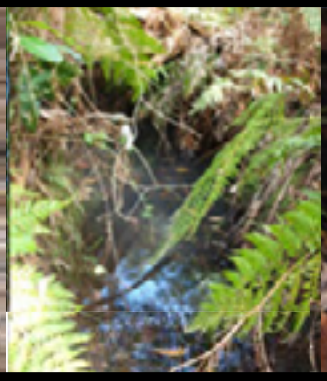


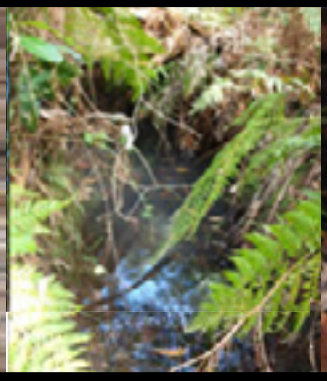
The Vertebrate Fauna of Dalrymple Hay Nature Reserve & Browns Forest

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

THE VERTEBRATE FAUNA OF DALRYMPLE-HAY NATURE RESERVE AND BROWNS FOREST

FINAL REPORT Version 1

August 2012



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This project was primarily funded by the Friends of Lane Cove National Park Incorporated via grants obtained from the Environmental Trust and the Ku-ring-gai Council Environmental Levy Fund.

Cover Photos
Front cover
Feature photo: Tall grey ironbark trees in Dalrymple-Hay Nature Reserve. Photo © M. Schulz/OEH
White-striped freetail-bat. Photo © M. Schulz
Water pools in a creekline within the reserves. Photo © M. Schulz/OEH
Long-nosed bandicoot. Photo © N. Williams

Back cover
Red-browed finch. Photo © K. Stepnell
Tall open forest in the reserves. Photo © M. Schulz/OEH
Eastern water-skink basking in Dalrymple-Hay Nature Reserve. Photo © M. Schulz/OEH

OVERVIEW

Driving along Mona Vale Road heading for the beach or an appointment, with eyes directed forward and glancing every so often in the rear view mirror, most people do not even notice the remnant patch of tall forest nestled between houses in St Ives. Within this remnant forest majestic trees tower to a height of up to 45 metres. The stand comprises two different reserves located side-by-side: Dalrymple-Hay Nature Reserve (11.1 hectares) managed by the Office of Environment and Heritage and Browns Forest (4.6 hectares) managed by Ku-ring-gai Council. The remnant forms the largest remaining stand of Blue Gum High Forest, which is listed as a Critically Endangered Ecological Community under both State and Commonwealth legislation. The flora present within these reserves is well documented with a large amount of bush regeneration having occurred since the 1980s. To date, however, the fauna is less well known, particularly within Dalrymple-Hay Nature Reserve.

This report documents a systematic vertebrate fauna survey of the reserves undertaken in 2011-12. It provides a current inventory of native and pest fauna species, profiles the occurrence of threatened species, summarises threats posed to native species, and provides recommendations for management of the most important fauna values.

In total 129 native vertebrate fauna species have been recorded in the reserves in the last 25 years comprising six frog, 12 reptile, 94 native bird and 17 native mammal species. Some of the most significant fauna occurrences are listed below.

- The reserves support a high diversity of insectivorous bat species compared with many small sandstone reserve remnants in northern Sydney. Three of these species are listed as threatened under State legislation. This high diversity of bats has been attributed to a high insect biomass, the large girth of the trees, and the abundance of tree hollows.
- The reserves support a breeding pair of powerful owls, a species listed as threatened under State legislation.
- When key tree species are in flower the reserves provide important feeding habitat for the grey-headed flying-fox, also listed as threatened under State legislation.
- A number of other threatened species are rare visitors to the reserves, including the glossy black-cockatoo, the little lorikeet, and the barking owl.
- The reserves support one of the few surviving long-nosed bandicoot populations within urban Sydney. Other fauna species that are uncommon within small urban reserves in the metropolitan Sydney landscape also occur, such as the swamp wallaby, the lace monitor and the sugar glider.
- A number of forest-dwelling species that are uncommon in the Sydney area have been recorded in the reserves, including the noisy pitta and the oriental cuckoo. Some species patchily distributed in forest habitat elsewhere in the region are relatively common, such as the brown gerygone.

A key to conserving the native fauna values of the reserves is to protect all remaining habitat in the forest remnant, including remnant trees present on adjacent private land. Other management actions that will also be important include minimising incursion of wide-ranging domestic cats, combating myrtle rust, and undertaking reserve-wide bush regeneration in a manner that will not result in the loss of shrub- and ground-dwelling fauna species. Maintaining the narrow habitat link with Garigal National Park and Middle Harbour along High Ridge Creek is also likely to be important to conservation of native fauna in the reserves.

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1 INTRODUCTION

1.1 PROJECT RATIONALE

Biodiversity information is required by many arms of the Office of Environment and Heritage (OEH) for regulation, conservation assessment and land management purposes. In the Sydney Basin Bioregion over 60 per cent of extant native vegetation occurs in OEH reserves making it the largest custodian of native flora and fauna. OEH is working to ensure that all reserves in greater Sydney have adequate flora and fauna information to underpin park management decision-making and to understand the contribution reserves make to statewide conservation efforts.

Vegetation within Dalrymple-Hay Nature Reserve (NR) and Browns Forest (together referred to as 'the reserves') has recently been documented as part of a vegetation mapping project across the Sydney Metropolitan Catchment Management Authority area (DECCW 2009). The reserves are dominated by Blue Gum High Forest, a Critically Endangered Ecological Community under both the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This community is extremely restricted within the Sydney Basin Bioregion yet, despite its location within an urban setting, has received little previous systematic fauna survey effort. The aim of the current project is to address this information shortfall by undertaking a systematic native terrestrial vertebrate fauna survey using OEH standard techniques. The field survey is supplemented by gathering additional published and other information on the reserves. The systematic surveys and resulting report will result in a more detailed understanding of fauna occurring in the reserves and the role that these areas play in the regional conservation of vertebrate fauna.

1.2 PROJECT AIMS

The primary objectives of the surveys were to:

- undertake a review of previous fauna survey effort across Dalrymple-Hay NR and Browns Forest and identify knowledge gaps for particular fauna groups
- undertake systematic fauna surveys to fill the gaps identified above.

The specific objectives of this report are to:

- document the methodology of the survey techniques applied
- document, review and collate information on the terrestrial vertebrate fauna of the two reserves, bringing together results of the current survey with those of previous studies to provide an accurate inventory of species that have been recorded in the reserves
- identify and profile threatened fauna species and pest fauna species that are known to occur
- identify threatening processes impacting on native fauna in the reserves
- identify priorities for conservation management of vertebrate fauna and propose strategies to maintain or enhance current fauna values
- identify fauna monitoring to be considered within the reserves.

1.3 THE RESERVES

1.3.1 Location of the reserves

The reserves are located within the Upper North Shore of the Sydney metropolitan area, approximately 15 kilometres from the centre of Sydney. Dalrymple-Hay NR is managed by the Office of Environment and Heritage. It is located on the east side of Mona Vale Road in the suburb of St Ives, northern Sydney (Map 1). It is 11.1 hectares in area. The contiguous Browns Forest reserve covers approximately 4.6 hectares and is managed by Ku-ring-gai Council. There is no discernible boundary between the two reserves. The two reserves are surrounded by the residential suburbs of St Ives and Pymble. They are situated in the headwaters of High Ridge Creek that flows into Rocky Creek which discharges through Garigal National Park into Middle Harbour (Map 1). The reserves are isolated by residential land from larger reserves to the north, in particular Ku-ring-gai Chase National Park (NP). A narrow band of riparian vegetation along High Ridge Creek links the two reserves through easements, council reserves, and private property with Garigal NP to the south-east.

Dalrymple-Hay Nature Reserve is bordered on two sides by roads in a leafy residential setting. Photo © M. Schulz/OEH

1.3.2 Bioregional and regional setting

The reserves are within the Sydney Basin Bioregion (Thackway and Cresswell 1995). This Bioregion is dominated by extensive sandstone plateaux between Ulladulla, the Hunter Valley and Mudgee. The bioregion context is useful in understanding broad patterns in biota within the state and national context. In a more local context, the reserves fall within the Sydney Metropolitan Catchment Management Authority area (see DECC 2008a). The term region (when used on its own in this report) refers to the Sydney Metropolitan Catchment Management Authority (SMCMA) area.

1.3.3 Geomorphology, hydrology, soils and elevation

Within the reserves, Wianamatta series Ashfield and Bringelly Shale forms a capping over Hawkesbury Sandstone. The derived Wianamatta clay soils have a high nutrient content relative to most other soils in the Sydney area (Chapman and Murphy 1989, DEC 2004). These soils become saturated in wet weather and are highly prone to slumping; during dry weather they are prone to cracking (Chapman and Murphy 1989). No sandstone outcrops are present in the reserves, but in the lower (south) side of Dalrymple-Hay NR the soil capping has worn down to the sandstone bedrock, principally along the major drainage lines.

The reserves are situated on the ridge forming part of the Hornsby Plateau between Middle Harbour and Cowan Creek in the headwaters of High Ridge Creek. The reserves range in elevation from 120 to 160 metres above sea level with a south-east to south-west aspect. The southerly aspect in the reserves protects the area from hot dry westerly winds. The south-east aspect slopes remain damp for long periods and only the upper slopes become dry in the summer months (DEC 2004). The creeks in the reserve only run after heavy rain but retain moisture for a considerable period, with some deep pools present.

Pools are present in ephemeral-running drainage lines within the reserves. Photo © M. Schulz/OEH

1.3.4 Climate

The reserves are located in one of the wettest areas of Sydney, with an average rainfall of 1400 millimetres per annum (DEC 2004). The nearest rainfall station is approximately one kilometre away at Canisius College in Pymble; here mean monthly precipitation ranges from 66.8 millimetres in September to 160.3 millimetres in February (Bureau of Meteorology 2011). The nearest temperature measuring station is approximately five kilometres away at Macquarie University; here the monthly mean maximum temperature ranges from 16.4 degrees Celsius in July to 25.8 degrees Celsius in November and the monthly mean minimum temperature ranges from 3.7 degrees Celsius in July to 16.2 degrees Celsius in January (Bureau of Meteorology 2011).

1.3.5 Vegetation

Vegetation of the reserves was mapped as part of a Sydney Metropolitan Catchment Management Authority area wide project (DECCW 2009). A brief overview is given here to provide context for understanding the range of fauna habitats available within the reserves. The two vegetation communities identified in the reserves are Blue Gum High Forest (96 per cent of the total area) and Sydney Turpentine-Ironbark Forest (four per cent of the area) (DECCW 2009) (Map 2). Both of these communities fall within the Wet Sclerophyll Forest statewide vegetation formation of Keith (2004). Blue Gum High Forest is grouped in the North Coast Wet Sclerophyll Forests statewide vegetation class (after Keith 2004) while Sydney Turpentine-Ironbark Forest is grouped in the Northern Hinterland Wet Sclerophyll Forests statewide vegetation class (after Keith 2004).

Blue Gum High Forest reaches towering heights in the reserves. Photo © M. Schulz/OEH

Blue Gum High Forest is listed as a Critically Endangered Ecological Community both under the TSC Act and the EPBC Act. It is the principal vegetation within the reserves (Table 1) and occurs from the upper slopes to gullies (DECCW 2009, Map 2). It is dominated by Sydney blue gum (*Eucalyptus saligna*), blackbutt (*E. pilularis*) and turpentine (*Syncarpia glomulifera*). The presence of small trees ranges from sparse to dense and includes a variety of sclerophyllous and mesophyllous species. The ground cover varies, with extensive areas of grasses and ferns where the shrub layer is open to sparse (DECCW 2009, D. Connolly pers. comm.).

Sydney Turpentine-Ironbark Forest grows in the north-east corner of the reserves. Photo © M. Schulz

Sydney Turpentine-Ironbark Forest is listed as an Endangered Ecological Community under the TSC Act and as a Critically Endangered Ecological Community under the EPBC Act. The dominant tree species in this vegetation community are blackbutt and turpentine. It is the least well represent vegetation community within the reserves and predominantly occurs within the north-east section of the area (Table 1, Map 2). The community is difficult to separate within the reserves from Blue Gum High Forest particularly as it transitions. Characteristics used to distinguish the community include: its occurrence on shallower shale soils on the margins of the crests, benches and sandstone slopes that have some shale influence from the eroding shales above; occurring in situations where soil moisture is less well retained by the shallower layer and sandier texture; the absence of Sydney blue gum; the dominance of blackbutt, turpentine and smooth-barked apple (*Angophora costata*); and the ground layer generally not dominated by ferns as well less mesophyllous shrubs present (D. Connolly pers. comm.). This

vegetation community shares many species and features with the Blue Gum High Forest and together both communities are a unique feature of higher rainfall fertile shales of the SMCMA area (DECCW 2009).

Table 1: Vegetation communities within the reserves (from DECCW 2009)

Reserve	Total area (hectares)	Area of Blue Gum High Forest (hectares)	Area of Sydney Turpentine-Ironbark Forest (hectares)
Dalrymple-Hay Nature Reserve	11.1	10.8	0.2
Browns Forest	4.6	3.6	1.0
Total	15.7	14.4	1.2

1.3.6 Fire

The urban nature of the reserves, their small size and the past low fire frequency combined with the reserves' southerly aspects mean that the potential for naturally-occurring fires is considered low (DEC 2004). The potential of fires starting from arson or accidental ignition is considered to be much higher than as a result of natural ignition sources (DEC 2004). There is little known about the previous fire history of the reserves with no specific fire records available for Dalrymple-Hay NR before 1978 (DEC 2006). Apart from a small prescribed burn in Dalrymple-Hay NR in 1978, a fire in the north-west section of the area in 1998 and a number of weed eradication burns since 1997 in the two reserves, there have been no major fires for the past 50 years (DEC 2004, DEC 2006, Duffy 2011, A. Duffy pers. comm.). This low fire frequency has probably contributed to the increase in the presence of mesophyllic shrub and tree species such as sweet pittosporum (*Pittosporum undulatum*) and blueberry ash (*Elaeocarpus reticulatus*). The low fire frequency may also have contributed to a substantial increase in exotic shrub species such as privet (*Ligustrum sinense*), lantana (*Lantana camara*) and camphor laurel (*Cinnamomum camphora*) (DEC 2004).

1.3.7 Past and present land-use

The reserves are situated within the area occupied by the Guringai (or Kuringai) Aboriginal people, whose territory stretched from the north shore of Sydney Harbour to Broken Bay. Little is known about the Guringai because European diseases and conflict killed most of their population within the first few years of European settlement of Sydney (DEC 2004). There is little physical evidence remaining of past use of the reserve by Aboriginal people (DEC 2004).

A summary of the European history of the area is as follows (adapted from DEC 2004): "In 1838 the area was part of a grant to Daniel Mathews, who had previously established a sawmill nearby in Cowan Road. Its closeness to the mill suggests that the reserves were selectively logged in those early days. In the 1870s Thomas Brown purchased an area which, unlike most of the surrounding land, remained uncleared. In the 1920s Richard Dalrymple-Hay, the first Commissioner of Forests in NSW, proposed acquiring a remnant of the remaining forest for use as a demonstration forest. Fifty-six acres (approximately 23 hectares) were resumed in 1926 and the Minister for Lands paid Mr Dalrymple-Hay the honour of naming the demonstration forest after him; Dalrymple-Hay Demonstration State Forest No. 793. As a result of this declaration the forest in the area is unique in that it was preserved in its original state, with only minor tree harvesting having been undertaken before this time (Duffy 2011). The acquisition of the northern 29 acres was, however, not completed and in 1931 this area was revested in the former owners who proposed it for subdivision. The Dalrymple-Hay Forest Preservation Committee managed to obtain an option on 11 of these acres, which were subsequently purchased with 350 pounds raised by the Australian Forest League and 800 pounds paid by Ku-ring-gai Council and named Browns Forest. The Forestry Commission subsequently discovered their acquired land was too small to be managed economically as a forest, so no use was made of it. In 1971 Dalrymple-Hay State Forest was handed to the now OEH and the area was dedicated as a nature reserve".

In the present day the reserves are popular with local residents for short walks and nature appreciation, with bird watchers using the area extensively (DEC 2004). Browns Forest is under a voluntary conservation agreement (VCA) with OEH.

1.3.8 Adjacent land-uses

The reserves are adjacent to the residential areas of St Ives and Pymble and bordered on two sides by sealed public roads, including the dual-lane Mona Vale Road. The north-east boundary of Browns Forest is bordered by a water storage facility on Sydney Water land.

