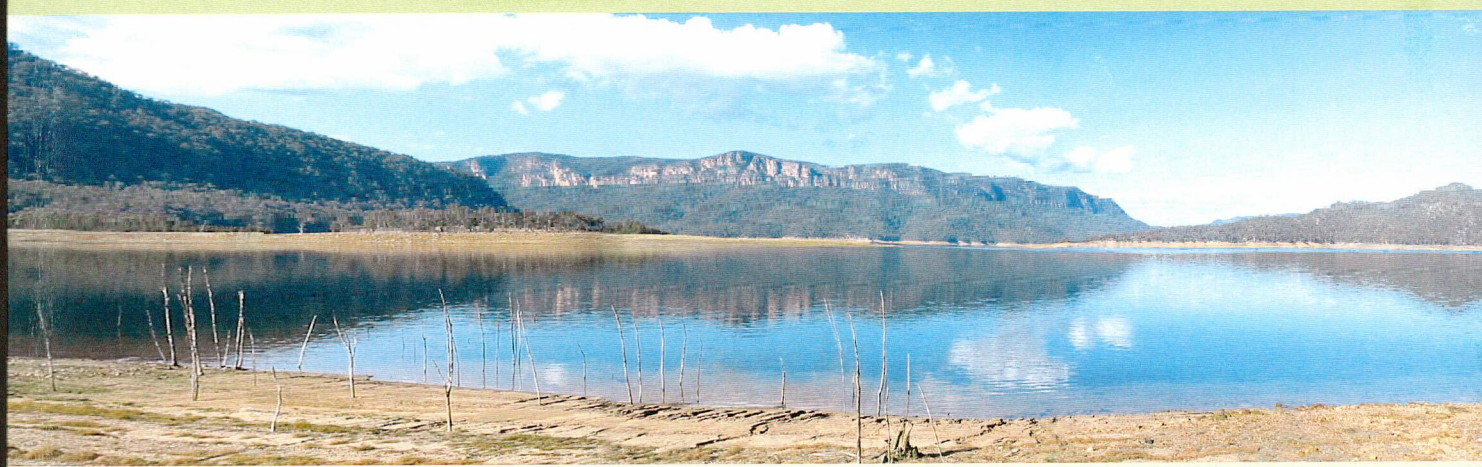

Volume 3: Summary of findings and recommendations

The Fauna of the Warragamba Special Area

Department of **Environment & Climate Change** NSW

Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region

VOLUME 3

The Fauna of the Warragamba Special Area

Summary of findings and recommendations

A joint project between the Sydney Catchment Authority and Parks and Wildlife Group of the Department of Environment and Climate Change.

Special Areas Strategic Plan of Management (SASPoM) Research and Data Program: Project No: RD01

Information and Assessment Section
Metropolitan Branch
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Department of Environment and Climate Change (NSW)
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Cover Photo

Lake Burragorang from below Butcher's Creek Hut. © Peter Ewin/DECC

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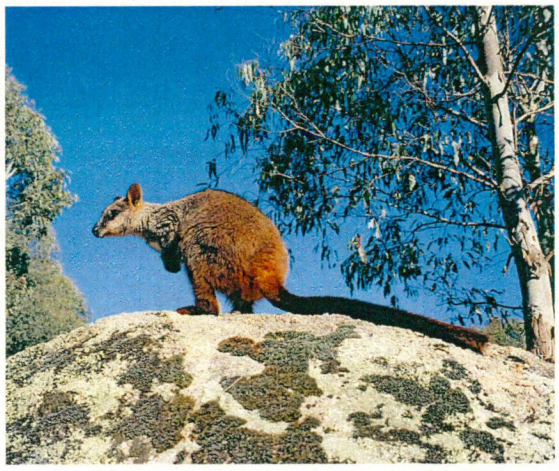
1 Summary

1.1 Fauna Species Priorities

- The highest priority fauna species in the Warragamba Special Area are the Brush-tailed Rock-wallaby, Regent Honeyeater, Swift Parrot and Stuttering Frog. Each is close to extinction in the Greater Southern Sydney Region and listed as Endangered under the TSC Act (1995).
- The next highest priorities are the Squirrel Glider, seven declining woodland bird species, the Broad-headed Snake, Dingo and Large-eared Pied Bat. For these species, most high-quality habitat in the Region occurs within the Warragamba Special Area.
- After this, there are a further 13 priority species where the Warragamba Special Area contains a large proportion of high-quality habitat in the region: the Koala, Spotted-tailed Quoll, five threatened bat species, three threatened owls, Rosenberg's Goanna, Rockwarbler and Eastern Pygmy-possum.



Brush-tailed Rock-wallaby – highest priority © DECC

1.2 Fauna Habitat Priorities and Linkages

- There are three Priority Fauna Habitats found in the Special Area: Grassy Box Woodlands, Alluvial Forests and Woodlands and Upland Swamps.
- Two important Fauna Linkages have been identified: the Bargo and Wollondilly Linkages.
- Important sites and populations that require management are the Wollondilly-Kowmung Brush-tailed Rock-wallaby population and the Mt. Werong Stuttering Frog population.
- Pest and weed management, and ecological rehabilitation and restoration should focus on Priority Fauna Habitats, Fauna Linkages and Priority Fauna Populations.
- Land acquisition for fauna in the Special Area should aim to be part of a fauna linkage or corridor, and include Priority Fauna Habitats and Populations.
- The development of an Ecological Restoration Plan is recommended for the Burragorang and Wollondilly Valleys. This should deal with regeneration, reconstruction, land acquisition, and feral animal management.

1.3 Key Threatening Processes

- There are 18 Key Threatening Processes, as identified on the TSC Act, operating within the Warragamba Special Area (Appendix C).
- The most important threats are habitat alteration, *predation or competition from Feral Pigs, Foxes, Cats, Goats and Rabbits*. Control of these pests within priority fauna habitats will benefit multiple threatened fauna species.
- *Invasion of exotic perennial grasses* is a Key Threatening Process that is very important for this Special Area, with the Burragorang and Wollondilly Valleys supporting many threatened woodland birds.
- *Loss of native vegetation and clearance of dead wood and trees* are Key Threatening Processes within the small areas of freehold land in the Wollondilly and Burragorang Valleys.
- *Collection of Bushrock* is a Key Threatening Process that has historically been well controlled in much of the Special Areas by access restrictions. It is very important that this activity continues to be controlled in the future to protect populations of Broad-headed Snake and Red-crowned Toadlet.

1.4 Fire Management and Fauna

- Fire management should aim for a mosaic of fire regimes.
- Mosaic burning should aim to retain some examples of all fauna habitats (including the highly flammable Upland Swamps) in a long unburnt state.
- Fire planning should recognise the role of unburnt refugia have in the recolonisation of burnt landscapes particularly after extensive and intense wildfire.
- Unburnt refugia should remain unburnt for more than four years following extensive and intense wildfire.
- Special consideration should be given toward fire management of the Priority Fauna Habitats as these environments support a large proportion of the areas threatened fauna.
- Carefully considered fire management should be given to isolated populations of very rare species, particularly the Brush-tailed Rock-wallaby and Stuttering Frog.

1.5 Recovery Planning Actions

- Recovery Plans for the Koala, Regent Honeyeater, Brush-tailed Rock-wallaby, Swift Parrot, Barking Owl and Blue Mountains Water Skink are relevant to the Warragamba Special Area. For these species there is important habitat and active threats in the area.
- Recovery of these species in the Special Area could include threat amelioration, habitat model refinement

and community education (in particular for landholders within the Schedule Two areas).

- The Yellow-bellied Glider and large forest owls have current Recovery Plans but are relatively common and secure within the Warragamba Special Area. At present no targeted actions are required for the recovery of these animals.

The Powerful Owl – no targeted recovery actions required
© N. Williams

- This project has fulfilled the recovery plan objective of surveying and mapping the extent of the range of the above species within the Special Area.

1.6 Pest Species and Biodiversity

- Control of feral predators and all other introduced species should be focused on sites or habitats of particular conservation significance.
- Feral predator control is most important where there are isolated populations of species that are: a) the highest conservation priority in the Greater Southern Sydney Region; and b) considered to be threatened by introduced predators.
- In the Warragamba Special Area targeted control of introduced predators should be focused on populations and habitat of the Brush-tailed Rock-wallaby (in accordance with the Fox Threat Abatement Plan). Any discovered populations of the Long-nosed Potoroo, Southern Brown Bandicoot, Ground Parrot, Eastern Bristlebird and Bush Stone-curlew are also high priorities for targeted predator control.
- For the conservation of biodiversity generally, the highest priority species for control are the Fox, Feral Goat and Feral Pig.
- Foxes consume a far greater range of prey than Wild Dogs and Dingoes. Therefore, for the conservation of biodiversity, Foxes are a higher priority for control than Wild Dogs.
- Control of pest species should also be focused on Priority Fauna Habitats: Grassy Box Woodlands, Alluvial Forests and Woodlands and Upland Swamps. These habitats support the majority of threatened species. Pest control in these habitats will achieve the maximum benefit for faunal biodiversity.
- At a landscape level, control of Foxes is most important in the sandstone plateaux of the Warragamba Special Area (including sandstone woodlands, forests, heaths and swamps) due to the diversity of prey taken.
- Reduction of Fox numbers is particularly important in Upland Swamps, such as is found on the Narrowneck Plateau and Kings Tableland. This is a high-diversity environment where Foxes feed almost exclusively on native mammals, including many uncommon species.
- Fox and Rabbit control should always be undertaken simultaneously in the Burragorang and Wollondilly Valleys. This is less important to undertake concurrently in the sandstone environments.
- Feral predator control is most important in the period following fire when open vegetation affords little cover to native species.
- Deer of all species are an emerging problem and should be considered a high priority for control programs to prevent establishment and significant expansion of their range.
- Feral Pigs have been identified as impacting on Priority Fauna Habitats in the Burragorang Valley, particularly Alluvial Forests and Woodlands. They are considered to be a high priority for control, particularly in this environment.
- Feral Goats are a high priority for control around the Brush-tailed Rock-wallaby population at Bullio, and in all Brush-tailed Rock-wallaby habitat, such as that found in the rocky escarpment between Wombeyan Caves and Yerranderie east to the Wollondilly River and along the Wingecarribee River.
- Efforts should be made to avoid the establishment of the Common Myna and Common Starling in the Grassy Box Woodlands of the Burragorang and Wollondilly Valleys where they will compete with threatened hollow-nesting species such as the Brown Treecreeper and Squirrel Glider. It is also possible that these birds will eventually transport African Olive into the Burragorang Valley.
- The impacts of the Eurasian Blackbird are unknown but this bird is likely to contribute to the spread of some weed species such as Blackberry and compete with some birds (e.g. Bassian Thrush).
- Control of introduced bird species in undisturbed sandstone environments is a low priority.

2 Introduction

2.1 Background

The Warragamba Special Area is of outstanding zoological interest. A total of 360 terrestrial vertebrate fauna species are known to occur, with 40 of these listed on the New South Wales Threatened Species Conservation (TSC) Act (1995). As a single management area it includes some of the most varied fauna habitats in New South Wales, including rainforests, freshwater swamps, rainshadow valleys and plains, sandstone escarpments as well as montane and subalpine environments. The large number of animal species reflects this diversity in the landscape with Koalas, Yellow-tailed Black-cockatoos and Superb Lyrebirds in the forests; Emus, Eastern Grey Kangaroos and Dingoes on the plains, Platypus in the rivers, and bats that inhabit every environment in the Special Area. Incongruously, all this is found within 40 kilometres of Australia's largest metropolis.

This document is an outcome of a joint project between the Department of Environment and Climate Change (DECC) and the Sydney Catchment Authority.

2.2 Objectives

The Special Areas Strategic Plan of Management (SASPoM) was implemented by the New South Wales Minister for the Environment in May 2001 (Sydney Catchment Authority and NPWS 2001) and provides a basis for the joint management of the Special Areas. Environmental management strategies for the Warragamba Special Area recognised an information shortfall on the biodiversity values of the area. This vertebrate fauna project follows the completion of detailed vegetation mapping (NPWS 2003a, 2003b).

