

MANAGEMENT PLAN
FOR
THREATENED FAUNA AND FLORA
IN
PITTWATER

Prepared for
Pittwater Council
by
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Adopted from: 14.8.00

SUMMARY OF MANAGEMENT ISSUES AND ACTIONS

Management issue	Management actions	Responsibility	Priority
Recovery plans (3.2)	Co-operate with the National Parks and Wildlife Service in the preparation of recovery plans for threatened fauna and flora.	National Parks and Wildlife Service, Pittwater Council	High
	Implement measures for the recovery of threatened fauna and flora as identified in recovery plans, and for which Pittwater Council is responsible.		High
Conservation of remnant bushland (3.3)	Prepare and implement plans of management for Council bushland reserves to conserve endangered ecological communities and other native bushland that provides habitat for threatened fauna and flora.	Pittwater Council	High
	Prepare and implement a Development Control Plan for the Conservation of Biodiversity in Pittwater to ensure that future development is compatible with conservation of threatened fauna and flora.		High
	Develop and implement programs to rehabilitate and restore native bushland in degraded areas on Council lands as habitat for threatened fauna and flora, and encourage other landowners and managers to undertake similar programs.		High
Habitat degradation in remnant bushland (3.4)	Prepare and implement plans of management for Council bushland reserves that address habitat degradation issues such as weed invasion, eucalypt dieback and long-term vegetation change.	Pittwater Council	High
	Review the operation and effectiveness of the bushland plans of management over time. Develop and implement additional control measures where necessary.		High
	Encourage other landowners and managers to adopt similar measures to control and reverse habitat degradation in remnant bushland on their lands.		High
	Continue and expand the existing volunteer bushcare program, by which the community can become involved in managing and maintaining remnant urban bushland in Pittwater.		High

Management issue	Management actions	Responsibility	Priority
Fire management (3.5)	Prepare and implement plans of management for Council bushland reserves that address fire management issues in relation to threatened fauna and flora, including the desirability of ecological burns for habitat restoration purposes, as well as the impacts and preferred techniques of hazard reduction.	Pittwater Council, Warringah-Pittwater Bushfire Management Committee, National Parks and Wildlife Service	High
	Liaise with the Warringah-Pittwater Bush Fire Management Committee to integrate conservation of threatened fauna and flora with bushfire risk management in Pittwater.		High
	Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for high frequency fire in New South Wales.		High
Bushrock removal (3.6)	Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for bushrock removal in New South Wales.	National Parks and Wildlife Service, Pittwater Council	Medium
	Enforce restrictions on bushrock removal from public lands.		Medium
Tree preservation in urban areas (3.7)	Implement the Pittwater Tree Preservation and Management Order. Review its operation and effectiveness to ensure that losses of native trees and shrubs in urban areas are fully compensated by new plantings.	Pittwater Council	High
	Amend the Order to apply to all specimens of the threatened tree and shrub species, <i>Eucalyptus camfieldii</i> , <i>Grevillea caleyi</i> , <i>Persoonia hirsuta</i> and <i>Syzygium paniculatum</i> , irrespective of their dimensions.		High
	Amend the Order to apply to all specimens of <i>Eucalyptus punctata</i> and <i>E. robusta</i> , irrespective of their dimensions.		Medium
	Extend the list of desirable trees in the Order to include additional food plants for threatened fauna.		Low

Management issue	Management actions	Responsibility	Priority
Habitat enhancement by food tree plantings (3.8)	Identify priority areas for planting additional food plants in Pittwater. Plant these on Council lands, especially in high priority areas, with particular emphasis on <i>Eucalyptus punctata</i> and <i>E. robusta</i> , but also other species used by threatened fauna.	Pittwater Council	High
	Encourage other landowners and managers to plant additional food plants on their lands, especially in high priority areas.		High
Wildlife corridors (3.9)	Implement the Pittwater Habitat and Wildlife Corridors Conservation Strategy. Review its operation and effectiveness. Develop and implement additional measures for protection and enhancement of corridors where necessary.	Pittwater Council	High
	Plant additional native trees and shrubs on Council lands in high priority wildlife corridors identified in the Habitat and Wildlife Corridors Conservation Strategy.		High
	Encourage similar plantings by other land owners and managers in high priority wildlife corridors.		High
	Prepare and implement a Development Control Plan for the Conservation of Biodiversity in Pittwater to ensure that future development is compatible with retention of wildlife corridors and, where possible, incorporates measures to enhance and restore corridors.		High
Protection of waterways (3.10)	Prepare and implement plans of management for Council bushland reserves with wetland and waterways habitats used by threatened fauna.	Pittwater Council, Pittwater Estuary Management Committee, Sydney Harbour Catchment Management Board	High
	Liaise with the Pittwater Estuary Management Committee and Sydney Harbour Catchment Management Board to integrate management of threatened fauna and flora with catchment and estuary management in Pittwater.		Medium

Management issue	Management actions	Responsibility	Priority
Control of dog and cat predation (3.11)	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.	Pittwater Council, National Parks and Wildlife Service	High
	Implement Council's statutory obligations and responsibilities for control of dogs and cats under the Companion Animals Act.		High
	Continue and expand existing community education programs aimed at reducing the impact of cats and dogs on native fauna. Encourage the community to report feral cats, dogs and foxes to Council.		High
	Impose conditions prohibiting the keeping of cats and dogs on new residential developments in sites where they are a particular threat to threatened fauna species.		High
	Co-operate with the National Parks and Wildlife Service and other authorities in the development and implementation of a threat abatement plan for feral cat predation in New South Wales.		High
Control of fox predation (3.12)	Develop and implement effective and humane control programs for foxes in the Pittwater area. Eradication of foxes from the Careel Bay area is the first priority.	Pittwater Council, National Parks and Wildlife Service	High
	Co-operate with the National Parks and Wildlife Service and other authorities in the development and implementation of a threat abatement plan for fox predation in New South Wales.		High
Control of Plague Minnow predation (3.13)	Identify locations in Pittwater where Plague Minnows pose a threat to Giant Burrowing Frog and Red-crowned Toadlet populations. Develop and implement control programs to eradicate the species at these locations.	Pittwater Council, National Parks and Wildlife Service	Medium
	Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for Plague Minnow predation in New South Wales.		Medium

Management issue	Management actions	Responsibility	Priority
Fauna road casualties (3.14)	Identify sites where road casualties pose a particular threat to threatened fauna species in Pittwater. Implement traffic control and/or fauna control measures at these sites.	Pittwater Council	Medium
	Ensure through the development assessment process that new developments include appropriate measures to prevent increased road casualties of threatened fauna.		Medium
Rehabilitation of sick, injured or orphaned animals (3.15)	Encourage, support and publicise organisations which rescue and rehabilitate sick, injured or orphaned animals in Pittwater.	Wildlife rescue organisations, Pittwater Council	Medium
	Implement community education programs publicising wildlife rescue organisations in Pittwater, and describing appropriate handling and first aid protocols for sick, injured or orphaned animals		Medium
	Maintain records of rescues and releases of threatened fauna.		Medium
Disturbance at nesting, roosting and feeding sites (3.16)	Identify nesting, roosting and feeding sites where excessive human disturbance, deliberate or accidental, poses a threat to threatened fauna species in Pittwater. Implement measures to reduce the impact.	Pittwater Council	Medium
Depletion of intertidal invertebrate populations (3.17)	Liaise with NSW Fisheries in management and monitoring of Intertidal Protection Areas and other rock platforms in the Pittwater area. Enforce the restrictions on collection of intertidal invertebrates.	Pittwater Council, NSW Fisheries	Medium
	Continue with community awareness and education initiatives through Project Aware - On the Rocks and the Coastal Environment Centre.		Medium
Translocation (3.18)	Adopt a policy in development assessment and natural resource management of advocating and implementing conservation of threatened plant species and communities <i>in situ</i> wherever possible, recognising the low probability of success of translocation programs as an alternative.	Pittwater Council	Medium

Management issue	Management actions	Responsibility	Priority
Beach dune management (3.19)	Identify sites where the endangered plant species, <i>Chamaesyce psammogeton</i> , occurs on Pittwater beaches. Incorporate measures to conserve the species as part of the beach dune management programs at these sites.	Pittwater Council	High
	Train employees, contractors and volunteers involved in dune restoration works in Pittwater to recognise <i>Chamaesyce psammogeton</i> and to be aware of its conservation significance.		High
Control of Bitou Bush (3.20)	Implement weed control programs targeting Bitou Bush infestations on Pittwater beaches, especially in sites where there are populations of <i>Chamaesyce psammogeton</i> .	Pittwater Council, National Parks and Wildlife Service	High
	Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for bushrock removal in New South Wales.		High
Loss of genetic integrity (3.21)	Identify sites where interbreeding with introduced plants poses a threat to <i>Grevillea caleyi</i> and <i>Syzygium paniculatum</i> in Pittwater. Implement measures to eliminate or reduce the threat.	Pittwater Council	Low
Unauthorised collection of plant material (3.22)	Identify sites where unauthorised collection of plant material poses a significant threat to populations of threatened plants in Pittwater. Implement measures to reduce the impact at these sites.	Pittwater Council	Low
	Avoid making information on the precise locations of threatened plant species in Pittwater widely available.		Low
Community education (3.23)	Develop and implement community education programs on threatened fauna and flora. Co-operate with other organisations in their community education programs.	Pittwater Council	Medium
	Encourage active community participation in threatened fauna and flora management.		Medium

Management issue	Management actions	Responsibility	Priority
Lack of knowledge of threatened fauna and flora (3.24)	Maintain and expand Council's register of threatened fauna and flora records.	Pittwater Council	Medium
	Undertake specific studies and long-term monitoring to improve management of threatened fauna and flora in Pittwater. The first priority are studies of the three listings that are restricted to Pittwater (Pittwater Squirrel Glider population, Pittwater Koala population, Pittwater Spotted Gum Forest).		Medium
	Liaise with the National Parks and Wildlife Service, university researchers and other relevant organisations to encourage and support management-oriented studies of threatened fauna and flora in Pittwater.		Medium

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1.0 INTRODUCTION

1.1 Management Objectives

The natural environments of Australia have been modified dramatically since European settlement, and there has been a great loss of biodiversity. Since 1788, some 125 species and subspecies of plants and animals are known to have become extinct. Among mammals, Australia has had the worst extinction rate of any continent, with the loss of Australian species representing about half of all mammal extinctions world-wide over the last two hundred years.

In New South Wales, about 61% of the original native woody vegetation has been cleared or severely degraded. Clearing of native vegetation still continues at a rate that has been conservatively estimated at about 150 000 hectares per year (Environment Protection Authority 1997). At least 40 species of fauna and 40 species of flora have become extinct in New South Wales. Further extinctions are likely in the future, with some 200 fauna species and 400 flora species considered threatened.

The Threatened Species Conservation Act was introduced by the State Government in 1995 in response to community concern over loss of native fauna and flora and degradation of natural environments. The Act seeks to identify the species, populations and ecological communities threatened with extinction in New South Wales, to halt their decline and to bring about their recovery. To achieve these objectives will require co-operation between government agencies, local government, non-government organisations, community groups and individuals.

Pittwater Council is committed to the conservation of the native biological diversity of the lands and waters under its control. This management plan has been prepared to summarise information on threatened fauna and flora in Pittwater, and to identify the management issues and actions that need to be addressed to fulfil Council's obligations under the Threatened Species Conservation Act.

Council's management objectives for threatened fauna and flora in Pittwater are to:

- **ensure the survival and recovery of threatened fauna and flora species, populations and communities in the Pittwater Local Government Area,**
- **identify and mitigate threats to the survival and recovery of threatened fauna and flora in Pittwater,**
- **integrate the conservation of threatened fauna and flora with natural resource management in Pittwater,**
- **integrate the conservation of threatened fauna and flora with land-use planning and development assessment in Pittwater,**
- **co-operate with other organisations in the development of co-ordinated programs for threatened fauna and flora conservation through the recovery planning process and other initiatives,**

- **inform, motivate and achieve the support of the community in conservation of threatened fauna and flora, and**
- **encourage and facilitate increased understanding of the ecology and conservation requirements of threatened fauna and flora in Pittwater through scientific research, survey and monitoring.**

1.2 Area to which the Management Plan Applies

The Pittwater Local Government Area covers a total area of 125 square kilometres including the Pittwater inlet. Some 43% of the Local Government Area lies within Ku-ring-gai Chase National Park (Pittwater Council 1997a). This plan of management applies to the whole of the Pittwater Local Government Area, both public lands and private lands, except for Ku-ring-gai Chase National Park, where the management authority is the NSW National Parks and Wildlife Service.

Excluding Ku-ring-gai Chase National Park and the waterways, approximately 350 ha of natural areas remain in the Pittwater Local Government Area (Map 1), of which 267 ha are contained in various bushland reserves (Pittwater Council 1997a). These reserves vary greatly in size, shape and vegetation. Outside of reserves, many parts of Pittwater have retained a significant indigenous tree canopy and there are important areas of remnant bushland. Large parcels of privately owned bushland occur in Ingleside and Warriewood.

1.3 The Pittwater Environment

The Pittwater Local Government Area is renowned for the great beauty and diversity of its natural environment. It supports a rich array of fauna and flora. For example, it has been estimated that around 220 native vertebrate species could inhabit Pittwater Council's bushland reserves (Pittwater Council 1997b).

The diversity of fauna and flora in Pittwater is attributable in part to the proximity of large areas of relatively undisturbed bushland in the adjacent Ku-ring-gai Chase and Garigal National Parks. It is also a reflection of the diversity of geology, landforms, soils and vegetation communities in the area. Such diversity combines to provide a multitude of habitats and opportunities for different fauna and flora species. Habitats ranging from estuarine and freshwater bays, lagoons, wetlands and creeks, to a variety of eucalypt forests and woodlands, to heath and scrub vegetation, to cliffs and rock outcrops, and to rocky coasts, headlands and beaches, occur in close proximity. The natural features of Pittwater are summarised briefly below. Sources that can be consulted for more detailed and comprehensive information are indicated.

Geology and Landforms

The deeply dissected western plateaus and ridges of the Pittwater area, including most of the area of Ku-ring-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 sandspit, 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

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.

Vegetation

Benson and Howell (1994) have mapped the vegetation of the Sydney region at a scale of 1:100 000. Eleven of the vegetation map units that they describe occur within the Pittwater Council area, although only seven of these units were actually mapped (local occurrences of the other units were too restricted for mapping at this scale). Vegetation units associated with Hawkesbury Sandstone are Sydney Sandstone Gully Forest, Sydney Sandstone Ridgetop Woodland, Coastal Sandstone Heath and Duffys Forest. Units associated with the Newport Formation are Spotted Gum-Blackbutt Forest, Narrabeen Slopes Forest and Coastal Clay Heath. Units associated with Quaternary alluvium are the Estuarine Complex, Coastal Dune Heath, Coastal Swamp Forest Complex and Coastal Freshwater Swamp.

Descriptions and maps of plant communities occurring in bushland in Council reserves were prepared by Roger Lembit for Council's Urban Bushland Inventory and Action Plan (Pittwater Council 1997b) and for Council's Coastal Zone Flora and Fauna Study (Lembit and Burcher 1997). Fifteen plant communities were distinguished. Vegetation patterns in the area have also been examined in other studies, including those of Shortland Wetlands Centre (1989), Smith and Smith (1990b, 1997) and Cunningham (1994a, 1994b). Combining the information from the various studies, the 11 vegetation map units of Benson and Howell (1994) have been subdivided into 26 vegetation communities in a preliminary analysis of vegetation patterns in the Pittwater area as a whole (Pittwater Council 1998).

The variety of vegetation communities in Pittwater provides a variety of fauna habitats. The communities associated with Newport Formation and Quaternary alluvium are generally poorly represented in the nearby national parks. For example, Swamp Mahogany Forest, which is an important habitat for threatened fauna species, is not represented at all in Ku-ring-gai Chase, Garigal, Brisbane Water or Bouddi National Parks.

1.4 Listing of Threatened Fauna and Flora

The schedules of the Threatened Species Conservation Act include lists of the following:

- **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.

Additions, deletions and other amendments to the schedules are the responsibility of an independent Scientific Committee established under the Act. Any person may make nominations to the Committee regarding changes to the schedules. The Committee is then required to prepare a preliminary determination outlining their intentions with regard to the proposed listing, delisting or amendment. The preliminary determination is published and submissions are sought. After the exhibition period the Committee considers all submissions received and makes a final determination.

The Act also makes provision for the declaration of critical habitat, that is, the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species, population or ecological community that is critical to its survival. The process of identification and declaration of critical habitat involves extensive consultation with public authorities, landholders and the wider community. The Director-General of National Parks and Wildlife is responsible for maintaining a register of critical habitat.

1.5 Threatened Fauna and Flora in Pittwater

Thirty-one fauna species, eight flora species and two vegetation communities recorded in the Pittwater Council area or just outside (within 1 km) are listed in the current (June 2000) schedules of the Threatened Species Conservation Act (Table 1). Seven fauna species and four flora species are listed as endangered species. Seven fauna species and four plant species are listed as vulnerable species. The Pittwater populations of two of the vulnerable fauna species are listed as endangered populations. Two vegetation communities are listed as endangered ecological communities, including one, Pittwater Spotted Gum Forest, that is restricted to the Pittwater Local Government Area.

One other vulnerable fauna species, the Grass Owl (*Tyto capensis*), has been mistakenly listed as occurring in the Pittwater Council area in some reports. References to a breeding attempt by Grass Owls at Warriewood Wetlands in 1974 (ICF and Australian Museum 1994, Pittwater Council 1997b), actually refer to a Masked Owl record. There was also a 1990's record of the Grass Owl at Warriewood in the Australian Bird Count database of Birds Australia. However, this has proved to be an incorrect entry of what should have been a Rainbow Lorikeet record. Debus *et al.* (1998), in their comprehensive review of Grass Owl records in New South Wales, list no records for the Pittwater area.

Table 1. Threatened fauna and flora recorded in the Pittwater Council area or nearby (within 1 km).

Schedule 1: Endangered species, populations and ecological communities

Part 1: Endangered species

Animals

Birds

- Burhinus grallarius* (Bush Stone-curlew)
- Diomedea exulans* (Wandering Albatross)
- Lathamus discolor* (Swift Parrot)
- Pterodroma leucoptera* subspecies *leucoptera* (Gould's Petrel)
- Xanthomyza phrygia* (Regent Honeyeater)

Mammals

- Isoodon obesulus* (Southern Brown Bandicoot)

Invertebrates

- Petalura gigantea* (Giant Dragonfly)

Plants

- Chamaesyce psammogeton*
- Grevillea caleyi*
- Microtis angusii*
- Persoonia hirsuta* (Hairy Geebung)

Part 2: Endangered populations

Animals

Mammals

- Petaurus norfolcensis* (Squirrel Glider) on Barrenjoey Peninsula, north of Bushrangers Hill

Part 3: Endangered ecological communities

Duffys Forest Vegetation Community (as described in the final determination of the Scientific Committee)
Pittwater Spotted Gum Forest (as described in the final determination of the Scientific Committee)

Schedule 2: Vulnerable species

Animals

Amphibians

Heleioporus australiacus (Giant Burrowing Frog)

Pseudophryne australis (Red-crowned Toadlet)

Reptiles

Chelonia mydas (Green Turtle)

Varanus rosenbergi (Rosenberg's Goanna)

Birds

Botaurus poiciloptilus (Australasian Bittern)

Calyptorhynchus lathami (Glossy Black-Cockatoo)

Haematopus fuliginosus (Sooty Oystercatcher)

Haematopus longirostris (Pied Oystercatcher)

Ixobrychus flavicollis (Black Bittern)

Ninox connivens (Barking Owl)

Ninox strenua (Powerful Owl)

Pandion haliaetus (Osprey)

Ptilinopus superbus (Superb Fruit-dove)

Puffinus assimilis (Little Shearwater)

Sterna fuscata (Sooty Tern)

Tyto novaehollandiae (Masked Owl)

Mammals

Chalinolobus dwyeri (Large-eared Pied Bat)

Dasyurus maculatus (Spotted-tailed Quoll)

Miniopterus schreibersii (Common Bentwing-bat)

Petaurus norfolcensis (Squirrel Glider)

Phascolarctos cinereus (Koala)

Scoteanax rueppellii (Greater Broad-nosed Bat)

Marine Mammals

Eubalaena australis (Southern Right Whale)

Megaptera novaeangliae (Humpback Whale)

Plants

Eucalyptus camfieldii (Heart-leaved Stringybark)

Pimelea curviflora variety *curviflora* (Curved Rice-flower)

Syzygium paniculatum (Magenta Lillypilly)

Tetratheca glandulosa

1.6 Preparation of Management Plan

Profiles were compiled for the threatened fauna species of Pittwater in February-October 1998, excluding marine species that do not normally come ashore in Pittwater (Southern Right Whale, Humpback Whale, Gould's Petrel, Little Shearwater, Wandering Albatross,

Sooty Tern and Green Turtle) and the Superb Fruit-Dove, whose occurrence in Pittwater is as a rare vagrant outside its normal range. The Southern Brown Bandicoot was included in the study, even though it has not yet been recorded within the Pittwater Council area, because it occurs just outside the boundaries of the area. Thus profiles were compiled for a total of 23 fauna species.

A variety of sources were consulted for general ecological information on the threatened fauna species. References have been included in each account to indicate the sources. Specific information in relation to Pittwater was obtained from previous local studies (Pittwater Council 1995a, 1995b, 1996, 1997a, 1997b, Smith and Smith 1990b, 1992a, 1992b, 1997a, Shortland Wetlands Centre 1989, Adams 1990, Higgs and Campbell 1993, Ecotone Ecological Consultants 1993, 1996, 1997, ICF and Australian Museum 1994, Antcliff 1996, Smith 1996, Recsei 1997, Lembit and Burcher 1997, Skelton and Williams 1998), Pittwater Council files, the National Parks and Wildlife Service's Atlas of NSW Wildlife database and annual NSW bird reports published in *Australian Birds*. Information was also sought from local naturalists (listed in Acknowledgements). Fieldwork undertaken during the project provided additional records and information on several species (Large-eared Pied Bat, Common Bentwing Bat, Osprey, Sooty Oystercatcher, Powerful Owl and Regent Honeyeater).

The species profiles were updated in June 2000, including additional records obtained from recent Pittwater Council files, the Atlas of NSW Wildlife database (records to 2.6.00), and recent NSW bird reports (up to the 1997 report, published April 2000). Information from profiles compiled by the National Parks and Wildlife Service (1999a) was also incorporated.

Profiles for the eight threatened flora species and two ecological communities were compiled in May-June 2000. Two of these species (*Eucalyptus camfieldii* and *Pimelea curviflora*) have not yet been recorded within the Pittwater Council area, but occur just outside the boundaries. Specific information on occurrences of threatened flora species and communities in Pittwater was obtained from previous local studies (including, in addition to the ones listed above, Cunningham 1994a, 1994b, Benson and Howell 1994, Scott *et al.* 1995, Skelton and Dalby-Ball 1998, 1999, Skelton 1999, National Parks and Wildlife Service 1999b, Burcher 1999), Pittwater Council files, and the Atlas of NSW Wildlife database (records to 2.6.00). Particular sources of information on the communities were Holden's (1999) study of Pittwater Spotted Gum Forest, and Smith and Smith's (2000) study of the Duffys Forest Vegetation Community.

Records of threatened fauna and flora species in the Pittwater Council area were collated and entered into a database. A printout of the database is provided below as an appendix. Some records that we considered doubtful have not been included in the database.

Management issues were identified for each species and community and are listed in the profiles. The issues are discussed individually in the management section of the report and management actions outlined to address these issues.

2.0 THREATENED FAUNA AND FLORA PROFILES

2.1 Endangered Populations

2.1.1 Squirrel Glider (*Petaurus norfolcensis*)

Family: Petauridae

Conservation Status: Vulnerable species in NSW (TSC Act). The Squirrel Glider population on Barrenjoey Peninsula, north of Bushrangers Hill, has been listed separately as an endangered population (NSW Scientific Committee 1996). At national level the Squirrel Glider is regarded as a 'near threatened' species (Maxwell *et al.* 1996).

Distribution: The Squirrel Glider is found from the base of Cape York in northern Queensland through the eastern half of Queensland and New South Wales to western Victoria. In New South Wales it occurs inland to the Pilliga and Coonabarabran areas, but has been most frequently reported in coastal districts between the Hawkesbury River and Port Stephens, and between Grafton and Lismore (National Parks and Wildlife Service 1999a). Barrenjoey Peninsula is the only known location for the species in the Sydney suburbs.

Pittwater Population: Elucidation of the distribution and abundance of the Squirrel Glider in Pittwater is complicated by the presence in the area of another very similar species, the Sugar Glider *Petaurus breviceps*. The Sugar Glider is much more common around Sydney than the Squirrel Glider. The existence of the Squirrel Glider in Pittwater is confirmed by several specimens lodged at the Australian Museum and two sightings. All records to date have been from the Careel Bay/Avalon/Newport area of Barrenjoey Peninsula. The Squirrel Glider has not been recorded from Ku-ring-gai Chase or Garigal National Parks. Details of the records are:

- Late summer 1999 - Barrenjoey Road, Bilgola Bends, near Attunga Reserve, one seen running across road by L. Van Der Wallen (NPWS).
- March 1994 - Palmgrove Road, Avalon, opposite Palmgrove Reserve, cat kill specimen lodged at Australian Museum.
- March 1994 - northern end of Prince Alfred Parade, Newport, one observed at night by P. and J. Smith.
- October 1989 - Careel Bay, adult female and two pouch young, cat kill specimens lodged at Australian Museum.
- December 1988 - Palmgrove Road, Avalon, cat kill specimen lodged at Australian Museum.
- 1949 - Avalon, specimen lodged at Australian Museum.
- 1948 - Avalon Beach, specimen lodged at Australian Museum.

Habitat: Squirrel Gliders are generally found in dry eucalypt forests and woodlands. They are absent from coastal forests in Victoria, but occur along the coasts of both New South Wales and Queensland (Suckling 1995). Their coastal habitats range from low, scrubby eucalypt woodlands and banksia thickets (Quin 1995, Sharpe and Goldingay 1998) to tall, wet eucalypt forests bordering on rainforest (Suckling 1995). The availability of a year-round supply of carbohydrates (nectar, sap, gum and honeydew) appears to be a critical habitat requirement. In coastal New South Wales they typically inhabit areas with a diversity of tree and shrub species, including high nectar-producing species and one or more winter-flowering species (Quin 1995, Smith 1996, Sharpe and Goldingay 1998). In some habitats in inland Victoria, however, their main winter carbohydrate sources appear to be *Acacia* gum and *Eucalyptus* sap rather than nectar (Menkhorst and Collier 1988, Menkhorst *et al.* 1988).

