating the two areas to species with low dispersal abilities.

8.5 Discovery of New Species for the Reserves

This report has documented a likely inventory of species found in the reserves in 2009/10 and those that are occasional visitors. New species may arrive or be discovered at any time. However where new 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 priority so that resources are continually directed toward those species 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 listed as extinct or suspected loss, should be verified and reviewed. A reordering of species conservation priorities may be warranted depending on the conservation status of newly discovered species.

8.6 Using Species Habitat Models

A series of species habitat models were produced (DECC 2007b) to help with regional conservation prioritisation and land management activities. Appendix 3 assesses the performance of these models against the results of new survey work completed in this project. The results indicate that many of the priority fauna species described in this report have reliable maps of habitat available for use by staff. This means that new park management works such as hazard reduction burning, track construction and maintenance, weeding and slashing can consider potential impacts on some priority species using these maps in a GIS system. The application of each species and model is presented in Appendix 3. Digital data is available from GIS and Database Officer Biodiversity Survey and Assessment Section Metropolitan EPRG.

8.7 MAINTAINING WILDLIFE DATA SYSTEMS

The assessment of the fauna values of the reserves is made more difficult by poor maintenance of corporate wildlife data systems. A significant number of research results and sightings from DECCW staff, contractors and park visitors have not been entered into the Atlas of NSW Wildlife.

Any one-off survey is 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. Therefore the following recommendations are strongly recommended to provide a better understanding of the fauna present within the survey area:

- All research studies must contribute their records (e.g. trapping effort and results) to the Atlas of NSW Wildlife. This is a mandatory condition of the issue of scientific research permits though irregularly enforced. Staff should reinforce the obligations of wildlife research permits to consultants and academic researchers. This includes accompanying photographs or ultrasound recording files of rare species or species that have not been previously been confirmed.
- DECCW staff and contractors to enter wildlife sightings into the Atlas of NSW Wildlife, where possible with accompanying photographs if the species is rare or has not been previously recorded. Any new work should ensure that sufficient funds are set aside to undertake data entry of results.
- DECCW staff, in particular field staff, to undertake training to aid in the identification of species that are currently considered locally extinct or suspected lost, such as the Green and Golden Bell Frog, Eastern Ground Parrot, Fruit-Doves, Spotted-tailed Quoll and Red-necked Pademelon.

8.8 SPECIES RE-INTRODUCTION

A large number of species have become locally extinct or are suspected to have more recently been lost from the survey area (see Section 4.2). One potential approach to improve biodiversity values of the survey area is to undertake re-introductions of selected species. However, in this report it is recommended that re-introductions be considered a last resort, with biodiversity management strategies instead being directed toward maintaining and improving the current fauna values following management recommendations outlined above. Additionally, species re-introductions are typically expensive, require a large amount of labour and have no certainty of a positive outcome. Any re-introduction program needs to be coupled with a statistically robust fauna monitoring program which provides baseline population trend data that can be used to assist in the evaluation of re-introduction proposals (see Section 9.1).

Where species re-introductions are being considered as an option for improving biodiversity values within the reserves a number of questions need to be addressed for each species before such an approach is undertaken:

Was the species known to be present within the survey area?

Assessing the robustness of both habitat suitability and the evidence of the species previous occurrence are important considerations. For example, one species that has been suggested for re-introduction is the Yellow-bellied Glider. However, given its apparent absence on the Woronora Plateau (e.g. DECC 2007c) and its presence within the survey reliant on several anecdotal records (Robinson 1988) there is considerable doubt as to whether this species was ever present.

a  b 

Hauled out seals, such as this Leopard Seal, are often labour intensive to manage both to protect the public and protect the resting seal from disturbance. Photos © M. Schulz

Is the species really not present anymore?

Observations of some species are uncommon either because they are shy and cryptic, sparsely distributed or that surveys have not targeted suitable habitat. For example, the Common Wombat has been suggested as a potential species for re-introduction to Royal NP. However, a population of this species occurs adjacent to the Woronora Dam Road in Heathcote NP.

Why did the species become locally extinct?

If the factors that caused the decline and local extinction of a species in the first place have not been identified and addressed there is no point in re-introducing the species. It is paramount to understand the reasons behind the species loss since it will be an important factor in determining whether a species can be successfully re-introduced. For example, the Greater Glider is possibly the species most commonly proposed for re-introduction. It was present in the area until just after the 1994 wildfire and its decline is probably associated with factors such as lack of hollow availability due to past forest harvesting practices, frequent wildfire, limited prime habitat availability and isolation. To ascertain the exact reasons for decline will be difficult and therefore the success of re-introduction cannot be assured, particularly with additional factors such as the presence of Powerful Owls that commonly prey on this glider. The Green and Golden Bell Frog formerly occurred in the Jibbon and Marley Lagoons, and this species has been proposed for re-introduction into Marley Lagoon (e.g. McEntee 2005). However, this species is particularly susceptible to Amphibian Chytrid Fungus and other factors such as predation of eggs by introduced fish, such as the Plague Minnow. These impacts are so severe that this species has declined within several decades from being Sydney's most common frog to now being restricted to a small number of isolated populations. Therefore to have some chance of success with respect to re-introduction it needs to be ascertained that Amphibian Chytrid Fungus is not present in other frog species that frequent the sites, such as the Striped Marsh Frog and Common Eastern Froglet, and to ascertain whether predatory introduced fish populations are present.

Does the biology of the animal lend itself to successful re-introduction?

Far-ranging species that are likely to cross roads and spend part of their time on adjacent lands are unlikely to become successfully established. For example, a Spotted-tailed Quoll was released in Royal NP and soon after became a road fatality (D. Andrew, DECCW, pers. comm.). This incident strongly suggests that it is unlikely that this species will be successfully re-introduced into the area unless it is fenced in.

Are sufficient funds available?

Re-introductions are ongoing, time consuming and expensive. For a re-introduction to be successful long-term funding assurance is required.

Re-introduction approval

Re-introduction approval is required by the Wildlife Licensing Unit of DECCW. Such approvals may not be provided if there are insufficient grounds for such a re-introduction to be successful.

a  b  c 

Species that have been proposed for re-introduction into the Royal NP section of the survey area: a) Greater Glider that has not been seen since 1994 Photo © N. Williams; b) Common Wombat which is actually still present Photo © M. Schulz; c) Green and Golden Bell Frog that formerly occurred at Jibbon and Marley Lagoons Photo © M. Schulz.

9 RECOMMENDATIONS FOR MONITORING, FURTHER SURVEY AND RESEARCH

9.1 FAUNA MONITORING

9.1.1 Background

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 NSW, the reasons why monitoring programs often fail and to suggest monitoring projects that are relevant to fauna within the reserves that are 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 Royal 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).

PWG has recently initiated a programme called ParkIQ to improve the strategic approach to coordinating survey, monitoring, evaluation and research work on reserves across the state. The programme has three main components: development of a Monitoring and Evaluation Guide (MEG, DECCW 2010d); compilation of a Monitoring, Survey and Research Inventory (MSR inventory, currently being populated); 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. Development and roll out of the ParkIQ will inform the design and implementation of monitoring and research programmes undertaken within the survey area in the future.

The completion of the current report and survey program is actually a key step towards the development of a monitoring program for these reserves. It provides the baseline fauna data against which future trends can be gleaned by adopting the same systematic methods employed here. The results of the current work help answer questions not only about the state of fauna in Royal, Heathcote and Garawarra reserves but also about the contribution these areas make toward the persistence of species in the region and within the state. This is particularly the case for threatened species.

9.1.2 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 DECCW 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 24 presents a summary of the issues that confront fauna monitoring programs.

Table 23: 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.
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 per cent 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 per cent 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 two per cent increase, then a two per cent decline, then a four per cent decline, then in the fourth year, the population drops by nine per cent. Because we have set eight per cent 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.

9.1.3 Suggested monitoring programs

As discussed above, the design of monitoring programs is a complex issue requiring extensive planning and consultation. The simplest way to start is by integrating with established monitoring projects to ensure that they are supported and relevant to the management of the reserves. These already address some priority species and priority threats present in the reserves.

- The first phase of WildCount will concentrate on fauna monitoring using digital cameras across reserves in the east of the State, and is due to commence in 2012. DECCW Area staff are encouraged to continue to actively participate in this initiative and maintain close links with the PIQS (and other components of Park IQ) as it rolls out.
- Staff or volunteers be encouraged to contribute to regular national or statewide surveys for priority species, such as the Swift Parrot and Regent Honeyeater (see relevant Species Profiles).
- DECCW to provide encouragement for the regular monthly counts of waders and other waterbirds at Constables Point as part of the Botany Bay monthly wader counts and Birds Australia National Wader counts.
- While the post-fire fauna study on the Woronora Plateau (DEC 2004) offers valuable insights into the impacts of a single extensive wildfire event, it equally offers a benchmark and foundation to extend such work into further seasons and onto the reserves of Royal, Heathcote and Garawarra and elsewhere in the region. Understanding the impacts of fire on fauna in Sydney sandstone environments is frequently cited by rangers across the region as one of the most needed information resources to help plan and implement fire management objectives. A coordinated program between local, regional and statewide DECCW resources and the Sydney Catchment Authority could make use of this initial post-fire study to progress long term fire and fauna impact questions and contribute significantly to wider MER objectives.

A broader program of monitoring fauna in the reserves is recommended for at least the next 100 years using five or ten yearly survey periods. Such monitoring should use data collected during this survey and previous systematic surveys (e.g. the trapping sites of Andrew (2001)) as the baseline data from which to build. However such a program should be integrated with broader regional and statewide objectives, such as ParkIQ, and be robustly designed and implemented. Such a program should identify the slow changes in species numbers and composition that have the potential to come about as a result of changes in both the reserve and surrounding environments. Issues such as increased isolation arising from denser urbanisation of surrounding lands (such as between Helensburgh and Stanwell Park), higher traffic volumes along major transport corridors, or higher numbers of feral predators would bring gradual cumulative changes rather than sudden dramatic impacts. Over the long term the prevention of further fauna species losses (particularly species with low mobility) will depend on: monitoring to detect long term changes in species presence, abundance and population viability; the identification of impacting processes and species vulnerabilities; the ability of cross-tenure land use strategies and management techniques to ameliorate the impacts; and the ability to detect and monitor success of management actions.

9.2 FURTHER FAUNA SURVEY

The systematic and targeted fauna survey work undertaken to date has resulted in an adequate baseline understanding of terrestrial vertebrate fauna in the survey area, and enabled the setting of local conservation priorities. In addition, the work has highlighted issues that require further survey to broaden the understanding of fauna in the area, and enable effective management in the long term. The following targeted surveys are recommended to address these issues. Survey priorities between species are shown in brackets.

9.2.1 Frogs

- Conduct further spring and summer surveys at Jibbon and Marley Lagoons after heavy rain for the Green and Golden Bell Frog, including tadpole surveys and the installation of automated voice recorders to sample frog calls nightly for a whole spring and summer period. (Medium)
- Conduct further late spring and summer surveys in creeks flowing into the Hacking River, particularly Cawleys Creek and adjacent watercourses for the Stuttering Frog. These surveys are to include tadpole surveys and the installation of automated voice recorders to sample frog calls nightly between late spring and autumn. (Medium)

- Conduct surveys for the Red-crowned Toadlet in peak calling periods to map their location along management trails, walking tracks and roads to minimise the loss of populations as a result of road/trail upgrading and firebreak preparation works.(Higher)
- Conduct mid-spring to summer surveys for Littlejohn's Tree Frog in higher altitude heathlands and associated drainage lines following periods of prolonged rainfall. (Medium)

9.2.2 Reptiles

- Conduct pitfall trapping in higher altitude Coastal Upland Swamps (e.g. Uloola Swamp) to ascertain whether the Bold-striped Cool-skink is present within the survey area. (Lower)

a) Bold-striped Cool-skink; b) Stuttering Frog. Photos © M. Schulz/DECCW

9.2.3 Birds

- Conduct targeted searches for the Australasian and Black Bitterns to increase the understanding of occupation rates and habitat usage within the survey area. (Higher)
- Conduct regular aural survey for the Eastern Ground Parrot using automated electronic acoustic monitoring devices every three years at all the sites listed in Table 5. (Medium)
- Conduct further targeted searches for the Grass Owl to increase understanding of occupation rates and habitat usage within the survey area. (Higher)
- Conduct targeted searches for the Australian Logrunner to determine whether the species is still extant in Littoral Rainforest, such as in the Palm Jungle area. (Lower)

9.2.4 Mammals

- Conduct additional surveys for the Platypus and Water Rat using multiple trained observers from the National Parks Association and the Friends of Royal National Park. (Lower)
- Conduct additional surveys for the Greater Glider, particularly in North Coast Wet Sclerophyll Forest stands away from management trails and roads, such as on the western side of the Hacking River. (Lower)
- Conduct Anabat surveys for the East-coast Freetail-bat, particularly along the Hacking River valley and adjacent to Helensburgh. (Lower)
- Conduct additional targeted harp trapping for the Golden-tipped Bat, including in all rainforest and adjacent wet sclerophyll forest communities. (Lower)

9.3 POTENTIAL RESEARCH PROJECTS

9.3.1 Impact of road mortality on frequently killed High Priority fauna populations

Over the last four years there has been documentation of a sample of the diversity and number of vertebrate fauna species killed on roads within the survey area, yet the actual impact of this rate of road mortality on particular priority species at the population level remains largely unknown. Quantification of this impact is necessary before appropriate longer term amelioration measures can be recommended or designed. High Priority fauna species found roadkilled more than ten times in the study by Schulz and Madden (in prep., see Appendix 2) were Eastern Pygmy-possum, Beautiful Firetail, Rosenberg's Goanna

and Grey-headed Flying-fox. Investigations into the pattern of road fatalities for these species, and where possible assessment of impacts at the population level, are warranted. For example, does the high number of road fatalities of Eastern Pygmy-possum indicate a high population density that may be able to withstand high road mortality, or conversely is the actual rate of mortality very high and unsustainable. A project studying Rosenberg's Goanna in the survey area more broadly is suggested below, into which an assessment of the threat posed by road fatality could be incorporated. For Grey-headed Flying-fox it is recommended that road kills continue to be recorded by Area staff, providing information on whether the seasonal pattern of fatalities in heathland that was observed during the current survey is repeated in future years. For Eastern Pygmy-possum and Beautiful Firetail, research aimed at assessing the impact that road barriers have on the viability of populations within the survey area and surrounding region is considered to be warranted. Such a study may require a variety of approaches, from genetic studies (e.g. to determine whether occurrences of the species in different parts of the study area separated by roads are genetically distinct and how genetically robust and diverse clusters of the species are) to observational studies (e.g. determining the number of successful versus unsuccessful road crossings). Such research projects would obviously require significant investment and a commitment to multiple years of work.

9.3.2 Ecology of and threats to Rosenberg's Goanna

Royal NP and the Woronora Plateau are thought to form one of the most important population centres for the Rosenberg's Goanna in NSW (DECC 2007c). Yet this threatened High Priority species remains poorly understood, and there is still much to learn about its ecology and the relative significance of various threats to it's survival in survey area and neighbouring lands. A research project on the Rosenberg's Goanna in Royal NP and surrounding lands is therefore considered warranted. Such a project would clearly require careful planning and a commitment to multiple years of work. Topics worthy of study include diet, habitat preferences and use, fire ecology, rate and impact of consumption of Fox baits, and impacts of roads and other transport corridors including through fatalities and barrier effects. Results of such a research project(s) would inform appropriate management strategies for the Rosenberg's Goanna in the survey area and across the region.

a) and b) Examples of high impact road signs used for the Long-nosed Bandicoot on North Head; c) Eastern Pygmy-possum roadkilled on Sir Bertram Stevens Drive; d) The Princess Highway/Illawarra Railway corridor. Photos © M. Schulz

10 REFERENCES

Andrew, D. (1985a) Mammals. Pages 57-66 in *The Upper Hacking Catchment: a natural resource survey.* NSW National Parks and Wildlife Service, Sydney.

Andrew, D. (1985b) Amphibians and reptiles. Pages 67-71 in *The Upper Hacking Catchment: a natural resource survey*. NSW National Parks and Wildlife Service, Sydney.

Andrew, D. (2001) *Post fire vertebrate fauna survey – Royal and Heathcote National Parks and Garawarra State Recreation Area.* Unpublished report. Sydney South Region, NSW National Parks and Wildlife Service, Audley.

Anyon-Smith, S. (2006) *Birdwatching in Royal & Heathcote National Parks*. Sydney South Region, DEC, Audley.

Astondoa, E. (1995) *Amphibian faunal survey in ephemeral sites throughout the Helensburgh/Otford regions*. B. Env. Sci. (Hons) thesis, University of Wollongong, Wollongong.

Barrett, G., Silcocks, A., Barry S., Cunningham, R. & Poulter, R. (2003) *The New Atlas of Australian Birds*. Royal Australian Ornithologists Union. Hawthorn East, Victoria.

Belcher, C.A. & Darrant, J.P. (2004) Home range and spatial organisation of the marsupial carnivore, *Dasyurus maculatus maculatus* (Marsupialia: Dasyuridae) in south-eastern Australia. *Journal of Zoology London* **262**: 271-280.

Berger, L., Speare, R., Daszak, P., Green, D.E., Cunningham, A.A., Coggin, C.L., Slocombe, R., Ragan, M.A., Hyatt, A.D., McDonald, K.R., Hines, H.B., Lips, K.R., Marantelli, G. & Parkes, H. (1998) Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Science USA* **95**: 9031-9036.

Bilney, R.J., Kavanagh, R.P. & Harris, J.M. (2007) Further observations on the diet of the Sooty Owl *Tyto tenebricosa* in the Royal National Park, Sydney. *Australian Field Ornithology* **24**: 64-69.

Bishop, K.A. (1993) *Woronora River proposed water quality treatment plant freshwater fish study: Woronora River downstream*. Report to Mitchell McCotter and Associates for Sydney Water, Sydney.

Blakers, M., Davies, S.J.J.F. & Reilly, P.N. (1984) *The Atlas of Australian Birds*. Melbourne University Press, Carlton, Victoria.

Booth, C. (2006) *Barbed wire action plan.* Queensland Conservation Society, Brisbane.

Bruce, A., Growns, I. & Gehrke, P. (2001) *Woronora River Macquarie Perch survey*. NSW Fisheries Report Series 32, NSW Fisheries, Sydney.

Brunner, H. & Coman, B. (1974) *Identification of Mammalian Hair*. Inkata Press, Melbourne.

Cann, J. (1998) *Australian freshwater turtles*. Beaumont Publishing, Singapore.

Carrick, A. (2009) Birds & dogs? Maianbar. Submission to the Sutherland Shire Council.