1.4 PROJECT TEAM

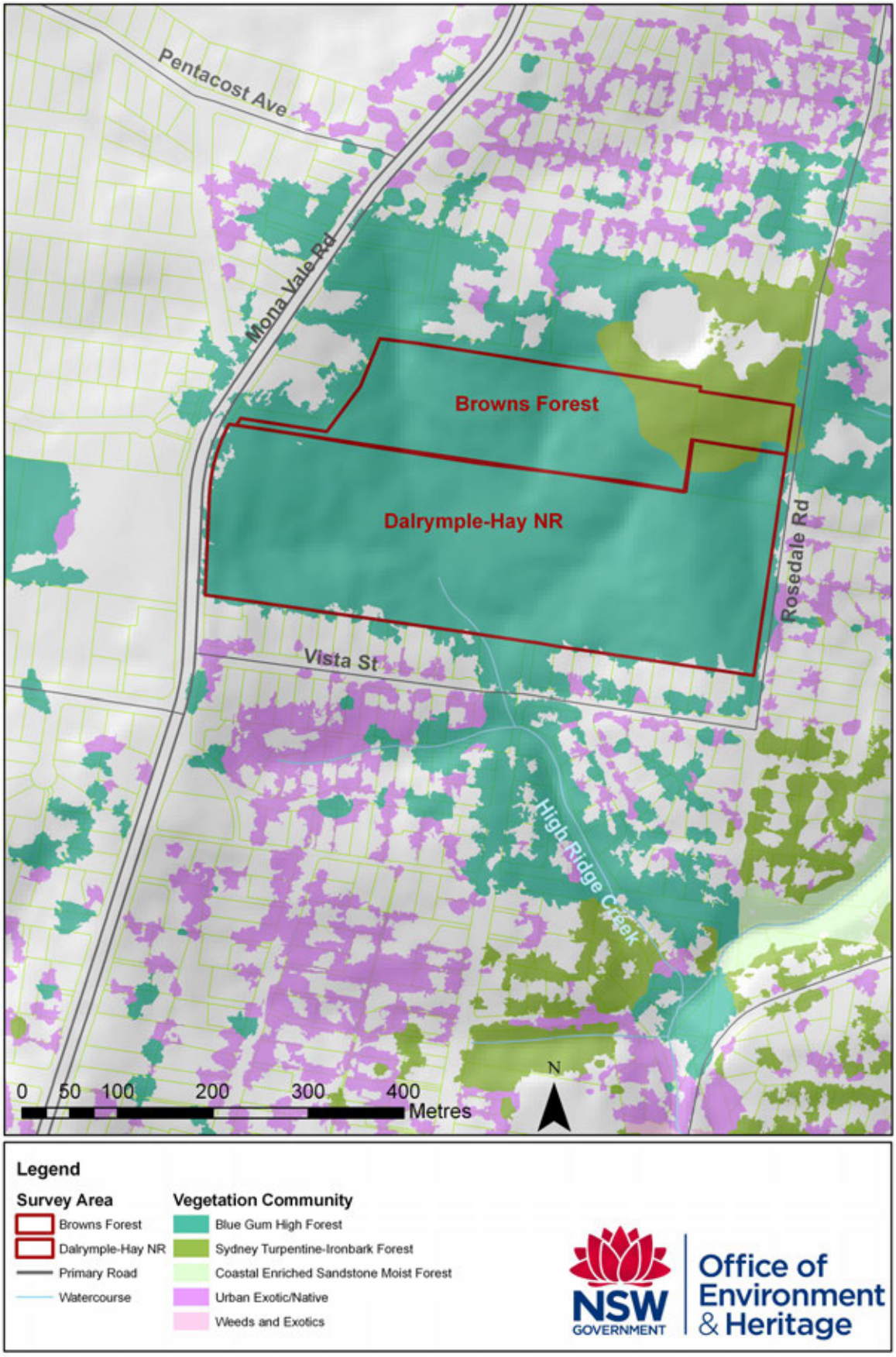
This project was carried out by the Biodiversity Survey and Assessment Section in the Metropolitan Branch of the Conservation and Regulation Division of OEH. The project was jointly funded by the Friends of Lane Cove NP and OEH.

Martin Schulz was responsible for the systematic field survey in 2011 and 2012, background research and report writing. The following OEH staff assisted with the fauna survey: Debbie Andrew, Andrew Duffy, Josh Madden, Sean O'Riley, Rob Porter, Pete Taggart and Katherine Wem. Elizabeth Magarey assisted with organisation of the project and logistics, supplied background information and edited the report. Andrew Duffy assisted with organisation of the project and logistics and provided previous fauna reports and information. Report maps were produced by Elizabeth Magarey. Kerry Oakes designed the report cover and formatted the report.

Fauna survey signs were erected at reserve entry points over the period of the field survey. Photo © M. Schulz/OEH

Map 1: Location of Dalrymple-Hay Nature Reserve and Browns Forest

Map 2: **Vegetation communities within and around Dalrymple-Hay Nature Reserve and Browns Forest (from DECCW 2009)**



2 METHODS USED TO BUILD THE SPECIES INVENTORY

2.1 COMPILATION OF EXISTING FAUNA DATA

The reserves have a long history of visitation, however there has been little comprehensive systematic survey of vertebrate fauna in Dalrymple-Hay NR prior to this project (e.g. Duffy 2011). Some systematic survey work has been undertaken in Browns Forest (e.g. Conacher Travers Pty Ltd 2000, Smith and Smith 2001, 2004). There have been a variety of formal and informal studies carried out on vertebrates, the results of which are retained in many different formats. Some are recorded in corporate databases such as the Atlas of NSW Wildlife and Ku-ring-gai Council Bio-base, some in published and unpublished reports and many remain anecdotal. This project attempted to extract information from as many of these resources as possible. These records have various levels of reliability depending on the type of observation, as well as the certainty and identification experience of the observer.

2.1.1 Systematic fauna survey data

Systematic surveys are those where the same methods are employed at each site, including timed search efforts within fixed areas. These surveys record all species found using a standardised method, and importantly record nil results (i.e. no animals were found). In this way all survey effort is recorded and detection rates can be compared to elsewhere or other time periods.

Despite the reserves' location within metropolitan Sydney little documented systematic fauna survey work had been conducted in the reserves prior to this survey. No previous projects within the reserves had used the techniques described in section 2.4.1, hereafter referred to as OEH standard systematic fauna survey techniques. However a number of fauna survey projects had been undertaken in the reserves using systematic point- or transect-based survey techniques that differ from the OEH standard. In order to document the methods used in these previous surveys in one report, the surveys are summarised below.

- A bushland fauna assessment in Browns Forest was undertaken by Conacher Travers Pty Ltd (2000) and Smith and Smith (2001, 2004) as part of Ku-ring-gai Council scientific survey. The project followed the Ku-ring-gai Council fauna assessment guidelines (Ku-ring-gai Municipal Council 1999). Surveys included two 60 minute early morning diurnal bird searches within a two hectare area, two 60 minute reptile searches in a two hectare area, two 60 minute searches for nocturnal fauna (mammals, birds, reptiles and frogs) within a two hectare area, two one hour periods sampling bats with an Anabat II detector at a stationary site, and incidental records. Additionally, 22 single-ended hair-tubes (baited tubes with adhesive tape around the entrance to collect mammalian hair samples) were left out for 11 to 14 days. These hair-tubes comprised 15 small tubes (entrance dimensions 53 millimetres x 105 millimetres) and seven large tubes (entrance dimensions 80 millimetres x 105 millimetres). Ten small tubes and two large tubes were placed in trees and shrubs, while five small tubes and five large tubes were placed on the ground. Each tube was baited with a mixture of peanut butter, oats, honey, sardines, aniseed and almond essence and canola oil. The hair samples obtained were identified from Brunner and Coman (1974) and a set of reference hairs.
- Two consecutive nights of sampling with a stationary Anabat II detector was undertaken in March 2005 as part of an Honour's project investigating the occurrence of micro-bats in an urban landscape in northern Sydney (Basham 2005).
- A baseline fauna survey was undertaken in April 2010 by Duffy (2011) in Dalrymple-Hay NR. This included trapping along four 100-150 metre long transects running from the Vista Street fire break north into the centre of the reserve, with at least one Elliott A trap and a small wire cage trap (600 x 300 x 300 millimetres) set for five consecutive nights. Traps were baited with peanut butter, rolled oats and honey, two with 'cat food' and one cage trap with a chicken wing. Traps were positioned at stations 20-30 metres apart. One of the Elliott traps was positioned on a two metre high wooden platform attached to a tree. A single pitfall trap comprising PVC pipe (200 millimetres diameter x 400 millimetres in length) located on two transects with a 10 metre long drift fence comprising 400 millimetre wide black plastic builder's flashing was sampled for five consecutive nights. Diurnal bird surveys were conducted while checking traps. Spotlight surveys

were undertaken along the same transects. Sand plots at least one by one metre in dimension and consisting of a mix of 'Sydney' sand and brick layers sand laid at a depth of 100 millimetres were set on selected runways and left for three consecutive nights with all plots checked early in the morning. Call playback was undertaken at random locations within the reserve following the technique of Debus (1995); calls of the following species were played through an amplifier for three nights in sequential order: powerful owl (*Ninox strenua*), southern boobook (*N. novaeseelandiae*), barking owl (*N. connivens*), masked owl (*Tyto novaehollandiae*), eastern barn owl (*T. javanica*), Australian owlet-nightjar (*Aegotheles cristatus*) and tawny frogmouth (*Podargus strigoides*).

- Small mammal trapping was undertaken using a similar methodology as described above in May 2009 (D. Nance, Macquarie University unpublished records) and January 2011 (M. Werakoonn, University of NSW, unpublished records).

2.1.2 Other Atlas of NSW Wildlife records

The Atlas of NSW Wildlife (OEH 2011) was the primary resource used to access data on the fauna of the reserves. The area has been visited by numerous fauna enthusiasts resulting in a number of sighting records. Records within the Atlas of NSW Wildlife derive from observations made by: park rangers and field officers; bush regenerators, local residents; naturalists; scientific researchers; environmental consultants; and visitors to the park. These records have various levels of reliability depending on the type of observation, as well as the certainty and identification experience of the observer.

2.1.3 Literature review

As part of this project an effort was made to collate fauna records from various written sources that have not been entered into the Atlas of NSW Wildlife.

2.1.4 Unpublished and other information

As part of this project an effort was made to collate fauna sightings made by various naturalists, reserve staff and community members that had not previously been entered into the Atlas of NSW Wildlife or documented in the literature. Websites and forums were scanned for sighting information including birding-aus (http://180.95.17.21/home/birding/), BirdlineNSW and Ku-ring-gai Council Bio-base. A key resource was a list of fauna recorded for the area, including species recorded by bird watchers, OEH staff, environmental consultants, researchers, personnel from the Bushland and Rainforest Regeneration Company and the Ku-ring-gai Council Bio-base (Anon. 2006).

2.2 REVIEW OF EXISTING RECORDS

2.2.1 Reviewing the status of existing fauna records

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

- **Accepted**: Species for which there are reliable and accurate records *or* species for which there is some evidence and can reasonably be presumed to exist due to suitable habitat within the reserves and reliable records in the surrounding area. This includes species that are resident, visitors or vagrants. This category also includes species that have become locally extinct but have been reliably recorded in the past.
- **Excluded (poor locational accuracy)**: Species for which all records had low spatial reliability (generally the accepted cut-off for records was those with a stated accuracy of 1000 metres), or the description indicated that the species was actually seen elsewhere, or the species has only been recorded flying over the reserve. For all these species there is no suitable habitat in the reserve or other supporting evidence of its occurrence within the reserve.
- **Excluded (unconfirmed, misidentification or data entry error)**: Species that have either been unconfirmed, misidentified or recorded via a data entry error. These were identified by highlighting all species that had no suitable habitat in the reserve, and/or were outside their known range *and* for which no supporting evidence existed to indicate that they were actually reliably-recorded vagrants or recent extinctions.

Species that were accepted based on the above criteria were included in this report. Species that were excluded based on the above criteria have been left out of the species inventories in this reported and are detailed in section 4.1.

2.3 ANALYSIS OF PREVIOUS SURVEY EFFORT

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

2.3.1 Gap analysis of systematic survey effort

The aim of systematic surveying is to ensure that each habitat type within the reserves is systematically sampled in proportion to the land area it occupies. However, due to the small size of the survey area and the presence of only two vegetation communities which grade into one another the gap analysis conducted was based on viewing fauna records, the techniques previously deployed within the area, timing of the previous surveys and discussions with local OEH staff.

The primary gaps identified in OEH standard systematic fauna survey were:

- diurnal bird census
- reptile census
- nocturnal site spotlighting census
- nocturnal call playback census
- nocturnal streamside search
- insectivorous bat surveys, including harp trapping and bat ultrasound call recordings (Anabat)
- small native mammal surveys in areas not previously sampled by Duffy (2011).

2.4 SURVEY PROGRAM

2.4.1 Systematic fauna survey techniques

The systematic fauna survey techniques used for this survey are based on those developed for the Comprehensive Regional Assessments in 1997 (NPWS 1997) which have been adopted as the OEH standard ever since. In this document these systematic fauna survey techniques are referred to as OEH standard systematic fauna survey techniques. These techniques sample the following vertebrate fauna groups: diurnal and nocturnal birds, diurnal and nocturnal reptiles, bats, arboreal mammals and amphibians. Consistency in the use of these systematic techniques allows a comparison between fauna species detected in different vegetation communities and habitats, not only within Dalrymple-Hay NR and Browns Forest but also across other reserves and environments.

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

Site Selection

OEH standard systematic sites are typically placed a minimum of one kilometre apart, or two kilometres for nocturnal call playback surveys. However in the current survey area this spacing would have resulted in the selection of only a single survey site. Therefore, in the current small survey area sites were separated by a distance of 200 metres or less depending on the techniques deployed at particular locations. Sites sampled gully, mid-slope and upper slope locations where present within the two vegetation communities. Systematic survey sites were 100 x 200 metres (two hectares) in area.

Site Attributes

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

Diurnal Bird Survey

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

Diurnal Herpetofauna Search

A standard half-hectare (50 x 100 metre) area was searched for one person-hour at each site. 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 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.

Nocturnal Streamside Search

Streamside search for frogs was undertaken for one half person-hour along a 200 metre stretch of creek. 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.

Nocturnal Site Spotlighting Survey

This census comprised searching for arboreal mammals and other fauna along a 200 metre transect for half a person-hour. Fifty watt spotlights were used to scan the vegetation for animals and enable detection of reflected eye shine. Surveyors also listened intently for fauna calls during the survey period. All fauna observed or heard within the census period were recorded, noting whether they were on or off site.

Harp traps were set on tracks or within gaps between trees where micro-bats were likely to fly. Photo © M. Schulz/OEH

Harp Trapping

While ultrasonic recorders are used principally to detect high-flying bat species, collapsible bat traps, known as harp traps (Tidemann and Woodside 1978), capture low-flying species. Sites were selected for their perceived potential to interrupt bats along their flight paths. Traps were positioned on tracks or within gaps between trees where adjacent vegetation may 'funnel' flying bats. Traps were set for two consecutive nights Traps were checked during the night and each morning. Any animals captured within the traps were identified, sexed, assessed for age and breeding status if possible, and released. Each site was sampled in both spring and autumn, resulting in two samples at each location.

Bat Ultrasound 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 1992), 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. This method records the principally ultrasonic echolocation 'calls' made by bats (i.e. most species emit signals that are inaudible to the human ear).

The recording equipment for the current surveys consisted of a combined Anabat SD1 detector housed within a plastic box for weather protection. The box was set up at sites where bats were expected to fly, such as over water bodies and along tracks. The standard technique deploys an

Anabat detector overnight at a site, set to commence detection at dusk and turn off at dawn. During the night, a delay switch operates to turn on the recording device when bat activity is detected and then de-activate the device while no bat activity is occurring. Anabat recordings were transferred onto computer and analysed by Martin Schulz. Identification was designated as definite, probable or possible, following the methodology of Parnaby (1992b) and Pennay et al. (2004).

Nocturnal Call Playback for Threatened Forest Owls

Nocturnal birds and mammals are often detected only when they vocalise for territory or social contact, behaviour which can be elicited by broadcasting specific calls. A standard survey census involved broadcasting the calls of each of the four large forest owls – powerful owl, masked owl, sooty owl (*Tyto tenebricosa*) and barking owl – from the centre of a site. Prior to call broadcasts, on arrival at the site, the surrounding area was searched by spotlight for five minutes to detect any fauna in the immediate vicinity and then a ten minute period of listening was undertaken. A pre-recorded compact disc of each species' call series was played, amplified through a megaphone. Calls of each species were played for five minutes, followed by a five minute listening period. The surrounding area was again searched by spotlight after a final ten minute listening period. After the census, the response or presence of any fauna, date and time that a response occurred, and weather details such as amount of cloud cover was recorded. Very windy periods were avoided where possible.

2.4.2 Targeted fauna survey techniques

At the commencement of the current project, species and habitats were identified that would require targeted survey effort on top of the standard systematic work. For Dalrymple-Hay NR and Browns Forest, the standard systematic survey techniques were expected to adequately survey for most threatened species known or expected to occur. Exceptions to this were:

- Small- and medium-sized native terrestrial mammals – this group is poorly sampled by standard techniques.
- Red-crowned toadlet (*Pseudophryne australis*) – due to the dry conditions during the two survey periods this species may have been overlooked without targeted surveys.

The targeted survey techniques employed are described below. The small mammal trapping and infra-red camera trapping survey effort was entered into the BSS of the Atlas of NSW Wildlife, together with resulting records. However the red-crowned toadlet survey effort was not entered into the BSS.

Small Mammal Trapping

Target Species: Small native mammals, such as the bush rat (*Rattus fuscipes*) and brown antechinus (*Antechinus stuartii*).

Technique: Small mammal trapping principally targeted sections of the reserve north of the transects used by Duffy (2011) and others. Twenty-five Elliott A traps were set at approximately 10 metre intervals at three sites. However due to the small size of the reserve the 75 traps essentially formed one continuous transect. Two cage traps were also set on the transect. Traps were baited with a mixture of peanut butter, rolled oats and honey. Traps were left in place for four consecutive nights, checked and emptied every morning soon after dawn. Any animals captured within the traps were identified, sexed if possible, and released.

Infra-red Camera Trapping

Target Species: Small native mammals, such as the bush rat and brown antechinus, and cryptic species that may have been overlooked by the systematic survey techniques.

Technique: Single infra-red camera traps were deployed at each location for either 26-28 days (spring – four sites) or 41-42 days (autumn – five sites). During both periods, the camera traps (Moultrie Model 160 Digital Game Camera) were attached to saplings or small trees (with one camera rested against a log in a scrub thicket) and aimed at either a bait station positioned approximately two metres from the camera and baited with peanut butter, rolled oats, honey and walnuts (spring period) or at open ground with walnuts and sardines scattered for varying distances in front of the cameras (autumn period). At the end of each period the cameras were collected, the memory cards downloaded and all species that had tripped the camera were identified by Martin Schulz.