Smith (1996) has suggested that important food sources for Squirrel Gliders on Barrenjoey Peninsula are likely to be the winter-flowering Coast Banksia *Banksia integrifolia* and Spotted Gum *Corymbia maculata*, and the summer-flowering Old Man Banksia *Banksia serrata* and Grey Ironbark *Eucalyptus paniculata*. Other species that are likely to be important, being known Squirrel Glider food trees and a major food source for other fauna in the Sydney area, are the winter-flowering Swamp Mahogany *Eucalyptus robusta* (Ecotone Ecological Consultants 1996) and the autumn-flowering Red Bloodwood *Corymbia gummifera* (Quin 1995). Additional Squirrel Glider food plants are listed below.

Apart from food sources, Squirrel Gliders also require an abundance of tree hollows for use as den sites and for raising young. Their usual source of hollows are trees of the genera *Eucalyptus*, *Corymbia* and *Angophora*, although occasionally trees of other genera can provide suitable hollows, such as *Melaleuca quinquenervia* (Quin 1995, Traill and Lill 1997, Rowston 1998). Hollows in dead trees are used extensively, as well as those in live trees (Rowston 1998). Favoured hollows typically have a tight-fitting entrance hole, which may help to exclude larger hollow-using species (Traill and Lill 1997). Squirrel Gliders are known to travel up to 1 km from their foraging area to a preferred hollow (Menkhorst 1995). Quin (1995) has estimated that individual gliders on the north coast of New South Wales range over an average area of about 3 ha.

Smith (1996) has analysed the data of Higgs and Campbell (1993) on glider sightings by local residents on Barrenjoey Peninsula (Squirrel and Sugar Gliders not distinguished) and found a steep decline in the frequency of reported sightings with increasing distance from remnant bushland. This suggests that although urban areas with food plants are important for movements and as a feeding resource for Squirrel Gliders on Barrenjoey Peninsula, it is the large bushland reserves, such as Stapleton Park, Angophora Reserve and Attunga Reserve, and linking smaller reserves, such as Palmgrove and Toongari Reserves, that seem to provide the core refuge and breeding habitat.

Feeding: Squirrel Gliders have a varied diet. They feed on nectar, sap, gum and honeydew for their energy needs, and take arthropods and pollen to satisfy their protein requirements (Menkhorst and Collier 1988, Quin 1995, Sharpe and Goldingay 1998). They have also been recorded feeding at times on *Trochocarpa* and mistletoe fruits, *Acacia* seeds and arils, and lichens (Sharpe and Goldingay 1998), and even on birds and their eggs (Winter 1966).

Plants that occur on Barrenjoey Peninsula and whose flowers are known to be a source of nectar and pollen for Squirrel Gliders are *Banksia integrifolia*, *B. serrata*, *B. spinulosa*, *Corymbia gummifera*, *Eucalyptus robusta*, *Melaleuca quinquenervia*, mistletoes and *Xanthorrhoea* species (Quin 1995, Ecotone Ecological Consultants 1996, Sharpe and Goldingay 1998). *Banksia integrifolia* has been identified by Sharpe and Goldingay (1998) as particularly important. Other local species that are likely to be used include *Angophora costata*, *Banksia ericifolia*, *Corymbia maculata*, *Eucalyptus botryoides*, *E. paniculata* and *E. punctata* (Smith 1996, P. and J. Smith).

Squirrel Gliders will gouge and lick incisions on the trunks and main branches of *Eucalyptus*, *Corymbia* and *Angophora* trees to feed on sap, and *Acacia* trees and shrubs to feed on gum, especially when nectar is in short supply (Menkhorst and Collier 1988, Sharpe and Goldingay 1998). Locally occurring *Acacia* species that are known to be used are *A. irrorata* and *A. longifolia* (Sharpe and Goldingay 1998). The gliders have also been observed feeding on honeydew (sugary secretions of sap-sucking insects) from the foliage and small branches of

Eucalyptus and *Angophora* trees (Quin 1995, Sharpe and Goldingay 1998). Insects and other arthropods are an important component of the diet and are taken throughout the year, including a variety of species from a variety of substrates, but most often beetles and caterpillars (Menkhorst and Collier 1988) and most often from bark (Sharpe and Goldingay 1998).

Breeding: The typical social unit in coastal New South Wales is a family group of 2-9 individuals, consisting of one male and usually at least two adult females and their dependent offspring, which shelter by day and breed in leaf-lined nests in tree hollows (Quin 1995). The litter size is one or two and the young remain in the pouch for about 70 days, after which they stay in the nest for another 30 days or so, and are weaned at about four months (Williams 1990). Births may occur throughout the year in coastal New South Wales, usually with a peak in winter, and most females exhibit a capacity to raise two litters in a year, the young gliders dispersing at a mean age of 12.5 months (Quin 1995).

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas (hollows for nesting and denning; food resources; allow the gliders to move through urban areas, gliding from tree to tree).
- Habitat enhancement by food tree plantings.
- Wildlife corridors (the gliders may undertake local movements as different food plants flower during the year, and thus they may be particularly vulnerable to clearing of movement corridors and loss of seasonally important habitats).
- Habitat degradation in remnant bushland.
- Fire management (fires are a potential cause of mortalities and may also affect food resources).
- Control of dog and cat predation (recent Australian Museum specimens from the area have all been cat kills).
- Control of fox predation.
- Road casualties.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (one is currently being prepared for the species).

2.1.2 Koala (*Phascolarctos cinereus*)

Family: Phascolarctidae

Conservation Status: Vulnerable species in NSW (TSC Act). The Koala population in the Pittwater Local Government Area has been listed separately as an endangered population (NSW Scientific Committee 1998a). At national level the Koala is regarded as a 'near threatened' species (Maxwell *et al.* 1996).

Distribution: Koalas have a fragmented distribution in eastern Australia, from northern Queensland through New South Wales, Victoria, and South Australia (Phillips 1990). The present populations in South Australia and in many parts of Victoria are the result of reintroductions of the species after it had become locally extinct. There is also a small introduced population in Western Australia. Koalas occur widely in New South Wales, but

most commonly on the central and north coasts (National Parks and Wildlife Service 1999a). Around Sydney, Koalas are sparsely distributed over the Hornsby Plateau (Curtin and Lunney 1995, O'Brien 1995), including Ku-ring-gai Chase National Park (Smith and Smith 1990b). They are also sparsely distributed over the Woronora Plateau (Robinson 1985), including the well-known population near Campbelltown (Close 1993). Koalas are rare west of Sydney, in the Blue Mountains (Smith and Smith 1990a).

Pittwater Population: Koalas were once common and widespread in Pittwater and Warringah and were particularly numerous on Barrenjoey Peninsula (Smith and Smith 1990b). They are now rarely encountered. Small populations are still present on Barrenjoey Peninsula and in Ku-ring-gai Chase National Park, and possibly also in Garigal National Park. Occasional records of Koalas elsewhere in Pittwater and Warringah appear to be wandering individuals from these populations. Most Koala records over the last 12 years have come from around Avalon (Map 2). This population is isolated from Ku-ring-gai Chase National Park by the density of urban development in Mona Vale and Newport and the lack of bushland corridors in this part of Pittwater (Map 1).

History of Koalas in Pittwater: The history of Koalas in the Pittwater Local Government Area has been one of dramatic decline. From the 1940's to the 1970's, the Koala colony on Barrenjoey Peninsula was the largest and best known colony in the Sydney region, estimated in 1970 at over 123 Koalas. By 1989, however, the population had been reduced to only about eight animals (Smith and Smith 1990b). A subsequent survey in 1993 estimated the population at only four to six animals (Higgs and Campbell 1993), and there may be even fewer animals now. The following account has been drawn mainly from Smith and Smith (1990b).

1788-1899

Koalas were scarce around Sydney at the time of European settlement. Their apparent scarcity at this time has generally been attributed to heavy hunting pressure from Aborigines. In subsequent decades, Koala numbers increased rapidly throughout eastern Australia, as their predators declined - dingoes and, especially, Aborigines. The Koala was so abundant by the late 1870's that it became one of the staples of a major fur industry. In keeping with this general pattern, Koalas had become abundant in the northern suburbs of Sydney by 1890 (reminiscences of David Stead in the Sydney Morning Herald, 25.iv.1929).

1900-1939

As spectacularly as they had increased, Koala populations collapsed in New South Wales around the turn of the century. They were undoubtedly heavily depleted by the fur trade, but other factors contributed to their demise. Disease epidemics, now believed to have been caused by the bacterium *Chlamydia psittaci*, decimated their populations. Other contributing factors were the severe droughts of the 1890's and early 1900's, and the extensive clearing of forests and woodlands on the more fertile soils, which supported the greatest numbers of Koalas. By the 1930's there were fears that the Koala was facing extinction in NSW.

Little information is available on the status of Koalas in Warringah and Pittwater between 1900 and 1939. Koalas were present and could be readily found behind Paradise Beach, Clareville, throughout this period (reminiscences of Barbara Powell, whose family owned the land and who remembered the period 1924-34 in particular). In the Sydney Morning Herald of 22.xii.1938 it was reported that five Koalas had been killed by cars on Barrenjoey

Peninsula over the previous 18 months, and that the secretary of the Koala Club of Australia estimated that fewer than 30 Koalas remained in the area. Fourteen Koala deaths were reported on the Peninsula in 1939 (Koala Club of Australia 1940). The causes weren't specified, but were possibly linked to a major bushfire in January of that year.

1940-1949

The Fauna Protection Panel of NSW conducted a state-wide questionnaire survey for Koala records in 1949. They reported that there appeared to be some thousands of Koalas in NSW and that there were a number of colonies around Sydney, with the most numerous being on Barrenjoey Peninsula, especially around Avalon. One respondent estimated that there were four or five families of Koalas living around Palm Grove, Avalon. Elsewhere in Pittwater in the 1940's, Koalas were reported at Scotland Island, Mona Vale, Warriewood and North Narrabeen. Koalas were also reported at Cottage Point in Ku-ring-gai Chase National Park.

1950-1959

Until the early 1950's the major threats to Koalas in Pittwater were generally reported as bushfires, motor vehicles and dogs. However, the next few years saw the emergence of concern about a new threat – the loss of trees associated with extensive housing development in the Newport-Avalon-Palm Beach area (Parliament of NSW 1953, 1954). This has remained the chief threat ever since. In response to public concern about the effects of clearing, the Fauna Protection Panel carried out a survey of Koalas on Barrenjoey Peninsula in 1955. The size of the population was estimated at about 120, with evidence of breeding and no signs of disease (Parliament of NSW 1955). Koalas were also reported during the 1950's at Mona Vale and Warriewood, and at Cottage Point in Ku-ring-gai Chase National Park.

1960-1969

Concern over clearing of trees on Barrenjoey Peninsula continued through the 1960's. One resident of Newport estimated at the time that the total Koala population on the Peninsula was down to 50-60 (Sydney Morning Herald, 20.ix.1962). Responses to a 1989 questionnaire survey indicated that Koalas were regularly seen throughout the Peninsula in the 1960's (Smith and Smith 1990b). Koalas were even reported on Barrenjoey Head in 1967. It would seem, in fact, that 50-60 was an underestimate of the number of Koalas on the Peninsula at this time. Elsewhere in Pittwater in the 1960's, Koalas were reported at Mona Vale, Bayview, Elanora Heights, Elvina Bay, Great Mackerel Beach and other localities in Ku-ring-gai Chase National Park (records of the National Parks and Wildlife Service and Taronga Zoo).

1970-1979

Koalas were common and widely distributed on Barrenjoey Peninsula in the early 1970's. A comprehensive survey was carried out by local residents in September 1970, from which it was estimated that there was a total population of over 123 Koalas on the Peninsula, distributed from Palm Beach to Mona Vale, with the greatest numbers in the Avalon-Clareville area. By February 1979, however, it was reported that counts by the Avalon Preservation Trust over the previous eight years had indicated a drop in Koala numbers on the Peninsula from over 100 to an estimated 26 (Sydney Morning Herald, 1.ii.1979). Koalas were widely reported from Ku-ring-gai Chase National Park during the 1970's, particularly in the vicinity of the major waterways. In 1973 a resident of Cottage Point reported to the National Parks and Wildlife Service that Koalas were always about his house and that he had seen up

to 12 around Cottage Point. Apart from Barrenjoey Peninsula and Mona Vale, Koalas were also reported during the 1970's in the Pittwater Council area at Browns Bay and Towlers Bay.

1980-1989

Clearing of remnant bushland on Barrenjoey Peninsula continued during the 1980's, although to a lesser extent than during the previous three decades. By 1986 the area of forested land on the Peninsula had been reduced to about 125 ha, or 8% of the Peninsula, compared with about 705 ha of forested land (47% of the Peninsula) in 1946 (Smith and Smith 1990b). The Koala population continued to decline during the 1980's and the results of a questionnaire survey in 1989 indicated that only about eight animals remained (Smith and Smith 1990b). Koalas were reported on Barrenjoey Peninsula during the 1980's from Bynya Road, Palm Beach, south to Bardo Street, Newport. There were no reports of Koalas anywhere else in the Pittwater Council area during the 1980's.

In Ku-ring-gai Chase National Park, Koalas were reported from several locations, with the nearest to Pittwater being in the McCarrs Creek area. The population appeared to be in decline, with only 10 records from Ku-ring-gai Chase National Park during the 1980's, compared with 32 records during the 1970's. Possible reasons for the decline are the extensive bushfires in the Park during the late 1970's and early 1980's, and chlamydial disease. The only report from Cottage Point during the 1980's was a male suffering from a chlamydial disease, which was taken to Waratah Park Wildlife Reserve for treatment, but subsequently died.

1990-2000

The Barrenjoey Peninsula Koala population appears to have declined further since 1989. There have been continual reports of Koalas on the Peninsula during the 1990's up to the latest in February 2000, but the number of reports has been noticeably fewer than in the 1980's. A household questionnaire survey targeting Koalas, bandicoots and gliders and covering the whole of the Pittwater Council area was undertaken in early 1993 by Higgs and Campbell (1993), who estimated that there were only four to six Koalas remaining on the Peninsula. Koalas have been reported on the Peninsula during the 1990's from McKay Reserve, Palm Beach, south to Gladstone Street, Newport, but predominantly between the southern side of Careel Bay and Algona Reserve, Bilgola Plateau, and Attunga Reserve, Newport (Map 2).

Of special interest were a number of sightings between January 1990 and January 1991 of a Koala with a green tag in its right ear. This was an animal that had been found in a distressed condition in Wandeen Road near Angophora Reserve, Avalon, in September 1989 and taken to Taronga Zoo for rehabilitation. It was a middle-aged female, estimated 7-10 years old, with no indication that it had ever bred. It was released again at Avalon in November 1989. The subsequent sightings all came from the area between Angophora Reserve and Stapleton Park (Avalon Pde, Hilltop Rd, Central Rd and Chisholm Ave). There have been no further records of this animal since 1991. The general lack of breeding records during the 1990's is a matter of some concern. However, the most recent record, February 2000, was an adult with a juvenile on its back, showing that breeding is still occurring.

There have also been occasional records of Koalas elsewhere in the Pittwater Council area during the 1990's. In 1992, Koalas were seen at Ingleside near Ku-ring-gai Chase National Park, and at Irrawong Reserve, North Narrabeen. In 1997, scratchmarks thought to have been

made by Koalas were observed at Bayview Woods, and probable Koala droppings were found at Monash Golf Course. These were the first records of Koalas from these parts of Pittwater since the 1960's (Smith and Smith 1990b). The sites are linked to Ku-ring-gai Chase National Park by bushland corridors (Map 1), and it is likely that the Koalas came from there rather than from the isolated Barrenjoey Peninsula population. In Ku-ring-gai Chase National Park itself there have been only two records of Koalas during the 1990's. One of these was on a ridge above Elvina Bay after the January 1994 bushfires. More recently, in November 1999, there has been another report of a Koala at Elvina Bay, suggesting that there are resident animals in this part of Pittwater, as well as on Barrenjoey Peninsula.

Food Trees: Koalas are foliage feeders, especially on eucalypt foliage (trees of the genera *Eucalyptus*, *Corymbia* and *Angophora*). Field studies in various regions have consistently indicated strong preferences for feeding on the foliage of only one or two of the eucalypt species locally available, although Koalas will also feed to a limited extent on the foliage of other eucalypt species and other genera, including exotic genera (Hindell and Lee 1990). The favoured species vary from region to region (Callaghan and Phillips 1995) and, even within a region, species that are favoured food trees in some situations may be less favoured when growing on different soils or topography (Jurskis 1996). Thus, it is important to assess food tree preferences at the local level.

Food tree preferences on Barrenjoey Peninsula were assessed by Smith and Smith (1990b) by identification of the individual trees in which Koalas had been reported by local residents (Figure 1). The trees in which Koalas roost during the day generally provide a good indication of their feeding preferences (Robbins and Russell 1978, Hindell *et al.* 1985, Melzer *et al.* 1995), although some caution is necessary in interpretation of these data (Melzer *et al.* 1995).

Every *Eucalyptus*, *Corymbia* and *Angophora* species that occurs naturally on the Peninsula has been reported used by Koalas, at least occasionally, in other regions, as well as a variety of species of other plant genera found on the Peninsula, such as *Allocasuarina*, *Casuarina*, *Melaleuca*, *Syncarpia* and *Banksia* (Bergin 1978, Reed *et al.* 1990, Blanshard 1994, Callaghan and Phillips 1995). However, the Smith and Smith (1990b) study indicated that by far the most favoured food tree on the Peninsula is Grey Gum *Eucalyptus punctata*, which constitutes only 5% of the trees on the Peninsula, but 45% of the trees in which Koalas were reported. The preference of the Koalas for this species has long been recognised locally and it is known to be a staple food tree from nutritional studies (Cork *et al.* 1983, Cork 1986).

Apart from Grey Gum, the Barrenjoey Peninsula Koalas also favoured Broad-leaved Scribbly Gum *E. haemastoma*, Swamp Mahogany *E. robusta* and, to a minor extent, the introduced species, Narrow-leaved Black Peppermint *E. nicholii* (Figure 1). Koalas were also often reported in Spotted Gum *Corymbia maculata* trees, but this species was not favoured, being distinctly under-exploited relative to its abundance on the Peninsula (it is much the most common species in the area). Other tree species in which Koalas were reported on at least three occasions, but which were under-exploited relative to their abundance were, in descending order of Koala use, Red Bloodwood *C. gummifera*, Bangalay *E. botryoides*, Grey Ironbark *E. paniculata* and Sydney Red Gum *Angophora costata* (Figure 1).

The Smith and Smith (1990b) study also noted that the Koalas appeared to favour certain individual trees. Similar preferences for individual trees have been reported in studies of Koalas in other regions as well (Hindell and Lee 1990). Of the 38 trees reported to be specially favoured on Barrenjoey Peninsula, 31 were *Eucalyptus punctata* trees, five were *E. haemastoma*, one was *E. umbra*, and one was the introduced species *E. leucoxydon*.

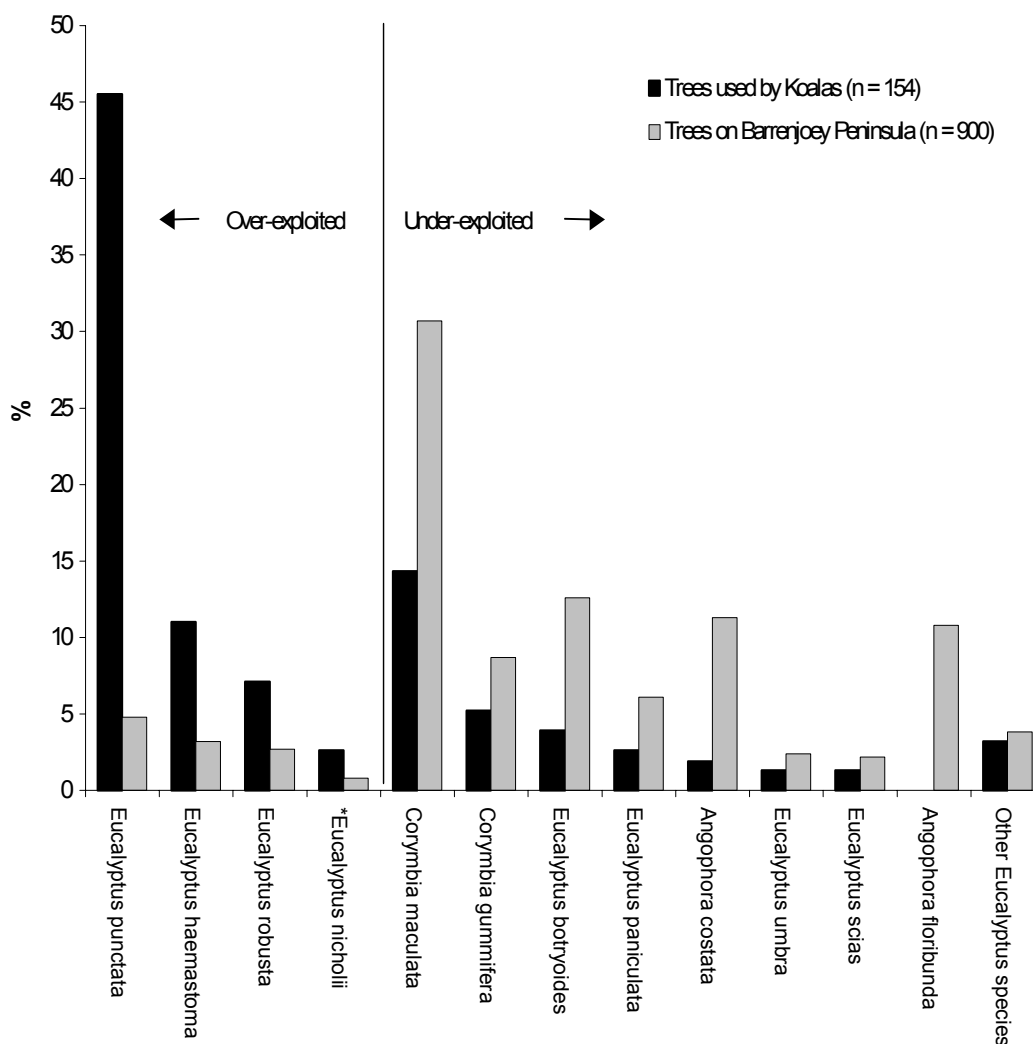


Figure 1. Tree species use (roosting observations) by Koalas on Barrenjoey Peninsula, based on the data of Smith and Smith (1990b). * planted species

Food tree preferences of Koalas in Ku-ring-gai Chase National Park and the western parts of the Pittwater Council area have not been investigated like those on Barrenjoey Peninsula. However, a study by Robbins and Russell (1978) of feeding behaviour in a captive Koala colony in a semi-natural situation at Cowan provides some indication of the likely preferences of wild Koalas in these areas. Their study indicated a strong preference for feeding in *Eucalyptus punctata*, as on Barrenjoey Peninsula (Figure 2). Other favoured food tree species were Narrow-leaved Scribbly Gum *E. racemosa* and, to a minor extent, White Stringybark *E. globoidea*. Other species that the Koalas fed in, although under-exploited relative to their abundance in the enclosure, were Sydney Peppermint *E. piperita*, *Angophora costata* and *Corymbia gummifera*.

To summarise, *Eucalyptus punctata* is by far the most important food tree for Koalas in Pittwater and is a critical habitat component for them. Other favoured food trees are *E. haemastoma*, *E. robusta* and *E. racemosa*. The available information suggests that the next most important food trees are *Angophora costata*, *Corymbia gummifera*, *C. maculata*, *Eucalyptus botryoides*, *E. globoidea*, *E. paniculata*, *E. piperita* and *E. umbra*. However,

Koalas can be expected to feed to a limited extent on all species of *Eucalyptus*, *Corymbia* and *Angophora* that they encounter in Pittwater, and to some extent on other genera as well.

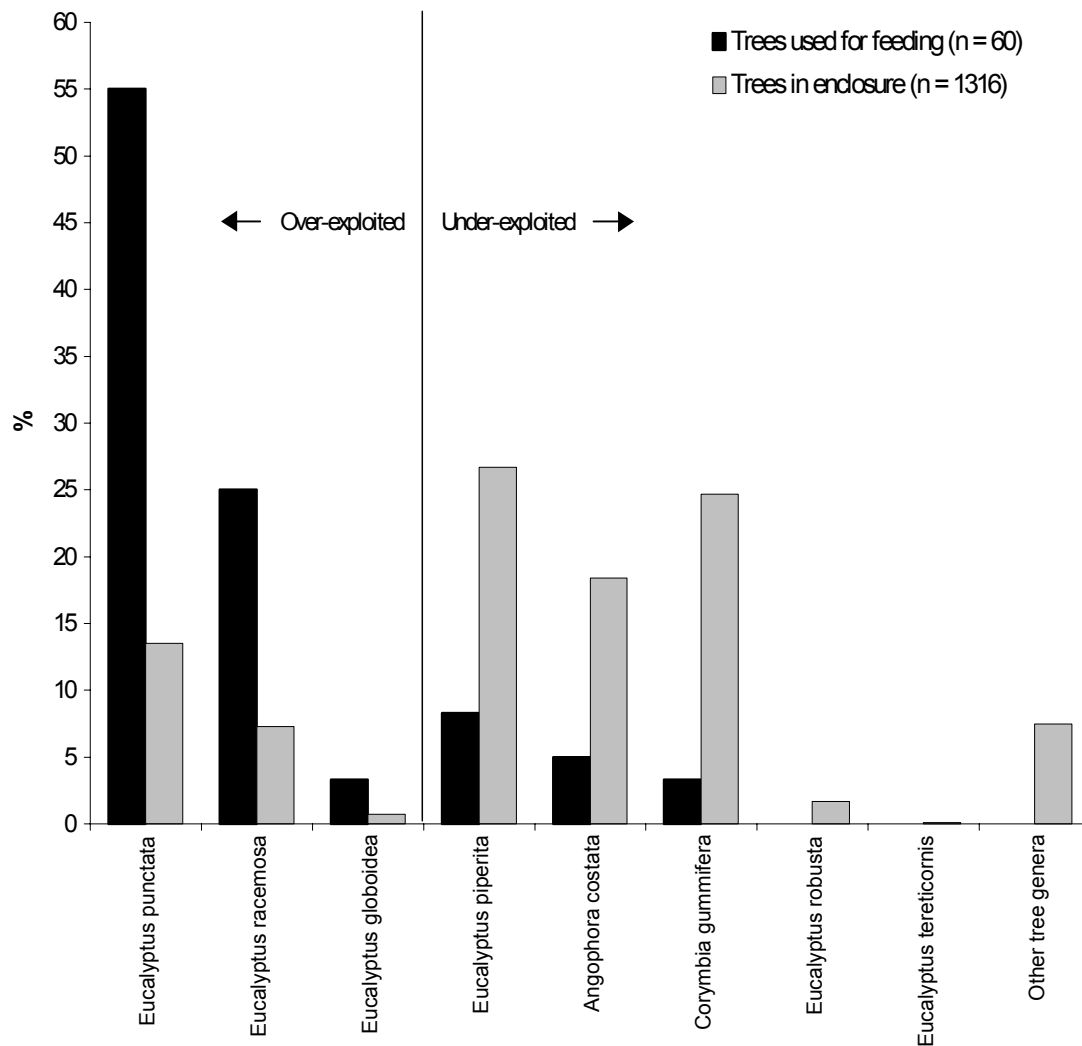


Figure 2. Tree species use (feeding observations) by captive Koalas at Cowan, based on the data of Robbins and Russell (1978).