Catling, P.C. & Burt (1994) Studies of the ground-dwelling mammals of eucalypt forests in south-eastern New South Wales – the species, their abundance and distribution. *Wildlife Research* **21**: 219-239.

Cayley, N. W. (1923) The birds of National Park. Pages 27-29 in *Guide Book to the Excursions in the Sydney District.* Pan Pacific Science Congress Australia (August to September 1923), Sydney.

Chafer, C.J. (2004) *Unusual observations in the Illawarra, Shoalhaven and adjacent tablelands*. http://mail.speedlink.com.au/users/cchafer/studies/2001%20Observations.htm Accessed 21 May 2010.

Chafer, C.J. & Andersen, M. (1994) Sooty Owls in the Hacking River catchment. *Australian Birds* **27**: 77-84.

Chafer, C.J., Brandis, C.C.P. & Wright, D. (1999) *Handbook of birds found in the Illawarra, Shoalhaven and adjacent tablelands. Illawarra* Bird Observer's Club, Wollongong.

Christidis, L. & Boles, W.E. (2008) *Systematics and taxonomy of Australian birds*. CSIRO Publishing, Collingwood.

Churchill, S. (2008) *Australian Bats*. Second Edition. Allen & Unwin, Crows Nest, NSW.

Clevenger, A.P., Chruszcz, B. & Gunson, K.E. (2001) Highway mitigation fencing reduces wildlife-vehicle collisions. *Wildlife Society Bulletin* **29**: 646-653.

Cogger, H.G. (1996) *Reptiles and Amphibians of Australia*. Fifth Edition with Amendments. Reed Books Australia, Port Melbourne.

Corben, C. (1989) Computer-based call analysis for microbat identification. *Macroderma* **5**:7.

Coughran, J., McCormack, R.B. & Daly, G. (2009) Translocation of the Yabby *Cherax destructor* into eastern drainages of New South Wales, Australia. *Australian Zoologist* **35**: 100-103.

Curtis, D. (2001) *Investigation to determine whether Platypus populations exist in waterways of the Royal and Heathcote National Parks*. Unpublished report. NSW national Parks and Wildlife Service, Audley.

Daly, G., Pennay, M. & Coombes, D. (2002) Surveys for the Stuttering Frog *Mixophyes balbus* on the south coast of New South Wales. *Herpetofauna* **32**: 110-130.

Debus, S.J.S., Agnew, L.R. & Schulz, M. (2001) Surveys of the Grass Owl *Tyto capensis* in coastal New South Wales. *Australian Bird Watcher* **19**: 94-102.

DEC (2003) *Fauna of the Illawarra Escarpment, coastal plain and plateau.* Wollongong Local Government Area Bioregional Assessment (Part I). NSW Dept of Environment and Conservation, Hurstville.

DEC (2004) *Post-fire Study of the fauna of the Woronora Plateau. Progress Report, July 2004*. Unpublished report funded under the Special Areas Plan of Management by the Department of Environment and Conservation (NSW), Conservation Assessment and Data Unit, Environmental Protection and Regulation Division, NSW Dept of Environment and Conservation, Hurstville.

DEC (2005) *Deer management plan 2005-2008 for Royal National Park and NPWS Parks and Reserves in the Sydney South Region*. NSW Department of Environment and Conservation, Audley.

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

DEC (2006b) Fauna summaries of the Cumberland Protected Areas from field surveys, 2006. Unpublished protected area reports. Information & Assessment Section, Metro Region, Environment Protection and Regulation Division, NSW Dept of Environment and Conservation, Hurstville.

DECC (2007a) *The vertebrate fauna of the Dharawal reserves and adjacent public lands.* Information and Assessment Section, Metropolitan Branch, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2007b) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 – Background Report*. A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by the Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2007c) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 2 – Fauna of Conservation Concern including priority pest species.* A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by the Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2007d) *Terrestrial Vertebrate Fauna of the Greater Southern Syd ney Region: Volume 4 – Fauna of the Woronora, O'Hares Creek and Metropolitan Special Areas*. A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by the Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2007e) Lord Howe Island Biodiversity Management Plan. http://www.environment.nsw.gov.au/resources/parks/LHI_bmp.pdf Accessed 8 June 2010.

DECC (2008a) *Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area.* Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2008b) *The Vertebrate Fauna of Werakata National Park and Werakata State Conservation Area.* Unpublished report. Information and Assessment Section, Metropolitan Branch, CCEPG, NSW Department of Environment and Climate Change, Hurstville.

DECC (2008c) *The Vertebrate Fauna of Sugarloaf State Conservation Area.* Unpublished report. Information and Assessment Section, Metropolitan Branch, CCEPG, NSW Dept of Environment and Climate Change, Hurstville.

DECC (2008d) *Best practice guidelines: managing threatened beach-nesting shorebirds.* NSW Dept of Environment and Climate Change, Sydney.

DECC (2008e) *Draft recovery plan for the Koala* Phascolarctos cinereus. NSW Dept of Environment and Climate Change, Sydney.

DECC (2009) *Royal and Heathcote National Parks and Garawarra State Conservation Area fire management strategy 2009.* NSW Dept of Environment and Climate Change, Sutherland.

DECCW (2009) *The Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area. Volume 1: Technical Report* and *Volume 2: Vegetation Community Profiles*. *Working Drafts.* Department of Environment, Climate Change and Water NSW, Hurstville.

DECCW (2010a) *Atlas of NSW Wildlife. Database of Fauna and Flora records*. Spatial Data Programs Section, NSW Department of Environment Climate Change and Water, Hurstville. Data extracted April 2010.

DECCW (2010b) *Standard operating procedures for Pinniped haul outs.* Final Draft. Marine Fauna Program, NSW Department of Environment Climate Change and Water, Hurstville.

DECCW (2010c) *Standard operating procedures for cetacean strandings.* Final Draft. Marine Fauna Program, NSW Department of Environment Climate Change and Water, Hurstville.

DECCW (2010d) *PWG Monitoring and Evaluation Guide*. Draft, August 2010. A product of the Park Management Program.

DECCW (2011) *The Vertebrate Fauna of Kamay Botany Bay National Park.* Department of Environment, Climate Change and Water NSW, Hurstville.

Department of Local Government (2007) *Information for cat owners in NSW*. Information brochure. NSW Dept of Local Government, Sydney.

Department of Primary Industries and Fisheries (2007) Warning Declared Class 1 Red-eared Slider Turtle *Trachemys scripta elegans*. http://www.dpi.qld.gov.au/documents/Biosecurity_EnvironmentalPests?IPA-Slider-Turtle-Warning.pdf Accessed 10 June 2010.

Dickman, C.R. (1996) Impact of exotic generalist predators on the native fauna of Australia. *Wildlife Biology* **2**: 185-195.

Dickman, C.R. & Watts, C.H.S. (2008) Black Rat *Rattus rattus*. Pages 707-709 in *The Mammals of Australia*. (eds.) van Dyck, S. & R. Strahan. Third edition. Reed New Holland, Sydney.

Donnellan, S.C. & Mahony, M. (2004) Allozyme, chromosomal and morphological variability in the *Litoria lesueuri* group (Anura: Hylidae) including a description of a new species. *Australian Journal of Zoology* **52**: 1-29.

Donnellan, S.C., McGuigan, K., Knowles, R., Mahony, M. & Moritz, C. (1999) Genetic evidence for species boundaries in frogs of the *Litoria citropa* species-group (Anura: Hylidae). *Australian Journal of Zoology* **47**: 275-293.

Eby, P., Richards, G.C., Collins, L. & Parry-Jones, K. (1999) The distribution, abundance and vulnerability to population reduction of a nomadic nectarivore, the Grey-headed Flying Fox *Pteropus poliocephalus* in New South Wales, during a period of resource concentration. *Australian Zoologist* **31**: 240-253.

Engel, D. (2010) A waterproofing option for Anabat detectors – protecting your tool. *Consulting Ecology* **24**: 51-57.

Evans, J. (2000) *The fungi in the diet of the Swamp Wallaby (Wallabia bicolor) across different vegetation types in the Royal National Park*. Hons thesis, University of Western Sydney, Penrith South.

Garnett, S.T. & Crowley, G.M. (2000) *The Action Plan for Australian Birds 2000*. Environment Australia, Canberra.

Glen, A.S. & Dickman, C.R. (2005) Complex interactions among mammalian carnivores in Australia, and their implications for wildlife management. *Biological Reviews* **80**: 387-401.

Giles, J.R. & McKenzie, L.B. (1973) *The ecology of the Javan Rusa in the Royal National Park.* Unpublished report. NSW National Parks and Wildlife Service, Audley.

Gillespie, G.R. (1996) *Survey design and management prescriptions for the Giant Burrowing Frog (*Heleioporus australiacus*) and the Stuttering Frog (*Mixophyes balbus*).* Report to the NSW National Parks and Wildlife Service. Arthur Rylah Institute, Dept of Natural Resources and Environment, Melbourne.

Goldingay, R.L. and Newell, D.A. (2000) Experimental rock outcrops reveal continuing habitat disturbance for an endangered Australian Snake. *Conservation Biology* **14 (6)**: 1908-1912.

Goosem, M., Izumi, Y. & Turton, S. (2001) Efforts to restore habitat connectivity for an upland tropical rainforest fauna: a trial of underpasses below roads. *Ecological Management and Restoration* **2**: 196-202.

Grant, T.R. (1998) Current and historical occurrence of Platypuses, *Ornithorhynchus anatinus*, around Sydney. *Australian Mammalogy* **20**: 257-266.

Griffiths, K. (2006) *Frogs & Reptiles of the Sydney Region*. Reed New Holland, Sydney.

Hamilton, C.A. (1981) *Rusa Deer in the Royal National Park: diet, dietary overlap with Wallabia bicolor, influence on the vegetation, distribution and movements*. MSc thesis, University of Sydney, Sydney.

Hayes, I.F. & Goldingay, R.L. (2009) Use of fauna road-crossing structures in north-eastern New South Wales. *Australian Mammalogy* **31**: 89-95.

Higgins, P.J. (ed.) (1999) *Handbook of Australian, New Zealand and Antarctic Birds. Volume 4. Parrots to Dollarbird*. Oxford University Press, Melbourne.

Higgins, P.J. & Davies, S.J.J.F. (eds.) (1996) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 3: Snipe to Pigeons.* Oxford University Press, Melbourne.

Higgins, P.J. & Peter, J.M. (eds.) (2002) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 6: Pardalotes to Shrike-thrushes.* Oxford University Press, Melbourne.

Higgins, P.J., Peter, J.M. & Cowling, S.J. (eds.) (2006) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 7: Boatbill to Starlings.* Oxford University Press, Melbourne.

Higgins, P.J., Peter, J.M. & Steele, W.K. (eds.) (2001) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 5: Tyrant-flycatchers to Chats.* Oxford University Press, Melbourne.

Hobcroft, D. & James, D.J. (1997) Records of the Grass Owl from southern New South Wales. *Australian Bird Watcher* **17**: 91-93.

Hoskin, E.S. (1977) The birds of Royal National Park. The Keith Alfred Hindwood Memorial Birdlist. Unpublished list for NSW National Parks and Wildlife Service, Audley.

Hoskin, E.S., Hindwood, K.A. & McGill, A.R. (1991) *The birds of Sydney, County of Cumberland, New South Wales, 1770-1989.* Surrey Beatty and Sons, Chipping Norton.

Hunter, D. & Gillespie, G.R. (2006). *Draft recovery plan for the Stuttering Frog Mixophyes balbus 2006-2010.* Report to the Biodiversity Group, Dept of Environment and Heritage, Canberra.

IUCN (International Union for the Conservation of Nature) (2005) 100 of the world's worst invasive alien species. http://www.issg.org/database/species/search.asp?st=100ss&fr=1&sts Accessed 21 May 2010.

Jaeger, J.A.G. & Fahrig, L. (2004) Effects of road fencing on population persistence. *Conservation Biology* **18**: 1651-1657.

Jones, M. (2008) Eastern Quoll *Dasyurus viverrinus*. Pages 62-64 in *The Mammals of Australia*. (eds.) van Dyck, S. & R. Strahan. Third edition. Reed New Holland, Sydney.

Kavanagh, R.P. & Jackson, R. (1997) Home-range, movements, habitat and diet of the Sooty Owl *Tyto tenebricosa* near Royal National Park. Pages 2-13 in *Australian Raptor Studies*. (eds.) G.V. Czechura and S.J.S. Debus. Birds Australia Monographs No. 3, RAOU, Melbourne.

Keith, D.A. (2004) *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*. NSW Dept of Environment and Conservation, Hurstville.

Keith, D.A. & Myerscough, P.J. (1993) Floristics and soil relations of upland swamp vegetation near Sydney. *Australian Journal of Ecology* **18**: 325-344.

Keith, D. & Pellow, B. (2005) Effects of Javan Rusa Deer (*Cervus timorensis*) on native plant species in the Jibbon-Bundeena area, Royal National Park, New South Wales. *Proceedings of the Linnean Society of NSW* **126**: 99-110.

Keith, D., Rodoreda, S., Holman, L. & Lemmon, J. (2006) *Monitoring change in Upland Swamps in Sydney's Water Catchments: the roles of fire and rain.* Vegetation Dynamics Unit, Biodiversity Conservation Science Section, Environment and Conservation Science Branch, Policy & Science Division, Department of Environment and Climate Change (NSW), Hurstville.

Keith, D.A. & Tozer, M. (unpubl.) *Vegetation map of Royal National Park and surrounds*. NSW National Parks and Wildlife Service, Hurstville.

Kemper, C.M. & Wilson, B.A.. (2008) New Holland Mouse *Pseudomys novaehollandiae*. Pages 643-644 in *The Mammals of Australia*. (eds.) van Dyck, S. & R. Strahan. Third edition. Reed New Holland, Sydney.

Kevin Mills & Associates (1995) *Fauna assessment of proposed wetland sites in Royal National Park, Engadine, Shire of Sutherland.* Kevin Mills & Associates Pty Ltd, Jamberoo.

Lemckert, F. & Mahony, M. (2008) Core calling periods of the frogs of temperate New South Wales, Australia. *Herpetological Conservation and Biology* **3**: 71-76.

Lesryk Environmental Consultants (1996) *Fauna assessment of proposed fencing programme adjacent to the Illawarra Railway Line between Heathcote and Waterfall Railway Stations.* Report prepared for State Rail. Lesryk Environmental Consultants, Bundeena.

Lesryk Environmental Consultants (2005) *Ecological assessment of proposed culvert works.* Report prepared for the Roads and Traffic Authority. Lesryk Environmental Consultants, Bundeena.

Lesryk Environmental Consultants (2007) *Flora and fauna assessment of proposed culvert works.* Report prepared for the Roads and Traffic Authority. Lesryk Environmental Consultants, Bundeena.

Lesryk Environmental Consultants (2008) *Roadside flora and fauna survey.* Report prepared for the Roads and Traffic Authority. Lesryk Environmental Consultants, Bundeena.

Lesryk Environmental Consultants (2010) *Flora and fauna assessment of proposed table drain clearing and culvert upgrading work.* Report prepared for the Roads and Traffic Authority. Lesryk Environmental Consultants, Bundeena.

Lindenmayer, D.B., Cunningham, R.B., Tanton, M.T., Smith, A.P. & Nix, H.A. (1990) Habitat requirements of the Mountain Brushtail Possum and Greater Glider in the montane ash-type forests of the central highlands of Victoria. *Australian Wildlife Research* **17**: 467-478.

Lindenmayer, D.B., Dubach, J. & Viggers, K.L. (2002) Geographic dimorphism in the Mountain Brushtail Possum (*Trichosurus caninus*): the case for a new species. *Australian Journal of Zoology* **50**: 369-393.

Lunney, D., Matthews, A. & Triggs, B. (2002) Long-term changes in the mammal fauna of logged, coastal forests near Bega, New South Wales, detected by analysis of dog and fox scats. *Australian Mammalogy* **23**: 101-114.

Mackowski, C.M. (1984) The ontogeny of hollows in Blackbutt (*Eucalyptus pilularis*) and its relevance to the management of the forests for possums, gliders and timber. Pages 553-567 in *Possums and Gliders* (eds.) A.P. Smith & I.D. Hume. Surrey Beatty and Sons, Sydney.

Mahood, I. (1981) Rusa of Royal National Park. *Australian Deer* **6**: 15-24.

Maloney, K.S. (2007) The status of the Greater Glider “Petauroides volans” in the Illawarra region. MSc-Res thesis, School of Biological Sciences, University of Wollongong, 2007.

Marchant, S. & Higgins, P.J. (eds.) (1990) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 1: Ratites to Ducks.* Oxford University Press, Melbourne.

Marchant, S. & Higgins, P.J. (eds.) (1993) *Handbook of Australian, New Zealand & Antarctic Birds. Volume 2: Raptors to Lapwings.* Oxford University Press, Melbourne.

Martin, R.W., Handasyde, K.A. & Krockenberger, A. (2008) Koala *Phascolarctos cinereus.* Pages 198-201 in *The Mammals of Australia*. (eds.) van Dyck, S. & R. Strahan. Third edition. Reed New Holland, Sydney.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S. (eds.) (1990) *Australian Soil and Land Survey Field Handbook* (second edition). Inkata Press, Melbourne.

McEntee, B.A. (2005) *An investigation into the feasibility of reintroducing the Green and Golden Bell Frog (Litoria aurea) into Marley Lagoon, in the Royal National Park*. B. Env. Sci. (Hons) thesis, University of Wollongong, Wollongong.

McFarland, D.C. (1991) The biology of the Ground Parrot *Pezoporus wallicus*, in Queensland. III. Distribution and abundance. *Wildlife Research* **18**: 199-213.

Menkhorst, P., Schedvin, N. & Geering, D. (1999) *Regent Honeyeater recovery plan 1999-2003*. Report prepared for the Regent Honeyeater Recovery Team, Dept of Natural Resources and Environment, Melbourne.

Meredith, C.W. (1984) Management of the Ground Parrot (*Pezoporus wallicus*) in Victoria – May 1984. Report to the Dept of Conservation, Forests and Lands, Melbourne.

Mills, K. (2004) *The Swift Parrot on the south coast of New South Wales*. Illawarra Wildlife Studies Series. Coachwood Publishing, Jamberoo.

Moran, C., Catterall, C.P., Green, R.J. & Olsen, M.F. (2004) Fate of feathered fruit-eaters in fragmented forests. Pages 699-712 in *Conservation of Australia’s forest fauna* (ed.) Lunney, D. Royal Zoological Society of NSW, Mosman.

Moriarty, A. (2004) *The environmental impacts of Rusa Deer in the Royal National Park*. PhD thesis, University of Western Sydney, Penrith South.