The purpose of this document is to summarise the main findings of the vertebrate fauna survey and data analysis (Volumes 1 and 2) as they apply to the Warragamba Special Area. This document is Volume 3 in the report series and:

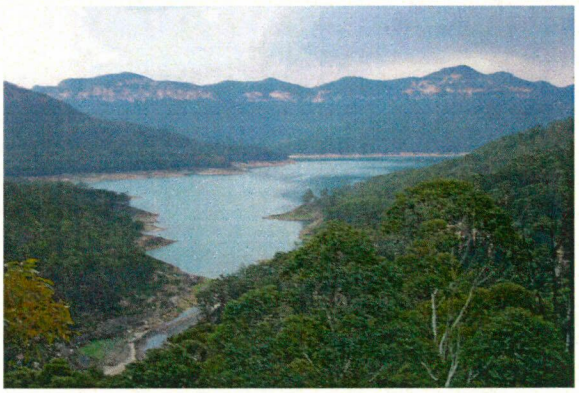
- lists all vertebrate fauna recorded in the Warragamba Special Area highlighting those listed as threatened under State or Commonwealth legislation;
- provides a ranking of priority fauna species for land managers and planners working in the Special Area;
- maps where habitat exists for species of conservation concern;
- identifies the most important native fauna habitats and corridors;
- presents a series of management recommendations to guide land management and assessment for fauna conservation;
- reviews pest species issues in the Special Area as they relate to the conservation of biodiversity and in particular examines the diets of feral predators;
- gives recommendations on the management of feral species;

2.3 The Warragamba Special Area

The Warragamba Special Area consists of the stored waters of Lake Burragorang and adjacent lands. It covers over 250000 ha and extends from Warragamba township in the north-eastern corner to Wombeyan Caves in the south-west (see Map 1). The Special Area is jointly managed by the Sydney Catchment Authority and DECC. Over 70 percent of the Special Area is gazetted as a National Park or Nature Reserve under the NPW Act (1974). The Special Area encompasses part of the Greater Blue Mountains World Heritage Area and part of the Kanangra-Boyd and Nattai Wilderness areas (see Map 2).

2.4 How to Use This Document

This document summarises project findings and recommendations for the management of vertebrate fauna within the Warragamba Special Area. Detail is provided on issues that require management action for the conservation of biodiversity.



Lake Burragorang and the Warragamba Special Area. © DECC/ N. Corkish

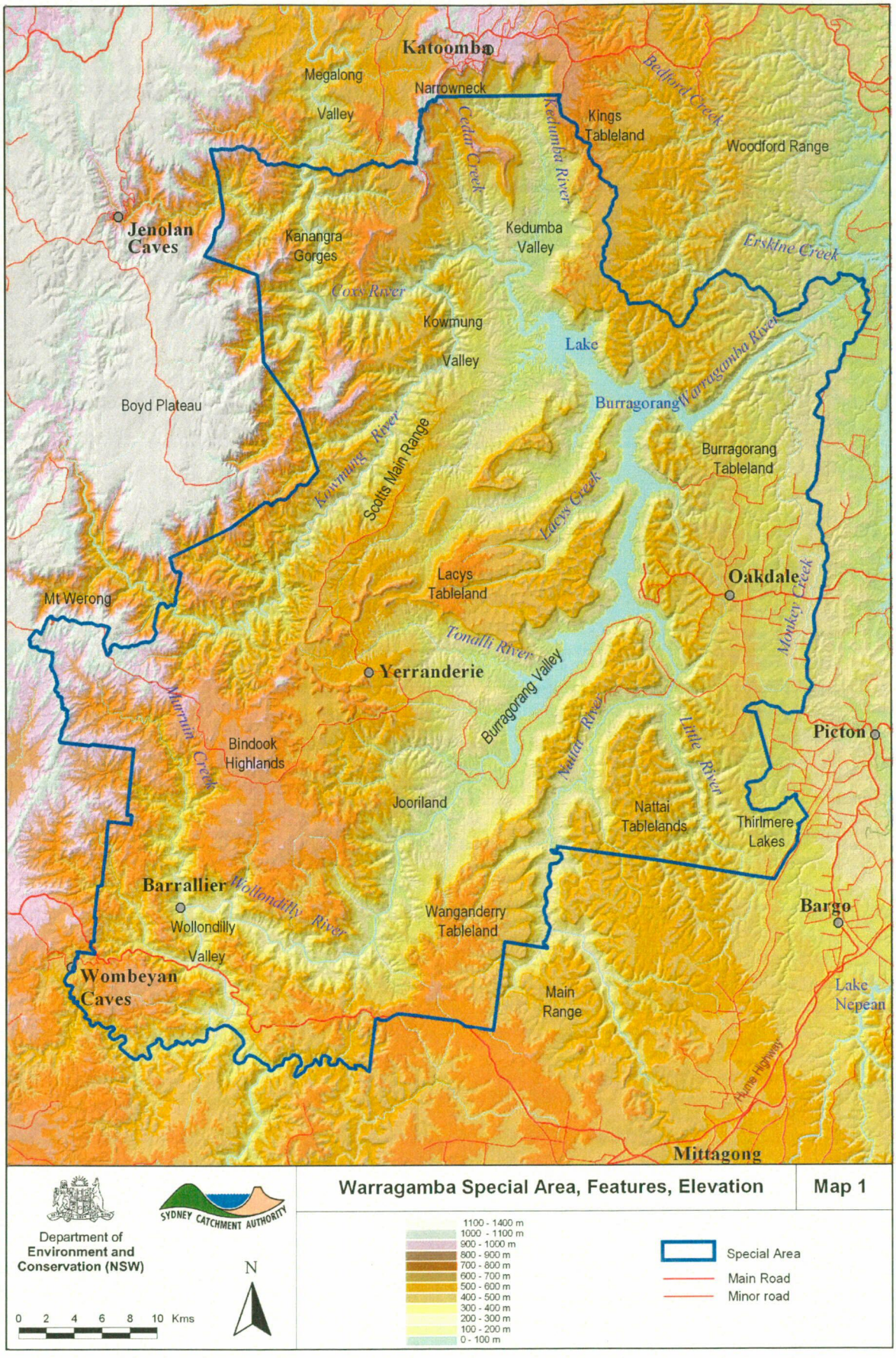
Information on fauna survey techniques, results, conservation assessment methods and outcomes are available in **Volume 1 – Background Report** of this series (DECC 2007a). This volume also gives details of how priority fauna habitats and corridors were derived.

Comprehensive information on each native species of conservation concern and pest species is provided in **Volume 2 – Fauna of Conservation Concern and Priority Pest Species** (DECC 2007b).

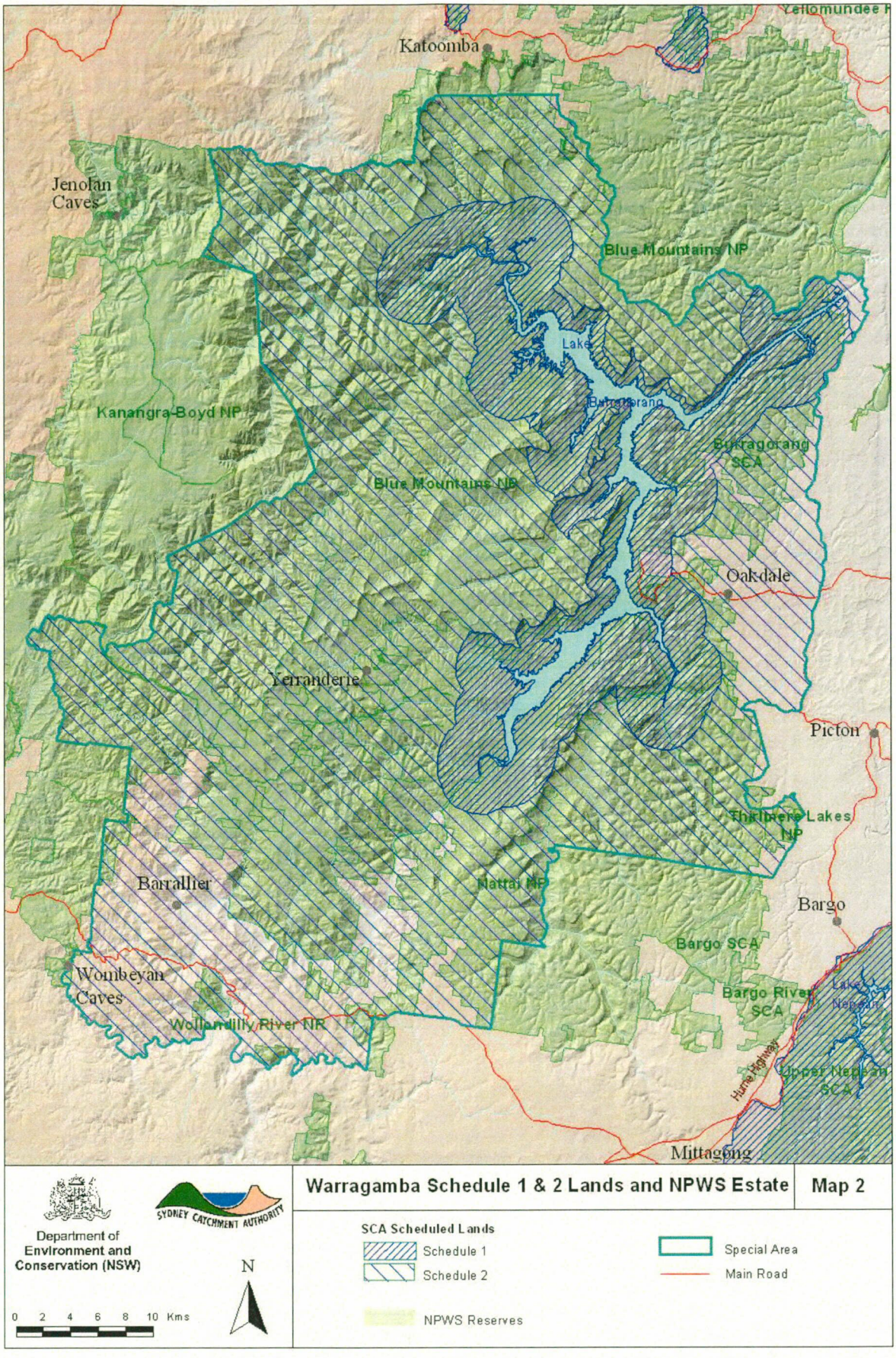
Management reports are also available for the Metropolitan, O'Hares Creek and Woronora Special Areas (**Volume 4**; DECC 2007c) and the Blue Mountains Special Areas (**Volume 5**; DECC 2007d).

A general audience volume **Threatened and Pest Animals of Greater Southern Sydney** is also available (DEC 2007e).

This series is accompanied by species habitat maps available in digital format for use in Geographic Information Systems (GIS).



Map 1: Warragamba Special Area Features and Elevation.



Map 2: Warragamba Schedule 1 and 2 lands and NPWS Estate.

3 Native Fauna

3.1 Summary of Survey Effort

Extensive vertebrate fauna surveys were conducted within the Warragamba Special Area and adjoining reserves between 2002 and 2004, with a total of 1233 sites investigated. Within the Warragamba Special Area, almost 1300 separate censuses have been undertaken at 600 sites with thousands of person hours expended surveying all major habitats. Survey teams undertook overnight walks, a helicopter-assisted survey in the Lacy's Tableland area and surveyed the gullies and slopes around Lake Burragorang using boats. Including prior surveys, this survey has brought the total number of systematic sites in the Warragamba Special Area to 699. Map 3 shows the distribution of survey sites within the Special Area.

Systematic and opportunistic survey techniques were used to target diurnal and nocturnal birds, bats, reptiles, arboreal and terrestrial mammals, frogs and vertebrate pests. Some groups were well sampled by systematic techniques, such as forest and woodland birds, most arboreal mammals, bats and reptiles. Other groups, particularly the frogs and large terrestrial mammals (including many vertebrate pests), were primarily recorded opportunistically. More information on the methods undertaken is provided in **Volume 1 – Background Report**.

3.2 Native Species

A complete species list of native vertebrate fauna within the Warragamba Special Area is presented in Appendix A. A tally of records is provided as well as the current legal status of the species under the NPW Act (1974) and the TSC Act (1995). Almost 350 native species are confirmed to occur, including 209 species of birds, 47 species of mammals (including 19 species of bats), 23 species of frogs and 48 species of reptiles. This is a high level of species diversity, attributed to the wide variety of habitats present within the area, and the largely intact nature of these environments. In fact, 88% of all terrestrial vertebrates known from the Greater Southern Sydney Region are found within the Warragamba Special Area.