Habitat: Records during the 1980's (Smith and Smith 1990b) and 1990's (Map 2) indicate that the Koala colony on Barrenjoey Peninsula is concentrated around two major Council bushland reserves, Angophora Reserve and Stapleton Park. These reserves appear to act as refuges, from which the Koalas periodically wander into nearby residential areas with good tree cover. The records suggest that they wander outside the reserves more often in spring and summer than in autumn and winter (Smith and Smith 1990b). Other large Council bushland reserves that may act as refuges are McKay Reserve and Careel Headland Reserve in the north, and Algona Reserve, Crown of Newport Reserve and the Bilgola Bends bushland (including Attunga Reserve and Hewitt Park) in the south. The overall frequency of Koala records around these reserves is much less than around Angophora Reserve and Stapleton Park (Smith and Smith 1990b, Map 2), although it is noteworthy that the three reports of Koalas in 1999-2000 have all been around the Bilgola Bends bushland.

The importance of bushland reserves to the Barrenjoey Peninsula Koalas is further illustrated by Andrew Smith's (1996) analysis of the data of Higgs and Campbell (1993), which showed a steep decline in the frequency of reported Koala sightings with increasing distance from bushland remnants.

Barrenjoey Peninsula has a complex geology, topography and soils, and the tree species composition of the native vegetation varies accordingly. Smith and Smith (1990b) have examined these patterns to determine which habitats on the Peninsula have (or had) the highest proportions of Koala food trees. The best habitats are described below on the basis of that study, with some additional information from Smith and Smith (1992b) and the present study. The habitats are described in terms of the vegetation community terminology of Pittwater Council (1997b, 1998) and related to geology (Geological Survey of NSW 1983; Herbert 1983) and soils (Chapman *et al.* 1989, Chapman and Murphy 1989).

- **Swamp Mahogany Forest.** Main tree species: *Eucalyptus robusta* 64%, *E. botryoides* 18%, *E. punctata* 14% (n = 28). Major food trees: *E. robusta* 64%, *E. punctata* 14%. Occurs in low-lying, swampy areas on Quaternary alluvium (Warriewood soil landscape unit). This community formerly occurred in several locations on Barrenjoey Peninsula south of Careel Bay, but is now represented only by a tiny patch in Toongari Reserve and remnant *E. robusta* (Swamp Mahogany) trees elsewhere. The largest remaining stand of the community in Pittwater, and the Sydney region in general, occurs south of the Peninsula in the Warriewood/Irrawang wetlands. A Koala was sighted there in 1992 (Higgs and Campbell 1993), but the absence of any other records over the last 30 years suggests that it was a wandering individual from Ku-ring-gai Chase National Park, not part of a resident population.
- **The ecotone between Spotted Gum Forest and Hawkesbury Sandstone Open-forest.** Main tree species: *Angophora costata* 19%, *Corymbia maculata* 16%, *C. gummifera* 14%, *A. floribunda* 13%, *Eucalyptus botryoides* 10% (n = 289). Major food trees: *E. punctata* 9%, *E. haemastoma* <1%, *E. robusta* <1%. Occurs on sheltered slopes at the junction between Hawkesbury Sandstone (Hawkesbury soil landscape unit) and the underlying Newport Formation (Watagan soil landscape unit). *E. punctata* is more common in the ecotonal zone than in either the Hawkesbury Sandstone Open-forest upslope or the Spotted Gum Forest downslope. Ecotonal vegetation of this type occurred widely on Barrenjoey Peninsula between Careel Bay and Newport. It is now represented mainly by remnant trees and tiny patches of bushland outside the major reserves, although some examples are evident in Stapleton Park, Algona Reserve and, to a minor extent, Angophora Reserve (Smith and Smith 1990b). Similar vegetation occurs away from the Peninsula on the western side of the Pittwater inlet.
- **Northern form of Coastal Sandstone Woodland at Whale Beach.** Main tree species: *Angophora floribunda* 40%, *Eucalyptus haemastoma* 30%, *E. botryoides* 15% (n = 33). Major food trees: *E. haemastoma* 30%, *E. robusta* 3%. Coastal Sandstone Woodland occurs on sheltered sites on Hawkesbury Sandstone headlands (Hawkesbury soil landscape unit). It is restricted in Pittwater to the headlands between Bangalley Head and Whale Beach. There are two forms of the community. The southern form is represented in Careel Headland Reserve, but has only a low percentage of *E. haemastoma* trees (4%). *E. haemastoma* was a more common component of the community north of the reserve, but this area has been cleared for urban development and the northern form of the community is now represented only by remnant trees.

- **Red Bloodwood-Scribbly Gum Woodland.** Main tree species: *Corymbia gummifera* 53%, *Eucalyptus haemastoma* 24%, *Angophora costata* 20% (n = 79). Major food trees: *E. haemastoma* 24%, *E. punctata* 3%. Occurs on Hawkesbury Sandstone plateaus and ridges on the Gynea soil landscape unit. This community occurs on both Bilgola Plateau and the Palm Beach plateau, but representation in major reserves on the Peninsula is restricted to a small area in McKay Reserve. The community occurs widely outside the Peninsula in western Pittwater and Ku-ring-gai Chase and Garigal National Parks. It usually supports only very sparse Koala populations, except on Barrenjoey Peninsula, where its importance may have been enhanced by its proximity to other vegetation communities on more fertile soils.
- **Bilgola Plateau Forest.** Main tree species: *Corymbia gummifera* 55%, *Eucalyptus haemastoma* 18%, *Angophora costata* 17%, *E. sieberi* 7% (n = 95). Major food trees: *E. haemastoma* 18%. Occurs on lateritic soils on the Hawkesbury Sandstone Bilgola Plateau (Somersby soil landscape unit). It is similar in tree species composition to the Red Bloodwood-Scribbly Gum Woodland, but occurs on more fertile soils, resulting in a taller, denser forest and differences in the understorey vegetation. It was never a common community on the Peninsula and is now restricted to a small remnant stand in Plateau Park. Similar vegetation also occurs in Ingleside near the Baha'i Temple.
- **Grey Ironbark-Grey Gum form of Newport Bangalay Woodland.** Main tree species: *Eucalyptus paniculata* 29%, *E. punctata* 29%, *Angophora floribunda* 29%, *E. umbra* 14% (n = 14). Major food trees: *E. punctata* 29%. An unusual form of Newport Bangalay Woodland with little, if any, Bangalay (*E. botryoides*). Occurs on the western side of the Peninsula on Newport Formation geology, Erina soil landscape unit. It appears to have been restricted to the vicinity of Old Mangrove Bay, Newport, where the original vegetation has been cleared and the community is now represented only by remnant trees.

The larger bushland reserves on the Peninsula are crucial to the survival of Koalas in the area, but they represent a poor sample of the best Koala habitats. In every case the ratio of major food trees to other eucalypts is below the Peninsula average (Table 2). The low numbers of food trees in the reserves makes retention of food trees in the surrounding urban areas an important issue. Furthermore, major problems of tree health are evident in many of the reserves (Table 3). The precise cause of tree death has not been established, but it is clearly associated with urban runoff, the dead and dying trees being concentrated about drainage lines that receive such runoff. The same problem is also evident in many locations outside the reserves.

Breeding: Most females breed towards the end of their second year, but males of this age, although sexually mature, are usually prevented from gaining access to females by older males (Lee and Martin 1988, Menkhorst 1995). Mating occurs in late spring and summer. A single young (rarely two) is born after a gestation period of 35 days and remains in the pouch for seven months and then remains on the mother's back until weaned at about one year. In disease-free populations most females produce a single young each year. Juveniles become independent at two years old and leave to find their own home range, becoming nomadic if no suitable area is found.

Table 2. Occurrence of Koala food trees in major bushland reserves on Barrenjoey Peninsula (Smith and Smith 1990b).

	Barrenjoey Peninsula	Angophora Reserve	Stapleton Park	McKay Reserve	Careel Headland Reserve	Algonia Reserve	Crown of Newport Reserve	Bilgola Bends bushland
Area (ha)	1515	19	8	26	6**	2.5	4	17
Mean no. eucalypts*/ha	83	125	393	313	660	430	35	175
% <i>Eucalyptus punctata</i>	5	4	3	1	0	7	0	0
% <i>Eucalyptus haemastoma</i>	3	1	0	5	3	0	0	0
% <i>Eucalyptus robusta</i>	3	<0.5	0	0	0	0	0	0
Total % major food trees	11	5	3	6	3	7	0	0
Mean no. major food trees/ha	9	7	10	20	20	30	0	0

* Eucalypts = live trees of the genera *Eucalyptus*, *Corymbia* and *Angophora* over 6 m tall.

** Forested section of reserve.

Table 3. Health of eucalypts (*Eucalyptus*, *Corymbia* and *Angophora* trees over 6 m tall) in major bushland reserves on Barrenjoey Peninsula (Smith and Smith 1990b, 1992b).

	Barrenjoey Peninsula	Angophora Reserve	Stapleton Park	McKay Reserve	Careel Headland Reserve	Algonia Reserve	Crown of Newport Reserve	Bilgola Bends bushland
% of trees dead	4	24	3	12	6	2	50	7
% unhealthy (>1/3 crown dead)	12	9	4	9	4	14	21	20
% healthy	84	67	93	79	90	84	29	73

Causes of Death: Smith and Smith (1990b) collated the limited information available on causes of death of Koalas on Barrenjoey Peninsula between 1947 and 1989 (25 records). Dog attacks were the single most important reported cause, accounting for at least 24% of deaths, while at least 8% of deaths were caused by motor vehicles and 8% by possible chlamydial diseases. By comparison, in other urban areas, Lee and Martin (1988) have reported that 60% of deaths are caused by motor vehicles and 6% by dogs on Phillip Island, Victoria, while Canfield (1987) has reported that 30% of deaths at Port Macquarie are caused by motor vehicles, 7% by dogs and other carnivores, and 35% are probably linked to chlamydial diseases. Koalas are particularly susceptible to disease compared to other marsupials, and the suite of diseases associated with the bacterium *Chlamydia psittaci* are the most common diseases found in Koalas (Lavin *et al.* 1990). The reported incidence of chlamydial diseases in the Barrenjoey Peninsula population has been relatively low, but it still represents a major threat for such a small colony.

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas.
- Habitat enhancement by food tree plantings.

- Wildlife corridors (between reserves on Barrenjoey Peninsula, and between Barrenjoey Peninsula and Ku-ring-gai Chase National Park).
- Habitat degradation in remnant bushland (eucalypt dieback; expansion of non-eucalypt vegetation as a result of altered fire, nutrient and water regimes).
- Fire management (fires are a known cause of Koala mortalities and can also greatly reduce the available food resources, at least in the immediate post-fire period before the trees reshoot).
- Control of dog and cat predation.
- Control of fox predation.
- Road casualties.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of Koalas in Pittwater, especially outside Barrenjoey Peninsula (the scarcity of records suggests that they occur here only as occasional visitors from Ku-ring-gai Chase National Park, rather than resident animals, but further investigation is warranted through questionnaire surveys to local residents).
- Recovery plan (one is currently being prepared for the species).

2.2 Endangered Fauna Species

2.2.1 Bush Stone-curlew (*Burhinus grallarius*)

Formerly known as *Burhinus magnirostris*. Other common names for the species are Bush Curlew and Bush Thick-knee.

Family: Burhinidae

Conservation Status: Endangered species in NSW (TSC Act). At national level it is regarded as a species 'of special concern' (Garnett 1993).

Distribution: The Bush Stone-curlew is essentially confined to Australia, although there have been several records from southern New Guinea (Marchant and Higgins 1993). It occurs widely in all mainland states, but is absent from Tasmania. Though the species remains common in northern Australia, it has declined dramatically in southern Australia. In New South Wales, it was formerly widespread and abundant, but its numbers are now much reduced and its distribution fragmented (Smith 1991). It was once a common bird around Sydney, especially in the drier eucalypt woodlands on Wianamatta Shale, but is now extremely rare.

Pittwater Population: In Pittwater, there is a resident breeding pair living on the fringes of Careel Bay (Smith and Smith 1997a). This is now the only site in the County of Cumberland where the species is regularly recorded. The birds have been present at Careel Bay since at least 1952 (Hindwood 1971). The nearest known population to Careel Bay is a couple of pairs that live on Rileys Island in Brisbane Water in similar mangrove, saltmarsh and casuarina habitat to Careel Bay (Roberts 1993). Rileys Island is only 15 km north of Careel Bay and movement of birds between the two areas is quite likely to occur, particularly with dispersing young. Adult birds are sedentary.

Habitat: The typical habitat of the Bush Stone-curlew is considered to be eucalypt woodland with a dry, grassy understorey (Marchant and Higgins 1993). It is absent from both treeless areas and dense forests. Although not usually a bird of wetlands, many of the birds reported in New South Wales coastal districts over the last 20 years have been associated with mangroves and saltmarshes in estuaries, often in island situations where they are afforded protection from foxes, dogs and cats (Smith 1991). At Careel Bay, the birds utilise the areas of mangroves, saltmarsh, Swamp Oak *Casuarina glauca* forest, grassland and intertidal mudflats (Smith and Smith 1997a). They roost by day in the saltmarsh. In recent years calls have been heard during the day from dense vegetation on the eastern side of Careel Creek and they may roost here as well as in the saltmarsh.

Feeding: The Bush Stone-curlew feeds at night on seeds, fruits and other plant material, a variety of insects and other invertebrates, as well as small reptiles and frogs (Barker and Vestjens 1989). At Careel Bay in 1997 the birds were observed foraging at night on the intertidal mudflats (Smith and Smith 1997a). They also appeared to be foraging in the dog exercise area and probably forage in the saltmarsh, mangroves and Swamp Oak forest as well. In the past they have been observed to visit Avalon Golf Course at night to feed and may still do so (Smith and Smith 1997a).

Breeding: The Bush Stone-curlew lays one to three eggs, usually two, on the ground amongst trees or in the open. The incubation period is 22-24 days and the hatchlings take about 50 days to reach adult size (Garnett 1985, Lane 1987). In New South Wales, eggs have been recorded between August and January (Morris *et al.* 1981). In early January 1996, one live and two dead chicks were found in the saltmarsh at Careel Bay. The surviving chick was raised by a WIRES carer and eventually released at Rileys Island, Brisbane Water, after an initial unsuccessful attempt to return it to Careel Bay. A Bush Stone-curlew egg shell was found at Careel Bay in the saltmarsh in late February 1997. The egg appeared to have hatched successfully, but no young birds were seen accompanying the adults during observations of them between February and May (Smith and Smith 1997a). More recently, a nest with two eggs was observed at Careel Bay in November 1999 (Morris and Gladwin 2000).

Management Issues:

- Conservation of remnant bushland.
- Habitat degradation in remnant bushland. Saltmarsh is a critical habitat for the Bush Stone-curlews at Careel Bay as a daytime roost and a nesting site. 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.
- Protection of waterways (Careel Bay).
- Control of cat and dog predation (stone-curlews are particularly vulnerable to predation because they feed, roost and nest on the ground).
- Control of fox predation (thought to be a major factor in the decline of the species in southern Australia this century).
- Disturbance at nesting sites, daytime roosting sites and nocturnal feeding sites (the species is especially vulnerable to disturbance because it nests, roosts and feeds on the ground).
- Rehabilitation of sick, injured or orphaned animals.
- Lack of knowledge of Bush Stone-curlews at Careel Bay, especially their breeding success, dispersal of young and the likelihood of replacement of the adults when they die, either by young birds bred locally or by birds from Brisbane Water.
- Recovery plan (one is currently being prepared for the species).

2.2.2 Swift Parrot (*Lathamus discolor*)

Family: Psittacidae

Conservation Status: Endangered species in NSW (TSC Act). Also listed as an endangered species at national level in the Endangered Species Protection Act.

Distribution: A migratory species, the Swift Parrot breeds in eastern and northern Tasmania and over-winters on the Australian mainland from March to November, in suitable areas from the Mount Lofty Ranges, South Australia, through Victoria and New South Wales to south-eastern Queensland (Forshaw and Cooper 1981, Garnett 1993). The birds wander widely over the mainland during winter in search of suitable nectar sources.

Population Size: The breeding population in Tasmania has declined from in excess of 10 000 pairs to less than 1000 pairs (NSW Scientific Committee 2000a). Only part of this population visits New South Wales.

Pittwater Population: Large flocks of Swift Parrots have occurred in the past in the Pittwater Council area. In April and May 1938, hundreds of Swift Parrots were present at Mona Vale, where they were feeding on nectar from the blossoms of the Swamp Mahogany (*Eucalyptus robusta*) trees (Hindwood 1939). A few were also seen at Bayview in June of the same year, again feeding in Swamp Mahogany. There have been few records of Swift Parrots in recent times. Small flocks were reported at Ingleside in July and August 1986 (Cooper 1990) and 4-5 birds were sighted just outside the Pittwater area on the southern side of Deep Creek in May 1998 (Reg Angus pers. comm.). Allan Foster (pers. comm.) reported that Swift Parrots have occurred sporadically over the last 20 years in flowering Swamp Mahogonies in the Warriewood/Irrawong wetlands.

Habitat: The species inhabits eucalypt forest and woodland, particularly where there are flowering eucalypts. In its winter range on the mainland it congregates in areas where eucalypts are flowering profusely, and is thus dependent on species that flower in autumn and winter (Garnett 1993). It occurs during winter not only in extensively forested areas, but also in remnant patches of mature eucalypts within heavily cleared agricultural and urban areas. In Pittwater, the Swift Parrot is most likely to be attracted by flowering Swamp Mahogany trees. Remnant stands of Swamp Mahogany known or likely to be used by the species include those in the Warriewood/Irrawong wetlands, around Bayview Golf Course and at Toongari Reserve, Avalon. As the Swift Parrot is a highly mobile species, even individual Swamp Mahogonies in streets, parks, schools, golf courses and private gardens can be an important food source, particularly where the trees are large, mature specimens. Another tree species in Pittwater that could be an important food source for Swift Parrots, at least occasionally, is Spotted Gum (*Corymbia maculata*).

Feeding: The Swift Parrot feeds mainly on eucalypt nectar and pollen, although it will also feed on lerps, honeydew, banksia nectar, fruits, seeds and other plant material, and insects and their larvae (Forshaw and Cooper 1981).

Breeding: The Swift Parrot breeds only in Tasmania and its nearby islands, from October to December, using hollows in eucalypt trees.

Management Issues:

- Conservation of remnant bushland, especially stands of Swamp Mahoganies and Spotted Gums.
- Tree preservation in urban areas.
- Habitat enhancement by food tree plantings.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the pattern of occurrence and habitat requirements of Swift Parrots in Pittwater.
- Recovery plan (no plan has yet been prepared for this species)

2.2.3 Regent Honeyeater (*Xanthomyza phrygia*)

Family: Meliphagidae

Conservation Status: Endangered species in NSW (TSC Act). Also listed as an endangered species at national level in the Endangered Species Protection Act.

Distribution: The Regent Honeyeater is endemic to south-eastern mainland Australia, occurring from south-eastern Queensland to western Victoria. Its distribution has contracted since 1950 - it formerly occurred further north to central-eastern Queensland and further west to Kangaroo Island and the Mount Lofty Ranges in South Australia. Within its present distribution it has declined greatly in numbers and has become much more patchily distributed, disappearing from many areas where it was once regularly recorded. It is a nomadic species, wandering widely in search of flowering eucalypts and other plants, and its movements are often unpredictable, although in some districts it appears each year when its food plants flower (Blakers *et al.* 1984, Longmore 1991, Garnett 1993).

Population Size: Webster and Menkhorst (1992) estimated the total population of Regent Honeyeaters at between 500 and 1500 individuals.

Pittwater Population: Hindwood (1939, 1944) reported that the Regent Honeyeater was a breeding visitor to the Wianamatta Shale country west of Sydney and the forests of the shale cap in the Pymble-Wahroonga area. The species was rarely observed in the Sydney area in some years, but in favourable seasons it moved to the coast in numbers during autumn and winter to feed on flowering eucalypts and banksias. Flocks of fifty or more birds would be seen. In 1938, when there was a prolific flowering of various eucalypt species over autumn and winter, large concentrations of Regent Honeyeaters were seen at Avalon, Bayview and other localities from April to July (Hindwood 1939). In 1958, flocks of 15-30 birds were reported at Church Point and Bayview (Atlas of NSW Wildlife).

Regent Honeyeaters have rarely been recorded in or near Pittwater in recent times. There were records from Garigal National Park in 1987 and from Terrey Hills in 1988 and 1991, but no recent records from the Pittwater Council area until May 1998, when four birds were observed feeding at the flowers of Swamp Mahogany (*Eucalyptus robusta*) trees in Irrawong Reserve (P. and J. Smith).

Habitat: The Regent Honeyeater is chiefly a species of eucalypt woodland and open-forest, including forest edges, wooded farmland and urban areas with patches of mature eucalypts (Garnett 1993). Coastal heathland and scrub with flowering banksias are also utilised at times by the birds (Hindwood 1944). Optimum habitat supports large, mature eucalypts, rather than younger trees, so that high nectar flows occur when the trees flower (Franklin *et al.* 1989, Webster and Menkhorst 1992). In Pittwater, the Regent Honeyeater is most likely to be attracted by the autumn- and winter-flowering Swamp Mahoganies. Geering (1997) has suggested that Swamp Mahogany stands in coastal New South Wales, although not visited each year by Regent Honeyeaters, are important refuges for them when flowering is poor in the box-ironbark woodlands on the tablelands and western slopes. Remnant stands of Swamp Mahogany in Pittwater, including those in the Warriewood/Irrowong wetlands, around Bayview Golf Course and at Toongari Reserve, Avalon, provide potentially important habitat for this species. Even individual Swamp Mahoganies in gardens, parks and other urban situations can be an important food source for the species, particularly where the trees are large, mature specimens. Other eucalypt and banksia species in the Pittwater area that flower in autumn and winter may also attract Regent Honeyeaters, especially Spotted Gum (*Corymbia maculata*), Heath-leaved Banksia (*Banksia ericifolia*) and Coast Banksia (*B. integrifolia*). Mistletoes are another potentially important food source, since they are known to be important in other areas such as the Capertee Valley (Geering and French 1998).

Feeding: Regent Honeyeaters feed chiefly on nectar, with some insects also taken. A highly mobile species, Regent Honeyeaters travel long distances in search of nectar. Their movements can be irregular, but the birds appear to return to certain regions, sites and tree species that provide reliable nectar flows. The main nectar sources are usually eucalypts, although banksias and mistletoes are also important in some areas (Franklin *et al.* 1989, Garnett 1993).

Breeding: The Regent Honeyeater breeds from August to January in a variety of woodland habitats, sometimes in small colonies (Webster and Menkhorst 1992, Geering and French 1998). Cup-shaped nests of bark and grass are built in forks of trees or shrubs or in mistletoe. There have been no breeding records in the Pittwater area. Even when the species was more common, it apparently did not breed in the area (Hindwood 1944).

Management Issues:

- Conservation of remnant bushland, especially stands of Swamp Mahoganies, but also other winter-flowering eucalypts and banksias.
- Tree preservation in urban areas.
- Habitat enhancement by food tree plantings.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the pattern of occurrence and habitat requirements of Regent Honeyeaters in Pittwater.
- Recovery plan (one is currently being prepared for the species).

2.2.4 Southern Brown Bandicoot (*Isoodon obesulus*)

Other common names for the species are Short-nosed Bandicoot and Brown Bandicoot.

Family: Peramelidae

Conservation Status: Endangered species in NSW (TSC Act). At national level, the relevant subspecies, *obesulus*, is considered a ‘near threatened’ taxon (Maxwell *et al.* 1996).

Distribution: The Southern Brown Bandicoot consists of five geographically isolated subspecies (Seebeck *et al.* 1990). Subspecies *obesulus* is distributed from the Sydney area through south-eastern New South Wales and southern Victoria to Eyre Peninsula and Kangaroo Island, South Australia. Subspecies *fusciventer* occurs in the south-west of Western Australia. Subspecies *affinis* occurs in Tasmania. Subspecies *peninsulae* occurs on Cape York. Subspecies *nauticus* occurs on islands in western South Australia. Lyne and Mort (1981) have suggested that the last two subspecies should be considered as separate species.

The Southern Brown Bandicoot has a patchy distribution in New South Wales. It is most numerous in and around Nadgee Nature Reserve (Claridge *et al.* 1991). Another important population occurs in Ku-ring-gai Chase National Park (Ashby *et al.* 1990, National Parks and Wildlife Service 1999a).

Last century, Krefft (1866) collected *Isoodon* specimens near the junction of the Murray and Darling Rivers in inland New South Wales, where this species was regarded as the most common of the bandicoots. However, there is dispute over the identity of these specimens, whether *Isoodon obesulus*, *I. auratus* (Golden Bandicoot) or a separate, undescribed *Isoodon* species (Ellis *et al.* 1991, Menkhorst 1995). Whichever is the case, the genus is now extinct in inland regions of the state.

Pittwater Population: The presence of the Southern Brown Bandicoot in the Pittwater Council area is yet to be confirmed. However, the adjacent Ku-ring-gai Chase National Park is the stronghold of the species in the Sydney area, with many records over the years (Atlas of NSW Wildlife). It has also been recorded just west of the Pittwater Council area at Kimbriki Tip in 1990 (ICF and Australian Museum 1994). In a recent study of bandicoots in northern Sydney, Southern Brown Bandicoots were recorded in Ku-ring-gai Chase National Park and both sections of Garigal National Park, but not in any of the smaller patches of bushland surveyed (Kia Atkins, pers. comm.).