NPWS (1985) *The Upper Hacking Catchment: a natural resource survey.* NSW National Parks and Wildlife Service, Sydney.

NPWS (1997a) *NSW Comprehensive Regional Assessments: Vertebrate fauna surveys, 1997-1998 summer survey season: Field survey methods*. NSW National Parks and Wildlife Service, Hurstville.

NPWS (1997b) *Management manual for marine mammals in NSW*. NSW National Parks and Wildlife Service, Hurstville.

NPWS (1999) Threatened species information – Australasian Bittern. http://www.nationalparks.nsw.gov.au/pdfs/tsprofile_australasian_bittern.pdf Accessed 21 May 2010. *Get updated version.*

NPWS (2000a) Royal National Park, Heathcote National Park and Garawarra State Recreation Area plan of management. NSW National Parks and Wildlife Service, Sydney.

NPWS (2000b) *Biodiversity Study for the Georges River Catchment. Volume 1: Native Vegetation.* NSW National Parks and Wildlife Service, Hurstville.

NPWS (2000c) *Biodiversity Study for the Georges River Catchment. Volume 2: Fauna Assessment.* NSW National Parks and Wildlife Service, Hurstville.

NPWS (2001a) *Hygiene protocol for the control of disease in frogs*. Information Circular No. 6. NSW National Parks and Wildlife Service, Hurstville NSW.

NPWS (2001b) *Threat abatement plan for predation by the Red Fox (*Vulpes vulpes*)*. NSW National Parks and Wildlife Service, Hurstville NSW.

NPWS (2001c) *Draft fire management plan for Royal, Heathcote National Parks and Garawarra State Recreation Area*. NSW National Parks and Wildlife Service, Audley.

NPWS (2002) *Wollongong LGA Bioregional Assessment (Part II): Fauna of the Illawarra Escarpment, Coastal Plain and Plateau*. Unpublished report for the commission of inquiry into planning and development on the Illawarra Escarpment. NSW National Parks and Wildlife Service, Central Conservation Assessment and Data Unit.

NPWS (2003a) *The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments.* Conservation Assessment and Data Unit, Central Planning and Programs Division, NSW National Parks and Wildlife Service, Hurstville.

NPWS (2003b) *Draft recovery plan for the Barking Owl* Ninox connivens. NSW National Parks and Wildlife Service, Hurstville.

NPWS (2003c) *Little Tern* (Sterna albifrons) *recovery plan*. NSW National Parks and Wildlife Service, Hurstville.

NPWS (2003d) *Threat abatement plan for predation by Gambusia holbrooki - the Plague Minnow.* NSW National Parks and Wildlife Service, Hurstville.

NPWS (2003e) *Procedural guidelines for the rescue and rehabilitation of oiled wildlife.* NSW National Parks and Wildlife Service, Hurstville.

NSW Natural Resources and Environment CEO Cluster Group (2006) *NSW Natural Resources Monitoring, Evaluation and Reporting Strategy.* *http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/296649/MER-Strategy.pdf*

Nolan, L. (2006) *Biodiversity survey report 2006: Royal and Heathcote National Parks*. Unpublished report. NSW National Parks and Wildlife Service, Audley.

O'Sullivan, T., Cooper, T. & Nicolson, O. (2001) *Bate Bay management plan: natural and cultural heritage*. Report prepared for Sutherland Shire Council. Biosis Research, Chippendale.

Osborne, W.S. (1990) Declining frog populations and extinctions in the Canberra region. *Bogong* **11**: 4-7.

Parnaby, H. (1992a) *An interim guide to identification of insectivorous bats of south-eastern Australia. Technical Reports of the Australian Museum Number 8.* Australian Museum, Sydney.

Parnaby, H. (1992b) *An ultrasonic survey of microchiropteran bats of north-east NSW forests. North East Forests Biodiversity Study Report No. 3b.* NSW National Parks and Wildlife Service, Hurstville.

Parnaby, H. (2001) *Bat call survey of Royal and Heathcote National Parks.* Unpublished report. Sydney South Region, NSW National Parks and Wildlife Service, Audley.

Pennay, M. (2000) The collection of reference echolocation calls from the microchiropteran bats of New South Wales. The results of field work undertaken and notes on recording reference sequences of bat calls. Unpublished report. NSW National Parks and Wildlife Service, Hurstville.

Pennay, M., Law, B. and Reinhold, L. (2004) *Bat calls of New South Wales: region based guide to the echolocation of microchiropteran bats.* NSW Department of Environment and Conservation, Hurstville.

Pringle, R.M., Webb, J.J. & Shine, R. (2003) Canopy structure, microclimate and habitat selection by a nocturnal snake, *Hoplocephalus bungaroides*. *Ecology* **84**: 2668-2679.

Ramp, D. & Ben-Ami, D. (2006) The effect of road-based fatalities on the viability of a peri-urban Swamp Wallaby population. *Journal of Wildlife Management* **70**: 1615-1624.

Ramp, D., Wilson, V.K. & Croft, D.B. (2006) Assessing the impacts of roads in peri-urban reserves: road-based fatalities and road usage by wildlife in the Royal National Park, New South Wales, Australia. *Biological Conservation* **129**: 348-359.

Recher, H.F., Date, E.M. & Ford, H.A. (1995) *The biology and management of rainforest pigeons in NSW.* Species Management Report No. 16, NSW National Parks and Wildlife Service, Hurstville.

Reid, T.A., Hindell, M.A., Eades, D.W. & Newman, M. (2002) *Seabird atlas of south-eastern Australian waters.* Monograph 4, Birds Australia, East Hawthorn.

Reinhold, L., Law, B., Ford, G. & Pennay, M. (2001) *Key to the bat calls of south-east Queensland and north-east New South Wales*. Queensland Department of Natural Resources and Mines, Indooroopilly.

Rice, J.P. (1995) *A survey of amphibian populations associated with permanent waterways in the Helensburgh region of the Upper Hacking River catchment*. B. Env. Sci. (Hons) thesis, University of Wollongong, Wollongong.

Richards, G.C. (1992) *Fauna Survey: Wingham Management Area, Port Macquarie Region. Part 4: Bats.* Forest Resources Services Report No. 22. Forestry Commission of New South Wales, Sydney.

Richards, G.C. (2001) Towards defining adequate bat survey methodology: why electronic call detection is essential throughout the night. *The Australasian Bat Society Newsletter* **16**: 24-28.

Robinson, N.H. (1977) The need for joining Illawarra wilderness areas. *Australian Zoologist* **19**: 125-132.

Robinson, N.H. (1984) Marine mammals of the coastal waters of the Illawarra region. *Victorian Naturalist* **101**: 152-161.

Robinson, N.H. (1987) *Mammals of the national parks and nature reserves between Port Hacking and the Shoalhaven River.* Illawarra Heritage Committee, Wollongong.

Robinson, N.H. (1988) *The impact of European man on the status of mammals in the Illawarra Region*. MSc thesis, University of Wollongong, Wollongong.

Rohweder, D.A. & Baverstock, P.R. (1999) Distribution of Platypus, *Ornithorhynchus anatinus*, in the Richmond River catchment, northern New South Wales. *Australian Zoologist* **31**: 30-37.

Schodde, R. & Mason, I.J. (1980) *Nocturnal birds of Australia*. Lansdowne, Melbourne.

Schulz, M. (1999) *The conservation ecology of the rare Golden-tipped Bat* Kerivoula papuensis *and Flute-nosed Bat* Murina florium *(Chiroptera: Vespertilionidae)*. PhD thesis, Southern Cross University, Lismore.

Schulz, M. (2000a) Roosts used by the Golden-tipped Bat *Kerivoula papuensis* (Chiroptera: Vespertilionidae). *Journal of Zoology, London* **25**: 467-478.

Schulz, M. (2000b) Relative abundance and other aspects of the natural history of the rare Golden-tipped Bat, *Kerivoula papuensis* (Chiroptera: Vespertilionidae). *Acta Chiropterologica* **1**: 165-178.

Schulz, M. (2000c) Diet and foraging behaviour of the Golden-tipped Bat *Kerivoula papuensis*. *Journal of Mammalogy* **22**: 23-33.

Schulz, M. (2003) Frequency of sea snake strandings in north-eastern New South Wales. *Herpetofauna* **33**: 109-110.

Schulz, M. (2006) *Fauna survey, Towra Nature Reserve area.* Report prepared for South Sydney Region, NSW National Parks and Wildlife Service, Sutherland.

Schulz, M. (in prep. 1) Land-based observations of inshore cetaceans and seals from the sea cliffs of Royal National Park, New South Wales. In preparation. To be submitted to Australian Zoologist.

Schulz, M. (in prep. 2) Land-based observations of seabirds from the sea cliffs of Royal National Park, New South Wales. In preparation. To be submitted to the Australasian Seabird Group Newsletter.

Schulz, M. & Eyre, T.J. (2000) Habitat selection by the rare Golden-tipped Bat *Kerivoula papuensis. Australian Mammalogy **22***: 23-33.

Schulz, M. & Madden, K. (in prep.) Wildlife mortality on roads in Royal National Park over a three-year period. In preparation. To be submitted to Australian Zoologist.

Seville, B.P. (2009) *Visitor-interactions at Audley, Royal National Park, with particular reference to the Sulphur-crested Cockatoo*. B. Env. Sci. (Hons) thesis, University of Wollongong.

Shine, R. & Fitzgerald, M. (1989) Conservation and reproduction of an endangered species: the Broad-headed Snake, Hoplocephalus bungaroides (Elapidae). *Australian Journal of Zoology* **25**: 65-67.

Shirihai, H. (2007) *A complete guide to Antarctic wildlife: the birds and marine mammals of the Antarctic Continent and Southern Ocean*. A. & C. Black, London.

Smith, A.P. & Murray, M. (2003) Habitat requirements of the Squirrel Glider (*Petaurus norfolcensis*) and associated possums and gliders on the New South Wales central coast. *Wildlife Research* **30**: 291-301.

Smith, P. (1985) Birds. Pages 46-56 in *The Upper Hacking Catchment: a natural resource survey*. NSW National Parks and Wildlife Service, Sydney.

Smith, P. (2001) *Review of the conservation status of marine mammal species in New South Wales.* Report to the NSW Scientific Committee. NSW National Parks and Wildlife Service, Hurstville.

Stokes, V.L., Banks, P.B., Pech, R.P. & Williams, R.L. (2009) Invasion by *Rattus rattus* into native coastal forests of south-eastern Australia: are native small mammals at risk? *Austral Ecology* **34**: 395-408.

Swift Parrot Recovery Team (2001) *Swift Parrot (Lathamus discolor) Recovery Plan 2001-2005.* Tasmanian Department of Primary Industries, Water and Environment and the Australian Department of Environment and Heritage, Canberra.

Thackway, R. & Cresswell, I.D. (Eds.) (1995). *An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves, version 4.0*. Australian Nature Conservation Agency, Canberra.

Thomson, B. (2002) *Australian handbook for the conservation of bats in mines and artificial cave-bat habitats*. Australian Centre for Mining Environmental Research, Melbourne.

Thumm, K. (1997) *The Red-crowned Toadlet,* Pseudophryne australis*: microhabitat profile, life history, management issues and survey techniques.* Report written for the NSW National Parks and Wildlife Service, Hurstville.

Thumm, K. & Mahony, M. (2002) Evidence for continuous iteroparity in a temperate-zone frog, the Red-crowned Toadlet, *Pseudophryne australis* (Anura: Myobatrachidae). *Australian Journal of Zoology* **50**: 151-167.

Tidemann, C.R. & Woodside, D.P. (1978) A collapsible bat trap compared with mist-nets. *Australian Wildlife Research* **5**: 363-384.

Townsend, C.H. (1935) The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica* **19**: 1-50.

Triggs. B. (2001) *Tracks, scats and other traces: a field guide to Australian mammals*. Oxford University Press, Melbourne.

Trustees (1915) Official Guide to the National Park of New South Wales. Published by Authority of the Trustees. William Applegate Gullick, Government Printer, Sydney.

Tuck, M. (1971) *Javan Rusa Deer (*Cervus timoriensis*) in the Royal National Park – habitat utilization and distribution*. Hons thesis, University of Wollongong, Wollongong.

Tulloch, A. (2001) *Distribution, abundance and habitat use of the Eastern Pygmy Possum,* Cercartetus nanus*, in Royal and Heathcote National Parks, New South Wales*. B. Sci. (Hons) thesis, University of Sydney, Sydney.

Tulloch, A. (2003) *Post-fire distribution, abundance and habitat use of small mammals in Royal National Park, Heathcote National Park and Garawarra State Recreation Area, New South Wales*. Royal National Park, NSW National Parks and Wildlife Service, Sydney South Region, Audley.

Van Dyck, S. & Strahan, R. (eds.) (2008) *The Mammals of Australia*. Third Edition. Reed New Holland, Sydney.

Walker, J. & Hopkins, M.S. (1990) Vegetation. Pages 58-86 in *Australian Soil and Land Survey Field Handbook*. Second edition. (eds.) R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker & M.S. Hopkins. Inkata Press, Melbourne.

Ward, S. (1994) *Small mammals and wildfire: habitat use and condition*. B. Sci. (Hons) thesis, University of Wollongong, Wollongong.

Ward, S. & Close, R. (2004) Southern Sydney's urban Koalas: community research and education at Campbelltown. Pages 44-55 in *Urban wildlife: more than meets the eye*. (eds.). D. Lunney & S. Burgin. Royal Zoological Society of NSW, Mosman.

Ward, S.J. & Turner, V. (2008) Eastern Pygmy-possum *Cercartetus nanus.* Pages 219-221 in *The Mammals of Australia*. (eds.) van Dyck, S. & R. Strahan. Third edition. Reed New Holland, Sydney.

Webb, J.K., Brook, B.W. & Shine, R. (2002) Collectors endanger Australia's most threatened snake, the Broad-headed Snake *Hoplocephalus bungaroides*. *Oryx* **36**: 170-181.

Webb, J.K. & Shine, R. (1997) Out on a limb: conservation implications of tree hollow use by a threatened snake species *Hoplocephalus bungaroides*: Serpentes, Elapidae). *Biological Conservation* **81**: 21-23.

Wells, R. (2002) Notes on the Red-crowned Toadlet (*Pseudophryne*) *australis* (Gray 1835) – an endangered frog from the Sydney Basin of New South Wales. *Australian Biodiversity Record* **4**: 1-25.

Whelan, R.J., Coles, R., Ooi, M., Engel, D. & Jordan, R. (1991) *Lady Carrington Estate Helensburgh, Stage 1 Investigation. Fauna survey and recommendations.* Report prepared for Quality Environmental Management Pty Ltd. Australian Flora and Fauna Research Program, University of Wollongong, Wollongong.

Whelan, R.J., Ward, S., Hogbin, P. & Wasley, J. (1996) Responses of heathland *Antechinus stuartii* to the Royal National Park wildfire in 1994. *Proceedings of the Linnean Society of NSW* **116**: 97-108.

White, A.W. (1994). Frog species list – Helensburgh District. Unpublished.

White, A.W. & Pyke, G.H. (1996) Distribution and conservation status of the Green and Golden Bell Frog (*Litoria aurea*) in New South Wales. *Australian Zoologist* **30**: 177-189.

WIRES (Wildlife Information and Rescue Service, NSW) (2006) If you're prepared to speed, be prepared to kill. Media release 29 March 2006. WIRES, Sydney.

Young, B. and Young, A. (2006) *Understanding the Scenery: the Royal National Park and Heathcote National Park.* Envirobook, Annandale, NSW.

Royal NP sea cliffs. Photo © M. Schulz/DECCW

APPENDIX 1: SUMMARY OF PELAGIC SPECIES OCCURENCE

Introduction

Pelagic species may be regularly observed flying or swimming off the coast of the reserves and less frequently as beach washed individuals. These species were not given detailed assessment in this report as they do not come ashore to rest within the survey area. However this group of species is diverse and as a result this appendix provides a short overview of the pelagic species known or likely to occur. A table of species considered to be threatened under relevant State and/or Federal listing is provided. A short summary of results of pelagic species surveys is presented in monthly intervals. A short species description is provided for each species known to occur.

Threatened Pelagic Species

Table 24 presents a list of pelagic species listed on the NSW *TSC Act* and or the Commonwealth *EPBC Act*.

Table 24: Threatened marine species recorded from the survey area which have not been included as priority species.

Species	*TSC Act*	*EPBC Act*
Loggerhead Turtle *Caretta caretta*	Endangered	Endangered
Hawksbill Turtle *Eretmochelys imbricata*	-	Vulnerable
Green Turtle *Chelonia mydas*	Vulnerable	Vulnerable
Leatherback Turtle *Dermochelys coriacea*	Vulnerable	Endangered
Red-tailed Tropicbird *Phaethon rubricauda*	Vulnerable	-
Wandering Albatross *Diomedea exulans*	Endangered	Vulnerable
Gibson's Albatross *Diomedea exulans gibsoni*	Vulnerable	Vulnerable
Black-browed Albatross *Thalassarche melanophrys melanophris*	Vulnerable	Vulnerable
Campbell Albatross *Thalassarche melanophrys impavida*	-	Vulnerable
Shy Albatross *Thalassarche cauta cauta*	Vulnerable	Vulnerable
White-capped Albatross *Thalassarche cauta steadi*	-	Vulnerable
Salvin's Albatross *Thalassarche cauta salvini*	-	Vulnerable
Grey-headed Albatross *Thalassarche chrysostoma*	-	Endangered
Buller's Albatross *Thalassarche bulleri bulleri*	-	Vulnerable
Yellow-nosed Albatross *Thalassarche chlororhynchos carteri*	-	Vulnerable
Sooty Albatross *Phoebetria fusca*	Vulnerable	Vulnerable
Southern Giant-Petrel *Macronectes giganteus*	Endangered	Endangered
Northern Giant-Petrel *Macronectes halli*	Vulnerable	Vulnerable
Blue Petrel *Halobaena caerulea*	-	Vulnerable
Flesh-footed Shearwater *Ardenna carneipes*	Vulnerable	-
Little Shearwater *Puffinus assimilis*	Vulnerable	-
Providence Petrel *Pterodroma solandri*	Vulnerable	-
Gould's Petrel *Pterodroma leucoptera*	Vulnerable	Endangered
Black-winged Petrel *Pterodroma nigripennis*	Vulnerable	-
Sooty Tern *Onychoprion fuscata*	Vulnerable	-
Dugong *Dugong dugon*	Endangered	-
Southern Right Whale *Eubalaena australis*	Vulnerable	Endangered
Humpback Whale *Megaptera novaeangliae*	Vulnerable	Vulnerable

Pelagic Species Census (Schulz, in prep)

This section outlines the monthly occurrence of marine species seen from various locations off the Royal NP sea cliffs (Table 25). This summary is derived from 564 one-hour sea watches (all weather conditions combined) using a Swarovski 20-60X spotting scope and 10 x 42 Leica binoculars between May 2007 and May 2010 (Schulz in prep. 1, 2). The scores denote frequency of observation of each species for each month: 6 = seen on all sea watches; 5 = 80-99% of sea watches; 4 = 50-80%; 3 = 25-50%; 2 = 5-25% and 1 = <5%. Species with an asterisk have included all subspecies.

