



Native Fauna Management Plan for the Pittwater Local Government Area

May 2011



PITTWATER COUNCIL

Native Fauna Management Plan Pittwater LGA

Prepared by
Pittwater Council

with the assistance of
**Ecotone Ecological Consultants
Pty. Limited**

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
1.1 Management Objectives and Background	1
1.2 Description of the Pittwater LGA Study Area	2
1.4 Management Plan Methodology	4
2.0 FAUNA RECORDED IN PITTWATER	4
2.1 Overview of Fauna Species Recorded in Pittwater	4
2.2 Threatened Species Recorded in Pittwater (TSC Act and EPBC Act)	4
3.0 LOCALLY SIGNIFICANT SPECIES AND CHANGES IN DISTRIBUTION AND ABUNDANCE OVER TIME	12
4.0 FAUNA OF THE ENDANGERED ECOLOGICAL COMMUNITIES IN PITTWATER	12
5.0 COMMUNITY INVOLVEMENT AND EDUCATION	12
5.5 Coastal Environment Centre	14
6.0 MANAGEMENT ISSUES	14
6.1 Legislation and Guidelines relevant to Native Fauna	14
6.1.1 Key Threatening Processes, Threat Abatement Plans and Species Recovery Plans	14
6.1.2 Overall Management Options	15
6.2 Conservation and Rehabilitation of Core Habitat and Remnant Bushland	15
6.2.1 Weed Invasion	16
6.2.2 Eucalypt Dieback	16
6.2.3 Invasion of Saltmarsh by Mangroves	16
6.2.4 Expansion of Rainforest and She-oak Vegetation at the Expense of Eucalypt Vegetation	16
6.2.5 Specific Management Options	17
6.3 Wildlife Corridors, Fragmentation and Edge Effects	17
6.4 Fire Management	18
6.5 Reintroduction of Native Fauna	19
6.6 Impacts of Domestic (companion animals) and Feral Animals (predators)	19
6.7 Management Issues associated with Broadscale Insecticide Use	20
6.8 Fauna Casualties and the Rehabilitation of Sick, Injured and Orphaned Wildlife	21
6.9 Feeding Wildlife	23
6.10 Disturbance at Nesting, Roosting and Feeding Sites	23
6.11 Fencing	24
6.12 Use of Nest Boxes	24
6.13 Cane Toads	26
<i>Specific Management Options:</i>	26
6.14 Depletion of Intertidal Invertebrate Populations	27
7.1 Bats (Microchiroptera)	28
7.2 Bats (Megachiroptera – Flying-foxes)	29
7.3 Arboreal Mammals	29
7.4 Ground Dwelling Mammals	30
7.5 Reptiles	31
7.6 Frogs	31
7.7 Birds	32
7.8 Marine Vertebrates and Invertebrates	33
8.0 MANAGEMENT OF KEY SITES	34
8.1 Proposed Land Release Area in Ingleside	34
8.2 Cannes Reserve Flying-fox Colony	34
8.3 Careel Bay	35
8.4 St Michaels Cave	36
9.0 RAPID ASSESSMENT TOOL	37
10.0 FURTHER RESEARCH REQUIRED	37
11.0 POSSIBLE GRANT PROJECTS AND PARTNERS	37
12.0 ACKNOWLEDGEMENTS	38
13.0 REFERENCES	39

APPENDIX 6 SUPPLEMENTARY SURVEYS	52
1.0 Introduction	52
2.0 Methods	52
3.0 Results	54
4.0 Discussion	54
APPENDIX 9 DEFINITIONS	55
APPENDIX 10. PROJECT PERSONNEL	56

LIST OF TABLES

	Page
Table 1. Threatened fauna recorded in the Pittwater LGA	6
Table 2. Summary of relevant protected matter under the Commonwealth EPBC Act 1999	8
Appendix 3 - Table 1. Locally Significant Fauna Species	124
Appendix 4 – Table 1. Fauna species identified in an Aboriginal midden at Angophora Reserve	126
Appendix 6 - Table 1. Survey Effort	133

EXECUTIVE SUMMARY

Key Directions of Council

The Native Fauna Plan of Management has been developed to implement the management directions of Pittwater Council's Strategic Plan.

A key direction for Pittwater Council is valuing and caring for the natural environment. This involves the need to be a model community that leads the way towards sustainable living by reducing ecological footprints, protecting and enhancing the bush, beaches and waterways as well as achieving long-term sustainability of biodiversity. The key strategies include:

- supporting viable and thriving biodiversity and sustainable ecosystems;
- sustainably managing our areas of urban forest, bushland and waterways;
- providing a diverse range of accessible recreational opportunities for a broad range of ages, abilities and interests inspired by bush, beach and water.

The Native Fauna Plan of Management will help meet the objectives of the Biodiversity Strategy within the Pittwater Strategic Plan 2020, and identifies required actions in habitat management, updating and creating Plans of Management for bushland reserves, identification of faunal communities at risk and minimising risk elements, conditions for development, community engagement and grant applications.

Background

This plan replaces the previous plan by Smith and Smith, 2000. Fauna lists for the LGA and specific areas within including Council reserves were updated via a number of methods. Surveys were undertaken by the consultant Ecotone Ecological in certain reserves where funding permitted, other areas of the LGA were updated using recent fauna reports from trusted stakeholders and DECCW Wildlife Atlas records. Emphasis was placed on fauna species listed as threatened under the Threatened Species Conservation Act 1995, as well as species which are deemed locally significant to the Pittwater LGA. A comprehensive bird survey had been undertaken in 2008, additional surveys by the consultants focused on bats, small terrestrial and arboreal mammals, frogs and reptiles. Records earlier than 1995 were generally discounted as being still viable, despite being discussed in some cases. Species profiles have been included in the appendices of the management plan which profile each listed threatened species known or having the potential to occur in the LGA. These profiles give scientific information as well as details of the population in or near the LGA.

Summary of Management Issues and Actions

Management actions are provided in the report in the following table and are prioritised and cross-referenced to relevant sections in the plan. These actions reflect and aim to mitigate any relevant Key Threatening Processes as per the Threatened Species Conservation Act 1995 and are focussed on habitat retention, enhancement of wildlife corridors, fire management, minimising disturbance to wildlife, controlling pests and invasive species, minimising the impact of domestic animals and wildlife road fatalities.

Actions

Actions to address the above key directions are presented in the table of Management Issues and Actions overleaf.

Priorities

Each has been allocated a priority as follows:

Action:

- ongoing – important actions that Council needs to continue and improve;
- high priority – to be completed within two years;
- medium priority – to be completed within the next five years;
- low priority – to be completed.

These timeframes are subject to allocation of resources via Council's Annual Delivery Plan.

Summary of Management Issues and Actions

Management Issue	Management Actions	Priority	Section(s) in Management Plan
Preservation of remnant bushland, including creek lines and riparian vegetation	Retain native vegetation where possible including specific habitat types for threatened species i.e. <i>Allocasuarina torulosa</i> stands (Glossy Black-cockatoo), Swamp Mahoganies and Spotted Gums (Swift Parrot and Regent Honeyeater).	Ongoing	6.2 6.3 7.7
Pittwater Council's Tree Preservation Order (October 2009).	Implement and monitor Tree Preservation Order (TPO). Ensure compliance with the Threatened Species Act and Local Government Act.	Ongoing Ongoing	6.3
	Amend to include bushland in LEP.	High	
Retention of hollow-bearing trees, dead trees and dead wood	Hollow-bearing trees, dead trees and dead wood should be conserved where possible within reserves.	Ongoing	6.2 7.1 7.2 Appendix 7
Bush-rock removal	Restrict bush-rock removal from any areas of bushland.	Ongoing	6.2 Appendix 7
Wildlife Corridors	Review and update the Pittwater LGA Wildlife Corridors Plan and amend associated Pittwater 21 DCP controls.	High	6.4
Habitat enhancement (e.g. by food tree plantings)	Plant additional food plants on council land.	Medium	6.3
Fire Management	Identify and manage risks to threatened or locally significant fauna in areas where hazard reduction burns are to be undertaken.	High	6.5 Appendix 7
	Hazard reduction or ecological burns are to be conducted in a manner that retains patches of unburnt vegetation as fauna refuges.	Ongoing	
	Liaise with the relevant authority (formerly the Dept. of Environment, Climate Change and Water (DECCW)) and the Rural Fire Service (RFS) to develop habitat requirements of threatened fauna in relation to fire regimes. Implement fire management practices accordingly.	High	
Education and Community Involvement	Ongoing community education on the following topics to reduce impacts on wildlife: <ul style="list-style-type: none"> • Backyard bushcare - e.g. creating habitat, tree netting ; • Bush regeneration; • Responsible disposal of litter and recycling; • Climate Change – reducing greenhouse emissions; 	Ongoing	5.0 6.2 6.8 6.10 Appendix 2

Management Issue	Management Actions	Priority	Section(s) in Management Plan
Education and Community Involvement continued	<ul style="list-style-type: none"> • Tick control; • Reducing pollutants in waterways; • General ecological information about fauna species. 		
	Develop community education on the following topics: <ul style="list-style-type: none"> • Marine fauna; • Feeding wildlife, disease and related issues; • Conservation of tree hollows and value of dead wood; • Landscaping for conservation; • Pest species including cane toads; • Management issues associated with broadscale insecticide use. 	High	5.0 6.2 6.8 6.10 6.14
Depletion of intertidal invertebrate populations	Continue with community awareness and education initiatives through the Coastal Environment Centre.	Ongoing	5.0 6.15
	Continue in partnership with Dept Industry & Investment (Fisheries) such education programs as the Kid's Fishing Clinic	Ongoing	
Frogs – Chytrid fungus	Provide web-based information on handling frogs in Pittwater LGA. Any persons should be encouraged to follow suitable hygiene methodology.	Medium	6.2 7.6 Appendix 7
Infection of Native Plants by <i>Phytophthora cinnamomi</i>	Bush regenerators to practice good hygiene if entering areas known to contain disease.	Medium	6.2 Appendix 7
	Encourage planting of canopy trees where there have been losses due to dieback.	Medium	
Control of Vertebrate Pest Species	Continue to develop effective and humane control programs for feral animals (rabbits, foxes, feral cats, dogs etc.) in the Pittwater area, with special emphasis on sites where they are a particular threat to threatened fauna species. This should be carried out in conjunction with the relevant authority (formerly DECCW) and Rural Lands Protection Board.	Ongoing	5.0 6.2 6.7 6.14 Appendix 7
	Encourage the community to report the presence of feral animals to Council.	Medium	
Impacts of Domestic (Companion) Animals	Implement Council's statutory obligations and responsibilities for control of dogs and cats under the Companion Animals Act.	Ongoing	6.7 6.10
	Educate dog owners as to the importance of keeping dogs on	Ongoing	6.11

Management Issue	Management Actions	Priority	Section(s) in Management Plan
Impacts of Domestic (Companion) Animals continued	leads when walking through bushland areas.		
	Continue and expand existing community education programs aimed at reducing the impact of cats and dogs on native fauna, including advice on suitable fencing for dogs and outdoor cat enclosures.	High	
Fencing	Investigate in association with other Councils and the relevant authority (formerly DECCW) suitable types of fencing that will confine pets, but also not hinder the movement of wildlife through a corridor.	Medium	6.12
Fauna road casualties and the rehabilitation of sick, injured or orphaned native wildlife	Develop a recording system for the reporting of rescues and releases of threatened fauna species in Pittwater.	High	6.9
	Encourage, support and publicise organisations which rescue and rehabilitate sick, injured or orphaned animals in Pittwater. Guidelines for people finding sick, injured or orphaned native animals should be more widely publicised.	High	
Fauna Assessments for Development Proposals	Further develop guidelines for fauna assessments in line with changes to state guidelines.	Ongoing	6.2
Further Research and Grants	Continue development of fire management plans for large reserves.	Medium	11.0
	Seek partnerships with external bodies to undertake research i.e. universities, animal rescue agencies, community groups, National Parks Association etc..	Ongoing	
	Seek grants to fund research projects.	High	11.0
Disturbance at Nesting, Roosting and Feeding Sites	Consideration to known roost sites for threatened and significant species (e.g. rerouting a footpath to avoid a nest or roost tree area rather than signage which may increase visitors). Temporary closure or rerouting of walking tracks may be an option during the breeding seasons of sensitive species.	Medium	6.11
			7.2
			8.4
	Investigate designated feeding areas on mudflats, with signage asking people to avoid these areas.	Medium	
Investigate protection for known micro-bat roost sites including culverts, drains, bridges and caves known to be used. E.g. St Michaels Cave.	High		

Nest Boxes	Nest boxes installed in areas where hollow availability is poor – targeting threatened and significant species.	Medium	6.13
	Use nest boxes as a survey technique.	Low	
Marine Fauna	Partner with the NSW Department of Industry and Investment (Fisheries) and relevant authority (formerly DECCW) to determine the most suitable methods of ensuring impacts upon these species are minimised.	Medium	3.5 6.2 7.8
	Partner with the NSW Dept. of Industry and Investment (Fisheries) to provide education programs through the Coastal Environment Centre and other avenues to educate the community regarding these species and their protection.	Medium	
	Council should notify the relevant authority (formerly DECCW) of any injured or dead threatened species in this category or of any issues involving these fauna groups.	Low	
Depletion of Intertidal Invertebrate Populations	Partner with NSW Dept. of Industry and Investment (Fisheries) and in management and monitoring of Intertidal Protection Areas and other rock platforms in the Pittwater area.	High	6.15 6.15
	Establish a local fish care program through the Coastal Environment Centre including rock platform tours and signage.	Low	
Control of Plague Minnow	Identify occurrence of species within reserves, then implement control programs in conjunction with the relevant authority (formerly DECCW).	Low	6.2 Appendix 7
Feral Honey Bees	Identify any hives in the LGA and encourage responsible management of bee hives by local apiarists.	Low	6.2 Appendix 7
Impacts of Domestic (Companion) Animals	Investigate development conditions to manage the impacts of cats and dogs on new residential developments in sites where they are a particular threat to threatened fauna species.	High	6.7
Importation of Red Fire Ants	Notify the relevant authority (formerly DECCW) if a population of Fire Ants is identified within the LGA.	High	6.2 Appendix 7
Fauna Road Casualties and the Rehabilitation of Sick, Injured and Orphaned Wildlife	Identify sites where road casualties pose a particular threat to native fauna species in Pittwater. Investigate reduction strategies (reduce speed zones, speed humps and islands, increased signage) and/or fauna control measures at these sites.	High	6.9

Fauna Road Casualties and the Rehabilitation of Sick, Injured and Orphaned Wildlife continued	Monitor and review the development assessment process such that new developments include appropriate measures to prevent increased road casualties of threatened fauna.	Medium	6.9
Flying-fox Camps	Identify camps in the Pittwater LGA.	High	7.2
	Develop a Plan of Management for the flying-fox camp at Cannes Reserve, Avalon.	High	8.2
	Raise community awareness and respond to complaints quickly with an information package, developed in consultation with the NSW Office of Environment and Heritage (formerly DECCW).	High	
Careel Bay	Investigate the provision of a new wader roost at Careel Bay.	Low	8.3
	Monitor and control domestic dog use of intertidal areas at Careel Bay.	Ongoing	
	Partner with the NSW Office of Environment and Heritage (formerly DECCW) and the Dept of Industry & Investment (Fisheries) to investigate the activity of yabbie pumping in Careel Bay to determine the level of disturbance upon the bay.	Medium	
Rapid Assessment Tool	Develop and trial rapid assessment tool across Pittwater LGA.	High	9.0 Appendix 8
Species Inventory for Pittwater and Reserves	Conduct fauna surveys in reserves on a priority basis throughout Pittwater to supplement known fauna information.	Medium	Appendix 1
	Add to Appendix 1 – Fauna species known to occur in Pittwater as new information becomes available, particularly of threatened and locally significant species.	Medium	2.0 Appendix 1
	Develop database of fauna species within Pittwater LGA as information becomes available from all sources and regularly submit to NSW Office of Environment and Heritage - Wildlife Atlas (formerly DECCW).	High	
	Develop GIS Mapping of threatened, regionally and locally significant fauna species for inclusion in wildlife corridor planning and Council website.	High	

This page has
intentionally been left blank

INTRODUCTION

Pittwater Council's Strategic Plan 2020 & Our Sustainable Future sets out the community vision of what Pittwater should be like in 2020 as well as Council's strategies to achieve this vision. One of the five key directions is '*Valuing & Caring for our Natural Environment – the need to be a model community, leading the way towards sustainable living by reducing our ecological footprint, protecting and enhancing our bush, beach and waterways as well as achieving long-term sustainability and biodiversity.*' Within this key direction, there are five strategies including:

- Beach & Coastal Management Strategy
- Biodiversity Strategy
- Sustainability & Climate Change Coordination Strategy
- Vegetation Strategy
- Waste Management & Pollution Control Strategy

All of these strategies are necessary for the long-term viability of native fauna within the Pittwater LGA; however the Biodiversity strategy is the most relevant.

1.1 Management Objectives and Background

In response to the Strategic Plan 2020 & Our Sustainable Future, Pittwater Council has undertaken an update of the fauna management plan (prepared by Smith and Smith in 2000). The Native Fauna Management Plan is to assist council in improving the viability of locally native fauna in Pittwater and effectively manage habitat and vegetation types within the LGA. The plan applies to the entire Pittwater Local Government Area, including both public and private land, excluding National Parks, which are managed by the NSW Office of Environment and Heritage (formerly DECCW). This management plan will be useful in reaching the objectives listed in the Biodiversity Strategy within the Strategic Plan 2020 & beyond:

- **to maintain and enhance bush, beach and waterways resulting in improved biodiversity;**
- **to manage catchments, habitats, corridors and ecosystems effectively;**
- **to halt the loss of biodiversity and advance its recovery;**
- **to understand and respond to the threats to biodiversity including climate change;**
- **to conserve and enhance biodiversity through appropriate land use and development controls;**
- **to foster community pride and action in environmental care and natural heritage;**
- **to lead by example in managing natural and built assets;**
- **to have an effective wildlife corridor network;**
- **to effectively manage the urban interface in a way that supports biodiversity;**
- **to recognise the long-term economic and social value of our environment;**
- **to protect threatened species and habitats;**
- **to prevent human induced erosion thereby reducing sedimentation in creeks and loss of top soil.**

The management plan will also more specifically aid in the following:

- **general fauna management;**
- **habitat management and update of the Plans of Management for Bushland Reserves;**
- **identify faunal communities at risk and minimising risk elements;**
- **development application assessments;**
- **community education, including information on the Pittwater website; and**
- **grant applications.**

Native species and communities have been lost or are in decline within Australian urban environments. For instance, the 1993 household endangered species survey indicated a general decline in all native fauna and dramatic increases in non-native species within the Pittwater area (Higgs and Campbell, 1993).

Some people may ask why we should put so much energy into conserving nature within urban areas when there are large national parks and less developed rural areas where this can take place. The answer to this question could be discussed at length, the following quote from Lunney and Burgin (2004) summarises one aspect to this question. '*Conservation of wildlife in the urban environment is important as this is where the bulk of the population live and subsequently where they form ideas and gain knowledge about our natural environment*'. It is also important for species to be able to move between good areas of habitat via corridors to recolonise, migrate and encourage genetic variation. Particular habitat types have been favoured for urban development for reasons such as, proximity to the coast and beaches, river or lake views, ease of building and so on. Therefore a greater pressure has been put on these habitat types as high percentages have already been removed or highly modified. For example, the communities associated with Newport Formation and Quaternary alluvium are generally poorly represented in the nearby national parks (Smith and Smith, 2000). For example, Swamp Mahogany Forest is not represented at all in Ku-ring-gai Chase, Garigal, Brisbane Water or Bouddi National Parks (Smith and Smith, 2000).

Thorough planning, management and implementation are required to maintain the natural flora and fauna of an area, particularly in an urban area where so many people with differing objectives are involved. It is easier to create habitat for those species that have adapted well to the urban environment, however this forms an unnatural assemblage of species. A greater level of care is required to maintain habitat for those species with more specific habitat requirements to in turn maintain a more natural assemblage of native species. The more natural an assemblage, the greater success a community and ecosystem will have. For instance, small insectivorous birds may be beneficial in the control of insects, but this faunal group is impacted by urbanisation (see **Appendix 4**). It is evident that fragmentation and urbanisation increases herbivory by insects on trees and this is likely due to a reduction of predators in such areas (Hochuli, *et al.*, 2004).

1.2 Description of the Pittwater LGA Study Area

The Pittwater Local Government Area covers a total area of 125 square kilometres (Smith and Smith, 2000). Pittwater LGA includes the north eastern suburbs of Sydney, north of Narrabeen Lagoon and throughout Barrenjoey Peninsula, as well as the estuary of Pittwater and large tracts of National Park (43% of the total LGA area (Pittwater Council 1997a)). The LGA is bounded in the east by the Pacific Ocean and in the west by Cowan Creek, Coal and Candle Creek and McCarrs Creek. The Northern Boundary adjoins Broken Bay and the Hawkesbury River, with National Park and suburbs of the Central Coast on the opposite shore.

Urban development has spread throughout Barrenjoey Peninsula, whereas rural residential properties still occur in Ingleside, western Bayview and Warriewood. Small residential settlements occur along the Western Foreshores of Pittwater.

Included in the Pittwater LGA are 103 bushland reserves covering 330ha. Approximately sixty of these reserves are less than 1 ha in size, with approximately thirty between 1-5ha, six are 5-10 ha and eight are greater than 10ha. Warriewood Wetlands is the largest reserve at 31ha. Ingleside Chase, Deep Creek, Angophora and MacKay Reserves are other examples of larger reserves in Pittwater. A significant remnant indigenous tree cover still remains in areas of Pittwater. Large areas of national parks (Ku-ring-gai Chase and Garigal) are part of and adjoin the Pittwater LGA. These large areas of bushland assist in the diversification and recolonisation of fauna in the area. The diversity of geology, landforms, soils and vegetation communities also contribute to the wide range of habitats available.

Maps of bushland within Pittwater LGA are available at:

<http://www.pittwater.nsw.gov.au/environment/bushland/maps>

There is a diverse range of habitat types within the Pittwater LGA. The following is a list of Endangered Ecological Communities currently found in Pittwater.