Habitat: Southern Brown Bandicoots are solitary animals that occupy overlapping home ranges whose size has been estimated at 0.8 to 3.2 ha in Victoria (Lobert 1990) and 2.3 to 6.6 ha in Tasmania (Heinsohn 1966). They are usually nocturnal, but can be diurnal in some situations (Heinsohn 1966, Lobert 1990). During the day they rest in nests on the ground, usually in dense vegetation, constructed from grass and other plant material, sometimes mixed with earth. They inhabit heath, scrub and heathy forest and woodland, usually on well drained soils (Opie *et al.* 1990, Menkhorst 1995). They are not found in wet forests. Stoddart and Braithwaite (1979) have suggested that heathland regenerating after fire is a favoured habitat that they are able to utilise because of their high reproductive rate and their use of less favourable adjacent habitats from which burnt heathland can be reinvaded.

Feeding: The Southern Brown Bandicoot is a secretive species that prefers to stay under or near cover when foraging (Heinsohn 1966). It is an opportunistic omnivore, feeding on insects (both adult and larval), earthworms and other soil invertebrates, also fungi and plant material (mainly subterranean), taken from the surface of the ground or by digging conical holes about 10 cm deep (Heinsohn 1966, Quin 1988, Claridge *et al.* 1991).

Breeding: Births occur in Victoria from July to December (Lobert and Lee 1990). Litter size varies from one to six. The gestation period is less than 15 days and lactation about 60 days, with females producing up to three litters per breeding season in Victoria. Females breed in the breeding season following their birth. Litter size and the number of litters produced per year appear to be related to food abundance. The species can build up its population rapidly under favourable conditions. Maximum longevity of wild animals is about 3.5 to 4 years (Lobert and Lee 1990).

Management Issues:

- Lack of knowledge of the species in Pittwater (likely to occur in the area, but no known sites).
- Conservation of remnant bushland.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management (an important and complex issue with this species - 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).
- Control of cat and dog predation.
- Control of fox predation.
- Road casualties.
- Rehabilitation of sick, injured or orphaned animals.
- Community education (there is sometimes public antipathy towards bandicoots because they carry ticks and dig up lawns and gardens in their search for food).
- Recovery plan (one is currently being prepared for the species).

2.2.5 Giant Dragonfly (*Petalura gigantea*)

Family: Petaluridae

Conservation Status: Endangered species in NSW (TSC Act).

Distribution: Coastal and tableland regions of New South Wales from Moss Vale north to southern Queensland. It has not been recorded from most of its known sites for many years (NSW Scientific Committee 1998b). The adults are spectacular and highly visible, and the scarcity of recent records is likely to be indicative of a real decline in the species. The largest known extant population of the species occurs in patches of sphagnum swamp within Wingecarribee Swamp near Moss Vale (NSW Scientific Committee 1998b).

Pittwater Population: The species is known to occur in Pittwater from a specimen at the Australian Museum that was collected at Avalon Beach in 1974. Two specimens in the Australian National Insect Collection were collected at Narrabeen in 1950.

Habitat: Boggy seepages and swamps (Watson *et al.* 1991). The larvae are distinguished from typical dragonfly species by their terrestrial habits. They occupy permanent long-chambered burrows built in wetland soils, but opening above the water level. They emerge from the burrows at night and in wet weather to feed. Although they inhabit wetlands and

require moist conditions, the larvae avoid open water and are apparently unable to swim. The adults are large, but are poor flyers and do not disperse far after metamorphosis.

Feeding: Both larvae and adults are predators on insects and other arthropods.

Breeding: The larval stage is unusually long, from at least 10 to 30 years. The adults emerge in October and November and live until late January, mating and laying their eggs.

Management Issues:

- Conservation of remnant wetland vegetation.
- Habitat degradation in remnant wetland vegetation.
- Protection of waterways.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.3 Endangered Flora Species

2.3.1 *Chamaesyce psammogeton* (Coastal Spurge)

Formerly known as *Euphorbia sparrmanii* and as *Chamaesyce sparrmanii*.

Family: Euphorbiaceae

Conservation Status: Endangered species in NSW (TSC Act).

Distribution: Recorded sporadically along the New South Wales and Queensland coasts from Jervis Bay northwards, and from Lord Howe Island (NSW Scientific Committee 1998c). Although formerly regarded as widespread, a survey of coastal dune plants in New South Wales in the late 1980's recorded it at few sites, leading to concern that it was in danger of extinction in this state (Clarke 1989, Clarke and Carolin 1991).

Pittwater Population: The species was recorded at Avalon Beach in 1987 by Peter Clarke (Atlas of NSW Wildlife). It has also been recorded at Palm Beach (Benson and McDougall 1995).

Habitat: *Chamaesyce psammogeton* is a prostrate herb which forms mats up to one metre across on the unstable sands of the strandline zone of coastal foredunes (Carolin and Clarke 1991). It also sometimes grows in exposed sites on headlands (NSW Scientific Committee 1998c).

Ecology: Individual populations reported during the last two decades have been small, comprising only one to a few plants (NSW Scientific Committee 1998c). Plants are perennial with a life span of 5 to 30 years and often form a woody rootstock (Clarke 1989). Seeds are produced from the first year. Flowers are borne in spring and summer, and fruit in autumn and winter. It is not known whether seeds persist in the soil seed bank, but seeds float so dispersal between beaches may occur. Seedlings and adults are tolerant of wind, drought and salinity. The effects of fire on the plants are unknown.

Management Issues:

- Beach dune management.
- Control of Bitou Bush control.
- Translocation (as an alternative to conservation *in situ*).
- Community education.
- Lack of knowledge of the species (in particular, the specific locations where it occurs in Pittwater).
- Recovery plan (no plan has yet been prepared for this species).

2.3.2 *Grevillea caleyi* (Caley's Grevillea)

Family: Proteaceae

Conservation Status: Endangered species in NSW (TSC Act). Also listed as an endangered species at national level in the Endangered Species Protection Act.

Distribution: *Grevillea caleyi* occurs in northern Sydney over an area of approximately 6 x 6 km which is centred on Terrey Hills and also includes parts of Duffys Forest, Belrose and Ingleside. Within this distribution some 20 stands of *Grevillea caleyi*, remnants of former populations, persist (Scott *et al.* 1995, as updated 2000). Only five of these stands occur within, or partly within, National Parks and Wildlife Service lands: three in Ku-ring-gai Chase National Park and two in the eastern section of Garigal National Park.

Pittwater Population: *Grevillea caleyi* occurs at Ingleside in the vicinity of the Baha'i Temple. The population here extends into both the Pittwater and Warringah Local Government Areas, with plants growing on privately owned land, land owned by the Roads and Traffic Authority and the Department of Land and Water Conservation, as well as in Garigal National Park. The population at this site is disturbed and fragmented by land clearing for the Baha'i Temple, a carpark, residential properties and Mona Vale Road, which bisects the habitat. Six months after the January 1994 fires, the section of the population within the Pittwater Council area numbered some 281 live adults, 544 dead adults and 428 seedlings on the north-western side of Mona Vale Road, and several plants in the vicinity of Powder Works Road (Scott *et al.* 1995). The section of the population in Garigal National Park numbered an estimated 1400 seedlings in Garigal National Park on the south-eastern side of Mona Vale Road. The latter have now grown to maturity and formed a good-sized stand of adult plants.

Specimens at the National Herbarium of New South Wales, Royal Botanic Gardens Sydney, show that *Grevillea caleyi* has been present around the Baha'i Temple since at least 1963. Other specimens at the herbarium suggest that the species was once more widespread in Pittwater. However, the localities given for these specimens are imprecise and it is unclear whether they were collected in Pittwater or Warringah: specimens from 'Pittwater Road' collected in 1914 and 1917, and a specimen from 'Elanora Heights-Collaroy' collected in 1950.

Habitat: Typically, *Grevillea caleyi* grows on iron-rich lateritic soils on ridgetops (170-240 m above sea level). It is usually found in open-forest vegetation, generally dominated by Silvertop Ash *Eucalyptus sieberi* and Red Bloodwood *Corymbia gummifera* (Scott *et al.* 1995). This community, known as the Duffys Forest Vegetation Community, is listed as an endangered ecological community and is discussed below in section 2.6.1. *Grevillea caleyi* is

also occasionally found in more typical Hawkesbury Sandstone ridgetop vegetation, low woodland of Red Bloodwood and Broad-leaved Scribbly Gum *Eucalyptus haemastoma*. One stand is located in Hawkesbury Sandstone gully forest, dominated by Sydney Red Gum *Angophora costata* and Sydney Peppermint *Eucalyptus piperita*, but the species appears to have been introduced to this site, rather than a natural occurrence.

Ecology: *Grevillea caleyi* is an open, spreading shrub that may grow to about 4 m high and 4 m across. It does not usually flower and produce seeds before 2.5-5 years of age (Scott *et al.* 1995). Flowers are produced sporadically throughout the year with a peak flowering period in late winter and spring. The large 'toothbrush' flowers appear to be bird pollinated and may be self compatible. Fruit maturation takes 2-3 months. Usually one large seed is produced per fruit. Fecundity is low with only about 3% of flowers resulting in seed. As individual plants age they produce more flowers and fruit. Seed dispersal is minimal. Upon maturity the fruits dehisce, dropping the seed to the ground beneath the parent plant. The viability of seeds is high and most are released in a dormant state. Through time there is a slow loss of dormancy resulting in a fluctuating trickle of germination, though most seedlings do not survive in the undisturbed environment. Seeds are predated at the fruit stage by weevils and then on the ground after seeds are shed by Bush Rats and Swamp Wallabies. Adult plants senesce from 12-15 years onwards.

Grevillea caleyi is fire-sensitive and relies on germination from a soil seedbank to recover after fire. Seedlings are common after fire, or in open disturbed places. The seed dormancy mechanism is not fully understood and it is unclear how fire promotes germination. During the 1994 fires, some 60% of the total habitat of *Grevillea caleyi* was burnt and many population fragments now consist solely of plants that have germinated since the fires. The number of plants in a population may thus fluctuate widely over short periods of time in response to fire or adult senescence. It takes some 8-12 years for the soil seedbank to reach a sufficient level to replace a population and so it is critical that the interval between successive fires is not less than 8-12 years at a site. Repeated fires at intervals of less than eight years may lead to the local extinction of *Grevillea caleyi* from a site. In sites unburnt for more than 15 years adult senescence may result in marked declines of the soil seedbank unless high levels of fecundity are maintained (Scott *et al.* 1995).

Management Issues:

- Recovery plan - a plan has been prepared (Scott *et al.* 1995) and a recovery team established, on which Pittwater Council is represented, to implement the plan. A new recovery plan is in preparation to comply with the requirements of the Threatened Species Conservation Act.
- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management (as discussed above, fire is a major factor in the *Grevillea caleyi* life cycle).
- Preservation of remnant individuals in urban areas.
- Loss of genetic integrity through hybridisation with planted *Grevillea* species.
- Translocation (as an alternative to conservation *in situ*).
- Unauthorised collection of plant material.
- Community education.
- Lack of knowledge of the species (the species is relatively well known compared with other threatened plants in the area, but there are still gaps in our knowledge).

2.3.3 *Microtis angusii* (Angus's Onion Orchid)

Family: Orchidaceae

Conservation Status: Endangered species in NSW (TSC Act). Also listed as an endangered species at national level in the Endangered Species Protection Act.

Distribution: *Microtis angusii*, which was first discovered in 1987, and formally described and named in 1996 (Jones 1996), is known from just two widely disjunct sites, one at Ingleside and the other at Sunny Corner State Forest, 100 km west of Sydney (National Parks and Wildlife Service 1999b).

Pittwater Population: The Ingleside population is located within the Mona Vale Road road reserve at the junction of the Pittwater and Warringah Local Government Areas. In September 1998 a total of 336 plants were counted at this site (National Parks and Wildlife Service 1999b).

Habitat: The natural habitat of this orchid is unknown as both confirmed locations are highly disturbed. The Ingleside population occurs in a ridgetop site that has been cleared of its original vegetation, used as a soil depot and vehicle parking site, and the dominant species at the site are now introduced weeds (*Acacia saligna* and *Hyparrhenia hirta*). It is possible that *Microtis angusii* may have been transported to the site as seeds within dumped soil (National Parks and Wildlife Service 1999b). The most likely natural habitat of *Microtis angusii* in the Pittwater-Warringah area is the Duffys Forest Vegetation Community, which has been listed as an endangered ecological community and is discussed below in section 2.6.1.

Ecology: *Microtis angusii* is a terrestrial orchid. For most of the year it is present only as underground tubers. It produces leaves and then flowering stems usually in late winter and spring (National Parks and Wildlife Service 1999b). Flowers have been recorded from May to October (Jones 1996). Other *Microtis* species flower prolifically after fires, and the same is probably true of *M. angusii*. *Microtis* flowers mature from the bottom of the inflorescence to the top, and the capsules at the bottom of the inflorescence may have released their seed before the flowers at the top have opened. By summer the above ground parts have withered and there is no visible evidence of the species.

Most *Microtis* species reproduce vegetatively by the formation of 'daughter' tubers from the main tuber, and can produce huge clonal colonies this way (Bates 1986). It is likely that *M. angusii* reproduces vegetatively in the same manner. Other *Microtis* species have been reported to use a 'three chance' system for reproduction from seed. That is, they produce seeds through the use of insects as pollination vectors, self fertilisation (autogamy) or production of seed without pollination (apomixis). However, not all species are capable of autogamy or apomixis.

M. angusii produces large quantities of minute seeds (Jones 1996), but little is known about seed production, dispersal, germination and recruitment in the species. It may be that the species reproduces primarily by vegetative means and that seed production is relatively unimportant (National Parks and Wildlife Service 1999b). It is unclear at this stage what factors trigger germination in *Microtis angusii*, or what level of seedling recruitment occurs. The time from germination to flowering is usually less than twelve months in *Microtis* species (National Parks and Wildlife Service 1999b).

Management Issues:

- Recovery plan - a draft plan has been prepared (National Parks and Wildlife Service 1999b).
- Lack of knowledge of the biology and ecology of the species.
- Fire management (fire is likely to be an important factor in the life cycle, but the most appropriate fire regime for the species is unknown).
- Habitat degradation (the only known site in Pittwater has been severely and repeatedly disturbed, and some level of disturbance, natural or otherwise, may be beneficial in promoting reproduction in the species, but other forms of disturbance are likely to be detrimental, such as soil compaction, rubbish dumping and overgrowth by weeds).
- Translocation (as an alternative to conservation *in situ*).
- Unauthorised collection of plant material (as a rare orchid, *Microtis angusii* is a possible target for unscrupulous orchid collectors).
- Community education.

2.3.4 *Persoonia hirsuta* (Hairy Geebung)

Family: Proteaceae

Conservation Status: Endangered species in NSW (TSC Act). Also listed as an endangered species at national level in the Endangered Species Protection Act.

Distribution: *Persoonia hirsuta* comprises two subspecies: *hirsuta* (narrower leaves with revolute margins) and *evoluta* (wider leaves with recurved margins). Both are considered to be endangered. Subspecies *hirsuta* grows along the coast from Gosford to Royal National Park, while subspecies *evoluta* extends from the Putty district west to Glen Davis and south to Hilltop. The subspecies intergrade extensively from the lower Blue Mountains to within 15 km of the coast (Harden 1991). The species has a very patchy distribution within its overall range, occurring as tiny populations in widely scattered locations.

Pittwater Population: The only record for the Pittwater Council area is from the vicinity of the Baha'i Temple at Ingleside (Scott 1995). A single plant was found here during a survey for *Grevillea caleyi* in 1994 (T. Auld pers. comm.). Another single plant was found during the 1994 *Grevillea caleyi* surveys about 2.5 km west of the Baha'i Temple at Tumbledown Dick Hill in Warringah. The latter plant has since been destroyed by human disturbance. The species has also been recorded in Ku-ring-gai Chase National Park, but not in Garigal National Park (NSW Scientific Committee 1998d).

Habitat: Typically grows in woodland or scrub/heath on sandstone, often where there is a clay influence at a shale/sandstone ecotone (James 1997). At both the Baha'i Temple and Tumbledown Dick Hill, the species was growing in the Duffys Forest Vegetation Community on lateritic soils associated with shale lenses within Hawkesbury Sandstone. This community has been listed as an endangered ecological community and is discussed below in section 2.6.1.

Ecology: *Persoonia hirsuta* is a spreading shrub that grows to about 1 m high, but may spread out over 2-3 m. At most of its known locations the population consists of only one to three plants (plus seeds in the soil seedbank), with the exception of two locations in the Baulkham Hills Local Government Area, where there are 10-20 plants (NSW Scientific Committee 1998d). There is evidence of a continued decline in the number of locations and the number

of individuals, and the species is particularly prone to local population extinctions because of the small number of plants found at all locations. The general ecology of the species and the requirements for successful reproduction are poorly known. Flowers are produced in November-January (Robinson 1994). The small population sizes suggest that the seeds germinate and successfully grow to maturity only under certain conditions, such as after a fire or other disturbance.

Management Issues:

- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Lack of knowledge of the biology and ecology of the species.
- Fire management (fire is likely to be an important factor in the life cycle, but the most appropriate fire regime for the species is unknown).
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Preservation of remnant individuals in urban areas.
- Translocation (as an alternative to conservation *in situ*).
- Unauthorised collection of plant material.
- Community education.
- Recovery plan (no plan has yet been prepared for this species).

2.4 Vulnerable Fauna Species

2.4.1 Giant Burrowing Frog (*Heleioporus australiacus*)

Another common name for the species is Eastern Owl Frog.

Family: Myobatrachidae

Conservation Status: Vulnerable species in NSW (TSC Act). Also listed as a vulnerable species at national level in the Endangered Species Protection Act.

Distribution: The Giant Burrowing Frog occurs on the coast and ranges from central New South Wales to eastern Victoria (Cogger 1992). It is more patchily distributed to the south of Jervis Bay than to the north (Ehmann 1997).

Pittwater Population: The Giant Burrowing Frog has been recorded recently in the upper reaches of Narrabeen Creek and Fern Creek, Ingleside (Ecotone Ecological Consultants 1993, White 1994), and on the track at the entrance to Ingleside Reserve (observed by M. Turton in 1996).

Habitat: In the Sydney region, the Giant Burrowing Frog occurs in eucalypt forest, woodland and heathland, usually on Hawkesbury Sandstone (Ehmann 1997). It breeds in burrows in the banks of small, densely vegetated creeks and drainage lines. Out of the breeding season, the frogs may disperse hundreds of metres away onto the nearby ridges. They usually spend the day in burrows, but also shelter under fallen logs and in dense undergrowth (Cogger 1992, White 1994). Like most frogs, they are most active during or directly after rain. In Pittwater, Giant Burrowing Frogs are most likely to be found in bushland on sandstone plateaus, ridges

and upper slopes in the western and southern suburbs, occurring either on Hawkesbury Sandstone or on the Narrabeen Group slopes directly below.

Feeding: The adult frogs feed on small insects and other invertebrates taken on or near the ground or in water. The tadpoles feed in water on plant material and detritus.

Breeding: For breeding, the Giant Burrowing Frog apparently requires small watercourses or pools that are clear and unpolluted (Ehmann 1997). The species often breeds twice a year, in spring and again in autumn, although the breeding season may vary, depending on rainfall (White 1994, Recsei 1997). Eggs are laid in a foam nest near one of the openings of the breeding burrow. After rain the burrow may flood, releasing the tadpoles to complete metamorphosis in a creek or shallow pool.

Management Issues:

- Conservation of remnant bushland.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Protection of waterways from degradation (pollution, siltation, erosion, weed invasion, hydrological changes), especially minor creeks draining sandstone plateaus, ridges and upper slopes.
- Control of cat and dog predation.
- Control of fox predation.
- Control of predation on eggs and tadpoles by the introduced Plague Minnow (*Gambusia holbrooki*).
- Road casualties.
- Rehabilitation of sick or injured animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.2 Red-crowned Toadlet (*Pseudophryne australis*)

Family: Myobatrachidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level it is regarded as an 'insufficiently known species that may be of concern' (Tyler 1997).

Distribution: Restricted to areas around Sydney on sandstone geology, with records from the vicinity of Cooranbong and Morisset in the north to Barren Grounds in the south, and west to Mount Victoria (Ehmann 1997).

Pittwater Population: There is a 1955 Australian Museum specimen of this species collected at Church Point. More recently, the Red-crowned Toadlet has been recorded on a ridgetop near Woorarra Lookout in Deep Creek Reserve (Paul Burcher, December 1995), in an ephemeral drainage line near Ingleside Road (Recsei 1997), in the upper reaches of Narrabeen

and Fern Creeks, Ingleside (Ecotone Ecological Consultants 1993, J. Recsei pers. comm.), and in a seepage area at the base of a cliff at Minkara Road, Bayview (Skelton 1999).

Habitat: The Red-crowned Toadlet is often gregarious and colonies may number between 20 and 30 individuals (Barker *et al.* 1995). The species inhabits eucalypt forest, woodland and heath on sandstone geology. Breeding sites are usually located along minor non-perennial creeklines and drainage lines running from the summit of sandstone ridges, or in seepage areas on sandstone slopes (Ehmann 1997). Clay layers are frequently present in the sandstone at the breeding sites, and there are usually large quantities of leaf litter along the drainage lines. The toadlets are not normally found in the vicinity of permanent water. When not breeding they may be found under logs and rocks away from drainage lines. In Pittwater, the species is most likely to be found on sandstone plateaus, ridges and upper slopes in the western and southern suburbs, occurring either on Hawkesbury Sandstone or on the Narrabeen Group slopes directly below.

Feeding: The diet of the adult frogs is thought to consist chiefly of ants and termites (Wotherspoon 1998), although they probably take other insects and other types of invertebrates as well. The tadpoles feed in water on plant material and detritus.

Breeding: Breeding may occur at any time of year, but is infrequent in winter (Wotherspoon 1998). Males build crude nests in moist leaf litter or dense vegetation along minor drainage lines or in seepage areas. The nests are often built in pockets of clay soils. The water-holding capacity of the clay may help with egg development. Each female lays 20-30 eggs, but a successful male may have several females lay eggs in his nest, which may accumulate over 100 eggs. Males attend the eggs until hatching. The eggs absorb water from the surroundings and develop to an advanced stage. Further development then ceases until enough rainfall occurs to immerse the eggs in water and they hatch. The water bodies in which the tadpoles develop are usually only small puddles (Ehmann 1997). Rain must be sufficiently frequent to keep these puddles replenished if the tadpoles are to survive to metamorphosis, which may take from 28 to 180 days (Wotherspoon 1998).

Management Issues:

- Conservation of remnant bushland.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Protection of waterways from degradation (pollution, siltation, erosion, weed invasion, hydrological changes), especially minor creeks draining sandstone plateaus, ridges and upper slopes.
- Control of cat and dog predation.
- Control of fox predation.
- Control of predation on eggs and tadpoles by the introduced Plague Minnow (*Gambusia holbrooki*).
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Road casualties.
- Rehabilitation of sick or injured animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.3 Rosenberg's Goanna (*Varanus rosenbergi*)

Another common name for the species is the Heath Monitor.

Family: Varanidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level the south-eastern Australian population of the species (but not the species as a whole) is regarded as 'rare or insufficiently known' (Cogger *et al.* 1993).

Distribution: Rosenberg's Goanna occurs in the southern parts of Western Australia and South Australia, with isolated populations in Victoria and New South Wales (Cogger 1992). In New South Wales it has been recorded from coastal areas around Sydney and further south, and west to Mount Victoria and the Canberra area (Swan 1990, Smith and Smith 1990a).

Pittwater Population: Observed at Walter Road, Ingleside, in 1993 in an area of woodland near the Council nursery and Ku-ring-gai Chase National Park (ICF and Australian Museum 1994). The only other record is a road casualty found at Ingleside in 1999 (reported in *Bushland News: Friends of Katandra*, vol. 6, no. 1, summer 1999).

Habitat: Rosenberg's Goanna inhabits eucalypt woodland and heathland on sandy soils. It is more typical of ridgetop and plateau vegetation than the more common Lace Monitor (*Varanus varius*), which often occurs in gully forests (Smith and Smith 1990a). It is also more of a ground dweller than the Lace Monitor, although it will climb trees when threatened. Rosenberg's Goannas shelter in burrows, hollow logs, rock crevices or under dense bushes (Green and King 1993). They usually dig the burrows themselves, but will use rabbit burrows if available. The presence of terrestrial termite mounds is an important habitat feature as these are used by the goannas as egg-laying sites.

Green and King (1978, 1993) estimated that individual Rosenberg's Goannas on Kangaroo Island, South Australia, ranged over an average area of about 19 ha, although this varied widely between individuals. There was considerable overlap of home ranges and burrows were often used by different animals on different nights. On some occasions two goannas were found in the same burrow.

Feeding: Rosenberg's Goanna is a diurnal hunter and scavenger. It feeds on a wide range of invertebrates, reptiles and mammals, less often on birds and frogs (King and Green 1979, Green and King 1993). A large proportion of its food is obtained from carrion. The diet also includes the eggs of reptiles and birds.

Breeding: Rosenberg's Goanna breeds in spring and summer. Eggs are laid in an active terrestrial termite mound and the site is then sealed off by the termites (King and Green 1979, Green and King 1993). Young are fully developed in the eggs by four months. However, they do not appear to hatch until the termite mound is re-opened, usually by a female about to lay her eggs in the same place in the following year (Ehmann 1992). Juveniles are rarely seen and may be semi-arboreal (Green and King 1993).

Management Issues:

- Conservation of remnant bushland.

- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Tree and shrub planting to enhance and re-establish movement corridors.
- Control of cat and dog predation.
- Control of fox predation.
- Road casualties.
- Rehabilitation of sick or injured animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.4 Australasian Bittern (*Botaurus poiciloptilus*)

Another common name for the species is Brown Bittern.

Family: Ardeidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level it is classified as insufficiently known (Garnett 1993).

Distribution: The Australasian Bittern occurs in eastern Australia from southern Queensland through most of New South Wales and Victoria to the south-eastern corner of South Australia. It is also found in Tasmania and in the far south-west of Western Australia. Small populations also occur in New Zealand and New Caledonia.