Table 25: Summary of sea watches from the Royal NP sea cliffs 2007 to 2010

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Count Number	45	38	35	43	50	40	61	54	46	49	55	43
Reptiles												
Turtle spp	-	-	-	-	-	-	-	-	-	-	-	1
Birds												
Wilson's Storm-Petrel	-	-	-	1	-	-	-	-	-	-	-	-
Wandering Albatross*	-	-	-	-	-	1	2	2	2	3	1	1
Black-browed Albatross*	1	1	1	2	4	5	6	5	4	3	2	2
Shy Albatross*	-	1	-	1	2	3	3	3	3	2	1	1
Grey-headed Albatross*	-	-	-	-	-	-	-	1	1	-	1	-
Yellow-nosed Albatross	-	-	-	1	3	3	4	4	2	2	-	-
Buller's Albatross	-	-	-	-	2	1	1	1	1	2	-	-
Southern Giant-Petrel	-	-	-	-	1	2	2	1	1	1	-	-
Northern Giant-Petrel	-	-	-	-	1	-	1	-	-	-	-	-
Giant-Petrel spp.	-	-	-	-	2	3	2	2	2	2	1	-
Cape Petrel	-	-	-	-	1	-	-	-	-	-	-	-
Fairy Prion	-	-	-	-	-	1	1	2	-	-	-	-
Non-Fairy Prion spp.	-	-	-	-	-	-	1	2	-	-	-	-
Wedge-tailed Shearwater	6	6	6	6	2	-	-	-	5	5	6	6
Buller's Shearwater	1	-	1	-	1	-	-	-	-	1	-	-
Flesh-footed Shearwater	1	2	1	2	-	-	-	-	-	-	1	-
Sooty Shearwater	1	1	-	1	2	1	1	-	1	1	1	1
Short-tailed Shearwater	4	4	2	-	-	-	-	-	2	4	3	4
Streaked Shearwater	1	1	2	-	-	-	-	-	-	-	-	-
Fluttering Shearwater	2	2	1	1	2	3	4	4	5	4	3	2
Hutton's Shearwater	1	1	-	-	-	-	1	1	1	2	-	-
Great-winged Petrel	-	-	-	-	1	1	1	1	1	1	1	-
Providence Petrel	-	-	-	1	-	-	-	-	-	-	-	-
White-necked Petrel	-	1	-	-	-	-	-	-	-	-	-	-
Little Penguin	3	2	2	3	3	4	4	3	3	2	2	3
Australasian Gannet	4	4	5	6	6	6	6	6	6	5	5	5
Great Cormorant	4	4	2	2	2	3	2	2	2	4	3	4
Pied Cormorant	2	3	4	3	3	2	2	2	3	2	2	2
Brown Skua	-	-	1	1	2	1	2	3	2	1	-	-
Pomarine Jaeger	3	4	5	3	1	-	-	-	-	1	2	3
Arctic Jaeger	2	2	2	2	1	-	-	-	1	2	3	2
Long-tailed Jaeger	2	2	2	2	-	-	-	-	-	-	1	-
Sooty Tern	-	2	1	-	-	-	-	-	-	-	-	-
Little Tern	1	-	-	-	-	-	-	-	-	-	-	-
Caspian Tern	1	1	1	1	-	-	-	1	1	2	1	1
White-fronted Tern	-	-	-	1	2	2	3	2	-	-	-	-
Common Tern	-	-	-	-	-	-	-	-	-	1	1	-

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crested Tern	5	5	6	6	6	6	6	6	6	6	5	4
Kelp Gull	1	1	1	-	1	-	1	1	2	1	1	1
Silver Gull	5	6	6	6	6	6	6	6	6	5	6	5
Mammals												
Southern Right Whale	-	-	-	-	-	-	-	2	-	-	-	-
Large Unidentified Balaenoptera whale	-	-	-	-	-	-	-	1	-	-	-	-
Dwarf Minke Whale	-	-	-	-	1	1	-	1	-	-	1	1
Humpback Whale	-	-	-	1	2	5	4	3	3	4	3	1
Beaked Whale spp.	-	-	-	-	-	-	-	-	-	-	1	-
Indo-Pacific Bottlenose Dolphin	2	2	2	2	2	-	2	2	1	2	2	2
Short-beaked Common Dolphin	2	2	2	2	2	2	1	2	2	2	2	2
Risso's Dolphin	-	-	-	1	-	-	-	-	-	-	-	-
Pygmy Killer Whale	-	-	-	-	1	-	-	-	-	-	-	-
False Killer Whale	2	-	-	-	-	-	-	-	-	-	1	1
Killer Whale	-	-	-	-	1	-	1	-	-	-	-	-
Fur Seal spp.	2	1	2	2	1	2	2	2	2	1	1	-

Annotated list of Pelagic species

Reptiles

Green Turtle (*Chelonia mydas*) – Rare. One record from Port Hacking in June 1995. Occasional sight records from boats close inshore off the Royal NP sea cliffs appear to be of this species (M. Schulz pers. comm.).

Hawksbill Turtle (*Eretmochelys imbricata*) – Very rare. Two immatures beach washed on Marley Beach in May 2007 and June 2009 (M. Schulz pers. obs., DECCW 2010a).

Leathery Turtle (*Dermochelys coriacea*) – Very rare. Juvenile found live on Garie Beach in the 1970s (S. Anyon-Smith, pers. comm.) and another on Jibbon Beach in the 1990s (B. Sullivan, DECCW, pers. comm.).

Yellow-bellied Sea Snake (*Pelamis platurus*) – Irregular. There are a number of records in the Atlas of NSW Wildlife of this species from beaches in the area, including in Port Hacking; principally from the summer months. In the current survey one was found washed up dead on Garie Beach in December 2009. It was found beach cast in the high tideline at the same time as thousands of Portuguese Man O' War (*Physalia physalis*), By-the Wind-Sailors (*Velella velella*), salps (Thaliacea) and other oceanic floating marine life were washed ashore in the tideline; similar conditions to when this species has been recorded washed up elsewhere in New South Wales (e.g. Schulz 2003). The large numbers of attached Goose Barnacles (*Lepas* spp.) suggested that it had been afloat for some time.

Elegant Sea Snake (*Hydrophis elegans*) – Very rare. One old record from Port Hacking may have been along the Royal NP shoreline (DECCW 2010a).

2) Birds

Red-tailed Tropicbird (*Phaethon rubricauda*) – Very rare. One immature beach washed on Garie Beach in February 2009 (M. Schulz pers. obs.).

White-tailed Tropicbird (*Phaethon lepturus*) – Rare (Anyon-Smith 2006), with beach washed specimens from Garie Beach in March 1978 and Marley Beach in November 1984 (DECCW 2010a). One immature found beach washed in the current survey on Burning Palms Beach in February 2010.

Wilson's Storm-Petrel (*Oceanites oceanicus*) – Very rare. Two birds seen off the Bundeena sea cliffs in April 2010 (Schulz in prep. 2).

White-faced Storm-Petrel (*Pelagodroma marina*) – Very rare. One beach washed on Garie Beach in November 2008 (DECCW 2010a, M. Schulz pers. obs.).

Wandering Albatross (*Diomedea exulans exulans*) – Uncommon. Occasionally seen offshore (Anyon-Smith 2006); although not distinguished from other subspecies in the monthly sea watches outlined

above (Schulz in prep. 2). A banded individual was found washed ashore on Wattamolla Beach in July 1964 (Australian Museum specimen).

Gibson's Albatross (*Diomedea exulans gibsoni*) – Reasonably common (Anyon-Smith 2006); although not distinguished from other subspecies in the monthly sea watches outlined above (Schulz in prep. 2).

Black-browed Albatross (*Thalassarche melanophrys melanophrys*) – Commonly seen from the sea cliffs, mainly in the winter months (see above Section). Occasionally beach washed.

Campbell Albatross (*Thalassarche melanophrys impavida*) – Reasonably commonly seen from the sea cliffs (Anyon-Smith 2006); although not distinguished from other subspecies in the monthly sea watches outlined above (Schulz in prep. 2).

Shy Albatross (*Thalassarche cauta cauta*) – Uncommon (Anyon-Smith 2006); although not distinguished from the White-capped Albatross in the monthly sea watches outlined above (Schulz in prep. 2).

Shy Albatross (*Thalassarche cauta steadi*) – Reasonably common (Anyon-Smith 2006); although not distinguished from the Shy Albatross in the monthly sea watches outlined above (Schulz in prep. 2).

Salvin's Albatross (*Thalassarche cauta salvini*) – Rarely seen close enough inshore to distinguish from other subspecies (see above Section).

Grey-headed Albatross (*Thalassarche chrysostoma*) – Very rare. One individual beach washed on Wattamolla in July 2000 (Anyon-Smith 2006). Very rarely seen off the sea cliffs with single individuals observed in November 2007, August 2008 and September 2008 (Schulz in prep. 2).

Buller's Albatross (*Thalassarche bulleri*) – Rare (Anyon-Smith 2006). Occasionally observed off the sea cliffs, primarily between May and October (see above Section). One individual beach washed on Garie Beach in August 1967 (Hoskin *et al*. 1991).

Indian Yellow-nosed Albatross (*Thalassarche chlororhynchos carteri*) – Common; most commonly seen between May and October (see above Section. Occasionally beach washed.

Sooty Albatross (*Phoebetria fusca*) – Very rare. The only record is of two separate individuals found beach washed on Garie Beach in June and July 1975 (DECCW 2010a).

Southern Giant-Petrel (*Macronectes giganteus*) – Uncommon; mostly between May and October (see above Section). Occasional immature birds seen off the sea cliffs; with most too far offshore to distinguish from the similar-looking Northern Giant-Petrel. For this reason in the above Section this species was combined with the Northern Giant-Petrel.

Northern Giant-Petrel (*Macronectes halli*) – Rare. Occasional immature birds seen off the sea cliffs (see above Section); with most too far offshore to distinguish from the similar-looking Southern Giant-Petrel. For this reason in the above Section this species was combined with the Northern Giant-Petrel.

Southern Fulmar (*Fulmarus glacialoides*) – Very rare. Occasional beach washed records coinciding with an influx of this species into southern Australian waters, when numbers become wrecked along the coast (Reid *et al*. 2002). One bird was reported flying past Bald Hill in January 1958 (Hoskin *et al*. 1991) and another was observed off Royal National Park on 21 September 2010 (M. Schulz pers. obs.).

Cape Petrel (*Daption capense*) – Very rare. No beach washed specimens have been documented. The only record is of two individuals seen following a fishing trawler off the sea cliffs in May 2010 (Schulz in prep. 2).

Blue Petrel (*Halobaena caerulea*) - Very rare. Occasional beach washed records coinciding with an influx of this species into southern Australian waters, when numbers become wrecked along the coast (Reid *et al*. 2002). Several beach washed specimens recorded, such as one on Garie Beach in August 1986 (Hoskin *et al*. 1991).

Antarctic Prion (*Pachyptila desolata*) – Very rare. Recorded as beach washed by Anyon-Smith (2006) with no details provided. One specimen was found beach washed on Garie Beach in August 1986 (DECCW 2010a). Non-Fairy Prion type individuals seen off the sea cliffs in July and August may possibly include this species (see above Section). However, from a distance this species is very difficult to distinguish from the Slender-billed Prion and Salvin's Prion (*P. salvini*) (e.g. Shirihai 2007).

Slender-billed Prion (*Pachyptila belcheri*) – Uncommon, although common in some years. Recorded as beach washed specimens, with numbers found washed ashore in some years, such as in 1998 (Anyon-Smith 2006). Non-Fairy Prion type individuals seen off the sea cliffs in July and August are likely to include this species (see above Section). However, from a distance this species is very difficult to distinguish from the Antarctic and Salvin's Prions (e.g. Shirihai 2007).

Fairy Prion (*Pachyptila turtur*) – Uncommon, although moderately common in some years. Generally beach washed in small numbers on Royal NP beaches, mostly between June and October (M. Schulz pers. obs.). Seen off the sea cliffs in primarily small numbers between June and August (see above Section).

Wedge-tailed Shearwater (*Ardenna pacifica*) – Very common, occurring between September and May (see above Section). Sometimes aggregations of hundreds of birds occur close inshore. Regularly beach washed.

Buller's Shearwater (*Ardenna bulleri*) – Rare, with only a small number of sightings off the sea cliffs (e.g. Schulz in prep. 2, see above Section). During the current survey one individual was found beach washed on Werrong Beach in February 2010.

Flesh-footed Shearwater (*Ardenna carneipes*) – Uncommon, with only a small number of sightings off the sea cliffs (e.g. Schulz in prep. 2, see above Section). This species is likely to have been under-recorded due to the difficulty of separating distant individuals from other dark shearwaters. Occasional beach washed specimens found.

Sooty Shearwater (*Ardenna grisea*) – Rare, with only a small number of sightings of single individuals off the sea cliffs throughout the year (e.g. Schulz in prep. 2, see above Section). This species is likely to have been under-recorded due to the difficulty of separating distant individuals from the Short-tailed Shearwater.

Short-tailed Shearwater (*Ardenna tenuirostris*) – Common, with large numbers seen passing on its southward migration in September and November (see above Section). Commonly beach washed, with large wrecks sometimes occurring. For example, 87 individuals were found washed ashore along the length of Garie Beach on 7 November 2009 (M. Schulz pers. obs.).

Streaked Shearwater (*Calonectris leucomelas*) – Rare, with only a small number of sightings off the sea cliffs between January and March (e.g. Schulz in prep. 2, see above Section).

Fluttering Shearwater (*Puffinus gavia*) – Common, with rafts of thousands of individuals sometimes encountered close inshore. It is most regularly seen off the sea cliffs with the largest numbers present between June and November (see above Section). Regularly beach washed.

Hutton's Shearwater (*Puffinus huttoni*) – Uncommon, with only a small number of sightings off the sea cliffs throughout the year (e.g. Schulz in prep. 2, see above Section). This species is likely to have been under-recorded due to the difficulty of separating distant individuals from the more common Fluttering Shearwater. Occasional beach washed specimens found.

Little Shearwater (*Puffinus assimilis*) – Very rare. One beach washed specimen from Marley Beach in May 1980 (DECCW 2010a).

Kerguelen Petrel (*Lugensa brevirostris*) – Very rare. Occasional beach washed records primarily coinciding with an influx of this species into southern Australian waters, when numbers become wrecked along the coast (Reid *et al*. 2002). One found beach washed on Marley Beach in August 2007 (M. Schulz pers. obs.).

White-headed Petrel (*Pterodroma lessonii*) – Very rare. Occasional beach washed specimens, including from Garie Beach in March 1972 and July 1975 (DECCW 2010a).

Great-winged Petrel (*Pterodroma macroptera*) – Rare. Occasional individuals observed off the sea cliffs, primarily between May and November (see above Section). Occasional beach washed specimens, all of the New Zealand subspecies *P. m. gouldi* (M. Schulz pers. obs.).

Providence Petrel (*Pterodroma lessonii*) – Rare. Occasional individuals observed off the sea cliffs (see above Section).

Gould's Petrel (*Pterodroma leucoptera*) – Very rare. Occasional beach washed specimens, including from Bulgo Beach in March 1967 and Marley Beach in February 1968 (DECCW 2010a).

White-necked Petrel (*Pterodroma cervicalis*) – Very rare, with one seen off the Bundeena sea cliffs on 17 February 2010 (Schulz in prep. 2). Around this time a number of individuals were observed off the sea cliffs at Malabar and from boats further offshore (e.g. reports in NSW Birdline http://www.eremaea.com/BirdlineRecentSightings.aspx?Birdline:2).

Black-winged Petrel (*Pterodroma nigripennis*) – Very rare. The only documented record is of a beach washed specimen from Garie Beach in February 2009 (DECCW 2010a).

Common Diving-Petrel (*Pelecanoides urinatrix*) – Very rare. The only documented record is of a beach washed specimen from Marley Beach in September 1997 (DECCW 2010a).

Lesser Frigatebird (*Fregata ariel*) – Very rare. One individual was observed flying over Curra Moors in March 1983 (Hoskin *et al*. 1991); with no recent records (Anyon-Smith 2006).

Australasian Gannet (*Morus serrator*) – Abundant. Commonly occurs in large groups close inshore, including in the outer waters of Port Hacking. Although present throughout the year, the largest numbers occur between April and September (see above Section). Regularly beach washed.

Brown Booby (*Sula leucogaster*) - Very rare, with one recent record (Anyon-Smith 2006).

Brown Skua (*Stercorarius antarcticus*) – Uncommon. Regularly observed in small numbers between April and October off the sea cliffs (see above Section).

Pomarine Jaeger (*Stercorarius pomarinus*) – Common. Regularly observed between November and April off the sea cliffs (see above Section); also seen in the outer waters of Port Hacking.

Arctic Jaeger (*Stercorarius parasiticus*) – Common. Regularly observed between October and April off the sea cliffs (see above Section); also seen in the outer waters of Port Hacking.

Long-tailed Jaeger (*Stercorarius longicaudus*) – Rare. Infrequently observed between November and April off the sea cliffs (see above Section).

Sooty Tern (*Onychoprion fuscata*) – Rare. Infrequently observed in February and March off the sea cliffs (see above Section). During the current survey single juveniles or juveniles accompanied by an adult were observed flying over heathland inland of the sea cliff edge east of Bundeena, south west of the Water Run and south of Little Marley Beach between 3 and 5 February 2010. This species is occasionally beach washed in the late summer or early autumn months (M. Schulz pers. obs.).

Mammals

Dugong (*Dugong dugon*) – Very rare. Occasional sight records in Port Hacking, including two separate sightings off Jibbon Beach in September 1992 and April1993 (DECCW 2010a). One adult male was washed ashore on Constables Point in February 1959 (Robinson 1984).

Southern Right Whale (*Eubalaena australis*) – Uncommon. Occasional individuals observed off the sea cliffs, primarily in August (see above Section).

Dwarf Minke Whale (*Balaenoptera acutorostrata*) – Uncommon. Occasional individuals observed off the sea cliffs, primarily between May and December (see above Section).