- Coastal Saltmarsh
- Duffys Forest Ecological Community
- Littoral Rainforest
- Pittwater Spotted Gum Forest
- Swamp Oak Floodplain Forest
- Swamp Sclerophyll Forest on Coastal Floodplains
- Sydney Freshwater Wetlands
- Themeda Grasslands on Seacliffs and Coastal Headlands
- Sydney Turpentine-Ironbark Forest
- River-Flat Eucalypt Forest on Coastal Floodplains

More information on the vegetation communities in Pittwater, including a map illustrating the distribution of these communities can be found on the following website:

http://www.pittwater.nsw.gov.au/environment/plants_and_animals/vegetation_communities.

Pittwater LGA also contains aquatic habitat including the Pittwater estuary and the adjoining freshwater creeks, bays and lagoons as well as marine habitat along the eastern boundary.

1.3 Geology, Landforms and Soils (taken from Smith and Smith, 2000)

The deeply dissected western plateaus and ridges of the Pittwater area, including most of the area of Kuring-gai Chase National Park, as well as the suburbs of Ingleside and Elanora Heights, occur on Hawkesbury Sandstone. The eastern portion of Pittwater, including Barrenjoey Peninsula, consists largely of sloping land on the interbedded shales and sandstones of the underlying Newport Formation of the Narrabeen Group. These slopes are capped by small areas of Hawkesbury Sandstone. The Hawkesbury Sandstone and Newport Formation both date from the Triassic period. Low lying areas of Pittwater, including the lower reaches of Deep Creek and McCarrs Creek, large areas of Warriewood Valley, portions of Mona Vale, Newport, Avalon and Careel Bay, and the Palm Beach sand spit, are characterised by alluvial sands and muds of Quaternary age formed through deposition of marine, estuarine and riverine sediments.

A detailed description of the geology of the area is contained in the report by Herbert (1983), which accompanies the 1:100 000 geological map (Geological Survey of NSW 1983).

Soils formed on Hawkesbury Sandstone are generally shallow, sandy, stony and infertile. The soils formed on the Newport Formation are generally deeper, more clayey and more fertile than those on the Hawkesbury sandstone. Soils derived from Quaternary alluvium vary in fertility, salinity and soil moisture conditions, depending on the nature of the alluvium.

The soil landscapes of the area have been mapped at a scale of 1:100 000 by Chapman *et al.* (1989) and described in detail by Chapman and Murphy (1989). Soil landscapes are land units that have recognisable and specifiable topographies and soils.

1.4 Management Plan Methodology

The following steps were taken in the preparation of this management plan;

- 1) Review the current Fauna Management Plan (Smith and Smith 2000), extracting information to be used in this report;
- 2) Review records from a variety of sources to obtain a comprehensive fauna species list for Pittwater. Particular attention was given to threatened species records. The location of threatened species records were used to discuss on their distribution and abundance in Pittwater;
- 3) Compile species profiles for the threatened fauna species known to occur in Pittwater;
- 4) Investigate historical changes of fauna species assemblage and abundance over time;
- 5) Conduct community based field surveys as well as professional field surveys to supplement previous data (results from the supplementary surveys carried out by Ecotone Ecological Consultants in 2006 and 2009 are presented in **Appendix 6**);
- 6) Discuss management issues and actions relevant to native fauna in Pittwater;
- 7) Recommend further study required to improve the management of fauna in Pittwater;

2.0 FAUNA RECORDED IN PITTWATER

2.1 Overview of Fauna Species Recorded in Pittwater

In order to determine those fauna species that are known to occur within the study locality (Pittwater LGA), a review of available data has been undertaken. Fauna species records were accessed from the NPWS Atlas of NSW Wildlife Database for the Sydney 1: 100 000 map sheet (updated to September, 2010). Records held by Pittwater Council in the general locality were also reviewed as well as records and reports held by Ecotone Ecological Consultants from previous field surveys. Data from the minor baseline field surveys that were conducted in conjunction with this Fauna Management Plan has also been included. Records provided by both WIRES (NSW Wildlife Information and Rescue Service Inc.) and Sydney Wildlife (Sydney Metropolitan Wildlife Services Inc.) have also been reviewed for threatened and regionally significant species and included in this report. Other sources include scientific papers, books and personal communication.

A total of three hundred and thirty-six (336) fauna species are known to have been recorded within the Pittwater LGA (**Appendix 1**). This high number of species is a result of the variety of habitats available within the LGA. This would be an underestimate of the true species diversity, as most aquatic fauna and terrestrial invertebrates have not been included in this list. Some of these listed species may no longer occur in Pittwater. The number of species allocated to each fauna group is listed below:

Fauna Group	Number of Species
Birds	243
Mammals	58
Non-flying terrestrial mammals	(29)
Flying mammals	(18)
Marine mammals	(11)
Reptiles	41
Amphibians	21
Invertebrates	3

2.2 Threatened Species Recorded in Pittwater (TSC Act and EPBC Act)

Records of threatened fauna previously recorded in Pittwater LGA were extracted from the review in **Section 2.1** and are presented in **Table 1**. There is a possibility that some records have been duplicated if they have been extracted from different sources.

The EPBC Act Protected Matters online search tool was accessed February 2010 to identify the Protected Matters under the Commonwealth EPBC Act that occur or may occur within the study locality. This review yielded a report (summarised in **Table 2**) listing the matters that could potentially be relevant under the EPBC Act for Pittwater LGA. Species listed as threatened under the EPBC ACT are presented in **Appendix 2 (section 6)**.

It is recommended that these fauna sightings be recorded using GIS mapping tools to allow for quick referencing across the LGA and use when establishing and/or enhancing wildlife corridors. This information could also be made available to the community via Council's website.

2.2.1 Threatened Species

A total of fifty-six threatened terrestrial fauna species have previously been recorded within the study locality, including fourteen terrestrial mammals (nine flying and five non-flying), twenty-seven terrestrial birds, three frogs, one terrestrial reptile and one invertebrate, as well as ten marine species including four bird, four mammal and two reptile (See **Table 1**). Of these, twelve species are currently regarded as Endangered on Schedule 1, Part 1 of the *TSC Act 1995* and the remainder as Vulnerable on Schedule 2 of the Act. The endangered species include the Bush-stone Curlew, Australasian Bittern, Swift Parrot, Pied Oystercatcher, Southern Brown Bandicoot, Green and Golden Bell Frog, Giant Dragonfly, Little Tern, Cotton Pygmy-Goose, Grey-headed Flying-fox, Painted Snipe and Broad-headed Snake.

The Glossy Black-cockatoo, Powerful Owl, Eastern Bent-wing Bat, Grey-headed Flying-fox and Green Turtle appear to be the most commonly encountered of the threatened species, with a number of recent records for the area (outside the National Parks).

Profiles for these threatened species are listed in **Appendix 2**. The occurrence of these species in Pittwater is discussed in the individual profiles (**Appendix 2**).

The EPBC Protected Matters report revealed that thirty-five nationally threatened fauna species (of which eight are considered endangered, one critically endangered, one conservation dependant and the remainder as vulnerable) are likely or have habitat that is likely to occur within the vicinity of the Pittwater LGA, according to the EPBC modelling. Thirty-four species are listed as migratory. Three places are listed on the Register of the National Estate, including Angophora Reserve, Hudson Park, and Ku-ring-gai Chase National Park. There are four listed State and Territory Reserves, but no listed critical habitat (see **Table 2**).

2.2.2 Endangered Populations of Fauna

The Koala population in Pittwater Local Government Area and the Squirrel Glider population on Barrenjoey Peninsula, north of Bushrangers Hill are listed as Endangered on Schedule 2, Part 1 of the *TSC Act 1995*.

2.2.3 Critical Habitat

No areas of Critical Habitat are currently listed for the Sydney Basin Bio-region.

2.2.4 Threatened Fish and Marine Invertebrates

Threatened fish and marine invertebrates listed as threatened in NSW by the Department of Primary Industry (DPI) are listed in **Appendix 2** (section 5). Although the management of marine fauna is not a direct responsibility of Pittwater Council, there are activities that result in secondary impacts such as run-off, on marine fauna and therefore are considered in this management plan.

Table 1. Threatened Fauna Recorded in the Pittwater LGA

Scientific Name	Common Name	Status (TSC)	Earliest / latest record	Number of records	Minimum Number of records within last 10 years	Source
TERRESTRIAL BIRDS						
<i>Botaurus poiciloptilus</i>	Australasian Bittern	V	1984	1	0	1
<i>Ixobrychus flavicollis</i>	Black Bittern	V	2007	6	1	1, 2, 9, 17
<i>Haematopus longirostris</i>	Pied Oystercatcher	E	1988	1	0	6
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V	unknown	1	?	9
<i>Sterna fuscata</i>	Sooty Tern	V	1988	1	0	1
<i>Burhinus grallarius</i>	Bush Stone-curlew	E1	1981-2009	14	10	1, 2, 6, 17
<i>Collocephalon fimbriatum</i>	Gang-gang Cockatoo	V	1970-2004	3	2	1, 17
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V	1982-2007	31	12	1, 2, 4, 17
<i>Charadrius mongolus</i>	Lesser Sand Plover	V	unknown	1	?	12
<i>Daphoenositta chrysoptera</i>	Varied Sittella	V	unknown	1	?	
<i>Glossopsitta pusilla</i>	Little Lorikeet	V	1991-2008	4	1	1
<i>Hieraaetus morphnoides</i>	Little Eagle	V	1995-2007	2	1	1
<i>Lathamus discolor</i>	Swift Parrot	E1	1982-2009	7	2	1, 2, 17
<i>Lophoictinia isura</i>	Square-tailed Kite	V	2008	1	1	17
<i>Melithreptus gularis</i>	Black-chinned Honeyeater	V	unknown	1	?	9
<i>Neophema pulchella</i>	Turquoise Parrot	V	1983	1	0	1
<i>Ninox connivens</i>	Barking Owl	V	1984-2008	10	7	1, 17
<i>Ninox strenua</i>	Powerful Owl	V	1985-2009	35	30	1, 2, 5, 15, 16
<i>Petroica boodang</i>	Scarlet Robin	V	unknown	2	?	
<i>Sterna albifrons</i>	Little Tern	E1	unknown	1	0	12
<i>Tyto tenebricosa</i>	Sooty Owl	V	1984-2004	1	1	11, 17
<i>Tyto capensis</i>	Grass Owl	V	1992	1	0	12
<i>Tyto novaehollandiae</i>	Masked Owl	V	1935-1974	3	0	14, 17
<i>Pandion haliaetus</i>	Osprey	V	1985-2005	11	4	1, 2
<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V	1984-1992	2	0	1, 12
<i>Ptilinopus regina</i>	Rose-crowned Fruit-dove	V	1982	1	0	12
<i>Tringa terek</i>	Terek Sandpiper	V	unknown	1	0	12
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E1	1938-1998	5	0	1, 17
TERRESTRIAL NON-FLYING MAMMALS						
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	1969-2005	8	1	1, 15
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	1975-1998	7	1	1
<i>Isodon obesulus obesulus</i>	Southern Brown Bandicoot (eastern)	E1	1970-2008	24	5	1, 15
<i>Petaurus norfolcensis</i>	Squirrel Glider on Barrenjoey Peninsula, north of Bushrangers Hill	E2/V	2002-2006	3	3	1, 2, 15
<i>Phascolarctos cinereus</i>	Koala in the Pittwater LGA	E2/V	1900-2006	158	2	1, 2, 8

Scientific Name	Common Name	Status (TSC)	Earliest / latest record	Number of records	Minimum Number of records within last 10 years	Source
FLYING MAMMALS						
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V	1994-2009	18	17	1, 3, 5, 7, 10, 2
<i>Miniopterus australis</i>	Little Bentwing-bat	V	2005-2006	4	4	10, 18
<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat	V	2003-2004	1	1	1
<i>Myotis macropus</i>	Southern Myotis	V	2007	1	1	1
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	1996-2008	2	1	7, 1
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	1998-2005	1	1	10
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	1996	1	1	7
<i>Vespadelus troungtoni</i>	Eastern Cave Bat	V	2006	1	1	13
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	1977-2009	62	44	1, 15, 18
FROGS						
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	V	1968-2007	23	10	1, 5
<i>Pseudophryne australis</i>	Red-crowned Toadlet	V	1966-2007	24	3?	1, 5
<i>Litoria aurea</i>	Green and Golden Bell Frog	E	1955	1	0	19
TERRESTRIAL REPTILES						
<i>Varanus rosenbergi</i>	Rosenberg's Goanna	V	1993-2007	7	6	1, 2
TERRESTRIAL INVERTEBRATES						
<i>Petalura gigantea</i>	Giant Dragonfly	E	1974	1	0	14
MARINE FAUNA						
<i>Diomedea exulans</i>	Wandering Albatross	E1	1975-2004	2	1	1, 2
<i>Thalassarche melanophris</i>	Black-browed Albatross	V	1992	1	0	1
<i>Macronectes giganteus</i>	Southern Giant Petrel	E1	1975-1988	2	0	1, 6
<i>Thalassarche cauta</i>	Shy Albatross	V	1997	3	3	1
<i>Arctocephalus pusillus doriferus</i>	Australian Fur-seal	V	1985	1	0	1
<i>Dugong dugong</i>	Dugong	E1	1992	1	0	1
<i>Eubalaena australis</i>	Southern Right Whale	V	1989-1993	8	1	1
<i>Megaptera novaeangliae</i>	Humpback Whale	V	1987-1993	2	0	1
<i>Chelonia mydas</i>	Green Turtle	V	1993-2006	8	6	1
<i>Dermochelys coriacea</i>	Leathery Turtle	V	1972	1	0	1

Notes:

Status (TSC): refers to the NSW *Threatened Species Conservation Act 1995* (TSC)

E1 Schedule 1, Part 1: Endangered Species;

V Schedule 2: Vulnerable Species

Source

- 1: NSW Office of Environment and Heritage (formerly DECCW) wildlife atlas records
- 2: Pittwater council records (including records via emails or notes given to council from members of the public)
- 3: GIS Environmental Consultants, 1998. *Flora and Fauna at the site of proposed changes to Bayview Golf Course*.
- 4: Ecotone 1999. *Fauna Impact Assessment, 6 Chiltern Road, Ingleside, NSW*.
- 5: Ecotone 1999b. *Species Impact Statement for the proposed Burrawang Ridge Estate, Ingleside*
- 6: Smith P. and Smith J. 1997. *Bird Habitat Study of Careel Bay*
- 7: Turton M, 1996. *Chiropteran Survey of Five Bushland Reserves in Pittwater*

Source continued:

- 8: Higgs P. and Campbell D. 1993. *Endangered Species Household Survey 1993*
- 9: Plans of Managements prepared for Pittwater Council
- 10: Basham, R. 2005. *Microbats in Sydney's urban landscape: are they persisting, and what factors influence their presence?* Honours thesis University of NSW.
- 11: Kavanagh R. 2004. *Conserving owls in Sydney's urban bushland: current status and requirements*. PP 93-108 in *Urban Wildlife: more than meets the eye*, edited by D. Lunney and S. Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- 12: ICF PTY LTD and The Australian Museum, 1994. *Ingleside / Warriewood Urban Land Release Fauna Conservation Study*. Report prepared for Pittwater Council.
13. Brad Law *Pers. _comm*. DPI.
14. Smith P. and Smith J. 2000. *Management Plan for Threatened Fauna and Flora in Pittwater*. Report prepared for Pittwater Council.
15. WIRES records 2004 to early 2009
16. Ingleside Residents Bushcare Group: Bird List.
17. A Bird List for Sydney's Northern Beaches. Compiled by Bruce Cox.
18. Observations by Ecotone Ecological Consultants during current surveys (2006 and 2009).
19. White A and Pyke G. 1996. Distribution and Conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. *Australian Zoologist* **30(2)**: 177-189.

Please note: These records are based on information supplied by the NSW Department of Environment, Climate Change and Water and other sources, and may contain errors or omissions.

Table 2. Summary of relevant Protected Matter under the Commonwealth EPBC Act 1999

Protected Matter	Details
National Heritage Places	Ku-ring-gai Chase National Park, Lion Long and Spectacle Island Nature Reserves NSW
Wetlands of International Significance	Within the same catchment as Towra Point Nature Reserve
Threatened Fauna Species	<p>Thirty-five:</p> <p>Species or species habitat may occur within area according to EPBC modelling</p> <p><i>Carcharias taurus</i> (east coast population) Grey Nurse Shark (east coast population) (CE)</p> <p><i>Carcharodon carcharias</i> Great White Shark (V)</p> <p><i>Chalinolobus dwyeri</i> Large-eared Pied Bat, Large Pied Bat (V)</p> <p><i>Chelonia mydas</i> Green Turtle (V)</p> <p><i>Dermochelys coriacea</i> Leathery Turtle (V)</p> <p><i>Dasyurus maculatus maculatus</i> (SE mainland population) Spotted-tail Quoll (E)</p> <p><i>Diomedea antipodensis</i> Antipodean Albatross (E)</p> <p><i>Diomedea gibsoni</i> Gibson's Albatross (V)</p> <p><i>Galeorhinus galeus</i> School Shark (CD)</p> <p><i>Macronectes giganteus</i> Southern Giant-Petrel (E)</p> <p><i>Macronectes halli</i> Northern Giant-Petrel (V)</p> <p><i>Pterodroma neglecta neglecta</i> Kermadec Petrel (western) (V)</p> <p><i>Potorous tridactylus tridactylus</i> Long-nosed Potoroo (SE mainland) (V)</p> <p><i>Pristis zijsron</i> Green Sawfish (V)</p> <p><i>Rhincodon typus</i> Whale Shark (V)</p> <p><i>Rostratula australis</i> Australian Painted Snipe (V)</p> <p><i>Thalassarche bulleri</i> Buller's Albatross (V)</p> <p><i>Thalassarche cauta cauta</i> Shy Albatross (V)</p> <p><i>Thalassarche cauta salvini</i> Salvin's Albatross(V)</p> <p><i>Thalassarche cauta steadi</i> White-capped Albatross (V)</p> <p><i>Thalassarche melanophris impavida</i> Campbell Albatross (V)</p> <p><i>Litoria littlejohni</i> Littlejohn's Tree Frog, Heath Frog (V)</p>

Protected Matter	Details
Threatened Fauna Species Continued.....	<p>Species or species habitat likely to occur within area according to EPBC modelling <i>Eubalaena australis</i> Southern Right Whale (E) <i>Heleioporus australiacus</i> Giant Burrowing Frog (V) <i>Hoplocephalus bungaroides</i> Broad-headed Snake (V) <i>Isodon obesulus obesulus</i> Southern Brown Bandicoot (E) <i>Lathamus discolor</i> Swift Parrot (E) <i>Litoria aurea</i> Green and Golden Bell Frog (V) <i>Mixophyes balbus</i> Stuttering Frog (V) <i>Macquaria australasica</i> Macquarie Perch (E) <i>Prototroctes maraena</i> Australian Grayling (V) <i>Xanthomyza phrygia</i> Regent Honeyeater (E)</p> <p>Species or species known to occur within area according to EPBC modelling <i>Megaptera novaeangliae</i> Humpback Whale (V) <i>Natator depressus</i> Flatback Turtle (V)</p> <p>Foraging, feeding or related behaviour known within area according to EPBC modelling <i>Pteropus poliocephalus</i> Grey-headed Flying-fox (V)</p>
Migratory Species	<p>Thirty-four:</p> <p>Terrestrial Species Breeding likely to occur within area according to EPBC modelling <i>Myiagra cyanoleuca</i> Satin Flycatcher</p> <p>Breeding may occur within area according to EPBC modelling <i>Hirundapus caudacutus</i> White-throated Needletail <i>Monarcha melanopsis</i> Black-faced Monarch <i>Rhipidura rufifrons</i> Rufous Fantail</p> <p>Species or species habitat likely to occur within area according to EPBC modelling <i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle <i>Xanthomyza phrygia</i> Regent Honeyeater</p> <p>Species or species habitat may occur within area according to EPBC modelling <i>Merops ornatus</i> Rainbow Bee-eater</p>

Protected Matter	Details
Migratory Species Continued....	<p>Wetland species</p> <p>Species or species habitat may occur within area according to EPBC modelling <i>Ardea alba</i> Great Egret <i>Ardea ibis</i> Cattle Egret <i>Gallinago hardwickii</i> Latham's Snipe, Japanese Snipe <i>Rostratula benghalensis s. lat.</i> Painted Snipe</p> <p>Marine species</p> <p>Species or species habitat may occur within area according to EPBC modeling <i>Apus pacificus</i> Fork-tailed Swift <i>Balaenoptera edeni</i> Bryde's Whale <i>Caperea marginata</i> Pygmy Right Whale <i>Carcharodon carcharias</i> Great White Shark <i>Chelonia mydas</i> Green Turtle <i>Dermochelys coriacea</i> Leathery Turtle, Leatherback Turtle, Luth <i>Diomedea antipodensis</i> Antipodean Albatross <i>Diomedea gibsoni</i> Gibson's Albatross <i>Macronectes giganteus</i> Southern Giant-Petrel <i>Macronectes halli</i> Northern Giant-Petrel <i>Sterna albifrons</i> Little Tern <i>Thalassarche bulleri</i> Buller's Albatross <i>Thalassarche cauta</i> Shy Albatross <i>Thalassarche impavida</i> Campbell Albatross <i>Thalassarche salvini</i> Salvin's Albatross <i>Thalassarche steadi</i> White-capped Albatross <i>Lagenorhynchus obscurus</i> Dusky Dolphin <i>Orcinus orca</i> Killer Whale, Orca <i>Rhincodon typus</i> Whale Shark</p> <p>Species or species habitat likely to occur within area according to EPBC modeling <i>Eubalaena australis</i> Southern Right Whale</p>
Migratory Species Continued....	<p>Species or species habitat known to occur within area according to EPBC modeling <i>Megaptera novaeangliae</i> Humpback Whale <i>Natator depressus</i> Flatback Turtle</p>

Protected Matter	Details
Places on the Register of the National Estate	<p><u>Angophora Reserve / Hudson Park NSW</u> Approximately 18.5ha, in Avalon and Bilgola, comprising Hudson Park and Angophora Reserve.</p> <p><u>Ku-ring-gai Chase National Park (1980 boundary) NSW</u> Approximately 14713ha, on the northern side of Sydney. Located on southern shore of Broken Bay and comprising much of the catchment of Cowan Creek. Generally bounded by Broken Bay in north, Pittwater in East, Sydney suburbs in south and main north railway in west.</p>
State and Territory Reserves	<p>Barrenjoey Aquatic Reserve, NSW Garigal National Park, NSW Ku-ring-gai Chase National Park, NSW Narrabeen Aquatic Reserve, NSW</p>

Notes:

- V Species listed as Vulnerable under the Commonwealth *EPBC Act*.
 E Species listed as Endangered under the Commonwealth *EPBC Act*.
 CE Species listed as Critically Endangered under the Commonwealth *EPBC Act*.
 CD Species listed as Conservation Dependant under the Commonwealth *EPBC Act*.