Pittwater Population: There have been a number of reports of the Australasian Bittern from Deep Creek and Narrabeen Lagoon over the last 20 years (e.g. Lindsey 1986, Morris and Burton 1996) and it appears to be a regular inhabitant along Deep Creek (Alan Foster pers. comm.). There are old records of the species from dense wet vegetation beside a creekline at Bayview Golf Course in 1970 (P. Smith) and from wetland vegetation at Nareen Creek, North Narrabeen, in 1938 (E. Hoskin, reported in Pittwater Council 1995b).

Habitat: The Australasian Bittern favours freshwater wetlands with tall, dense vegetation (*Phragmites*, *Typha*, *Juncus*, *Eleocharis*, *Baumea*, *Gahnia*, *Bolboschoenus*, etc.), but also occurs in estuarine and brackish wetlands, and sometimes in flooded, rank pastures (Marchant and Higgins 1990). It generally keeps to dense vegetation and can be difficult to detect. The species is thought to be sedentary in areas of permanent habitat, but a nomadic or migratory visitor to less permanent or less suitable habitats. Due to its cryptic habits, it is most commonly detected by the distant, repeated foghorn call of males. At Deep Creek, most of the suitable habitat occurs on the southern side of the creek in Warringah Local Government Area. The wetland areas along Nareen Creek are now choked with weeds and debris and are in very poor condition.

Feeding: The Australasian Bittern forages in still, shallow water up to 30 cm deep, often at the edges of pools or waterways, or from a platform or mat of vegetation over deep water (Marchant and Higgins 1990). The diet includes fish (often eels), frogs, crustaceans, insects, reptiles, small mammals and birds (Pringle 1985). Most feeding takes place at dusk or dawn or at night.

Breeding: The species builds a shallow, saucer-like nest in dense reeds or similar wetland vegetation, breeding as dispersed pairs rather than in colonies. The breeding season is October to February (Marchant and Higgins 1990). The clutch size is four or five.

Management Issues:

- Conservation of remnant wetland and creekline vegetation.
- Habitat degradation in remnant wetland and creekline vegetation (weed invasion, pollution, hydrological modification).
- Fire management.
- Protection of waterways.
- Control of cat and dog predation (nestlings and juvenile birds are likely to be particularly vulnerable).
- Control of fox predation.
- Disturbance at nesting and roosting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.5 Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

Family: Cacatuidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level, subspecies *lathami* is classified as rare (Garnett 1993), while subspecies *halmaturinus* from Kangaroo Island is classified as endangered and listed in the Endangered Species Protection Act.

Distribution: The Glossy Black-Cockatoo is endemic to Australia and consists of two subspecies. Subspecies *lathami* occurs from about Eungella in Queensland along the coast, ranges and western slopes of New South Wales to Gippsland and the Central Highlands of Victoria. It occurs as far west as Cobar and Griffith, but most New South Wales records come from the coast and tablelands (National Parks and Wildlife Service 1999a). Subspecies *halmaturinus* is restricted to Kangaroo Island and the nearby mainland in South Australia.

Pittwater Population: Glossy Black-Cockatoos have been widely reported in the Pittwater Council area, including Barrenjoey Peninsula as well as the southern and western areas of Pittwater (Map 3). Recorded locations during the last 12 years have included Palm Beach, Newport, Deep Creek, Bayview, Church Point, Browns Bay, Ingleside, Mackerel Beach, Lovett Bay and Scotland Island. The species has also been recorded from Ku-ring-gai Chase and Garigal National Parks. There have been no breeding records from the Pittwater Council area, although breeding is likely, especially in the larger, more secluded areas of bushland. The birds are locally nomadic, wandering widely over their local district in search of food plants. Birds seen on Barrenjoey Peninsula, for example, may come and go from Ku-ring-gai Chase National Park. Most sightings in the Pittwater area have been single birds or small parties of up to four birds. At Browns Bay, Glossy Black-Cockatoos are seen several times a year (Jill Madden pers. comm.) and this seems to be typical of the pattern of sightings in the bushier residential areas of Pittwater.

Habitat: Eucalypt forest and woodland. The birds have two major habitat requirements: she-oaks (trees and shrubs of the genera *Allocasuarina* and *Casuarina*), the seeds of which are almost their only food source; and old eucalypts (live or dead) with large hollows for nesting (Forshaw and Cooper 1981, Garnett 1993). Hollows large enough for nesting by species such as the Glossy Black-Cockatoo usually do not form in eucalypt trees less than about 200 years old (Mackowski 1984).

Feeding: The birds extract she-oak seeds from unopened, young but mature, cones with their powerful bills (Forshaw and Cooper 1981, Clout 1989). The birds prefer she-oak trees with greater numbers of seed cones (Clout 1989). In Pittwater, as elsewhere in coastal New South Wales, the main food species are Forest Oak *Allocasuarina torulosa* and Black She-oak *A. littoralis*, although they are also known to eat the seeds of Shrub She-oak *A. distyla* at times (P. and J. Smith pers. obs.) and occasionally feed on Swamp Oak *Casuarina glauca* seeds (Morris 1993). Both of the major food plants are common in the Pittwater area and one of them, *Allocasuarina littoralis*, appears to be increasing in numbers in the absence of major wildfires in isolated reserves such as Angophora Reserve (Smith and Smith 1992a) and McKay Reserve (Smith and Smith 1992b).

Breeding: Eggs are laid in New South Wales between March and June (Morris *et al.* 1981). A single egg is laid on decayed debris within a hollow limb or hole, either in a live old eucalypt or in a large dead tree (Forshaw and Cooper 1981). Although there have been no confirmed breeding records in the Pittwater Council area, adults accompanied by a single young bird have been reported at Deep Creek in 1989 (Morris and Burton 1992) and 1997 (Allan Foster pers. comm.), indicating that the birds probably bred nearby, either in Garigal National Park or in the Pittwater or Warringah Council areas.

Management Issues:

- Conservation of remnant bushland, especially areas with stands of *Allocasuarina torulosa* or *A. littoralis*, or with hollow-bearing trees suitable for nesting.
- Tree preservation in urban areas.
- Wildlife corridors.
- Habitat degradation in remnant bushland (eucalypt dieback and expansion of non-eucalypt vegetation as a result of changes to fire regimes, soil nutrient status and hydrology pose a long-term threat to the supply of nesting hollows, even though in some cases it is the food tree, *Allocasuarina littoralis*, that is increasing at the expense of the hollow-bearing eucalypts).
- Fire management (she-oaks 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).
- Control of cat predation (cats are known to climb up to tree hollows to take the young of other hollow-nesting cockatoos).
- Disturbance at nesting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the local Glossy Black-Cockatoo population, especially its local nesting sites.
- Recovery plan (no plan has yet been prepared for this species).

2.4.6 Sooty Oystercatcher (*Haematopus fuliginosus*)

Family: Haematopidae

Conservation Status: Vulnerable species in NSW (TSC Act).

Distribution: The Sooty Oystercatcher is a strictly coastal species endemic to Australia (Marchant and Higgins 1993). It occurs all around the coast of both mainland Australia and Tasmania. There are two subspecies: *ophthalmicus* on the northern coastline of Australia, and *fuliginosus* on the southern coastline. The species occurs all along the NSW coast, but apparently breeds only on offshore islands (Smith 1991).

Population Size: The total Australian population has been estimated at 4000 (Watkins 1993). The NSW population was estimated by Smith (1991) as about 200 birds, spread fairly evenly along the coast. However, Chafer (1993) subsequently counted 176 birds along the coast between Long Reef and Ulladulla, from which Morris and Burton (1994) estimated the size of the state population to be over 500 birds. The population fluctuates each year with the influx of young birds during the breeding season.

Pittwater Population: Sooty Oystercatchers have been recorded in recent years on a number of rock platforms along the Pittwater coast. In May and June 1998 they were recorded at Bangalley Head, Bungan Head/Little Reef and Turimetta Head (P. and J. Smith). Sooty Oystercatchers are usually seen as singles, pairs or in small autumn and winter flocks. A group of 23 Sooty Oystercatchers observed at Bungan Head and Little Reef in late May 1998 is particularly significant. This is one of the largest concentrations of Sooty Oystercatchers recorded in New South Wales (Smith 1991). The Pittwater rock platforms are clearly important feeding areas for the species and much more important than has previously been recognised. The species does not breed in the Pittwater area. The nearest known breeding sites are at Moon Island off Swansea and the Five Islands off Wollongong (Smith 1991).

Habitat: The Sooty Oystercatcher favours intertidal rock platforms and reefs for feeding, but also forages on ocean beaches and occasionally estuarine mudflats. A study in central Victoria found that after breeding on offshore islands in spring and early summer, Sooty Oystercatchers moved to mainland rocky shores in summer, and then to ocean beaches in winter. These regular movements between habitats corresponded to a reduced period of exposure of rocky intertidal feeding sites during winter (Considine 1982).

The Pittwater Council area includes ten major coastal rock platforms from Narrabeen Headland in the south to Barrenjoey Headland in the north (Pittwater Council 1997a). Each provides potential habitat for Sooty Oystercatchers. Particularly suitable areas are located at Turimetta Head, Mona Vale Headland, Bungan Head/Little Reef, South Bilgola Headland, Bangalley Head, Little Head and Barrenjoey Headland. The birds have not been recorded feeding on local beaches. Possibly the high level of human disturbance and the continual removal of seaweed at local beaches discourage the birds from feeding on the beaches in winter as reported in Victoria. However, the large numbers of birds seen on the Pittwater rock platforms in winter 1998 suggests that adequate food resources are available there and the birds do not need to seek alternatives.

Feeding: The Sooty Oystercatcher takes a wide range of prey, including various molluscs (limpets, snails, mussels, chitons and pipis), crustaceans (crabs, barnacles and sandhoppers),

marine worms, sea-squirts and even washed-up dead fish (Hindwood and Hoskin 1954, Considine 1979, Barker and Vestjens 1989).

Breeding: In New South Wales, the Sooty Oystercatcher apparently breeds only on offshore islands. The nest is a simple scrape in sand or shingle, sometimes in a small cave or under grass tussocks or on top of a rock. Generally two, rarely three, eggs are laid between October and December (Morris *et al.* 1981).

Management Issues:

- Depletion of intertidal invertebrate populations on rock platforms by over-collecting and excessive disturbance, which could potentially affect the food resources available to Sooty Oystercatchers.
- Excessive disturbance by people and dogs of birds feeding on rock platforms (a particular problem for birds that feed in intertidal areas because of the limited time available to them for foraging).
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.7 Pied Oystercatcher (*Haematopus longirostris*)

Family: Haematopidae

Conservation Status: Vulnerable species in NSW (TSC Act).

Distribution: The Pied Oystercatcher lives in Australia, New Zealand and southern New Guinea. There are two subspecies: *longirostris* in Australia and New Guinea, and *finschi* in New Zealand (Marchant and Higgins 1993). The species occurs around the entire Australian coastline, including Tasmania.

Population Size: The world population has been estimated at 11 000 and the Australian population at 10 000 (Watkins 1993). An estimated 250 Pied Oystercatchers occur in New South Wales, spread fairly evenly along the coast (Smith 1991).

Pittwater Population: It is likely that the Pied Oystercatcher was originally a resident breeding species in the Pittwater area, but the high levels of human disturbance on the local beaches and mudflats have since rendered them uninhabitable for this species. It now only occurs as a very rare and unusual visitor to the area. The most recent record is from Careel Bay at least 10 years ago (Steege 1988). The nearest sites where the species still occurs and breeds are at Empire Bay and at Botany Bay.

Habitat: In New South Wales, the Pied Oystercatcher favours ocean beaches and estuarine sand and mudflats (Smith 1991). At high tide, when their feeding grounds are covered, Pied Oystercatchers often gather in small flocks to roost on rocks or mud islands above water (Pringle 1987). The level of human disturbance in Pittwater would seem to be such that the area currently provides no usable habitat for the species.

Feeding: Pied Oystercatchers feed almost entirely in the intertidal zone on sandy beaches and mudflats (Pringle 1987, Marchant and Higgins 1993). Their chief prey appears to be

molluscs, both bivalves and gastropods. The birds also take marine worms and small fish (Barker and Vestjens 1989).

Breeding: The nest is a scrape in sand or shingle on coastal or estuarine beaches, typically near the high-tide mark (Marchant and Higgins 1993). The birds occasionally nest in saltmarsh or grassy areas. In New South Wales, eggs have been recorded between September and January (Smith 1991). At this time of year the level of disturbance on local beaches is probably too high to permit nesting. The usual clutch is two, sometimes one or three, rarely four. A second and occasionally a third clutch will be laid if earlier ones are lost, but only one brood is raised per season (Newman 1983). The incubation period is 28-32 days. The young fledge six to seven weeks after hatching and stay with the parents in the breeding territory for between one and six months. In a Tasmanian study, the average number of young raised by a pair was one every two years (Lane 1987). A pair will stay together and breed in the same site in successive years.

Management Issues:

The species is unlikely to recolonise its former habitats in the Pittwater area in the foreseeable future because of the high levels of human disturbance on coastal beaches and estuarine mudflats. No specific management initiatives are warranted for this species, which is only likely to occur as a rare, irregular and brief visitor to the area.

2.4.8 Black Bittern (*Ixobrychus flavicollis*)

Formerly known as *Dupetor flavicollis*.

Family: Ardeidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level it is regarded as a species 'of special concern' (Garnett 1993).

Distribution: The Black Bittern lives in southern Asia, New Guinea and Australia. There are at least three subspecies. The Australian birds have been treated by some authors as an endemic subspecies, *gouldii*, but are now considered to be subspecies *australis*, which also occurs in New Guinea and Indonesia (Marchant and Higgins 1990). The species occurs across northern Australia and down the eastern seaboard to eastern Victoria, with an isolated and declining population in the south-west of Western Australia (Blakers *et al.* 1984).

Pittwater Population: Repeated records over the last decade (e.g. Burton and Morris 1993, Morris and Burton 1993, 1996, Morris 2000, P. & J. Smith pers. obs.) suggest that the Black Bittern, a sedentary species, is resident along the lower section of Deep Creek. It has also been observed in Warriewood Wetlands, most recently in 1987 (Water Resources Consulting Services 1997).

Habitat: Usually found along timbered watercourses, in wetlands where there are fringing trees and, particularly in northern Australia, in mangroves (Marchant and Higgins 1990). Occurs in both freshwater habitats and estuarine or brackish habitats. Generally associated with permanent rather than temporary waters. Typically rests by day in waterside trees and shrubs, which are an important habitat feature, but may form only a narrow fringe to the wetland or watercourse.

Feeding: Forages at the edge of running or still waters. Mostly crepuscular or nocturnal, but may also feed during the day. The diet includes fish, frogs, lizards, crustaceans, insects and molluscs (Pringle 1985, Marchant and Higgins 1990).

Breeding: Breeds in dense waterside vegetation in secluded places, building a stick nest usually in a leafy tree overhanging or near the water. The breeding season is September to March (Marchant and Higgins 1990). The clutch size is three to five.

Management Issues:

- Conservation of remnant creekline and wetland vegetation.
- Habitat degradation in remnant creekline and wetland vegetation.
- Fire management.
- Protection of waterways.
- Control of cat and dog predation (especially when the birds are feeding at dusk and during the night).
- Predation by foxes.
- Disturbance at nesting and roosting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.9 Barking Owl (*Ninox connivens*)

Family: Strigidae

Conservation Status: Vulnerable species in NSW (TSC Act).

Distribution: The Barking Owl is widely distributed over the Australian mainland, but is absent from central Australia and Tasmania (Blakers *et al.* 1984). It also occurs in New Guinea and adjacent islands. There are two subspecies in Australia: *connivens* in southern Australia and *peninsularis* in northern Australia. The species was recorded around Sydney in earlier years, then there were no records from 1903 until 1973 (Hoskin *et al.* 1991, Debus 1997). Since then, there have been a number of records from various sites around Sydney, particularly the northern suburbs and the northern parts of the Cumberland Plain, and breeding has been confirmed.

Pittwater Population: Heard calling at Avalon and Deep Creek in September-October 1978 (Debus 1997). One seen in eucalypt woodland near the Pittwater Council nursery at Ingleside in December 1993 (ICF and Australian Museum 1994). One seen a number of times on Scotland Island in January-March 1998 (Atlas of NSW Wildlife), and again in late winter 1999 (Tabatha Smith, pers. comm.). Also recorded at Palm Beach in April 1999 (reported to Council).

Habitat: The Barking Owl inhabits eucalypt forest and woodland, usually on fairly fertile soils. It seems to prefer open woodland vegetation and forest margins, rather than forest interiors. Timbered rivers and creeklines are a favoured habitat, especially inland, but also in coastal regions (Kavanagh *et al.* 1995, Debus 1997). The birds roost by day in trees or tall

shrubs. Although they often roost in eucalypts, they seem to prefer more densely foliated trees and shrubs when these are available.

Feeding: The Barking Owl is a generalised and adaptable nocturnal predator, with wide dietary flexibility that probably varies according to local prey availability. It feeds mainly on birds and mammals, but also takes many insects. A notable feature of the diet, compared with other large Australian owls, is the frequency of birds and insects as prey items. Introduced mammals and birds are major prey items in some areas. Typical mammalian prey include the European Rabbit, Sugar Glider and Black Rat, while typical bird prey include the Galah, Common Starling and Eastern Rosella (Kavanagh *et al.* 1995, Debus 1997).

Breeding: Barking Owls are dependent on hollows in old eucalypts for nest sites, and usually select hollows in live trees rather than dead trees. They are strictly seasonal breeders, raising a single brood per year. In New South Wales most eggs are laid in late winter and early spring, mainly August to October (Debus 1997). The incubation period is about 36 days. The chicks fledge at about seven weeks, but remain dependent on the adults until late summer (Strahan 1994).

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Control of cat predation (cats are known to climb up to tree hollows to take the young of other large hollow-nesting birds).
- Road casualties.
- Disturbance at nesting and roosting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.10 Powerful Owl (*Ninox strenua*)

Family: Strigidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level it is classified as rare (Garnett 1993).

Distribution: The Powerful Owl is endemic to the forests of south-eastern mainland Australia, from Yeppoon in eastern Queensland to the Victoria/South Australia border, mainly from the Great Dividing Range to the coast, although it does extend onto the inland slopes of the Great Dividing Range in places (Schodde and Mason 1980, Blakers *et al.* 1984).

Pittwater Population: There have been 30 records of Powerful Owls in the Pittwater Council area (appendix), most (26) of which have been for the period 1993-2000. This is consistent with an apparent general increase in the species in the Sydney area over the last decade. A similar trend has also been evident in the Blue Mountains (personal observations). Most of

the Pittwater records have come from the western parts of the area (Ingleside, Warriewood, Church Point, Bayview and western Mona Vale; Map 3). There have been only four records from Barrenjoey Peninsula: Newport 1980, Bungan Beach 1993, McKay Reserve 1998 and Avalon 1999 (appendix). Young birds have been reported at Narrabeen Creek, Warriewood, in 1994 (M. Cutting pers. comm.), McCarrs Creek, Church Point, in 1995 (Pittwater Council 1997a) and Bayview Woods in 1996 (Antcliff 1996), indicating that the species breeds in Pittwater.

Habitat: Breeding pairs are sedentary within large territories, whose size has been estimated at between 400 and 1450 ha (Fleay 1968, Seebeck 1976, Davey 1993). The species occurs chiefly in taller, wetter eucalypt forests, but also uses drier eucalypt forest and woodland, riparian habitats and rainforest (Debus 1993a, Debus and Chafer 1994). The birds roost by day in trees or tall shrubs, generally selecting those with dense canopies, such as Turpentine, she-oaks and rainforest trees. Favoured roost trees tend to be located in gullies rather than on ridges.

Feeding: The Powerful Owl feeds chiefly on small to medium-sized arboreal mammals. In Pittwater, its main prey species is likely to be the Common Ringtail Possum. The Sugar Glider and Squirrel Glider are also known prey. Other known prey items include flying-foxes, terrestrial mammals, birds and insects (Davey 1993, Debus 1993a, Debus and Chafer 1994).

Breeding: Powerful Owls reach sexual maturity at two years of age and pairs appear to mate for life. They nest in the hollows of mature, live eucalypts, usually in or near densely timbered gullies (Debus and Chafer 1994). Nest trees used are typically emergents, often the largest and oldest trees within the forest stand. Breeding is strictly seasonal and two eggs are laid in late autumn to mid-winter. The young remain dependent on the adults through to the next breeding season, which they may inhibit (Debus and Chafer 1994).

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Control of cat predation (cats are known to climb up to tree hollows to take the young of other large hollow-nesting birds).
- Road casualties (one has recently been reported killed on Mona Vale Road).
- Disturbance at nesting and roosting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.11 Osprey (*Pandion haliaetus*)

Family: Accipitridae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level it is regarded as a species 'of special concern' (Garnett 1993).

Distribution: The Osprey is widely distributed around the world, breeding in North America, Europe, Asia and Australia, and occurring as a non-breeding migrant in South America and Africa. Four subspecies are usually recognised, one of which, *leucocephalus*, occurs in Australia, New Guinea, Indonesia, Solomon Islands and New Caledonia (Marchant and Higgins 1993). It is found around the entire Australian coastline, but is only a rare non-breeding visitor to southern New South Wales, Victoria and Tasmania. Birds are also occasionally recorded on inland rivers and impoundments. The records from south-eastern and inland Australia show that individual birds may wander widely, but breeding adults appear to be sedentary in Australia and do not undertake migratory movements like populations in the northern hemisphere. After an earlier decline in New South Wales, the Osprey now appears to be increasing again, and the state breeding population is over 80 pairs (Morris and Burton 1997, Morris 2000). Clancy (1991) estimated its size as only 45-50 breeding pairs in 1990. The species is believed to have nested regularly near Sydney last century (Hoskin *et al.* 1991). However, the only confirmed nesting record south of Port Stephens during this century was a pair that nested but failed at South Kincumber in 1996 (Morris and Burton 1999).

Pittwater Population: Over the last decade, one or two Ospreys have been regularly recorded about Narrabeen Lagoon and the lower reaches of Deep Creek (e.g. Burton and Morris 1993, Morris and Burton 1993, Morris 2000). In recent years, a male and female pair (in adult birds the female is considerably larger than the male) have been observed a number of times apparently courting (Alan Foster pers. comm.; P. and J. Smith observations in May 1997 and May 1998) and are likely to nest in the area, either on the northern (Pittwater) or southern (Warringah) side of Deep Creek. Elsewhere in Pittwater, Ospreys have been recorded in the Pittwater inlet and along the coast at Whale Beach.

Habitat: The Osprey is predominantly coastal in Australia, feeding along the coast, in bays and estuaries and up coastal rivers and creeks (Marchant and Higgins 1993). It is not usually observed far from shore at sea, but ranges further offshore in bays and inlets. Sheltered waters are favoured because they provide protection from high waves and winds that interfere with fishing (Poole 1989). In the Pittwater area, Narrabeen Lagoon appears to be the most favoured feeding habitat.

Feeding: The Osprey preys chiefly on fish, although small terrestrial vertebrates, seabirds and crustacea have also been recorded as prey items (Marchant and Higgins 1993). The birds hunt over bodies of water, dropping steeply when prey is sighted and plunging feet-first into the water to capture their prey. Mullet feature prominently in the diet in New South Wales (Clancy 1991).

Breeding: Nests are large and bulky stick structures. The nesting site varies throughout the world from live or dead trees to cliffs, the ground and artificial structures such as power poles. In New South Wales the normal nesting site is a tall tree, usually dead, but occasionally alive (Clancy 1991). Sometimes they nest in a mangrove or other low bush, or on an artificial structure. Nest trees are typically located in exposed positions near water (usually within 1 km). Eggs are laid in New South Wales between July and September, and the young fledge between October and December (Marchant and Higgins 1993). Usually two or three, rarely four, eggs are laid. Resident pairs of Ospreys develop traditional nest sites. They use and add to the same nest year after year, sometimes eventually producing a massive pile of sticks and other materials.

Management Issues:

- Conservation of remnant bushland that may provide nesting sites.
- Habitat degradation in remnant bushland.
- Fire management.
- Protection of waterways - fish populations, particularly in Narrabeen Lagoon, where Ospreys feed regularly, could be impacted by pollution, overfishing, increased turbidity (making prey less visible) and other forms of aquatic habitat degradation.
- Disturbance of birds at nesting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the Pittwater Ospreys, particularly their possible nesting site or sites.
- Recovery plan (no plan has yet been prepared for this species).

2.4.12 Masked Owl (*Tyto novaehollandiae*)

Family: Tytonidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level, subspecies *novaehollandiae* is classified as rare (Garnett 1993), while subspecies *kimberli* and *melvillensis* are classified as vulnerable and listed in the Endangered Species Protection Act.

Distribution: The Masked Owl inhabits Australia, southern New Guinea and adjacent islands. Four subspecies are recognised in Australia: *novaehollandiae* in eastern and southern mainland Australia, from Cooktown in north-eastern Queensland around to the Pilbara in Western Australia (including records along inland watercourses); *kimberli* in northern Australia, from Cooktown across to the Kimberley Region of Western Australia; *melvillensis* on Melville and Bathurst Islands in the Northern Territory; and *castanops* in Tasmania (Blakers *et al.* 1984).

Pittwater Population: The Masked Owl was recorded at Avalon in 1935 (roosting under the canopy of a Cabbage-tree Palm) and Newport in 1965 (Debus and Rose 1994). In 1974 a pair was present at Warriewood throughout the year and attempted nesting, evidently without success (Rogers 1975). There have been no records of the Masked Owl in Pittwater since. However, it is a cryptic species and may still be present in the area. It has been recorded elsewhere in northern Sydney in recent years.

Habitat: The Masked Owl is a sedentary species and is most numerous in eucalypt forest and woodland, particularly where there is a mosaic of dense and open vegetation. Such areas provide old, hollow-bearing eucalypts for roosting and nesting, and more open vegetation and forest edges for hunting. The vegetation mosaic may enhance prey density and diversity and hence foraging opportunities. The species requires a large territory of 500-1000 ha per pair in coastal forested areas, with neighbouring pairs well separated (Debus and Rose 1994). The birds usually roost in tree hollows during the day, but will occasionally roost in dense vegetation.

Feeding: The Masked Owl preys opportunistically upon ground mammals up to rabbit size. The main prey appears to be terrestrial mammals and in disturbed areas introduced species such as House Mice and Black Rats are important prey items. Some arboreal prey is also taken, including possums and birds. The owls tend to hunt in cleared land at the forest edge,

along roads and other clearings within forests, and in open woodland. The Masked Owl is believed to be a stationary hunter, using a regular series of low perches within its territory to wait for prey, which it locates by sound. Prey appears to be taken in a slow deliberate attack rather than by pursuit (Debus 1993b, Debus and Rose 1994).