Unidentified large baleen whales (*Balaenoptera* spp.) – One sighting of a large unidentified baleen whales that was not the Humpback Whale was made off the Bundeena sea cliffs in August (Schulz in prep. 1).

Humpback Whale (*Megaptera novaeangliae*) – Common. Regular observed off the sea cliffs between May and November (see above Section). A decomposed female was washed ashore south of Bulgo in September 1993 (DECCW 2010a).

Sperm Whale (*Physeter macrocephalus*) – Very rare. Waters between New Zealand and New South Wales were an important whaling ground for pelagic whalers hunting this species in the 1800s with most hunting occurring between December and March (Townsend 1935). Despite its occurrence in deepwater it is rarely observed close to shore within the 5km limit of NSW waters (Smith 2001), with no individuals observed off the sea cliffs over a three year period (Schulz in prep. 1). One individual was washed ashore at Stanwell Park Beach just south of the survey area in June 2003 (R. Haering, DECCW, pers. comm.).

Pygmy Sperm Whale (*Kogia breviceps*) – Very rare. A number of stranded individuals, including on Garie Beach in February 1975 and again on February 1984 (DECCW 2010a).

Dwarf Sperm Whale (*Kogia simus*) – Very rare. One stranding of a male on Garie Beach in December 1994 (DECCW 2010a).

Blainville's Beaked Whale (*Mesoplodon densirostris*) – Very rare. One individual washed ashore immediately adjacent to the area at Stanwell Park Beach in May 1980 (Robinson 1984) and another at Bundeena in Port Hacking immediately adjacent to the survey area in April 2007 (R. Haering, DECCW, pers. comm.).

Gray's Beaked Whale (*Mesoplodon grayi*) – Very rare. One sighting off Wattamolla in February 2005 (S. Anyon-Smith, DECCW 2010a).

Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) – Common. Regularly observed off the sea cliffs and the outer parts of Port Hacking throughout the year (see above Section). Occasionally beach washed.

Short-beaked Common Dolphin (*Delphinus delphis*) – Common. Regularly observed off the sea cliffs throughout the year (see above Section). Occasionally beach washed, such as on Garie Beach in January 2008 (R. Haering, DECCW, pers. comm.).

Risso's Dolphin (*Grampus griseus*) – Rare. Two individuals observed off the Bundeena sea cliffs in April 2009 (Schulz in prep. 1).

Striped Dolphin (*Stenella coeruleoalba*) – One decomposed individual stranded on Marley Beach in July 2010; identification confirmed by DNA testing conducted by the Australian Museum (S. Ingleby, AM, pers. comm.).

Pygmy Killer Whale (*Feresa attenuata*) – Rare. Approximately 32 individuals were observed off the Bundeena sea cliffs in May 2010 (Schulz in prep. 1).

False Killer Whale (*Pseudorca crassidens*) – Uncommon. Occasionally pods seen off the sea cliffs of Royal NP (Schulz, in prep. 1).

Killer Whale (*Orcinus orca*) – Rare. Occasionally pods seen off the sea cliffs of Royal NP, including one sighting of a single individual close inshore chasing fish (Schulz, in prep. 1). Also reported off Royal NP in the 1950s, particularly in the month of October when they were observed hunting large whales (Robinson 1984).

Long-finned Pilot Whale (*Globicephala melas*) – One sighting off Marley Head in March 2007 (DECCW 2010a). Surprisingly no Pilot Whales (*Globicephala* spp.) were recorded during sea watches conducted over a three year period (Schulz in prep. 1).

a) Short-tailed Shearwater wreck, Garie Beach; b) Blue Petrel beachwashed on Marley Beach. Photos © M. Schulz

APPENDIX 2: SUMMARY OF ROAD MORTALITY SURVEY BY SCHULZ AND MADDEN (IN PREP.)

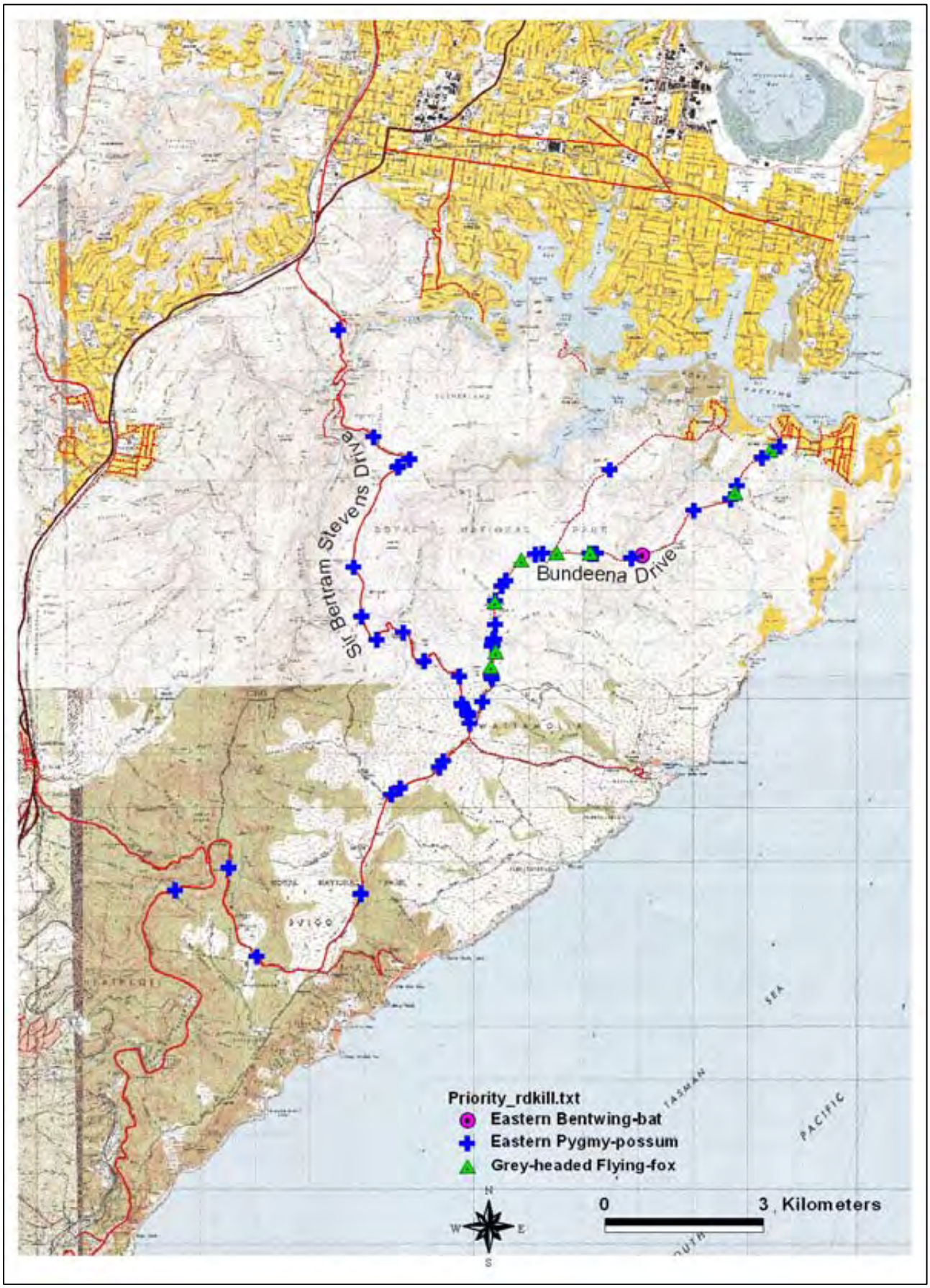
A study recording roadkill in Royal NP has been undertaken since May 2007 (Schulz and Madden in prep). This study is ongoing, however some results are presented here as they are of direct relevance to the management of Royal, Garawarra and Heathcote NPs.

This study involves the identification and reporting of all roadkill observed within Royal NP. Most days the authors drive roads within the reserve at the speed limit (between 50-80 km/hr) and the exact location of any roadkill is noted. Both authors are experienced with the identification of wildlife in the Sydney Basin. Where possible, all individuals are identified to the species level and removed from the road so as to avoid double counting. In some cases, specimens have been collected and taken to the Australian Museum for verification of the species identification. Also recorded is the route and total distance travelled for that trip, the visibility (day/night/rain/fog), and any features of particular interest regarding the specimen (e.g. age, sex, breeding condition). Trips where no roadkill is found are also recorded so as to be able to calculate kills/km travelled for each species. At the completion of this study an analysis will be undertaken of the relative frequency of roadkill and potential causal factors such as season, location, habitat and speed limit.

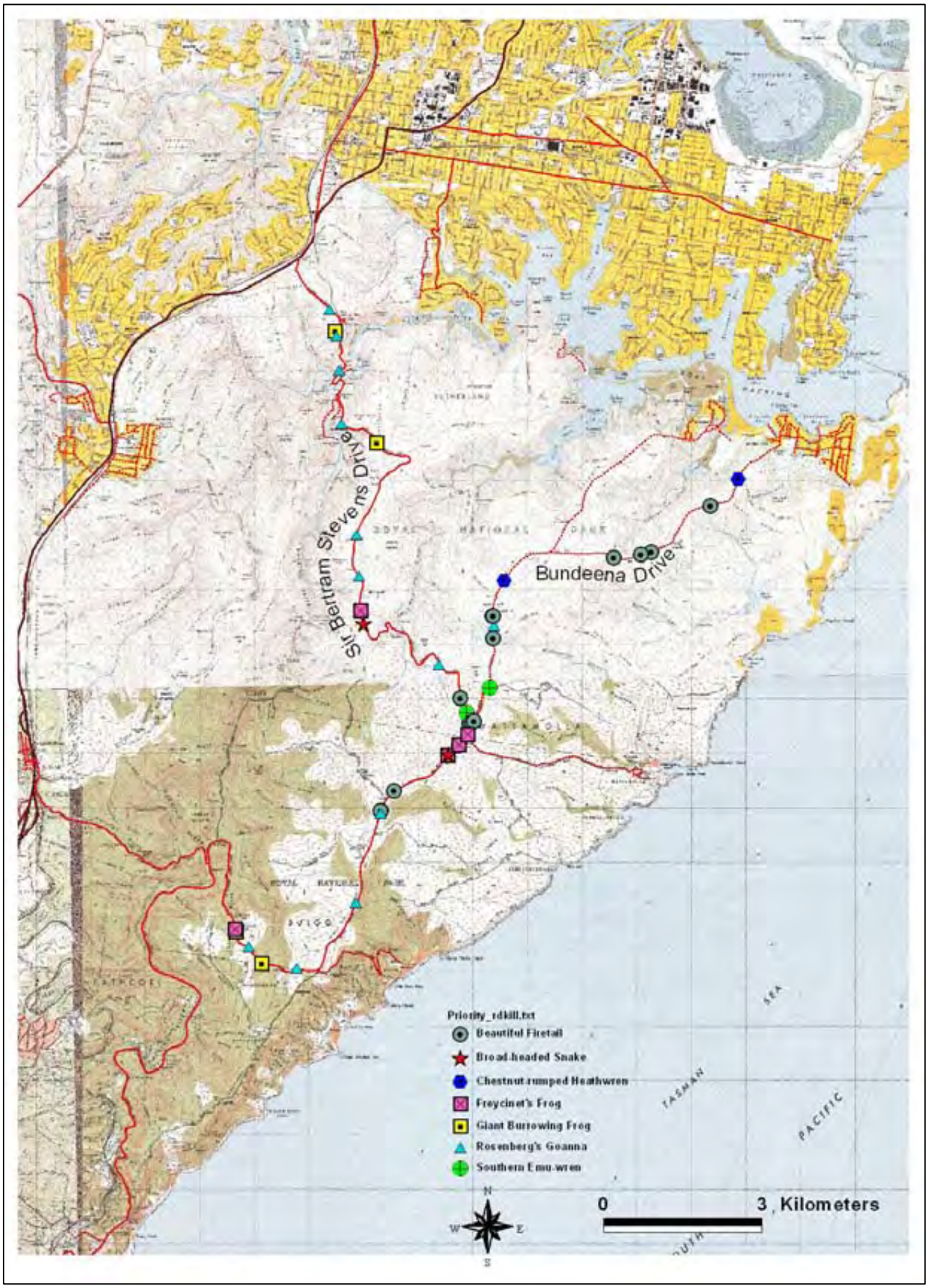
This study has so far recorded 90 species of native and introduced fauna as road fatalities. Thirteen of these are priority species (presented in Table 26, below).

Table 26: Priority species recorded as roadkill in Schulz and Madden (in prep) between May 2007 and March 2011.

Species	Number of individuals found dead on the road (Schulz & Madden in prep.)
Freycinet's Frog	6
Giant Burrowing Frog	5
Rosenberg's Goanna	14
Broad-headed Snake	2
Powerful Owl	1
Southern Emu-wren	6
Chestnut-rumped Heathwren	3
Beautiful Firetail	17
Eastern Pygmy-possum	65
Grey-headed Flying-fox	12
Eastern Horseshoe Bat	2
Eastern Bentwing-bat	1
New Holland Mouse	2



Map 7: **Road fatality locations of priority mammal species in Royal NP between May 2007 and May 2010 (from Schulz and Madden in prep.).**



Map 8: **Road fatality locations of priority amphibian, reptile and bird species in Royal NP between May 2007 and May 2010 (from Schulz and Madden in prep.).**

APPENDIX 3: USING HABITAT MODELS FOR PRIORITY SPECIES

Introduction

Predictive habitat models exist for many priority species in the survey area. These models were completed as part of the regional fauna assessment, Fauna of the Greater Southern Sydney Region (DECC 2007b, c). Predictive habitat models can help with many aspects of reserve and species management, particularly where the total amount and distribution of a species' habitat is useful information.

New data collected for this project allows a closer examination of regional habitat models at the local scale (i.e. the survey area). Each has been reviewed as to its quality at both a regional and local scale. This information has been presented in a table (Table 28) along with notes on the performance of the model in the survey area.

Review of Model Performance

For every available habitat model, high quality habitat was identified, and the number of hectares calculated for the survey area. The proportion of new records that fell within predicted high quality habitat was derived, and from this the performance of the model (within the survey area) was estimated (see Table 27). These new records are entirely independent from those used to derive the model and henceforth appropriate for validating the performance of the original model.

Table 27: Performance classification of regional habitat models

Performance classification	New records in modelled high quality habitat
Poor	<25%
Moderate	25-49%
Good	50-74%
Excellent	>75%

Records were taken as being 'within' modelled habitat if they fell wholly in the mapped area or within 50m of the boundary, as the regional models are not mapped to less than this level of accuracy. Where there were three or fewer new records, the models' performance was not classified. This was considered to be insufficient new information to be meaningful.

Forty priority species had regional habitat models that covered the survey area and have been assessed in Table 28, below. Each of these had been classified as either moderate, good or excellent quality for the Greater Southern Sydney Region. Some additional priority species for the survey area did not have a model, e.g. the Cat and the Large-footed Myotis. These species had 'poor quality' regional models and were not presented in the regional report and are not appropriate to be examined further here. Others, e.g. the Logrunner and Green Catbird, were not identified as conservation priorities at the regional scale and hence no model was developed.

Seventeen of the modelled priority species had no new records from the current survey. These have also been presented in Table 28 as this nil result is still useful information. For example, for the Brown Treecreeper and Hooded Robin, the model predicted no high quality habitat within the reserves. The lack of recent records supports this and reinforces that, despite historical records, the survey area only ever contained marginal habitat for these birds.

Twenty-three modelled species had between 1 and 92 new records with which to assess the performance of the models in the survey area. Nine models were found to have 'excellent' performance within the survey area, with 75 per cent or more of new records within the mapped high quality habitat. These included species such as the Beautiful Firetail, Powerful Owl and Southern Emu-wren. Seven models were considered to be 'good' with 50-75 per cent of new records falling within mapped high quality habitat, e.g. the Sooty Owl and Grey-headed Flying Fox. Only the Broad-headed Snake model was classed as 'moderate' and the Rockwarbler was 'poor'. It is important to note that for these last two species, the mapped habitat is not wrong, but appears to be an underestimation of the amount of high quality habitat within the survey area. In Table 28 we have suggested more appropriate cut-off points for the delineation of 'high quality habitat' for use in the survey area.

Table 28: Habitat models available for the survey area, including total amount of modelled high-quality habitat, number of new records and an assessment of the model quality (performance) for the survey area.

Species	Model scale	Hectares of high quality habitat in survey area	New locations	Records within high quality habitat	Model quality in survey area	Notes
Giant Burrowing Frog	Broad	6823	16	63%	Good	Model is a very good indication of breeding habitat, but is an underestimation of the total high quality habitat within the survey area.
Green and Golden Bell Frog	Broad	439	0	N/A	Unknown	Predicts habitat in low-lying areas mostly around Jibbon and Marley Lagoon. As this frog is suspected to have been lost from the reserves the model cannot be validated.
Red-crowned Toadlet	Broad	8514	28	82%	Excellent	High quality habitat is predicted very well. The five records that were not within modelled high quality habitat were not more than 100m outside it.
Stuttering Frog	Broad	556	0	N/A	Unknown	High quality habitat predicted in the wet forests of the Hacking River and other major waterways. As this frog is suspected to have been lost from the reserves the model cannot be validated.
Broad-headed Snake	Broad	1599	8	25%	Moderate	The model appears to be an underestimate of high quality habitat within the survey area. A more appropriate cut-off value for high quality habitat within the survey area is 71.
Rosenberg's Goanna	Fine	8569	14	79%	Excellent	Model is a very good indication of high quality habitat within the survey area.
Australasian Bittern	Broad	241	1	100%	Sample size too small to calculate	One new record for this bird was found in Jibbon Lagoon. This location has some of the small amount of predicted high quality habitat for the survey area.
Black Bittern	Broad	24	1	0%	Sample size too small to calculate	One new record for this bird was found in Cabbage Tree Creek, 300m from a patch of predicted high quality habitat.
Glossy Black-cockatoo	Fine	102	0	N/A	Unknown	Small amount of habitat predicted for the Hacking River Valley. May be used occasionally.