3.0 LOCALLY SIGNIFICANT SPECIES AND CHANGES IN DISTRIBUTION AND ABUNDANCE OVER TIME

A total of 138 species (not listed as threatened) are considered to be locally significant within the Pittwater area. The degree to which these species are significant varies. The number is high due to the highly disturbed nature of the Pittwater LGA, particularly Barrenjoey Peninsula. These species include 103 birds, 8 frogs, 14 mammals and 14 reptiles. These species are listed in **Appendix 3**.

3.1 Vagrants and Unusual Sightings

Occasionally birds or marine fauna may travel outside of their normal range, creating unusual sightings. For example a Pied Imperial-pigeon, usually occurring in northern Australia was observed in Newport in 2009 (Pittwater Council records). The Hoary-headed Grebe is also a vagrant visitor to Pittwater (Cox, 2008). The Noisy Pitta, White-plumed Honeyeater, Square-tailed Kite, Grass Owl, Black-chinned Honeyeater, Crested Shrike-tit and White-rumped Swiftlet are examples of unusual or very rare sightings for Pittwater (Cox, 2008).

3.2 Changes in Distribution and Abundance over Time

Appendix 4 contains a historical discussion on changes in distribution and abundance of fauna in Pittwater over time.

4.0 FAUNA OF THE ENDANGERED ECOLOGICAL COMMUNITIES IN PITTWATER

Eight Endangered Ecological Communities (EECs), as listed in Part 3, Schedule 1 of the TSC Act, 1995, are known to occur in the Pittwater LGA. These are:

- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Duffys Forest Ecological Community in the Sydney Basin Bioregion
- Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions
- Pittwater Spotted Gum Forest
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East corner Bioregions.
- Swamp Sclerophyll Forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner.
- Sydney Freshwater Wetlands
- Themeda Grassland on sea cliffs and coastal headlands in the NSW North Coast, Sydney Basin and South-east corner Bioregions.

A description of these EEC's can be found on the NSW Office of Environment and Heritage (formerly DECCW) website.

These Endangered Ecological Communities all provide habitat for both threatened and non-threatened fauna species. These communities should not only be conserved for their floristic characteristics, but also for their role in providing habitat. **Appendix 5** contains a list of threatened species known to utilise these EEC's as part of their range.

5.0 COMMUNITY INVOLVEMENT AND EDUCATION

There are many ways that the community can assist with environmental issues, ranging from eco friendly practices in one's own backyards to helping at a local bush regeneration site or assisting with local research projects.

5.1 Sustainability Workshops

Pittwater Council and the Coastal Environment Centre run regular seminars regarding the following issues:

Creating Habitat

Habitat for native wildlife can be created in suburban gardens. This is most successful when a bushland reserve is adjoining or near by. The following is a list of some actions that may be taken:

- planting native trees and shrubs (preferably those indigenous to the area, using local seed stock);
- planting native grasses and leaving areas free from mowing;
- retain and / or place hollow logs and rocks amongst or near to vegetation;
- leave areas of leaf litter;
- remove weeds;
- use non poisonous methods for pest control (i.e. refrain from using snail bait, other chemical pesticides and chemical herbicides);
- protect wildlife from domestic and feral animals;
- retain tree hollows where possible;
- install nest boxes;
- create a frog pond;
- refrain from providing artificial food for wildlife.

While artificial nest boxes may provide temporary shelter for hollow dwelling wildlife, it often takes over 100 years for a tree to develop hollows (Claridge and van der Ree, 2004). Therefore it is important for existing large trees and hollows to be retained.

Tree netting

Netting used over backyard fruit trees is often loosely placed over the tree. This is an unsafe practice as animals, particularly flying-foxes and birds can easily become entangled, causing extreme injuries and sometimes death. This is particularly the case where thin nylon monofilament netting is used (Saunders, 2004). Here are some suggestions of suitable methods to protect fruit (Saunders, 2004):

- 1) individually wrap the fruit in paper or shade cloth bags;
- 2) peg a 30% shade cloth cover over the tree canopy;
- 3) if using netting make a frame and stretch the netting over frame (mesh size less than 40mm).

Any netting or shade cloth needs to be pegged down so that an animal is unable to climb underneath and become trapped inside. Netting stretched tightly will allow flying animals to bounce off rather than become entangled. Light coloured netting is also more visible to the animal (Saunders, 2004).

5.2 Bushcare and Community Groups

Pittwater Council currently manages over 26 bushcare sites across the LGA. Bushcare groups meet monthly for a few hours to work in local bushland reserves. Council provides each group with tools and an experienced supervisor who gives training and guidance in basic bush regeneration techniques.

Information on local community groups such as bush regeneration can be found on the Pittwater Council website http://www.pittwater.nsw.gov.au/environment/get_involved/bushcare_groups.

5.3 Scientific Research Projects

Community based scientific research projects can be beneficial for the local residents and the scientists involved in the project. The residents are able to get involved with helping the local environment, are educated about the topics being studied and are then able to implement positive changes from the results of the project. For the scientists, projects are more economically viable with volunteers donating their time and knowledge. Residents are also able to provide historical information, access to private land and spread the results to the wider community (Lunney and Mathews, 2002). It is important, however, that volunteers are well trained and use suitable methodology to obtain good quality data (Wilson, 2002).

5.4 Recording Fauna Sightings (Wildlife Watch)

It is important for local residents to report sightings of significant and threatened wildlife to Pittwater Council as this information can be stored on a database that may subsequently be used in future management strategies.

A suitable database should be created that allows for a simple method of data entry and data extraction. The database design should include information such as, species name, both scientific and common, date of record, method recorded (e.g. heard or observed etc), location of record (both a description and a map grid reference, observers name and qualifications (e.g. experienced bird watcher etc). A ranking system for the reliability of the record is necessary. This information should be regularly submitted to the Department of Environment, Climate Change and Water for inclusion in their Wildlife Atlas.

5.5 Coastal Environment Centre

The Coastal Environment Centre (CEC) is a regional community environmental learning centre. The Centre has a focus on local biodiversity and ecosystems, coastal management, sustainability and climate change. Thousands of people benefit from the services provided by the centre each year. Pittwater benefits from the increased knowledge and understanding of environmental issues throughout the broader community.

Education programs run by the CEC should be encouraged, utilised and expanded as a valuable resource to aid in the management of fauna throughout Pittwater LGA.

6.0 MANAGEMENT ISSUES

The life histories and habitat requirements of threatened fauna and flora in Pittwater are extremely diverse. The threats to their continued existence are equally diverse and require a variety of management responses. The most general threat is loss of habitat. It cannot be stressed enough that the future of the various threatened fauna and flora species and communities in Pittwater is interlinked and is dependent to a large extent on protection, maintenance and enhancement of the area's remnant natural habitats, including bushland, creek lines, wetlands and intertidal areas (*Paragraph taken from Smith and Smith, 2000*).

Management issues relating to fauna are described below. The issue and suitable actions that should be implemented are discussed.

The success of most initiatives will be dependent on co-operative management involving Council, other government authorities and the community (Smith and Smith, 2000).

6.1 Legislation and Guidelines relevant to Native Fauna

The following is a list of legislation and guidelines relevant to native fauna:

- Environmental Planning & Assessment Act 1979
- Environmental Planning & Assessment Regulation 2000
- Environmental Protection & Biodiversity Conservation Act 1999
- Threatened Species Act 1995
- Fisheries Management Act 1994
- Rural Fires Act 1997
- Water Management Act 2000
- Native Vegetation Act 2003
- SEPP 44 - Koala Habitat Protection
- SEPP 19 - Bushland in Urban Areas
- SEPP 55 - Remediation of Land

6.1.1 Key Threatening Processes, Threat Abatement Plans and Species Recovery Plans

Key Threatening Processes are listed by the Scientific Committee as part of the Threatened Species Conservation Act (TSC Act), 1995. There are twenty-five Key Threatening Processes that may be relevant to the fauna of Pittwater. These Key Threatening Processes need to be considered for management and are listed and described in **Appendix 7**, with management options discussed. Threat Abatement Plans have been prepared for some of these processes of which details are summarised in **Appendix 7**. **Appendix 7** also contains details about Species Recovery Plans and a list of threatened species with current plans.

6.1.2 Overall Management Options

- Pittwater Council to implement management strategies outlined in the threat abatement and species recovery plans prepared by the NSW Office of Environment and Heritage (formerly DECCW) and the Department of Sustainability, Environment, Water, Population and Communities.
- Educate the public about these Key Threatening Processes and provide suggestions on how individuals may assist in the management of these processes.
- Coastal Environment Centre education programs can be utilised to educate the community as to these Key Threatening Processes and recovery strategies.

6.2 Conservation and Rehabilitation of Core Habitat and Remnant Bushland

Urbanisation in Pittwater has resulted in extensive native vegetation removal, leaving mostly small and isolated remnants under great pressure from the surrounding areas. In some parts of Pittwater, such as Mona Vale and North Narrabeen, very little native bushland now remains. On Barrenjoey Peninsula, in a period of rapid urbanisation, the area of forested land declined from 705 ha in 1946 to only 125 ha in 1986 (Smith and Smith, 2000). The most extensive areas of remnant bushland remaining in the Pittwater Council area are in the largely non-urban lands of the Ingleside/Warriewood area (Smith and Smith, 2000). A major urban land release program is underway for the Warriewood area and planned for the Ingleside area, resulting in further loss of remnant bushland.

The pressure to remove remaining bushland is continual and incremental. It comes not only from large-scale developments, but also from the many proposals for smaller subdivisions and dual occupancies, swimming pools, tennis courts and so on. The individual impacts of these small-scale developments may be minor, but their cumulative impact is continual and substantial (Smith and Smith, 2000).

An analysis of the distribution of reported sightings of Koalas, bandicoots and gliders in relation to remnant bushland on Barrenjoey Peninsula reported a rapid decline in the frequency of sightings with increasing distance from remnant bushland (Smith 1996). Smith and Smith (2000), illustrated that threatened fauna records strongly correlate with the distribution of remnant bushland in Pittwater and that areas with little remnant bushland are unable to support these species. Therefore the loss of bushland habitat is only partially compensated by planting of native trees and shrubs around houses. Urban areas with a good cover of indigenous trees and shrubs have value as movement corridors between bushland remnants (Smith and Smith, 2000).

Also tree preservation and food tree planting in urban areas adjoining core habitat and bushland remnants are important components to preserving these areas by reducing the edge effect and adding a buffer zone. They may also provide important feeding opportunities not available in the bushland remnants, important food plants lacking in the remnants. However, in the absence of intact bushland, garden and street plantings will not support populations of species over the long term (Smith and Smith, 2000).

It is vital that a variety of habitats are conserved as different species have different requirements and in some cases the same species requires elements found in different habitats.

It is essential that areas of core habitat and remnant bushland be conserved and rehabilitated to a healthy state. Natural ecosystems function more efficiently when habitat components are in a more pristine state, thereby more able to withstand the pressures of being in an urbanised landscape.

Urban bushland remnants are easily impacted by the surrounding activities, resulting in the following forms of degradation (*taken from* Smith and Smith, 2000):

6.2.1 Weed Invasion

This is a ubiquitous problem in urban bushland reserves around Sydney, although some vegetation communities are more prone to weed invasion than others. Of the two endangered ecological communities in Pittwater, Pittwater Spotted Gum Forest (Holden 1999) is much more susceptible to weed invasion than the Duffys Forest Vegetation Community (Smith and Smith 2000). In Angophora Reserve, for example, thickets of *Lantana camara* (Lantana) have replaced the native understorey in parts of the Spotted Gum Forest (Smith and Smith 1992a). Among a variety of other troublesome weeds in bushland reserves in Pittwater are *Acetosa sagitata* (Potato Vine), *Ageratina adenophora* (Crofton Weed), *Cinnamomum camphora* (Camphor Laurel), *Chrysanthemoides monilifera* (Bitou Bush), *Ipomoea indica* (Morning Glory), *Ligustrum lucidum* (Large-leaved Privet), *L. sinense* (Small-leaved Privet), *Lonicera japonica* (Japanese Honeysuckle), *Ludwigia peruviana* (Ludwigia), *Protasparagus aethiopicus* (Asparagus Fern), *Senna pendula* (Cassia) and *Tradescantia albiflora* (Wandering Jew) (Pittwater Council 1993, 1994, 1995a, 1996, 1997b). The worst cases of weed infestation in reserves are typically lower in the catchment and associated with sites affected by nutrient enrichment and increased moisture levels produced by runoff from adjacent urban areas.

6.2.2 Eucalypt Dieback

This is a major threat to remnant bushland in the Pittwater area (Pittwater Council 1997b) and is having a significant effect on the food and nesting resources of threatened fauna species. For example, Smith and Smith (1990b, 1992b) have estimated that 50% of all eucalypts over 6 m tall have died in Crown of Newport Reserve, 24% in Angophora Reserve and 12% in McKay Reserve. An investigation of dieback on Scotland Island was carried out by Woodlots and Wetlands Pty Ltd (1997), who concluded that the dieback was related to wastewater disposal systems.

6.2.3 Invasion of Saltmarsh by Mangroves

Saltmarsh areas at Careel Bay are a critical habitat for the Bush Stone-curlew as a daytime roost and a nesting site. Over the last 50 years the area of saltmarsh at Careel Bay has been drastically reduced through invasion by mangroves. If the process continues and the saltmarsh is entirely replaced by dense mangroves, it could lead to the elimination of the stone-curlews from the site, which is their only habitat in Pittwater. The reasons for the expansion of mangroves into the saltmarsh, which has also occurred at other sites around Sydney, are not clear.

6.2.4 Expansion of Rainforest and She-oak Vegetation at the Expense of Eucalypt Vegetation

Vegetation changes are occurring in urban bushland reserves throughout Sydney because their isolation has meant a reduced frequency of major wildfires and an increased influx of nutrients and water from the surrounding urban areas. In Pittwater these changes have tended to favour the expansion of rainforest plants (especially *Glochidion ferdinandi* and *Pittosporum undulatum*) and she-oaks (especially *Allocasuarina littoralis*) and these have inhibited eucalypt regeneration. These effects are evident, for example, in stands of the endangered Pittwater Spotted Gum Forest community in Angophora and McKay Reserves. Some threatened fauna species may benefit, notably the Glossy Black-Cockatoo, whose major food is she-oak seeds, but the loss of eucalypts will affect many other threatened fauna species and should be prevented. Eucalypts are a major food source for species such as the Koala, Squirrel Glider, Regent Honeyeater and Swift Parrot and an essential source of nest hollows for other species, such as the Powerful Owl, Masked Owl, Barking Owl, and the Glossy Black-Cockatoo.

6.2.5 Specific Management Options

Sufficient bushland habitat must be conserved in good condition for the long-term viability of Pittwater fauna, especially the threatened species populations. This needs to include a variety of habitats, supplemented by native vegetation being retained and planted in the adjoining suburbia.

Specific Management Options:

- review the operation and effectiveness of the bushland plans of management that have been prepared for Pittwater reserves. Develop and implement additional control measures where necessary;
- encourage other landowners and managers to adopt similar measures to control and reverse habitat degradation in remnant bushland on their lands;
- continue and expand the existing volunteer programs (e.g. Bush-care), by which the community can become engaged in managing and maintaining remnant urban bushland in Pittwater;
- review, update and implement the Pittwater LGA Wildlife Corridors Strategy and amend the associated Pittwater 21 DCP controls accordingly;
- ensure compliance with the Noxious Weeds Act;
- include this topic within education programs conducted by the Coastal Environment Centre.

6.3 Wildlife Corridors, Fragmentation and Edge Effects

Urban expansion has resulted in a high level of fragmentation and loss of suitable wildlife corridors over time. With most reserves being small and isolated, Barrenjoey Peninsula is particularly isolated by the Pittwater estuary and urban development around Mona Vale and Newport. This is likely to be a contributing cause to the decline of both the Koala and Squirrel Glider populations on the Peninsula (Smith and Smith, 2000). This isolation is also impacting a range of more common species that are becoming rare on the peninsula.

Fragmentation and isolation of habitat has a greater impact on the less mobile species, particularly those that are reluctant to cross open areas away from shelter. Many species of the more mobile fauna groups such as birds and bats are less affected by barriers.

Vegetation and wildlife communities have more reduced species diversity when they are isolated from other remnants by extensive water, urban or agricultural land barriers, with small isolated patches unable to support populations in the long term (Clancy, 2002).

While urban areas can never replicate all of the habitat values of a large, contiguous area of bushland, a network of wildlife corridors can be effective in encouraging a more robust and diverse fauna population by linking otherwise isolated patches of remnant bushland (Pittwater Wildlife Corridor Strategy 2010).

Wildlife corridors have a range of benefits as they:

- allow increased migration rates of species/ individuals to assist in the maintenance of species; richness and diversity; decrease the likelihood of local extinction; and prevent inbreeding;
- provide increased foraging area for species with large ranges;
- provide refuge from predators such as domestic pets;
- widen the variety of habitat available;
- provide refuge from disturbed habitat (e.g. fire affected bushland);
- provide visual amenity within urban areas.

Wildlife corridors include: natural corridors (e.g. bands of riparian vegetation along watercourses); corridors of remnant vegetation (vegetation remaining after clearing of the surrounding area); regenerated corridors (natural regrowth of vegetation that was formally cleared or degraded); and planted corridors (deliberately created either as wildlife corridors or for other purposes such as windbreaks).

Bush gardens may also provide habitat for small reptiles, amphibians and some birds, allowing the area to be used as a movement corridor (Clancy, 2002). Long-nosed Bandicoots for example will readily use gardens that have lawn areas with soft moist soil for foraging, are free from domestic predators and have dense understorey vegetation nearby for shelter. See **Section 5.0** for ideas on how to 'improve' your garden. Tree preservation and food tree planting are also important components in the maintenance of wildlife corridors.

An increase in fragmentation results in an increase of *edge effects* (degradation and disturbances occurring around the boundary of a bushland remnant). The smaller and narrower the fragment, the greater the level of edge effect. Impacts include; weed invasion, predation and competition from introduced species, human disturbances such as night light, noise and ground disturbance, pollutants, soil erosion etc.

Corridors become more important with higher levels of fragmentation and smaller remnants. A wildlife corridor is considered to be of better quality if (Pittwater, 1995b):

- it links two or more larger areas of habitat;
- the quality of these larger areas is greater;
- the quality of the corridor itself is greater;
- the corridor is wider;
- the corridor contains a variety of habitat types.

Pittwater Council currently has a Wildlife Corridors Strategy and an associated Development Policy. This strategy maps potential corridors throughout the Pittwater landscape. High priority corridors include: Ingleside escarpment through Warriewood Wetlands to the coast; Narrabeen, Fern and Mullet Creeks to the escarpment and National Park; Palm Beach to Ku-ring-gai and Garigal National Parks. This needs to be regularly updated and reviewed with relevant planning controls put in place.

The Ingleside area forms a significant wildlife corridor, due to its semi-rural nature and proximity to two large National Parks. Wildlife has the ability to move through this landscape, however could be at risk of motor vehicle accidents and attacks from domestic animals.

Specific Management Options:

- continue the review of and implement the Pittwater LGA Wildlife Corridors Strategy and development controls. **Section 4.2** contains a discussion on management.
- review operation and effectiveness of the Wildlife Corridor Strategy. Develop and implement additional measures for protection and enhancement of corridors where necessary.

6.4 Fire Management

Fires in remnant bushland, whether they are wildfires, hazard reduction burns or ecological burns, can cause significant mortalities amongst fauna, including threatened species. In addition, even low intensity fires, may render the burnt area uninhabitable for particular fauna species during the post-fire period, by reducing food resources and shelter sites, until regeneration occurs. The loss of cover may also make the animals more vulnerable to predation (Smith and Smith, 2000).

Fire management is one of the most complex and controversial issues in the management of remnant bushland. Fire is a natural disturbance in Sydney bushland, but its effects depend on the fire regime - the combination of fire frequency, fire intensity and season of fire occurrence. Changes to the fire regime can result in significant vegetation change and can seriously degrade the value of the bushland as habitat for threatened fauna and flora. Urban bushland fire management needs to take into consideration the ecological requirements of bushland flora and fauna, in addition to the risk posed by wildfires to life and property (Smith and Smith, 2000). Most terrestrial fauna species can be affected by an inappropriate fire regime, due to habitat alterations. This may occur as a result of higher or lower frequency of fire.

As the remnant bushland in the Pittwater area has become more fragmented and the individual remnants more isolated from other bushland areas, they have become less subject to severe wildfires. As a consequence of this and other factors (nutrient enrichment and increased moisture levels from urban runoff) habitat for eucalypt-dependent fauna is being degraded through invasion of eucalypt forest and woodland, and inhibition of eucalypt regeneration, either by dense stands of she-oaks (notably Black She-oak *Allocasuarina littoralis*) or by rainforest plants (notably Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*).

These trends are evident in Angophora Reserve (Smith and Smith 1992a), McKay Reserve (Smith and Smith 1992b), Stapleton Park (Pittwater Council 1995a) and elsewhere (*paragraph taken from Smith and Smith, 2000*).

Similarly heath habitat for the Southern Brown Bandicoot and Giant Burrowing Frog may become too dense for these species if fire frequency is too low.

The complexities of incorporating fauna requirements in fire management practices are illustrated by the case of the Southern Brown Bandicoot. This species appears to favour areas with a mosaic of burned and unburned habitat and, because of its high reproductive rate, can become common in areas regenerating after fire (Stoddart and Braithwaite 1979). However, it is a small ground mammal and subject to heavy mortality in fires. The direct impact of a fire in a small isolated reserve could easily eliminate the species from the reserve (*paragraph taken from Smith and Smith, 2000*).