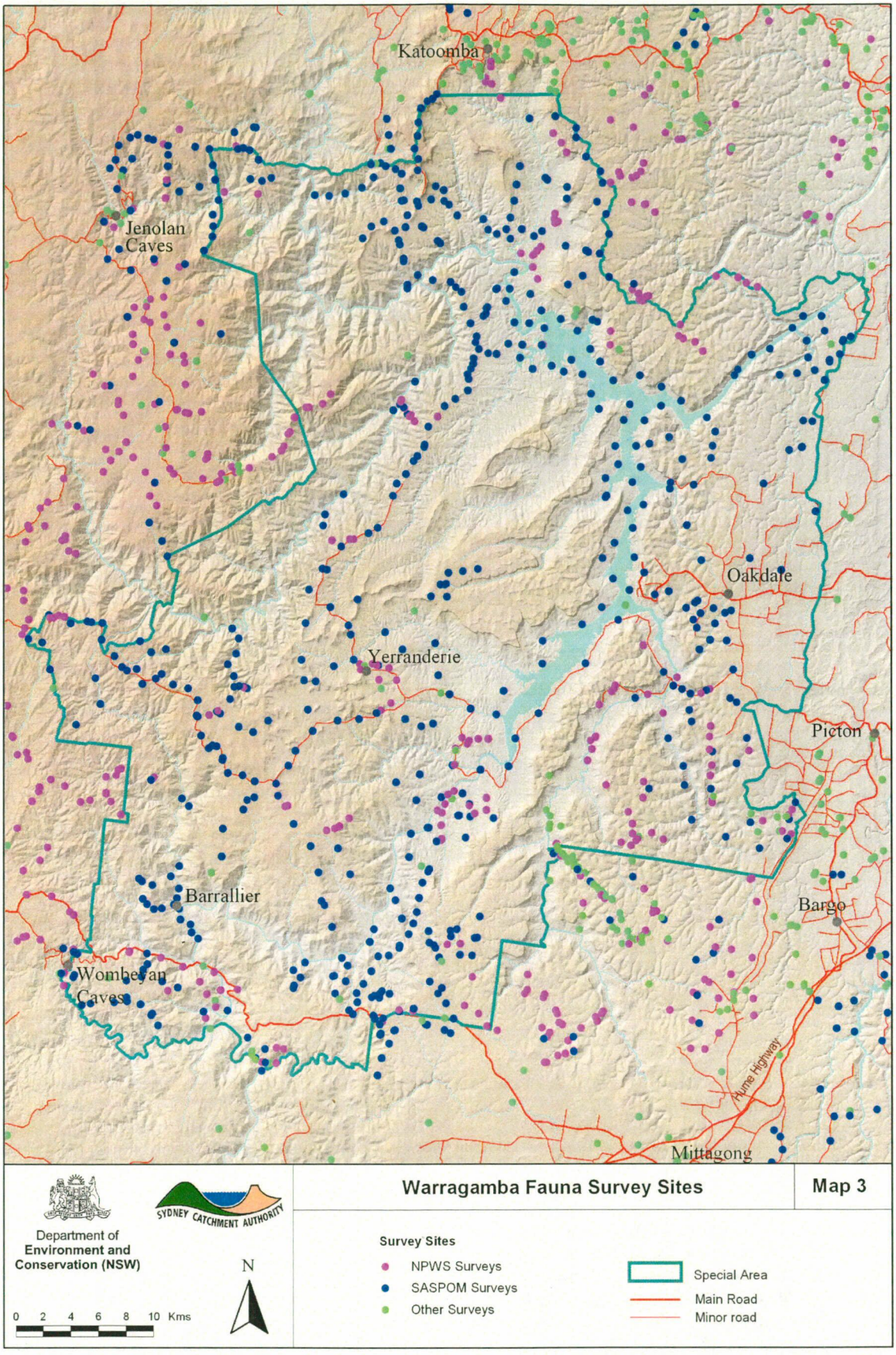
Diurnal birds are the largest faunal group in the Special Area. Of the 209 confirmed species of native birds recorded, 201 were diurnal birds, the other eight being nocturnal species. The most commonly recorded diurnal birds were the White-throated Treecreeper, Yellow-faced Honeyeater, Spotted Pardalote and Grey Fantail. Of the nocturnal species, the most commonly detected were the Australian Owlet-Nightjar and the Southern Boobook.

The 47 confirmed species of native mammals recorded in the area comprises ten species of arboreal mammals, 18 terrestrial species and 19 species of bats. The Greater Glider and Sugar Glider were the most frequently recorded arboreal mammals. Of the ground-dwelling mammals, larger species such as the Common Wombat were most frequently recorded, often seen grazing alongside tracks throughout the Special Area. The Swamp Wallaby and the Eastern Grey Kangaroo were also commonly encountered. These two species inhabit quite different environments, the latter common in more open, grassy habitats, such as the Burragorang Valley, while Swamp Wallabies were more common in more densely–vegetated habitats. There were also a number of smaller marsupial and rodent species recorded, such as the Brown Antechinus and the Bush Rat. Of the bats, most common was the tiny Little Forest Bat, regularly caught in harp traps alongside larger species such as Gould's Long-eared Bat and the Chocolate Wattled Bat. Weighing as little as 3 grams, the Little Forest Bat is encountered more than twice as often as any other microbat when trapping in the area.

A Little Forest Bat with juvenile – the most common microbat in the Special Area. © N. Williams

The diversity of environments present within the Warragamba Special Area supports a diverse array of reptile species, including 25 species of skinks, 11 snakes, four geckoes, four dragons, two monitors, one legless lizard and one freshwater turtle. The most commonly recorded skinks were the Pale-flecked Garden Sunskink, Eastern Water Skink and the Dark-flecked Sunskink. Other commonly recorded lizards included the Lace Monitor and the Jacky Lashtail. The most frequently encountered snake was the Red-bellied Black Snake.

The Common Eastern Froglet was by far the most frequently recorded frog species within the Warragamba Special Area, recorded twice as often as any other species. This species is known to call all year round, including at times when most other frogs find the weather too cold to breed. Peron's Tree Frog, was the next most commonly recorded species. Lesueur's Frog was another frequently encountered frog which has recently undergone a taxonomic review. This species has been split into two separate species, the blue-thighed form (*Litoria lesueurii*) and the yellow-thighed form (*Litoria wilcoxii*). At this stage, all records from the Warragamba Special Area appear to be the latter species.



Map 3: Warragamba Special Area Fauna Survey Sites.

3.3 Threatened Species

There are records of 40 threatened fauna species within the Warragamba Special Area as listed under the TSC Act (1995) or EPBC Act (1999) (Table 1). This includes five frogs, three reptiles, ten diurnal birds, four nocturnal birds, five terrestrial mammals, four arboreal mammals and nine bats. While most of these species have been confirmed by recent survey, two species are only known from old museum records: the Green and Golden Bell Frog and the Tasmanian Bettong. These species have hence been classified as 'unconfirmed' within the Warragamba Special Area. While these species may have once existed within the Special Area, the Tasmanian Bettong is long extinct on the Australian mainland, while the Green and Golden Bell Frog has suffered a massive range retraction and is unlikely to still exist in the Warragamba Special Area. A third threatened species has been listed as unconfirmed, the Southern Brown Bandicoot, which is only known from diggings in the north of the Special Area – an unreliable method of identification. There are single unconfirmed records of two threatened bat species within the Special Area; the Little Bentwing-bat and the Yellow-bellied Sheathtail-bat. Records of the Common Planigale within the Warragamba Special Area may be incorrect due to possible confusion with an unusually small race of the Brown Antechinus (Mount King Ecological Surveys 1989; M. Denny, wildlife consultant, pers. comm.).

The endangered Regent Honeyeater visits the Warragamba Special Area to feed on winter-flowering eucalypts. © G. Dabb

Table 1 details the number of individuals recorded, as opposed to the number of sightings (or locations) (which is given in Appendix A). This different information is equally important, for instance the Regent Honeyeater has been recorded at only 27 different locations within the Warragamba Special Area; however 246 individuals have been counted (Table 1). Groups of over 50 birds have been counted at the one location, thus the total number of individuals counted provides an additional view of how important the Warragamba Special Area is to this species, which has a total population of less than 1500 birds (see **Volume 2 – Fauna of Conservation Concern and Priority Pest Species**).

There is a great disparity from one threatened species to another in the number of individuals recorded. For fifteen of the 40 threatened species, there have been ten or fewer individuals recorded in the Special Area. For some species, this is due to difficulty of detection, while for others it is a reflection of the small amount of

Squirrel Gliders are extremely rare within the Warragamba Special Area. © N. Williams

suitable habitat within the catchment, such as the Giant Burrowing Frog and Blue Mountains Water Skink. For some species, low numbers are a true reflection of the rarity of the species in the region, including the Booroolong Frog and the Squirrel Glider. In contrast to these species, there are five species for which there have been over 200 individuals recorded in the Warragamba Special Area: the Brown Treecreeper, Diamond Firetail, Gang-gang Cockatoo, Regent Honeyeater and the Yellow-bellied Glider. There are also two species for which there are records of over 400 individuals: the Glossy Black-Cockatoo and the Eastern Bentwing-bat. For the Regent Honeyeater, as mentioned above, this is a reflection of the importance of the Special Area to the conservation of this critically endangered species. For other species, such as the Glossy Black-Cockatoo, Yellow-bellied Glider and Eastern Bentwing-bat, the large numbers confirm these species are not as uncommon in this area as was previously thought. The importance of the Warragamba Special Area to the overall conservation of each threatened species is discussed further in Section 6.

There are nine species listed as Endangered under the TSC Act (1995), including a disproportionate number of frogs, reflecting the declines that have been observed worldwide in this group. Also over-represented on the endangered list are the large forest owls and the terrestrial mammals. For the latter group, the introduction of the Feral Cat and Fox, combined with land clearance and altered fire regimes have had significant impacts. For a full discussion on patterns of decline and extinction, see **Volume 1**. Key Threatening Processes acting on each of these species within the Warragamba Special Area are addressed in Section 6.

The threatened species listed in Table 1 are discussed individually, in **Volume *2***, along with other species of conservation priority. For most there is also a map of habitat and sightings. Later in this report, these species have been prioritised for conservation management within the Warragamba Special Area.

Table 1: **An inventory of threatened vertebrate fauna found in the Warragamba Special Area, showing legal status under the TSC Act (1995) and the total number of individuals that have been recorded.**

Common Name	Scientific Name	Certainty	Legal Status	Individuals recorded
Amphibians				
Booroolong Frog	*Litoria booroolongensis*	Confirmed	Endangered	2
Giant Burrowing Frog	*Heleioporus australiacus*	Confirmed	Vulnerable	1
Green and Golden Bell Frog	*Litoria aurea*	Unconfirmed	Endangered	1
Red-crowned Toadlet	*Pseudophryne australis*	Confirmed	Vulnerable	12
Stuttering Frog	*Mixophyes balbus*	Confirmed	Endangered	2
Reptiles				
Blue Mountains Water Skink	*Eulamprus leuraensis*	Confirmed	Endangered	1
Broad-headed Snake	*Hoplocephalus bungaroides*	Confirmed	Endangered	1
Rosenberg's Goanna	*Varanus rosenbergi*	Confirmed	Vulnerable	4
Diurnal Birds				
Black-chinned Honeyeater (eastern subsp.)	*Melithreptus gularis gularis*	Confirmed	Vulnerable	13
Brown Treecreeper (eastern subsp.)	*Climacteris picumnus victoriae*	Confirmed	Vulnerable	214
Diamond Firetail	*Stagonopleura guttata*	Confirmed	Vulnerable	210
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Confirmed	Vulnerable	282
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	Confirmed	Vulnerable	429
Hooded Robin (southeastern subsp.)	*Melanodryas cucullata cucullata*	Confirmed	Vulnerable	62
Regent Honeyeater	*Xanthomyza phrygia*	Confirmed	Endangered	246
Speckled Warbler	*Pyrrholaemus sagittatus*	Confirmed	Vulnerable	114
Swift Parrot	*Lathamus discolor*	Confirmed	Endangered	95
Turquoise Parrot	*Neophema pulchella*	Confirmed	Vulnerable	110
Nocturnal Birds				
Barking Owl	*Ninox connivens*	Confirmed	Vulnerable	7
Masked Owl	*Tyto novaehollandiae*	Confirmed	Vulnerable	14
Powerful Owl	*Ninox strenua*	Confirmed	Vulnerable	49
Sooty Owl	*Tyto tenebricosa*	Confirmed	Vulnerable	44
Arboreal Mammals				
Eastern Pygmy-possum	*Cercartetus nanus*	Confirmed	Vulnerable	9
Koala	*Phascolarctos cinereus*	Confirmed	Vulnerable	19
Squirrel Glider	*Petaurus norfolcensis*	Confirmed	Vulnerable	10
Yellow-bellied Glider	*Petaurus australis*	Confirmed	Vulnerable	238
Terrestrial Mammals				
Brush-tailed Rock-wallaby	*Petrogale penicillata*	Confirmed	Endangered	48
Common Planigale	*Planigale maculata*	Probable Error	Vulnerable	1
Southern Brown Bandicoot	*Isoodon obesulus obesulus*	Unconfirmed	Endangered	1
Spotted-tailed Quoll	*Dasyurus maculatus*	Confirmed	Vulnerable	22
Tasmanian Bettong	*Bettongia gaimardi*	Unconfirmed	Extinct	2
Bats				
Eastern Bentwing-bat	*Miniopterus schreibersii*	Confirmed	Vulnerable	506
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Confirmed	Vulnerable	12
Eastern Freetail-bat	*Mormopterus norfolkensis*	Confirmed	Vulnerable	12
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Confirmed	Vulnerable	31
Grey-headed Flying-fox	*Pteropus poliocephalus*	Confirmed	Vulnerable	7
Large-eared Pied Bat	*Chalinolobus dwyeri*	Confirmed	Vulnerable	98
Large-footed Myotis	*Myotis adversus*	Confirmed	Vulnerable	81
Little Bentwing-bat	*Miniopterus australis*	Unconfirmed	Vulnerable	1
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Unconfirmed	Vulnerable	1

3.4 Patterns in Native Fauna Distribution

Distribution of fauna within the Warragamba Special Area reflects three broad landscape and climatic zones: the *Montane and Highland Environments*, *Coastal Hinterlands* and the *Dry Rainshadow Valleys and Plains*. While not all species fall neatly into this classification, there are trends worthy of discussion.