Species	Model scale	Hectares of high quality habitat in survey area	New locations	Records within high quality habitat	Model quality in survey area	Notes
Gang-gang Cockatoo	Fine	1443	0	N/A	Unknown	Habitat predicted in taller forests and woodlands. No recent records mean that the model cannot be validated at this point.
Swift Parrot	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area.
Ground Parrot	Broad	193	0	N/A	Unknown	Predicts swamps and heathlands. As this bird is currently considered locally extinct the model cannot be validated.
Powerful Owl	Broad	6478	4	100%	Excellent	Model is a very good indication of Powerful Owl habitat within the survey area.
Sooty Owl	Fine	236	4	50%	Good	Sooty Owl habitat is predicted very well within the survey area. Two records are within modelled habitat, one is within 170m of high quality habitat. The fourth record is from within Swamp Sclerophyll Forest, not a typical habitat for this owl. The model is fine scale with a high degree of accuracy.
Masked Owl	Broad	1820	4	75%	Excellent	Three out of four new records were within a relatively small amount of modelled high quality habitat for the Masked Owl. The model appears to perform well.
Brown Treecreeper	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Southern Emu-wren	Fine	3680	33	88%	Excellent	Most records were within high quality habitat and the model performs well within the survey area. Of the four records that were not within modelled habitat, 2 were within 150m, and 2 were within 400m.
Rockwarbler	Fine	154	32	16%	Poor	The model is an underestimate of the amount of good Rockwarbler habitat within the survey area. A cut-off point of 25 per cent from the raw model would be more appropriate for this region.

Species	Model scale	Hectares of high quality habitat in survey area	New locations	Records within high quality habitat	Model quality in survey area	Notes
Speckled Warbler	Fine	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Regent Honeyeater	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Tawny-crowned Honeyeater	Broad	10073	24	88%	Excellent	The model predicts a large amount of high quality habitat within the survey area and the new records support this.
Black-chinned Honeyeater	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Varied Sittella	Broad	4513	6	100%	Excellent	All records were within or very close to modelled high quality habitat and the model appears to perform well in the survey area.
Hooded Robin	Fine	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Diamond Firetail	Fine	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Beautiful Firetail	Fine	10347	36	100%	Excellent	All records were within modelled habitat. Survey area includes a large amount of high quality habitat and model appears to be a very good representation.
Spotted-tailed Quoll	Broad	6734	0	N/A	Unknown	High quality habitat is predicted along the Hacking River Valley and in higher productivity forests. As the Spotted-tailed Quoll is suspected to have been lost from the reserves the model cannot be validated.

Species	Model scale	Hectares of high quality habitat in survey area	New locations	Records within high quality habitat	Model quality in survey area	Notes
Koala	Fine	1421	1	0%	Sample size too small to calculate	High quality habitat is predicted along the Hacking River Valley and in higher productivity forests. There is only one new record, in the west of the survey area. The formerly resident population of Koalas is locally extinct in the Hacking River Valley, hence the model cannot be validated.
Eastern Pygmy-possum	Broad	11752	17	65%	Good	A large amount of high quality habitat is predicted for the survey area and most new records fall within this.
Yellow-bellied Glider	Fine	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Squirrel Glider	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Grey-headed Flying-fox	Fine	7182	27	63%	Good	Most records were within high quality habitat and those that weren't were generally within 100m of modelled habitat. The model performs well for the survey area.
East-coast Freetail-bat	Broad	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.
Eastern Bentwing-bat	Fine	8193	6	67%	Good	There is a large amount of habitat predicted for the survey area and most records fall within this.
Large-eared Pied Bat	Fine	1756	7	71%	Good	Most records fall within the high quality habitat modelled for this bat, and a further record is within 200m. The model performs very well for the survey area.
Eastern False Pipistrelle	Fine	0	0	N/A	No high quality habitat predicted	No high quality habitat is predicted for the survey area and the lack of new records supports this.

Species	Model scale	Hectares of high quality habitat in survey area	New locations	Records within high quality habitat	Model quality in survey area	Notes
Greater Broad-nosed Bat	Fine	56	3	0%	Sample size too small to calculate	There is a small amount of high quality habitat predicted for the survey area. None of the three new records fall within this, and it is likely to be an underestimation of the habitat available. Further records would clarify this.
Fox	Broad	12984	40	78%	Good	The model predicts most of the survey area as high quality habitat for the Fox and the new records support this
Rabbit	Broad	1946	2	100%	Sample size too small to calculate	There is a large amount of habitat for the Rabbit predicted in the survey area, though only two new records. It is not possible to say how well the model performs without further records, however it appears that it may over predict, particularly in the Hacking River Valley
Rusa Deer	Broad	17489	92	78%	Excellent	The majority of the survey area is classified as high quality Rusa Deer habitat and 72 new records were found within the mapped habitat. The model is thought to perform well for the survey area, though the records that exist outside the mapped area suggest the whole area is suitable habitat to some degree.

Application of the Models

Fauna models are appropriate for different applications depending on their **scale** and **quality**. Scale has been defined as either fine or broad.

Fine scale models (derived from fine scale variables mapped at 1:25,000 or less, e.g. those from vegetation mapping) are appropriate for site based and regional assessments plus a range of other applications. Broad scale models are derived from variables mapped at greater than 1:25,000, such as soil fertility or climatic variables. These are not suitable for site based assessment but may be used for regional-scale applications. Table 29 summarises the suitable applications for models based on their class and quality within the survey area.

Table 29: Criteria used to rank the quality of the models, along with suggested applications and an example (modified from DECC 2007 to apply to the survey area).

Class	Quality in survey area	Description	Suitable applications	Examples
Fine	Excellent	Model is excellent at outlining the broad distribution while also providing very good resolution at a fine scale	Assessment at >1:25000 scale: site-based and regional, accurate assessment of the species range and amount of habitat, differentiating habitat quality, estimating relative abundance	Rosenberg's Goanna
	Good	Model is good at outlining the broad distribution while also providing good resolution at a fine scale, with minor problems in certain areas	Assessment at >1:25000 scale: site-based and regional, assessment of species range and amount of habitat in parts, with reservations for some areas mentioned in text	Sooty Owl
	Moderate	Model is fair at outlining the broad distribution while also providing fair resolution at a fine scale, with minor problems across the distribution, or significant problems in certain areas	Assessment at >1:25000 scale: site-based and regional, rough assessment of species range and amount of habitat, with reservations for some areas mentioned in text	N/A
Broad	Excellent	Model is excellent at outlining the broad distribution but is not suitable for use at a fine scale	Assessment at > 1:100000 scale: regional assessment only - not site based, accurate assessment of species range, broad estimates of habitat quantity and quality and relative abundance	Red-crowned Toadlet
	Good	Model is good at outlining the broad distribution but is not suitable for use at a fine scale	Assessment at > 1:100000 scale: regional assessment only - not site based, broad assessment of species range, very broad estimates of habitat quantity and quality and relative abundance	Giant Burrowing Frog
	Moderate	Model is fair at outlining the broad distribution but is not suitable for use at a fine scale	Assessment at > 1:100000 scale: regional assessment only - not site based, rough assessment of species range	Broad-headed Snake

For the survey area, fine scale models that are of good or excellent quality include the Rosenberg's Goanna, Sooty Owl, Southern Emu-wren, Beautiful Firetail, Grey-headed Flying-fox and Eastern Bentwing-bat. These models have the maximum range of applications, from site-based assessments such as the construction of a new walkway or picnic area or identifying no-burn areas for fire management strategy. These models are also appropriate for application to broader scale assessments, such as calculating the total amount of habitat of a species within a reserve for a Plan of Management, or identifying priority species that may be impacted by a Fox baiting program.

Models that are of a broad scale, e.g. Giant Burrowing Frog, Masked Owl, Rusa Deer or Fox should not be used for site-based applications without on-ground habitat assessment, as the variables from which they were derived are not appropriate for use at this scale. These models may be used for applications at the reserve scale, such as in the development of a burn plan. Models may be used to calculate the total habitat within the reserve or for determining the amount of habitat of a species that will be lost in a fuel reduction burn. Another example of uses for broader-scale models is using them to assess the relative importance of a local park to the regional conservation of a species (e.g. how important is Royal NP for the Giant Burrowing Frog?).

APPENDIX 4: VERTEBRATE FAUNA RECORDED WITHIN HIGH CONSERVATION VALUE LANDS ADJOINING THE RESERVES

This appendix provides a list of vertebrate fauna (excluding fish and pelagic species) that currently or have previously been accurately recorded within the three areas outside of the reserves that are considered to have high conservation value (Table 30): Constables Point in Port Hacking; Garrawarra Hospital CR incorporating the crown reserve between the F6 Freeway and the old Princes Highway adjacent to the Garrawarra Aged Care Centre; and the Upper Hacking which refers to bushland in the Lilyvale-East Helensburgh area (refer to Map 1).

Records are compiled from the current survey, Atlas of NSW Wildlife (DECCW 2010a) and M. Schulz (pers. obs.). Additional records for the Constables Point area were provided by A. Carrick (pers. comm.) and for the Upper Hacking additional records were sourced from Andrew (1985a, b), NPWS (1985) and Whelan *et al.* (1991).

The list combines recent sightings with observations from over 25 years ago. Species that have been recorded in the past but are considered to no longer occur in the high conservation value lands and have been removed from the species inventories in this report are listed in grey text. Species that are vagrants are labelled. See Table 28 for definitions of terms used for such species.

The species order used in these tables follow: for birds Christidis and Boles (2008); for mammals Van Dyck and Strahan (2008); for reptiles Cogger (1996); for amphibians Cogger (1996). All recent taxonomic changes (as of June 2010) have been incorporated or in the case of very recent changes (or where species are commonly known under a different name) noted next to the previous scientific or common name. The exception to this is threatened species, where nomenclature follows that used in the NSW Scientific Committee determinations to list each species. Introduced species are denoted by a *.

Table 30: Vertebrate fauna recorded within high conservation value lands adjoining the reserves

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Amphibians						
Crinia signifera	Common Eastern Froglet	P			+	+
Limnodynastes dumerilii grayi	Eastern Banjo Frog	P				+
Limnodynastes peronii	Brown-striped Frog	P				+
Uperoleia laevigata	Smooth Toadlet	P			+	
Litoria dentata	Bleating Tree Frog	P				+
Litoria lesueuri	Lesueur's Frog	P				+
Litoria nudidigita	Leaf Green River Tree Frog	P				+
Litoria peronii	Peron's Tree Frog	P			+	+
Litoria phyllochroa	Leaf-green Tree Frog	P				+
Litoria verreauxii	Verreaux's Tree Frog	P				+
Reptiles						
Phyllurus platurus	Broad-tailed Gecko	P				+
Amphibolurus muricatus	Jacky Lashtail	P			+	+
Physignathus lesueurii lesueurii	Eastern Water Dragon	P			+	+
Varanus rosenbergi	Rosenberg's Goanna	V			+	
Acritoscincus platynota	Red-throated Skink	P			+	+
Cryptoblepharus virgatus (taxonomy revised to *C. pulcher)*	Cream-striped Shining-Skink (also known as Eastern Fence Skink)	P		+		
Ctenotus taeniolatus	Copper-tailed Skink	P			+	+
Egernia cunninghami	Cunningham's Skink	P				+
Eulamprus quoyii	Eastern Water-skink	P			+	+
Eulamprus tenuis	Barred-sided Skink	P				+
Lampropholis delicata	Dark-flecked Garden Sunskink	P		+	+	+

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Lampropholis guichenoti	Pale-flecked Garden Sunskink	P				+
Saiphos equalis	Three-toed Skink	P				+
Saproscincus mustelinus	Weasel Skink	P			+	+
Tiliqua scincoides	Eastern Blue-tongue	P		+		+
Morelia spilota	Diamond Python	P				+
Acanthophis antarcticus	Common Death Adder	P				+
Cacophis squamulosus	Golden-crowned Snake	P				+
Cryptophis nigrescens	Eastern Small-eyed Snake	P				+
Hemiaspis signata	Black-bellied Swamp Snake	P				+
Pseudechis porphyriacus	Red-bellied Black Snake	P			+	+
Vermicella annulata	Bandy-bandy	P				+
Birds						
Cygnus atratus	Black Swan	P		+		
Chenonetta jubata	Australian Wood Duck	P		+		+
Anas gracilis	Grey Teal	P		+		
Anas castanea	Chestnut Teal	P		+		
Anas superciliosa	Pacific Black Duck	P		+		+
Columba leucomela	White-headed Pigeon	P				+
Streptopelia chinensis	Spotted Dove*	U		+		
Macropygia amboinensis	Brown Cuckoo-Dove	P				+
Chalcophaps indica	Emerald Dove	P				+
Ocyphaps lophotes	Crested Pigeon	P		+		
Leucosarcia picata	Wonga Pigeon	P				+
Lopholaimus antarcticus	Topknot Pigeon	P				+
Podargus strigoides	Tawny Frogmouth	P			+	+
Aegotheles cristatus	Australian Owlet-nightjar	P			+	+
Hirundapus caudacutus	White-throated Needletail	P		+	+	+
Apus pacificus	Fork-tailed Swift	P		+		
Anhinga novaehollandiae	Australasian Darter	P		+		
Microcarbo melanoleucos	Little Pied Cormorant	P		+		
Phalacrocorax carbo	Great Cormorant	P		+		
Phalacrocorax sulcirostris	Little Black Cormorant	P		+		
Phalacrocorax varius	Pied Cormorant	P		+		
Pelecanus conspicillatus	Australian Pelican	P		+		
Ardea modesta	Eastern Great Egret	P		+		
Butorides striata	Striated Heron	P		+		
Egretta novaehollandiae	White-faced Heron	P		+		
Egretta garzetta	Little Egret	P		+		
Nycticorax caledonicus	Nankeen Night Heron	P		+		
Threskiornis molucca	Australian White Ibis	P		+		
Threskiornis spinicollis	Straw-necked Ibis	P				
Platalea regia	Royal Spoonbill	P		+		
Pandion haliaetus	Osprey (revised to Eastern Osprey)	V		+		
Elanus axillaris	Black-shouldered Kite	P		+		
Aviceda subcristata	Pacific Baza	P				+
Haliaeetus leucogaster	White-bellied Sea-Eagle	P		+		

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Haliastur sphenurus	Whistling Kite	P		+		
Accipiter fasciatus	Brown Goshawk	P		+	+	+
Accipiter cirrocephalus	Collared Sparrowhawk	P		+		
Accipiter novaehollandiae	Grey Goshawk	P				+
Circus approximans	Swamp Harrier	P		+		
Aquila audax	Wedge-tailed Eagle	P			+	
Hieraaetus morphnoides	Little Eagle	V			+	
Falco cenchroides	Nankeen Kestrel	P		+		
Falco longipennis	Australian Hobby	P		+		
Falco peregrinus	Peregrine Falcon	P		+		+
Porphyrio porphyrio	Purple Swamphen	P				
Esacus neglectus	Beach Stone-curlew	CE		+ Vagr		
Haematopus longirostris	Pied Oystercatcher	E		+		
Pluvialis fulva	Pacific Golden Plover	P		+		
Charadrius ruficapillus	Red-capped Plover	P		+		
Charadrius bicinctus	Double-banded Plover	P		+		
Vanellus miles	Masked Lapwing	P		+		
Limosa lapponica	Bar-tailed Godwit	P		+		
Numenius phaeopus	Whimbrel	P		+		
Numenius madagascariensis	Eastern Curlew	P		+		
Actitis hypoleucos	Common Sandpiper	P		+		
Tringa brevipes	Grey-tailed Tattler	P		+		
Turnix varius	Painted Buttonquail	P				+
Hydroprogne caspia	Caspian Tern	P		+		
Sterna hirundo	Common Tern	P		+		
Thalasseus bergii	Crested Tern	P		+		
Larus dominicanus	Kelp Gull	P		+		
Chroicocephalus novaehollandiae	Silver Gull	P		+		
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	P			+	+
Callocephalon fimbriatum	Gang-gang Cockatoo	V				+
Eolophus roseicapillus	Galah	P		+		+
Cacatua tenuirostris	Long-billed Corella	P		+		
Cacatua sanguinea	Little Corella	P		+		+
Cacatua galerita	Sulphur-crested Cockatoo	P		+	+	+
Trichoglossus haematodus	Rainbow Lorikeet	P		+	+	+
Alisterus scapularis	Australian King-Parrot	P			+	+
Platycercus elegans	Crimson Rosella	P		+	+	+
Platycercus eximius	Eastern Rosella	P		+		
Centropus phasianinus	Pheasant Coucal	P				
Eudynamys orientalis	Eastern Koel	P		+		+
Scythrops novaehollandiae	Channel-billed Cuckoo	P				+
Chalcites basalis	Horsfield's Bronze-Cuckoo	P		+		
Chalcites lucidus	Shining Bronze-Cuckoo	P			+	+
Cacomantis flabelliformis	Fantailed Cuckoo	P		+	+	+
Cacomantis variolosus	Brush Cuckoo	P				+
Ninox strenua	Powerful Owl	V				+

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Ninox novaeseelandiae	Southern Boobook	P			+	+
Tyto tenebricosa	Sooty Owl	V				+
Tyto javanica	Eastern Barn Owl	P				+
Dacelo novaeguineae	Laughing Kookaburra	P		+	+	+
Todiramphus sanctus	Sacred Kingfisher	P		+		+
Eurystomus orientalis	Dollarbird	P		+		
Menura novaehollandiae	Superb Lyrebird	P				+
Cormobates leucophaea	White-throated Treecreeper	P				+
Ailuroedus crassirostris	Green Catbird	P				+
Ptilonorhynchus violaceus	Satin Bowerbird	P				+
Malurus cyaneus	Superb Fairy-wren	P		+	+	+
Malurus lamberti	Variegated Fairy-wren	P			+	+
Pycnoptilus floccosus	Pilotbird	P				+
Origma solitaria	Rockwarbler	P				+
Sericornis citreogularis	Yellow-throated Scrubwren	P				+
Sericornis frontalis	White-browed Scrubwren	P		+	+	+
Sericornis magnirostra	Large-billed Scrubwren	P				+
Hylacola pyrrhopygia	Chestnut-rumped Heathwren	P			+	
Gerygone mouki	Brown Gerygone	P				+
Acanthiza lineata	Striated Thornbill	P			+	+
Acanthiza pusilla	Brown Thornbill	P		+	+	+
Pardalotus punctatus	Spotted Pardalote	P		+	+	+
Pardalotus striatus	Striated Pardalote	P				+
Acanthorhynchus tenuirostris	Eastern Spinebill	P			+	+
Meliphaga lewinii	Lewin's Honeyeater	P		+		+
Lichenostomus chrysops	Yellow-faced Honeyeater	P		+	+	+
Manorina melanocephala	Noisy Miner	P		+		+
Anthochaera chrysoptera	Little Wattlebird	P		+	+	+
Anthochaera carunculata	Red Wattlebird	P		+	+	+
Myzomela sanguinolenta	Scarlet Honeyeater	P				+
Phylidonyris novaehollandiae	New Holland Honeyeater	P		+	+	+
Melithreptus lunatus	White-naped Honeyeater	P				+
Philemon corniculatus	Noisy Friarbird	P				+
Orthonyx temminckii	Australian Logrunner	P				+
Cinclosoma punctatum	Spotted Quail-thrush	P				+
Psophodes olivaceus	Eastern Whipbird	P		+	+	+
Daphoenositta chrysoptera	Varied Sittella	V				+
Coracina novaehollandiae	Black-faced Cuckoo-shrike	P		+		+
Coracina papuensis	White-bellied Cuckoo-shrike	P				+
Coracina tenuirostris	Cicadabird	P				+
Falcunculus frontatus	Crested Shrike-tit	P				+
Pachycephala pectoralis	Golden Whistler	P				+
Pachycephala rufiventris	Rufous Whistler	P			+	+
Colluricincla harmonica	Grey Shrike-thrush	P			+	+
Oriolus sagittatus	Olive-backed Oriole	P		+		+
Cracticus torquatus	Grey Butcherbird	P		+	+	+