Breeding: The Masked Owl nests in tree hollows, typically in live eucalypts in moist, sheltered areas such as gullies and creeklines. In New South Wales breeding occurs from late February to early October, commonly March to July, and one or two chicks are reared per pair (Debus and Rose 1994).

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas, especially large, old, hollow-bearing eucalypts (potential roosting and nesting sites).
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Control of cat predation (cats are known to climb up to tree hollows to take the young of other large hollow-nesting birds).
- Road casualties (the species is particularly vulnerable because of its habit of hunting along roads).
- Disturbance at nesting and roosting sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.13 Large-eared Pied Bat (*Chalinolobus dwyeri*)

Family: Vespertilionidae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level, it is not listed on the Endangered Species Protection Act, but has been identified as a vulnerable species in the recent Action Plan for Australian Bats (Duncan *et al.* 1999).

Distribution: The Large-eared Pied Bat has been recorded from scattered localities in eastern Australia from near Rockhampton in central coastal Queensland to Bungonia in southern New South Wales.

Pittwater Population: Calls that were subsequently identified as the Large-eared Pied Bat were recorded in September 1998 at dusk at the entrance of St Michaels Cave, North Avalon (P. and J. Smith). The bat (or bats) had apparently been roosting in the cave with several hundred Common Bentwing-bats.

Habitat: The Large-eared Pied Bat has been recorded from a range of habitats in New South Wales, including dry and wet eucalypt forest, *Callitris* forest, eucalypt forest with a rainforest understorey, sub-alpine woodland and sandstone outcrop country (Duncan *et al.* 1999). Daytime roost sites are caves and disused mine shafts, and even the abandoned, bottle-shaped

mud nests of Fairy Martins. In caves, individuals huddle in groups of 3 to 37, often close to the cave entrance, in contrast to other cave-dwelling bats, which usually seek the deeper, darker parts of cave systems (Hoye and Dwyer 1995, Churchill 1998).

Feeding: Little is known about the species' foraging ecology, but it probably forages for small flying insects below the forest canopy (Hoye and Dwyer 1995). It flies relatively slowly, with rapid but shallow wing beats (Churchill 1998). The flight is direct and moderately manoeuvrable.

Breeding: Knowledge of the species is largely based on observations at Copeton in northern New South Wales (Hoye and Dwyer 1995). Up to 13 adult females and a few males assembled here deep inside a mine tunnel in early spring. Females gave birth to one or two young during late November and early December and these were suckled until late January. The colony dispersed during autumn and became difficult to locate until the following spring. It is likely that they hibernate over winter. It is uncertain whether mating occurs early in winter or in spring. Banding records show that females can give birth when 12 months old (Hoye and Dwyer 1995).

Management Issues:

- Conservation of remnant bushland.
- Wildlife corridors
- Habitat degradation in remnant bushland.
- Fire management.
- Disturbance of bats roosting in caves, stormwater drains and similar sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.14 Spotted-tailed Quoll (*Dasyurus maculatus*)

Other common names for the species are Tiger Quoll or Tiger Cat.

Family: Dasyuridae

Conservation Status: Vulnerable species in NSW (TSC Act). At national level, subspecies *maculatus* is listed as vulnerable and subspecies *gracilis* (the North Queensland form) as endangered in the Endangered Species Protection Act.

Distribution: The species is endemic to Australia and consists of two subspecies. Subspecies *gracilis* is restricted to north-eastern Queensland, while subspecies *maculatus* is patchily distributed from south-eastern Queensland, through New South Wales, to western Victoria and Tasmania (Maxwell *et al.* 1996). It formerly extended also to south-eastern South Australia, but now appears to be extinct there. Its range has also contracted markedly in Victoria and Queensland (Mansergh 1984).

Pittwater Population: The Spotted-tailed Quoll has been recorded from both Ku-ring-gai Chase and Garigal National Parks. There have also been several records in the Pittwater Council area. One was observed raiding a guinea-pig pen at Elvina Bay in the early 1990s (Pittwater Council 1997b). An adult male was trapped at a chicken coop in Marinna Road, Elanora Heights, on 9 May 1993, after a couple of reports in the area on 6 May. It was tagged

and released in the Deep Creek area, but turned up and was re-trapped months later at Granville, again at a chicken coop (D. Andrew pers. comm.). One was reported at Avalon on 18 May 1993, possibly the same animal. More recently, there have been reports from western Mona Vale in July 1998 and summer 1999 (appendix).

Habitat: In Pittwater, remnant areas of eucalypt forest and woodland, and rainforest provide potential habitat for the Spotted-tailed Quoll. It is most likely to be found in or near Ku-ring-gai Chase and Garigal National Parks or in bushland areas that connect with the parks. Radio-tracking studies at two sites in northern New South Wales have shown that individual quolls have large home ranges of 3.5 to 15 km², those of males being two or three times larger than those of females (Firestone 1996, D. Andrew pers. comm.). During a single night an animal may move several kilometres. Although forested areas appear to be the core habitat, quolls may also be found, at least occasionally, in adjacent habitats such as heathland, farmland and urban areas. Males wander widely in May, June and July during the mating season. Most of the quolls that are trapped at chicken coops or killed on roads are males (D. Andrew pers. comm.). Quolls are nocturnal and rest during the day in hollow trees or logs, rock crevices or caves, although they may bask or forage in daylight when the weather is cold.

Feeding: The Spotted-tailed Quoll is an opportunistic hunter and scavenger. It is known to prey on a variety of native and introduced mammals (up to small wallabies in size), birds, reptiles and invertebrates, including poultry and other domestic birds and mammals, and it also feeds on carrion (Menkhorst 1995, Belcher 1995). It apparently hunts mostly on the ground, but it is an agile climber and may take some prey in trees and use trees as vantage points to detect and pounce on prey (Settle 1978). In eastern Victoria, Belcher (1995) found it to be largely dependent on medium-sized mammals (0.5-5 kg), the most important prey species being the European Rabbit *Oryctolagus cuniculus*, Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus*. Young quolls tended to feed on smaller prey than adults, taking more small mammals (such as rats and antechinus), Common Ringtail Possums, reptiles and invertebrates, and fewer rabbits.

Breeding: Both sexes become sexually mature when about one year old and mating takes place in late autumn and winter (Fleay 1940, Edgar and Belcher 1995, Menkhorst 1995). An average litter of five young is born three weeks after mating. Young are attached to the teat for approximately seven weeks, are suckled in the nest for a further six weeks and become independent at about five months

Management Issues:

- Conservation of remnant bushland.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Road casualties.
- Rehabilitation of sick, injured or orphaned animals.
- Community education, especially to prevent destruction of quolls that attack chicken coops and aviaries.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.15 Common Bentwing-bat (*Miniopterus schreibersii*)

Family: Vespertilionidae

Conservation Status: Vulnerable species in NSW (TSC Act). Classified as 'lower risk (least concern)' at national level (Duncan *et al.* 1999).

Distribution: The Common Bentwing-bat has a wide distribution including Australia, New Guinea, the Indo-Malayan archipelago, Africa and Eurasia to 45° north. Two subspecies are currently recognised in Australia. Subspecies *orianae* occurs in north-western Australia, while subspecies *oceanensis* occurs along the coast and ranges, from north Queensland to the far south-eastern corner of South Australia. The two subspecies are expected to be elevated to separate species in the near future (Duncan *et al.* 1999). Populations in South Australia and western Victoria are considered to represent another distinct form that warrants taxonomic recognition.

Movements: Common Bentwing-bats are strong fliers and often travel long distances, with one individual recorded moving 1300 km (Dwyer 1969). The pattern of movement varies in response to local climatic conditions and the dispersion of suitable roosting and breeding caves. With the onset of spring, adult females move from numerous widely scattered roosts to specific nursery caves where the young are born and reared to independence (Dwyer 1966, 1969, 1995). Scattered colonies located within a single large watershed often use a particular nursery cave year after year. Nursery colonies disband between February and March, adults and juveniles going separate ways, with some juveniles dispersing many hundreds of kilometres at this time.

Pittwater Population: There have been a number of recent records of this bat in Pittwater based on identification of their calls. It was recorded in Deep Creek Reserve and McKay Reserve in February/March 1996 (Turton 1996) and at Bayview Woods in November 1996 (Ecotone Ecological Consultants 1997). It was recorded at Bayview Golf Course in February 1998 (Skelton and Williams 1998) and May 1998 (P. and J. Smith). Bats are known by local residents to occur regularly in St Michaels Cave, North Avalon. These were identified as Common Bentwing-bats in September 1998 from their calls as they emerged at dusk (P. and J. Smith). Several hundred had been roosting in the cave, although only about 20 had been seen there on a visit a month before. It is clearly an important roosting site for the species in the Sydney region, but the bats are unlikely to breed in this cave. There are no known nursery caves in the vicinity of Sydney, the nearest being at Bungonia (Dwyer 1969). Unidentified bats that may be this species have been reported roosting elsewhere in Pittwater at Careel Cave and in a culvert at the Bilgola Bends.

Habitat: The Common Bentwing-bat has been recorded in a wide range of habitats from grasslands through to subtropical rainforests, but it is typically found in well-timbered valleys (Dwyer 1995). Its chief habitat requirements are for suitable roosting and breeding sites. These are found in caves, mines, stormwater pipes and similar sites, even sometimes in buildings. Colonies vary greatly in size. Some are dominated by males, others by females; some consist mainly of adults, others mostly young (Dwyer 1966). In winter the bats occupy special winter caves or specific sites within caves that are typified by cold temperatures and stable humidity, allowing them to hibernate at a time when insect food is scarce (Hall 1982). In spring the females gather in large colonies in which to give birth and nurture young. Nursery caves are of a more specific nature than normal roosting sites, being characterised by high temperature and humidity throughout the year or being shaped such that the air warmed

by the bats' activities is retained within the cave while the colony is present (Dwyer 1981). Nearly all adult females within a radius of several hundred kilometres may congregate in the one nursery cave and such caves are of critical importance for the survival of the species at a regional level (Dwyer 1995, Gilmore and Parnaby 1994).

Feeding: Common Bentwing-bats fly level and fast, making rapid shallow dives for flying insects above the vegetation canopy. They can lay down fat reserves before winter and in many areas feeding virtually ceases during the coldest months, possibly because of a scarcity of insects (Dwyer 1966, 1995, Reardon and Flavel 1987). The main dietary item is believed to be moths (Churchill 1998).

Breeding: The bats are sexually mature in their second year and may live to over 17 years (Dwyer 1995). In New South Wales, mating occurs from late May to early June, just prior to hibernation. Delayed implantation occurs and development of the young does not commence until late August. Births occur in December (one young per female), young are independent by February or March, and then disperse over long distances (Dwyer 1963, 1966, Richardson 1977).

Management Issues:

- Conservation of remnant bushland. (The floristic diversity of an area is important as it promotes the diversity and abundance of the insect populations that bats feed on. Habitat fragmentation results in isolated pockets of degraded vegetation, but even these can help bats to move between larger areas of bushland, so their Conservation in urban areas is important.)
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Disturbance of bats roosting in caves, culverts and similar sites.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.4.16 Greater Broad-nosed Bat (*Scoteanax rueppellii*)

Formerly known as *Nycticeius rueppellii*.

Family: Vespertilionidae

Conservation Status: Vulnerable species in NSW (TSC Act). Classified as 'lower risk (near threatened)' at national level (Duncan *et al.* 1999).

Distribution: This bat is endemic to Australia and is restricted to the east coast and adjacent areas of the Great Dividing Range, from the Atherton Tableland in northern Queensland south to the Victorian border (Parnaby 1992, Hoye and Richards 1995). In the southern part of its range it appears to be restricted to lower altitude forests, while in the central part it occurs in both coastal and upland areas (Duncan *et al.* 1999). In the north it is apparently restricted to higher altitudes.

Pittwater Population: The Greater Broad-nosed Bat was recorded at Bilgola in July 1982 (Long 1983) and at Deep Creek Reserve in February/March 1996 (Turton 1996).

Habitat: The species occurs in a variety of habitats, including dry and wet eucalypt forest and woodland, and rainforest, but apparently prefers moist gully forests (Churchill 1998). It usually roosts in tree hollows (chiefly eucalypts), but has also been recorded in the roof spaces of old buildings (Hoye and Richards 1995). It is believed to be dependent on mature forest on soils of high fertility (Braithwaite *et al.* 1993)

Feeding: The species has a varied insectivorous and carnivorous diet. Its flight is slow and direct, with poor manoeuvrability. It feeds on slow-flying prey such as large moths and a variety of beetles (Churchill 1998). It regularly consumes other bat species, at least in bat traps (Gilmore and Parnaby 1994). In dense vegetation it forages along natural and man-made flyways such as roads. Creeks and small rivers are favoured corridors where the species hawks backwards and forwards for prey, sometimes within 1 m of water. It also hunts at forest edges (Hoye and Richards 1995).

Breeding: Prior to birth, females congregate at maternity sites, located in suitable tree hollows, where males appear to be excluded during the birth and raising of the young. The single young is born in January (Hoye and Richards 1995).

Management Issues:

- Conservation of remnant bushland.
- Tree preservation in urban areas.
- Wildlife corridors.
- Habitat degradation in remnant bushland.
- Fire management.
- Rehabilitation of sick, injured or orphaned animals.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.5 Vulnerable Flora Species

2.5.1 *Eucalyptus camfieldii* (Heart-leaved Stringybark)

Family: Myrtaceae

Conservation Status: Vulnerable species in NSW (TSC Act). Also listed as a vulnerable species at national level in the Endangered Species Protection Act

Distribution: Rare and localised, usually in coastal scrub or heath, from Norah Head south to Bulli Pass and west to Peats Ridge and Hornsby. It has been recorded in Brisbane Water, Ku-ring-gai Chase, Royal and Sydney Harbour National Parks (Briggs and Leigh 1996).

Pittwater Population: As yet, not recorded in the Pittwater Council area. However, it occurs just outside the area in Ku-ring-gai Chase National Park, west of Elvina Bay (Lembit 1997,

Atlas of NSW Wildlife). It is a potential inhabitant of ridges and plateaus on Hawkesbury Sandstone geology in the western and southern parts of Pittwater.

Habitat: *Eucalyptus camfieldii* is found on sandstone ridgetops with shallow, low-nutrient soils, often where drainage is restricted. Soils are sandy or loamy, often lateritic. Typically these ridgetops support heath which includes species such as *Allocasuarina distyla*, *Angophora costata*, *A. hispida*, *Banksia oblongifolia*, *Corymbia gummifera*, *Eucalyptus haemastoma*, *E. oblonga*, *E. sieberi* and *Leptospermum trinervium* (Pryor 1981, Benson and McDougall 1998).

Ecology: *Eucalyptus camfieldii* is a mallee or small tree that is usually only 3-5 m high, although the bigger specimens may reach about 10 m (Pryor 1981, Benson and McDougall 1998). The plants live for more than 100 years and develop extensive lignotubers which may be up to 25 m across. What appears to be a large number of plants may be only one or a few individuals, and consequently population sizes are difficult to measure. The flowering period is variable and extends between April and December. The woody seed capsules are retained for up to one year before the seed is shed. Seed is dispersed locally by wind or gravity and there is no dormancy mechanism. Seeds are able to germinate without treatment, but seedlings are rarely reported. Following fire the species resprouts from the lignotuber and epicormic buds. Plants at North Head during the 1980's appeared to be dying in the absence of fire (30 years unburnt) due to competition from taller vegetation (Benson and McDougall 1998).

Management Issues:

- Lack of knowledge of the species in Pittwater (likely to occur in the area, but no known sites).
- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management.
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Preservation of remnant individuals in urban areas.
- Translocation (as an alternative to conservation *in situ*).
- Unauthorised collection of plant material.
- Community education.
- Recovery plan (no plan has yet been prepared for this species).

2.5.2 *Pimelea curviflora* variety *curviflora* (Curved Rice-flower)

Family: Thymelaeaceae

Conservation Status: Vulnerable species (variety *curviflora* only) in NSW (TSC Act). Variety *curviflora* is also listed as vulnerable at national level in the Endangered Species Protection Act.

Distribution: *Pimelea curviflora* is a widespread species in which seven varieties have been distinguished (Threlfall 1983). The species is endemic to Australia and is found in all states. Six of the seven varieties occur in New South Wales (Harden 1990). Some of the varieties are common, but variety *curviflora* is restricted to the northern suburbs of Sydney and is rare

even within its restricted distribution. It is currently known from about 20 locations between South Maroota, Cowan, Narrabeen, Allambie Heights, Northmead and Kellyville (NSW Scientific Committee 1998e). Its former range extended south to the Parramatta River and Port Jackson, including Five Dock, Bellevue Hill and Manly.

Pittwater Population: As yet, *Pimelea curviflora* var. *curviflora* has not been recorded in the Pittwater Council area. However, it occurs just south of the area on the southern side of Narrabeen Lagoon (Smith and Smith 1995). In view of this, it is a species that should be targeted in future threatened flora surveys in Pittwater.

Habitat: In Warringah, *Pimelea curviflora* var. *curviflora* is mainly found in the Duffys Forest Vegetation Community (Smith and Smith 1997b, 2000). This community is associated with shale lenses on ridges in Hawkesbury Sandstone geology. It has been listed as an endangered ecological community and is discussed below in section 2.6.1. The population on the southern side of Narrabeen Lagoon is an exception, being found in *Angophora* Woodland, a Hawkesbury Sandstone community dominated by *Angophora costata* and found on ridges and slopes in the vicinity of coastal lagoons and estuaries (Smith and Smith 1995, 1997b). This community, like the Duffys Forest Vegetation Community, is a taller vegetation type than is typical of Hawkesbury Sandstone ridges, and appears to be associated with more fertile conditions.

Ecology: *Pimelea curviflora* var. *curviflora* is a spindly, inconspicuous subshrub or shrub, mostly under 50 cm high. It may not always be visible at a site as it appears to survive for some time without any foliage after fire or grazing, relying on energy reserves in its tuberous roots (NSW Scientific Committee 1998e). Little is known of its ecological requirements.

Management Issues:

- Lack of knowledge of the species in Pittwater (likely to occur in the area, but no known sites).
- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management.
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Translocation (as an alternative to conservation *in situ*).
- Community education.
- Recovery plan (no plan has yet been prepared for this species).

2.5.3 *Syzygium paniculatum* (Magenta Lillypilly)

Family: Myrtaceae

Conservation Status: Vulnerable species in NSW (TSC Act). Also listed as a vulnerable species at national level in the Endangered Species Protection Act.

Distribution: Grows naturally at widely separated localities in coastal areas between Bulahdelah and Jervis Bay (Harden 1991). It has been recorded in Booti Booti National Park, Myall Lakes National Park, Wamberal Lagoon Nature Reserve, Wyrabalong National Park, Captain Cooks Landing Place Historic Site and Jervis Bay National Park (Briggs and Leigh

1996). Although rare in the wild, it is a popular ornamental species and is widely cultivated in the Sydney region (Benson and McDougall 1998). There may be some confusion over the name *Syzygium paniculatum* because in the past it was also applied to another, more common species now known as *Syzygium australe* (Brush Cherry), e.g. Floyd (1979).

Pittwater Population: In Pittwater, reported from Browns Bay (Cunningham 1994a), Scotland Island (Cunningham 1994a), Irrawong Reserve (Cunningham 1994b), and Hillside Road, Newport (Burcher 1999).

Habitat: *Syzygium paniculatum* typically grows in littoral (beach) rainforest on coastal sand dunes or in gallery (watercourse) rainforest on alluvial soils (Benson and McDougall 1998). However, it also grows in other rainforest types and in wetter eucalypt forest types. At Irrawong Reserve, it grows in alluvial Swamp Mahogany *Eucalyptus robusta* forest along Mullet Creek (Cunningham 1994b). Elsewhere in Pittwater it has been recorded growing on moist slopes on Narrabeen Group geology.

Ecology: *Syzygium paniculatum* varies in size from a shrub to a medium-sized tree. The trees live for 75-200 years. They produce flowers in December-January and are able to self-pollinate. Fruits are purple fleshy berries. Trees fruit irregularly, perhaps every second year. Fruits are dispersed locally by gravity and possibly more widely by birds and mammals, such as the Pied Currawong and Grey-headed Flying Fox, both of which are known to eat the fruit. Each fruit can produce multiple seedlings. Seeds are viable for less than three months and germinate readily without treatment. Seedlings found under adult plants are possibly short-lived. *Syzygium paniculatum* tolerates shade but needs light for regeneration. Trees may be killed by wildfire or may resprout from the base or epicormic shoots (Benson and McDougall 1998).

Management Issues:

- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management.
- Preservation of remnant individuals in urban areas.
- Translocation (as an alternative to conservation *in situ*).
- Loss of genetic integrity of the Pittwater population through interbreeding with planted specimens from other regions.
- Unauthorised collection of plant material.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.5.4 *Tetratheca glandulosa* (Glandular Pink-bell)

Family: Tremandaceae

Conservation Status: Vulnerable species in NSW (TSC Act). Also listed as a vulnerable species at national level in the Endangered Species Protection Act.

Distribution: *Tetratheca glandulosa* is endemic to the Sydney region, where it is restricted to the area between Mangrove Mountain and Port Jackson (Harden 1992).

Pittwater Population: *Tetratheca glandulosa* has been recorded from six locations in the Pittwater Council area during the last few years, all at Ingleside (appendix, Map 4). It has also been recorded in both Ku-ring-gai Chase National Park (Thomas and Benson 1985) and Garigal National Park (Sheringham and Sanders 1993).

Habitat: *Tetratheca glandulosa* usually grows on Hawkesbury Sandstone ridges and plateaus in eucalypt woodland, scrub and heath on sandy or rocky soils. James (1997) found that in western Sydney it was often associated with the sandstone/shale interface where soils have a stronger clay influence. In the Warringah-Pittwater area, it is sometimes found in the endangered Duffys Forest Vegetation Community, which is associated with shale lenses in Hawkesbury Sandstone, but occurs more often in other Hawkesbury Sandstone ridgetop woodland and heath communities (Smith and Smith 1997b, 2000).

Ecology: *Tetratheca glandulosa* is a spindly, inconspicuous subshrub 20-50 cm high. It flowers mainly between July and November (Harden 1992). The species is fire sensitive, that is adult plants are killed by fire and regenerate after fire only from seed (Sheringham and Sanders 1993). Species from the same genus, *T. ericifolia* and *T. shiressii*, took three to four years to flower following a fire in Brisbane Water National Park (Benson 1985).

Management Issues:

- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management (too frequent fires may exhaust the soil seedbank before it can be replenished, and thus eliminate the species from a site).
- Bushrock removal - identified as adversely affecting this species by NSW Scientific Committee (1999a).
- Translocation (as an alternative to conservation *in situ*).
- Unauthorised collection of plant material.
- Community education.
- Lack of knowledge of the species.
- Recovery plan (no plan has yet been prepared for this species).

2.6 Endangered Ecological Communities

2.6.1 Duffys Forest Vegetation Community

Conservation Status: Endangered ecological community in NSW (TSC Act). The final determination (NSW Scientific Committee 1998f) identifies the community as occurring in the Pittwater, Warringah and Ku-ring-gai Local Government Areas.

Description: The community is an open-forest or woodland varying in height from about 11 m to 22 m (Smith and Smith 2000). The main tree species are *Corymbia gummifera* (Red Bloodwood), *Eucalyptus sieberi* (Silvertop Ash), *Angophora costata* (Sydney Red Gum) and *Eucalyptus capitellata* (Brown Stringybark). However, not all of these occur in every stand, and other tree species may also be present. Common species in the shrub layer include *Acacia myrtifolia*, *Banksia spinulosa*, *Bossiaea obcordata*, *Pultenaea elliptica*, *Ceratopetalum gummiferum*, *Dillwynia retorta*, *Platysace linearifolia*, *Epacris pulchella*, *Boronia pinnata*, *Pimelea linifolia*, *Grevillea linearifolia*, *Hakea sericea*, *Pultenaea daphnoides*, *Pultenaea*

polifolia and *Lasiopetalum ferrugineum*. Common species in the ground layer include *Entolasia stricta*, *Micrantheum ericoides*, *Cyathochaeta diandra*, *Pteridium esculentum*, *Stipa pubescens*, *Tetrarrhena juncea*, *Lomandra obliqua*, *Themeda australis*, *Patersonia glabrata* and *Imperata cylindrica*. Not all of the above are present at every site.

A taller form of the community (18-26 m) occurs in the best sites and is characterised by the presence of *Eucalyptus pilularis* (Blackbutt) and/or *Syncarpia glomulifera* (Turpentine). However, this form of the community does not appear to be represented in Pittwater.

Distribution: The Duffys Forest Vegetation Community has a discontinuous distribution from Duffys Forest south to Seaforth, with a few outlying patches west to Pennant Hills Park and east to Bilgola Plateau. The total remaining area of the community is 236.5 ha, consisting of 94.3 ha in Ku-ring-gai Chase National Park, 19.3 ha in Garigal National Park, 3.2 ha in Lane Cove National Park, 103.5 ha in Warringah, 12.2 ha in Ku-ring-gai, 0.3 ha in Manly and 3.7 ha in Pittwater (Smith and Smith 2000). The original extent of the community has been estimated at about 1450 ha. Thus, only some 16% now remains.

Only two small stands of the Duffys Forest Vegetation Community are known in the Pittwater Council area (Map 5). One is a fragmented area of about 1.8 ha around the Baha'i Temple at Ingleside (a further 1.5 ha occurs here on the other side of Mona Vale Road in Garigal National Park). The other is an area of about 1.8 ha in Plateau Park, Bilgola.

Habitat: The Duffys Forest Vegetation Community is found on Hawkesbury Sandstone ridges, generally occurring where there are shale lenses and lateritic soils (NSW Scientific Committee 1998f, Smith and Smith 2000). Lateritic soils are characterised by a layer of ironstone gravel overlying a pallid, clayey zone of iron depletion. Sandstone outcrops are usually absent from stands of the community, although they may be present on the fringes. The greater height and grassiness of the Duffys Forest Vegetation Community indicates that the soils on which it develops are more fertile than those associated with typical Hawkesbury Sandstone ridge vegetation. Stands of the community generally occur on the tops of the ridges, upslope of other Hawkesbury Sandstone communities. However, Duffys Forest vegetation may also occur in a band downslope of other sandstone vegetation (although still in a ridge rather than a gully situation). This presumably reflects the presence of a shale lens, with sandstone layers both above and below.