Targeted survey techniques included setting Elliott A traps for small native mammals (left) and setting infra-red camera traps to take photographs of cryptic species over extended periods of time (right). Photos © M. Schulz/OEH

Diurnal Call Playback for Red-crowned Toadlet

Target Species: Red-crowned toadlet

Technique: The potential presence of the red-crowned toadlet was investigated in the spring survey by conducting two-minute call playback sessions during the daytime, approximately every 50 metres along all larger drainage lines within the reserves.

2.4.3 Opportunistic techniques

Opportunistic techniques were also employed wherever possible and included the identification of indirect signs, such as scats and footprints.

A concerted effort was directed towards locating predator scats or pellets, as analysis of their contents is an efficient sampling technique for prey animals. All tracks within the survey area were searched on foot and searches were undertaken for roosts of the powerful owl. Despite this, no predator scats or pellets were located.

Effort was also directed towards locating the characteristic chewed cones of she-oak species (in the reserves forest she-oak (*Allocasuarina torulosa*)) that are left behind by foraging glossy black-cockatoos (*Calyptorhynchus lathami*). Whenever a forest she-oak was encountered during the survey periods, the ground beneath it was searched for chewed cones.

As detailed above, OEH standard systematic bat ultrasound survey involves deploying a detector overnight. However, due to the risk of equipment theft or vandalism, in the spring period sites were only sampled for a period of 3-3.5 hours after dusk. An Anabat SD1 detector was used. The detectors were either set and left in locations where bats were expected to fly within a site, such as over waterbodies, in forest openings or along tracks, or were carried while undertaking other survey activities, such as spotlighting. As this method is not systematic, records collected were treated as incidental observations.

Incidental sightings were recorded of fauna encountered opportunistically during the survey, particularly of species infrequently located using the above techniques and/or rare within the region. The date, time, observer, map grid location (obtained from a GPS) and microhabitat of the animal were recorded on a data sheet.

All fauna records collected during the opportunistic survey techniques and incidental sightings were entered into the BSS of the Atlas of NSW Wildlife.

2.4.4 Survey timing

The 2011-12 systematic and targeted field surveys were undertaken between October 2011 and May 2012. Table 2 summarises the timing of all systematic and targeted survey techniques.

Table 2: Timing of systematic and targeted fauna surveys conducted within the two reserves during the current survey

Timing	Systematic techniques employed	Targeted and opportunistic techniques employed
14-16 October 2011	Diurnal bird survey, diurnal herpetofauna search, nocturnal streamside search, nocturnal site spotlighting, harp trapping, and nocturnal call playback.	Small mammal trapping, setting up infra-red camera traps, red-crowned toadlet playback along all main drainage lines, part night bat ultrasound recording, predator scat searches, searches for chewed she-oak cones, incidental sightings.
15 October-12 November 2011	-	Monitoring by and retrieval of infra-red camera traps.
14-16 March 2012	Harp trapping, bat ultrasound recording and nocturnal call playback.	Setting up infra-red camera traps, predator scat searches, searches for chewed she-oak cones, incidental sightings.
15 March - 25 April 2012	-	Monitoring by and retrieval of infra-red camera traps.

2.4.5 Survey site locations and effort

A total of seven systematic sites were established and surveyed in the two reserves as part of the current survey. Not all techniques were undertaken at all sites. Maps 3 and 4 show the location of systematic survey sites and Map 5 shows the location of targeted survey techniques that have been entered into the BSS. Table 3 summarises the amount of OEH standard systematic survey work and targeted survey work undertaken during the current survey, broken down by technique type. The red-crowned toadlet call playback locations have not been entered into BSS and are not shown in Map 5 or Table 3.

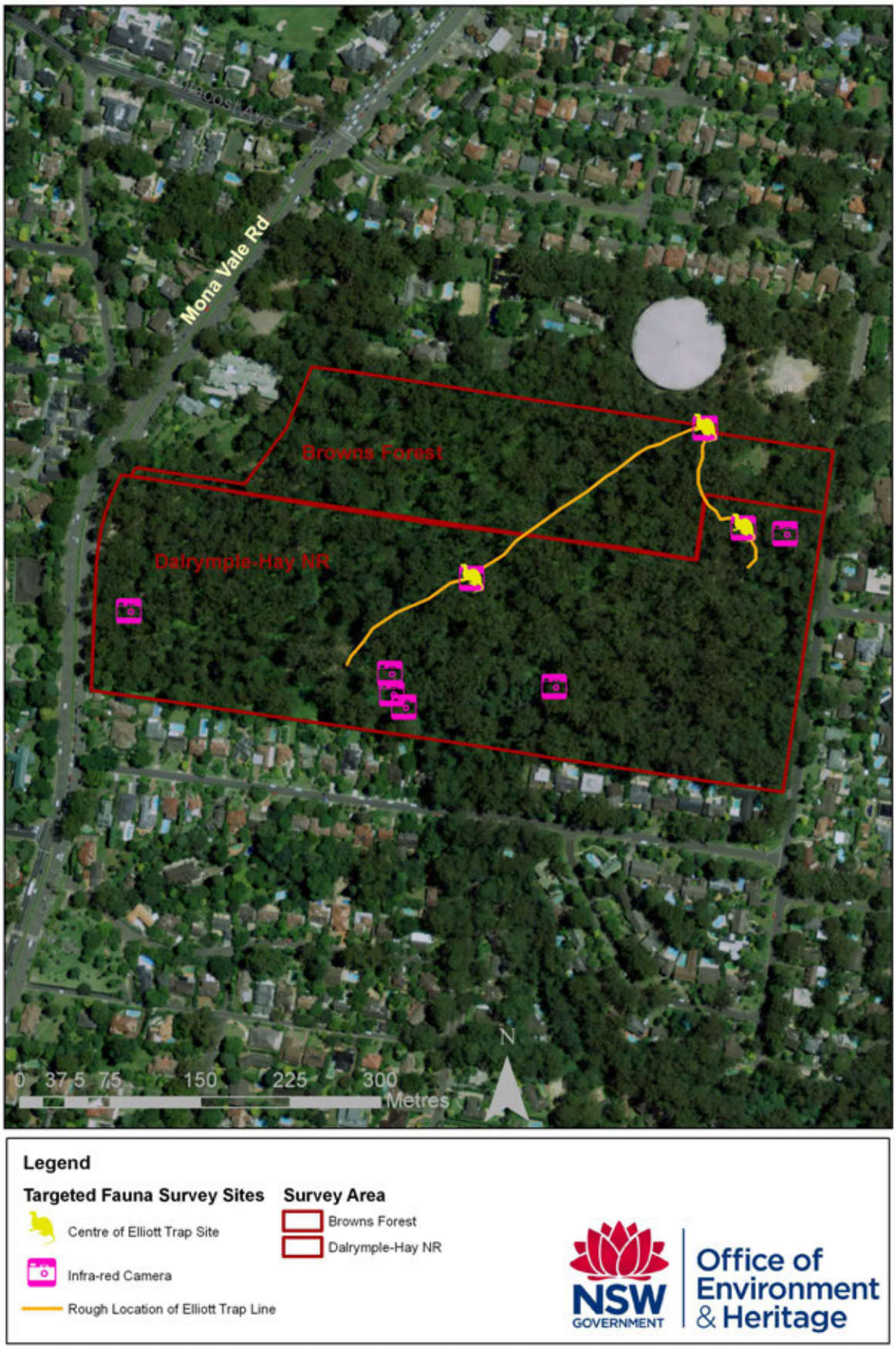
Table 3: Summary of systematic and targeted fauna survey effort conducted within the two reserves during the current survey

Reserve	Diurnal bird survey	Diurnal herpetofauna search	Nocturnal site spotlighting survey	Harp trapping	Bat ultrasound recording	Nocturnal streamside search	Nocturnal call playback	Small mammal trapping	Infra-red camera trap
Dalrymple-Hay NR	4	6	5	8	1	1	3	2	8
Browns Forest	1	1	0	2	1	0	1	1	1
Total	5	7	5	10	2	1	4	3	9

Map 3: **Location of OEH standard systematic diurnal survey sites in Dalrymple-Hay Nature Reserve and Browns Forest in the current survey**

Map 4: **Location of OEH standard systematic nocturnal survey sites in Dalrymple-Hay Nature Reserve and Browns Forest in the current survey**

Map 5: **Location of targeted small mammal and infra-red camera trapping sites in Dalrymple-Hay Nature Reserve and Browns Forest in the current survey**



3 METHODS USED TO ASSESS AND PRIORITISE SPECIES AND THREATS

3.1 SPECIES

Three ranking processes were undertaken to help identify fauna species that require 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. In addition, species considered to be locally significant (but not already included as priority species) were identified.

3.1.1 Definition of priority species

On completion of the field survey and compilation of the species inventory, the fauna species list was examined to identify *priority species*. Each priority species has a species profile to detail their current status in the reserves. This is presented in sections 5 and 6. A priority species is any fauna species with record(s) from within the survey area's boundary that meets one of the following criteria.

- **Listed as threatened under the TSC Act and/or the EPBC Act.** This includes all species reported from the reserves that currently occur or are known to have occurred in the past as well as species only known from unconfirmed records or records with low spatial accuracy.
- **Introduced species that are recognised as a key threatening process (KTP).** This includes introduced terrestrial vertebrates that are listed as a KTP under the TSC Act and/or the EPBC Act. One species, the black rat (*Rattus rattus*), is listed as a KTP only on off-shore islands, but was never-the-less included (see section 6).

3.1.2 Setting the management ranking for native priority species

Land managers are faced with a long list of threatened fauna species to manage, however not all require the same level of effort directed towards them. Some warrant active site-based management or further survey or monitoring, while others simply require general conservation management of habitats within the reserves. For the two reserves, each native priority species has been ranked as to its priority for active conservation management. Ranks were determined by assessing information on a species' status within the survey area and relating this to information gained from research and conservation assessments across the Sydney basin over the past 15 years. The term region (when used on its own in this report) refers to the Sydney Metropolitan Catchment Management Authority (SMCMA) area. Note that some threatened species were given a 'nil' priority ranking as they are either locally extinct or all records from the reserve were reviewed and assessed as inaccurate.

The rankings are defined as follows:

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

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

Moderate: Species for which there is currently inadequate information to assess their status in the reserves and are not reserved in high numbers elsewhere in the region. These species have been sighted within the reserves on very few occasions and there is a lack of information on their current distribution or rate of occupation of suitable habitats. If more information is gained on these species in the survey area and other reserves in the region, a review of their status would likely see them moved to one of the other priority categories.

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

Nil as Inaccurate Record: Species that have been assessed as incorrectly recorded in the reserves, either by misidentification, inaccurately sited records or a data entry error.

3.1.3 Definition of locally significant species

On completion of the field survey and compilation of the species inventory, the fauna species list was examined to identify *locally significant species.* Locally significant fauna species are species that are resident in the reserves and are uncommon within small bushland remnants within the SMCMA area. These species are widespread and common to moderately common in larger forest areas throughout the Sydney Basin Bioregion (e.g. DECC 2007).

3.2 THREATS TO FAUNA

Locally significant species resident in the reserves are swamp wallaby (left, photo © M. Schulz), long-nosed bandicoot (centre, photo © OEH and sugar glider (right, photo © N. Williams).

3.2.1 Identifying threats to native fauna

Effective management of fauna species requires understanding the threats acting upon them. This project aimed to identify current threats in the two reserves, as well as those with the potential to emerge in the near future. Threats were identified by collating the following: KTPs listed under the TSC Act and/or the EPBC Act; observations of threats made during the 2011-2012 field surveys; assessment of the vulnerabilities of priority fauna species; threats noted in published or unpublished literature; and threats mentioned during discussions with park staff, bush regenerators and volunteers during the course of the project.

3.2.2 Setting priorities for threats

To enable management to be targeted to threats that pose the *greatest risk* to native fauna in the two reserves, all threats identified were classed and ranked. These rankings were determined by collating all known information about threats and species in the reserves and relating this to information from research and conservation assessments across the Sydney basin from the past 15 years. Ranks may require review when more comprehensive information on the conservation status of a species becomes available, further research on threats is conducted or new threats become apparent.

An algorithm was developed to assess the relative importance of threats that were identified as acting upon vertebrate fauna in these reserves. This algorithm multiplied scores given to each threat for: a) the number of priority species that were impacted by the threat (species impacted), b) the eventual seriousness of that threat should it occur (severity) and c) the likelihood of that threat eventuating (risk) (see Table 4).

Threat importance score = species impacted score X severity score X risk of occurrence score

The score for 'threat importance' was used to split threats into three categories – very high (score above 20), high (10-19), and moderate (less than 10). Threats that are not currently acting within the reserve but have the potential to do so (e.g. climate change) were unranked and labelled 'future threats'.

Table 4: Factors used to calculate the importance of threats to fauna identified in the two reserves

Category	Rank	Definition	Score
Species impacted	Very high	Known or potentially impacting on more than one of the Highest Priority fauna species.	4
	High	Known or potentially impacting on over half of the High Priority fauna species.	3
	Moderate	Known or potentially impacting less than half of the High Priority fauna species and/or more than half of the Moderate Priority fauna species.	2
	Low	Key current threats not considered to be Very High, High or Moderate.	1
Severity	High	Serious impact resulting in significant mortality of priority species.	3
	Moderate	Moderately serious impact resulting in some mortality and/or reduced population viability (e.g. reduced foraging or nesting habitat).	2
	Low	Lower seriousness with some impact on long-term population viability.	1
Risk of occurrence	High	Likely to occur with limited ability to mitigate this risk.	3
	Moderate	Moderately likely to occur, or likely to occur but currently being widely mitigated or able to be mitigated.	2
	Low	Lower likelihood of occurrence.	1

4 THE SPECIES INVENTORY

4.1 EXCLUDED SPECIES RECORDS

Following the field surveys and data audit, a species inventory for the two reserves was collated. The inventory is provided at the end of this report (Appendix A). A number of species that had previously been documented as present within the reserves were removed from the final inventory (listed in Table 5). Excluded species are presented here for reference, as the records remain in the Atlas of NSW Wildlife (OEH 2011) or in existing inventories or plans of management (e.g. DEC 2004).

Table 5: Species excluded from the inventories provided in this report

Common name	Scientific name	Reason for omission from species inventory
White-necked heron	*Ardea pacifica*	*Overhead species* – Mentioned as occurring in Anon. (2006). However, this species prefers terrestrial wetlands and grasslands (Marchant and Higgins 1990) rather than tall open forest. No suitable habitat is present within the reserves. Therefore, it is likely that this species was recorded flying over the reserves and should not be considered part of the reserves' avifaunal assemblage.
Double-banded plover	*Charadrius bicinctus*	*Overhead species* – Mentioned as occurring in Anon. (2006). However, this species prefers ocean beaches, estuarine shorelines and occasionally inland lake and swamp edges (Marchant and Higgins 1993) rather than tall open forest. No suitable habitat is present within the reserves. Therefore, it is likely that this species was recorded flying over the reserves and should not be considered part of the reserves' avifaunal assemblage.
Masked lapwing	*Vanellus miles*	*Overhead species* – Mentioned as occurring in Anon. (2006) and heard calling at the east end of Browns Forest between 7 and 8 January 2004 by P. and J. Smith as part of the Ku-ring-gai Council scientific survey. However, this species prefers wetlands and open grassy habitat (e.g. Marchant and Higgins 1993) rather than tall open forest. No suitable habitat is present within the reserves. Therefore, it is likely that this species was recorded either flying over or heard calling adjacent to the reserves and should not be considered part of the reserves' avifaunal assemblage.
Jacky winter	*Microeca fascinans*	*Unconfirmed species* – Mentioned as occurring in Anon. (2006). However, this species prefers lightly wooded habitats with a sparsely vegetated ground layer (e.g. Higgins and Peter 2002) rather than moist tall open forest with a generally dense understorey. Therefore, the presence of this species in the reserves is considered unconfirmed.
Eastern false pipistrelle	*Falsistrellus tasmaniensis*	*Unconfirmed species* – reported from Anabat recordings by Basham (2005), although no confidence rating was assigned to the records. Also ultrasonic calls attributed to either this species or the eastern broad-nosed bat (*Scotorepens orion*) were recorded in Browns Forest on 3 January 2004 by P and J Smith as part of the Ku-ring-gai Council scientific survey of the area. Given that the ultrasonic signals of this bat are readily confused with the greater broad-nosed bat (*Scoteanax rueppellii*), Gould's wattled bat (*Chalinolobus gouldii*) 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 Sydney Basin Bioregion due to the absence of capture records even though this species is readily trapped when known to occur in an area. All records in the Atlas of NSW Wildlife in coastal areas of Sydney are based on Anabat recordings (e.g. DECC 2007, 2008a). Therefore, the presence of this species in the reserves is considered unconfirmed.

4.2 FAUNA SPECIES INVENTORY

A total of 129 native vertebrate fauna species have been recorded in Dalrymple-Hay NR and Browns Forest combined within the last 25 years comprising six frog, 12 reptile, 94 native bird and 17 native mammal species (Table 6, Appendix A). In addition, six introduced bird and four introduced mammal species have been confirmed to occur within the reserves in the last 25 years. It is unlikely that any species is limited to one of the two reserves. Rather all species recorded are likely to occur within both the two contiguous reserves as well as in neighbouring residential areas. In the current survey four frog, seven reptile, 54 bird and 13 mammal species were recorded, including 12 species that had not been previously been documented within the reserves. These species were the bleating tree frog (*Litoria dentata*), bar-sided skink (*Eulamprus tenuis*), three-toed skink (*Saiphos equalis*), golden-crowned snake (*Cacophis squamulosus*), musk lorikeet (*Glossopsitta concinna*), noisy pitta (*Pitta versicolor*), silvereye (*Zosterops lateralis*), mistletoebird (*Dicaeum hirundinaceum*), chocolate wattled bat (*Chalinolobus morio*), eastern broad-nosed bat (*Scotorepens orion*), little forest bat (*Vespadelus vulturnus*) and the introduced house mouse (*Mus musculus*).