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Cracticus tibicen	Australian Magpie	P		+	+	+
Strepera graculina	Pied Currawong	P		+	+	+
Rhipidura rufifrons	Rufous Fantail	P				+
Rhipidura albiscapa	Grey Fantail	P		+	+	+
Rhipidura leucophrys	Willie Wagtail	P		+		+
Corvus coronoides	Australian Raven	P		+	+	+
Myiagra rubecula	Leaden Flycatcher	P				+
Monarcha melanopsis	Black-faced Monarch	P				+
Grallina cyanoleuca	Magpie-lark	P		+		+
Petroica rosea	Rose Robin	P				+
Eopsaltria australis	Eastern Yellow Robin	P			+	+
Zosterops lateralis	Silvereye	P		+	+	+
Hirundo neoxena	Welcome Swallow	P		+	+	+
Petrochelidon nigricans	Tree Martin	P		+		
Pycnonotus jocosus	Red-whiskered Bulbul*	U		+		+
Zoothera lunulata	Bassian Thrush	P				+
Sturnus vulgaris	Common Starling*	U		+		+
Sturnus tristis	Common Myna*	U		+		+
Dicaeum hirundinaceum	Mistletoebird	P			+	+
Neochmia temporalis	Red-browed Finch	P			+	+
Passer domesticus	House Sparrow*	U		+		+
Anthus novaeseelandiae	Australian Pipit	P		+		
Mammals						
Tachyglossus aculeatus	Short-beaked Echidna	P			+	+
Antechinus stuartii	Brown Antechinus	P				+
Antechinus swainsonii	*Dusky Antechinus*	*P*				+ *Suspected Species Loss*
Sminthopsis murina	*Common Dunnart*	*P*		+		
Perameles nasuta	*Long-nosed Bandicoot*	*P*			+	+
Phascolarctos cinereus	*Koala*	*V*			+	+
Vombatus ursinus	*Common Wombat*	*P*				+
Petaurus breviceps	*Sugar Glider*	*P*			+	+
Petauroides volans	*Greater Glider*	*P*			+	+ *Suspected Species Loss*
Pseudocheirus peregrinus	Common Ringtail Possum	P			+	+
Trichosurus cunninghami	Mountain Brushtail Possum	P				+
Trichosurus vulpecula	Common Brushtail Possum	P		+		+
Wallabia bicolor	Swamp Wallaby	P		+	+	+
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	+	+	+
Rhinolophus megaphyllus	Eastern Horseshoe Bat	P				+
Mormopterus "Species 2"		P				+
Tadarida australis	White-striped Freetail-bat	P		+		+
Miniopterus australis	Little Bentwing-bat	V				+
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V				+
Nyctophilus gouldi	Gould's Long-eared Bat	P				+

Scientific name	Common name	NSW legal status	Federal legal status	Constables Point	Garrawarra Hospital CR	Upper Hacking
Chalinolobus gouldii	Gould's Wattled Bat	P		+	+	+
Chalinolobus morio	Chocolate Wattled Bat	P				+
*Myotis macropus (*formerly *M. adversus)*	Large-footed Myotis (also known as the Southern Myotis)	V				+
Scotorepens orion	Eastern Broad-nosed Bat	P				+
Vespadelus darlingtoni	Large Forest Bat	P				+
Vespadelus vulturnus	Little Forest Bat	P		+	+	+
Pseudomys novaehollandiae	New Holland Mouse	P	V	+ (but spatially inaccurate record and does not actually occur)		
Rattus fuscipes	Bush Rat	P			+	+
Rattus lutreolus	Swamp Rat	P				+
Mus musculus	House Mouse*	U		+	+	+
Rattus rattus	Black Rat*	U		+		+
Rattus norvegicus	Brown Rat*	U				+
Canis lupus familiaris	Feral Dog*	U				+
Vulpes vulpes	Fox*	U		+	+	+
Felis catus	Feral Cat*	U				+
Oryctolagus cuniculus	Rabbit*	U				+
Sus scrofa	Feral Pig*	U				+
Cervus timorensis	Rusa Deer*	U		+		+

APPENDIX 5: VERTEBRATE FAUNA ACCURATELY RECORDED IN THE SURVEY AREA

Introduction

This appendix provides a list of vertebrate fauna (excluding fish and pelagic species) that currently or have previously been accurately recorded in Royal NP, Heathcote NP and/or Garawarra SCA and/or adjoining high conservation value lands assessed in this study. The list is based on records from current surveys and the Atlas of NSW Wildlife, with additional records from Anyon-Smith (2006) and personal communications with park staff, experienced scientists and naturalists. Species that are only represented by records with high spatial inaccuracy, by unconfirmed sightings, probable misidentifications or database errors, as well as introduced and non-local species that do not have established wild populations within the survey area have been removed from this list (see Table 11 for a list of these species). Users should be aware that such inaccurate species records are still present in several wildlife databases, most notably the Atlas of NSW Wildlife and the Birds Australia databases.

The list provided in Table 32 presents all fauna confidently and accurately recorded within the reserves, whether historically or in the present. Many of these species no longer occur in the reserves and hence have not been included in the current species inventories tallied in this report. Other species have suffered declines within or outside of the survey area (or both) while others visit on extremely rare occasions or are vagrants. Yet others are characterised by little information and as a consequence there is uncertainty whether the species is a resident, a seasonal visitor, a vagrant, or has been lost from the survey area. The list has therefore been annotated to summarise the current status of all fauna species within the reserves. The terms used in the list are defined in Table 31.

The species order used in these tables follow: for birds Christidis and Boles (2008); for mammals Van Dyck and Strahan (2008); for reptiles Cogger (1996); for amphibians Cogger (1996). All recent taxonomic changes (as of June 2010) have been incorporated or in the case of very recent changes (or where species are commonly known under a different name) noted next to the previous scientific or common name. The exception to this is threatened species, where nomenclature follows that used in the NSW Scientific Committee determinations to list each species, except for *Mormopterus norfolkensis* which herein is referred to as East-coast Freetail-bat to avoid confusion with the common name of *Mormopterus* "Species 2".

Table Definitions

Table 31: Terms used in species inventory lists

Column heading	Definition of terms used
NSW legal status	Current listing under the *TSC Act* (as of June 2010). 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 2010). E=Endangered, V=Vulnerable
Current status in survey area	Summary of the way that the species currently uses, or doesn't use, the survey area. Vagr= Vagrant= Species for which there are fewer than 5 reliable records and which are outside their currently accepted normal distribution. ERV= Extremely Rare Visitor= Species for which there are fewer than 5 reliable records and/or have not been confidently recorded within the last 25 years but which are within their currently accepted normal distribution. LE= Locally Extinct= Species that once sustained local populations in the survey area that have been impacted within the area to such an extent that breeding and/or primary habitat use no longer occurs and have not been confirmed within the survey area for over 50 years. These species have been excluded from the current species tallies in this report and are presented in grey text. See Table 12 and species profiles for notes on these species. SSL= Suspected Species Loss= Species that once sustained local populations in the survey area that have been impacted within the area to such an extent that breeding and/or primary habitat use no longer occurs but have been recorded within the last 50 years though they are considered to no longer have established *resident* populations today. These species have been excluded from the current species tallies in this report and are presented in grey text. See Table 12 and species profiles for notes on these species.

Column heading	Definition of terms used
	PSL= Peripheral Species Loss= Species which probably only ever used the survey area as peripheral or marginal habitat and due to changes in habitat within the survey area coupled with loss of higher quality habitat elsewhere are today unlikely to use the survey area any more, except perhaps during extremely unusual circumstances. These species have been excluded from the current species tallies in this report and are presented in grey text. See Table 13 and species profiles for notes on these species. PSD= Peripheral Species Decline= Species which probably only ever used the survey area as peripheral or marginal habitat and due to changes in habitat within the survey area coupled with loss of or changes to higher quality habitat elsewhere today use the survey area to a smaller extent, occurring irregularly or in low numbers. DV= Declining Visitor= Wide ranging and/or nomadic species, which are likely to have once made use of the habitats present in the survey area to varying extents, but have suffered severe impacts across their known range and hence are no longer recorded or are recorded far less frequently. Suitable habitat remains for these species. SU= Status Uncertain= Species for which the current status cannot be clearly defined, including species with less than five records that are likely to have been under recorded due to their cryptic behaviour or preference for rarely surveyed specialised habitats. No annotation= Species which have been recorded on several occasions, often by more than one observer.
Current survey records	Species recorded in the current survey are denoted by '+'
Other DECCW systematic survey records	Species recorded during previous systematic DECCW surveys as outlined in Section 2.1.1 are denoted by '+'
Other records	The source of these records are as follows: 1 = Atlas of NSW Wildlife; if no records in Atlas then: 2 = Anyon-Smith (2006); 3 = Robinson (1987, 1988); 4 = Andrew (2001) and D. Andrew, DECCW, pers. comm.; 5 = B. Sullivan, DECCW, pers. comm.; 6 = Cayley (1923); 7 = T. Keene on Birdline NSW July 2010; 8 = M. Schulz personal observations. Where an Atlas record is considered unconfirmed an additional confirmed record source is provided.

Table 32: Vertebrate fauna accurately recorded in the survey area

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Amphibians							
Crinia signifera	Common Eastern Froglet	P			+	+	1
Heleioporus australiacus	Giant Burrowing Frog	V			+	+	1
Limnodynastes dumerilii grayi	Eastern Banjo Frog	P			+	+	1
Limnodynastes peronii	Brown-striped Frog	P			+	+	1
Mixophyes balbus	Stuttering Frog	V	E	SSL			1
Paracrinia haswelli	Haswell's Froglet	P			+		1
Pseudophryne australis	Red-crowned Toadlet	V			+	+	1
Pseudophryne bibronii	Bibron's Toadlet	P				+	1
Uperoleia laevigata	Smooth Toadlet	P			+	+	1
Litoria aurea	Green and Golden Bell Frog	E	V	SSL			1
Litoria caerulea	Green Tree Frog	P		SU			1
Litoria citropa	Blue Mountains Tree Frog	P			+	+	1
Litoria dentata	Bleating Tree Frog	P			+	+	1
Litoria fallax	Eastern Dwarf Tree Frog	P			+	+	1
Litoria freycineti	Freycinet's Frog	P			+	+	1
Litoria jervisiensis	Jervis Bay Tree Frog	P				+	1
Litoria latopalmata	Broad-palmed Frog	P					1
Litoria lesueuri	Lesueur's Frog	P			+	+	1
Litoria nudidigita	Leaf Green River Tree Frog	P			+		-
Litoria peronii	Peron's Tree Frog	P			+	+	1
Litoria phyllochroa	Leaf-green Tree Frog	P			+	+	1
Litoria verreauxii	Verreaux's Tree Frog	P					1
Litoria wilcoxii	Wilcox's Frog	P			+		-
Reptiles							
Chelodina longicollis	Eastern Snake-necked Turtle	P			+		1
Emydura sp.	Unidentified Emydura	P		SU	+		1
Diplodactylus vittatus	Eastern Stone Gecko	P			+	+	1
Oedura lesueurii	Lesueur's Velvet Gecko	P			+	+	1
Phyllurus platurus	Broad-tailed Gecko	P			+	+	1
Underwoodisaurus milii	Thick-tailed Gecko	P			+	+	1
Lialis burtonis	Burton's Snake-lizard	P			+		1
Pygopus lepidopodus	Common Scaly-foot	P			+	+	1
Amphibolurus muricatus	Jacky Lashtail	P			+	+	1
Physignathus lesueurii lesueurii	Eastern Water Dragon	P			+	+	1
Pogona barbata	Eastern Bearded Dragon	P		SU	+		1
Rankinia diemensis	Mountain Dragon	P			+	+	1
Varanus rosenbergi	Rosenberg's Goanna	V			+	+	1
Varanus varius	Lace Monitor	P			+	+	1
Acritoscincus platynota	Red-throated Skink	P			+	+	1
Cryptoblepharus virgatus (taxonomy revised to C. pulcher)	Cream-striped Shining-Skink (also known as Eastern Fence Skink)	P			+	+	1
Ctenotus taeniolatus	Copper-tailed Skink	P			+	+	1

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Cyclodomorphus michaeli	Mainland She-oak Skink	P			+		-
Egernia cunninghami	Cunningham's Skink	P			+	+	1
Egernia whitii (taxonomy revised to Liopholis whitii)	White's Rock-skink	P			+	+	1
Eulamprus quoyii	Eastern Water-skink	P			+	+	1
Eulamprus tenuis	Barred-sided Skink	P			+	+	1
Lampropholis delicata	Dark-flecked Garden Sunskink	P			+	+	1
Lampropholis guichenoti	Pale-flecked Garden Sunskink	P			+	+	1
Saiphos equalis	Three-toed Skink	P			+	+	1
Saproscincus mustelinus	Weasel Skink	P			+	+	1
Tiliqua scincoides	Eastern Blue-tongue	P			+	+	1
Ramphotyphlops nigrescens	Blackish Blind Snake	P			+	+	1
Morelia spilota	Diamond Python	P			+	+	1
Boiga irregularis	Brown Tree Snake	P			+		1
Dendrelaphis punctulatus	Common Tree Snake	P			+	+	1
Acanthophis antarcticus	Common Death Adder	P			+	+	1
Cacophis squamulosus	Golden-crowned Snake	P			+	+	1
Cryptophis nigrescens	Eastern Small-eyed Snake	P			+	+	1
Demansia psammophis	Yellow-faced Whip Snake	P			+	+	1
Furina diadema	Red-naped Snake	P			+	+	1
Hemiaspis signata	Black-bellied Swamp Snake	P			+	+	1
Hoplocephalus bungaroides	Broad-headed Snake	E	V		+	+	1
Notechis scutatus	Tiger Snake	P			+		1
Pseudechis porphyriacus	Red-bellied Black Snake	P			+	+	1
Pseudonaja textilis	Eastern Brown Snake	P			+	+	1
Vermicella annulata	Bandy-bandy	P			+		1
Birds							
Alectura lathami	Australian Brush-turkey	P		ERV			2
Coturnix pectoralis	Stubble Quail	P		ERV			1
Coturnix ypsilophora	Brown Quail	p			+	+	1
Dendrocygna eytoni	Plumed Whistling-Duck	P		Vagr			2
Biziura lobata	Musk Duck	P					2
Stictonetta naevosa	Freckled Duck	V		Vagr			2
Cygnus atratus	Black Swan	P			+		1
Tadorna tadornoides	Australian Shelduck	P		Vagr			2
Chenonetta jubata	Australian Wood Duck	P			+	+	1
Anas gracilis	Grey Teal	P			+	+	1
Anas castanea	Chestnut Teal	P			+	+	1
Anas platyrhynchos	Northern Mallard*	U			+		1
Anas superciliosa	Pacific Black Duck	P			+	+	1
Aythya australis	Hardhead	P		ERV			2
Tachybaptus novaehollandiae	Australasian Grebe	P			+	+	1
Poliocephalus poliocephalus	Hoary-headed Grebe	P		ERV			2

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Podiceps cristatus	Great Crested Grebe	P		ERV			2
Columba livia	Rock Dove*	U					1
Columba leucomela	White-headed Pigeon	P				+	1
Streptopelia chinensis	Spotted Dove*	U			+	+	1
Macropygia amboinensis	Brown Cuckoo-Dove	P			+	+	1
Chalcophaps indica	Emerald Dove	P		SU	+	+	2
Phaps chalcoptera	Common Bronzewing	P			+		1
Phaps elegans	Brush Bronzewing	P			+	+	1
Ocyphaps lophotes	Crested Pigeon	P			+	+	1
Geopelia striata	Peaceful Dove	P		PSL			2
Geopelia humeralis	Bar-shouldered Dove	P			+		1
Leucosarcia picata	Wonga Pigeon	P			+	+	1
Ptilinopus superbus	Superb Fruit-Dove	V		ERV, DV			2
Ptilinopus regina	Rose-crowned Fruit-Dove	V		ERV, DV			1
Lopholaimus antarcticus	Topknot Pigeon	P			+	+	1
Podargus strigoides	Tawny Frogmouth	P			+	+	1
Eurostopodus mystacalis	White-throated Nightjar	P			+	+	1
Aegotheles cristatus	Australian Owlet-nightjar	P			+	+	1
Hirundapus caudacutus	White-throated Needletail	P			+	+	1
Apus pacificus	Fork-tailed Swift	P			+	+	1
Eudyptula minor	Little Penguin	P			+		1
Anhinga novaehollandiae	Australasian Darter	P			+		1
Microcarbo melanoleucos	Little Pied Cormorant	P			+	+	1
Phalacrocorax carbo	Great Cormorant	P			+	+	1
Phalacrocorax sulcirostris	Little Black Cormorant	P			+	+	1
Phalacrocorax varius	Pied Cormorant	P			+	+	1
Pelecanus conspicillatus	Australian Pelican	P			+	+	1
Botaurus poiciloptilus	Australasian Bittern	V		SU	+		-
Ixobrychus dubius	Australian Little Bittern	P		ERV			1
Ixobrychus flavicollis	Black Bittern	V		SU	+		1
Ardea pacifica	White-necked Heron	P			+		2
Ardea modesta	Eastern Great Egret	P			+	+	1
Ardea intermedia	Intermediate Egret	P					2
Ardea ibis	Cattle Egret	P					1
Butorides striata	Striated Heron	P			+	+	1
Egretta novaehollandiae	White-faced Heron	P			+	+	1
Egretta garzetta	Little Egret	P			+		1
Egretta sacra	Eastern Reef Egret	P			+	+	1
Nycticorax caledonicus	Nankeen Night Heron	P		SU	+	+	1
Threskiornis molucca	Australian White Ibis	P			+	+	1
Threskiornis spinicollis	Straw-necked Ibis	P				+	1
Platalea regia	Royal Spoonbill	P			+	+	1
Platalea flavipes	Yellow-billed Spoonbill	P		ERV			2
Pandion haliaetus (taxonomy revised to P. cristatis)	Osprey (revised to Eastern Osprey)	V			+	+	1
Elanus axillaris	Black-shouldered Kite	P			+	+	1
Lophoictinia isura	Square-tailed Kite	V					2