Specific Management Options:

- fire management practices need to find a compromise between hazard reduction burning and what is acceptable to maintain habitat for fauna species, particularly threatened species;
- individual fires occurring in bushland remnants should be limited in extent so that unburnt refuges are available to allow fauna populations to survive and eventually recolonise the burnt areas (Smith and Smith, 2000);
- areas of known suitable habitat for a threatened species, that are becoming too dense may need to be occasionally burnt (in a mosaic format) to allow those species to continue using the area.
- liaise with the relevant authority (formerly DECCW) and the NSW Rural Fire Service to determine appropriate fire regimes.

6.5 Reintroduction of Native Fauna

Reintroduction of native fauna is unlikely to occur due to the encumbrances of current legislation and the unlikely probability of a species surviving in the area when it has already become locally extinct, due to a complexity of causes.

If a population is lost as a result of a catastrophic event such as bush fire there is some scope for the reintroduction of a species with individuals sourced locally. Any proposal must be developed and partnered with the relevant responsible authorities.

6.6 Impacts of Domestic (companion animals) and Feral Animals (predators)

Predation by the Red Fox and Feral Cat are listed Key Threatening Processes in the TSC Act, 1995 and are discussed in **Appendix 7**. Further discussion on predation by cats is presented here, as wildlife is also impacted on by domestic cats, particularly in an urban environment when the cat population may be quite high. Domestic dogs also impact on local wildlife. Ten percent of known causes for native fauna rescues by WIRES on the Northern Beaches have been attributed to dog and cat attacks (WIRES database 1990-2009).

Studies have shown that domestic cats take native prey including mammals, birds, frogs and lizards and the heavy impact of domestic and feral cats on native wildlife has been well documented (e.g. Potter 1991, Dickman 1996). The proportion of native species taken increases on suburban fringes adjacent to bushland and in rural areas (Grayson and Calver, 2004).

Meek (2003), carried out a study of fourteen cats living in a residential area surrounded by National Park. Eight of these cats used natural bushland, with 92 % of radio-tracking fixes occurring within the fringes of the urban boundary. The mean home-range size of a house cat was 2.9ha and a mean travelling distance of 70m for males and 30m for females, with 1.17km being the furthest recorded distance from a residence. The majority of forays from home were undertaken at night and in the afternoon.

Cats capture their prey both on the ground and in trees. They are known to climb to nest hollows and take the young of hollow-nesting birds (Smith and Smith, 2000). Threatened birds in Pittwater that are at risk from this behaviour pattern are the Glossy Black-Cockatoo, Powerful Owl, Barking Owl and Masked Owl (Smith and Smith, 2000).

Squirrel Gliders resting during the day in tree hollows are also at risk (Smith and Smith, 2000). Cats are a concern for the endangered Squirrel Glider population, as specimens obtained by the Australia Museum from this area in recent years have all been animals caught and killed by domestic cats (Smith and Smith, 2000).

Dogs have been the most frequently reported cause of death of large marsupials on Barrenjoey Peninsula and have contributed to the decline in Koalas (Smith and Smith 1990b).

A few experiments have indicated that at least some native rodents and small marsupials are unperturbed by the presence of dog faeces (Banks, Hughes and Rose, 2003). It may be possible that wildlife may contract scat-borne parasites, such as hydatids and nematode worms from coming into contact with dog faeces (Banks, Hughes and Rose, 2003). Toxoplasmosis is known to affect macropods and the Spotted-tailed Quoll (Williams and Williams, 1999; Belcher 2004). This disease is caused by a parasite contracted by eating grass where infected cat faeces have been deposited (Williams and Williams, 1999).

The impact of dogs, cats and foxes is a particular concern for the Bush Stone-curlew on Barrenjoey Peninsula. The single pair of Bush Stone-curlews at Careel Bay is especially vulnerable to the threat of local extinction through predation, being birds that feed, nest and roost on the ground. Even if the adults can survive, breeding success may be severely curtailed by predation of the small, inexperienced young (Smith and Smith, 2000).

Other threatened fauna species at risk of predation by cats and dogs in Pittwater include the Eastern Pygmy-possum, Eastern and Little Bentwing-bats, Large-eared Pied Bat, Eastern Cave Bat, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Broad-headed Snake, Australasian Bittern, Black Bittern. Even if the bats escape predation, regular disturbance, particularly during the cooler months may be detrimental.

Many non-threatened species are also preyed heavily upon by these introduced predators, including many listed as locally or regionally significant in Pittwater (e.g. Long-nosed Bandicoot, Brown Antechinus, Bush Rat and Common Bluetongue).

There are many options for outdoor cat enclosures, with commercially available designs available in a range of sizes and cost. This allows cats to be protected from injuries, motor vehicle accidents, fights with other domestic animals etc and at the same time protect the local diurnal and nocturnal wildlife from the cats at all times. Many people feel they are being responsible by locking their cats in at night, but this only protects the nocturnal animals, and does not protect the birds and reptiles that are active during the day.

Specific Management Options:

- investigate, develop and implement effective and humane control programs for feral cats and dogs in the Pittwater area, with special emphasis on sites where they are a particular threat to threatened fauna species.
- implement Council's statutory obligations and responsibilities for control of dogs and cats under the Companion Animals Act.
- ensure dog owners to keep dogs on leads when walking through bushland areas that are not designated Wildlife Protection Areas.
- continue and expand existing community education programs aimed at reducing the impact of cats and dogs on native fauna, including advice on suitable fencing for dogs and outdoor cat enclosures. Encourage the community to report feral cats, dogs and foxes to Council.
- impose conditions managing the keeping of cats and dogs on new residential developments with prohibition in sites where they are a particular threat to threatened fauna species.

6.7 Management Issues associated with Broad-scale Insecticide Use

Despite their small size, the sheer numbers or biomass of insects means that they have a significant impact on the environment and therefore upon our lives. Their species richness or diversity surpasses any other group of organisms. It has been said that insects outnumber all the other species of animals and plants combined.

An insect may be of benefit to us or be regarded as a pest. Most are beneficial or have an indirect influence. Fewer than 0.1% are regarded as pests.

Some broad-scale insecticide use for the control of ticks may be an issue in Pittwater. The species of tick in Pittwater is *Ixodes holocyclus*. It is also known as the 'Paralysis Tick', or 'Shell-back Tick'. Ticks are a part of the natural environment, and native animals tend to be immune from tick toxin. The most problematic time for ticks is October-January during the adult phase of the life cycle, at which time domestic pets and small children may be at high risk of tick poisoning.

Some people feel that broad-scale spraying would help. However pesticide legislation restricts the use of broad scale application. It would not eradicate all ticks, and could create health problems for people. Spraying also interferes with ecosystem function, affecting other native wildlife which predate on ticks such as birds and reptiles, and hence could worsen the problem.

Specific Management Options:

- that Council continues to provide information and seminars regarding ticks, tick control and the use of pesticides to the community on a regular basis through the Coastal Environment Centre. This information should include recommendations regarding the lawfulness and effectiveness of tick killing spray and alternative control techniques (such as using personal repellent rather than spraying bushland).

6.8 Fauna Casualties and the Rehabilitation of Sick, Injured and Orphaned Wildlife

There are many scenarios that may result in injuries, death or displacement of a native animal. There are natural causes such as old age, fighting among individuals, diseases etc. However in many cases in urban areas the cause is human induced, including: habitat loss; collision with vehicles; electrocution; attacks by domestic pets, as well as by humans; entanglement; poisoning and some diseases.

Dr Derek Spielman* has listed the following examples of diseases and ailments affecting native Australian animals in Sydney that can be attributed to the urbanisation of their natural environment:

- injuries or death caused by motor vehicle accidents;
- injuries or death caused by other human attacks (especially for reptiles);
- injuries or death caused by cat and dog attacks;
- toxoplasmosis (protozoan carried by cats);
- angiostrongyliasis (rat lung worm carried by introduced rats);
- avian malaria (blood parasites carried by introduced sparrows and perhaps other exotic birds);
- avian tuberculosis in native birds from introduced birds;
- trichomoniasis (protozoan carried by feral pigeons and affecting mostly raptors);
- salmonellosis in birds due to people putting out communal feed stations (e.g. seed stations, honey and fruit for lorikeets, etc);
- burnt paws in ringtail and brushtail possums due to running across very hot ceramic and metal roofs;
- burns due to bushfires caused by altered fire regimes, introduced plants and lit by people;
- botulism due to rotting organic matter in altered waterways and pollution affecting mostly native ducks and other water birds;
- chytridiomycosis fungal disease affecting many native amphibian species from introduced frogs and perhaps hobby fish releases;
- several murine viruses (murine cytomegalovirus, mouse hepatitis virus, murine rotavirus, mouse adenovirus strain K87, parvovirus, reovirus type 3, lymphocytic choriomeningitis virus, (LCMV), and Sendai virus) from exotic house mice affecting native rodents.

*wildlife vet for WAIF (wildlife assistance and information foundation) and lecturer Veterinary Science, University of Sydney

Unfortunately not all injured animals are able to be captured and may die at a later date due to their injuries. When an injured animal or orphaned young is able to be captured, it should be taken to a local vet or trained native animal carer. Below is a list of native animal care groups / facilities that will aid wildlife in the Pittwater area. Native animals are best left alone unless obviously sick, injured or orphaned. For example, an animal on the ground is not necessarily sick. It may be a perfectly healthy animal that is simply moving between food trees (Smith and Smith, 2000).

The most commonly rescued species by both Wires and Sydney Wildlife include the Common Brushtail Possum, Common Ringtail Possum, Tawny Frogmouth, Sulphur-crested Cockatoo, Rainbow Lorikeet, Noisy Miner, Laughing Kookaburra and Australian Magpie.

Native animal care groups / facilities

- Wildlife Clinic, Taronga Zoo
Contact: Phone **02 9969 2777**
- WIRES Inc. (<http://www.wires.org.au>)
Contact: Hotline, phone **1800 641 188**
Northern Beaches Branch: **02 8977 3333**
- Sydney Metropolitan Wildlife Services Inc. (SMWS)
Native Animal Rescue and Advice
Contact: Phone **02 9413 4300**
- Kangaroo Protection Co-operative Pty Ltd
Contact: Phone **02 9651 2557** (for kangaroos and wallabies)
- WAIF (Wildlife Assistance and Information Foundation) Wildlife Vet Clinic
Contact: Phone **02 9456 0452** www.waif.org.au

The aim of each of these organisations is to rescue, rehabilitate and return native animals to their original location, whenever possible. Any proposals to return threatened fauna species to a different location should be discussed with NSW Department of Environment and Climate Change and Water and Council's Natural Resources Unit (Smith and Smith, 2000).

For threatened fauna with specialised requirements the most appropriate organisation for rehabilitation is the Wildlife Clinic at Taronga Zoo. The Wildlife Clinic has had considerable experience with such species. It has ready access to veterinarians skilled in dealing with these species and is well equipped with specialised diagnostic services such as pathology and radiology (Smith and Smith, 2000).

6.8.1 Road Kill Hotspots

There are certain areas around Pittwater that may be considered road kill hotspots as a result of the number of injuries and deaths caused to wildlife. Some examples are Wakehurst Parkway at North Narrabeen, Mona Vale Road between Terrey Hills and Mona Vale and Bilgola Bends on Barrenjoey Road.

6.8.2 Fauna Road Crossings

Fauna crossings are most effective where they link two patches of relatively intact habitat. In areas where a road divides two patches of bushland, the use of fauna fencing in conjunction with fauna crossings is recommended. At some locations restoration of connectivity for non-flying species would only be possible with the installation of a fauna crossing (e.g. glider pole, aerial rope crossing or underpass).

The use of fauna crossings may also be beneficial in other areas, particularly on roads with a high incidence of road-kill. Fauna crossings are shown to be most effective when used in conjunction with fauna fencing to direct animals towards a crossing. In urban areas it may be difficult or inadvisable to install fauna fencing. Use of fauna fencing is recommended in conjunction with a fauna crossing in areas where a road divides a reasonable sized patch of bushland (e.g. Mona Vale Road, Bilgola Bends).

Specific Management Options:

- identify sites where road casualties pose a particular threat to threatened fauna species in Pittwater. Investigate the use of traffic control and/or fauna control measures at these sites (reduce speed zones, speed humps and islands, increased signage).
- ensure through the development assessment process that new developments include appropriate measures to prevent increased road casualties of threatened fauna;

- encourage the community to notify council if they know of a threatened species being killed or an area with a high level of road-kill.
- maintain records of rescues and releases of threatened fauna species in Pittwater;
- encourage, support and publicise organisations which rescue and rehabilitate sick, injured or orphaned animals in Pittwater. Guidelines for people finding sick, injured or orphaned native animals should be more widely publicised;
- increase signage with contact details of local care groups;
- liaise with the Northern Beaches Roadkill Committee and the Roads & Traffic Authority to investigate the feasibility of installing fauna crossings on roadways identified as posing greatest hazard to wildlife.

6.9 Feeding Wildlife

Residents and visitors should refrain from feeding wildlife. Often the wrong types of food are provided, which may cause illness. Feeding stations may also increase the spread of disease amongst a population. Availability of artificial food and some garden plant varieties increase the abundance of some introduced and native bird species, upsetting the natural balance of species assemblages, resulting in a reduced abundance of those less aggressive species.

Specific Management Options:

- continue with community awareness and education through the Coastal Environment Centre.
- provide information on Council website regarding this issue.

6.10 Disturbance at Nesting, Roosting and Feeding Sites

High levels of human disturbance may seriously disrupt the breeding, roosting or feeding behaviour of birds and other fauna. Ground-dwelling birds are particularly susceptible. Nests, eggs and young may be accidentally or deliberately destroyed or collected. Nesting failure may result simply from the parent birds being kept away from the nest by the continual presence of people or their dogs nearby. Birds that are repeatedly flushed from their daytime roosting or feeding sites by human activities may eventually abandon the area. The daytime roosts of bats in caves and similar situations may also be subject to adverse impacts from high levels of disturbance (*Paragraph taken from Smith and Smith, 2000*). Wading birds foraging on mudflats may be regularly disturbed by people walking along the shoreline or collecting fishing bait.

Even species such as the Osprey, which generally nests high in a tree, may be disrupted by human activities. A traditional nest site may be lost to nesting Ospreys if the level of disturbance becomes too great. Even if disturbance does not cause the birds to abandon their nest, it can result in reduced breeding success (Clancy 1991).

The threatened fauna species in Pittwater likely to be affected by high levels of human disturbance are:

- Bush Stone-curlew - nesting, roosting and feeding sites
- Australasian Bittern - nesting and roosting sites
- Black Bittern - nesting and roosting sites
- Barking Owl - nesting and roosting sites
- Powerful Owl - nesting and roosting sites
- Sooty Owl – nesting and roosting sites
- Masked Owl - nesting and roosting sites
- Glossy Black-Cockatoo - nesting sites
- Gang-gang Cockatoo – nesting sites
- Osprey - nesting sites
- Large-eared Pied Bat - roosting sites
- Eastern Cave Bat – roosting sites
- Eastern Bent-wing Bat - roosting sites
- Little Bent-wing Bat – roosting sites

- Sooty Oystercatcher - feeding sites
- Pied Oystercatcher – feeding sites
- Terek Sandpiper – feeding sites

Specific Management Options:

- consideration should be given to known roost sites for threatened and significant species (e.g. Powerful Owl). For instance rerouting a footpath to avoid a nest or roost tree area (rather than signage which may increase visitors). Temporary closure of walking tracks may be an option during the breeding seasons of sensitive species;
- have designated feeding areas on mudflats, with signage asking people to avoid these areas;
- installation of rubbish and detangler bins to encourage responsible disposal of rubbish;
- community education programs.

6.11 Fencing

Fencing is often used as a method of wildlife management. Fences may be used to restrict companion animals as well as access by humans to sensitive habitat areas. Fences may also be used in areas where wildlife crossings are common to reduce road casualties. However fencing may also restrict the natural movement of fauna that is required for breeding, foraging or recolonisation. For example, a fence constructed to keep a dog in a yard, thereby protecting local wildlife outside the fence, also removes that area as potential habitat for that fauna. Wildlife may also become entangled or trapped in fences, resulting in stress and injuries. Fences may also guide animals to areas of greater risk i.e. onto a road.

Specific Management Options:

- fencing in the semi-rural areas should be designed to allow movement of wildlife, particularly within the proposed wildlife corridors. Dogs and cats should be restrained using fencing that does not encompass large areas that would inhibit the passage of wildlife from one area of habitat to another. Fencing design to allow wildlife passage to be included on Council website.
- barbed wire should be avoided for use in fencing as wildlife may become entangled and seriously injured. Grey-headed flying-foxes and Squirrel Gliders are particularly susceptible to getting their wing/gliding membranes caught on barbed wire.

6.12 Use of Nest Boxes

6.12.1 Use of Nest Boxes to Supplement Roost / Nest Availability

The installation of nest-boxes may be a relevant management tool for hollow roosting micro chiropteran bat species, bird species and arboreal mammals. For these species tree-hollows provide habitat for both roosting and breeding purposes. In urban areas tree hollows are becoming limited, particularly since hollows generally form in trees that are dead, dying or have suffered some damage or insect attack. These trees are also seen as a danger to people and property and are therefore readily removed from the environment.

‘Nest boxes have been used to assist population recovery in areas where natural hollows have been depleted. Nest boxes also have the potential to increase populations of common, introduced and pest species’ (Gibbons and Lindenmayer, 2002). It is therefore imperative that boxes designed to accommodate the targeted species are used, rather than generic boxes which may just increase the abundance of an undesirable species.

Little is known about the specific roost requirements of many hollow dwelling fauna species, therefore the design of successful nest boxes in Australia may be considered to still be in a design phase. There have been successes for some species, particularly those that are more opportunistic in their use of hollows, e.g. Common Brushtail Possum. Squirrel Gliders and Sugar Gliders have been found to quickly colonise nest boxes (Ecotone pers. obs.).

Nest boxes should not be considered a suitable replacement for tree hollows, but a temporary measure, or as a supplement where hollows are already lacking. Hollow-bearing trees and mature trees capable of

becoming future hollow-bearing trees should still be retained and planned for the future wherever possible. To date there has been little success with nest box use by many fauna species reliant on tree hollows. Natural hollows provide a range of microhabitats that are difficult to artificially replicate.

Nest boxes also require regular maintenance and may only have a life as short as 10 years. Gibbons and Lindenmayer (2002) state that 'a reliance on nest boxes is an indication that management practices are failing to provide sufficient natural hollows and are therefore not ecologically sustainable'.

6.12.2 Use of Nest Boxes to Conduct Field Surveys

The use of artificial nest boxes has also been a successful way to detect and monitor populations of arboreal mammals and tree dwelling bats and birds (Gibbons and Lindenmayer, 2002). Goldingay et al. (2003) are using nest boxes to study the social system and dispersal in an urban Squirrel Glider population in Brisbane. Ward (1999) found that Feathertail Gliders were much more easily detected using nest boxes than spotlighting in Wombat State Forest, Victoria. Over two years only one Feathertail was observed with 13.8 hours of spotlighting, however 76 captures were recorded using nest boxes. There are disadvantages of using nest boxes which include the longer time frame required to obtain a result and the greater cost. In a trial of 240 bat nest boxes, Hoyer (2004), found that there was little use in the first 12 months, but by the second year, four species were using the boxes, with increased use each subsequent year. Nest-boxes can often be checked with a camera, minimising disturbance to the roosting animal. State Forests have had recent success in detecting eastern pygmy-possums by using natural log nest-boxes (B. Law, DPI *pers.comm.*).

6.12.3 Nest Box Design

The design of a nest box will usually need to be specific for the targeted species. Dimensions of the box (volume, depth and wall thickness), internal structure, position and dimension of entrance, construction materials are all to be considered. As a general rule, the dimensions for the entrance hole should be no larger than required for the body size of the target species (Gibbons and Lindenmayer, 2002; Goldingay and Stevens, 2008). This reduces the risk of predation. The position of the nest box, as well as the method used to install is also important. Nest box designs and installation information is provided on Council's website.

Nest boxes also suffer from invasion by feral bees and ants. No reliable method to control these problems has been found.

The following references may assist with nest box design:

- Goldingay R. and Stevens J. (2009) Use of artificial tree hollows by Australian birds and bats. *Wildlife Research* **36(2)**: 81-97.
- Gibbons P. and Lindenmayer D. (2002) Tree Hollows and Wildlife Conservation in Australia. CSIRO Publishing, Victoria, Australia.
- Goodrich T. (2002). A modified bat box design for scientific purposes. Pg 18 in The Australasian Bat Society Newsletter, Number 19.
- Reardon T. (2001). Artificial Bat Roost Box Design. Pg 54-55 The Australasian Bat Society Newsletter, volume 17.
- Tidemann C.R. and Flavel S.C. (1987). Factors affecting choice of diurnal bat roost site by tree-hole bats (Microchiroptera) in south-eastern Australia. *Australian Wildlife Research*, **14**: 459-473.
- Franks A. and Franks S. (2004) *Nest Boxes for Wildlife: A Practical Guide*. Bloomings.
- Gould Group (2008) *The Nest Box Book 2nd Edition*. Melbourne.
- <http://www.hollowloghomes.com.au>
- <http://www.gardenexpress.com.au/native-nest-boxes/>

6.12.4 Potential Nest Box Use for the Fauna Species of Pittwater

The following lists the species in Pittwater that may benefit from the use of nest boxes. Species well adapted to the urban environment and that are common in the LGA are not included (e.g. common parrots and the Brushtail Possum). However, only some of these species have been shown to use nest boxes to date.

Bold: indicates the species known to use nest boxes.

Birds	Microchiropteran Bats	Arboreal Mammals
<ul style="list-style-type: none"> • Glossy black-cockatoo • Yellow-tailed black-cockatoo • Gang-gang cockatoo • Striated pardalote • Spotted pardalote • Australian owllet nightjar • Powerful owl • Sooty owl • Masked owl • Barking owl • Barn owl • Southern boobook • Sacred kingfisher • Scarlet robin • White-throated treecreeper • Woodswallow species • Chestnut Teal • Australian Wood Duck • Pacific Black Duck • Australasian Shoveler • Grey Teal 	<ul style="list-style-type: none"> • Little forest bat • Large forest bat • Eastern broad-nosed bat • Greater broad-nosed bat • Eastern false-pipistrelle • Chocolate wattled bat • Gould's wattled bat • Gould's long-eared bat • White-striped freetail bat • Eastern freetail bat 	<ul style="list-style-type: none"> • Feathertail glider • Squirrel glider • Sugar glider • Eastern pygmy-possum • Common Brushtail Possum • Common Ringtail Possum

6.13 Cane Toads

Cane toads were introduced to Queensland from South America in 1935, in an unsuccessful attempt to control cane beetles, a pest of the sugar cane industry. Having no natural enemies, the toads spread west into the Northern Territory and south into New South Wales. They are now a major threat to native animals on the far north coast of NSW.