Table 6: Number of vertebrate fauna species known to occur in the reserves

	Number of species
Total number of native fauna species known to occur	129
Number of species listed as threatened under the TSC Act	8
Number of species listed as threatened under the EPBC Act	1
Number of introduced mammals	4
Number of introduced birds	6

4.2.1 Amphibians

Six species of amphibian have been recorded from the reserves, with no species listed as threatened under the TSC Act or the EPBC Act. The most frequently heard species was Peron's tree frog (*Litoria peronii*), which was most commonly heard calling in properties adjacent to the reserves. Within the reserves individuals were heard calling from high up in stags and living trees, particularly adjacent to the Sydney Water land in Browns Forest. The leaf-green tree frog (*Litoria phyllochroa*) is widespread adjacent to pools in densely vegetated drainage lines across the reserves, while the common eastern froglet (*Crinia signifera*) was confined to pools in the lower reaches of High Ridge Creek adjacent to the Perimeter Track. The bleating tree frog was recorded for the first time in the current survey; one individual was heard during the day from a grey ironbark (*Eucalyptus paniculata*) stag adjacent to Sydney Water land in Browns Forest. One species that had previously been recorded in the reserves, the brown-striped frog (*Limnodynastes peronii*) was not located during the current survey but is likely to occur in and adjacent to deeper pools, particularly along the lower reaches of High Ridge Creek. All larger drainage lines were traversed during the survey to target the threatened red-crowned toadlet. Targeted surveys comprised the broadcasting of this species' call at intervals through a speaker. However, no individuals were located.

Peron's tree frog was most commonly heard callling in properties adjacent to the reserves. Photo © M. Schulz

4.2.2 Reptiles

Twelve species of reptile have been recorded from the reserves, comprising one dragon, one goanna, seven skinks and three snakes. No species listed under the TSC Act or the EPBC Act have been recorded within the reserves and all species are widespread within the northern fringes of the Sydney metropolitan area. The current survey added three species to the reserves' species list; the bar-sided skink, three-toed skink and the golden-crowned snake. The most commonly encountered

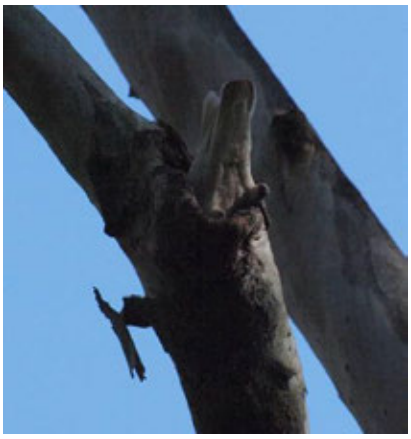
The dark-flecked garden sunskink is common in the reserves. Photo © M. Schulz

reptiles during the survey were the eastern water-skink (*Eulamprus quoyii*) and the dark-flecked garden sunskink (*Lampropholis delicata*). A number of species were only recorded in small numbers, including the weasel skink (*Saproscincus mustelinus*) and the eastern blue-tongue (*Tiliqua scincoides*). Five species that are known to occur within the reserves were not located during the current survey. These species were the lace monitor (*Varanus varius*), eastern water dragon (*Physignathus lesueurii*), pale-flecked garden sunskink (*Lampropholis guichenoti*), red-naped snake (*Furina diadema*) and the red-bellied black snake (*Pseudechis porphyriacus*). Given the small size of the reserve, the presence of the lace monitor is surprising. The sporadic nature of records suggests that possibly individuals occasionally range into the area rather than being resident. The most recent record was of a large individual observed along the Centre Track in January 2012 (A. Duffy pers. comm.).

The eastern water-skink is common in the survey area – here one is seen sunning itself on a boardwalk in Browns Forest (left). The golden-crowned snake (right) was documented for the first time in the reserves during the current survey. Photos © M. Schulz

4.2.3 Native birds

Birds are the most obvious form of wildlife that visitors encounter in the reserves, with a variety of parrots and other hollow-nesting species filling the air with a cacophony of sound. The avifauna present is typical of that occurring in wet sclerophyll forest in the SMCMA area (e.g. DECC 2008a). In all 94 species of native birds have been recorded (Appendix A). This includes four species listed under the TSC Act but no species listed under the EPBC Act (section 5.2). The powerful owl is the only resident threatened species occurring in the reserves. The other species are infrequently recorded and were not located during the current survey (refer to section 5.2). During the survey two recently fledged powerful owls were observed at a number of locations in the southern section of Dalrymple-Hay NR indicating this species is likely to nest in the area.



Tree hollows are a very important habitat resource in the reserves. Here a little corella is inspecting a hollow in a Sydney blue gum. Photo © M. Schulz

The most obvious component of the avifauna are the hollow-nesting birds, in particular various parrot species. The most prevalent parrots are the rainbow lorikeet (*Trichoglossus haematodus*), sulphur-crested cockatoo (*Cacatua galerita*), little corella (*C. sanguinea*), crimson rosella (*Platycercus elegans*), eastern rosella (*P. eximius*), Australian king-parrot (*Alisterus scapularis*) and the galah (*Eolophus roseicapillus*). The majority of these species nest and roost in the reserves but range out into surrounding areas to feed, in particular more typically open-country species such as the little corella and galah. Two hollow-nesting species were only recorded in the autumn survey: the musk lorikeet and the scaly breasted lorikeet (*Trichoglossus chlorolepidotus*). Other prominent hollow-nesting species present within the reserves include the dollarbird (*Eurystomus orientalis*) and the laughing kookaburra (*Dacelo novaeguineae*). A number of other bird species are prominent in the high forest canopy, such as the black-faced cuckoo-shrike (*Coracina novaehollandiae*), spotted pardalote (*Pardalotus punctatus*) and mistletoebird. A variety of raptors have been recorded primarily above the canopy with two species, the brown goshawk (*Accipiter fasciatus*) and pacific baza (*Aviceda subcristata*) recorded in the current survey. A number of other species recorded are likely to be only rarely encountered hunting over the reserves,

such as the wedge-tailed eagle (*Aquila audax*). Other bird species that were recorded in the current survey hawking insects above the high forest canopy were the welcome swallow (*Hirundo neoxena*) and the white-throated needletail (*Hirundapus caudacutus*).

The eastern yellow robin occurs in dense shrubby areas of the reserves. Photo © M. Schulz

The avifauna in the subcanopy and shrubbery tends to be overshadowed by the cacophony made by the species overhead. However, a number of species are well represented in dense shrubland areas, including sections of the reserves dominated by weed species such as lantana. These species included the brown gerygone (*Gerygone mouki*), white-browed scrubwren (*Sericornis frontalis*), eastern whipbird (*Psophodes olivaceus*), brown thornbill (*Acanthiza pusilla*) and eastern yellow robin (*Eopsaltria australis*). A number of summer migrants frequent shrubbier sections of the reserves, in particular the rufous fantail (*Rhipidura rufifrons*) and black-faced monarch (*Monarcha melanopsis*). A small population of Australian brush-turkeys (*Alectura lathami*) frequents the reserves although no mounds were located during the current survey. One species that had previously not been recorded in the reserves, the noisy pitta, was detected by an infra-red camera set in dense understorey along High Ridge Creek. This species is poorly known in the Sydney area, primarily occurring as a rare sporadic visitor mostly between April and July (Higgins et al. 2001). An infra-red camera also detected the only record in the current survey of a collared sparrowhawk (*Accipiter cirrocephalus*). One individual was photographed in Browns Forest stalking prey on the ground in dense shrubbery.

Forty-three per cent of the birds known from the reserves were not located during the current survey (Appendix A). These species can be divided into the following categories: a) infrequent visitors to the reserves, such as the cicadabird (*Coracina tenuirostris*), fork-tailed swift (*Apus pacificus*), striated pardalote (*Pardalotus striatus*) and various honeyeater species; b) edge species that occasional range into the reserves, such as the magpie lark (*Grallina cyanoleuca*) and willie wagtail (*Rhipidura leucophrys*); c) species that have declined in the SMCMA area and are currently unlikely to occur within the reserves, such as the peaceful dove (*Geopelia striata*) and pallid cuckoo (*Cacomantis pallidus*); d) vagrants to the reserves, such as the white-headed pigeon (*Columba leucomela*), topknot pigeon (*Lopholaimus antarcticus*) and oriental cuckoo (*Cuculus optatus*); and e) species that may once have occurred but now appear to be locally extinct possibly as a result of small population size, reserve isolation and undocumented stochastic events, such as the white-throated treecreeper (*Cormobates leucophaea*), grey shrike-thrush (*Colluricincla harmonica*) and the large-billed scrubwren (*Sericornis magnirostra*). Further survey work during different seasons of the year over several years is required to confirm the disappearance of these latter species.

Birds that may no longer occur within the reserves include white-throated treecreeper (left), grey shrike-thrush (centre) and large-billed scrubwren (right). Photos © M. Schulz

4.2.4 Native mammals

Seventeen species of native mammal have been recorded in the reserves. Bats comprise 67 per cent of the total number of native mammal species. Three insectivorous bat species were documented for the first time during the current survey: the chocolate wattled bat, eastern broad-nosed bat and the little forest bat. Four native mammal species listed under the TSC Act and one species listed under the EPBC Act occur, all of which are bat species (Appendix A; see species profiles in section 5.2). Four native mammal species occurring on the reserves are identified as locally significant: long-nosed bandicoot, sugar glider, swamp wallaby and eastern broad-nosed bat.

A large amount of small mammal trapping has been conducted in recent years, with the same transects and trapping formation used in the past three years (refer to section 2.1.1). In the current survey small mammal trapping targeted areas of the reserves that were not covered by these previous trapping projects. The results of recent trapping surveys, including the current survey, indicated the absence of small native ground-dwelling mammals with no native rats or antechinus recorded. The only small mammal species captured in these surveys was the introduced black rat. In the current survey the only native mammal trapped in a total of 308 trap nights (Elliott and cage traps combined) was a single juvenile long-nosed bandicoot (*Perameles nasuta)*. The only small mammal species detected during the total of 315 camera nights was the introduced black rat. The black rat comprised 17 per cent of animals photographed during the spring period and 32 per cent during the autumn period. The absence of small native mammals, such as the bush rat or brown antechinus, from the reserves is not surprising given that in Sydney these species are not known from bushland less than 199 hectares in area (Matthews et al. 1999).

The infra-red camera traps detected a total of 14 fauna species including long-nosed bandicoot (right). Photographs taken by the cameras show that the reserves support a breeding population of swamp wallabies (left). Photos © OEH

The swamp wallaby was the most commonly detected ground-dwelling mammal species in the reserves. Photo © M. Schulz

The swamp wallaby was the most commonly detected ground-dwelling mammal in the reserves. This macropod species comprised 66.1 and 41.3 per cent of animals photographed during the spring and autumn infra-red camera sample periods respectively. At least three different individuals were observed during a spotlighting census adjacent to Rosedale Road in the spring survey. An important result of the infra-red camera trapping was the confirmation that this species breeds within the reserves, with both pouch young and young at foot being photographed. The other ground-dwelling mammal species that was frequently observed during the current survey was the long-nosed bandicoot. This species comprised 7.9 per cent and 11.5 per cent of animals photographed during the spring and autumn infra-red camera sample periods respectively. As mentioned above, one juvenile was captured in an Elliott A trap. In addition, diggings were encountered at all seven systematic survey sites as well as numerous other locations within the reserves. Duffy (2011) trapped nine individuals in 64 cage trap nights, but none in Elliott traps. The presence of this species in the reserves is of local significance.

The status of the short-beaked echidna (*Tachyglossus aculeatus*) in the reserves is uncertain. The few sightings that have been made may be either of wide-ranging individuals from adjacent extensive bushland areas or of released individuals. During the current survey no individuals were seen or photographed by infra-red camera traps and no characteristic diggings or footprints were located.

The grey-headed flying-fox (*Pteropus poliocephalus*) frequently forages within the reserves, their presence dependant on which canopy and subcanopy trees are in flower there and elsewhere. During the current survey large streams of individuals were observed flying overhead at dusk in both October

and March as they flew out from the nearby Gordon colony. Small numbers were observed feeding in flowering turpentine in the reserves in October.

The reserves support an assemblage of insectivorous bats that corresponds to other reserves in shale forest areas in northern Sydney, such as Cumberland State Forest and Sheldon Forest (Basham 2005). Basham (2005) found that the shale reserves had higher micro-bat activity, species richness and a different species composition to other forest remnants occurring on poorer soils, such as sandstone geologies. This assemblage of insectivorous bats may reflect greater productivity, as these areas support greater insect biomass and correspondingly greater foraging activity; this is in addition to the extensive hollow formation of the tall trees present within the reserves.

The white-striped freetail-bat is common in the greater Sydney area and was recorded in the reserves. Photo © M. Schulz

A number of species not recorded by Basham (2005) were detected using Anabat during the current survey. These species were the white-striped freetail-bat (*Tadarida australis*), chocolate wattled bat and little forest bat. All these additional species have been recorded from other shale forest reserves in northern Sydney (e.g. Basham 2005) and their presence in the reserves is not surprising. Additionally, the Gould's long-eared bat (*Nyctophilus gouldi*) was recorded in Browns Forest during the Ku-ring-gai Council scientific survey of the area.

In the current survey, a surprising result was that no individuals were captured in harp traps set at five localities across the reserves for a total of 10 harp trap nights in the spring survey and 10 harp trap nights in the autumn survey. Additionally, no insectivorous bats were spotlighted during the spring survey, and during this period in six sample hours only 64 passes (comprising 64 per cent unidentified signals and the calls of six identified species) were recorded using Anabat. The nil capture rate and small number of passes of insectivorous bats is surprising and contrasted with the findings of Basham (2005).

Gould's wattled bat was one of the most frequently identified species using Anabat in the current survey. Photo © M. Schulz

In the autumn survey a much larger number of calls were recorded with Anabat. Two nights of all-night Anabat sampling in autumn resulted in the recording of 321 bat calls, which was within the range of calls recorded from sites in northern Sydney over two nights by Basham (2005) and for the Sydney area by Threlfall et al. (2012). Of these, 158 calls (49 per cent total calls recorded) were identified, with records dominated by the Gould's wattled bat (51 per cent) and the eastern freetail-bat (25 per cent). Both these species share traits with other bats commonly encountered in cities around the world, including lower frequency echolocation, and relatively high wing loading and aspect ratio (Avila-Flores and Fenton 2005, Everette et al. 2001). The dominance of these two species corresponds to other Anabat studies in Sydney in which these two species accounted for a high percentage of ultrasonic signals recorded (Basham 2005, Threlfall et al. 2012). The high percentage of unidentified calls was due to many recorded call sequences being of either less than three individual call pulses in a recorded sequence or of poor quality calls due to the bat either flying away or being distant from the Anabat recorder. Only small numbers of ultrasonic signals of other species were identified: eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) (six per cent of calls recorded), unidentified long-eared bat (*Nyctophilus* spp.) (six per cent), white-striped freetail-bat (four per cent) and the eastern broad-nosed bat (two per cent). The eastern broad-nosed bat was not recorded by Basham (2005), although it has been detected from other shale forest reserves in northern Sydney and therefore its presence in the reserves is not surprising. The remaining six per cent of calls were attributed to the species group comprising the greater broad-nosed bat, eastern broad-nosed bat or the eastern false pipistrelle, but could not be identified to species level due to the difficulty of separation based on ultrasonic signal characteristics

(Pennay et al. 1994). Interestingly, in this autumn period no little forest or chocolate wattled bats were recorded.

Four species occurring within the reserves have been classified as tolerant to urbanisation (Gould's wattled bat, eastern freetail-bat, white-striped freetail-bat and the eastern bentwing-bat), while the majority of the remaining species confirmed to occur are considered moderately sensitive to disturbance (i.e. east-coast freetail-bat, chocolate wattled bat, Gould's long-eared bat, eastern broad-nosed bat and the little forest bat) (Threlfall et al. 2012). It is considered that although reserves such as Dalrymple-Hay NR and Browns Forest only cover a small area, the maintenance of such small productive suburban remnants should be a management imperative. Patch quality is likely more important than patch size for bats, with lower species diversity found in larger patches of bushland on poorer soils within the Sydney area (Fischer et al. 2010, Threlfall et al. 2012).

Three arboreal mammal species have been recorded within the reserves. The common ringtail possum (*Pseudocheirus peregrinus*) was the most frequently located during the current survey. The common brushtail possum (*Trichosurus vulpecula*) was photographed at four sites by the infra-red camera traps (Appendix B) and during the autumn period one individual was observed at dusk emerging from a shed adjoining High Ridge Creek and moving into Dalrymple-Hay NR to feed. In contrast the third arboreal mammal species, the sugar glider, has only occasionally been recorded (e.g. Duffy 2011). The only record from the current survey was of an individual that called during a nocturnal call playback census for forest owls along the Centre Track.

Three micro-bat species were detected using Anabat for the first time in the reserves: the chocolate wattled bat (left), little forest bat (centre), and the eastern broad-nosed bat (right). Photos © M. Schulz

4.2.5 Introduced birds and mammals

Six introduced bird species and four introduced mammal species have been recorded in the reserves in the last 25 years. Three introduced mammal and two introduced bird species were recorded during the current survey. The introduced species are detailed in section 6 of this report.