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Aviceda subcristata	Pacific Baza	P			+	+	1
Haliaeetus leucogaster	White-bellied Sea-Eagle	P			+	+	1
Haliastur sphenurus	Whistling Kite	P			+	+	1
Milvus migrans	Black Kite	P		Vagr			1
Accipiter fasciatus	Brown Goshawk	P			+	+	1
Accipiter cirrocephalus	Collared Sparrowhawk	P			+	+	1
Accipiter novaehollandiae	Grey Goshawk	P			+	+	1
Circus assimilis	Spotted Harrier	V					1
Circus approximans	Swamp Harrier	P			+	+	1
Aquila audax	Wedge-tailed Eagle	P			+		1
Hieraaetus morphnoides	Little Eagle	V			+		1
Falco cenchroides	Nankeen Kestrel	P			+	+	1
Falco berigora	Brown Falcon	P			+		1
Falco longipennis	Australian Hobby	P			+	+	1
Falco subniger	Black Falcon	P		Vagr			2
Falco peregrinus	Peregrine Falcon	P			+	+	1
Porphyrio porphyrio	Purple Swamphen	P			+	+	1
Lewinia pectoralis	Lewin's Rail	P		SU	+		1
Gallirallus philippensis	Buff-banded Rail	P			+		1
Porzana pusilla	Baillon's Crake	P		ERV			2
Porzana fluminea	Australian Spotted Crake	P		ERV			2
Porzana tabuensis	Spotless Crake	P		SU	+		2
Gallinula tenebrosa	Dusky Moorhen	P			+		1
Fulica atra	Eurasian Coot	P			+		1
Burhinus grallarius	Bush Stone-curlew	E		LE			2
Esacus neglectus	Beach Stone-curlew	CE		Vagr			1
Haematopus longirostris	Pied Oystercatcher	E				+	1
Haematopus fuliginosus	Sooty Oystercatcher	V			+	+	1
Himantopus himantopus	Black-winged Stilt	P		ERV			2
Pluvialis fulva	Pacific Golden Plover	P		ERV, DV			2
Charadrius ruficapillus	Red-capped Plover	P		DV			1
Charadrius bicinctus	Double-banded Plover	P				+	1
Elseyornis melanops	Black-fronted Dotterel	P			+	+	1
Vanellus miles	Masked Lapwing	P			+	+	1
Gallinago hardwickii	Latham's Snipe	P		SU	+		2
Limosa lapponica	Bar-tailed Godwit	P			+	+	1
Numenius phaeopus	Whimbrel	P			+		1
Numenius madagascariensis	Eastern Curlew	P			+	+	1
Actitis hypoleucos	Common Sandpiper	P		ERV			2
Tringa brevipes	Grey-tailed Tattler	P		ERV, DV			2
Tringa incana	Wandering Tattler	P		ERV			8
Arenaria interpres	Ruddy Turnstone	P		ERV		+	-
Calidris acuminata	Sharp-tailed Sandpiper	P		ERV, DV			2
Turnix varius	Painted Button-quail	P			+	+	1
Sternula albifrons	Little Tern	E			+		2
Hydroprogne caspia	Caspian Tern	P					1
Sterna striata	White-fronted Tern	P			+		1

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Sterna hirundo	Common Tern	P					2
Thalasseus bergii	Crested Tern	P			+	+	1
Larus pacificus	Pacific Gull	P		ERV, DV			1
Larus dominicanus	Kelp Gull	P			+	+	1
Chroicocephalus novaehollandiae	Silver Gull	P			+	+	1
Calyptorhynchus lathami	Glossy Black-Cockatoo	V					1
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	P			+	+	1
Callocephalon fimbriatum	Gang-gang Cockatoo	V					1
Eolophus roseicapillus	Galah	P			+	+	1
Cacatua tenuirostris	Long-billed Corella	P			+		1
Cacatua sanguinea	Little Corella	P			+	+	1
Cacatua galerita	Sulphur-crested Cockatoo	P			+	+	1
Trichoglossus haematodus	Rainbow Lorikeet	P			+	+	1
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet	P			+		1
Glossopsitta concinna	Musk Lorikeet	P			+	+	1
Glossopsitta pusilla	Little Lorikeet	V			+	+	1
Alisterus scapularis	Australian King-Parrot	P			+	+	1
Platycercus elegans	Crimson Rosella	P			+	+	1
Platycercus eximius	Eastern Rosella	P			+	+	1
Lathamus discolor	Swift Parrot	E	E				1,2
Psephotus haematonotus	Red-rumped Parrot	P					2
Pezoporus wallicus wallicus (taxonomy revised to Pezoporus wallicus)	Eastern Ground Parrot (revised to Ground Parrot)	V		LE			1,2
Centropus phasianinus	Pheasant Coucal	P			+		1
Eudynamys orientalis	Eastern Koel	P			+	+	1
Scythrops novaehollandiae	Channel-billed Cuckoo	P			+	+	1
Chalcites basalis	Horsfield's Bronze-Cuckoo	P			+	+	1
Chalcites osculans	Black-eared Cuckoo	P		Vagr			2
Chalcites lucidus	Shining Bronze-Cuckoo	P			+	+	1
Cacomantis pallidus	Pallid Cuckoo	P		PSD			1
Cacomantis flabelliformis	Fan-tailed Cuckoo	P			+	+	1
Cacomantis variolosus	Brush Cuckoo	P			+	+	1
Cuculus optatus	Oriental Cuckoo	P		ERV			2
Ninox strenua	Powerful Owl	V			+	+	1
Ninox connivens	Barking Owl	V		PSD			1,2
Ninox novaeseelandiae	Southern Boobook	P			+	+	1
Tyto tenebricosa	Sooty Owl	V			+	+	1
Tyto novaehollandiae	Masked Owl	V			+		1
Tyto javanica	Eastern Barn Owl	P			+		1
Tyto capensis (taxonomy revised to T. longimembris)	Grass Owl (revised to Eastern Grass Owl)	V		SU	+		-
Ceyx azureus	Azure Kingfisher	P			+	+	1
Dacelo novaeguineae	Laughing Kookaburra	P			+	+	1

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Todiramphus macleayii	Forest Kingfisher	P					2
Todiramphus sanctus	Sacred Kingfisher	P			+	+	1
Eurystomus orientalis	Dollarbird	P			+	+	1
Pitta versicolor	Noisy Pitta	P		SU	+	+	1
Menura novaehollandiae	Superb Lyrebird	P			+	+	1
Cormobates leucophaea	White-throated Treecreeper	P			+	+	1
Climacteris erythrops	Red-browed Treecreeper	P			+		1
Ailuroedus crassirostris	Green Catbird	P			+	+	1
Sericulus chrysocephalus	Regent Bowerbird	P		LE			1,2
Ptilonorhynchus violaceus	Satin Bowerbird	P			+	+	1
Malurus cyaneus	Superb Fairy-wren	P			+	+	1
Malurus lamberti	Variegated Fairy-wren	P			+	+	1
Stipiturus malachurus	Southern Emu-wren	P			+	+	1
Dasyornis brachypterus	Eastern Bristlebird	E	E	LE			
Pycnoptilus floccosus	Pilotbird	P			+	+	1
Origma solitaria	Rockwarbler	P			+	+	1
Sericornis citreogularis	Yellow-throated Scrubwren	P			+	+	1
Sericornis frontalis	White-browed Scrubwren	P			+	+	1
Sericornis magnirostra	Large-billed Scrubwren	P			+	+	1
Hylacola pyrrhopygia	Chestnut-rumped Heathwren	P			+	+	1
Pyrrholaemus saggitatus	Speckled Warbler	V		PSL			1,2
Gerygone mouki	Brown Gerygone	P			+	+	1
Gerygone levigaster	Mangrove Gerygone	P		SU			2
Gerygone albogularis	White-throated Gerygone	P		ERV, PSD			2
Acanthiza lineata	Striated Thornbill	P			+	+	1
Acanthiza nana	Yellow Thornbill	P			+	+	1
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	P		PSD			1,2
Acanthiza reguloides	Buff-rumped Thornbill	P			+		2
Acanthiza pusilla	Brown Thornbill	P			+	+	1
Pardalotus punctatus	Spotted Pardalote	P			+	+	1
Pardalotus striatus	Striated Pardalote	P				+	1
Acanthorhynchus tenuirostris	Eastern Spinebill	P			+	+	1
Meliphaga lewinii	Lewin's Honeyeater	P			+	+	1
Lichenostomus chrysops	Yellow-faced Honeyeater	P			+	+	1
Lichenostomus leucotis	White-eared Honeyeater	P			+	+	1
Lichenostomus melanops	Yellow-tufted Honeyeater	P			+	+	1
Lichenostomus fuscus	Fuscous Honeyeater	P			+	+	1
Lichenostomus penicillatus	White-plumed Honeyeater	P			+		-
Manorina melanocephala	Noisy Miner	P			+	+	1
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	P		Vagr	+	+	2
Anthochaera chrysoptera	Little Wattlebird	P			+	+	1
Xanthomyza phrygia	Regent Honeyeater	CE	E	ERV, DV			1,2
Anthochaera carunculata	Red Wattlebird	P			+	+	1
Sugomel niger	Black Honeyeater	P		Vagr			2

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Myzomela sanguinolenta	Scarlet Honeyeater	P			+	+	1
Gliciphila melanops	Tawny-crowned Honeyeater	P			+	+	1
Lichmera indistincta	Brown Honeyeater	P					1,2
Phylidonyris pyrrhoptera	Crescent Honeyeater	P			+		1
Phylidonyris novaehollandiae	New Holland Honeyeater	P			+	+	1
Phylidonyris niger	White-cheeked Honeyeater	P			+	+	1
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V		PSL			2
Melithreptus brevirostris	Brown-headed Honeyeater	P			+	+	1
Melithreptus lunatus	White-naped Honeyeater	P			+	+	1
Entomyzon cyanotis	Blue-faced Honeyeater	P		PSL			2
Philemon corniculatus	Noisy Friarbird	P			+	+	1
Philemon citreogularis	Little Friarbird	P		PSL			2
Grantiella picta	Painted Honeyeater	V		PSL			2
Orthonyx temminckii	Australian Logrunner	P			+	+	1
Cinclosoma punctatum	Spotted Quail-thrush	P				+	1
Psophodes olivaceus	Eastern Whipbird	P			+	+	1
Daphoenositta chrysoptera	Varied Sittella	V			+	+	1
Coracina novaehollandiae	Black-faced Cuckoo-shrike	P			+	+	1
Coracina papuensis	White-bellied Cuckoo-shrike	P		ERV		+	2
Coracina tenuirostris	Cicadabird	P			+	+	1
Lalage sueurii	White-winged Triller	P		ERV, PSD			1,2
Falcunculus frontatus	Crested Shrike-tit	P			+		1
Pachycephala pectoralis	Golden Whistler	P			+	+	1
Pachycephala rufiventris	Rufous Whistler	P			+	+	1
Colluricincla harmonica	Grey Shrike-thrush	P			+	+	1
Sphecotheres vieilloti	Australasian Figbird	P			+		1
Oriolus sagittatus	Olive-backed Oriole	P			+	+	1
Artamus personatus	Masked Woodswallow	P		PSD, ERV			6
Artamus superciliosus	White-browed Woodswallow	P		PSD, ERV	+		1
Artamus cyanopterus	Dusky Woodswallow	P			+	+	1
Cracticus torquatus	Grey Butcherbird	P			+	+	1
Cracticus nigrogularis	Pied Butcherbird	P		PSL			1,2
Cracticus tibicen	Australian Magpie	P			+	+	1
Strepera graculina	Pied Currawong	P			+	+	1
Strepera versicolor	Grey Currawong	P			+	+	1
Dicrurus bracteatus	Spangled Drongo	P					1
Rhipidura rufifrons	Rufous Fantail	P			+	+	1
Rhipidura albiscapa	Grey Fantail	P			+	+	1
Rhipidura leucophrys	Willie Wagtail	P			+	+	1
Corvus coronoides	Australian Raven	P			+	+	1
Corvus orru	Torresian Crow	P		Vagr			2
Myiagra rubecula	Leaden Flycatcher	P			+	+	1
Myiagra cyanoleuca	Satin Flycatcher	P					1

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Myiagra inquieta	Restless Flycatcher	P		ERV, PSD			1,2
Monarcha melanopsis	Black-faced Monarch	P			+	+	1
Symposiachrus trivirgatus	Spectacled Monarch	P		ERV			1,2
Grallina cyanoleuca	Magpie-lark	P			+	+	1
Struthidea cinerea	Apostlebird	P		Vagr			1,2
Microeca fascinans	Jacky Winter	P		PSL			2
Petroica boodang	Scarlet Robin	V				+	2
Petroica goodenovii	Red-capped Robin	P		ERV			7
Petroica rosea	Rose Robin	P			+	+	1
Eopsaltria australis	Eastern Yellow Robin	P			+	+	1
Cisticola exilis	Golden-headed Cisticola	P			+		2
Acrocephalus australis	Australian Reed-Warbler	P			+		2
Megalurus timoriensis	Tawny Grassbird	P		SSL			2
Megalurus gramineus	Little Grassbird	P			+		1
Cincloramphus mathewsi	Rufous Songlark	P		PSL			2
Cincloramphus cruralis	Brown Songlark	P		ERV			1,2
Zosterops lateralis	Silvereye	P			+	+	1
Hirundo neoxena	Welcome Swallow	P			+	+	1
Petrochelidon ariel	Fairy Martin	P					1,2
Petrochelidon nigricans	Tree Martin	P			+	+	1
Pycnonotus jocosus	Red-whiskered Bulbul*	U			+	+	1
Zoothera lunulata	Bassian Thrush	P			+	+	1
Turdus merula	Eurasian Blackbird*	U					1
Sturnus vulgaris	Common Starling*	U			+		1
Sturnus tristis	Common Myna*	U			+	+	1
Dicaeum hirundinaceum	Mistletoebird	P			+	+	1
Taeniopygia bichenovii	Double-barred Finch	P					1
Neochmia temporalis	Red-browed Finch	P			+	+	1
Stagonopleura guttata	Diamond Firetail	V		PSL			2
Stagonopleura bella	Beautiful Firetail	P			+	+	1
Passer domesticus	House Sparrow*	U			+		1
Anthus novaeseelandiae	Australian Pipit	P			+	+	1
Mammals							
Ornithorhynchus anatinus	Platypus	P		SSL			1
Tachyglossus aculeatus	Short-beaked Echidna	P			+	+	1
Dasyurus maculatus	Spotted-tailed Quoll	V	E	SSL			1
Dasyurus viverrinus	Eastern Quoll	E		LE			3
Antechinus stuartii	Brown Antechinus	P			+		1
Antechinus swainsonii	Dusky Antechinus	P		SSL			1
Sminthopsis murina	Common Dunnart	P			+	+	1
Perameles nasuta	Long-nosed Bandicoot	P			+	+	1
Phascolarctos cinereus	Koala	V		SU	+		1
Vombatus ursinus	Common Wombat	P			+	+	1
Cercartetus nanus	Eastern Pygmy-possum	V			+	+	1
Petaurus breviceps	Sugar Glider	P			+	+	1
Petauroides volans	Greater Glider	P		SSL			1
Pseudocheirus peregrinus	Common Ringtail Possum	P			+	+	1
Acrobates pygmaeus	Feathertail Glider	P			+	+	1

Scientific name	Common name	NSW legal status	Federal legal status	Current status in survey area	Current survey records	Other DECCW systematic surveys	Other records
Trichosurus cunninghami	Mountain Brushtail Possum	P			+	+	1
Trichosurus vulpecula	Common Brushtail Possum	P			+	+	1
Macropus parma	Parma Wallaby	V		LE			3
Macropus robustus	Common Wallaroo	P		SU	+		1
Thylogale thetis	Red-necked Pademelon	P		SSL			
Wallabia bicolor	Swamp Wallaby	P			+	+	1
Pteropus poliocephalus	Grey-headed Flying-fox	V	V		+	+	1
Rhinolophus megaphyllus	Eastern Horseshoe Bat	P			+	+	1
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		SU			4
Mormopterus "Species 2" (taxonomy revised to *Mormopterus ridei*)	Eastern Freetail-bat	P			+	+	-
Tadarida australis	White-striped Freetail-bat	P			+	+	1
Miniopterus australis	Little Bentwing-bat	V				+	1
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V			+	+	1
Nyctophilus geoffroyi	Lesser Long-eared Bat	P		SU	+		-
Nyctophilus gouldi	Gould's Long-eared Bat	P			+	+	1
Chalinolobus dwyeri	Large-eared Pied Bat	V	V		+	+	1
Chalinolobus gouldii	Gould's Wattled Bat	P			+	+	1
Chalinolobus morio	Chocolate Wattled Bat	P			+	+	1
Myotis macropus (formerly M. adversus)	Large-footed Myotis (also known as Southern Myotis)	V			+	+	1
Scoteanax rueppellii	Greater Broad-nosed Bat	V			+	+	1
Scotorepens orion	Eastern Broad-nosed Bat	P			+	+	-
Vespadelus darlingtoni	Large Forest Bat	P			+	+	1
Vespadelus vulturnus	Little Forest Bat	P			+	+	1
Pseudomys novaehollandiae	New Holland Mouse	P	V		+	+	
Hydromys chrysogaster	Water Rat	P		SSL			1
Rattus fuscipes	Bush Rat	P			+	+	1
Rattus lutreolus	Swamp Rat	P			+	+	1
Mus musculus	House Mouse*	U			+	+	1
Rattus norvegicus	Brown Rat*	U					1
Rattus rattus	Black Rat*	U			+	+	1
Arctocephalus forsteri	New Zealand Fur-seal	V					1
Arctocephalus pusillus doriferus	Australian Fur-seal	V					1
Mirounga leonina	Southern Elephant Seal	P	V	Vagr			1
Hydrurga leptonyx	Leopard Seal	P					1
Canis lupus familiaris	Feral Dog*	U				+	1
Vulpes vulpes	Fox*	U			+	+	1
Felis catus	Feral Cat*	U			+	+	1
Oryctolagus cuniculus	Rabbit*	U			+	+	1
Sus scrofa	Feral Pig*	U				+	5
Cervus timorensis	Rusa Deer*	U			+	+	1

43 Bridge Street
Hurstville 2220
www.environment.nsw.gov.au