Montane and Highland Environments occur at elevations greater than 800 m above sea level (asl), and are characterised by a year-round cooler climate. Primary locations are the Bindook Highlands, Mt. Werong, Little Wombeyan and Murruin Creek Catchments and the Upper Blue Mountains. Vegetation cover is dominated by dry sclerophyll eucalypt forest, often with an open grassy understorey. The vertebrate fauna of this environment is generally more typical of the Southern Highlands, Australian Alps and even Victoria, than the Sydney Basin itself. The reptiles found in these montane and highland environments are particularly distinctive. A suite of skinks specialised for cooler temperatures occur, including the Tussock, Bold-striped, Trunk-climbing and Southern Forest Cool-skinks. Some larger reptiles display similar trends, such as the Highlands Copperhead and Blotched Bluetongue. Highland environments also have a distinctive suite of diurnal birds, particularly in the summer months when some species migrate from their wintering grounds in the coastal lowlands. Typical bird species of the highlands include the Flame and Scarlet Robins, Gang-gang Cockatoo and the Crescent Honeyeater. Mammals that typify higher elevation forests and woodlands are the Greater Broad-nosed Bat, Eastern False Pipistrelle and Greater Glider, all of which are scarce or absent from lower elevations. It was within this landscape that a significant range extension for the Southern Brown Tree Frog was made, a species more typically found in southern New South Wales and Victoria.

The *Coastal Hinterland* is the dissected sandstone plateaux between approximately 200 and 800 m asl. This landscape dominates the majority of the Warragamba Special Area, in the eastern and northern parts, including the Nattai, Wanganderry, and Burragorang Tablelands and the Erskine Range. The vegetation of these areas is characterised by dry sclerophyllous shrub forests and woodlands. Fauna that thrive in this impoverished landscape are those typical of the Sydney Sandstones of the Hawkesbury and Narrabeen Group and there are many species that are endemic to this landscape. Rocky outcrops are a feature of the plateaux, supporting a distinctive suite of reptiles including the Copper-tailed Ctenotus, White's Rock-skink, Lesueur's Velvet Gecko and Mountain Heath Dragon. Several reptiles are unique to this environment: the Broad-headed Snake and the Sydney subspecies of the Cunningham's Skink. Given the rugged nature of this environment, there is a surprising array of frog species, though many are closely associated with the hanging swamps that occur in the higher rainfall zones of the coastal escarpment and upper Blue Mountains. Typical species include Haswell's Froglet, Blue Mountains Tree Frog, Red-crowned Toadlet and the Giant Burrowing Frog. The bird species are similarly diverse, with a variety of honeyeaters that capitalise on the flowering shrub layer that is typically associated with this landscape. Typical species include the New Holland Honeyeater, Eastern Spinebill, Little Wattlebird and the Yellow-faced Honeyeater. One bird species, the Rock Warbler is endemic to the Sydney Sandstone. Arboreal mammals are diverse but relatively uncommon due to the poor soils and the relative scarcity of tree hollows in the exposed woodlands of this landscape. The Common Ringtail Possum, which does not necessarily rely on tree hollows, is the most common species in this environment, followed by the Sugar Glider. Other smaller arboreal species are rarely recorded, such as the Eastern Pygmy-possum and Feathertail Glider. Taller forests that occur along gully lines and on sheltered slopes support additional arboreal mammals; particularly the threatened Yellow-bellied Glider whose gurgling call is commonly heard emanating from the gullies of the Warragamba Special Area.

Dry Rainshadow Valleys and Plains are a third important landscape of the Warragamba Special Area. The Burragorang Valley is the primary example, sharing many environmental characteristics with the Cumberland Plain, the western-most extent of which also occurs within the Warragamba Special Area. The Burragorang Valley and Cumberland Plain are underlain by relatively fertile clay soils that support an abundance of grasses, despite relatively low annual rainfall (of around 700 mm). The Grassy Box Woodland that dominates this type of environment is more typical of the western slopes and ranges of New South Wales. The fauna of the Burragorang Valley is likewise reminiscent of more western environments. Typical bird species include the Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin, and Restless Flycatcher. The endangered Swift Parrot and Regent Honeyeater also visit the Burragorang Valley. Lizards found in this area are also characteristic of open, dry grassy woodlands with Bell's phase Lace Monitor, Tree-base Litter-skink, Robust Ctenotus, Thick-tailed Gecko and the Three-toed Earless Skink all more typical of the western slopes and/or Hunter Valley.

Mammal species typical of the Dry Rainshadow Valleys and Plains include the Common Brushtail Possum and Eastern Grey Kangaroo - both of which are far more common in the Burragorang Valley than anywhere else in the Special Area. In addition, the very uncommon Common Dunnart, was most often found in the dry woodlands of the Burragorang Valley - exhibiting a preference for grassy woodlands mirrored by DECC survey work in the Hunter Valley (DEC 2005a). Other mammals found in this environment include the Yellow-footed Antechinus and the Squirrel Glider. There are also several bat species associated with this landscape, primarily the threatened Eastern Freetail-bat.

A disproportionate number of fauna species found in the Dry Rainshadow Valleys and Plains are listed as threatened, or have suffered significant declines since European settlement. Across Australian this landscape has been extensively cleared and modified, and is mostly in a degraded or regenerative state - even within Schedule One of the Warragamba Special Area. Nevertheless, the Burragorang Valley is one of few examples where this landscape is conserved and is regenerating. The vast majority of species that occupied the Burragorang Valley before European settlement still maintain viable populations there. It is the single most important landscape in the Special Areas for the conservation of biodiversity.

4 Species Conservation Status

4.1 Overview

Land managers are currently faced with an overwhelmingly large list of threatened fauna species. However, threatened species do not all warrant equivalent management attention. Furthermore, priorities vary from one region to another, as does the management response required.

Volume 1 reviewed all terrestrial fauna known to occur in the Greater Southern Sydney Region, identifying a list of Species of Conservation Concern. This list included species listed as threatened under State or Federal legislation; species thought to be declining regionally or locally; species thought to impact on water quality; and species of cultural interest, particularly to indigenous communities. Table 2 lists all Species of Conservation Concern for the Warragamba Special Area and cites key threats and key locations there. The importance of the Warragamba Special Area to the conservation of the species in the Region has been summarised in the final column. This has been derived by assessing how much hiqh-quality habitat is present, and the proportion of habitat in the Region that occurs in the Warragamba Special Area (Appendix B).

Each of the species listed in Table 2 are described in detail, along with maps showing habitat and sightings in **Volume 2 - Fauna of Conservation Concern and Priority Pest Species**.

4.2 Setting Priorities for Conservation and Management

When setting the conservation priorities for the Greater Southern Sydney Region, including the Warragamba Special Area, factors included for consideration were:

- The level of decline within the Region;
- The level of threat to remaining populations;
- The total amount of habitat in the Region;
- The importance of the Region to the overall survival of the species in question; and
- The amount of habitat that has already been lost.

This process has been described in detail in **Volume 1**. A prioritised list of species is given in Table 2. The most important for the Warragamba Special Area are those of moderate-highest conservation priority where the significance of the Special Area to their regional survival is critical. A list of threats operating in the Warragamba Special Area is given. Importantly, habitat loss, which is a major threat outside of the Special Areas, is generally minor within them.

The Warragamba Special Area makes an enormous contribution to the conservation of threatened and declining fauna in Greater Sydney. Of the 92 Species of Conservation Concern within the Greater Southern Sydney Region, 79% occur within the Warragamba Special Area – with the remainder generally coastal species or locally extinct. Furthermore, 80% of the Region's *highest conservation priority* fauna - that is, the most threatened species in the Region - occur within the Special Area. For many, this area is critical - for example the Brush-tailed Rock-wallaby. This wallaby has experienced a massive range contraction with only one known population in the southern Blue Mountains. This population and most predicted habitat is found within the Warragamba Special Area.

For numerous species, the Warragamba Special Area contains most available habitat in the Region. Without it their long-term survival in the Region would be seriously compromised. In total 15 priority fauna have 40% or more of their habitat within the Special Area (Table 2). For over 70% of priority species the Warragamba Special Area is classed as critical or important to their persistence in the Region. Additionally, seven species of lower conservation priority have 40% or more of their habitat within the Special Area, including the Emu, Eastern Grey Kangaroo, Glossy Black-Cockatoo and the White-winged Chough (Table 2).

Within the Region, 90% of remaining habitat for the Diamond Firetail is within the Warragamba Special Area. © H. Fallow

The Brown Treecreeper and Diamond Firetail have over 85% of high-quality habitat in the Greater Southern Sydney Region within Schedule One and Two areas. This habitat, centred on the Burragorang Valley, is critical to the long-term survival of these species in the region. Currently, both are relatively secure within the valley, so they have been ranked as a moderately high conservation priority in the Greater Southern Sydney Region (Table 2).

The Blue Mountains Water Skink is an example of a species that, while highly endangered and an important regional conservation priority, has very little habitat within the Warragamba Special Area.

Conversely, the Glossy Black-Cockatoo is relatively common within the Special Area with no evidence of major historic declines, and a large amount of habitat available. It is therefore a lower conservation priority for the Warragamba Special Area. However, over 85% of high-quality habitat in the region is found within the Warragamba Special Area and it is *critical* to the long-term survival of this bird in the Sydney area (Table 2).

Table 2: **Species of Conservation Concern in the Warragamba Special Area ranked as to their conservation priority in the Greater Southern Sydney Region. The importance of the Warragamba Special Area to the regional conservation of a species is given in the last column. Critical = 40% or more high-quality habitat within Warragamba Special Area; Important = 10-39%; Limited = 1-9%**

Conservation Priority	Species	Key Threats in Warragamba Special Area	Key locations in Warragamba Special Area	Significance of habitat in the Warragamba Special Area
Highest	Brush-tailed Rock-wallaby	Feral predators, feral goats	Wollondilly-Bullio, Bindook Highlands, Kowmung	Critical
	Booroolong Frog	Disease, introduced fish	Wombeyan, Wollondilly, Little River and Kowmung (potential) Rivers	Important
	Stuttering Frog	Disease	Mt. Werong/Ruby Creeks	Critical
	Green and Golden Bell Frog	Disease	Last known record from around The Oaks	Probably extinct from Warragamba SA
	Regent Honeyeater	Habitat loss	Burragorang Valley-Joorilands	Critical
	Swift Parrot	Habitat loss	Burragorang Valley-Joorilands	Critical
	Long-nosed Potoroo	Feral predators, frequent fire	Notts Swamp, Erskine Range	Limited
	Bush Stone-curlew	Habitat loss, feral predators	Thirlmere Lakes (potential), Jooriland (potential)	Possibly extinct from Warragamba SA
High	Large-eared Pied Bat	Habitat loss	Burragorang and Nattai Valleys	Critical
	Eastern Freetail-bat	Habitat loss	Burragorang Valley	Important
	Large-footed Myotis	Habitat loss, water quality	Wollondilly, Nattai, Little Nattai and Kowmung Rivers	Important
	Blue Mountains Water Skink	Habitat loss, climate change	Kings Tableland, Narrowneck Plateau	Limited
	Broad-headed Snake	Collection, bushrock removal	Erskine Range, Nattai Tableland	Critical
	Australasian Bittern	Habitat loss	Thirlmere Lakes	Limited
	Black-chinned Honeyeater	Habitat loss	Burragorang Valley	Critical
	Dingo	Hybridisation, baiting, trapping	Burragorang Valley, Lacy's Tablelands	Critical
	Squirrel Glider	Habitat loss, feral predators	Burragorang and Wollondilly River Flats	Critical
	Koala	Habitat loss	Mt. Wanganderry, Tallygang Mountain, Nattai River, East and Southern Nattai Tableland	Important
	Spotted-tailed Quoll	Competition with feral predators, 1080 baiting?	Sheay's Creek, Beloon Pass	Important
	Masked Owl	Habitat loss	Burragorang and Wollondilly Valleys	Important
	Barking Owl	Habitat loss	Burragorang Valley, Bindook Highlands	Important
	Green Tree Frog	Possibly disease	Burragorang Valley	Limited
	Littlejohn's Tree Frog	Disease	Erskine Range, Kings Tableland	Limited
Moderately High	Greater Broad-nosed Bat	Habitat loss	Kedumba, Mt. Werong	Important
	Eastern False Pipistrelle	Habitat loss, climate change	Bindook Highlands, Yerranderie	Important
	Grey-headed Flying-fox	Habitat loss	Warragamba Gorges, Erskine Range, Nattai and Burragorang Tablelands	Important
	Beautiful Firetail	Habitat loss, frequent fire	Narrowneck Plateau (potential)	Limited
	Brown Treecreeper	Habitat loss	Burragorang Valley, Scotts Main Range, Burragorang and Nattai Escarpment Slopes and Flats	Critical
	Diamond Firetail	Habitat loss	Burragorang Valley	Critical
	Hooded Robin	Habitat loss	Burragorang Valley	Critical
	Restless Flycatcher	Habitat loss	Burragorang Valley	Critical
	Speckled Warbler	Habitat loss	Burragorang Valley	Critical