Feral bird species recorded on the edge of the reserves were common myna (left), spotted dove (centre) and rock dove (right). Photos © M. Schulz

5 PROFILES OF THREATENED SPECIES

5.1 FORMAT OF THE SPECIES PROFILES

Colour of the heading correlates to that used for animal groups in DECC (2007) being amphibians, reptiles, diurnal birds, nocturnal birds, terrestrial mammals, arboreal mammals and bats.

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 Reserves

This section details the species status in the reserves (i.e. Dalrymple-Hay NR and Browns Forest), 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 reserves to the conservation of the species in the Sydney Metropolitan Catchment Management Authority (SMCMA) area.

Threats in the Reserves

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

5.2 THREATENED SPECIES PROFILES

GLOSSY BLACK-COCKATOO		*CALYPTORHYNCHUS LATHAMI*
EPBC Act: Not Listed	TSC Act: Vulnerable	Survey Area: Low Priority

Glossy black-cockatoo. Photo © N. Williams/OEH

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

Occurrence in the Reserves

Rare visitor with few recent records (Anon. 2006, OEH 2011). This species was not recorded during the current survey. The current survey included searches for the chewed cones that the species characteristically leaves beneath forest oak (*Allocasuarina torulosa*) (see photo), but failed to locate any evidence of the species presence. Similarly, the species was not recorded during the Ku-ring-gai Council scientific survey of Browns Forest.

Regional Conservation Significance

There are a number of recent records of the glossy-black cockatoo in the northern part of the SMCMA area, including around Belrose, Narrabeen and in Garigal NP (OEH 2011). The species is rare in the southern parts of the region and very rare on the Woronora Plateau. The scarcity of this species in Dalrymple-Hay NR and Browns Forest, despite suitable food trees being present, may be a reflection of the reserves' isolation from other suitable habitat, such as from Garigal and Ku-ring-gai national parks. Currently the reserves are not considered to significantly contribute to the regional conservation of this species.

Threats in the Reserves

No threats identified due to the rarity of the species within the two reserves.

Management Considerations

- Due to the rarity of the species within the reserves, no management actions specific to this species are required in the reserves at this time.
- Encourage visitors to the reserves and bush regenerator personnel to report any sightings and enter these in the Atlas of NSW Wildlife.

LITTLE LORIKEET		GLOSSOPSITTA PUSILLA
EPBC Act: Not Listed	TSC Act: Vulnerable	Survey Area: Low Priority

Little lorikeet. Photo © H. Cook

Occurrence in the Reserves

Rare visitor, with few recent records (Anon. 2006, OEH 2011). This species was not recorded within the reserves during the current survey, during the Ku-ring-gai Council scientific survey or by N Clark and N and G Jones (unpublished records). Movements of this species are irregular and the number of individuals present in any given area varies between years depending on the prevalence of key flowering trees. Important flowering trees within the survey area include the blackbutt (taken from Higgins 1999). The little lorikeet is likely to be an infrequent visitor to the reserves, primarily occurring when the blackbutt is in flower.

Regional Conservation Significance

The little lorikeet is a declining species across the region (Hoskin et al. 1991), but is still a regular visitor to many bushland remnants in the SMCMA, such as Georges River catchment, Royal NP and the Woronora Plateau (OEH 2001a). In this region the little lorikeet primarily feeds in the canopy of flowering eucalypts (Higgins 1999). Due to the species only been a rare irregular visitor to the reserves, and that habitat is reserved elsewhere, currently Dalrymple-Hay NR and Browns Forest are not considered to significantly contribute to the regional conservation of this species.

Threats in the Reserves

No threats identified due to the rarity of the species within the two reserves.

Management Considerations

- Due to the rarity of the species within the reserves, no management actions specific to this species are required in the reserves at this time.
- Encourage visitors to the reserves and bush regenerator personnel to report any sightings and enter these in the Atlas of NSW Wildlife.

POWERFUL OWL		NINOX STRENUA
EPBC Act: Not Listed	TSC Act: Vulnerable	Survey Area: High Priority

Powerful owl with greater glider (not taken within the survey area). Photo © M. Schulz

Occurrence in the Reserves

Regularly recorded resident. At least one pair of powerful owls is resident in the reserves (e.g. Duffy 2011). During the spring period of the current survey two recently fledged individuals were seen and heard, suggesting that the species nests within Dalrymple-Hay NR. This species has been recorded roosting during the day adjacent to High Ridge Creek on a number of occasions (A. Duffy pers. comm.).

Regional Conservation Significance

The powerful owl is relatively common and widespread in the region, particularly south of Port Hacking and north of Sydney Harbour (OEH 2011). It is due to the likely nesting of this owl in the survey area that the reserves are considered to significantly contribute to the regional conservation of this species.

Threats in the Reserves

The removal of hollow-bearing trees and dead trees through reserve management practices, such as adjacent to adjoining private land boundaries; clearance of potential nest and roost trees on neighbouring private land; disturbance at known roosts; uncontrolled use of call playback; predation of fledglings by the fox and cat; road mortality; and hollow competition with the introduced honeybee (*Apis mellifera*) and the common myna.

Management Considerations

- Follow relevant management recommendations outlined in the statewide recovery plan (DEC 2006b).
- Search for nesting tree(s) and then ensure their protection.
- Avoid felling any hollow-bearing or dead standing trees.
- Avoid the clearance of remnant canopy trees on the reserve boundary and on adjacent private land.
- Discourage the use of call playback by birdwatchers.
- Eradicate colonies of honeybees using tree hollows within the reserves.
- Eradicate pairs of common mynas using tree hollows within the reserves.
- Maintain the band of riparian vegetation linking the reserves to Garigal NP.
- Monitor the presence of the fox in the reserves by remote infra-red cameras and when detected take steps to eliminate individuals present.
- Reduce the incidence of domestic cats accessing the reserve from adjoining private properties.

BARKING OWL		*NINOX CONNIVENS*
EPBC Act: Not Listed	TSC Act: Vulnerable	Survey Area: Low Priority

Barking owl. Photo © M. Schulz

Occurrence in the Reserves

Rare visitor. This species was recorded by Anon. (2006) and bush regenerators heard an individual calling approximately 500 metres south-west of Dalrymple-Hay NR in autumn 2010 (Duffy 2011). No individuals were located during the current survey despite being targeted by four nocturnal call playback censuses in autumn. Similarly this species was not recorded in Browns Forest during the Ku-ring-gai Council scientific survey.

Regional Conservation Significance

There are only a small number of recent records of the barking owl in the region, including nearby Lane Cove NP (e.g. DECC 2008a). Due to the fact that the species appears to be only a rare irregular visitor to the reserves, Dalrymple-Hay NR and Browns Forest are not considered to significantly contribute to the regional conservation of this species.

Threats in the Reserves

No threats identified due to the rarity of the species within the two reserves.

Management Considerations

- Due to the rarity of the species within the reserves, no management actions specific to this species are required in the reserves at this time.
- Encourage visitors to the reserves and bush regenerator personnel to report any sightings and enter these in the Atlas of NSW Wildlife.
- In the advent of individuals becoming resident follow relevant management recommendations outlined in the statewide recovery plan (NPWS 2003).

GREY-HEADED FLYING-FOX		*PTEROPUS POLIOCEPHALUS*
EPBC Act: Vulnerable	**TSC Act: Vulnerable**	**Survey Area: Moderate Priority**

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

Occurrence in the Reserves

Regular visitor when key plants are in flower. Key plant species are the blackbutt and to a lesser extent other tree species such as turpentine. There are no camps present within the reserves. The closest camp is located at Ku-ring-gai Flying-fox Reserve in Gordon, approximately two kilometres south-east of the survey area. Streams of individuals from this camp regularly fly out over the reserves at dusk. Individuals from the Gordon camp forage within the reserves when suitable canopy and subcanopy trees are in flower or fruit.

Regional Conservation Significance

The grey-headed flying-fox is a well-known feature of the wildlife of the region, with records across the SMCMA area (OEH 2011). However there are only few camps present in the region. The camp in Gordon has high regional conservation significance. The relative importance of different foraging habitats in the region is not well understood, particularly as there is large variation in food resources between years. The contribution that Dalrymple-Hay NR and Browns Forest make is uncertain, however at this stage the reserves are considered to support an important food source for the species, particularly when there are food shortages elsewhere in the region or state.

Threats in the Reserves

Clearance of potential roost trees on neighbouring private land and the edges of the reserves; road mortality; and electrocution on powerlines on the edge of the reserves.

Management Considerations

- Avoid the loss of key flowering trees (blackbutt and turpentine) as well as fruiting shrubs from the reserves and adjacent private land.
- Identify any powerline locations where bats are regularly electrocuted. If such black spots are identified, implement measures to reduce deaths. Potential measures may include making the powerlines more visible to grey-headed flying-foxes such as by putting up flags, thickening wires and/or cutting back foliage.

YELLOW-BELLIED SHEATHTAIL-BAT		*SACCOLAIMUS FLAVIVENTRIS*
EPBC Act: Not Listed	**TSC Act: Vulnerable**	**Survey Area: Moderate Priority**

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

Occurrence in the Reserves

Status uncertain. Yellow-bellied sheathtail-bat was not recorded during the current survey. This species was identified by ultrasonic call by Basham (2005), although no confidence rating was assigned to the record. The species was also recorded in Browns Forest on 13 March 2000 by Conacher Travers Environmental Consultants as part of the Ku-ring-gai Council scientific survey of the area. No details of this record, such as identification confidence rating, are provided. Yellow-bellied sheathtail-bat is readily distinguished by spotlight, but no records have been documented using this technique within the reserves.

Regional Conservation Significance

The status of the yellow-bellied sheathtail-bat in the SMCMA area is very poorly understood. There are a small number of Australian Museum specimens (primarily deriving from sick or dead animals), no capture records and a number of Anabat records, some of uncertain reliability (OEH 2011). In a study of microchiropteran bats occurring in northern Sydney, this species was identified from ultrasonic call at six out of 40 sites sampled (Basham 2005). Due to the uncertainty of the occurrence in the reserves and the species uncertain status within the region it is currently unclear how significantly the reserves contribute to the regional conservation of the species. If further records were collected on the reserves and/or a roost site was discovered, then the priority of the species would require review.

Threats in the Reserves

The removal of hollow-bearing trees and dead standing trees through reserve management practices, such as adjacent to adjoining private land boundaries; clearance of potential nest and roost trees on neighbouring private land; and hollow competition with the introduced honeybee and the common myna. Roosting individuals, particularly if young are present, may potentially be at predation risk from the introduced black rat.

Management Considerations

- Take a precautionary approach by maintaining tree hollow resources on the reserves as they have the potential to be roost sites. Maintain all hollow-bearing trees and standing dead trees in the reserves, avoid clearing canopy trees on the reserve boundary and adjacent private land, and eradicate colonies of feral honeybees or pairs of common mynas using tree hollows within the reserves.
- Consider establishing an annual monitoring program for micro-bats in the reserves using Anabat at set locations overnight on warm and dry nights in summer. An important component of such a program is that all ultrasonic signals recorded be analysed by a bat call expert. Survey effort and results should be entered into the BSS of the Atlas of NSW Wildlife.
- It is recommended that any Anabat recordings from the reserve provisionally identified as this species be sent to one or more bat call experts for confirmation.

EAST-COAST FREETAIL-BAT		*MORMOPTERUS NORFOLKENSIS*
EPBC Act: Not Listed	**TSC Act: Vulnerable**	**Survey Area: Moderate Priority**

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

Occurrence in the Reserves

Status uncertain. During the current survey, a call was identified as probably the east-coast freetail-bat, but identification could not be confirmed. This species was identified by ultrasonic call by Basham (2005).

Regional Conservation Significance

The majority of records of east-coast freetail-bat in the SMCMA area are from the western part of the region, particularly the Cumberland Plain, with scattered records in the northern and southern suburbs (OEH 2011). The species preferred habitat is grassy box woodlands on fertile soils in flatter terrain (DECC 2007). In a study of microchiropteran bats occurring in northern Sydney, this species was identified from ultrasonic call at six out of 40 sites sampled (Basham 2005). Due to the uncertainty of the occurrence in the reserves it is currently unclear how significantly the reserves contribute to the regional conservation of the species. If further records were collected on the reserves and/or a roost site was discovered, then the priority of the species would likely be elevated to high.

Threats in the Reserves

The removal of hollow-bearing trees and dead standing trees through reserve management practices, such as adjacent to adjoining private land boundaries; clearance of potential nest and roost trees on neighbouring private land; and hollow competition with the introduced honeybee and the common myna. Roosting individuals, particularly if young are present, may potentially be at predation risk from the introduced black rat.

Management Considerations

- Take a precautionary approach by maintaining tree hollow resources on the reserves as they have the potential to be roost sites. Maintain all hollow-bearing trees and standing dead trees in the reserves, avoid clearing canopy trees on the reserve boundary and adjacent private land, and eradicate colonies of feral honeybees or pairs of common mynas using tree hollows within the reserves.
- Consider establishing an annual monitoring program for micro-bats in the reserves using Anabat at set locations overnight on warm and dry nights in summer. An important component of such a program is that all ultrasonic signals recorded be analysed by a bat call expert. Survey effort and results should be entered into the BSS of the Atlas of NSW Wildlife.
- It is recommended that any Anabat recordings from the reserve provisionally identified as this species be sent to one or more bat call experts for confirmation.

EASTERN FALSE PIPISTRELLE		*FALSISTRELLUS TASMANIENSIS*
EPBC Act: Not Listed	**TSC Act: Vulnerable**	**Survey Area: Nil as Inaccurate Record**

Eastern false pipistrelle. Photo © M. Schulz

Occurrence in the Reserves

Occurrence unconfirmed. The eastern false pipistrelle was reported from Anabat recordings by Basham (2005), although no confidence rating was assigned to the records. Ultrasonic calls attributed to *either* the eastern false pipistrelle or the eastern broad-nosed bat (*Scotorepens orion*) were recorded in Browns Forest in January 2004 by P and J Smith as part of the Ku-ring-gai Council scientific survey, but identification to species level was not made. The ultrasonic signals of eastern false pipistrelle are readily confused with those of the greater broad-nosed bat (*Scoteanax rueppellii*), Gould's wattled bat (*Chalinolobus gouldii*) and the eastern broad-nosed bat (Reinhold et al. 2001, Pennay et al. 2004), making identification of the species by Anabat very difficult. Hence the presence of this species within the area is currently considered unconfirmed, and it has been removed from the species inventory for the reserves (see section 4.1). This approach is similar to that adopted elsewhere within the coastal part of the Sydney Basin Bioregion (e.g. DECC 2007, 2008a).

Regional Conservation Significance

All but three records of eastern false pipistrelle in the SMCMA area since 1980 derive from ultrasonic call identification (OEH 2011). This is despite extensive trapping of micro-bats in the region, and the fact that the species is readily trapped in harp traps. There is a concentration of trapping records of the species at higher elevations west of the SMCMA, including the Boyd Plateau, Newnes Plateau and Bindook Highlands; forested highlands provide the best quality habitat for this species (DECC 2007). Due to the difficulty in identifying this species by Anabat and the absence of records based on trapped individuals the survey area is not considered to contribute to the regional conservation of this species.

Threats in the Reserves

No threats identified in the reserves.

Management Considerations

- It is recommended that any Anabat recordings from the reserve provisionally identified as this species be sent to one or more bat call experts for confirmation.

EASTERN BENTWING-BAT	*MINIOPTERUS SCHREIBERSII OCEANENSIS*	
EPBC Act: Not Listed	**TSC Act: Vulnerable**	**Survey Area: Low Priority**

Eastern bentwing-bat. Photo © M. Schulz

The eastern bentwing-bat is likely to roost in stormwater drains, under bridges or other artificial situations in close proximity to the survey area. Photo © M. Schulz

Occurrence in the Reserves

Likely to be a regular foraging visitor to the reserves. Nine confirmed calls of the species were recorded during the autumn period of the current survey. This species was identified by ultrasonic call within the reserves by Basham (2005). There is no suitable roosting habitat within the reserves since this species roosts in caves, abandoned mine shafts and under bridges and culverts (Hoye and Spence 2004). The closest documented roost is located under a bridge on the Comenarra Parkway adjacent to Twin Creeks Reserve, Turramurra, approximately three kilometres south-west of the survey area (DECC 2008a). It is likely that other roosts occur in the vicinity under bridges, in stormwater drains or in other situations.

Regional Conservation Significance

In a study of microchiropteran bats in northern Sydney this species was one of the most frequently recorded, identified by ultrasonic call at 16 out of 40 sites (Basham 2005). The species widespread occurrence within the northern Sydney landscape may result from it being a habitat generalist; it readily travels and forages across urban areas and has the ability to roost in a variety of artificial situations. It is not reliant on tree hollows, a resource under pressure from feral honeybees, introduced birds such as the common myna and increasing hollow-dwelling native species, such as various parrots (Law et al. 1999, Hoye and Spence 2004, Basham 2005). Although the eastern bentwing-bat is widespread across the region, there are no confirmed maternity caves (DECC 2008a). The reserves do not significantly contribute to the regional conservation of this species due to the absence of roosting habitat and the species ability to occur in a wide range of habitats, including urban areas.

Threats in the Reserves

No threats identified in the reserves.

Management Considerations

- Assist with the protection of nearby roost sites of this species.
- Consider establishing an annual monitoring program for micro-bats in the reserves using Anabat at set locations overnight on warm and dry nights in summer. An important component of such a program is that all ultrasonic signals recorded be analysed by a bat call expert. Survey effort and results should be entered into the BSS of the Atlas of NSW Wildlife.

6 INTRODUCED SPECIES

6.1 FERAL BIRD SPECIES

Five feral bird species have been recorded in the reserves, as listed below.