In the past year two Cane Toads have been found in the Pittwater LGA, the first in Newport, the second in North Narrabeen. It is suspected these animals have been transported into Pittwater unwittingly under cars or trailers.

The toad's toxin is lethal to native animals and they compete for food with bandicoots, owls and local frogs. While handling the toads poses little threat to humans, the milky toxin they secrete when they are stressed can be lethal if ingested.

The NPWS have reported that cane toads are occasionally found in produce trucks carrying fruit and vegetables from Queensland or the north coast of NSW. Each female cane toad can lay as many as 35,000 eggs at a time and produce two clutches a year, leading to a population explosion.

Specific Management Options:

- continue with community awareness and education initiatives through the Coastal Environment Centre;
- create an information page on Council website regarding this issue.

6.14 Depletion of Intertidal Invertebrate Populations

(Taken from Smith and Smith, 2000)

Human collection and harvesting of intertidal invertebrates can threaten the biodiversity and sustainability of rock platforms. People can have an impact through diverse recreational activities including fishing, gathering of various animals for food, bait or aquarium specimens, fossicking, overturning of boulders and inadvertent trampling (Kingsford *et al.* 1991). These activities, in addition to their direct impact on rock platform invertebrate communities, could potentially have a significant impact on the food resources available to one of the threatened species in Pittwater, the Sooty Oystercatcher. The rock platforms of the Pittwater area are an important feeding habitat for this species.

In order to conserve intertidal plants and animals, NSW Fisheries have established a number of Intertidal Protection Areas in the Sydney Region. In 1993 four of the ten major rock platforms in Pittwater (Barrenjoey Headland, Bungan Headland including Little Reef, Mona Vale Headland and Narrabeen Headland) were gazetted as Intertidal Protected Areas under NSW Fisheries jurisdiction. Intertidal Protection Areas extend from mean high water to 10 m below low water and in this area the collection of invertebrate animals is prohibited. Fishing is permitted if you bring your own bait. On the rock platforms not gazetted as Intertidal Protection Areas, bag and size limits apply to collection of marine invertebrates. Collecting methods that damage the environment are not permitted.

Council Rangers have been trained and empowered as Fisheries Officers under the Fisheries Management Act to apprehend people collecting in Intertidal Protection Areas or exceeding bag limits on other rock platforms. Interpretative signs have been installed at major access routes to the Intertidal Protection Areas. The success of the Intertidal Protection Areas is currently being monitored.

Pittwater Council has undertaken a community awareness program, 'Project Aware on the Rocks'. Community volunteers are trained in this program in ecology, awareness and conservation of rock platform habitats and their component species, and threats to their survival. Volunteers assist with surveys to quantify user behaviour, identify user groups and increase understanding of user impacts. These surveys have indicated that substantial numbers of people who are harvesters of intertidal invertebrates on rock platforms in Pittwater live outside the area.

Council, through the Coastal Environment Centre, also provides environmental education programs for schools and the wider community that build an understanding of the intertidal ecology of rock platform environments.

Specific Management Options:

- liaise with Dept Industry and Investment (NSW Fisheries) in management of Intertidal Protection Areas and other rock platforms in the Pittwater area. Enforce the restrictions on collection of intertidal invertebrates;
- continue community awareness and education initiatives through the Coastal Environment Centre in conjunction with the Dept. Industry and Investment (Fisheries) such as rockplatform tours, Fishcare programs, signage and fishing clinics for children.

7.0 Management issues related to specific fauna groups

The following management issues affect all terrestrial fauna groups. Management issues that are more specific to particular fauna groups are discussed in sections 7.1 to 7.8.

- Relevant Key Threatening Processes
 - Exotic vines and scramblers
 - Removal of dead wood and dead trees
 - Importation of red imported fire ants into NSW
 - Clearing of native vegetation
 - Human-caused climate change
 - Ecological consequence of high frequency fires
 - *Lantana camara*
- Conservation and rehabilitation of Core Habitat and remnant bushland
- Wildlife corridors and Fragmentation
- Fire Management
- Reintroduction of Native Fauna
- Impacts of Domestic and Feral Animals (Predators)
- Disturbance at nesting, roosting and feeding sites
- Fauna road casualties and the rehabilitation of sick, injured and orphan wildlife

7.1 Bats (Microchiroptera)

Management Issues:

- Relevant Key Threatening Processes
 - Competition from feral honey bees
 - Predation by feral cats
 - Predation by the red fox
 - Bush rock removal
 - Loss of Hollow-bearing trees
- Management issues associated with broad scale insecticide use
- Disturbance at nesting, roosting and feeding sites

Although bats are mobile species able to travel between patches of remnant bushland, with many species using cleared areas to forage, conservation of remnant bushland, wildlife corridors and reduced land clearance are still important. Diverse and ample vegetation is required to provide a healthy and diverse insect population for the microbats.

Conservation of roost sites is particularly important, as suitable roost sites is the main limiting resource for this fauna group. These roost sites include tree hollows, sandstone caves and crevices in 'bush rock', artificial roost sites such as tunnels and culverts.

Different species appear to have different requirements for suitable roost sites. Therefore a variety of tree hollows and cave structures are required in the environment. For example the Eastern False Pipistrelle appears to have a preference for fissures in large tree trunks (R. Williams, Ecotone, *pers.obs.*). Many tree dwelling species appear to frequently change roosts (e.g. Lesser Long-eared Bat and Gould's Wattled Bat (Lumsden and Bennet, 1998)). Different characteristics are also sought for particular seasons, for instance large old trees are often selected for maternity roosts. A variety of studies have shown that microbats appear to select some of the oldest and largest trees in a stand for roosting (e.g. Rhodes, 2001). It is therefore important to conserve trees that are presently old as well as younger trees that can become old and hollow-bearing in the future.

Hollow-dwelling microbats are also in competition with the feral honeybee for hollows. A discussion on use of nest-boxes is provided in **section 6.13**.

Suitable roost sites (both natural and artificial) for cave dwelling microbats are extremely rare and every known roost site for a threatened cave-dwelling bat species should be protected and managed efficiently. As these species often congregate at these roost sites, a loss of such a site can be highly detrimental to a species. Gating and/or appropriate fencing may be required to prevent human related disturbances, particularly during the cooler months, when bats may be hibernating and breeding seasons when juveniles are present. Unfortunately gating across an entrance may also deter bats from using a roost if inappropriate methods are used.

The presence of street lights and floodlights has the ability to affect the composition of a bat assemblage foraging in an area. For instance, some species such as the Gould's Wattle Bat and Eastern Bent-wing Bat appear to be advantaged, while others, for instance Long-eared Bats and Myotis appear to stay away from lit areas.

A broad-scale use of pesticides may significantly affect insect populations and potential food availability for microbats.

7.2 Bats (Megachiroptera – Flying-foxes)

Management Issues:

Relevant Key Threatening Processes

- Clearing of native vegetation
- Disturbance at roosting and feeding sites
- Injuries or death caused by inappropriate netting / fencing around fruit trees
- Electrocutation on powerlines

Flying-foxes help to preserve native forests by pollinating plants and dispersing seed (DECCW, 2007). Clearing and modification of native vegetation has resulted in a significant reduction of foraging and roosting habitat for flying-foxes, including the grey-headed flying-fox which occur in Pittwater. Flying-foxes also forage on introduced and planted food sources in urban / developed areas.

Flying-foxes congregate in groups to roost, known as camps. A network of camps is used by this nomadic species, which moves in response to available food resources. If suitable resources are available, a camp may be in use all year round, whilst others are only used temporarily for part of the year (DECC, 2007). Camps may vary in size from only a small group up to 200,000 individuals (Churchill, 1998).

Typical complaints from the public regarding flying-foxes include smell, noise, droppings, fear of disease and loss or damage to backyard fruit crops (DECC, 2007).

A small grey-headed flying-fox camp is located in a small council reserve at Gunya Place in Avalon. See **section 8.2** for a discussion on management of this site. Pittwater Council is currently developing a management plan for the Grey-headed Flying-fox in Pittwater in conjunction with the Department of Environment, Climate Change and Water and local residents. Council will develop management plans based on individual camps being located.

7.3 Arboreal Mammals

Management Issues:

- Relevant Key Threatening Processes
 - Competition from feral honey bees
 - Predation by feral cats
 - Predation by the red fox
 - Loss of Hollow-bearing trees
- Management issues associated with broad scale insecticide use

The major threats to arboreal mammals include foraging and roosting habitat loss, fragmentation and predation by cats, foxes and dogs. Most arboreal mammals require tree hollows for roosting and nesting and this resource is a major limiting factor for these species. The loss of hollows includes removal and competition with the feral honey bee. A variety of hollows are required to cater for a diverse range of species seeking different roost characteristics.

Wildlife corridors, containing a good level of canopy cover are particularly important to arboreal mammals. Goldingay and Sharpe, (2004) recommended that for the long term survival of gliders in urban Brisbane functional corridors would need to be established as there is a high level of predation and road kill of gliders that have to move across gaps in the tree vegetation. Goldingay and Sharpe, (2004) also predicted that adding a large remnant to the patch system is likely to substantially reduce the probability of urban glider extinction. This larger patch would allow dispersion and migration into smaller patches which are subjected to a greater mortality rate.

Squirrel Gliders appear to require a diversity of dietary items. Claridge and van der Ree (2004), suggest that plantings targeting Squirrel Gliders should include a mix of their preferred overstorey and shrub species (eucalypts, acacias and banksias).

A discussion on use of nest-boxes is provided in **section 6.13**.

Broad scale insecticide use may affect available resources for arboreal mammals, such as gliders that include insects as part of their diet.

7.4 Ground Dwelling Mammals

Management Issues:

- Relevant Key Threatening Processes
 - Infection of native plants by *Phytophthora cinnamoni*
 - Competition and grazing by the feral European Rabbit
 - Predation by feral cats
 - Predation by the red fox
 - Bush rock removal
- Management issues associated with broad scale insecticide use
- Predation by dogs

The major threats to ground dwelling mammals include loss of foraging and roosting habitat, fragmentation and predation by cats, foxes and dogs. Most ground dwelling mammals require dense vegetation, hollow logs or rock outcrops with caves, cracks and crevices for shelter. The infection of plants by *Phytophthora cinnamoni* has the potential to affect the density and composition of vegetation in some habitats and is thought to be of most concern to the Southern Brown Bandicoot (Office of Environment and Heritage website – key threatening process determination).

Many small ground-dwelling mammals prefer natural ground cover and shrub layer with a high level of connectivity. The risk of predation / road kill increases with the increased width of a barrier, such as open space and roads. Ground-dwelling mammals are readily preyed upon by foxes, and both feral and domestic cats and dogs. Cats generally target the smaller size class, such as marsupial mice and rodents, while the medium sized Long-nosed Bandicoot and Southern Brown Bandicoot are readily taken by foxes and dogs. A domestic dog was observed attempting to dig a Southern Brown Bandicoot out of a burrow under a rock ledge at Duffy's Forest (A. Rowles, Ecotone, *pers. obs.*). Foxes and dogs will also attack the larger Swamp Wallaby.

Fire management is also a major concern for ground dwelling fauna. This a very complex issue with species differing in their response to particular fire regimes. For example, wildfires and hazard reduction burns can cause heavy bandicoot mortalities and can reduce their cover and food resources in the short term, yet areas regenerating after fire appear to provide a habitat that is particularly favoured by Southern Brown Bandicoots and may be critical for the long-term survival of the population (Smith and Smith, 2000).

The carnivorous diet of the Spotted-tailed Quoll has subjected the species to a few extra threats. Evidence suggests that local populations have declined in areas of 1080 baiting (Belcher, 2004), indicating that Quolls are also taking the baits set for feral dogs, foxes and cats. Quolls will readily prey on domestic poultry and are extremely skilled at getting into chicken coups. This has resulted in them being hunted, trapped and killed by the poultry owners. The Spotted-tailed Quoll may also compete with introduced predators for food and may occasionally be preyed on by these predators. Belcher (2004) suggests that although all these causes add to the cumulative impact, the greatest causes of decline for the Spotted-tailed Quoll is loss of forest cover, fragmentation and perhaps an epidemic disease in the early 1900's.

Use of rabbit bait (Pindone in rolled oats or poisoned carrots) may also be affecting ground-dwelling mammals that will readily eat rolled oats or carrots (e.g. macropods and native rodents). Council should provide suitable recommendations for the use of these poisonous pest control methods.

Community education is important and needs to focus on the positive reasons for promoting wildlife in your garden, as often people become fixed on the negative (e.g. 'bandicoots dig holes in my lawn and carry ticks').

7.5 Reptiles

Management Issues:

- Relevant Key Threatening Processes
 - Competition from feral honey bees
 - Predation by feral cats
 - Predation by the red fox
 - Bush rock removal
 - Loss of Hollow-bearing trees
- Management issues associated with broad scale insecticide use
- Illegal collection of reptiles

The major threats to reptiles include loss of foraging and roosting habitat, fragmentation and predation by cats, foxes and dogs. A study examining reptiles in Sydney reserves highlighted the following urban impacts: direct human intervention that resulted in death or removal (e.g. goannas and large snakes); illegal collection of reptiles, including small skinks as snake food (e.g. snakes, pythons, geckoes, dragons, skinks) interference with habitat such as bush rock removal (e.g. smaller snakes, geckoes, skinks); fire (e.g. non burrowing small residents) and exotic predators (e.g. dragons, turtles, skinks) (White and Burgin, 2004).

Many reptiles require hollow logs or rock outcrops with caves, cracks and crevices, tree hollows, flaking bark or dense vegetation for shelter. Bush rock removal results in a loss of shelter for the Broad-headed Snake, Lesueur's Gecko, Velvet Gecko and Southern Leaf-tail Gecko, Eastern Small-eyed Snake and Yellow-faced Whip Snake (White and Burgin, 2004).

Many ground-dwelling reptiles prefer a dense ground cover and/or shrub layer nearby to retreat to away from potential predators. A high level of connectivity is advantageous to reduce the risk of predation. Road kill increases with the increased width of a barrier such as open space and roads. Ground-dwelling reptiles are readily preyed upon by foxes, and both feral and domestic cats and dogs, as well as native predators such as Kookaburras. The Common Bluetongue is an example of a reptile readily killed by dogs. This species is also subjected to a high level of road kill. Although the Eastern Long-necked Turtle is still common in Sydney it appears that recruitment is lower than expected and foxes are known to prey on their eggs (White and Burgin, 2004).

Small skinks have been able to succeed in gardens and are therefore still common in urban environments. The Blue-tongue Lizard and the Eastern Water Dragon have also adapted to urbanisation, however most medium-sized skinks and the other dragons have diminished (White and Burgin, 2004). With the exception of the Southern Leaf-tail Gecko, all other geckoes are slowly disappearing (White and Burgin, 2004). Goannas have large home ranges, which are not generally supported in urban areas (White and Burgin, 2004). Snakes with the best chance of survival include the Yellow-faced Whip Snake, Golden Crown snake, Green Tree Snake and Red-bellied Black Snake. However since the Green Tree Snake specialises on frogs, the decrease in frogs will impact on this species (White and Burgin, 2004).

7.6 Frogs

Management Issues:

- Relevant Key Threatening Processes
 - Infection of frogs by amphibian chytrid causing the disease chytridiomycosis
 - Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
 - Predation by feral cats
 - Predation by the red fox
 - Bush rock removal
 - Predation by the plague minnow (*Gambusia holbrooki*)
- Management issues associated with broad scale insecticide use
- Illegal collection of frogs and tadpoles

White and Burgin (2004) suggest that the most significant factor contributing to frog decline is loss of breeding sites and deterioration of water quality. Ground frogs are less susceptible than tree frogs as they breed in a wider range of aquatic sites (White and Burgin, 2004). Tree frogs are more sensitive to polluted water, have a greater dependence on open water breeding sites and sometimes have a long larval stage (White and Burgin, 2004).

Other major threats include infection of frogs by amphibian chytrid and predation of tadpoles by the introduced plague minnow. Predation of frogs by cats and foxes as well as illegal collection of tadpoles and frogs also contribute to cumulative impacts.

Bush Rock removal results in a loss of shelter sites for the Red-crowned and Red-groined Toadlets, Eastern Banjo Frog and Common Eastern Froglet (White and Burgin, 2004). Many frog species shelter in dense vegetation around water courses, generally with a preference for habitat in good condition.

Alterations to the natural flow of waterways can change habitat available to species. For example, changes in moisture levels due to expansion of hard surfaces or development sites on ridge-tops reduces leaf litter and associated insect biomass and may therefore also result in the loss of Red-crowned Toadlet breeding sites (White and Burgin, 2004).

Garden ponds are an important source of habitat for some common frog species (e.g. Striped Marsh Frog, Eastern Dwarf Tree Frog and Peron's Tree Frog) in the urban environment.

7.7 Birds

Management Issues:

- Relevant Key Threatening Processes
 - Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations
 - Competition from feral honey bees
 - Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
 - Predation by feral cats
 - Predation by the red fox
 - Invasion of native plant communities by bitou bush and boneseed
 - Loss of Hollow-bearing trees
- Management issues associated with broad scale insecticide use
- Depletion of intertidal invertebrate populations
- Illegal collection of birds

Feeding habitat for waders, such as the Sooty Oystercatcher, is under threat, due to the depletion of intertidal invertebrate populations on rock platforms by over-collecting and excessive disturbance. Human and dog activity on mudflats and adjoining areas may also have an impact on foraging waders if they are disturbed frequently.

A number of threatened bird species have specific foraging requirements. The Glossy Black-cockatoo forages on She-oaks with a preference for stands of mature *Allocasuarina torulosa*, but will also forage on *A. littoralis*. Swamp Mahoganies and Spotted Gums are particularly important food resources for the Swift Parrot and Regent Honeyeater when visiting the area. In fact, these winter flowering eucalypts, when flowering well, appear to be the reason for these nomadic birds to visit the area. It is therefore important to retain healthy populations of such vegetation.

Fire management is a concern for many birds. For example, She-oaks, the diet of the Glossy Black-cockatoo, are fire-sensitive and although favoured by the present fire regime in isolated bushland reserves, a high frequency of major wildfires in larger areas of bushland in and around the national parks could potentially reduce She-oak populations in these areas (Smith and Smith, 2000). Fire management must also consider secondary impacts such as strategies that suit prey species for threatened species. For example the effect of particular fire regimes on the Common Ringtail Possum which is the major food source for the Powerful Owl in Sydney (Kavanagh, 2001).

Vegetation clearance, fragmentation and isolation has a significant impact on many bird species (e.g. small insectivorous birds and threatened owls), but has improved conditions for some other species (e.g. Noisy Miner, Currawongs, Magpie) (**Appendix 4**). Dense shrub and ground cover provide very important shelter from predators, for the small birds that use this strata level.

Predation from cats, foxes and dogs is high for birds. Cats are even known to climb trees, raiding nests of hollow-nesting Cockatoos (Smith and Smith, 2000).

Alterations in the vegetation, either with a change in composition of native plant species or the invasion of weed species, has the potential to significantly impact on many bird species. For example, saltmarsh is a critical habitat for the Bush Stone-curlews at Careel Bay as a daytime roost and a nesting site (Smith and Smith, 2000). Over the last 50 years, the area of saltmarsh has been drastically reduced through invasion by mangroves (Smith and Smith 1997a). If the process continues and the saltmarsh is entirely replaced by dense mangrove forest, it could lead to the elimination of the stone-curlews from the site (Smith and Smith, 2000). Cat, fox and dog predation is of concern to this ground dwelling species, as is disturbance at feeding sites.

Kavanagh (2004) explains that it is essential that the large areas of bushland, particularly forested gully systems throughout Sydney be protected from development in order to conserve owls in the Sydney region as these areas provide nesting, roosting and core foraging habitat.

Infection by beak and feather disease (*Psittacine cirovirus* disease) is listed as a key threatening process. The Gang-gang Cockatoo is an example of a threatened species known to be susceptible to the disease (Office of Environment and Heritage website – threatened species determination). Common species such as the Rainbow Lorikeet are also known to be affected by the disease.

The protection of waterways (i.e. from pollution and increased turbidity etc) is important for wetland and wading birds species and the Osprey which forages mainly on fish and other aquatic vertebrates and invertebrates.

A discussion on use of nest-boxes is provided in **Section 6.13**.

7.8 Marine Vertebrates and Invertebrates

Management Issues:

- Relevant Key Threatening Processes
 - Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments
 - Death or injury to marine species following capture in shark control programs on ocean beaches
 - Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
 - Human-caused climate change
- Rehabilitation of sick, injured and orphan wildlife
- Disturbance at nesting, roosting and feeding sites
- Depletion of intertidal invertebrate populations

7.9 Little Fairy Penguin (*Information provided by Pittwater Council*):

The largest southern population of Little Fairy Penguins occur at Lion Island in Pittwater estuary. These animals are often seen and noticed by residents swimming in small numbers around Pittwater.

It is recommended that Council liaise with the relevant authorities and stakeholders to monitor and protect the endangered population of Little Penguins on Lion Island and Pittwater foreshores. The status of the population is an environmental issue that has the potential for significant community interest and involvement. Initiatives may include:

- The installation of penguin nest boxes at known breeding or roosting sites;
- Ongoing penguin monitoring in conjunction with the relevant authority;
- Designation of Wildlife Protection Areas at known breeding or roosting sites;
- The application of strict development control conditions;
- Educating the community regarding impacts upon this species and their vulnerable status.

8.0 MANAGEMENT OF KEY SITES

8.1 Proposed Land Release Area in Ingleside

The Ingleside Biodiversity Assessment was prepared by Eco Logical Australia in 2008 (Draft Ingleside Biodiversity Assessment, Eco Logical Australia Pty Ltd, May, 2008). Field surveys carried out by Eco Logical detected 90 fauna species, including 10 frogs, 49 birds, 19 mammals, 1 crustacean and 11 reptiles. This list included 5 threatened species, including the Eastern Bent-wing Bat, Large-eared Pied Bat, Grey-headed Flying-fox, Glossy Black-Cockatoo and Powerful Owl. This list also included a range of regionally significant species.