Conservation Priority	Species	Key Threats in Warragamba Special Area	Key locations in Warragamba Special Area	Significance of habitat in the Warragamba Special Area
	Turquoise Parrot	Habitat loss	Burragorang Valley	Critical
Moderate	Southern Emu-wren	Frequent fire, restricted habitat	Erskine Range, Narrowneck Plateau	Limited
	Tawny-crowned Honeyeater	Restricted habitat	Kings Tableland, Narrowneck Plateau (potential)	Limited
	Rosenberg's Goanna	Restricted habitat	Medlow Gap, Butchers Creek	Important
	Giant Burrowing Frog	Restricted habitat	Erskine Range, Narrowneck Plateau	Limited
	Red-crowned Toadlet	Restricted habitat	Erskine Range, Blue Labyrinth, Nattai Tableland	Limited
	Sooty Owl	Restricted habitat	Erskine Creek, Nattai and Burragorang Tablelands	Important
	Rockwarbler	Restricted habitat	Warragamba Gorges, Erskine Range, Nattai and Burragorang Tablelands	Important
	Flame Robin	Climate change, habitat loss	Woodland and forest on higher fertility soil	Important
	Square-tailed Kite	Habitat loss?	Grassy Woodlands and other	Limited
	Eastern Pygmy-possum	Restricted habitat, frequent fire	Erskine Range, Blue Labyrinth, Kedumba	Important
Lower	Bibron's Toadlet	Largely secure	Woodland and forest on higher fertility soil	Important
	Eastern Bentwing-bat	Secure (excluding communal roost sites)	Many	Important
	Eastern Grey Kangaroo	Secure	Grassy Woodland, clearing and other	Critical
	Eastern Snake-necked Turtle	Secure	Rivers and riparian	Important
	Emu	Secure	Grassy Woodlands, clearing	Critical
	Gang-gang Cockatoo	Secure	Woodland and forest on higher fertility soil	Important
	Glossy Black-cockatoo	Secure	Open Woodlands and forests	Critical
	Greater Glider	Secure	Woodland and forest on higher fertility soil	Critical
	Highlands Copperhead	Secure	Highlands	Limited
	Long-nosed Bandicoot	Probably secure	Many	Limited
	Mainland Tiger Snake	Secure	Many	Limited
	Painted Button-quail	Secure	Many	Important
	Platypus	Probably secure	Rivers and riparian	Critical
	Powerful Owl	Secure	Many	Important
	Red-browed Treecreeper	Secure	Many	Important
	Satin Bowerbird	Secure	Many	Important
	Short-beaked Echidna	Secure	Many	Important
	Spotted Quail-thrush	Secure	Many	Important
	Superb Lyrebird	Secure	Many	Critical
	Tree-base Litter-skink	Secure	Grassy Woodlands	Critical
	Varied Sittella	Secure	Many	Important
	White-winged Chough	Secure	Woodland and forest on higher fertility soil	Critical
	Yellow-bellied Glider	Secure	Wet sclerophyll forests, Open forests	Critical

5 Priority Fauna Habitats, Populations and Linkages

5.1 Introduction

A *fauna habitat* is an environment utilised by a suite of fauna with similar habitat requirements. For this project, *Priority Fauna Habitats* have been defined as habitats that are exceptionally important for the conservation of threatened species and biodiversity. Given limited resources, protection and enhancement of Priority Fauna Habitats will achieve the maximum benefit to threatened species conservation and to vertebrate diversity in the region.

Fauna habitats vary widely in their spatial extent, with some being naturally restricted and others heavily depleted due to clearing. They also vary greatly in the level of modification and in the number of threatened fauna. These disparities are largely because threatening processes operate unequally across the landscape, with habitats that occur on fertile soils and in coastal areas experiencing greatest disruption. This results in a few environments providing habitat for a disproportionately large number of threatened species. For example, in the Greater Southern Sydney Region, just four Priority Fauna Habitats support 32 of the 45 highest priority threatened species.

5.1.1 *How can Priority Fauna Habitats be used in conservation management?*

Priority Fauna Habitats may be used to guide conservation efforts toward areas that will have the greatest outcomes for fauna. Within the Greater Southern Sydney Region, the preservation of habitats identified in this section will have the maximum benefit to threatened fauna, and will help ensure that vertebrate diversity is maintained in the long-term.

Identification of Priority Fauna Habitats may inform land management actions, including:

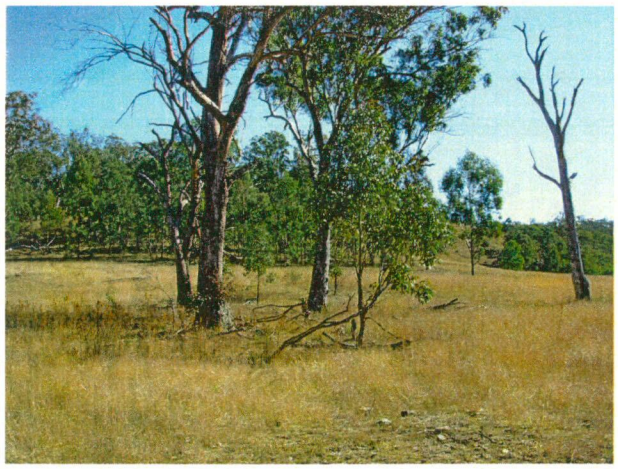
- *land acquisition strategies* - by highlighting areas that provide maximum benefit to priority fauna and vertebrate diversity;
- *pest species management* - allow for control programs that are targeted towards areas that will benefit vertebrate diversity and the greatest number of priority fauna;
- *fire management* - by highlighting environments that require special attention with regard to appropriate fire regimes;
- *threatened species management* - by highlighting areas that are of greatest importance as habitat for species listed under the TSC Act (1995); and
- *management of Key Threatening Processes* - by highlighting areas that require special attention with regard to the mitigation of Key Threatening Processes.

5.2 Priority Fauna Habitats in the Warragamba Special Area

Three of the four Priority Fauna Habitats of the Greater Southern Sydney Region are found within the Warragamba Special Area. These are, in order of priority for the Warragamba Special Area: Grassy Box Woodlands, Alluvial Forests and Woodlands and Upland Swamps (Map 4). For further details on how Priority Fauna Habitats have been identified and mapped, see **Volume 1 – Background Report**.

5.2.1 *Grassy Box Woodlands*

Grassy Box Woodland is the highest Priority Fauna Habitat within the Greater Southern Sydney Region. It was once far more extensive, occurring on higher-fertility soils of the Cumberland Plain, Illawarra Coastal Plain as well as in the rain-shadow valleys of the Warragamba Special Area, such as in the Burragorang, Nattai and Wollondilly Valleys.



Grassy Box Woodlands in the Burragorang Valley are habitat to many threatened species – they are the highest priority fauna habitat in the Special Area. © M. Schulz

It is key habitat for at least 16 of the 45 highest ranked priority fauna species in the Region, plus a number of others that are already locally extinct. Grassy Box Woodlands are extremely important for two of Australia's rarest birds: the Regent Honeyeater and Swift Parrot. Other declining woodland birds that use Grassy Box Woodlands in the Warragamba Special Area are: the Diamond Firetail, Brown Treecreeper, Hooded Robin, Restless Flycatcher and the Speckled Warbler.

Most Grassy Box Woodlands have experienced some degree of disturbance, and on the Cumberland and Illawarra Coastal Plains they are heavily depleted and fragmented. In these areas, smaller isolated remnants are no longer utilised by species that are sensitive to fragmentation. Many Grassy Box Woodland species are locally extinct or close to extinction on the Cumberland and Illawarra Coastal Plains. For this reason, when defining Grassy Box Woodlands as a

priority habitat, a condition filter was applied in order to highlight the best-quality remnants that are most likely to support viable populations of priority fauna into the future. This filter identified all remnants of over 50 ha in size (core remnants) and any patches greater than 10 ha within 1km of a core remnant. This was based on published minimum patch size and connectivity requirements for declining woodland birds. For further details on the filtering process, see **Volume 1**.

The Burragorang Valley contains the largest area of semi-intact Grassy Box Woodland remaining in the Region. It single most significant landscape in terms of the conservation of faunal diversity. Although Grassy Box Woodlands in this area have suffered significant disturbance, the connectivity between remaining patches is extremely good, and as such almost the entire area functions as a single remnant. It is vital to the long-term health of this ecosystem that connectivity is retained or enhanced, particularly along the Wollondilly River between Long Flat and Goodfellow Creek and along the Wollondilly and Wingecarribee Rivers between the two portions of the Wollondilly River Nature Reserve (NR).

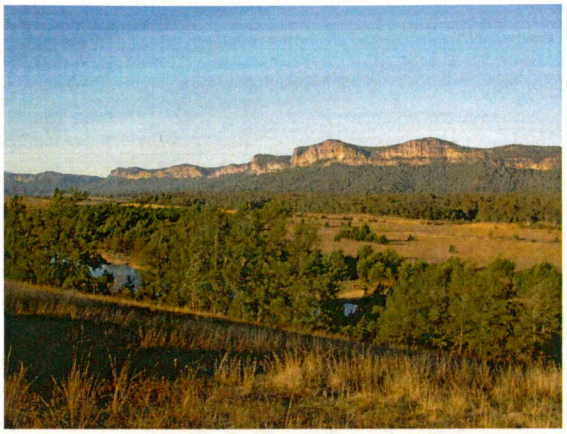
The most important Key Threatening Process that impacts on Grassy Box Woodlands is *habitat loss due to clearing of vegetation*. Land clearance has already impacted the majority of Grassy Box Woodlands in the Special Area, although within the Burragorang Valley they are now mostly in a regenerative state. Another significant Key Threatening Processes affecting this habitat is *invasion of native plant communities by exotic perennial grasses*, which will impact on a number of the declining woodland birds. Further, *removal of dead wood and dead trees* is a Key Threatening Process of particular significance, potentially affecting the Brown Treecreeper, Turquoise Parrot, Squirrel Glider and other Grassy Box Woodland species.

5.2.2 Alluvial Forests and Woodlands

Alluvial Forests and Woodlands occur along the creek and riverflats of waterways throughout the Greater Southern Sydney Region. These environments vary between the coast and tablelands, though all grow on deep, fertile alluvial soils. These types of soil are almost universally impacted by clearing and other factors associated with agriculture. A large number of fauna species rely on these environments including at least five of our most threatened fauna: the Booroolong Frog, Australasian Bittern, Black-chinned Honeyeater, Large-footed Myotis and Regent Honeyeater. In addition, the Green and Golden Bell Frog is also found in floodplain river systems and associated wetlands. Rivers and riparian vegetation are also very important for the Large-eared Pied Bat, which uses these environments for foraging and to move about the landscape (see **Volume 2 – Fauna of Conservation Concern and Priority Pest Species**).

A large proportion of the remaining Alluvial Forests and Woodlands in the Region occur within the Warragamba Special Area. For example, along the Wollondilly, Nattai, Kowmung, Cox's and Kedumba Rivers. Alluvial Forests and Woodlands within the Special Area have also been subjected to fewer disturbances than elsewhere.

The most important Key Threatening Process that impacts on Alluvial Forests and Woodlands is *habitat loss due to clearing of vegetation*. Land clearance has already removed or fragmented the majority of Alluvial Forests and Woodlands and is the greatest ongoing threat to this priority habitat. Another Key Threatening Process that is particularly relevant is *impacts of the Feral Pig*, which favours these environments and causes severe habitat degradation (see **Volume 2**). A final Key Threatening Process, *alteration to the natural flow regimes of rivers, streams, floodplains and wetlands* is relevant to this priority habitat and all fauna that use it.