Rock dove (*Columba livia*): Not recorded during the current survey. Occasional individuals may occur on the edge of the reserves or be observed flying overhead. This species is not currently actively managed (A. Duffy pers. comm.). It is unlikely to be significantly affecting native vertebrate fauna.

Spotted dove (*Streptopelia chinensis*): Occasional individuals occur on the edge of the reserves. One individual was observed adjacent to Sydney Water land west of Rosedale Road in the current survey. This species is not currently actively managed (A. Duffy pers. comm.). It is unlikely to be significantly affecting native vertebrate fauna.

Red-whiskered bulbul (*Pycnonotus jocosus*): Not recorded during the current survey. A number of records were made of this species on the eastern edge of Browns Forest in the Ku-ring-gai Council scientific survey of the area. This bird is likely to be an occasional visitor that may range throughout the reserves rather than being restricted to the reserve margins. This species is not currently actively managed (A. Duffy pers. comm.). It is unlikely to be significantly affecting native vertebrate fauna.

Common myna (*Sturnus tristis*): This species primarily occurs in disturbed habitat on the edge of the reserves. Several individuals were observed in the current survey adjacent to Mona Vale Road and there is a record of this species from the eastern edge of Browns Forest from the Ku-ring-gai Council scientific survey of the area. This species is not currently actively managed (A. Duffy pers. comm.). The common myna is known to compete with native fauna for hollow resources and thus has the potential to impact on native vertebrate fauna species in the reserves. Recommendations for management of the common myna in the reserves are provided in section 8.1.

House sparrow (*Passer domesticus*): Not recorded during the current survey. Occasional individuals may occur in disturbed habitat on the edge of the reserves. This species is not currently actively managed (A. Duffy pers. comm.). It is unlikely to be significantly affecting native vertebrate fauna.

6.2 NON-PRIORITY FERAL MAMMAL SPECIES

House mouse (*Mus musculus*): This species had not been documented as occurring within the reserves prior to the current survey despite trapping studies undertaken over the past three years (e.g. Duffy 2011, A. Duffy pers. comm.). During the survey a single individual was located under rubbish at the old house site in Browns Forest adjacent to the Sydney Water fenceline west of Rosedale Road. However no individuals were photographed during the 315 camera nights undertaken. The species status in the reserves is currently uncertain.

6.3 DOMESTIC SPECIES

Domestic cats were encountered in Dalrymple-Hay NR on all days of the current survey. Many of these cats were observed hunting skinks during the day. Predation by the domestic cat poses a threat to native fauna species. Management of domestic cats is discussed in the feral cat profile in section 6.4 and also in section 8. Domestic dogs, both on- and off- leash, were occasionally observed in the reserves during the current survey, either accompanied by their owners or unaccompanied.

6.4 PRIORITY FERAL SPECIES PROFILES

Fox	*Vulpes vulpes*
EPBC Act: Key Threatening Process	TSC Act: Key Threatening Process

Fox. Photo © M. Schulz

The detection of tracks and/or the use of remote cameras are the best techniques for assessing the presence of the fox. Photo © M. Schulz

Occurrence in the Reserves

The fox is a rare visitor to the reserves with infrequent sightings reported (A. Duffy pers. comm.). No individuals or indirect signs were located in the current survey, despite targeted searches for scats on all tracks in both spring and autumn and 315 nights of remote camera trapping.

Impacts in the Reserves

Predation by the fox is listed as a Key Threatening Process under the EPBC Act and TSC Act due to the major threat posed to the survival of native Australian fauna. Non-flying mammals weighing between 35 and 5500 grams and ground-nesting birds are at the greatest risk (e.g. NSW Scientific Committee 2008a). The locally significant long-nosed bandicoot population is at risk if individual foxes take up residence within the reserves.

Management Considerations

- Continue a regular monitoring program using remote cameras at strategic locations across the reserves to monitor the presence of this species.
- Encourage reserve visitors and adjacent landholders to report any fox sightings.
- When fox presence is detected eliminate individuals present.
- Consider a baiting program only when a number of foxes are determined to be present.

FERAL CAT *Felis catus*

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

Feral cat. Photo © M. Schulz

Domestic cats were observed hunting lizards within the reserves during the current survey. Photo © M. Schulz

Occurrence in the Reserves

Status uncertain with few sightings of feral cats reported (A. Duffy pers. comm.). A single individual was photographed on the boundary of Sydney Water land and Browns Forest in 315 nights of remote camera trap sampling.

It is important to note that domestic cats from adjoining properties frequently range into the reserves. During the current survey individuals were seen on all days, including one individual stalking eastern water-skinks on the edge of the Perimeter Track and others encountered hunting dark-flecked garden sunskinks.

Impacts in the Reserves

The feral cat is listed as a Key Threatening Process under the EPBC Act and by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). In NSW, predation by the feral cat is listed as a Key Threatening Process under the TSC Act since it has been implicated in the extinction and decline of many species of mammals and birds in Australia and other parts of the world (NSW Scientific Committee 2008b). The impact of feral cats on birds, frogs, reptiles and small mammals within the reserves is currently unknown.

The impact of domestic cats on native fauna in the reservs is unknown, but is likely to be significant. For example, one of the only confirmed records of the sugar glider was the result of a domestic cat kill (A. Duffy pers. comm.). The impact on the locally significant long-nosed bandicoot population is unknown.

Management Considerations

- Continue a regular monitoring program using remote cameras at strategic locations across the reserves to monitor the presence of this species.
- Encourage reserve visitors and adjacent landholders to report any cat sightings.
- When feral cat presence is detected undertake control measures to eliminate individuals present.
- Undertake an awareness program for adjacent landholders with the aim of reducing the incursion of domestic cats into the reserves and hence reducing predation on native fauna.
- As a follow-up to the awareness program, trap wide-ranging domestic cats that regularly use the reserves for the hunting and taking of native fauna.

BLACK RAT *Rattus rattus*

EPBC Act: Key Threatening Process on Offshore Islands	TSC Act: Key Threatening Process on Lord Howe Island

Black rat in shrub. Photo © M. Schulz

Occurrence in the Reserves

The black rat is a widespread resident of the reserves. The species was recorded from three of the four infra-red camera sites in spring of the current survey, comprising 16.8 per cent of all animals photographed. In the autumn component of the survey the black rat was identified at four of the five infra-red camera sites and comprised 32.3 per cent of animals photographed (Appendix B). Although no individuals were captured in the 308 Elliott trap nights in the current survey, the species has been captured in small numbers during previous trapping studies (e.g. Duffy 2011).

Impacts in the Reserves

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, it 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, DEC 2005). Such an impact has been recognised through this species being listed on Lord Howe Island as a Key Threatening Process under the TSC Act. Additionally, the black rat has been included within a gazetted Key Threatening Process under the EPBC Act: 'Predation by exotic rats on Australian offshore islands of less than 1000 square kilometres (100,000 hectares)'. It has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Therefore, given the impact on isolated faunas it is expected that there is at least some impact on fauna within the reserves, particularly with respect to some shrub-nesting bird species.

Management Considerations

- Consider volunteering the reserves to be part of a trial reintroduction of the native bush rat ('Bogul') as an extension of the project being undertaken in parts of Sydney Harbour NP (University of Sydney 2012).
- Investigate the feasibility of targeted rodenticide baiting deploying bait stations as used elsewhere (e.g. Lord Howe Island), which greatly minimises take by non-target species.

7 THREATS TO NATIVE FAUNA

7.1 INTRODUCTION

There are many threats acting on vertebrate fauna in the two reserves. Threats tend to belong to one of three broad groupings: introduced species (including introduced diseases); habitat loss and degradation; or direct interference and mortality. This section identifies all threats impacting or likely to impact on all priority vertebrate fauna in the reserves. The relative importance of threats is ranked in section 7.3. Management recommendations for ameliorating these threats are provided in section 8.

7.2 LIST OF KEY THREATENING PROCESSES

Key Threatening Processes are threats listed under the TSC Act and/or EPBC Act as a process that *threatens, or could threaten, the survival or evolutionary development of species, populations or ecological communities.*

For reference all KTPs relevant to the survey area have been listed in Table 7 although not all are important at the current time. The relative priority of threats is analysed later in this section.

Table 7: All Key Threatening Processes listed under the TSC Act and/or EPBC Act that potentially operate in the two reserves

Threat	Act	Threat type
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	EPBC	Weed
Invasion, establishment and spread of *Lantana camara*	TSC	Weed
Invasion and establishment of exotic vines and scramblers	TSC	Weed
Invasion of native plant communities by exotic perennial grasses	TSC	Weed
Competition from feral honeybees	TSC	Pest animal
Predation by feral cats	TSC/EPBC	Pest animal
Predation by the fox	TSC/EPBC	Pest animal
Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands	TSC	Habitat loss/change
Anthropogenic climate change	TSC/EPBC	Habitat loss/change
Loss of hollow-bearing trees	TSC	Habitat loss/change
Removal of dead wood and dead trees	TSC	Habitat loss/change
Clearing of native vegetation	TSC	Habitat loss/change
Infection by Psittacine circoviral (beak and feather) disease affecting endangered *psittacine* species	TSC/EPBC	Disease
Infection of frogs by amphibian chytrid causing the disease *Chytridiomycosis*	TSC/EPBC	Disease
Introduction and establishment of exotic rust fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC	Disease

7.3 RELATIVE PRIORITY OF THREATS TO PRIORITY FAUNA SPECIES

In Table 8 the threats to native priority fauna species in the reserves are ranked in order of priority based on the methods outlined in section 3.2 – *Methods for prioritising threats to fauna*. The priority fauna species potentially impacted by each threat are listed in this table. Species that are included are the highest, high and moderate priority fauna.

Table 8: Prioritisation of threats to priority fauna species in the two reserves

		High threats					Moderate threats								Future threats	
		Clearing of native vegetation along fire breaks and on adjacent private land	Loss of hollow-bearing trees	Removal of dead wood and dead trees	Predation by the domestic cat	Competition for hollows by feral honeybees	Predation by the feral cat	Competition for hollows by the common myna	Predation by the black rat	Road mortality	Predation by the fox	Human disturbance at powerful owl roost and nest	Uncontrolled call playback	Electrocution on powerlines	Myrtle rust	Climate change
Species priority ranking ↓	Key threatening process? →	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes				Yes	Yes
High	Powerful owl	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓
Moderate	Grey-headed flying-fox	✓								✓				✓	✓	✓
	Yellow-bellied sheathtail-bat	✓	✓	✓	✓	✓	✓	✓	✓						✓	✓
	East-coast freetail-bat	✓	✓	✓	✓	✓	✓	✓	✓						✓	✓

7.4 SUMMARY OF THREATS TO PRIORITY FAUNA SPECIES

Threats to fauna are listed in order of priority based on a ranking using the method outlined in section 3.2 – *Methods for prioritising threats to fauna*. Suggested amelioration of these threats is given in the following section 8 – *Management of threats*.

7.4.1 Clearing of native vegetation along fire breaks and on adjacent private land

Since the area of the reserves is small, any clearance of canopy trees for additional fire breaks or enlargement of existing breaks may impact native fauna, both in terms of feeding and roosting/breeding habitat. Remnant canopy trees present in backyards on the north side of the reserve and in adjoining Sydney Water land are also likely to support important foraging and potentially roosting and breeding habitat. All identified priority native species are likely to be impacted by the clearing of native vegetation.

Blue Gum High Forest covers most of the survey area, here shown on the northern private property boundary with Browns Forest. Photo © M. Schulz/OEH

7.4.2 Loss of hollow-bearing trees

A significant proportion of threatened and common fauna species present within the reserves are reliant on tree hollows for shelter and reproductive sites, or are reliant on hollow-dependent species as prey. Tree hollows are typically only found in very old trees. They are therefore a scarce resource in many areas, particularly regenerating lands and urban areas. Large hollows used by owls are especially scarce, only occurring in very large trees which tend to grow in protected environments such as river flats and valleys – environments which have been extensively cleared within the urban setting. Those hollow-bearing trees that still remain within conservation areas are generally well


Left: Australian king-parrots investigating a nest hollow in Blue Gum High Forest, Dalrymple-Hay NR. Photo © M. Schulz/OEH. Right: Standing dead tree in Blue Gum High Forest, Dalrymple-Hay NR. Photo © M. Schulz/OEH

protected, but may be lost during fire operations (particularly during mop-up), during creation of fire breaks, where they pose a public safety threat, during road maintenance works or from neighbouring backyards on private land.

7.4.3 Removal of dead wood and dead trees

The removal of standing dead trees through excessive hazard reduction or 'tidying up' of bushland can result in reduced foraging habitat, prey density, refuge sites and nesting sites for a range of native species. This threat is particularly relevant adjacent to residential areas and along walking tracks within the reserves. Many priority species may be impacted including the powerful owl and east-coast freetail-bat.

7.4.4 Predation by the domestic cat

Domestic cats were observed on every day of the current field survey, including different individuals hunting skink species. It is likely that domestic cats also range widely into the reserves at night when, in particular, locally significant fauna such as the long-nosed bandicoot and young swamp wallabies are likely to be impacted. Domestic cats may potentially predate on powerful owl fledglings and also take roosting bat species, including the east-coast freetail-bat.

7.4.5 Competition for hollows by feral honeybees

Feral honeybees occur in moderately high numbers within the two reserves, colonising numbers of tree hollows in the area. This renders the hollows useless for native species whilst an active hive is present and for a significant period of time after the hive has been abandoned. There are numerous hollow-dependent species in the two reserves, all of which may be impacted by this threat, including the powerful owl.

Feral honeybees occur in moderately high numbers in the reserves, here seen at a hollow entrance in a dead stag in Blue Gum High Forest, Dalrymple-Hay NR. Photo © M. Schulz/OEH

7.4.6 Predation by the feral cat

Feral cats have been implicated in the decline and extinction of many native species. Feral cats are uncommon in the reserves, with only one individual photographed from nine sites in 315 infra-red camera trap nights (Appendix B). The exact impact of the feral cat is poorly understood due to the difficulty in locating faeces on which to perform dietary analyses, however they are known to prey on small- to medium-sized bird, mammal and reptile species. Similar to domestic cats they may potentially predate on powerful owl fledglings and also take roosting bat species, including the east-coast freetail-bat and locally significant species such as the long-nosed bandicoot and swamp wallaby.

7.4.7 Competition for hollows by the common myna

The common myna is listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). It competes aggressively for nesting hollows, displacing and excluding many native hollow-dependent species, including various parrots, gliders and insectivorous bats (e.g. Higgins et al. 2006). The common myna occurs in small numbers on the edge of the reserves, with several individuals observed in the current survey adjacent to Mona Vale Road. There are numerous hollow-dependent species in the two reserves, all of which may be impacted by this threat, including the powerful owl. However, at the time of the survey no nesting activity by the common myna was observed.

The common myna may displace and exclude native species from tree hollows. Photo © M. Schulz

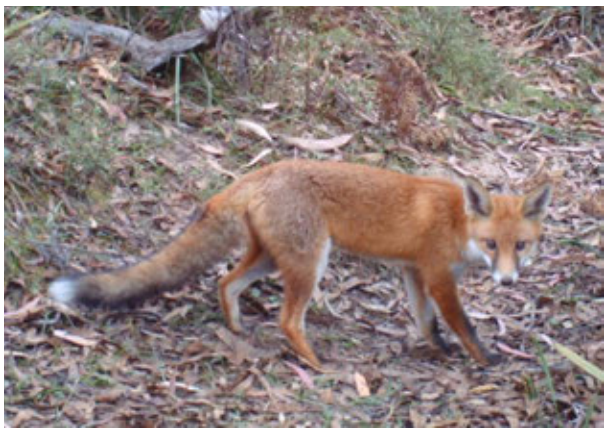
7.4.8 Predation by the black rat

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, it 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, DEC 2005). Such an impact has been recognised through this species being listed on Lord Howe Island as a KTP under the TSC Act. Additionally, the black rat has been included within a gazetted KTP under the EPBC Act: 'Predation by exotic rats on Australian offshore islands of less than 1000 square kilometres (100,000 ha)'. It has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Therefore, given the impact on island faunas, the lack of dietary studies in natural bushland, and the reserves serving as an 'island of remnant vegetation' within an expanse of suburbia it is expected that there is at least some impact on fauna within the reserve (after Stokes et al. 2009).

Black rat bait stations, such as used on Lord Howe Island, could potentially be deployed within the reserves. Photo © M. Schulz

7.4.9 Road mortality

The reserves are bordered by, or situated close to, a number of roads, in particular the high traffic volume dual carriageway Mona Vale Road (i.e. 44,000 vehicles per day in 2002 (Roads and Traffic Authority 2003)) that borders the western edge of Dalrymple-Hay NR. Animals are likely to be regularly killed on these roads, including potentially the powerful owl and grey-headed flying-fox. During the course of the survey several animals were found road-killed including one each of the locally significant swamp wallaby and long-nosed bandicoot, both on Rosedale Road.



The fox appeared to be absent from the reserves at the time of the current survey. Photo © M. Schulz

7.4.10 Predation by the fox

Foxes pose a threat to a range of native species. Particularly susceptible are ground-dwelling and semi-arboreal mammals and ground-frequenting birds (Dickman 1996, DECC 2007). Additionally, foxes can spread weed species such as blackberry through the deposition of seeds in the faeces. The fox is common and widespread in most bushland reserves within the Sydney metropolitan area,

but appeared to be absent from Dalrymple-Hay NR and Browns Forest at the time of the current survey. During the current survey no scats or tracks were located; no individuals were spotlighted or incidentally seen; and no individuals were photographed from nine sites in 315 infra-red camera trap nights (Appendix B). Similar to cats, this introduced predator may potentially predate on powerful owl fledglings and also take roosting bat species, including the east-coast freetail-bat and locally significant species such as the long-nosed bandicoot and swamp wallaby.