The biodiversity assessment described the following creek lines as containing areas of riparian habitat that are in good condition and therefore significant habitat: Wirreanda Creek; Cicada Glen Creek; Upper reaches of Fern Creek; and Upper reaches of Mullet Creek.

The management for this area should include the following:

- Corridors and links between the National Park and Warriewood Wetland need to be retained, to ensure the future health of the council reserves. The biodiversity in Ingleside Park, Heydon Reserve, Irrawong Reserve and Warriewood Wetland is higher than in other reserves along the peninsula where they are isolated from large areas of bushland.
- Creek lines should be protected and regenerated, with suitable buffer widths designated (e.g. habitat for the Red-crowned Toadlet and Giant Burrowing Frog).
- Rock outcrop habitat should be conserved and buffered, particularly areas that contain caves, overhangs or crevices (e.g. potential habitat for Large-eared Pied Bat, Heath (Rosenberg's) Monitor and other reptiles that are regionally significant).
- Other specific habitat features (e.g. a stand of casuarina woodland, which is foraging habitat for the Glossy Black-Cockatoo) should be retained and buffered.
- Pristine quality bushland should be considered for conservation, as opposed to similar vegetation community that is highly disturbed and weed infested.
- Conservation may also be aided by weed control and the planting of local native species in both private and public landscaping.

8.2 Cannes Reserve Flying-fox Colony

A small Grey-headed Flying-fox camp is located in a small council reserve at Gunya Place in Avalon. During a site visit in March 2009, 30 to 50 individuals were observed roosting in a couple of Turpentine *Syncarpia glomulifera* and adjacent rainforest trees. The most popular tree was quite defoliated. The site contains remnant rainforest with many cabbage palms and some rainforest trees, as well as eucalypts. The understorey is extremely weed infested.

The following are some recommended management suggestions from the Flying-fox Camp Management Policy (DECC, 2007). (For more detailed information see the Flying-fox Camp Management Policy document):

- Raise community awareness:
 - 1) Understanding of flying-foxes including ecological information demonstrating the benefits they provide to the environment.
 - 2) Demonstrate the importance of camps
 - 3) Discuss disease risk and how to avoid infection (NSW Department of Health <http://www.health.nsw.gov.au/factsheets/infectious/rabiesbatinfection.html> accessed July 09)
 - 4) Provide suitable netting guidelines
- Create and implement a Plan of Management for the flying-fox camp at Cannes Reserve including bush regeneration, to ensure future roosting trees.
- Respond to complaints quickly with an information package, including the above listed information, as well as follow up communication.

Best Practice Guidelines for the Grey-headed Flying-fox (DECC, 2008), contains general information about the species, as well as providing an example of management of a flying-fox camp at Cabramatta Creek Reserve.

Pittwater Council is currently developing a management plan for the Grey-headed Flying-fox at Cannes Reserve in conjunction with the community due to a recent (March 2010) increase in the number of roosting individuals using this area.

8.3 Careel Bay

(Modified from Coughlan, 2008)

The depauperate migratory wader population on Careel Bay reflects a number of negative processes which, with appropriate management, can be reversed. This site clearly has a much larger carrying capacity for migratory waders than it is currently supporting.

There are a number of historical and anecdotal records which indicate that this site has held large numbers of migratory wading birds in the past. These include Eastern Curlew (*Numenius madagascariensis*), Whimbrel *Numenius phaeopus*, Bar-tailed Godwit (*Limosa lapponica*), Common Greenshank *Tringa nebularia*, Grey-tailed Tattler *Tringa brevipes*, Red Knot *Calidris Canutus* and Sharp-tailed Sandpiper *Calidris acuminata*. The site may possibly have been visited by Curlew Sandpiper *Calidris ferruginea*, Terek Sandpiper *Xenus cinereus*, Red-necked Stint *Calidris ruficollis*, Common Sandpiper *Actitis hypoleucos* and Pacific Golden Plover *Pluvialis fulva*. Changes in this site following European settlement have rendered it unsuitable for these birds.

These changes have arisen from:

- housing encroachment;
- changes to the hydrology of the bay as a result of dredging and alterations of Careel Creek;
- disturbance from watercraft, dogs, fishermen and yabbie pumpers.

The outcomes are:

- loss of a high tide wader roost (urban encroachment, changes to hydrology);
- encroachment by Grey Mangroves *Avicennia marina* onto mudflats and sea grass *Zostera capricorni* meadows, which reduces foraging opportunities and reduces biodiversity (changes to hydrology);
- disturbance which reduces foraging capacity for waders (dogs, watercraft, yabbie pumping);
- destruction of silt layers and habitat for benthic organisms (yabbie pumping).

These threatening processes have severely depleted the diversity and abundance of migratory shorebirds at this site. Some of the species which have historically visited and currently visit this site are listed as Threatened Species. They are also listed on the China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA). Under the terms of these agreements Statutory Authorities in Australia are obliged to protect these birds from direct threats and protect their habitats from degradation.

The following outlines some recommendations for the management of Careel Bay:

Wader Roost

It is suggested that a new wader roost be constructed. The requirements for a successful roost are:

- situating it where a commanding view of the surrounding mudflats/waters of the bay is provided;
- building it to an elevation where it is above the highest high tides;
- placing it where it is surrounded by water on the lowest high tides;
- a sandy surface to primarily be sand (most waders do not like wood, cement, gravel, metals, etc.).

Domestic Animal Disturbance

Disturbance by domestic dogs is the greatest threat to biodiversity in Careel Bay. If this is not completely curtailed, all other efforts to restore Careel Bay will fail.

It is recommended that Rangers visit this area frequently and penalise transgressors and that these incidents be reported in local newspapers to act as a deterrent to others.

It is recommended that interpretive and "no dogs" compliance signs be placed in the park adjacent to Currawong Ave, as the mudflats adjacent to this site are frequently used by waders when the tide begins to fall and especially if disturbance levels are high adjacent to Etival Street.

It is also recommended that access to the “off leash” area on Careel Bay Ovals from Etival Street be blocked, changing the access point to the car park adjacent to Avalon Soccer Fields.

Disturbance by Watercraft

Some disturbance by watercraft was observed during the course of surveys. This was mostly kayakers paddling close to the edges of channels, where shorebirds feed, or pulling kayaks ashore. Currently this is the least important of threats to bird life on Careel Bay.

Yabbie Pumping

Currently the NSW Department of Industry and Investment (NSW Fisheries) advises fishermen to collect Yabbies, otherwise known as Ghost or Mud Shrimps, *Thalassinidea*, from Careel Bay. This practice is widely promoted as an acceptable means of acquiring bait for recreational fishing.

Yabbie pumping may directly compete with migratory waders if the density of participants in a given area is high. It is a source of disturbance on mudflats and sandbars (as participants move about the mudflats during wader feeding times) and brings people who frequently have little knowledge of how to interact with sensitive environments into contact with just such a very sensitive environment. Yabbie pumping and the trampling of mudflats by yabbie pumpers has been found to disturb sediment stratification and destroy burrow networks in a manner which leads to a loss of diversity and abundance of benthic life in areas subject to this practice¹.

It is recommended that the Dept. of Industry and Investment (NSW Fisheries) be contacted to monitor Careel Bay to determine the level of disturbance and damage which it inflicts upon the bay and to possibly develop restrictions.

Mangrove Encroachment

Modification to Careel Creek and alterations to rainwater run-off in Pittwater (resulting from urbanisation) has led to changes in the hydrology of Careel Bay. This is one cause of a proliferation of Grey Mangroves on the mudflats and in the Sea Grass *Zostera capricorni* meadows of the bay, posing a threat to these important and vanishing habitats.

Despite the increase in the area of mangrove forest around Careel Bay beyond historical limits, it is not recommended that any established mangroves be removed (with the possible exception of a small patch which was planted by a resident some years ago). This is because species such as the Mangrove Gerygone are found in these mangroves and these habitats are under threat across the Sydney region. The mangroves are also an essential ingredient in the health of adjacent saltmarshes which support a population of the threatened Bush Stone-curlew. It is recommended that the health of the mangrove forest be monitored and along with any future spread of the forest onto the mudflats and sea grass meadows. The Management Plan should be modified in consultation with Dept Industry and Investment to allow for the removal of mangroves.

The presence of mangroves as a buffer between land and estuarine habitats is an essential requirement for Grey-tailed Tattler and Whimbrel, species which any rejuvenation of this site would be seeking to attract.

Monitoring the Mangrove Gerygone Population

The population and movements of the Mangrove Gerygone population at Careel Bay would add significantly to our understanding of this species and help contribute to management guidelines on the reserve.

8.4 St Michaels Cave

St Michaels Cave is south of Bangalley Head at North Avalon and is known to provide roosting habitat for the Eastern Bent-wing Bat and Large-eared Pied Bat. The Little Bent-wing Bat is also likely to make use of this cave.

¹ GA Skilleter, Y Zharikov, B Cameron, DP McPhee, Effects of harvesting callianassid (ghost) shrimps on subtropical benthic communities *Journal of Experimental Marine Biology and Ecology* Volume 320, Issue 2, June 2005, 133-158

Ecotone inspected St Michaels Cave in October 2006. Two Eastern Horseshoe Bats were observed, as well as two dead Eastern Bent-wing Bats, and a few piles of fresh guano. Common Brushtail Possum footprints and a dead Black Rat was also observed. There was evidence of frequent human activity within the cave. Attempts have been made to reduce human access to the cave through a tall, vertical paling steel fence armed with razor wire however it is still possible to enter the cave by squeezing through a gap at the end of the fence. It is recommended that more secure measures are taken to restrict access to the cave whilst still retaining access by bats through the gap above the fence. It is evident that a large colony of bats formerly used the cave as the guano deposit was mined for fertiliser and the remains of the winch mechanism is still in place on the cliff top above the cave entrance.

9.0 RAPID ASSESSMENT TOOL

A rapid assessment is a process that does not require comprehensive studies for a site. A complete inventory is extremely time consuming and needs to be carried out over a range of seasons. It provides a condition assessment for a reserve.

The Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Areas (DECC, 2007b) was used to guide the design of this assessment methodology.

The ranks given for each category are added to give an overall score for the reserve, with the highest number representing the highest condition. There are also some valuable habitat features listed at the end that contribute to the worth of a site but are unable to be used as part of the ranking process. Negative points may be given for the presence of introduced fauna species. It would be undesirable for a site to be given points because an introduced species has not yet been recorded, when the species may actually occur.

One example has been trialled in Pittwater reserves but requires refinement of its assessment matrix.

10.0 FURTHER RESEARCH REQUIRED

Some suggestions for further research that will aid in the management of fauna in Pittwater are discussed below:

- 1) Comprehensive field surveys within the reserves to record the species that are still present. These surveys would need to be carried out during a range of seasons.
 - Surveys should be designed to also target species of concern. For example a Squirrel Glider study near Port Macquarie found that a single trapping census 4-7 nights could detect 60-85% of the population, with trappability increasing when abundant food sources were absent (Quin, 1995).
 - A nest box program should be developed as a survey technique as well as increasing roost availability (see **section 6.13** for details).
- 2) The largest areas of natural bushland in Pittwater (outside Ku-ring-gai Chase National Park) occur along the Ingleside escarpment. This area contains records and suitable habitat for a number of threatened species. Since intensive development is proposed for this area, further study should be conducted to monitor fauna assemblages in this area and maintain suitable movement corridors. This reserve currently has a new Plan of Management which discusses fauna and habitat issues.
- 3) Update and further investigate habitat links.
- 4) More research is required to develop fire management plans that are suitable for the threatened fauna species in Pittwater.

11.0 POSSIBLE GRANT PROJECTS AND PARTNERS

There are now several publications available to assist in the effective and timely submission of grant applications. It is recommended Council continue to pursue partnerships and grant funding for environmental projects, works and community education programs that promote the conservation of native species.

12.0 ACKNOWLEDGEMENTS

Pittwater Council (Mia Dalby-Ball, Sonja Elwood and Kim Caswell, Matt Hansen), particularly in relation to provision of records and information regarding coastal species. Peter and Judy Smith for their work on the threatened fauna and flora management plan written in 2000, which was used as the basis for sections of this report. Ricki Coughlan, 2006-7 Bird Survey. Also thank you to volunteers who assisted with field work, particularly Paula Hutton and Sonja Elwood.

The following officers of Ecotone Ecological were also involved in the writing of this report.

PROJECT COMPONENTS	STUDY TEAM MEMBERS	QUALIFICATIONS
Project Management, Fauna Field Surveys, Report writing	Mr. Ray Williams	Biotechnician Cert. MECA
Fauna Field Surveys, Literature Review, Report Writing.	Ms. Amy Rowles	B.Sc (Hons.)
Fauna Field Surveys	Ms Jenny Lewis	B. Sc (Res. & Env. Mgt.), TAFE Cert II (Conserv. & Land Mgt. Nat. Area Rest.), MECA
Fauna Field Surveys	Mr. Narawan Williams	Certificate II Conservation and Land Mgt (Nat. Area Restoration). MECA

13.0 REFERENCES

- Antcliff, P. 1996. Flora and fauna survey: proposed Bayview Woods Residential Development, Bayview. Report to Landscan Pty Ltd. Wildsearch Flora and Fauna Surveys, North Manly.
- Ashby, E., Lunney, D., Robertshaw, J. and Harden, R. 1990. Distribution and status of bandicoots in New South Wales. Pp. 34-50 in *Bandicoots and Bilbies*. J.H. Seebeck, P.R. Brown R.M. Wallis and C.M. Kemper (eds). Surrey Beatty and Sons, Chipping Norton.
- Banks, P. Hughes N. and Rose T. 2003. Do native Australian small mammals avoid faeces of domestic dogs? Responses of *Rattus fuscipes* and *Antechinus stuartii*. 32 (3): 406-409. Australian Zoologist.
- Barker, J., Grigg, G.C. and Tyler, M.J. 1995. *A Field Guide to Australian Frogs*. Surrey Beatty and Sons, Chipping Norton.
- Barker, R.D. and Vestjens, W.J.M. 1989. *The Food of Australian Birds. 1. Non-passerines*. CSIRO, Melbourne.
- Basham R. 2005. *Microbats in Sydney's Urban Landscape: are they persisting and what factors influence their presence?*. Honours Thesis
- Belcher, C.A. 1995. Diet of the tiger quoll (*Dasyurus maculatus*) in East Gippsland, Victoria. *Wildlife Research* 22: 341-357.
- Belcher C. 2004. The largest surviving marsupial carnivore on mainland Australia: the Tiger or Spotted-tailed Quoll *Dasyurus maculates*, a nationally threatened, forest-dependent species. Pp 612-623 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.
- Blakers, M., Davies, S.J.J.F. and Reilly, P.N. 1984. *The Atlas of Australian Birds*. Royal Australasian Ornithologists Union and University of Melbourne Press, Melbourne.
- Braithwaite, L.W., Belbin, L., Ive, J. and Austin, M.P. 1993. Land use allocation and biological conservation in the Batemans Bay forests of New South Wales. *Australian Forestry*, 56: 4-21.
- Bruce Cox (2008) A Bird List for Sydney's Northern Beaches.
- Burnett S. and Marsh H. 2004. Conservation of the Spotted-tailed Quoll *Dasyurus maculates*: a conceptual and applied model with particular reference to populations of the endangered *D. m. gracilis*. Pp 624-638 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.
- Burton, A.C.G. and Morris, A.K. 1993. New South Wales Annual Bird Report - 1990. *Australian Birds* 26: 89-120.
- Cahill D, Rookes J, Wilson B, Gibson L. and McDougall K (2008) TURNER REVIEW No. 17. *Phytophthora cinnamomi* and Australia's biodiversity: impacts, predictions and progress towards control. *Australian Journal of Botany* 56(4) 279-310.
- Catterall C.P. 2004. Birds, garden plants and suburban bush lots: where good intentions meet unexpected outcomes. Pp 21-31 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Canfield, P.J. 1987. A mortality survey of free range koalas from the north coast of New South Wales. *Australian Veterinary Journal* 64: 325-327.
- Chafer, C.J. 1993. The foraging ecology of Sooty Oystercatchers on rocky intertidal shores. B.Sc.(Hons) thesis, University of Wollongong, Wollongong.
- Chapman, C.A. and Murphy, C.L. 1989. *Soil Landscapes of the Sydney 1:100 000 Sheet*. Soil Conservation Service, Sydney.

- Chapman, C.A., Murphy, C.L., Tille, P.J., Atkinson, G. and Morse, R.J. 1989. *Sydney 1:100 000 Soil Landscapes Map Sheet*. Soil Conservation Service, Sydney.
- Churchill, S. 1998. *Australian Bats*. Reed New Holland, Sydney.
- Clancy, G.P. 1991. *The Biology and Management of the Osprey (Pandion haliaetus cristatus) in NSW*. Special Management Report No. 6. NSW National Parks and Wildlife Service, Sydney.
- Clancy G. 2002. Vertebrate fauna and its management on an urban block in northern New South Wales. Pp 155-162 in *A Zoological revolution. Using native fauna to assist in its own survival*. Edited by Daniel Lunney and Chris Dickman, 2002. Royal Zoological Society of New South Wales, Mosman 2088 and Australian Museum.
- Claridge, A.W., McNee, A., Tanton, M.T. and Davey, S.M. 1991. Ecology of bandicoots in undisturbed forest adjacent to recently felled logging coupes: a case study from the Eden Woodchip Agreement Area. Pp. 331-345 in *Conservation of Australia's Forest Fauna*. Lunney, D. (ed.). Royal Zoological Society of NSW, Sydney.
- Claridge A and van der Ree R. 2004. Recovering endangered populations in fragmented landscapes: the squirrel glider *Petaurus norfolcensis* on the south-west slopes of New South Wales. Pp 678-687 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.
- Close, R.L. 1993. Campbelltown's koalas: what is their future? *National Parks Journal* 37(4): 22-25.
- Clout, M. 1989. Foraging behaviour of Glossy Black-Cockatoos. *Australian Wildlife Research* 16: 467-473.
- Cogger, H.G. 1992. *Reptiles and Amphibians of Australia*. 5th edition. Reed Books, Sydney.
- Cogger, H.G., Cameron, E.E., Sadler, R.A. and Egger, P. 1993. *The Action Plan for Australian Reptiles*. Australian Nature Conservation Agency, Canberra.
- Considine, M.T. 1979. The feeding behaviour of the Sooty Oystercatcher (*Haematopus fuliginosus*) on rocky shores in Victoria. Honours thesis, Department of Zoology, Monash University, Melbourne.
- Considine, M.T. 1982. Notes on the seasonal movements of the Sooty Oystercatcher (*Haematopus fuliginosus*) in southern Victoria. *Victorian Wader Studies Group Bulletin* 5:11-15.
- Cooke R., Wallis R. and Webster A. 2002. Urbanisation and the Ecology of Powerful Owls (*Ninox strenua*) in Outer Melbourne, Victoria. Pg 100 in *Ecology & Conservation of Owls*. Ed. I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood.
- Cooper, R.M. 1990. 1986 New South Wales Bird Report. *Australian Birds* 23: 68-101.
- Cork, S.J., Hume, I.D. and Dawson, T.J. 1983. Digestion and metabolism of a mature foliar diet (*Eucalyptus punctata*) by an arboreal marsupial, the koala (*Phascolarctos cinereus*). *Journal of Comparative Physiology B*. 153: 181-190.
- Cork, S.J. 1986. Foliage of *Eucalyptus punctata* and the maintenance nitrogen requirements of koalas, *Phascolarctos cinereus*. *Australian Journal of Ecology* 34: 17-23.
- Coughlan (2008). *Pittwater LGA Bird Survey 2006-2007*. Report prepared for Pittwater Council.
- Curtin, A. and Lunney, D. 1995. A comparison of community-based survey and field-based survey for koalas in a large reserve system on the outskirts of Sydney, New South Wales. Pp. 186-188 in *Proceedings on a Conference on the Status of the Koala in 1995, incorporating the Fourth National Carers Conference, 21st, 22nd, 23rd August 1995, Greenmount Beach Resort*. Australian Koala Foundation, Brisbane.
- Davey, S.M. 1993. Notes on the habitats of four Australian owl species. Pp. 126-142 in *Australian Raptor Studies*. Olsen, P. (ed.). Australasian Raptor Association, Royal Australasian Ornithologists Union, Melbourne.

NSW Office of Environment and Heritage website (formerly DECCW) - Final Determinations.
<http://www.npws.nsw.gov.au>

NSW Office of Environment and Heritage (formerly DECCW - *NSW Threatened Species Profiles*)
http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/browse_allspecies.aspx.

Department of Environment and Conservation (NSW), 2005. *Draft Recovery Plan for the Green and Golden Bell Frog* (*Litoria aurea*).

DECC 2007. *Flying-fox Camp Management Policy*. Department of Conservation and Climate Change.

DECC 2007b. Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Areas.

DECC 2008 – *Best Practice Guidelines for the Grey-headed Flying-fox*. Report Prepared by the State of NSW and Department of Environment and Climate Change NSW

Debus, S.J.S. 1993a. Further notes on owls from the diaries of E.L. Hyem. *Australian Birds* 27: 22-27.

Debus, S.J.S. 1993b. The mainland Masked Owl *Tyto novaehollandiae*: a review. *Australian Bird Watcher* 15: 168-191.

Debus, S.J.S. 1997. The Barking Owl in New South Wales. *Australian Birds* 30: 53-80.

Debus, S.J.S. and Chafer, C.J. 1994. The Powerful Owl *Ninox strenua* in New South Wales. *Australian Birds* 28: 21-38.

Debus, S.J.S. and Rose, A.B. 1994. The Masked Owl *Tyto novaehollandiae* in New South Wales. *Australian Birds* 28: 40-59.

Dickman, C.R. 1996. *Overview of the Impacts of Feral Cats on Australian Native Fauna*. Australian Nature Conservation Agency, Canberra.

Duncan, A., Baker, G.B. and Montgomery, N. 1999. *The Action Plan for Australian Bats*. Environment Australia, Canberra.

Dwyer, P.D. 1963. The breeding biology of *Miniopterus schreibersii blepotis* (Temminck) (Chiroptera) in north-eastern New South Wales. *Australian Journal of Zoology* 11: 219-240.

Dwyer, P.D. 1966. The population pattern of *Miniopterus schreibersii* (Chiroptera) in north-east New South Wales. *Australian Journal of Zoology* 14: 1073-1137.