The Wollondilly River fringed with Alluvial Woodland - the second highest priority fauna habitat in the Warragamba Special Area. © M. Schulz

5.2.3 Upland Swamps

Upland Swamps contain a diverse and unique array of fauna, many of which are threatened. They are key habitat for at least 12 priority fauna species, including the Beautiful Firetail and Giant Burrowing Frog (Table 2). Some species are entirely restricted to this environment, such as the Blue Mountains Water Skink.

An Upland Swamp on Kings Tableland. This fragile, high-diversity environment is the third highest priority fauna habitat in the Special Area. © DECC/ H. Achurch

The Greater Southern Sydney Region contains a large amount of Upland Swamp compared to other parts of New South Wales. However, only a small proportion is in the Warragamba Special Area, mostly on the Narrowneck Plateau, Erskine Range and Kings Tableland but also on Lacy's Tableland. Examples of Upland Swamps in the Warragamba Special Area

include Notts Swamp on the Erskine Range and Cedar Head Swamp on Narrowneck Plateau.

The most important Key Threatening Process that impacts on Upland Swamps is the *ecological consequences of high-frequency fires*. Inappropriate fire regimes have been implicated in the decline and local extinction of a number of priority species from this habitat in the Metropolitan Special Area (see **Volumes 1 and 4**). Other Key Threatening Processes that have the potential to impact on Upland Swamps are *predation by the Red Fox* and, of less relevance to the Warragamba Special Area *alteration to habitat following subsidence due to longwall mining.*

5.3 Priority Fauna Populations

5.3.1 Wollondilly-Kowmung Rock-wallaby Populations

The Brush-tailed Rock-wallaby colony near Bullio is a high priority for management as a population, being small, isolated and highly endangered. This site is already being monitored as part of the Fox Threat Abatement Plan (TAP) (NPWS 2001a) and by the Metropolitan Biodiversity Conservation Section of DECC (D. Ashworth pers. comm.).

It is likely that this is a remnant of the Brush-tailed Rock-wallaby populations that once occurred throughout much of the escarpment country of the Wollondilly and Kowmung region, with old records from near the Warragamba Dam wall and Wombeyan Caves amongst other places (see **Volume 2**). It is possible that other isolated, remnant populations occur within this habitat and, once found, they will also be high priorities for conservation management. In particular, there are unconfirmed records in suitable habitat from around Bindook and Mt. Tallygang. Both the known population and any others discovered in the future should be managed for the control of feral predators, rabbits and goats, and when populations are very small, inbreeding.

5.3.2 Mt. Werong Stuttering Frog Population

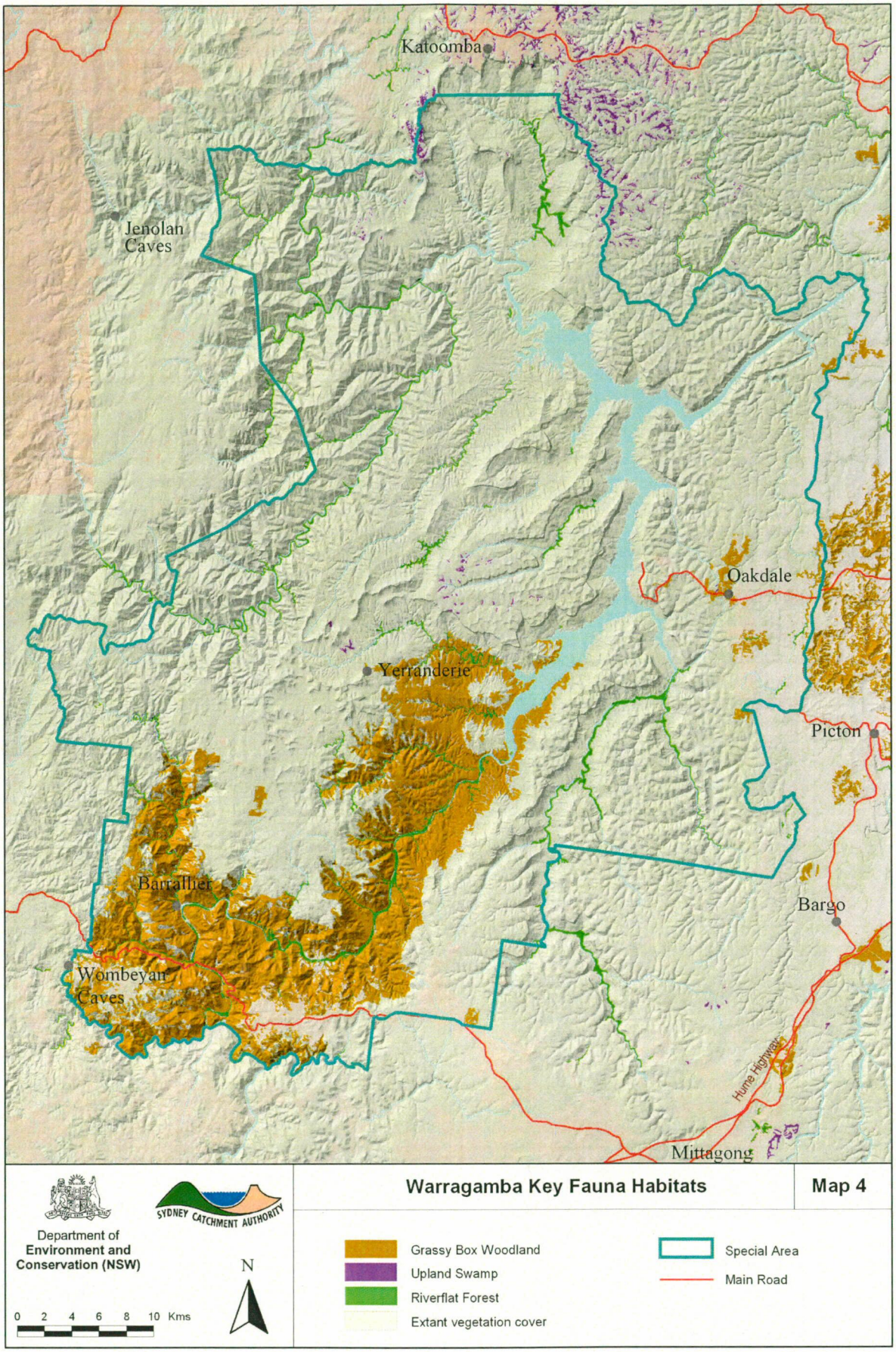
The endangered Stuttering Frog is perilously close to extinction within southern New South Wales and is of the highest conservation priority within the Warragamba Special Area. This species once occurred across much of the Southern Blue Mountains, particularly in the moister gullies (see **Volume 2**). The Stuttering Frog has severely declined over the past 20 years and is now found in only two locations within the Greater Southern Sydney Region, at Macquarie Pass and at Mt. Werong on the western edge of the Warragamba Special Area.

The Stuttering Frog was first discovered just outside the Special Area at Ruby Creek in 2000, when two adults were located in a pool near the falls (C. Barker, wildlife consultant, pers. comm.). This is an eastern flowing creek within the catchment of the Kowmung River. Targeted surveys for the species undertaken as part of the current study located tadpoles in every large pool along Ruby Creek from 150 metres above the abandoned mine site to two kilometres north east of the falls. Also along this stretch, three dead metamorphs of the species were found. These were collected, and a post mortem undertaken by the Veterinary and Quarantine Centre at Taronga Zoo revealed the presence of Chytrid Fungus. Stuttering Frog tadpoles were also located at two sites on Mt. Werong Creek, 6 km west of the Special Area.

The endangered Stuttering Frog is known from a population on Ruby Creek and its tributaries. Frogs infected with Chytrid Fungus were found at this site. © Narawan Williams

The occurrence of the Stuttering Frog at Ruby and Mt. Werong Creeks has very high conservation significance. These are the only known extant high elevation populations of the species (between 690 and 1080 m asl), with all other populations occurring below 280 m (White in prep.). These sites are the western-most known location of the species in New South Wales (DEC 2004a). Mt. Werong Creek is the only known occurrence of the species on the western watershed of the Divide south of the Hunter Valley. Between 1999 and 2004 tadpoles of the species have been recorded at only two other locations in the Greater Sydney Basin (A. White, wildlife consultant, pers. comm.). Conservation of the species within the Special Area is of very high priority, and crucial to the survival of the species across its range in New South Wales.

The finding of frogs infected with Chytrid Fungus at Ruby Creek should be treated with extreme concern. This fatal disease has been implicated in the rapid decline and extinction of a number of high-altitude stream-breeding frogs. Chytrid is virulent only to adult and metamorphosing amphibians, though it may be carried on the keratinised mouthparts of tadpoles (Berger *et al.* 1998). The dead Chytrid-infected individuals located in this study were metamorphs, a stage in development when frogs are generally most susceptible to disease. It is probable that tadpoles in the population carry the disease, which then becomes virulent on metamorphosis. This may reduce the rate of recruitment to the adult population below a critical level, leading to a long-term population decline or crash. Understanding this issue and the demographics of the population should be a focus of scientific research into the population. Causes of the local extinctions of this species from all other historic sites above 280 metres in altitude are not known, but could be due to Chytrid infections or to some related factor associated with elevated UV-B levels at higher elevations (White in prep.).



Map 4: Priority Fauna Habitats in the Warragamba Special Area. Grassy Box Woodland and Alluvial Forests and Woodland continue south along the Wollondilly River. They have not been mapped in this area as they are outside the Greater Southern Sydney Region (see Volume 1).

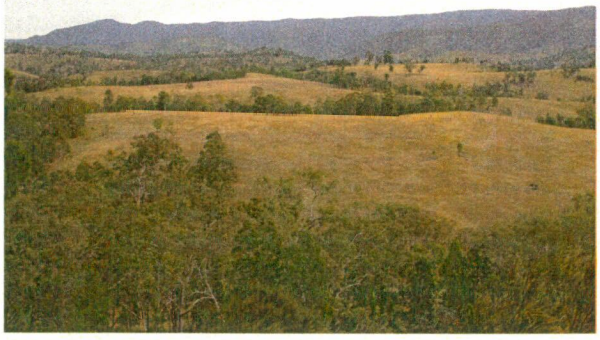
5.4 Fauna Linkages

Fauna Linkages were developed by identifying all species of conservation concern that require linked vegetation of a particular habitat type to assist with their continued survival in the area. These are mostly species that are sensitive to fragmentation and isolation, and whose habitat has already been extensively cleared, or are species that are large-bodied, sparsely distributed and require linkages to retain connectivity and genetic viability between populations. A full description of the process involved in identifying and mapping the Fauna Linkages is given in **Volume 1**. This process identified three key areas in the Greater Southern Sydney Region that fulfil this role for a number of species of conservation concern. Two of these are of great significance to the Warragamba Special Area. These are:

- remnants of closely-spaced Grassy Box Woodland that occur along the Wollondilly River and adjacent escarpment, the *"Wollondilly Linkage"*;
- the sandstone vegetation that links the sandstone plateaux of the Woronora with that of Nattai, the *"Bargo Linkage"*. This linkage connects the Metropolitan Special Area with the Warragamba Special Area.

5.4.1 Wollondilly Linkage

The Wollondilly Linkage (Map 5) is a vitally important linkage of Grassy Box Woodland environments. This project has identified that a large number of species rely on a narrow band of habitat that runs along the length of the Wollondilly River, from the Burragorang Valley south. Species that use this linkage include some of the highest priority fauna species in the Region (see **Volume 1**). In addition, this linkage is mostly comprised of fauna habitats that are recognised as being of the highest priority in the region: Grassy Box Woodlands and Alluvial Woodlands and Forests.



A network of Grassy Box Woodland in the Burragorang Valley - part of the Wollondilly Linkage. © K. Madden

The path of the Wollondilly Linkage was based on the modelled high-quality habitat of seven Grassy Box Woodland bird species: the Black-chinned Honeyeater, Brown Treecreeper, Hooded Robin, Diamond Firetail, Restless Flycatcher, Turquoise Parrot and the Speckled Warbler. All of these bird species have been identified as declining in the Grassy Box Woodlands of the sheep-wheat belt (Reid 1999) and only one, the Restless Flycatcher, is not listed under the TSC Act (1995). All of these species were identified as being of moderately high or high conservation concern for the Greater Southern Sydney Region (**Volume 1**). They were chosen as focal species for the Grassy Box Woodlands of the Wollondilly Valley for a number of reasons. Firstly, this linkage of suitable vegetation (particularly the Burragorang Valley) provides a refuge for these species and this it is vitally important to their long-term survival in the Region. Secondly, all of these species are habitat specialists to some extent and are known to be sensitive to fragmentation and isolation of habitat. All are locally extinct, or nearly so on the Cumberland Plain. By designing the linkage around these key species, it is thought that it will also be suitable for many other more mobile species, such as the Masked Owl.