7.4.11 Disturbance at powerful owl roost and nest

Human disturbance of roosts and nests can lead to stress and injury, mortality and reduced breeding success. It is a particular problem for species such as owls and raptors that are naturally rare in the environment and have a low reproductive rate. The powerful owl roosts and nests within the reserve and may be subjected to disturbance by visiting bird watchers and other visitors to the park.

7.4.12 Uncontrolled call playback

Regular and uncontrolled playback of the powerful owl call, as suggested with other threatened owl species such as the sooty owl, may interfere with the owls that are resident in the reserves (e.g. Higgins 1999).

7.4.13 Electrocution on powerlines

The grey-headed flying-fox is prone to electrocution on powerlines, particularly in urban areas. Powerlines run along all roads fringing the reserves and therefore it is likely that during flowering or fruiting of canopy and subcanopy trees individuals are susceptible to electrocution.

7.5 Summary of Additional Threats to Locally Significant Fauna Species

Some of the resident species identified as locally significant (locally significant species are long-nosed bandicoot, sugar glider, swamp wallaby and eastern broad-nosed bat) face additional threats to those presented in the above section, as summarised below.

7.5.1 Weed invasion

Invasive introduced plant species impact on fauna by degrading habitat. Leaf litter from exotic plants has been shown to support a different invertebrate assemblage to leaf litter from native plants (Hills et al. 2008). A major problem in the reserve is the dumping of garden waste which may result in the establishment of escaped garden plants. Such plants may significantly alter the vegetation structure of the reserve thereby impacting on ground- and shrub-dwelling fauna, including locally significant species such as the long-nosed bandicoot.

The dumping of garden waste is a problem on the reserve edges. Photo © M. Schulz

Additionally, a large part of the reserves was previously heavily infested with weeds prior to a major bush regeneration project undertaken by Ku-ring-gai Bushland and Environmental Society since the 1980s (DEC 2004). Over the last 30 years a number of different weed management strategies have been implemented across the reserves, including several weed management control burns and the extensive removal of lantana, camphor laurel, wandering Jew (*Tradescantia fluminernsis*), small-leaved privet, broad-leaved privet (*Ligustrum lucidum*), micky mouse plant (*Ochna serrulata*) and fishbone fern (*Nephrolepis cordifolia*) (DEC 2004, Duffy 2011).

7.5.2 Predation and disturbance by dogs

The impact of domestic dogs, both roaming individuals originating from adjacent private properties and dogs accompanying walkers within the reserves, is poorly known. However, it is likely that dogs at times may result in the loss of individuals of locally significant fauna species, in particular the swamp wallaby.

7.6 EMERGING THREATS

7.6.1 Myrtle rust

Myrtle rust is a plant disease caused by the exotic fungus *Uredo rangelii* which infects young actively growing shoots, leaves, flower buds and fruits of plants in the family Myrtaceae. Infected plants die as a result of the infection. It was recently discovered, and its presence confirmed, in Dalrymple-Hay NR and during the survey in Browns Forest. This rust may infect a range of species within the reserve, including canopy trees, such as the smooth-barked apple and blackbutt (Department of Primary Industries 2012). Although not listed, other important canopy tree species, such as the Sydney blue gum may also be potentially impacted. Widespread infection within the reserves may result in an alteration in the structure and species composition of the vegetation communities, which may impact a range of fauna, including threatened species.

7.6.2 Human-induced climate change

Climate change, including changes in temperature and other climatic factors, has the potential to impact on many vertebrate fauna species. Recent modelling for Australian species indicates that changes in rainfall patterns and distribution will be far more important determinants of species distribution in the future (P. Wilson pers. comm.). The continued drying pattern already observed in south-east Australia is expected to continue and intensify, resulting in many changes to species distributions (Alexander and Arblaster 2009, CSIRO and Bureau of Meteorology Australia 2010).

Management of reserves immediately adjacent to urban areas poses many challenges. Photo © M. Schulz

8 MANAGEMENT OF THREATS

8.1 RECOMMENDATIONS FOR THE MANAGEMENT OF THREATS TO FAUNA

The following section details ways that managers may mitigate each of the identified threats to vertebrate fauna in the two reserves. Many of these management actions are already in place as part of existing programs. The following table (Table 9) lists each threat to priority fauna species in order of priority, as well as additional threats to locally significant fauna species. The table presents recommended management actions and target areas or habitats. Also given is a list of fauna that will be benefited by the introduction or continuation of this management action.

Table 9: Recommendations for management of threats

Management Response	Target Areas or Habitats	Species Affected
Clearing of native vegetation along fire breaks and on adjacent private land		
Avoid the clearance of canopy trees on the reserve boundary and on adjacent private land. Requires a cross tenure approach with adjoining landholders.	Both reserves as well as immediately adjacent lands.	All species.
Minimise the clearance of native subcanopy trees and shrubs.	Fire breaks, walking tracks and elsewhere in reserves.	All subcanopy, shrub and ground-dwelling species.
Loss of hollow-bearing trees		
Avoid removal of hollow-bearing trees, including during PWG works.	Both reserves as well as immediately adjacent lands.	Native species that use hollow trees, especially the powerful owl, various insectivorous bats and the sugar glider.
Removal of dead wood and dead trees		
Avoid removal of dead standing trees, including during PWG works.	Both reserves as well as immediately adjacent lands.	Native species that use hollow trees, especially the powerful owl, various insectivorous bats and the sugar glider.
Avoid removal of fallen timber, especially large logs since these resources are scarce.	Across the two reserves.	Long-nosed bandicoot, various bird and reptile species and other forest fauna.
Predation by the domestic cat		
Undertake an **awareness program** with the aim of reducing incursion of domestic cats into the reserves.	All neighbouring and nearby residences.	All species predated upon by the cat.
Encourage staff and reserve visitors to **report cat sightings**, especially if animals are seen stalking native fauna.	Across the two reserves.	All species predated upon by the cat.
As a follow-up to the awareness program **trap wide-ranging domestic cats** that regularly use the reserves for the hunting and taking of native fauna.	Boundaries of the two reserves bordering residential areas.	All species predated upon by the cat.
Competition for hollows by feral honeybees		
Remove honeybees that establish in hollows within the reserves.	Across the two reserves.	Powerful owl and potentially any hollow-nesting mammal or bird.

Management Response	Target Areas or Habitats	Species Affected
Predation by the feral cat		
Conduct a **monitoring program** using remote cameras to monitor the presence of this species. This program can simultaneously be used to monitor foxes, locally significant native species (e.g. long-nosed bandicoot and swamp wallaby), and cryptic species.	Across the two reserves.	All species predated upon by the cat.
Encourage staff and reserve visitors to **report cat sightings** so that feral animals may opportunistically be targeted for removal.	Across the two reserves.	All species predated upon by the cat.
Where feral cats are photographed or reported, implement a **trapping and removal program**.	Known locations across the two reserves.	All species predated upon by the cat.
Competition for hollows by the common myna		
Remove common mynas that establish in hollows within the reserves.	Across the two reserves, primarily adjacent to the boundaries.	Powerful owl and potentially any hollow-nesting mammal or bird.
Predation by the black rat		
Consider volunteering the reserves to be part of a trial **reintroduction of the native bush rat**.	Across the two reserves.	Species potentially impacted by the black rat, such as reptiles, birds and bats.
Investigate baiting protocols that **minimise the likelihood of off-target poisoning** by rodenticides but reduce black rat numbers within the reserves e.g. use of bait stations such as illustrated in section 7.4.8.	Across the two reserves.	Species potentially impacted by the black rat, such as reptiles, birds and bats.
Road mortality		
Consider **installing highly visible road signs** warning motorists of the presence of wildlife on the roads.	Rosedale Road and Mona Vale Road abutting the reserves.	Various species, including the swamp wallaby and long-nosed bandicoot.
Consider **installing speed humps** to ensure speeds are kept low to minimise roadkills.	Rosedale Road abutting the reserves.	Various species, including the swamp wallaby and long-nosed bandicoot.
Predation by the fox		
Conduct a **monitoring program** using remote cameras to monitor the presence of this species. This program can simultaneously be used to monitor cats, locally significant native species (e.g. long-nosed bandicoot and swamp wallaby), and cryptic species.	Across the two reserves.	All species predated upon by the fox.
Encourage staff and reserve visitors to **report fox sightings** so that feral animals may opportunistically be targeted for removal.	Across the two reserves.	All species predated upon by the fox.
Where foxes are photographed or reported, implement a **trapping and removal program**.	Known locations across the two reserves.	All species predated upon by the fox.
Consider a baiting program only when a number of foxes are determined to be present.	Across the two reserves.	All species predated upon by the fox.
Human disturbance at powerful owl roost and nest		
Do not publicise the locality of any roosting or nesting powerful owls.	Across the two reserves.	Powerful owl.
Avoid activities that might disrupt nesting powerful owls e.g. road maintenance.	Known powerful owl nest site.	Powerful owl.

Management Response	Target Areas or Habitats	Species Affected
Uncontrolled call playback		
Do not publicise the locality of any roosting or nesting powerful owls.	Across the two reserves.	Powerful owl.
Electrocution on powerlines		
Identify any powerline locations where bats are regularly electrocuted. If black spots are identified, implement measures to reduce deaths. Potential measures may include making the powerlines more visible to grey-headed flying-foxes such as by putting up flags, thickening wires and/or cutting back foliage.	Powerlines bordering the reserves.	Grey-headed flying-fox.
Weed invasion		
Continue **weed removal and bush regeneration program**.	Across the two reserves.	Most fauna.
Continue to ensure that weed removal is complemented by **adequate replacement with native plants so as not to leave shrub-dependant species without habitat for foraging and sheltering**.	Across the two reserves.	Reptiles and some shrub-dwelling passerine birds.
Undertake an **awareness program** with the aim of reducing the dumping of garden waste and hence reducing further establishment of garden escapees.	All neighbouring and nearby residences.	Most species occurring in reserves.
Strategically **set cameras to identify dumpers** of garden waste.	Strategic locations across the two reserves.	Most species occurring in reserves.
Predation and disturbance by dogs		
Undertake an **awareness campaign** with the aim of reducing the incidence of free-ranging dogs in the reserves.	All neighbouring and nearby residences.	Reptiles and ground/shrub-frequenting birds and mammals.
Encourage staff and reserve visitors to **report dog sightings**, especially if animals are seen stalking native fauna.	Across the two reserves.	Reptiles and ground/shrub-frequenting birds and mammals.
As a follow-up to the awareness program **trap wide-ranging domestic dogs** that regularly use the reserves for the hunting and taking of native fauna.	Across the two reserves.	Reptiles and ground/shrub-frequenting birds and mammals.
Conduct **occasional patrols** during the weekends, and on week days early in the morning and towards dusk, to identify dog walkers using tracks within the reserves and alert them of the potential impacts on native fauna.	Tracks across the two reserves.	Reptiles and ground/shrub-frequenting birds and mammals.
Disease		
Ensure park workers and visitors are aware of myrtle rust and **close tracks adjacent to myrtle rust outbreaks**.	Across the two reserves.	Potentially all species.

8.2 MANAGEMENT OF NEW SPECIES FOR THE RESERVES

This report gives an accurate current inventory of terrestrial vertebrate species for the two reserves. New species may arrive or be discovered over time, and species that are suspected to have become locally extinct may return or be rediscovered. When new species are reported it is important that reliable supporting evidence is sourced so that an accurate inventory can be maintained. Annual checks of species recorded in the Atlas of NSW Wildlife are recommended. Recent records can be compared to the inventory in this report. Records of species not discussed in this report, or noted as a presumed extinction, should be verified and reviewed. A re-ordering of conservation priorities may be warranted depending on the conservation status of newly discovered species. For instance, the barking owl may take up breeding residence within the reserves. Despite targeted searches, this species was not found during the current surveys and therefore has been given a low management priority ranking. However, should the species take up residence and nest within the reserves then it would be elevated to high management priority, requiring targeted management programs to ensure its continued presence.

8.3 MAINTAINING WILDLIFE DATA SYSTEMS

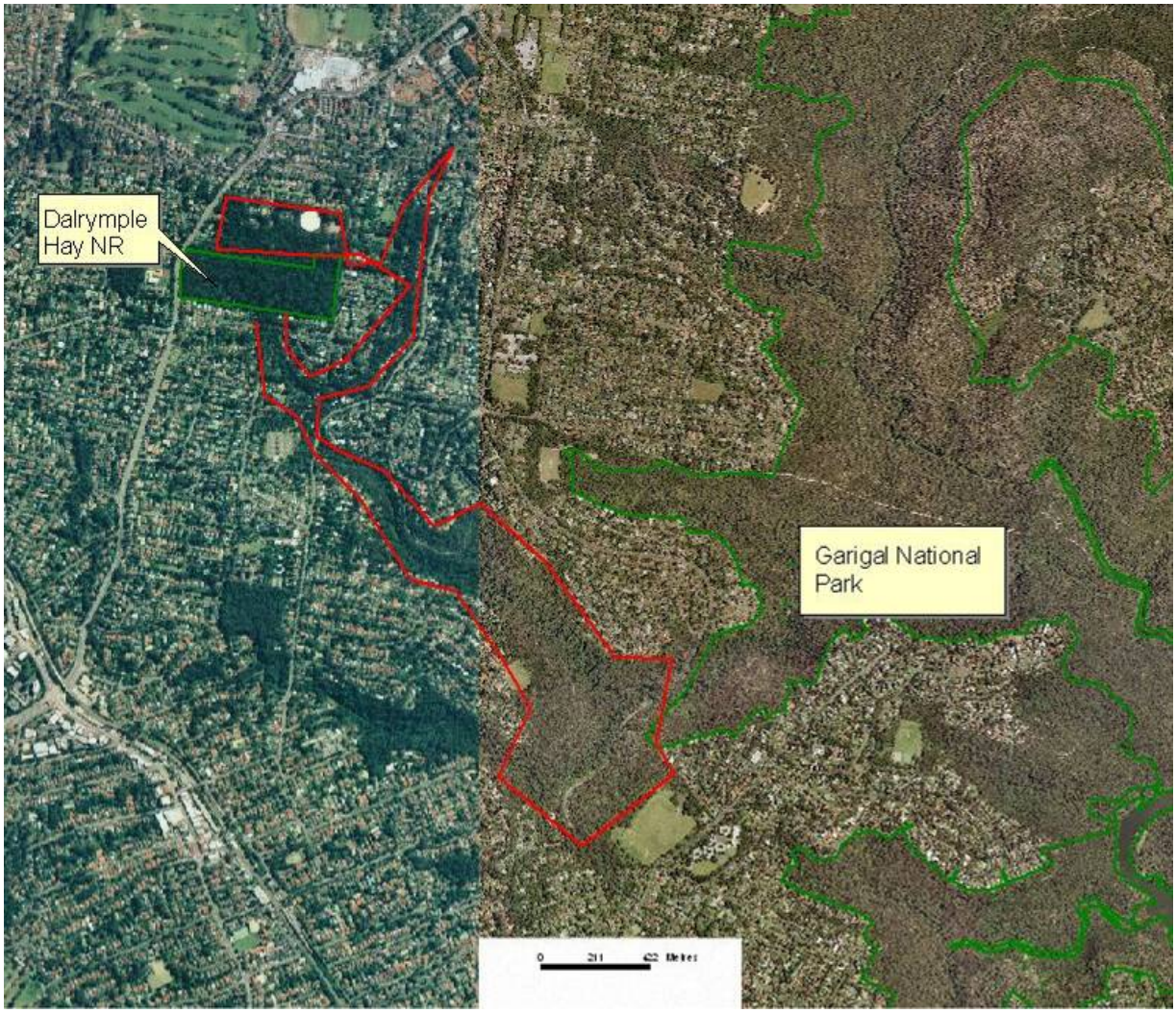
A survey such as the current one is restricted in that it provides only a 'snapshot in time' of the fauna present. Fauna patterns would vary during different annual cycles, such as drought and above-average rainfall years. The following recommendations are therefore provided with the aim of gaining a better understanding of the fauna present within the survey area.

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

8.4 MAINTAINING THE HABITAT LINK

The reserves are isolated from larger reserves to the north, in particular Ku-ring-gai Chase NP, by residential land. A narrow band of riparian vegetation along High Ridge Creek links the two reserves through easements, council reserves, and private property with Garigal NP to the south-east (Map 6). It is important that this habitat link be: a) not interrupted by a discontinuity; b) widened where feasible; c) maintained in terms of fauna habitat quality.

Map 6: Habitat link between the two reserves and Garigal NP (taken from Duffy 2011)



9 FURTHER SURVEY AND MONITORING

9.1 LIMITATIONS OF THE CURRENT SURVEY

At the completion of the current systematic and targeted surveys, all vertebrate groups have been systematically sampled to an adequate baseline level for use in biodiversity assessment. The two vegetation communities present within the reserves have also been adequately sampled. The current fauna survey provided a baseline of the species occurring within the survey area, with systematic fauna sampling conducted in the months of October to November and March to April. However, no sampling was undertaken in the late autumn or winter periods which may have resulted in a number of winter-visiting bird species being missed. Additionally, a survey undertaken during a single snapshot in time (i.e. within a single year) does not account for year-by-year variation in species occurrence as a result of droughts, extremely wet periods or mass flowering events of key canopy trees occurring within the survey area or elsewhere within the state.

9.2 FURTHER FAUNA SURVEY

It is recommended that additional fauna survey work be undertaken during the following periods:

- Bird surveys in the winter months.
- Surveys for threatened nectarivorous species, such as the swift parrot (*Lathamus discolor*) and little lorikeet (*Glossopsitta pusilla*) when canopy trees are in flower, particularly blackbutt and ironbark species. These surveys should target years when these species are utilising flowering trees in coastal areas rather than inland flowering trees on the western slopes or in the grassy woodlands of the Sydney Basin Bioregion, such as the Capertee and Burragorang valleys.