Ecology: As is typical of most vegetation communities, the species composition of the Duffys Forest Vegetation Community varies from site to site, depending on local environmental factors and the past history of the site. At a given site the species composition is likely to vary over time in response to fire and other disturbances. Woody species found within the community include ones that regenerate vegetatively after fire (resprouters) and ones that are killed by fire and regenerate from the soil seedbank (obligate seeders). A number of the species killed by fire require fires for seed germination and establishment - there is generally no recruitment of new plants except after fire. These species will be eliminated from a site if fires are too frequent, preventing them from setting new seed and replenishing the soil seedbank, but will also be eliminated if fires are absent for too long, so that the plants senesce and die without being replaced, and survival of the population is dependent on the longevity of seed in the soil. One such species is *Grevillea caleyi*, an endangered species that is closely associated with the Duffys Forest Vegetation Community. *G. caleyi* requires fires preferably at intervals greater than eight years but less than 15 years (Scott *et al.* 1995). This fire regime is probably the most appropriate for the community as a whole.

Management Issues:

- Conservation of remnant bushland.
- Habitat degradation in remnant bushland.
- Fire management.
- Translocation (as an alternative to conservation *in situ*).
- Community education
- Lack of knowledge of the community.
- Recovery plan (no plan has yet been prepared for this community).

2.6.2 Pittwater Spotted Gum Forest

Conservation Status: Endangered ecological community in NSW (TSC Act). The final determination (NSW Scientific Committee 1998g) identifies the community as being restricted to the Pittwater Local Government Area.

Description: Pittwater Spotted Gum Forest is an open-forest (dieback has thinned some stands to woodland density), about 20-28 m high, dominated by *Corymbia maculata* (Spotted Gum). Other tree species include *Angophora costata*, *Angophora floribunda*, *Corymbia gummifera*, *Eucalyptus botryoides*, *E. paniculata*, *E. punctata*, *E. umbra* and *Syncarpia glomulifera*. Common low trees and shrubs include *Allocasuarina littoralis*, *A. torulosa*, *Dodonaea triquetra*, *Elaeocarpus reticulatus*, *Glochidion ferdinandi*, *Livistona australis*, *Macrozamia communis*, *Notelaea longifolia*, *Pittosporum undulatum*, *Platylobium formosum* and *Polyscias sambucifolia*. Ferns are prominent in the ground layer, especially in more sheltered sites, and include *Adiantum aethiopicum*, *Calochlaena dubia* and *Pteridium esculentum*. Other common species in the ground layer include *Desmodium rhytidophyllum*, *Dianella caerulea*, *Entolasia marginata*, *E. stricta*, *Lepidosperma laterale*, *Lomandra longifolia*, *Oplismenus aemulus* and *Themeda australis*. Climbers are common, including *Cissus hypoglauca*, *Geitonoplesium cymosum*, *Morinda jasminoides*, *Pandorea pandorana* and *Smilax glyciophylla* (Smith and Smith 1992a, 1992b).

Distribution: Forests dominated by Spotted Gum occur in various locations along the New South Wales coast. However, it is only the form found in the Pittwater Local Government Area that has been listed as an endangered ecological community (NSW Scientific Committee 1998g). This community is restricted to Barrenjoey Peninsula, Scotland Island and the western Pittwater foreshores, from Bayview to Towlers Bay (Map 5).

The major remnants on Barrenjoey Peninsula are within the Pittwater Council reserves, McKay Reserve, Angophora Reserve and Stapleton Park. Smaller remnants are located in some 17 smaller Council reserves and on private lands (Pittwater Council 1997b, Holden 1999). Away from Barrenjoey Peninsula, the largest remnants are on Council and private lands on Scotland Island and in the Elvina Bay/Lovett Bay/Towlers Bay area. Holden (1999) estimated that only about 51 ha of Pittwater Spotted Gum Forest remains in the Pittwater Council area. Thomas and Benson's (1985) vegetation map of Ku-ring-gai Chase National Park shows that the area of the community within the park is tiny, only a couple of hectares. The community does not occur in Garigal National Park (Sheringham and Sanders 1993), nor in the Warringah Council area (Smith and Smith 1997b).

Habitat: Pittwater Spotted Gum Forest is found on the interbedded shale, laminite and sandstone of the Newport Formation of the Triassic Narrabeen Group. The soils formed on the Newport Formation are generally deeper, more clayey and more fertile than those formed

on Hawkesbury Sandstone. Typically, Pittwater Spotted Gum Forest is found on hillslopes, but it may extend into gullies and up onto ridgetops (Holden 1999).

Ecology: As is typical of most vegetation communities, the species composition of Pittwater Spotted Gum Forest varies from site to site depending on local environmental factors and the past history of the site. At a given site the species composition is likely to vary over time in response to fire and other disturbances. The species composition of the understorey also varies within stands according to the aspect and topography. On drier, exposed sites the understorey contains more scleromorphic species, while on wetter, more sheltered sites it tends to be characterised more by ferns and rainforest species.

Some native rainforest species in the understorey of the Pittwater Spotted Gum Forest are actively spreading and becoming much denser within the community, particularly *Glochidion ferdinandi* and *Pittosporum undulatum*, but also *Livistona australis* and *Elaeocarpus reticulatus* (Holden 1999, Smith and Smith 1992a, 1992b). This trend has been linked to increasing nutrient and soil moisture levels from urban runoff, and prolonged absence of major bushfires. Stands of Pittwater Spotted Gum Forest often occur downslope of urban development and are thus particularly prone to impacts from urban runoff. Severe degradation of the community through eucalypt dieback and weed invasion is evident in sites subject to urban runoff (Smith and Smith 1992a, 1992b, Woodlots and Wetlands Pty Ltd 1997).

Most areas of Pittwater Spotted Gum Forest, now isolated within urban areas, have not been burnt in a high intensity fire since at least the 1960's (Holden 1999). The long-term absence of fire has been implicated in increases in certain native understorey species. In addition to the rainforest species discussed above, there is also concern over the increasing density of *Allocasuarina* species, especially *A. littoralis*, which are shading out other understorey species and inhibiting regeneration of tree species (Smith and Smith 1992a, 1992b). Species that are short-lived and dependent on fires for successful germination and recruitment from seed, such as many members of the Fabaceae family (peas and wattles), are likely to be eliminated from stands of Pittwater Spotted Gum Forest in the prolonged absence of fire. It is noteworthy that a high intensity pile burn in Spotted Gum Forest in Palmgrove Park resulted in the germination of a number of species of the family Fabaceae from the soil seedbank, species that were previously unknown in the park (Holden 1999).

Management Issues:

- Preservation of remnant bushland.
- Habitat degradation in remnant bushland (Pittwater Spotted Gum Forest shows more evidence of degradation, e.g. eucalypt dieback, weed invasion and increasing dominance of particular native species, than the Duffys Forest Vegetation Community)
- Fire management.
- Translocation (as an alternative to conservation *in situ*).
- Community education
- Lack of knowledge of the community.
- Recovery plan (no plan has yet been prepared for this community).

3.0 MANAGEMENT ISSUES

3.1 Introduction

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, creeklines, wetlands and intertidal areas.

Management issues pertaining to threatened fauna and flora are described below. The species and communities affected by each issue are indicated and actions to address the issue are outlined. The management issues are often inter-related and it can be simplistic to consider them in isolation. In most cases, a number of issues will need to be addressed if a species is to be effectively conserved in Pittwater. The success of most initiatives will be dependent on co-operative management involving Council, other government authorities and the community.

3.2 Recovery Plans

Species and Communities Affected:

All threatened fauna and flora species and communities.

Discussion:

The Threatened Species Conservation Act requires the National Parks and Wildlife Service to prepare and implement recovery plans for species, populations and communities of threatened fauna and flora listed in the Act. Recovery plans for endangered species, populations and communities are to be prepared as soon as practicable after listing, while recovery plans for vulnerable species are a longer term objective.

The Act requires local councils and other public authorities to take any appropriate action available to them to implement those measures included in a recovery plan for which they are responsible. They must not make decisions that are inconsistent with the provisions of a recovery plan. A council identified in a recovery plan as responsible for the implementation of measures included in the plan must report in its annual State of the Environment Report on the action taken by it to implement those measures.

A recovery plan has been prepared for one endangered plant species in Pittwater, *Grevillea caleyi* (Scott *et al.* 1995), and a recovery team, on which Pittwater Council is represented, has been established to implement the plan. However, the plan was prepared before the introduction of the Threatened Species Conservation Act, and a new recovery plan is currently being prepared to address the specific requirements of the Act. A draft recovery plan has also been prepared for another endangered plant species in Pittwater, *Microtis angusii* (National Parks and Wildlife Service 1999b). Recovery plans are not yet available for any of the other threatened species, populations or communities in Pittwater.

Management Objective:

- To encourage and support the development and implementation of recovery plans for threatened fauna and flora species, populations and communities in Pittwater.

Management Actions:

- Co-operate with the National Parks and Wildlife Service in the preparation of recovery plans for threatened fauna and flora.
- Implement measures for the recovery of threatened fauna and flora as identified in recovery plans, and for which Pittwater Council is responsible.

3.3 Conservation of Remnant Bushland

Species and Communities Affected:

Fauna: Squirrel Glider, Koala, Bush Stone-curlew, Swift Parrot, Regent Honeyeater, Southern Brown Bandicoot, Giant Dragonfly, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Australasian Bittern, Glossy Black-Cockatoo, Black Bittern, Barking Owl, Powerful Owl, Osprey, Masked Owl, Large-eared Pied Bat, Spotted-tailed Quoll, Common Bentwing-bat, Greater Broad-nosed Bat. **Flora:** *Grevillea caleyi*, *Microtis angusii*, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Pimelea curviflora*, *Syzygium paniculatum*, *Tetratheca glandulosa*. **Communities:** Duffys Forest Vegetation Community, Pittwater Spotted Gum Forest.

Discussion:

The most obvious impact of urbanisation in Pittwater on threatened fauna and flora habitats has been the removal of native vegetation for urban, industrial and other developments. 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 following the Second World War, the area of forested land declined from 705 ha in 1946 to only 125 ha in 1986, with a corresponding decline in the Koala population, which is now on the brink of local extinction (Smith and Smith 1990b). 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. A major urban land release program is planned for this part of Pittwater that will result in much more intensive development of the area and 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 insidious and substantial.

A recent 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). The

study showed that populations of these animals depend on patches of remnant bushland as refuge areas, and are unlikely to survive if these remnants are cleared. 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. They may also provide important feeding opportunities not available in the bushland remnants, for example, important food plants for Koalas and Squirrel Gliders may be lacking in the remnants. However, in the absence of intact bushland, garden and street plantings will not support populations of species such as the Koala and Squirrel Glider over the long term.

Conservation of remnants of the two endangered ecological communities, Pittwater Spotted Gum Forest and the Duffys Forest Vegetation Community, is a priority. However, other vegetation communities also provide habitat for threatened fauna and flora in Pittwater. Even for a single species such as the nectar-feeding Squirrel Glider, the retention of a variety of floristically different types of bushland may be necessary to ensure a continuous supply of food throughout the year as different plant species flower. The combined records of all threatened fauna and flora in Pittwater over the last 20 years (Maps 2-4) show a distribution pattern that is strongly correlated with the general distribution of remnant bushland in Pittwater (Map 1). Threatened fauna and flora records have come from many parts of Pittwater, with different species occurring in different areas and different vegetation types, but the dearth of records in areas with little remnant bushland is obvious.

Management Objectives:

- To ensure that sufficient bushland habitat is conserved in Pittwater for the long-term survival and recovery of the populations of threatened fauna and flora dependent on it.
- To ensure the survival and recovery of the endangered ecological communities in Pittwater (Pittwater Spotted Gum Forest and Duffys Forest Vegetation Community).

Management Actions:

- Prepare and implement plans of management for Council bushland reserves to conserve endangered ecological communities and other native bushland that provides habitat for threatened fauna and flora in Pittwater. Council has now largely completed preparation of plans of management for its bushland reserves (Pittwater Council 1993, 1994, 1995a, 1996, 1997b), and the plans are being implemented.
- Prepare and implement a Development Control Plan for the Conservation of Biodiversity in Pittwater (Pittwater Council 1998) to ensure that future development is compatible with conservation of threatened fauna and flora.
- Develop and implement programs to rehabilitate and restore native bushland in degraded areas on Council lands as habitat for threatened fauna and flora, and encourage other landowners and managers to undertake similar programs on the lands under their control.

3.4 Habitat Degradation in Remnant Bushland

Species and Communities Affected:

Fauna: Squirrel Glider, Koala, Bush Stone-curlew, Swift Parrot, Regent Honeyeater, Southern Brown Bandicoot, Giant Dragonfly, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Australasian Bittern, Glossy Black-Cockatoo, Black Bittern, Barking Owl, Powerful Owl, Osprey, Masked Owl, Large-eared Pied Bat, Spotted-tailed Quoll, Common Bentwing-bat, Greater Broad-nosed Bat. **Flora:** *Grevillea caleyi*, *Microtis angusii*, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Pimelea curviflora*, *Syzygium paniculatum*, *Tetratheca glandulosa*. **Communities:** Duffys Forest Vegetation Community, Pittwater Spotted Gum Forest.

Discussion:

Bushland stands within urban areas are prone to vegetation change and degradation. Active management of bushland reserves is frequently needed to improve bushland quality and to control and reverse adverse vegetation changes. This is essential if they are to be conserved over the long term as functional ecological communities in their own right, and as habitat for threatened fauna and flora species.

Forms of vegetation change and degradation that are affecting threatened fauna and flora communities and habitats in Pittwater include:

i) 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 (*Lantana camara*) 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 sites of weed infestation in reserves are typically associated with sites affected by nutrient enrichment and increased moisture levels associated with runoff from adjacent urban areas.

ii) 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.

iii) 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

(Smith and Smith 1997a). 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.

iv) 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 have inhibited eucalypt regeneration. These effects are evident, for example, in stands of the endangered Pittwater Spotted Gum Forest community in Angophora Reserve (Smith and Smith 1992a) and McKay Reserve (Smith and Smith 1992b). 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 major food sources 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 itself.

Management Objective:

- To prevent habitat degradation and improve the condition of endangered ecological communities and threatened fauna and flora habitats in Pittwater.

Management Actions:

- Prepare and implement plans of management for Council bushland reserves that address habitat degradation issues such as weed invasion, eucalypt dieback and long-term vegetation change. Council has now largely completed preparation of plans of management for its bushland reserves, and the plans are being implemented.
- Review the operation and effectiveness of the bushland plans of management over time. 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 bushcare program, by which the community can become involved in managing and maintaining remnant urban bushland in Pittwater.

3.5 Fire Management

Species and Communities Affected:

Fauna: Squirrel Glider, Koala, Swift Parrot, Regent Honeyeater, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Australasian Bittern, Glossy Black-Cockatoo, Black Bittern, Barking Owl, Powerful Owl, Osprey, Masked Owl, Large-eared Pied Bat, Spotted-tailed Quoll, Common Bentwing-bat, Greater Broad-nosed Bat. **Flora:** *Grevillea caleyi*, *Microtis angusii*, *Persoonia hirsuta*, *Eucalyptus camfieldii*,

Pimelea curviflora, *Syzygium paniculatum*, *Tetratheca glandulosa*. **Communities:** Duffys Forest Vegetation Community, Pittwater Spotted Gum Forest.

Discussion:

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.

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 such as the Koala 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.

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

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.

In a review of the impacts of fire regimes on plant populations, Keith (1996) identified many potential fire-driven mechanisms of plant population decline and extinction. Fire regimes associated with multiple mechanisms of decline and extinction, particularly of woody species (both obligate seeders and resprouters), are high fire frequency, low fire frequency, and repeated fires with poor vertical penetration of heat. He concluded that, despite many remaining deficiencies in knowledge of the effects of fire on plant species and communities, a strong scientific basis existed for the management of fire for conservation of plant populations and communities.

'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' has recently been listed as a key threatening process in the Threatened Species Conservation Act (NSW Scientific Committee 2000b).

High frequency fire is defined as two or more successive fires close enough together in time to interfere with or limit the ability of plants or animals to recruit new individuals into a population, or for plants to build up a seedbank sufficient in size to maintain the population through the next fire. High frequency fire and inappropriate fire regimes have been specifically identified as threats to a number of threatened species and communities, including the Duffys Forest Vegetation Community and Pittwater Spotted Gum Forest, *Grevillea caleyi*, Glossy Black-Cockatoo, Spotted-tailed Quoll, Southern Brown Bandicoot and Squirrel Glider (NSW Scientific Committee 2000b). The National Parks and Wildlife Service is now required to prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna and flora in New South Wales.

Management Objectives:

- To ensure that fire management in Pittwater is compatible with conservation of threatened fauna and flora species and communities.
- To maintain and enhance threatened fauna and flora habitats in Pittwater by appropriate fire management.

Management Actions:

- Prepare and implement plans of management for Council bushland reserves that address fire management issues in relation to threatened fauna and flora, including the desirability of ecological burns for habitat restoration purposes, as well as the impacts and preferred techniques of hazard reduction.
- Liaise with the Warringah-Pittwater Bush Fire Management Committee to integrate conservation of threatened fauna and flora with bushfire risk management in Pittwater.
- Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for high frequency fire in New South Wales.

3.6 Bushrock Removal

Species Affected:

Fauna: Red-crowned Toadlet, Spotted-tailed Quoll. **Flora:** *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Pimelea curviflora*, *Tetratheca glandulosa*.

Discussion:

Bushrock removal has been listed as a key threatening process in the Threatened Species Conservation Act (NSW Scientific Committee 1999a). The National Parks and Wildlife Service is now required to prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna and flora in New South Wales.

Bushrock removal is defined as the removal of natural surface deposits of rock from rock outcrops or from areas of native vegetation. The rocks may be loose rocks on rock or soil surfaces, or removal may involve excavation or blasting. Bushrock removal removes or

disturbs the habitat of native fauna species that shelter in or under rocks, or use rocks for basking, and native flora species that grow in rocky areas.

Threatened species specifically identified by the NSW Scientific Committee (1999a) as being adversely affected by bushrock removal include two fauna species recorded in Pittwater, the Red-crowned Toadlet and Spotted-tailed Quoll, and four flora species recorded in Pittwater or likely to occur there, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Pimelea curviflora*, *Tetratheca glandulosa*.

Management Objective:

- To prevent degradation of threatened fauna and flora habitats by bushrock removal.

Management Actions:

- Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for bushrock removal in New South Wales.
- Enforce restrictions on bushrock removal from public lands.

3.7 Tree Preservation in Urban Areas

Species Affected:

Fauna: Squirrel Glider, Koala, Swift Parrot, Regent Honeyeater, Glossy Black-Cockatoo, Barking Owl, Powerful Owl, Masked Owl, Greater Broad-nosed Bat. **Flora:** *Grevillea caleyi*, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Syzygium paniculatum*.

Discussion:

Outside of bushland reserves and other patches of remnant bushland, many urban areas of Pittwater still maintain a good cover of native trees and shrubs. These may include remnant individuals of threatened tree and shrub species. They may also provide valuable habitat for threatened fauna. A prime example is the Koala population on Barrenjoey Peninsula, where the bushland reserves are critical as refuge areas, but are a poor sample of what was once the best Koala habitat on the Peninsula. The reserves generally have low numbers of the major Koala food trees and the Koalas often move outside the reserves to feed on remnant trees in the surrounding urban areas (Smith and Smith 1990b).

As well as providing a food source for Koalas, the remnant trees also provide important resources for other threatened fauna. One resource of particular concern is tree hollows for roosting and nesting. These are found only in the oldest eucalypt trees (it may take 200 years or more for the tree to develop hollows suitable for species such as the Squirrel Glider, Greater Broad-nosed Bat, Glossy Black-Cockatoo and Powerful Owl; Mackowski 1984). Once lost they take a very long time to replace. Old eucalypt trees also tend to provide larger, more reliable nectar flows for species that rely on this food source, such as the Squirrel Glider, Regent Honeyeater and Swift Parrot. Ideally, habitat trees in urban areas should include a range of age classes and should be supplemented by further plantings to replace the older trees when they eventually die.

One of the aims of Pittwater Council's 1996 Tree Preservation and Management Order is to retain significant fauna habitat. Applications for removal are assessed on their visual significance, existing surrounding canopy character and function, the type and condition of vegetation to be removed, and the inherent reasons for removal. Vegetation removed is normally requested to be replaced on the allotment with a native tree of similar species. The number of trees removed and replaced are recorded by Council to assess overall vegetation loss and to monitor impacts of residential development on trees. Council records for 1996/97 (Pittwater Council 1997a) indicate that 295 trees were removed on private land (of which 32 were classed as significant), 320 lopped on private land, 216 trees removed on public land (street trees, reserves, commercial areas), 340 lopped on public land, and 29 trees lost due to storm damage. To offset this, 40 trees were planted on private land and 30 planted as street trees. The obvious imbalance in these figures demonstrates a substantial loss of fauna habitat that urgently needs to be redressed.

Management Objectives:

- To maintain and enhance the cover of native trees and shrubs in urban areas of Pittwater as habitat for threatened fauna.
- To protect specimens of threatened flora species located in urban areas of Pittwater.

Management Actions:

- Implement the Pittwater Tree Preservation and Management Order. Review its operation and effectiveness to ensure that losses of native trees and shrubs in urban areas are fully compensated by new plantings.
- Amend the Order so that it applies to all specimens of the threatened tree and shrub species, *Eucalyptus camfieldii* (Heart-leaved Stringybark), *Grevillea caleyi* (Caley's Grevillea), *Persoonia hirsuta* (Hairy Geebung) and *Syzygium paniculatum* (Magenta Lillypilly), irrespective of their dimensions.
- Amend the Order so that it applies to all specimens of *Eucalyptus punctata* (Grey Gum) and *E. robusta* (Swamp Mahogany), irrespective of their dimensions. These are the two most important food plants for threatened fauna in Pittwater.
- Extend the list of desirable trees in the Order to include the following, all of which are known or likely to be food plants for threatened fauna: *Acacia irrorata* (Blue-skin), *A. longifolia* (Sydney Golden Wattle), *Allocasuarina littoralis* (Black She-oak), *A. torulosa* (Forest Oak), *Banksia ericifolia* (Heath-leaved Banksia), *B. spinulosa* (Hairpin Banksia), *Corymbia gummifera* (Red Bloodwood), *Eucalyptus botryoides* (Bangalay), *E. globoidea* (White Stringybark), *E. piperita* (Sydney Peppermint), *E. racemosa* (Narrow-leaved Scribbly Gum), *E. umbra* (Broad-leaved White Mahogany) and *Melaleuca quinquenervia* (Broad-leaved Paperbark).

3.8 Habitat Enhancement by Food Tree Plantings

Species Affected:

Fauna: Koala, Squirrel Glider, Swift Parrot, Regent Honeyeater

Discussion:

There has been a long history of planting food trees for threatened fauna in Pittwater, especially for Koalas. This practice should be continued and expanded. Additional food tree plantings are highly desirable as a habitat enhancement measure, both within areas of remnant bushland and away from bushland in gardens, streets, parks and other urban situations, especially in the vicinity of bushland reserves and in corridors between reserves. Material for the plantings should be obtained from local sources in order to preserve the genetic integrity of the local plant populations.

Additional plantings are warranted of two species in particular: *Eucalyptus punctata*, which is the single most important local food tree for Koalas; and *E. robusta*, which is an important food plant for Koalas, Squirrel Gliders, Regent Honeyeaters and Swift Parrots, as well as many other fauna species. Other food plants that could be planted for these species include *E. haemastoma*, *E. racemosa*, *Banksia integrifolia*, *B. ericifolia* and *Corymbia maculata*. Further food plants are listed in the species profiles. One proviso is that plantings of Koala food trees should be avoided adjacent to busy roads, where the animals would be at risk when moving to and from the trees.

Management Objective:

- To ensure that sufficient food resources are available for threatened fauna species in Pittwater in the long term.

Management Actions:

- Identify priority areas for planting additional food plants in Pittwater. Plant these on Council lands, especially in high priority areas, with particular emphasis on *Eucalyptus punctata* and *E. robusta*, but also other species used by threatened fauna.
- Encourage other landowners and managers to plant additional food plants on their lands, especially in high priority areas.

3.9 Wildlife Corridors

Species Affected:

Fauna: Squirrel Glider, Koala, Swift Parrot, Regent Honeyeater, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Glossy Black-Cockatoo, Barking Owl, Powerful Owl, Masked Owl, Large-eared Pied Bat, Spotted-tailed Quoll, Common Bentwing-bat, Greater Broad-nosed Bat.

Discussion:

The Koala and Squirrel Glider populations on Barrenjoey Peninsula have been isolated from other areas of potential habitat by the intensive urban development that has occurred at the base of the Peninsula in Newport and Mona Vale. There is a large gap here with little remnant bushland and low urban tree densities (Map 1). Small isolated fauna populations such as these

are susceptible to inbreeding and loss of genetic variation, leading to an increased probability of local extinction. When numbers drop as low as they have in the Barrenjoey Peninsula Koala population, a simple imbalance of the sexes may inhibit breeding. Such populations are also particularly susceptible to the ravages of natural catastrophes including fire and disease, or just an unlucky combination of chance mortalities.

As the native bushland of Pittwater has become more and more fragmented, and the larger areas of bushland more isolated from each other, it has become increasingly important to maintain and re-establish vegetation links between these areas of core habitat. Such links are crucial in order to facilitate and encourage fauna movements. Termed 'wildlife corridors', their role and value is now widely recognised and they have become an important consideration in modern land-use planning (Saunders and Hobbs 1991).

Wildlife corridors provide a pathway for outbreeding, for recolonisation of former habitat, for dispersal of young, and for the adults of migratory or nomadic species. They are also habitat areas themselves, providing resources such as food, water and shelter. They can occur in a number of ways: natural corridors (e.g. bands of riparian vegetation along watercourses); remnant corridors (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). The quality of the corridors as fauna habitat is a critical factor in their effectiveness. A wide corridor of bushland in good condition, with the full diversity and strata of native vegetation, is obviously the best option, and it is important to retain and protect such links where they still exist. However, even corridors consisting of gardens and street plantings can play a vital role in maintaining connections between fauna populations. The frequency of use of the corridor may be very low, but the movement of just one or two animals between populations can be critical.

Birds and bats, because they can fly, are less dependent on wildlife corridors, especially those species that regularly travel long distances. Nevertheless, maintaining an obvious vegetation corridor across an area of alien habitat can be valuable in providing a guiding pathway, even for such long-distance travellers as the Swift Parrot, Regent Honeyeater and Common Bentwing-bat.