The Wollondilly Linkage is of exceptionally high conservation significance. It retains close to the full suite of grassy woodland birds, many of which have declined significantly across New South Wales and other parts of their range. Some of the most sensitive woodland bird species have been identified as disappearing from remnants of less than 300 ha (**Volume 2**). Notwithstanding this, nearly all of the grassy woodland bird species that once occurred in the Region survive in the Wollondilly Linkage. This is because, whilst having been heavily cleared in the past, remnants of the Wollondilly remain linked or are separated by only very small distances. This means that these remnants are operating together as a single, much larger ecosystem. Any further disruption to this ecosystem is likely to be detrimental to the long-term survival of many of the high conservation value species that live in this area.

Protection and enhancement of remnant habitat in the Wollondilly Linkage is a very high priority. Conservation measures should include acquisition of the patches within the linkage, and strategies to combat the impacts of weeds, particularly invasive grasses, which may impact on species such as the Diamond Firetail and Hooded Robin (**Volume 2**). Rehabilitation and restoration exercises within the Wollondilly or Burragorang area are best directed toward connecting patches within this Linkage.

5.4.2 Bargo Linkage

The Bargo Linkage (Map 5) is one of the most critical vegetative links in the Greater Southern Sydney Region. It links the Warragamba Special Area to the Metropolitan Special Area and is likely to be important in maintaining the biodiversity of both. It is the only remaining connection between the Woronora Plateau and the Nattai Plateau, and ultimately the entire southern Blue Mountains. It facilitates the movement of migratory and nomadic species between these plateaux and allows for seasonal and altitudinal movements between the highlands and the coast. Vegetative links between the hinterland and the coast are important insurance against climate change impacts.

In addition to facilitating fauna movements, the Bargo Linkage retains connectivity between populations of sandstone fauna. This is particularly important for naturally rare or large bodied species with large home

ranges that would always have made use of this connection - such as the top-order predators.

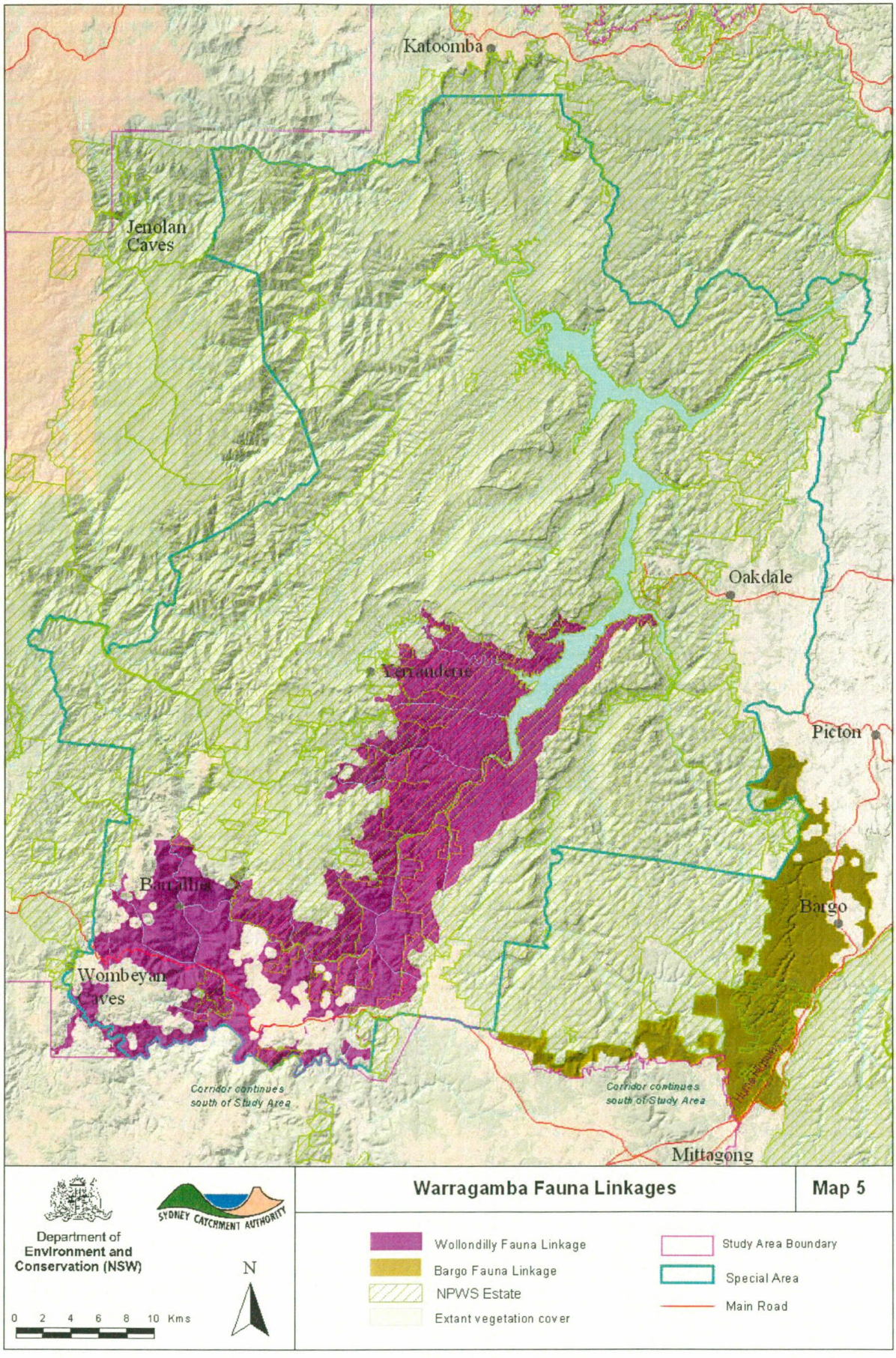
The Gang-gang Cockatoo is an example of a species that makes seasonal movements between the Warragamba Special Area and the Woronora Plateau. Both areas, and the Bargo Linkage, are likely to be important in the long term survival of this species in the area.

The Bargo Linkage connects the Warragamba Special Area to the Metropolitan Special Area. It is important for species that make seasonal, altitudinal or occasional movements such as the Glossy Black-Cockatoo. © P. Ekert

A further suite of species will use the Bargo Linkage only occasionally, such as the Glossy Black-Cockatoo. This bird is typical of the Warragamba Special Area but was regularly observed in the Woronora Plateau after the 2001 fires, and during the current drought. Although only used irregularly, the Bargo Linkage should still be considered as very important to the Glossy Black-Cockatoo, and perhaps other species. Populations may be completely reliant on making this crossing under extreme conditions – such as after large-scale wildfire. For a full list of species that are likely to use the Bargo Linkage, see **Volume 1**.

The Hume Highway bisects the Bargo Linkage. This wide road probably represents only a minor barrier to many bird species, such as the Powerful Owl and Gang-gang Cockatoo. For other species, traversing this road is far more difficult, such as for the Rosenberg's Goanna and the Koala. While there are numerous anecdotal reports of Koalas successfully crossing the Hume, it is without question a significant barrier. For other species, such as the Eastern Pygmy-possum, the Hume Highway is an almost insurmountable impediment. For such species this road is a significant block to gene flow between populations in the Warragamba Special Area and the Woronora Plateau. However, not all habitat is bisected by the road, with a number of bridges spanning gorges that leave connected habitats below. Some species are likely to use these gorges to traverse the east–west divide.

There are a number of measures that should be undertaken to improve the ability of wildlife to traverse the Hume Highway along the stretch that intersects the Bargo Linkage. Investigations should be undertaken as to the appropriateness and location of underpasses and overpasses. These should be installed in areas that are known (or predicted to be via habitat modelling) to be key crossing points for priority species. Key threatened fauna species to be investigated would be the Koala, Roseberg's Goanna and Spotted-tailed Quoll.



Map 5: Fauna Linkages in the Warragamba Special Area: the Wollondilly and Bargo Linkages. The Wollondilly Linkage has not been mapped outside of the Special Area, though it continues south along the Wollondilly River towards Tarlo River NR (see Volume 1).

6 Managing Native Species and Habitats

6.1 Introduction

Many approaches may be taken to the conservation of biodiversity. These include: preventing disturbance and clearing of fauna habitats, acquiring private land that contains fauna habitat, rehabilitating fauna habitats, controlling weeds and vertebrate and invertebrate pest species, managing fire and further research and monitoring. The Warragamba Special Area is over 250 000 ha in size, so applying these conservation measures to the entire area is not feasible. Rather, the successful management of biodiversity is achieved by targeting action toward species and habitats that are most unique and the most vulnerable. Some priorities are set by legislative responsibilities under the TSC Act (1995). These have been determined with a statewide perspective via an independent Scientific Committee. This Act also identifies Key Threatening Processes that impact on threatened species.

The purpose of this section is to provide a management approach to the fauna specifically for the Warragamba Special Area. It highlights the most important species and the most serious threatening processes operating in the catchments.

6.2 Key Threatening Processes

A Key Threatening Process (KTP) is defined under the TSC Act (1995) and EPBC Act (1999) as a process that threatens, or could threaten, the survival or evolutionary development of species, populations or ecological communities. Such processes represent another element used to assess fauna species conservation status. Appendix C summarises the KTPs currently listed under the TSC Act (1995) that impact on the threatened fauna species known to occur in the Warragamba Special Area. The most imminent threats relate to land clearing and the impacts of feral animal and plant species. These processes occur across the Special Area. However, threats relating to land clearing are higher for private land tenures. Feral species impact on all land tenures.

Dead tree in the Burragorang Valley used as a fence post and a roost site for an Australian Owlet-nightjar. 'Removal of dead wood and trees' is a KTP relevant to the Warragamba Special Area. © N. Corkish

Some KTPs are more significant than others within the Warragamba Special Area. The most important threats operating within this Special Area relate to competition and/or predation by introduced species including the Feral Pig, Feral Goat, Fox, Feral Cat and the Rabbit - all of which are thought to impact on the survival of a number of priority fauna. Another KTP is the alteration of water flow regimes, which may impact on Alluvial Forests and Woodlands, a Priority Fauna Habitat.

For most of the Special Area, the clearing of native vegetation and the removal of dead wood and trees is relatively unimportant, except for freehold land around Bullio on the Wollondilly River. Within this small area these threats are highly significant due to the number of species affected and the type of vegetation that occurs here – Grassy Box Woodland – a Priority Fauna Habitat.

The Green Tree Frog is one of many frogs from the Warragamba Special Area may have declined due to infection by Frog Chytrid fungus. There is a draft Commonwealth Threat Abatement Plan (DEH 2004a) that addresses this KTP. © N. Williams

Infection of frogs by the amphibian Chytrid Fungus, which causes the disease *Chytridiomycosis*, is a further KTP that appears to have been particularly catastrophic throughout the Warragamba Special Area. At least four species of frogs have disappeared or are close to extinction within the Special Area, with this disease largely attributed to their decline. These species are the Green and Golden Bell Frog, Green Tree Frog, Booroolong Frog and Stuttering Frog.

6.3 Threat Abatement Plans

There are several Threat Abatement Plans relevant to the Warragamba Special Area. The first is the Threat Abatement Plan for *predation by the Red Fox* (NPWS 2001a; DEH 1999a). Within the Warragamba Special Area, a research and monitoring project associated with this plan has incorporated the Brush-tailed Rock-wallaby site near Bullio. The "Fox TAP" seeks to monitor Brush-tailed Rock-wallaby sites where Fox control is being undertaken and compare the population to areas where Fox control is not being undertaken. The Bullio site is currently a 'control' site for this project i.e. no Fox baiting is being undertaken.

A second Threat Abatement Plan that is relevant to the Warragamba Special Area is that for *competition and land degradation by the Feral Goat* (DEH 1999b). This is a Commonwealth plan that is directly relevant to the

Brush-tailed Rock-wallaby population and other habitats where Feral Goats are in high numbers.

Probably the most important Threat Abatement Plan for the Warragamba Special Area is for *predation, habitat degradation, competition and disease transmission by the Feral Pig* (DEH 2005b). The Feral Pig is already a priority for control in the Special Areas due to impacts on water quality. The impact of this pest on threatened fauna and Priority Fauna Habitats in the Warragamba Special Area is also high.