9.3 FAUNA MONITORING

9.3.1 Background

Fauna monitoring is increasingly included as a key corporate management objective for park managers. It is a complex and difficult issue because answers about what to monitor are often poorly resolved and projects are rarely funded for sufficient time to generate meaningful results. This section discusses the current monitoring strategies in NSW, the reasons why monitoring programs often fail and to suggest monitoring projects that are relevant to fauna within Dalrymple-Hay NR.

Part of the complexity of fauna monitoring lies in the different sorts of 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 Dalrymple-Hay NR?” 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 such as the long-nosed bandicoot 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 2010); 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 the reserve. 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 Dalrymple-Hay NR but also about the contribution the area makes toward the persistence of species in the region and within the state. This is particularly the case for threatened species.

9.3.2 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 OEH to ensure that projects can as far as possible satisfy multiple monitoring objectives. This includes threatened species management, state of the parks reporting and scientific services research. Consultation with the relevant staff greatly increases the chances of implementing an integrated project that garners support for its continuation over time.

The scientific issues to consider before setting up a monitoring program are also complex. Table 10 presents a summary of the issues that confront fauna monitoring programs.

9.3.3 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 reserve. These already address some priority species and priority threats present in the reserves.

- **Existing study:** 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. OEH Region and Area staff are encouraged to continue to actively participate in this initiative where possible and maintain close links with the PIQS (and other components of Park IQ) as it rolls out.

  Due to its small size Dalrymple-Hay NR is unlikely to be chosen as a site for the WildCount program. However the same remote camera survey methodology could be adopted by Area staff, with survey effort and results entered into the BSS of the Atlas of NSW Wildlife. A remote camera program could be used to monitor the following: the presence of feral cats and foxes in the reserve; the presence of cryptic species (e.g. noisy pitta) or species in low numbers (e.g. lace monitor); and numbers of locally significant species, in particular the swamp wallaby and long-nosed bandicoot.

- **New study:** Consider establishing an annual monitoring program for micro-bats in the reserves using Anabat (or another ultrasonic detection and recording device) at set locations overnight on warm and dry nights in summer. An important component of such a program is that all ultrasonic signals recorded be analysed by a bat call expert. Survey effort and results should be entered into the BSS of the Atlas of NSW Wildlife.

Table 10: 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 five 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 +/- eight per cent annually (this translates into the species being at risk of extinction within 20 years), and for the first three 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.

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APPENDIX A: VERTEBRATE FAUNA OF DALRYMPLE-HAY NATURE RESERVE AND BROWNS FOREST

This appendix provides a list of vertebrate fauna (excluding fish) that currently or previously occurred within Dalrymple-Hay NR and Browns Forest (Table 11). Following a review of records conducted for this project a number of species are not included in this list and these are detailed in Table 5.

In this list the species order for amphibians and reptiles follows Cogger (1996), for birds Christidis and Boles (2008) and for mammals Van Dyck and Strahan (2008). All recent taxonomic changes have been incorporated (as of May 2012).

The following columns have been included for each species:

NSW Legal Status = Current listing under the TSC Act (as of October 2011). Codes used are CE=Critically Endangered, E=Endangered, EP=Endangered Population, V=Vulnerable, P=Protected, U=Feral species.

Commonwealth Legal Status = Current listing under the EPBC Act (as of May 2012).

Record Source = 1 – Current survey; 2 – Atlas of NSW Wildlife records; 3 – Anon. 2006; 4 – Basham 2005; 5 – A. Duffy, OEH, pers. comm.; 6 – R. Clark, and N. and G. Jones unpublished records; 7 – Ku-ring-gai Council scientific survey.

= Species recorded in the reserves for the first time during the current survey.

Table 11: Fauna species accurately recorded in Dalrymple-Hay Nature Reserve and Browns Forest

Family	Scientific name	Common name	NSW legal status	Commonwealth legal status	Record source
Frogs					
Myobatrachidae	*Crinia signifera*	Common eastern froglet	P		1
Myobatrachidae	*Limnodynastes peronii*	Brown-striped frog	P		3
Hylidae	*Litoria dentata*	Bleating tree frog#	P		1
Hylidae	*Litoria fallax*	Eastern dwarf tree frog	P		7
Hylidae	*Litoria peronii*	Peron's tree frog	P		1
Hylidae	*Litoria phyllochroa*	Leaf-green tree frog	P		1
Reptiles					
Scincidae	*Eulamprus quoyii*	Eastern water-skink	P		1
Scincidae	*Eulamprus tenuis*	Bar-sided skink#	P		1
Scincidae	*Lampropholis delicata*	Dark-flecked garden sunskink	P		1
Scincidae	*Lampropholis guichenoti*	Pale-flecked garden sunskink	P		3,7
Scincidae	*Saiphos equalis*	Three-toed skink#	P		1
Scincidae	*Saproscincus mustelinus*	Weasel skink	P		1
Scincidae	*Tiliqua scincoides*	Eastern blue-tongue	P		1
Agamidae	*Physignathus lesueurii lesueurii*	Eastern water dragon	P		3,5
Varanidae	*Varanus varius*	Lace monitor	P		5

Family	Scientific name	Common name	NSW legal status	Commonwealth legal status	Record source
Elapidae	*Cacophis squamulosus*	Golden-crowned snake#	P		1
Elapidae	*Furina diadema*	Red-naped snake	P		3
Elapidae	*Pseudechis porphyriacus*	Red-bellied black snake	P		5
Birds					
Megapodiidae	*Alectura lathami*	Australian brush-turkey	P		1
Anatidae	*Anas superciliosa*	Pacific black duck	P		3
Columbidae	*Columba livia*	Rock dove	U		2
Columbidae	*Columba leucomela*	White-headed pigeon	P		2
Columbidae	*Streptopelia chinensis*	Spotted dove	U		1
Columbidae	*Macropygia amboinensis*	Brown cuckoo-dove	P		1
Columbidae	*Phaps elegans*	Brush bronzewing	P		2
Columbidae	*Ocyphaps lophotes*	Crested pigeon	P		2
Columbidae	*Geopelia striata*	Peaceful dove	P		2
Columbidae	*Lopholaimus antarcticus*	Topknot pigeon	P		3
Podargidae	*Podargus strigoides*	Tawny frogmouth	P		1
Apodidae	*Hirundapus caudacutus*	White-throated needletail	P		1
Apodidae	*Apus pacificus*	Fork-tailed swift	P		2
Accipitridae	*Aviceda subcristata*	Pacific baza	P		1
Accipitridae	*Accipiter fasciatus*	Brown goshawk	P		1
Accipitridae	*Accipiter cirrocephalus*	Collared sparrowhawk	P		1
Accipitridae	*Accipiter novaehollandiae*	Grey goshawk	P		2
Accipitridae	*Aquila audax*	Wedge-tailed eagle	P		3,7
Falconidae	*Falco peregrinus*	Peregrine falcon	P		2
Cacatuidae	*Calyptorhynchus lathami*	Glossy black-cockatoo	V		2
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed black-cockatoo	P		2
Cacatuidae	*Eolophus roseicapillus*	Galah	P		1
Cacatuidae	*Cacatua tenuirostris*	Long-billed corella	P		2
Cacatuidae	*Cacatua sanguinea*	Little corella	P		1
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	P		1
Psittacidae	*Trichoglossus haematodus*	Rainbow lorikeet	P		1
Psittacidae	*Trichoglossus chlorolepidotus*	Scaly-breasted lorikeet	P		1
Psittacidae	*Glossopsitta concinna*	Musk lorikeet#	P		1

Family	Scientific name	Common name	NSW legal status	Commonwealth legal status	Record source
Psittacidae	*Glossopsitta pusilla*	Little lorikeet	V		2
Psittacidae	*Alisterus scapularis*	Australian king-parrot	P		1
Psittacidae	*Platycercus elegans*	Crimson rosella	P		1
Psittacidae	*Platycercus eximius*	Eastern rosella	P		1
Cuculidae	*Eudynamys orientalis*	Eastern koel	P		1
Cuculidae	*Scythrops novaehollandiae*	Channel-billed cuckoo	P		1
Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo	P		2
Cuculidae	*Chalcites lucidus*	Shining bronze-cuckoo	P		1
Cuculidae	*Cacomantis pallidus*	Pallid cuckoo	P		3
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed cuckoo	P		1
Cuculidae	*Cacomantis variolosus*	Brush cuckoo	P		2
Cuculidae	*Cuculus optatus*	Oriental cuckoo	P		3,7
Strigidae	*Ninox strenua*	Powerful owl	V		1
Strigidae	*Ninox connivens*	Barking owl	V		3
Strigidae	*Ninox novaeseelandiae*	Southern boobook	P		1
Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra	P		1
Halcyonidae	*Todiramphus sanctus*	Sacred kingfisher	P		2
Coraciidae	*Eurystomus orientalis*	Dollarbird	P		1
Pittidae	*Pitta versicolor*	Noisy pitta#	P		1
Climacteridae	*Cormobates leucophaea*	White-throated treecreeper	P		2
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin bowerbird	P		3
Maluridae	*Malurus cyaneus*	Superb fairy-wren	P		1
Maluridae	*Malurus lamberti*	Variegated fairy-wren	P		1
Acanthizidae	*Sericornis frontalis*	White-browed scrubwren	P		1
Acanthizidae	*Sericornis magnirostra*	Large-billed scrubwren	P		2
Acanthizidae	*Gerygone mouki*	Brown gerygone	P		1
Acanthizidae	*Acanthiza pusilla*	Brown thornbill	P		1
Pardalotidae	*Pardalotus punctatus*	Spotted pardalote	P		1
Pardalotidae	*Pardalotus striatus*	Striated pardalote	P		2
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern spinebill	P		1
Meliphagidae	*Meliphaga lewinii*	Lewin’s honeyeater	P		1
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced honeyeater	P		2

Family	Scientific name	Common name	NSW legal status	Commonwealth legal status	Record source
Meliphagidae	*Lichenostomus leucotis*	White-eared honeyeater	P		2
Meliphagidae	*Lichenostomus melanops*	Yellow-tufted honeyeater	P		2
Meliphagidae	*Manorina melanocephala*	Noisy miner	P		1
Meliphagidae	*Anthochaera chrysoptera*	Little wattlebird	P		1
Meliphagidae	*Anthochaera carunculata*	Red wattlebird	P		1
Meliphagidae	*Myzomela sanguinolenta*	Scarlet honeyeater	P		2
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland honeyeater	P		2
Meliphagidae	*Phylidonyris niger*	White-cheeked honeyeater	P		2
Meliphagidae	*Melithreptus lunatus*	White-naped honeyeater	P		2
Meliphagidae	*Philemon corniculatus*	Noisy friarbird	P		1
Psophodidae	*Psophodes olivaceus*	Eastern whipbird	P		1
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	P		1
Campephagidae	*Coracina tenuirostris*	Cicadabird	P		2
Pachycephalidae	*Pachycephala pectoralis*	Golden whistler	P		1
Pachycephalidae	*Pachycephala rufiventris*	Rufous whistler	P		3
Pachycephalidae	*Colluricincla harmonica*	Grey shrike-thrush	P		2
Oriolidae	*Oriolus sagittatus*	Olive-backed oriole	P		1
Artamidae	*Artamus cyanopterus*	Dusky woodswallow	P		2
Artamidae	*Cracticus torquatus*	Grey butcherbird	P		1
Artamidae	*Cracticus tibicen*	Australian magpie	P		1
Artamidae	*Strepera graculina*	Pied currawong	P		1
Dicruridae	*Dicrurus bracteatus*	Spangled drongo	P		2
Rhipiduridae	*Rhipidura rufifrons*	Rufous fantail	P		1
Rhipiduridae	*Rhipidura albiscapa*	Grey fantail	P		1
Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	P		2
Corvidae	*Corvus coronoides*	Australian raven	P		1
Monarchidae	*Myiagra rubecula*	Leaden flycatcher	P		1
Monarchidae	*Monarcha melanopsis*	Black-faced monarch	P		1
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	P		3
Petroicidae	*Petroica rosea*	Rose robin	P		2
Petroicidae	*Eopsaltria australis*	Eastern yellow robin	P		1
Timaliidae	*Zosterops lateralis*	Silvereye#	P		1

Family	Scientific name	Common name	NSW legal status	Commonwealth legal status	Record source
Hirundinidae	*Hirundo neoxena*	Welcome swallow	P		1
Hirundinidae	*Petrochelidon nigricans*	Tree martin	P		2
Pycnonotidae	*Pycnonotus jocosus*	Red-whiskered bulbul	U		2
Sturnidae	*Sturnus tristis*	Common myna	U		1
Sturnidae	*Sturnus vulgaris*	Common starling	U		6
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird#	P		1
Estrildidae	*Neochmia temporalis*	Red-browed finch	P		1
Passeridae	*Passer domesticus*	House sparrow	U		2
Mammals					
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	P		5
Peramelidae	*Perameles nasuta*	Long-nosed bandicoot	P		1
Petauridae	*Petaurus breviceps*	Sugar glider	P		1
Pseudocheiridae	*Pseudocheirus peregrinus*	Common ringtail possum	P		1
Phalangeridae	*Trichosurus vulpecula*	Common brushtail possum	P		1
Macropodidae	*Wallabia bicolor*	Swamp wallaby	P		1
Pteropodidae	*Pteropus poliocephalus*	Grey-headed flying-fox	V	V	1
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied sheathtail-bat	V		4,7
Molossidae	*Tadarida australis*	White-striped freetail-bat	P		1
Molossidae	*Mormopterus norfolkensis*	East-coast freetail-bat	V		4
Molossidae	*Mormopterus* "Species 2"	Eastern freetail-bat	P		1
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern bentwing-bat	V		1
Vespertilionidae	*Nyctophilus gouldi*	Gould's long-eared bat	P		7
Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat	P		1
Vespertilionidae	*Chalinolobus morio*	Chocolate wattled bat#	P		1
Vespertilionidae	*Scotorepens orion*	Eastern broad-nosed bat#	P		1
Vespertilionidae	*Vespadelus vulturnus*	Little forest bat#	P		1
Muridae	*Mus musculus*	House mouse#	U		1
Muridae	*Rattus rattus*	Black rat	U		1
Canidae	*Vulpes vulpes*	Fox	U		5
Felidae	*Felis catus*	Feral cat	U		1

APPENDIX B: INFRA-RED CAMERA TRAPPING RESULTS

The following symbols are used in Table 12 and Table 13:

= Species not recorded by other survey techniques during the corresponding survey period.

* = Camera did not work (location recorded here for future reference if a monitoring program is set up).

^ = Accompanied by young.

Digits in brackets = number of photos/videos and number of individuals. For example (2=2) = two photos/videos with 2 individuals, or (4=3) = 3 photos/videos with 4 individuals.

Table 12: Location of infra-red camera traps and results obtained during the Spring 2011 sampling period

						Total	**%Total**
Reserve	D-H	BF	BF	D-H	D-H*		
Grid Reference (AMG, Zone 56, Map Datum GDA94)	329119/ 6265430	329398/ 6265623	329293/ 6265570	329188/ 6265509	329373/ 6265409		
Set Up Date	15/10/11	15/10/11	15/10/11	15/10/11	15/10/11		
Finish Date	12/11/11	10/11/11	12/11/11	10/11/11	12/11/11		
Sample Nights	28	26	28	26	-	108	
Photos/Videos Taken	206	96	220	148	-	670	
Species							
Mammals							
Long-nosed bandicoot	9	12	4	-	-	25	7.9
Common ringtail possum	-	-	1	-	-	1	0.3
Common brushtail possum#	6	2	-	-	-	8	2.5
Swamp wallaby	24	26	91 (2=13)	68 (2=2)	-	209	66.1
Black rat#	46	6	1	-	-	53	16.8
Feral cat#	-	1	-	-	-	1	0.3
Birds							
Australian brush-turkey	8	1	-	-	-	9	3.0
Sulphur-crested cockatoo	-	-	7 (4=3; 5=2)	-	-	7	2.2
Noisy pitta#	1	-	-	-	-	1	0.3
Eastern whipbird	1 (2=1)	-	-	-	-	1	0.3
Australian raven	-	-	1	-	-	1	0.3
Reptiles							
Nil							
Amphibians							
Nil							

Table 13: Location of infra-red camera traps and results obtained during the Autumn 2012 sampling period

						Total	%Total
Reserve	D-H	D-H	D-H	D-H	D-H		
Grid Reference (AMG, Zone 56, Map Datum GDA94)	328902/ 6265482	329131/ 6265402	329121/ 6265413	329256/ 6265419	329448/ 6265546		
Set Up Date	15/3/12	15/3/12	15/3/12	15/3/12	15/3/12		
Finish Date	25/4/12	24/4/12	24/4/12	25/4/12	24/4/12		
Sample Nights	42	41	41	42	41	207	
Photos/Videos Taken	104	92	28	50	276	550	
Species							
Mammals							
Long-nosed bandicoot	5	10	5	-	11	31	11.5
Common ringtail possum	-	-	-	-	4	4	1.5
Common brushtail possum	-	-	1	-	4	5	1.9
Swamp wallaby	29^	29	4	21	25^ (2=3)	111	41.3
Black rat	1	2	5	-	79	87	32.3
Birds							
Collared sparrowhawk#	-	-	-	-	1	1	0.4
White-browed scrubwren	-	-	-	-	12 (2=2)	14	5.2
Eastern whipbird	-	-	-	-	11 (3=1)	12	4.4
Eastern yellow robin	-	-	-	-	4	4	1.5
Reptiles							
Nil							
Amphibians							
Nil							

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