Pittwater Council has adopted a Habitat and Wildlife Corridors Conservation Strategy (Pittwater Council 1995b), which identifies and maps six broad habitat and corridor categories. The Strategy outlines a range of measures to protect and enhance wildlife corridors in Pittwater

Management Objective:

- To maintain and restore the connectivity of fragmented and isolated bushland habitats in Pittwater in order to facilitate inter-population movements and recolonisation by threatened fauna.

Management Actions:

- Implement the Pittwater Habitat and Wildlife Corridors Conservation Strategy. Review its operation and effectiveness. Develop and implement additional measures for protection and enhancement of corridors where necessary.

- Plant additional native trees and shrubs on Council lands in high priority wildlife corridors identified in the Habitat and Wildlife Corridors Conservation Strategy:
 - Central Avenue, Avalon Parade, Ruskin Rowe (i.e. the area between Stapleton Park and Angophora Reserve – a critical movement corridor for Koalas).
 - Careel Bay playing fields and environs.
 - Bardo Road to Beaconsfield Street, Newport.
 - Waterview and Mona Streets, Mona Vale, and Bayview Golf Course.
 - Irrawong Reserve and Warriewood Wetlands.
- Encourage similar plantings by other land owners and managers in high priority wildlife corridors.
- Prepare and implement a Development Control Plan for the Conservation of Biodiversity in Pittwater (Pittwater Council 1998) to ensure that future development is compatible with retention of wildlife corridors and, where possible, incorporates measures to enhance and restore corridors.

3.10 Protection of Waterways

Species Affected:

Fauna: Bush Stone-curlew, Giant Dragonfly, Giant Burrowing Frog, Red-crowned Toadlet, Australasian Bittern, Black Bittern, Osprey.

Discussion:

Protection of water quality and waterside vegetation are important environmental issues in the Pittwater area and are being addressed in various management initiatives by Council and other authorities, as described in the annual State of the Environment Reports. Specific examples where protection of waterways and wetlands is important for threatened fauna management are as follows:

- Deep Creek – known habitat for Australasian Bittern and Black Bittern.
- Warriewood and Irrawong wetlands – potential habitat for Australasian Bittern, Black Bittern and Giant Dragonfly.
- Nareen Creek wetlands – potential habitat for Australasian Bittern and Giant Dragonfly.
- Narrabeen Lagoon – known habitat for Osprey.
- Careel Bay – known habitat for Bush Stone-curlew.
- Minor creeklines draining sandstone plateaus, ridges and upper slopes in western and southern suburbs of Pittwater – known habitat for Giant Burrowing Frog and Red-crowned Toadlet.

Management Objectives:

- To ensure that management of waterways and wetlands in Pittwater is compatible with conservation of threatened fauna and flora.

- To maintain and enhance threatened fauna and flora habitats in Pittwater by appropriate management of hydrological processes, water quality and waterside vegetation.

Management Actions:

- Prepare and implement plans of management for Council bushland reserves with wetland and waterways habitats used by threatened fauna.
- Liaise with the Pittwater Estuary Management Committee and Sydney Harbour Catchment Management Board to integrate management of threatened fauna and flora habitats with catchment and estuary management in Pittwater.

3.11 Control of Dog and Cat Predation

Species Affected:

Fauna: Squirrel Glider, Koala, Bush Stone-curlew, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Australasian Bittern, Glossy Black-Cockatoo, Black Bittern, Barking Owl, Powerful Owl, Masked Owl.

Discussion:

Native fauna in the Pittwater area are subject to predation by domestic and feral dogs and cats. Dogs are a particular concern in relation to Koalas. They have been the most frequently reported cause of death of Koalas on Barrenjoey Peninsula (Smith and Smith 1990b). Large dogs and dogs in packs pose the greatest threat, and the risk is greatest for Koalas that are young, small or in poor condition.

Cats are a concern in relation to many of the threatened fauna species in Pittwater, including the endangered Squirrel Glider population on Barrenjoey Peninsula. Squirrel Glider specimens obtained by the Australia Museum from this area in recent years have all been animals caught and killed by domestic cats. The heavy impact of domestic and feral cats on native wildlife has been well documented (e.g. Potter 1991, Dickman 1996). Cats take a wide variety of prey species, including mammals, birds, reptiles and frogs. 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 (D. Saunders pers. comm.). Threatened birds in Pittwater that are at risk from this behaviour pattern are the Glossy Black-Cockatoo, Powerful Owl, Barking Owl and Masked Owl. Squirrel Gliders resting during the day in tree hollows are also at risk.

The impact of dogs and cats is a particular concern on Barrenjoey Peninsula, with its tiny population (one pair) of one endangered species, the Bush Stone-curlew, and its endangered populations of two other species, the Koala and the Squirrel Glider. All three species are vulnerable to predation by dogs and cats (and foxes). The single pair of Bush Stone-curlews at Careel Bay are 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.

Predation by feral cats has recently been listed as a key threatening process in the Threatened Species Conservation Act (NSW Scientific Committee 2000c). The listing concerns only feral (free-living) cats, not domestic animals. The National Parks and Wildlife Service is now

required to prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna in New South Wales.

Management Objective:

- To minimise the impact of predation by domestic and feral dogs and cats on threatened fauna species in Pittwater.

Management Actions:

- 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.
- Continue and expand existing community education programs aimed at reducing the impact of cats and dogs on native fauna. Encourage the community to report feral cats, dogs and foxes to Council.
- Impose conditions prohibiting the keeping of cats and dogs on new residential developments in sites where they are a particular threat to threatened fauna species.
- Co-operate with the National Parks and Wildlife Service and other authorities in the development and implementation of a threat abatement plan for feral cat predation in New South Wales.

3.12 Control of Fox Predation

Species affected:

Fauna: Squirrel Glider, Koala, Bush Stone-curlew, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Australasian Bittern, Black Bittern.

Discussion:

Predation by the introduced European Red Fox (*Vulpes vulpes*) has been listed as a key threatening process under the Threatened Species Conservation Act (NSW Scientific Committee 1998h). The National Parks and Wildlife Service is now required to prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna in New South Wales.

The Act requires local councils and other public authorities to take any appropriate action available to them to implement those measures included in a threat abatement plan for which they are responsible. They must not make decisions that are inconsistent with the provisions of the threat abatement plan. A council identified in a threat abatement plan as responsible for the implementation of measures included in the plan must report in its annual State of the Environment Report on the actions taken by it to implement those measures.

The fox is an adaptable and elusive predator common in rural, urban and bushland areas throughout southern Australia. It does not appear to favour any particular habitat and the main determinants of its population size and distribution appear to be food supply, disturbance of natural habitats and availability of refuges. The fox is predominantly carnivorous and is largely opportunistic in its selection of prey. Medium-sized terrestrial mammals, and birds that feed, roost or nest on the ground are particularly vulnerable.

In the Pittwater area, fox predation is a concern for many species of threatened fauna, but a particular concern for the ground-dwelling Bush Stone-curlews at Careel Bay (Smith and Smith 1997a). Foxes are known to prey on Bush Stone-curlews at all stages of their life cycle, from eggs to adults, and fox predation has been implicated as a major factor in the decline of the Bush Stone-curlew in southern Australia during this century (Marchant and Higgins 1993). The first priority for management of foxes in Pittwater is to eradicate them from the Careel Bay area, and preferably the entire Barrenjoey Peninsula.

Management Objective:

- To minimise the impact of predation by foxes on threatened fauna species in Pittwater.

Management Actions:

- Develop and implement effective and humane control programs for foxes in the Pittwater area, with special emphasis on sites where they are a particular threat to threatened fauna species. Eradication of foxes from the Careel Bay area is the first priority.
- Co-operate with the National Parks and Wildlife Service and other authorities in the development and implementation of a threat abatement plan for fox predation in New South Wales.

3.13 Control of Plague Minnow Predation

Species affected:

Fauna: Giant Burrowing Frog, Red-crowned Toadlet.

Discussion:

Predation by the introduced Plague Minnow or Mosquito Fish (*Gambusia holbrooki*, formerly known as *G. affinis*) has been listed as a key threatening process in the Threatened Species Conservation Act (NSW Scientific Committee 1999b). The National Parks and Wildlife Service is now required to prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna in New South Wales.

The Plague Minnow is a small freshwater fish that was imported from North America in the 1920's as an aquarium fish and subsequently released into creeks around Sydney, Melbourne and Brisbane. During the Second World War a government-sponsored campaign was initiated to spread the Plague Minnow into as many east coast waterways as possible in an attempt to control mosquitoes. They are aggressive and voracious predators that have become so

abundant in some areas that they are now a serious pest, but they have had a negligible effect on mosquito populations.

Plague Minnows are known predators on the eggs and tadpoles of the endangered Green and Golden Bell Frog (*Litoria aurea*), and it has been suggested that this predatory behaviour has been a major factor in the decline of this frog species (Morgan and Buttemer 1996). They are also known to prey on other Australian frog species and their presence is implicated in the decline of a number of species.

In Pittwater, Plague Minnows are known to occur at Irrawong Reserve (Pittwater Council 1996) and Warriewood Wetlands (Shortland Wetlands Centre 1989), and are likely to be widespread and abundant in other creeklines and freshwater bodies. Their potential impact on the two threatened frog species in the area, the Giant Burrowing Frog and the Red-crowned Toadlet, is a matter of concern.

Management Objective:

- To minimise the impact of predation by Plague Minnows on threatened frog species in Pittwater.

Management Actions:

- Identify locations in Pittwater where Plague Minnows pose a threat to Giant Burrowing Frog and Red-crowned Toadlet populations. Develop and implement control programs to eradicate the species at these locations.
- Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for Plague Minnow predation in New South Wales.

3.14 Fauna Road Casualties

Species affected:

Fauna: Squirrel Glider, Koala, Southern Brown Bandicoot, Giant Burrowing Frog, Red-crowned Toadlet, Rosenberg's Goanna, Barking Owl, Powerful Owl, Masked Owl, Spotted-tailed Quoll.

Discussion:

Injuries inflicted by motor vehicles are a major cause of mortality in many Koala populations, such as those at Phillip Island (Lee and Martin 1988), Port Macquarie (Canfield 1987) and Port Stephens (Callaghan *et al.* 1994). However, in Pittwater there have been surprisingly few reports of Koala deaths caused by motor vehicles in recent decades (Smith and Smith 1990b). This may be a reflection of their declining numbers and the contraction of their distribution away from the main thoroughfare, Barrenjoey Road. However, motor vehicles must still be considered a serious threat to the remaining Koalas, particularly in view of the recent spate of

sightings in the vicinity of the Bilgola Bends, including one animal that had apparently been hit by a vehicle. Other locations where road casualties are likely to occur are Avalon Parade and Central Road.

Animals hit by cars may not be killed outright but may sustain injuries that eventually lead to their death. For example, animals with a jaw injury may move away but later die of starvation. Management actions in relation to rehabilitation of injured animals are discussed below in section 3.15.

Management Objective:

- To minimise road casualties of threatened fauna species in Pittwater.

Management Actions:

- Identify sites where road casualties pose a particular threat to threatened fauna species in Pittwater. Implement traffic control and/or fauna control measures at these sites.
- Ensure through the development assessment process that new developments include appropriate measures to prevent increased road casualties of threatened fauna.

3.15 Rehabilitation of Sick, Injured or Orphaned Animals

Species affected:

Fauna: all threatened fauna species except Giant Dragonfly.

Discussion:

Native animals are best left alone unless obviously sick, injured or orphaned. For example, a Koala on the ground is not necessarily sick. It may be a perfectly healthy animal that is simply moving between food trees. When an animal of a threatened fauna species does require help, expert assistance should be sought. Four organisations offer such assistance in Pittwater:

- Wildlife Clinic, Taronga Zoo
Contact: Libby Hall, Wildlife Rehabilitation Officer, phone 02 9978 4751, or
Wildlife Clinic, phone 02 9978 4754
- Wildlife ARC
Contact: Colleen Russell, phone 02 9918 3817
- WIRES
Contact: Hotline, phone 02 9975 1633
- Sydney Metropolitan Wildlife Services Native Animal Rescue and Advice
Contact: phone 02 9413 4300

The policy of each of these organisations is to rescue, rehabilitate and return native animals to their original location, whenever possible. Any proposals to return animals of threatened

fauna species to a different location should be discussed with National Parks and Wildlife Service and Council's Natural Resources Unit.

For threatened fauna with very specialised requirements, such as the Koala, 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.

Guidelines for people finding sick, injured or orphaned native animals should be more widely publicised. Such animals should be handled as little as possible. They are usually in shock and shock alone may kill them.

Management Objectives:

- To facilitate the rescue, rehabilitation and return of sick, injured or orphaned animals of threatened fauna species in Pittwater.
- To ensure that rehabilitated threatened fauna are returned to their original location whenever possible, or to the nearest most appropriate location.

Management Actions:

- Encourage, support and publicise organisations which rescue and rehabilitate sick, injured or orphaned animals in Pittwater.
- Implement community education programs (e.g. pamphlets) publicising wildlife rescue organisations in Pittwater, and describing appropriate handling and first aid protocols for sick, injured or orphaned animals.
- Maintain records of rescues and releases of threatened fauna species in Pittwater.

3.16 Disturbance at Nesting, Roosting and Feeding Sites

Species Affected:

Fauna: Bush Stone-curlew, Australasian Bittern, Glossy Black-Cockatoo, Sooty Oystercatcher, Black Bittern, Barking Owl, Powerful Owl, Osprey, Masked Owl, Large-eared Pied Bat, Common Bentwing-bat.

Discussion:

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.

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
- Masked Owl - nesting and roosting sites
- Glossy Black-Cockatoo - nesting sites
- Osprey - nesting sites
- Large-eared Pied Bat - roosting sites
- Common Bentwing-bat - roosting sites
- Sooty Oystercatcher - feeding sites

Management Objective:

- To prevent adverse impacts at nesting, roosting and feeding sites of threatened fauna species in Pittwater from excessive human disturbance.

Management Actions:

- Identify nesting, roosting and feeding sites where excessive human disturbance, deliberate or accidental, poses a threat to threatened fauna species in Pittwater. Implement measures to reduce the impact.

3.17 Depletion of Intertidal Invertebrate Populations

Species Affected:

Fauna: Sooty Oystercatcher

Discussion:

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, which build an understanding of the intertidal ecology of rock platform environments.

Management Objective:

- To conserve populations and biodiversity of intertidal rock platform invertebrates in Pittwater.

Management Actions:

- Liaise with NSW Fisheries in management and monitoring of Intertidal Protection Areas and other rock platforms in the Pittwater area. Enforce the restrictions on collection of intertidal invertebrates.
- Continue with community awareness and education initiatives through Project Aware - On the Rocks and the Coastal Environment Centre.

3.18 Translocation

Species and Communities Affected:

Flora: *Chamaesyce psammogeton*, *Grevillea caleyi*, *Microtis angusii*, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Pimelea curviflora*, *Syzygium paniculatum*, *Tetratheca glandulosa*.

Communities: Duffys Forest Vegetation Community, Pittwater Spotted Gum Forest.

Discussion:

Translocation refers to the deliberate transfer of plants or regenerative plant material from one place to another. When a population of a threatened plant species is threatened by development or other impacts at one site, translocation to another site may be advocated as a possible way around the conflict. However, attempts to translocate threatened plants have generally been unsuccessful, either failing immediately or over the longer term after an apparently successful establishment at the new site (Australian Network for Plant Conservation 1997). Translocation of threatened plants can be a useful technique, and requires further investigation, but it should not be adopted as an alternative to conservation *in situ* unless absolutely necessary. The success of translocation efforts cannot be guaranteed. At present, a lack of knowledge of threatened species and the means by which to carry out translocation, the amount of commitment required, especially on-going commitment to follow-up maintenance and monitoring, and the high probability of failure, means that translocation is not a proven or reliable method of amelioration for the loss of a threatened plant population at its original site.

The National Parks and Wildlife Service (1999c) has noted the very poor success rate of previous translocation programs for plant species, particularly threatened species. The Service has strongly urged that translocation of threatened flora should not be adopted as a standard approach to overcome development/conservation conflicts, only used as a last resort. The Service considers that resources are better directed towards implementing *in situ* conservation measures, which are likely to be more effective in the long term.

The same considerations apply, and even more so, to attempts to translocate patches of entire communities to new sites. This is a much more difficult proposition than translocation of a single species. A fully successful translocation of an entire community is highly unlikely.

Management Objective:

- To conserve threatened plant species and communities *in situ* wherever possible.

Management Actions:

- Adopt a policy in development assessment and natural resource management of advocating and implementing conservation of threatened plant species and communities *in situ* wherever possible, recognising the low probability of success of translocation programs as an alternative.

3.19 Beach Dune Management

Species Affected:

Flora: *Chamaesyce psammogeton*

Discussion:

The endangered plant, *Chamaesyce psammogeton* (Coastal Spurge), is a colonising species of the strandline zone of coastal foredunes. This environment is subject to high levels of natural disturbance (erosion by tides, storms and wind). It is also subject to heavy recreational use, to

weed invasion (especially Bitou Bush - see section 3.19), to erosion and pollution from stormwater discharge, and to increased erosion where the natural profile of the foredune has been altered or dune vegetation has been cleared.

Coastal beaches receive considerable management attention from Pittwater Council. There is an on-going program of dune stabilisation and revegetation on all coastal beaches in Pittwater. Most have protective fencing around dune regeneration areas to protect the vegetation from disturbance. Community groups are involved in dune restoration works at several sites.

Conservation measures for *Chamaesyce psammogeton* should be adopted as part of the dune stabilisation program in Pittwater. Those involved in dune restoration works, whether employees, contractors or volunteers, should be made aware of the species. Sites where the species occurs need to be identified and the species protected from disturbance at these sites.

Management Objective:

- To ensure the survival and recovery of the endangered plant species, *Chamaesyce psammogeton*, in Pittwater.

Management Actions:

- Identify sites where the endangered plant species, *Chamaesyce psammogeton*, occurs on Pittwater beaches. Incorporate measures to conserve the species as part of the beach dune management programs at these sites.
- Train employees, contractors and volunteers involved in dune restoration works in Pittwater to recognise *Chamaesyce psammogeton* and to be aware of its conservation significance.

3.20 Control of Bitou Bush

Species Affected:

Flora: *Chamaesyce psammogeton*

Discussion:

Bitou Bush (*Chrysanthemoides monilifera* subspecies *rotundata*) is a dense shrub that grows to about 2 m tall. A native of South Africa, it was first recorded in New South Wales from near Newcastle in 1908, and was extensively planted for dune stabilisation between 1946 and 1968. It has spread rapidly and is now found on 90% of the sandy coast of New South Wales, covering an area in excess of 70 000 ha (NSW Scientific Committee 1999c). It is the most pernicious weed of sand dunes in eastern Australia, occupying large areas as a dense monoculture that displaces the native dune vegetation.

Invasion of native plant communities by *Chrysanthemoides monilifera* has been listed in the Threatened Species Conservation Act as a key threatening process (NSW Scientific

Committee 1999c). One threatened species for which it is an identified threat is *Chamaesyce psammogeton*, a dune plant that has been recorded in Pittwater at Avalon Beach and Palm Beach. A consequence of listing is that the National Parks and Wildlife Service must prepare a threat abatement plan to manage this threatening process to minimise its impact on threatened fauna and flora in New South Wales.

Bitou Bush is a declared noxious weed in Pittwater (category W2 - the weed must be fully and continuously suppressed and destroyed). It is the most prolific weed present on sand dunes in the area and weed control programs are being implemented to eradicate the species from Pittwater beaches.

Management Objective:

- To eradicate the noxious weed, Bitou Bush (*Chrysanthemoides monilifera*), from dune vegetation in Pittwater, especially where it poses a threat to the endangered species, *Chamaesyce psammogeton*.

Management Actions:

- Implement weed control programs targeting Bitou Bush infestations on Pittwater beaches, especially in sites where there are populations of the endangered plant species, *Chamaesyce psammogeton*.
- Co-operate with the National Parks and Wildlife Service in the development and implementation of a threat abatement plan for bushrock removal in New South Wales.

3.21 Loss of Genetic Integrity

Species Affected:

Flora: *Grevillea caleyi*, *Syzygium paniculatum*.

Discussion:

Hybridisation of the endangered species, *Grevillea caleyi* (Caley's Grevillea), with other *Grevillea* species that occur naturally in its habitat is unknown. However, hybridisation may occur between *G. caleyi* and introduced *Grevillea* species and cultivars with toothbrush-type flowers, which are popular locally for use in gardening and landscaping. One of these species, *G. longifolia*, is known to have been successfully crossed with *G. caleyi* (Scott *et al.* 1995). Plantings of such species should be avoided in the vicinity of *G. caleyi* so as not to alter the genetic make-up of the populations.

A similar concern applies to one of the vulnerable species in Pittwater, *Syzygium paniculatum* (Magenta Lillypilly). Although it is a rare species in the wild, it is a popular ornamental species and is widely cultivated in the Sydney region (Benson and McDougall 1998). As a result, the genetic integrity of the population that grows naturally in Pittwater is potentially threatened by interbreeding with planted specimens that have been derived from other populations of the species outside Pittwater.

Management Objective:

- To prevent loss of genetic integrity of populations of threatened plant species in Pittwater through interbreeding with introduced plants of other species or populations.

Management Actions:

- Identify sites where interbreeding with introduced plants poses a threat to threatened plant species in Pittwater, specifically *Grevillea caleyi* and *Syzygium paniculatum*. Implement measures to eliminate or reduce the threat.

3.22 Unauthorised Collection of Plant Material

Species Affected:

Flora: *Grevillea caleyi*, *Microtis angusii*, *Persoonia hirsuta*, *Eucalyptus camfieldii*, *Syzygium paniculatum*, *Tetratheca glandulosa*.

Discussion:

Unauthorised collection of flowers, fruits, seeds, cuttings, seedlings or whole plants of threatened plant species, for propagation or display, could potentially have an effect on the population through loss of plants or interference with breeding success. This has been identified as a possible threat to both *Grevillea caleyi* (Scott *et al.* 1995) and *Microtis angusii* (National Parks and Wildlife Service 1999b). The threat is perhaps greatest from unscrupulous collectors and propagators who deliberately target rare species.

Management Objective:

- To prevent adverse effects on threatened plant populations in Pittwater from unauthorised collection of plant material.

Management Actions:

- Identify sites where unauthorised collection of plant material poses a significant threat to populations of threatened plants in Pittwater. Implement measures (such as community education, law enforcement, fencing) to reduce the impact at these sites.
- Avoid making information on the precise locations of threatened plant species in Pittwater widely available.

3.23 Community Education

Species and Communities Affected:

All threatened fauna and flora species and communities.

Discussion:

The success of most initiatives for conservation of threatened fauna and flora in the Pittwater area will be dependent on co-operation between Council, other government authorities and the local community. It is important that the community is aware and well informed about threatened fauna and flora species and communities, their habitat requirements, the threats to their survival in Pittwater, and the sort of management initiatives needed to counter these threats. Community education programs should promote an increased awareness and appreciation of Pittwater's threatened fauna and flora and their conservation needs. Specific aspects of threatened fauna and flora management where further community education is needed have been discussed in the previous sections.

Project SAFE (Saving Animals from Extinction) is an important recent initiative involving Pittwater Council, Taronga Zoo, the Coastal Environment Centre and the Threatened Species Network in a joint program to assist with threatened species management in the Pittwater area in collaboration with the local community.

Management Objectives:

- To inform, motivate and achieve the support of the community in conservation of threatened fauna and flora.

Management Actions:

- Develop and implement community education programs on threatened fauna and flora. Co-operate with other organisations in their community education programs.
- Encourage active community participation in threatened fauna and flora management.

3.24 Lack of Knowledge of Threatened Fauna and Flora

Species and Communities Affected:

All threatened fauna and flora species and communities.

Discussion:

Management of threatened fauna and flora in Pittwater is hindered to varying extents by a lack of knowledge of the species and communities. Even for species that are reasonably well known from studies outside Pittwater, specific information on the Pittwater populations is generally lacking. Sometimes the available information on these populations is very sketchy indeed, and can be misleading. Lack of knowledge of the local populations is a serious impediment to development of effective conservation measures. Further surveys and studies are needed. Over the longer term, monitoring of threatened fauna and flora in Pittwater will be essential to assess the adequacy and effectiveness of conservation efforts.

Threatened fauna species are generally difficult to survey and study, if for no other reason than that they are rare. Some of the species can be especially difficult to detect. Giant Burrowing Frogs, for example, are particularly cryptic, especially during dry periods. When

surveys are undertaken for threatened fauna it is important that they use appropriate methods and an appropriate level of survey effort. However, even with intensive surveys, a failure to detect threatened fauna species does not necessarily mean that they do not use the site. Under such circumstances, identification of areas of potential habitat becomes very important. The more knowledge gained of the species and their habitat requirements in the Pittwater area, the more readily can potential habitat be identified.

Records provided by local residents can contribute greatly to the understanding of threatened species in Pittwater. Previous community-based surveys in Pittwater have provided extremely valuable data regarding the distribution and abundance of threatened fauna species and their population trends, especially for Koalas. Such surveys also serve to heighten community awareness and understanding of these species. A Council register of Koala and other threatened fauna sightings has been established and information received from residents is passed on to the National Parks and Wildlife Service. When dead animals are found they should be sent to the Australian Museum. Staff at the Museum will identify the species and the specimens are of value to fauna researchers.

Management Objective:

- To encourage and facilitate increased understanding of the ecology and conservation requirements of threatened fauna and flora in Pittwater through scientific research, survey and monitoring.

Management Actions:

- Maintain and expand Council's register of threatened fauna and flora records. Encourage the local community to contribute records to Council's register and to send any threatened fauna specimens that they find to the Australian Museum. Provide records from the register to the National Parks and Wildlife Service's 'Atlas of NSW Wildlife' database.
- Undertake specific studies and long-term monitoring to improve management of threatened fauna and flora in Pittwater. The first priority are studies of the three listings that are restricted to Pittwater: Pittwater Squirrel Glider population (e.g. surveys to determine distribution, abundance and habitat requirements on Barrenjoey Peninsula), Pittwater Koala population (e.g. further questionnaire surveys of local residents to determine the current status of the population) and Pittwater Spotted Gum Forest (e.g. trials of possible management techniques to address habitat degradation problems).
- Liaise with the National Parks and Wildlife Service, university researchers and other relevant organisations to encourage and support management-oriented studies of threatened fauna and flora in Pittwater.

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