Dwyer, P.D. 1969. Population ranges of *Miniopterus schreibersii* (Chiroptera) in south-eastern Australia. *Australian Journal of Zoology* 17: 665-686.

Dwyer, P.D. 1981. Centrefold No. 9: Common Bent-wing Bat, *Miniopterus schreibersii*. *Australian Natural History* 20: 187-90.

Dwyer, P.D. 1995. Common Bentwing-bat *Miniopterus schreibersii*. Pp. 494-495 in *The Mammals of Australia*. R. Strahan (ed.). Australian Museum and Reed Books, Sydney.

Ecotone Ecological Consultants. 1996. Fauna impact statement for the proposed residential subdivision at 5A Wollombi Road, Bilgola. Report to Planning Workshop. Ecotone Ecological Consultants, Waratah.

Ecotone Ecological Consultants. 1997. Bat survey for the proposed Bayview Woods Residential Development, Bayview, NSW. Report to Wildsearch Flora and Fauna Surveys. Ecotone Ecological Consultants, Mount Kuring-gai.

Ecotone 1999. *Fauna Impact Assessment, 6 Chiltern Road, Ingleside, NSW*.

Ecotone 1999b. *Species Impact Statement for the proposed Burrawang Ridge Estate, Ingleside*

- Eby P. 2002. Using NSW Planning Instruments to Improve Conservation and Management of Grey-headed Flying-fox camps. Pg 240-250 in *Managing the Grey-headed Flying-fox as a threatened species in New South Wales*. Ed by P. Eby and D. Lunney, Royal Zoological Society of New South Wales, Mosman, NSW.
- Eby P. and Lunney D. 2002. Managing the Grey Headed Flying-fox *Pteropus poliocephalus* as a threatened species: a context for the debate. Pg 1-15 in *Managing the Grey-headed Flying-fox as a threatened species in New South Wales*. Ed by P. Eby and D. Lunney, Royal Zoological Society of New South Wales, Mosman, NSW.
- Edgar, R. and Belcher, C. 1995. Spotted-tailed Quoll *Dasyurus maculatus*. Pp. 67-68 in *The Mammals of Australia*. R. Strahan (ed.). Australian Museum and Reed Books, Sydney.
- Ehmann, H. 1992. *Encyclopedia of Australian Animals: Reptiles*. Angus and Robertson, Sydney.
- Ehmann, H. (ed.). 1997. *Threatened Frogs of New South Wales: Habitats, Status and Conservation*. Frog and Tadpole Study Group of NSW, Sydney.
- Ellis, M., Wilson, P. and Hamilton, S. 1991. The Golden Bandicoot, *Isodon auratus* Ramsay 1887, in western New South Wales during European times. *Australian Zoologist* 27: 36-37.
- Fleay, D.F. 1940. Breeding of the Tiger Cat. *Victorian Naturalist* 56: 158-163.
- Fleay, D. 1968. *Night Watchmen of Bush and Plain*. Jacaranda Press, Brisbane.
- Forshaw, J.M. and Cooper, W.T. 1981. *Australian Parrots*. 2nd edition. Lansdowne Editions, Melbourne.
- Franklin, D., Menkhorst, P.W. and Robinson, J.L. 1989. Ecology of the Regent Honeyeater, *Xanthomyza phrygia*. *Emu* 89: 140-154.
- Franks A. and Franks S. (2004) *Nest Boxes for Wildlife: A Practical Guide*. Bloomings.
- Garnett, S.T. 1985. Nesting behaviour of the Bush Thick-knee. *Stilt* 7: 24-5.
- Garnett, S. (ed.). 1993. *Threatened and Extinct Birds of Australia*. RAOU Report No. 82. Australian National Parks and Wildlife Service and Royal Australasian Ornithologists Union, Melbourne.
- Geering, D.J. 1997. Habitat selection and resource use by the Regent Honeyeater on the NSW Central Coast. *NSW Field Ornithologists Club Newsletter* 163: 10.
- Geering, D. and French, K. 1998. Breeding biology of the Regent Honeyeater *Xanthomyza phrygia* in the Capertee Valley, New South Wales. *Emu* 98: 104-116.
- Geological Survey of NSW. 1983. *Sydney 1:100 000 Geological Series Sheet 9130*. Department of Mineral Resources, Sydney.
- Gilmore, A. and Parnaby, H. 1994. *Vertebrate Fauna of Conservation Concern in North-east NSW Forests*. North East Forests Biodiversity Study Report No. 3e. NSW National Parks and Wildlife Service, Sydney.
- Grayson J. and Calver M. 2004. Regulation of domestic cat ownership to protect urban wildlife: a justification based on the precautionary principle. Pp 169-178 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Green, B. and King, D. 1978. Home range and activity patterns of the sand goanna *Varanus gouldii* (Reptilia: Varanidae). *Australian Journal of Wildlife Research* 5: 417-424.
- Green, B. and King, D. 1993. *Goanna: the Biology of Varanid Lizards*. University of NSW Press, Sydney.
- Green M., Thompson M. and Lemckert F. 2004. The effects of suspended sediments on the tadpoles of two stream-breeding and forest dwelling frogs, *Mixophyes balbus* and *Heleioporus australiacus*. Pp 713-720 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

- Gibbons P. and Lindenmayer D. (2002) *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Victoria, Australia.
- Goldingay R, Sharpe D and Dobson M (2003). *Ecological Studies on the Squirrel Glider in an Urban Forest Remnant*, Brisbane. Abstracts of presentations given at forty-ninth AGM, The Australian Mammal Society, 7-9th July 2003 at Sydney University.
- Goldingay R. and Sharpe D. 2004. How do we conserve the squirrel glider in Brisbane's urban matrix? Pp 663-677 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.
- Goldingay R. and Stevens J. (2009) Use of artificial tree hollows by Australian birds and bats. *Wildlife Research* **36(2)**: 81-97.
- Goodrich T. 2002. A modified bat box design for scientific purposes. Pg 18 in *The Australasian Bat Society Newsletter*, Number 19.
- Gould Group (2008) *The Nest Box Book 2nd Edition*. Melbourne.
- Hackett D and Goldingay R. 1999. Non-flying Mammals as pollinators of Banksia species in North-eastern New South Wales. Presentation given at The Australian Mammal Society Conference, 1999, University of Western Sydney, Hawkesbury, NSW.
- Hall, L.S. 1982. The effect of cave microclimate on winter roosting behaviour in the bat, *Miniopterus schreibersii blepotis*. *Australian Journal of Ecology* **7**: 129-136.
- Heinsohn, G.E. 1966. Ecology and reproduction of the Tasmanian bandicoots (*Perameles gunnii* and *Isodon obesulus*). *University of California Publications in Zoology* **80**: 1-107.
- Herbert, C. (ed.). 1983. *Geology of the Sydney 1:100 000 Sheet 9130*. Department of Mineral Resources, Sydney.
- Higgins P. 1999. *Handbook of Australian New Zealand and Antarctic Birds*. Volume 4: Parrots to Dollarbird. Oxford University Press.
- Higgins P., Peter J. and Steele W. 2001. *Handbook of Australian New Zealand and Antarctic Birds*. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press.
- Higgs, P. and Campbell, D. 1993. *Endangered Species Household Survey 1993*. Unpublished report. Pittwater Council, Warriewood.
- Hindell, M.A., Handasyde, K.A. and Lee, A.K. 1985. Tree species selection by free-ranging koala populations in Victoria. *Australian Wildlife Research* **12**: 137-144.
- Hindell, M.A. and Lee, A.K. 1990. Tree preferences of the koala. Pp. 117-121 in *Biology of the Koala*. A.K. Lee, K.A. Handasyde and G.D. Sanson (eds). Surrey Beatty and Sons, Sydney.
- Hindwood, K.A. 1939. Nectar-feeding birds near Sydney. *Emu* **34**: 40-44.
- Hindwood, K.A. 1944. Honeyeaters of the Sydney District (County of Cumberland), New South Wales. *Australian Zoologist* **10**: 231-251.
- Hindwood, K.A. and Hoskin, E.S. 1954. The waders of Sydney (County of Cumberland). *Emu* **54**: 217-255.
- Hochuli D.F., Gibb H., Burrows S.E. and Christie F.J. 2004. Ecology of Sydney's urban fragments: has fragmentation taken the sting out of insect herbivory? Pp 63-69 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Holden, T. 1999. Observations on aspects of the ecology of Pittwater Spotted Gum Forest. Bachelor of Science with Honours thesis, University of New South Wales.

- Hoskin, E.S., Hindwood, K.A. and McGill, A.R. 1991. *The Birds of Sydney, County of Cumberland, New South Wales, 1788-1989*. 2nd edition. Surrey Beatty and Sons, Chipping Norton.
- Hoye G. 2004. Results of an initial trial of bat boxes at Mt Owen Coal Mine, Ravensworth, New South Wales. Pg 31 in *The Australasian Bat Society Newsletter*, Number 22.
- Hoye, G.A. and Dwyer, P.D. 1995. Large-eared Pied Bat. Pp. 510-511 in *The Mammals of Australia*. R. Strahan (ed.). Australian Museum and Reed Books, Sydney.
- Hoye, G.A. and Richards, G.C. 1995. Greater Broad-nosed Bat *Scoteanax rueppellii*. Pp. 527-528 in *The Mammals of Australia*. R. Strahan (ed.). Australian Museum and Reed Books, Sydney.
- Hoye G. and Spence J. 2004. The Large Bent-wing Bat *Miniopterus shreibersii* in urban environments: a survivor? Pp 138-147 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- ICF and Australian Museum. 1994. Ingleside/Warriewood Urban Land Release Fauna Conservation Study. Report to Pittwater Council. ICF Pty Ltd and Australian Museum, Sydney.
- Jones V, 2001. Evening drinks for grey-headed flying foxes. Pg 41-42 *The Australasian Bat Society Newsletter*, volume 17.
- Kavanagh R. 2002. Comparative Diets of the Powerful Owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*) in south-eastern Australia. Pg 175 in *Ecology & Conservation of Owls*. Ed. I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood.
- Kavanagh R.P. 2004. Conserving Owls in Sydney's urban bushland: current status and requirements. Pp 93-108 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Kavanagh, R.P., Debus, S.J.S., Rose, A.B. and Turner, R.J. 1995. Diet and habitat of the Barking Owl *Ninox connivens* in New South Wales. *Australian Bird Watcher* 16: 137-144.
- Kavanagh R. and Stanton M. 2002. Response to habitat fragmentation by the Powerful Owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*), Masked Owl (*Tyto novaehollandiae*) and other nocturnal fauna in Southeastern Australia. Pg 265-276 in *Ecology & Conservation of Owls*. Ed. I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood.
- King, D. and Green, B. 1979. Notes on diet and reproduction of the sand goanna, *Varanus gouldii rosenbergi*. *Copeia* 1979: 64-70.
- Kingsford, M.J., Underwood, A.J. and Kennelly, S.J. 1991. Humans as predators on rocky reefs in New South Wales. *Australian Marine Ecology Progress Series* 72: 1-12.
- Krefft, G. 1866. On the vertebrated animals of the Lower Murray and Darling, their habits, economy and geographical distribution. *Transactions of the Philosophical Society of New South Wales (for 1862-1865)* 1866: 1-33.
- Lane, B.A. 1987. *Shorebirds in Australia*. Royal Australasian Ornithologists Union and Nelson, Melbourne.
- Lavin, M.F., Girjes, A.A., Hugall, A.F., Timms, P., Weigler, B.J. and Brown, S. 1990. Chlamydia psittaci and disease in Phascolarctos cinereus (koala). Pp. 261-266 in *Biology of the Koala*. A.K. Lee, K.A. Handasyde and G.D. Sanson (eds). Surrey Beatty and Sons, Sydney.
- Law B, Eby P, and Somerville D. 2002. Tree Planting to Conserve Flying-foxes and reduce orchard damage. Pg 84-90 in *Managing the Grey-headed Flying-fox as a threatened species in New South Wales*. Ed by P. Eby and D. Lunney, Royal Zoological Society of New South Wales, Mosman, NSW.
- Lee, A. and Martin, R. 1988. *The Koala: A Natural History*. NSW University Press, Sydney.
- Lindsey, T.R. 1986. New South Wales Bird Report for 1984. *Australian Birds* 20: 97-132.

- Lobert, B. 1990. Home range and activity period of the Southern Brown Bandicoot (*Isoodon obesulus*) in a Victorian heathland. Pp. 319-325 in *Bandicoots and Bilbies*. J.H. Seebeck, P.R. Brown, R.L. Wallis and C.M. Kemper (eds.). Surrey Beatty and Sons, Chipping Norton.
- Lobert, B. and Lee, A.K. 1990. Reproduction and life history of *Isoodon obesulus* in Victorian heathland. Pp. 311-18 in *Bandicoots and Bilbies*. J.H. Seebeck, P.R. Brown, R.L. Wallis and C.M. Kemper (eds.). Surrey Beatty and Sons, Chipping Norton.
- Long, A. 1983. Observations on carnivory by *Nycticeius rueppellii*. *Australian Bat Research News* 19: 9-10.
- Longmore, W. 1991. *Honeyeaters and Their Allies of Australia*. Angus and Robertson, Sydney.
- Lumsden L. and Bennet A. 1998. The Roosting Behaviour of the Lesser Long-eared Bat *Nyctophilus geoffroyi* and Gould's Wattled Bat *Chalinolobus gouldii* in a fragmented landscape in northern Victoria. Pg 34 in abstracts for presentations given at the 8th Australian Bat Conference, Rockhampton.
- Lunney D and Burgin S, 2004. Urban wildlife management: an emerging discipline. Pp 1-7 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Lunney D. and Mathews A. 2002. Community-based research: where are the rewards? Pp 8-19 in *A Clash of paradigms: community and research-based conservation*, edited by Daniel Lunney, Chris Dickman and Shelley Burgin 2002. Royal Zoological Society of New South Wales, Mosman.
- Lyne, A.G. and Mort, P.A. 1981. A comparison of skull morphology in the marsupial bandicoot genus *Isoodon*: its taxonomic implications and notes on a new species, *Isoodon arnhemensis*. *Australian Mammalogy* 4: 107-133.
- Mackowski, C.M. 1984. The ontogeny of hollows in Blackbutt (*Eucalyptus pilularis*) and its relevance to the management of forests for possums, gliders and timber. Pp. 553-567 in *Possums and Gliders*. A.P. Smith and I.D. Hume (eds). Surrey Beatty and Sons, Chipping Norton.
- Mansergh, I. 1983. The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia, with particular reference to Victoria. *Australian Zoologist* 21: 109-122.
- Marchant, S. and Higgins, P.J. (eds.). 1990. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks*. Oxford University Press, Melbourne.
- Marchant, S. and Higgins, P.J. (eds.). 1993. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings*. Oxford University Press, Melbourne.
- Mallick S.A., Driessen M.M. and Hocking G.J. 1998b. Biology of the Southern Brown Bandicoot (*Isoodon obesulus*) in South-eastern Tasmania. II. Demography. *Australian Mammalogy* 20: 339-347.
- Martin L and McIlwee A. P. 2002. The reproductive biology and intrinsic capacity for increase of the Grey-headed Flying-fox *Pteropus Poliocephalus* (Megachiroptera), and the implications of culling. Pg 91-108 in *Managing the Grey-headed Flying-fox as a threatened species in New South Wales*. Ed by P. Eby and D. Lunney, Royal Zoological Society of New South Wales, Mosman, NSW.
- Maxwell, S., Burbidge, A.A. and Morris, K. (eds.). 1996. *The 1996 Action Plan for Australian Marsupials and Monotremes*. Environment Australia, Canberra.
- McDonald J. 1992. *The Archaeology of the Angophora Reserve Rock Shelter*. Environmental Heritage Monograph Series No 1. National Parks and Wildlife Service.
- Meek, P. 2003. Felis Jeckyl and the cats that hyde: home range of house cats (*Felis Catus* L.) living within a national park. Abstracts of presentations given at forty-ninth AGM, The Australian Mammal Society, 7-9th July 2003 at Sydney University.
- Menkhorst, P.W. (ed.). 1995. *Mammals of Victoria: Distribution, Ecology and Conservation*. Oxford University Press, Melbourne.

- Menkhorst, P.W. and Collier, M. 1988. Diet of the Squirrel Glider, *Petaurus norfolcensis* (Marsupialia: Petauridae) in Victoria. *Australian Mammalogy* 11: 109-116.
- Menkhorst, P.W., Weavers, B.W. and Alexander, J.S.A. 1988. Distribution, habitat and conservation status of the squirrel glider *Petaurus norfolcensis* (Marsupialia: Petauridae) in Victoria. *Australian Wildlife Research* 15: 59-71.
- Morcombe M. 2000. *Field Guide to Australian Birds*. Steve Parish Publishing Pty Ltd. Archerfield, Qld,
- Morgan, L.A. and Buttemer, W.A. 1996. Predation by the non-native fish *Gambusia holbrooki* on small *Litoria aurea* and *L. dentata* tadpoles. *Australian Zoologist* 30: 143-149.
- Morris, A.K. 1993. Glossy Black-Cockatoos in New South Wales. *Bird Observer* 735: 5.
- Morris, A.K. 2000. New South Wales Annual Bird Report 1997. *Australian Birds* 32: 1-64.
- Morris, A.K. and Burton, A.C.G. 1992. 1989 New South Wales Bird Report. *Australian Birds* 26: 41-70.
- Morris, A.K. and Burton, A. 1993. New South Wales Annual Bird Report 1991. *Australian Birds* 27: 29-76.
- Morris, A.K. and Burton, A. 1994. New South Wales Annual Bird Report 1992. *Australian Birds* 27: 97-139.
- Morris, A.K. and Burton, A. 1996. New South Wales Annual Bird Report 1994. *Australian Birds* 29: 63-112.
- Morris, A.K. and Burton, A. 1997. New South Wales Annual Bird Report 1995. *Australian Birds* 30: 81-149.
- Morris, A.K. and Burton, A. 1999. New South Wales Annual Bird Report 1996. *Australian Birds* 31: 86-137.
- Morris, A.K. and Gladwin, C. 2000. Unusual records October to December 1999. *NSW Field Ornithologists Club Newsletter* 177: 16-18.
- Morris, A.K., McGill, A.R. and Holmes, G. 1981. *Handlist of Birds in New South Wales*. NSW Field Ornithologists Club, Sydney.
- National Parks and Wildlife Service. 1999a. *Threatened Species Management: Species Information*. NSW National Parks and Wildlife Service, Hurstville.
- New South Wales National Parks and Wildlife Services and Shoalhaven Catchment Management Committee, 2000. *Threatened Fauna of the Shoalhaven*. NPWS, Queanbeyan.
- Newman, O.M.G. 1983. Pied Oystercatcher - replacement clutches. *Occasional Stint* 2: 49-52.
- North J and Pasic V., 2003. A comparison of the microclimate conditions of 3 mines and their suitability as a roost for the Large Bent-wing Bat *Miniopterus schreibersii oceanensis*. Pg 22- 28 In The Australasian Bat Society Newsletter, Volume 21.
- NPWS Recovery Team Information, 2002. *Regent Honeyeater and Swift Parrot Volunteer Workshop*. Natural Heritage Trust Volunteer Manual.
- NPWS Recovery Team Information, 2002. Regent Honeyeater and Swift Parrot Volunteer Workshop. Natural Heritage Trust, Volunteer Manual.
- NSW Department of Minerals and Energy 1991. *Geological Series Mapsheet 9030 for Penrith*. Geological Survey of NSW Department of Minerals and Energy, Sydney.
- NSW Scientific Committee. 1996. Final determination to list the population of the Squirrel Glider *Petaurus norfolcensis* on Barrenjoey Peninsula north of Bushrangers Hill as an Endangered Population. NSW Scientific Committee, Hurstville.
- NSW Scientific Committee. 1998a. Final determination to list the population of the Koala *Phascolarctos cinereus* in the Pittwater Local Government Area as an Endangered Population. NSW Scientific Committee, Hurstville.

- NSW Scientific Committee. 1998b. Final determination to list the Giant Dragonfly *Petalura gigantea* as an Endangered Species. NSW Scientific Committee, Hurstville.
- NSW Scientific Committee. 2000a. Final determination to list the Swift Parrot *Lathamus discolor* as an Endangered Species. NSW Scientific Committee, Hurstville.
- O'Brien, D. 1995. Koala survey of the Brisbane Water National Park. Pp. 230-263 in *Proceedings on a Conference on the Status of the Koala in 1995, incorporating the Fourth National Carers Conference, 21st, 22nd, 23rd August 1995, Greenmount Beach Resort*. Australian Koala Foundation, Brisbane.
- Opie, A., Gullan, P. and Mansergh, I. 1990. Prediction of the geographic range and habitat preferences of *Isoodon obesulus* and *Perameles nasuta* in Gippsland. Pp. 327-334 in *Bandicoots and Bilbies*. J.H. Seebeck, P.R. Brown, R.L. Wallis and C.M. Kemper (eds.). Surrey Beatty and Sons, Chipping Norton.
- Parnaby, H. 1992. *An Interim Guide to Identification of Insectivorous Bats of South-eastern Australia*. Technical Report No. 8. Australian Museum, Sydney,
- Parsons H.M. and Major R.E. 2004. Bird interactions in Sydney gardens: some initial findings of the Birds in Backyards program. Pp 211-215 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Penman T. 2003. *Management of the Giant Burrowing Frog (Helioporus australiacus) in the forests of SE NSW*. Presentation given at Frog Talks Day 21st of July, 2003 at Research Division, State Forests of NSW, Cumberland State Forest, Beecroft.
- Pittwater Council Website: <http://www.pittwater.nsw.gov.au/environment>
- Pittwater Council. 1993. *Angophora Reserve and Hudson Park Plan of Management*. Pittwater Council, Warriewood.
- Pittwater Council. 1994. *McKay Reserve and Dark Gully Park Plan of Management*. Pittwater Council, Warriewood.
- Pittwater Council. 1995a. *Stapleton Park Plan of Management*. Pittwater Council, Warriewood.
- Pittwater Council. 1995b. *Habitat and Wildlife Corridors: A Conservation Strategy*. Prepared from a discussion paper by Paul Burcher. Pittwater Council, Warriewood.
- Pittwater Council. 1996. *Irrawong Reserve Plan of Management*. Pittwater Council, Warriewood.
- Pittwater Council. 1997a. *State of Environment Report 1997*. Pittwater Council, Warriewood.
- Pittwater Council. 1997b. *Urban Bushland Inventory and Action Plan*. Four volumes. Pittwater Council, Warriewood.
- Poole, A.F. 1989. *Ospreys*. Cambridge University Press, Cambridge UK.
- Potter, C. (ed.). 1991. *The Impact of Cats on Native Wildlife: Proceedings of a Workshop held on 8-9 May 1991*. Australian National Parks and Wildlife Service, Canberra.
- Pringle, J.D. 1985. *The Waterbirds of Australia*. Angus and Robertson, Sydney.
- Pringle, J.D. 1987. *The Shorebirds of Australia*. Angus and Robertson, Sydney.
- Pyke G., White, A. Bishop, P. and Waldman B. (2002) Habitat-use by the Green and Golden Bell Frog *Litoria aurea* in Australia and New Zealand. 32(1): 12-31. Australian Zoologist
- Quin, D.G. 1988. Observations on the diet of the Southern Brown Bandicoot, *Isoodon obesulus* (Marsupialia: Peramelidae), in southern Tasmania. *Australian Mammalogy* 11: 15-25.

- Quin . 1995. Population Ecology of the Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider (*P. breviceps*) (Marsupialia: Petauridae) at Limeburners Creek, on the Central North Coast of New South Wales. *Wildlife Research* **22**: 471-505.
- Reardon T, 2001. Artificial Bat Roost Box Design. Pg 54-55 The Australasian Bat Society Newsletter, volume 17.
- Reardon, T.B. and Flavel, S.C. 1987. *A Guide to the Bats of South Australia*. South Australian Museum, Adelaide.
- Recher H.F. 2004. The Kings Park Avifauna: keeping birds in the city. Pp 8-20 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Recsei, J. 1997. Investigation of certain crown land lots in Ingleside for threatened species of reptiles and frogs. Report to Pittwater Flora and Fauna Society. Ingleside Landcare Group, Ingleside.
- Rees M. and Paull D. 2000. Distribution of the Southern Brown Bandicoot (*Isodon obesulus*) in the Portland region of south-western Victoria. *Wildlife Research*. **27**: 539-545.
- Rhodes M. 2001. Roost ecology and conservation of insectivorous bats in suburban Brisbane: An assessment of natural roost habitat of the White-striped Freetail-bat (*Tadarida australis*), and artificial roost habitats (Bat boxes) for insectivorous bats in Brisbane. Pg 11-18 in The Australasian Bat Society Newsletter, Number 16.
- Richardson, E.G. 1977. The biology and evolution of the reproductive cycle of *Miniopterus schreibersii* and *M. australis* (Chiroptera: Vespertilionidae). *Journal of Zoology* 183: 353-375.
- Robinson, N.H. 1985. *Mammals of the Metropolitan Water, Sewerage and Drainage Board Catchments*. General Technical Report No. 3. Department of Biology, University of Wollongong, Wollongong.
- Rogers, A.E.F. 1975. NSW Bird Report for 1974. *Australian Birds* 9: 77-97.
- Ross G.A. 2004. Ibis in urban Sydney: a gift from Ra or a Pharaoh's curse? Pp 148-152 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- Rowston, C. 1998. Nest- and refuge-tree usage by squirrel gliders, *Petaurus norfolcensis*, in south-east Queensland. *Wildlife Research* 25: 157-164.
- Rowston C. and Catterall C. 2004. Habitat segregation, competition and selective deforestation: effects on the conservation status of two similar *Petaurus* gliders. Pp741- 747 in the *Conservation of Australia's Forest Fauna* (second edition) 2004, edited by Daniel Lunney. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.
- Sanderson K. and Kraenhenbuehl J. 2003. Southern Brown Bandicoots in Belair National Park. Abstracts of presentations given at forty-ninth AGM, The Australian Mammal Society, 7-9th July 2003 at Sydney University.
- Saunders L. 2004. Garden Fruit Trees and Wildlife. Pg 18-20 in The Australasian Bat Society Newsletter, Volume 23.
- Schodde, R. and Mason, I.J. 1980. *Nocturnal Birds*. Lansdowne Editions, Melbourne.
- Seebeck, J.H. 1976. The diet of the Powerful Owl *Ninox strenua* in western Victoria. *Emu* 76: 167-170.
- Seebeck, J.H., Brown, P.R., Wallis, R.M. and Kemper, C.M. (eds). 1990. *Bandicoots and Bilbies*. Surrey Beatty and Sons, Chipping Norton.
- Settle, G.A. 1978. The quality of quolls. *Australian Natural History* 19: 164-169.
- Sharpe D. J. and Goldingay R. L. 1998. Feeding Behaviour of the Squirrel Glider at Bungwalbin Nature Reserve, north-eastern New South Wales. *Wildlife Research*. **25**: 243-254.

- Shortland Wetlands Centre. 1989. *Warriewood Wetlands Bicentennial Park: Draft Plan of Management*. Pittwater Council, Warriewood.
- Simpson and Day, 2003. *The Claremont Field Guide to the Birds of Australia*. Penguin Books Australia.
- Skelton, N. and Williams, R. 1998. Flora and fauna at the site of proposed changes to Bayview Golf Course. Report to Bayview Golf Club. GIS Environmental Consultants, North Curl Curl.
- Skelton, N. 1999. Addendum to flora and fauna report on 48 Minkara Road. GIS Environmental Consultants, North Curl Curl.
- Slater P, Slater P and Slater R. (1998) *The Slater Field Guide to Australian Birds*. Landsdowne Publishing Pty Ltd, Sydney.
- Smith, A.P. 1996. Adequacy of fauna assessments: proposed subdivision 5A Wollombi Road, Bilgola. Two reports to Pittwater Council. Austeco Environmental Consultants, Armidale.
- Smith A. 1999. *Draft Sub-regional Squirrel Glider Study: North Wyong Shire*. Report prepared by Austeco Environmental Consultants.
- Smith, J. and Smith, P. 1990a. *Fauna of the Blue Mountains*. Kangaroo Press, Kenthurst.
- Smith, P. and Smith, J. 1990b. Decline of the urban Koala (*Phascolarctos cinereus*) population in Warringah Shire, Sydney. *Australian Zoologist* 26:109-129.
- Smith, P. 1991. *The Biology and Management of Waders (Suborder Charadrii) in NSW*. Species Management Report No. 9. NSW National Parks and Wildlife Service, Sydney.
- Smith, P. and Smith, J. 1992a. *Draft Angophora Reserve and Hudson Park Plan of Management*. Warringah Shire Council, Dee Why.
- Smith, P. and Smith, J. 1992b. Flora and Fauna Survey of McKay Reserve, Palm Beach. Report to Pittwater Council. P & J Smith Ecological Consultants, Blaxland.
- Smith, P. and Smith, J. 1997a. Bird Habitat Study of Careel Bay. Report to Pittwater Council. P & J Smith Ecological Consultants, Blaxland.
- Smith, P. and Smith, J. (2000). *Management Plan for threatened fauna and flora in Pittwater*. Report to Pittwater Council. P & J Smith Ecological Consultants, Blaxland.
- Smith, P. and Smith, J. 2000b. Survey of the Endangered Duffys Forest Vegetation Community. Report to NSW National Parks and Wildlife Service and Warringah Council. P & J Smith Ecological Consultants, Blaxland.
- Steege, J. (ed.) 1988. *Palm Beach: 1788-1988*. The Palm Beach Association, Palm Beach NSW.
- Stoddart, D.M. and Braithwaite, R.W. 1979. A strategy for the utilization of regenerating heathland habitat by the brown bandicoot (*Isodon obesulus*; Marsupialia: Peramelidae). *Journal of Animal Ecology* 48: 165-179.
- Strahan, R. 1994. *Cuckoos, Nightbirds and Kingfishers of Australia*. Angus and Robertson, Sydney.
- Strahan R. 2002. *The Mammals of Australia*. Australian Museum & Reed New Holland, Sydney.
- Suckling, G.C. 1995. Squirrel Glider *Petaurus norfolcensis*. Pp. 234-235 in *The Mammals of Australia*. R.
- Strahan (ed.). Australian Museum and Reed Books, Sydney.
- Swan, G. 1990. *A Field Guide to the Snakes and Lizards of New South Wales*. Three Sisters Productions, Winmalee.

- Taylor I., Kirsten I. and Peake P. 2002. Habitat, Breeding & Conservation of the Barking Owl *Ninox connivens* in Northeastern Victoria, Australia. Pg 116 in *Ecology & Conservation of Owls*. Ed. I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood.
- Taylor I., Kirsten I. and Peake P. 2002. Distribution and Habitat of Barking Owl (*Ninox connivens*) in Central Victoria, Australia. Pg 107 in *Ecology & Conservation of Owls*. Ed. I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood.
- Thumm K. *Evolution in an unpredictable environment: Bet-hedging and phenotypic plasticity in the red-crowned toadlet*. Presentation given at Frog Talks Day 21st of July, 2003 at Research Division, State Forests of NSW, Cumberland State Forest, Beecroft.
- Tidemann C.R. and Flavel S.C. (1987). Factors affecting choice of diurnal bat roost site by tree-hole bats (Microchiroptera) in south-eastern Australia. *Australian Wildlife Research*, **14**: 459-473.
- Traill B. J. and Lill A. 1997. Use of Tree Hollows by two sympatric gliding possums, the Squirrel Glider *Petaurus norfolcensis* and the Sugar Glider *P. breviceps*. *Australian Mammalogy* **20**: 79-88.
- Mallick S.A., Driessen M.M. and Hocking G.J. 1998a. Biology of the Southern Brown Bandicoot (*Isodon obesulus*) in South-eastern Tasmania. I. Diet. *Australian Mammalogy* **20**: 331-338.
- Turton, M. 1996. Chiropteran survey of five bushland reserves in Pittwater. Report to Pittwater Council. M. Turton, Wentworth Falls.
- Tyler, M.J. 1997. *The Action Plan for Australian Frogs*. Environment Australia, Canberra.
- Ward S. 1999. Nest boxes versus spotlighting for detecting feathertail gliders in an area. Presentation given at The Australian Mammal Society Conference, 1999, University of Western Sydney, Hawkesbury, NSW.
- Water Resources Consulting Services. 1997. Warriewood Wetland Draft Plan of Management, 1997. Report to Pittwater Council. Water Resources Consulting Services, Parramatta.
- Watkins, D. 1993. *A National Plan for Shorebird Conservation in Australia*. RAOU Report No. 90. Royal Australasian Ornithologists Union, Melbourne.
- Watson, J.A.L., Theischinger, G. and Abbey, H.M. 1991. *The Australian Dragonflies: A Guide to the Identification, Distributions and habitats of Australian Odonata*. CSIRO, Canberra and Melbourne.
- Webster, R. and Menkhorst, P. 1992. *The Regent Honeyeater (Xanthomyza phrygia): Population Status and Ecology in Victoria and New South Wales*. Arthur Rylah Institute Technical Report No. 126. Arthur Rylah Institute for Environmental Research, Department of Conservation and Environment, Melbourne.
- White A.W. and Burgin S. 2004. Current status and future prospects of reptiles and frogs in Sydney's urban-impacted bushland reserves. Pp 109- 123 in *Urban Wildlife: more than meets the eye*, edited by Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.
- White, A. 1994. Report on frog species and habitats, Mona Vale Road, Mona Vale. Report to G.J. Weynton and Associates. Biosphere Environmental Consultants, Rockdale.
- White A and Pyke G. 1996. Distribution and Conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. *Australian Zoologist* **30(2)**: 177-189
- Williams, R. 1990. Possums and Gliders. Pp. 97-108 in *The Care and Handling of Australian Native Animals*. S.J. Hand (ed.). Surrey Beatty and Sons, Chipping Norton.
- Williams A and Williams R, 1999. *Caring for Kangaroos and Wallabies*. Kangaroo Press, Kenthurst.
- Wilson P. 2002. Community-based research: science conducted as if people really matter. Pp74-87 in *A Clash of paradigms: community and research-based conservation*, edited by Daniel Lunney, Chris Dickman and Shelley Burgin 2002. Royal Zoological Society of New South Wales, Mosman.
- Wilson S. and Swan G. 2003. *A Complete Guide to Reptiles of Australia*. Reed New Holland, Sydney.

Wilson P. 2003. Analysis of movements by Large Bent-wing Bats *Miniopterus Schreibersii* based on 27 years of banding data. Pg 18-20 in The Australasian Bat Society Newsletter, Volume 21.

Winter, J.W. 1966. Bird predation by the Australian marsupial Squirrel Glider. *Journal of Mammalogy* 47: 530.

Woodlots and Wetlands Pty Ltd. 1997. Report on Investigation into Dieback of Native Trees on Scotland Island. Report to Pittwater Council. Woodlots and Wetlands Pty Ltd, Castle Hill.

Wotherspoon, D. 1998. Red-crowned Toadlet *Pseudophryne australis* in the Blue Mountains. Report to Blue Mountains Conservation Society. Blue Mountain Wilderness Trust, Faulconbridge

APPENDIX 6 SUPPLEMENTARY SURVEYS

1.0 Introduction

Some community based surveys were conducted by Ecotone in December 2006 and further field surveys were undertaken in March 2009. These surveys were designed as base line surveys, where techniques could be replicated in the future.

2.0 Methods

Survey sites were selected by Pittwater Council environment staff and are listed in **Appendix 6 - Table 1**. These reserves were chosen as examples of reserves where there has been a lack of survey work carried out in the past. Budget constraints limited the amount of survey work that could be carried out. The field surveys included the following methods:

2.1 Hair tubes

Hair-tube surveys targeting small to medium-sized arboreal and terrestrial mammals were utilised for the current investigation. Double-sided tape was placed at either end on the upper side of the tube to collect hairs of animals attracted to the bait. Medium hair-tubes were set on the ground and small hair-tubes were fixed onto the trunk of a tree with an attaching screw, at a height approximately 1.5 metres above the ground. Small tubes were baited with a standard mixture of peanut butter and rolled oats, and ground tubes were baited with a mixture of peanut butter, oats and fish flavoured cat food. Hairs collected were sent to an expert for analysis (Barbara Triggs, Genoa, Victoria).

2.2 Harp Traps

A harp trap was used to capture and identify insectivorous bats present at Angophora Reserve in October 2006. Harp traps consist of a 2 metre x 2 metre aluminium frame supporting two banks of 6 lb breaking strain vertical nylon fishing line, each strand being 2.5 cm apart. A plastic lined catching bag is positioned below. Harp traps are placed in suitable locations such as a flyway between trees or open corridors in the forest, such as tracks or creeks. Harp traps were inspected for captures each following morning. Any bats captured were identified to species level and released in the evening to avoid predatory birds, such as the Grey Butcherbird, Pied Currawong and Kookaburra that may have been present.

2.3 Ultrasonic Bat Call Detection

Anabat II detectors (Titley Electronics, Ballina, NSW) were used to collect ultrasonic calls of the bat species using the site. Bats emit ultrasonic calls as a method of navigating and searching for food. These calls are often at a higher frequency than calls audible to the human ear. In order to make the calls audible, bat detectors convert the call to a lower frequency. A Detector connected to a ZCAIM with a CFC card reader was used in a stationary position or hand-held during spotlighting activities. All recorded calls are later analysed with a computer package Analook, to identify the species recorded. Detectors set in a stationary position were placed at a 45 degree angle. Ultrasonic call detectors have proved useful for recording species that are difficult to capture. However, owing to variations in call strength and frequency within and between species and the difficulty in identifying short or poor quality calls, the identity of species recorded by bat detector cannot always be guaranteed. Some bats are difficult to detect due to their quiet calls (e.g. *Nyctophilus* sp., *Kerivoula papuensis*) and bats with extremely similar calls are sometimes difficult to differentiate (e.g. *Miniopterus schreibersii* and *Vespadelus darlingtoni*). Therefore, bat detectors cannot always provide positive species identification. Bat detection surveys should not be conducted during cold, wet or windy conditions.

2.4 Elliott and Cage Traps

Elliott traps are aluminium live traps of which two sizes were used (A size Elliott trap-10 x 8 x 32cm; B size Elliott traps - 46 x 15 x 15cm). Elliott traps were positioned on the ground along possible animal tracks or the base of trees and logs or amongst vegetation clumps.

These Elliott traps are designed to capture small mammals such as rodents and marsupial dasyurids. B Elliott traps were placed on the ground as for A Elliotts. All Elliott traps were baited with standard peanut butter, oat and honey balls. Two cage traps were set at Angophora Reserve in 2006. These traps are larger than the B Elliott traps and made with wire mesh. They were baited with the same standard bait.

All traps were positioned so as to avoid the morning sun and were covered with a plastic bag to reduce the risk of exposure (due to rain) to any captured animal. Bedding material of dry leaves gathered on site was also provided in the Elliott traps. All traps were checked early morning.

The combination of traps used for each line varied depending on the size of the reserve and suitable access.

A demonstration of setting B Elliot tree traps was conducted in 2006 at Angophora Reserve. This method is suitable for detecting arboreal mammals, such as possums and gliders. A ladder is used to climb to a height of approximately 2.5m, where a platform is attached to the tree trunk. The B Elliot trap is attached to this platform, with the door facing the trunk. The tree trunk is sprayed with honey water and the traps are baited with the standard Elliot baits as well as honey wrapped in paper towel baits. Traps are positioned away from morning sun and are checked early morning.

2.5 Spotlighting

Spotlighting was undertaken for all small, medium and large-sized mammals and nocturnal birds, reptiles and frogs within the study area. Both arboreal and terrestrial nocturnal animals were targeted during the spotlighting surveys. This involved the use of bright torches to scan eye shine and movement as well as listening for characteristic calls.

2.6 Diurnal Herpetofauna Search

Reptile searches were conducted during the day during suitable weather conditions.

2.7 Diurnal Bird Surveys

Bird Surveys were conducted by Ricki Coughlan (Coughlan, 2008)

2.8 Nocturnal Call Playback

The playback of pre-recorded calls of threatened nocturnal species was carried out at Angophora Reserve in December 2006 as a demonstration. After an initial listening period of ten minutes, each call was played (amplified by the use of a loud hailer) for a total of five minutes, followed by a five minute listening period, with the last listening period followed by ten minutes of spotlighting. Species targeted were the Koala, Powerful Owl, Masked Owl, Barking Owl and Sooty Owl. Any fauna were identified either by characteristic call or direct observation using spotlights.

2.9 Opportunistic records

All fauna species observed or heard during site activities were recorded.

Table 1. Survey Effort

Survey Session	Reserve Name	Survey Technique	Survey Effort
October 2006	Angophora Reserve	Harp Trap	1 night
		Spotlighting	1 night
		Ground Elliot and cage traps*	2 nights
		Tree Elliot traps*	2 nights
		Call playback	1 survey
		Hair tubes	2 nights
December 2006	Irrawong Reserve	Hair tubes	10 nights
March 2009	<ul style="list-style-type: none"> • McKay Reserve • Ingleside escarpment (access Laurel Rd) site centre 56 340580 6271676 (GDA 94) • Ingleside escarpment (access Mona Vale Rd) site centre 56 340394 6271903 (GDA 94) • Bungan Beach Reserve 	Ground Elliot traps*	4 nights
		Diurnal reptile search	60 min
		Spotlighting [#]	1 survey
		Ultrasonic bat recording	During evening activities
	Hair tubes	4 nights	
	<ul style="list-style-type: none"> • Stapleton Reserve • Bangalley Reserve 	Ground Elliot traps*	4 nights
		Diurnal reptile search	60 min
		Spotlighting [#]	1 survey
		Hair tubes	4 nights

* number of Elliot traps and hair tubes used varied depending on size of reserve and suitability of access.

[#] The length of time spent spotlighting also varied, depending on the size of the reserve.

3.0 Results

Fifty-two fauna species were recorded during the surveys. These included sixteen mammals (ten terrestrial and six flying species), nine reptiles, two frogs and twenty-five bird species. Four threatened species were recorded including the eastern bent-wing bat, little bent-wing bat, grey-headed flying-fox and powerful owl. Three introduced species were recorded, the black rat, rabbit and fox. All species recorded are indicated with an # in **Appendix 1**. The surveys were minimal and only recorded a sample of the species that would actually occur at each of these reserves.

4.0 Discussion

These supplementary surveys have contributed to the overall species inventories of Pittwater reserves. The surveys demonstrate suitable methods that may be used to conduct further community surveys throughout Pittwater.

APPENDIX 9 DEFINITIONS

The following definitions are given in the Threatened Species Conservation (TSC) Act 1995.

- **Endangered Species:** A species that is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction; or it might already be extinct, but is not presumed extinct. A species is defined in the Act as the entire species, or a defined subspecies or other taxon below a subspecies, or any recognisable variant of the species.
- **Endangered Populations:** A population whose numbers have been reduced to such a critical level, or whose habitat has been so drastically reduced, that it is in immediate danger of extinction; and it is not a population of a species already listed as an endangered species; and it is disjunct and at or near the limit of its geographic range, or it is or is likely to be genetically distinct, or it is otherwise of significant conservation value. A population is defined in the Act as a group of organisms, all of the same species, occupying a particular area.
- **Endangered Ecological Communities:** An ecological community that is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate; or it might already be extinct. An ecological community is defined in the Act as an assemblage of species occupying a particular area.
- **Species Presumed Extinct:** A species that has not been definitely located in nature during the preceding 50 years despite searching of known and likely habitats during that period.
- **Vulnerable Species:** A species that is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate.
- **Key Threatening Processes:** A threatening process that adversely affects two or more threatened species, populations or ecological communities, or could cause species, populations or ecological communities that are not threatened to become threatened.

APPENDIX 10. PROJECT PERSONNEL

PROJECT COMPONENTS	STUDY TEAM MEMBERS	QUALIFICATIONS
Project Management, Fauna Field Surveys, Report writing	Mr. Ray Williams	Biotechnician Cert. MECA
Fauna Field Surveys, Literature Review, Report Writing.	Ms. Amy Rowles	B.Sc (Hons.)
Fauna Field Surveys	Ms Jenny Lewis	B. Sc (Res. & Env. Mgt.), TAFE Cert II (Conserv. & Land Mgt. Nat. Area Rest.). MECA
Fauna Field Surveys	Mr. Narawan Williams	Certificate II Conservation and Land Mgt (Nat. Area Restoration). MECA