Feral Pig damage to an Upland Swamp. There is a Threat Abatement Plan relevant for the Warragamba Special Area for predation, habitat degradation, competition and disease transmission by the Feral Pig © M. Schulz

Other relevant Threat Abatement Plans to the Warragamba Special Area include (also refer to Appendix C):

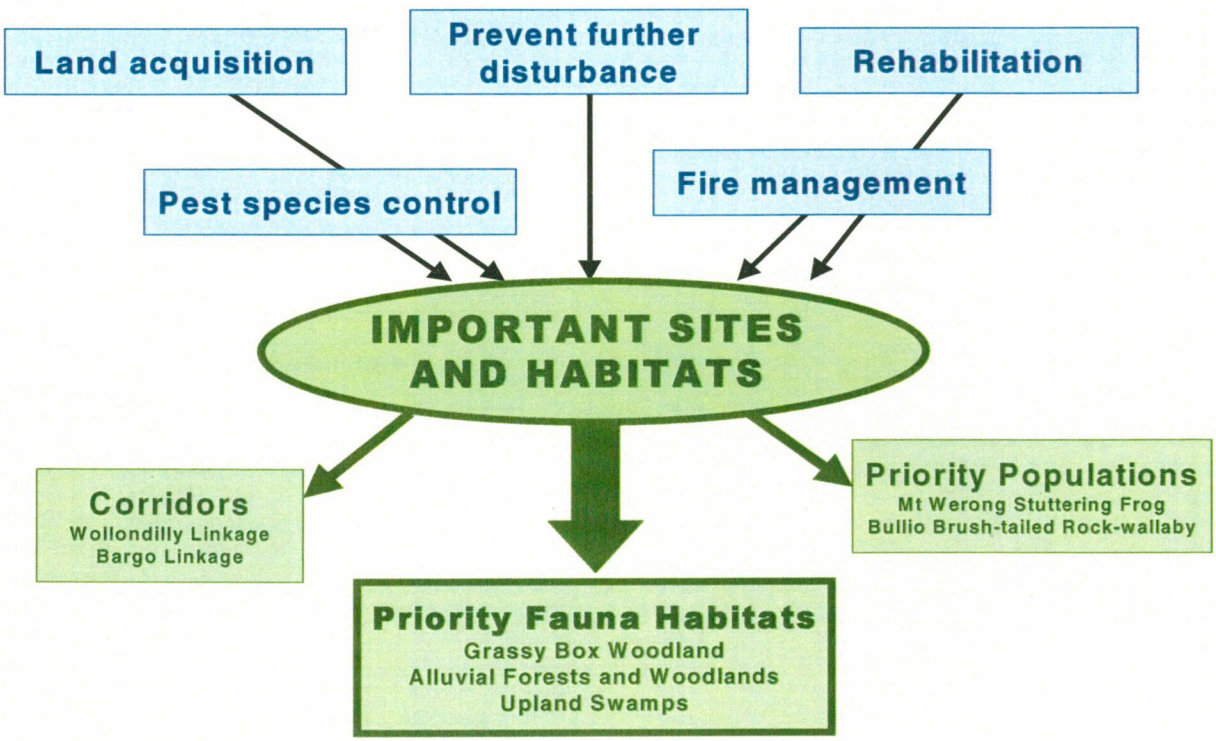
- Competition and land degradation by the Feral Rabbit (DEH 1999c);
- Predation by the Feral Cat (DEH 1999d);
- Predation by the Plague Minnow (NPWS 2003c);
- Beak and Feather Disease affecting endangered psittacine species (DEH 2005a); and
- Infection of amphibians with Chytrid Fungus resulting in *Chytridiomycosis* (DEH 2004a).

6.5 Management Approach for the Warragamba Special Area

Given limited resources, benefits to biodiversity in the Warragamba Special Area will be greatest if conservation actions are implemented in a strategic way - to the highest conservation value fauna habitats and populations in the Region (Figure 1).

This project has identified habitats, populations and other environments that are priorities for conservation management within the Warragamba Special Area. Further details are given below.

Figure 1: **Diagram showing a range of conservation actions (in blue) and where resources are best directed in order to achieve the maximum benefits to biodiversity within the Warragamba Special Area.**



6.6 Land Acquisition Strategies for Fauna

Acquiring land for the reserve system is a key means of protecting important fauna habitats and helping ensure the long-term viability of faunal populations. Acquisitions will maximise the benefits for conservation where they target Priority Fauna Habitats, Corridors and/or Priority Fauna Populations or sites (Figure 2). In the Warragamba Special Area, acquisitions of the Priority Fauna Habitats, *Grassy Box Woodlands* or *Alluvial Forests and Woodlands*, will offer the greatest gains to the reservation status of high conservation priority fauna, particularly when they lie within an identified corridor or are the site of a priority population. The third priority fauna habitat for the Special Area, Upland Swamps, is not as important with regards to land acquisition, as (within the Warragamba Special Area) this habitat is already well reserved within the Blue Mountains NP.

Warragamba Special Area contains the best remnant Grassy Box Woodland and Alluvial Forests and Woodlands in the Region. However, even within the Special Area, they are poorly reserved. Future development of the reserve system that serves the maximum benefit to biodiversity (and hence ecosystem health) should target sites that fulfil as many of the criteria below as possible.

Potential land acquisitions should be judged against the following criteria:

Key Criteria:

1. **The land has been identified as a Priority Fauna Habitat (Grassy Box Woodland or Alluvial Forests and Woodlands).**
2. **The lands fall within an identified fauna corridor (Wollondilly or Bargo Linkages).**
3. **The land is a site of a priority population (Bullio Brush-tailed Rock-wallaby or Mt. Werong Stuttering Frog).**

Additional Criteria:

Environments that have been identified as being Priority Fauna Habitats or as being part of a corridor have already been filtered for connectivity and patch size (see **Volume 1 – Background Report**). Nevertheless, further criteria may be applied, particularly in the instance of a potential acquisition not being Priority Fauna Habitat:

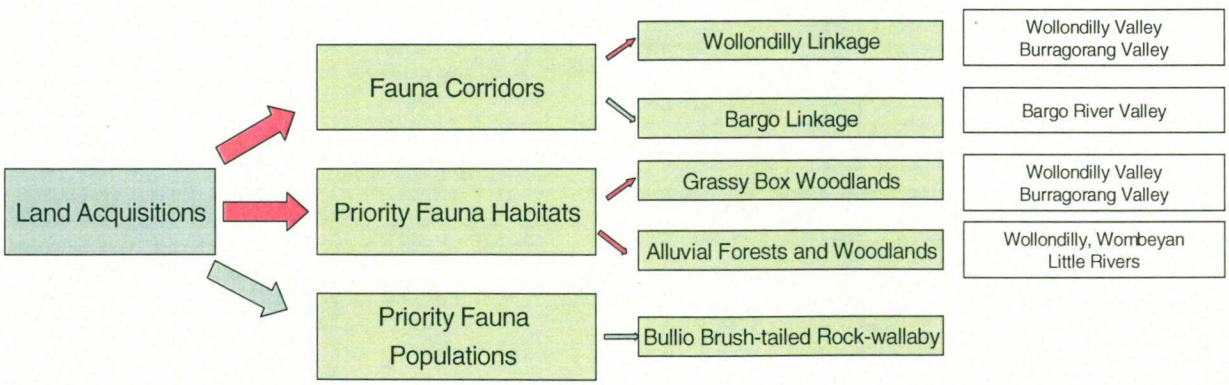
4. The land includes, or is proximate to, major watercourses.
5. The land is an important link between existing protected areas.
6. The land is part of, or linked to, a large remnant (> 50 ha).
7. The land is well connected to an area of extensive continuous vegetation cover (gaps of cleared land no greater than 600 m).
8. The land support high quality Priority Fauna Habitats that are relatively undisturbed, including the ground cover and understorey layers.
9. The areas are known to be used by any of the priority fauna listed in Table 2.

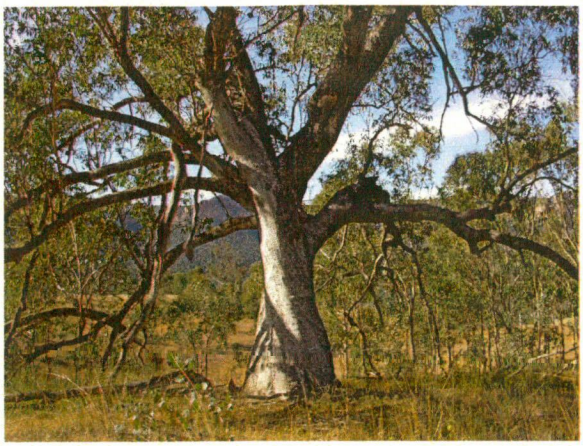
6.7 Ecological Rehabilitation and Restoration

Any rehabilitation and restoration of fauna habitats in the Warragamba Special Area should be focused on Priority Fauna Habitats (*Grassy Box Woodlands* and *Alluvial Forests and Woodlands*), sites that have support priority fauna populations (*Bullio Brush-tailed Rock-wallaby* and *Mt. Werong Stuttering Frog*) and the *Wollondilly Linkage* (Figure 3). The Bargo Linkage remains in relatively good condition and is well connected to extensive vegetative cover, and thus is not a priority for restorative projects.

Natural regeneration, assisted-regeneration and reconstruction can improve connectivity and/or condition of disturbed and fragmented vegetation. As shown in Figure 3, the application of these techniques to the Grassy Box Woodlands of the Burragorang and Wollondilly Valleys offers the greatest gains to fauna. Around Jooriland within the Schedule One lands, the primary method of restoration is **Natural Regeneration**, with significant amounts of regeneration having already occurred following the cessation of commercial grazing. Notwithstanding this, the rate of natural regeneration has most likely been suppressed by the large mobs of Eastern Grey Kangaroos that occur in the Burragorang Valley. In addition, there are a number of pest and weed species that, when removed, aid in the natural regeneration of this ecosystem.

Figure 2: Priority areas for land acquisitions (for fauna) in the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.





*An old-growth White Box (*Eucalyptus albens*) surrounded by saplings. Natural Regeneration is the most appropriate method of restoring the Grassy Box Woodlands of the Burragorang Valley. © M. Schulz*

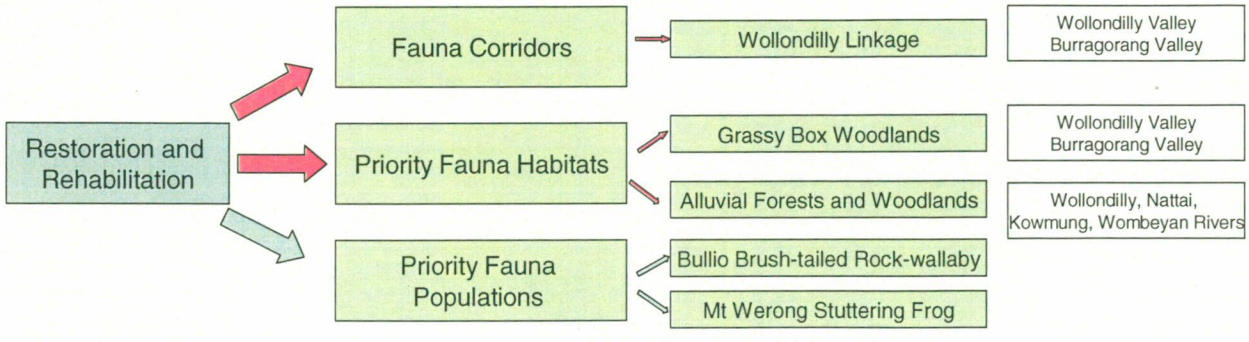
This process is known as **Assisted Regeneration** and involves active intervention in order help an ecosystem recover from disturbance (DEC 2005b), with the main focus being the control of weed species. The Grassy Box Woodlands of the Burragorang and Wollondilly Valleys are particularly prone to invasion by weed species such as Blackberry and exotic perennial grasses, such as Serrated Tussock, which is prevalent further upstream. The *invasion of native plant communities by exotic perennial grasses* is a Key Threatening Process within the Warragamba Special Area, and has the potential to greatly impact on a number of threatened birds, such as the Diamond Firetail, Hooded Robin and Speckled Warbler. Many of these species depend on Grassy Box Woodland in the Burragorang Valley for their continued survival in the Region. Therefore, control of Serrated Tussock and other invasive exotic perennial grasses is of the utmost importance within the Burragorang and Wollondilly Valleys. Other options for Assisted Regeneration within these Priority Fauna Habitats include efforts to reduce the overgrazing by the Eastern Grey Kangaroo of sapling Eucalypts and understorey plants within the regenerating Grassy Box Woodlands of the Burragorang Valley. This is likely to benefit a range of species that rely on these habitats, including the declining woodland birds. Control of introduced pest species is also relevant, particularly the Feral Pig in the Alluvial Woodlands and Forest (Section 7).

Reconstruction of the original native vegetation cover is a long-term strategy that may be used to improve the viability of Priority Fauna Habitats. This technique is particularly relevant to the Grassy Box Woodlands and the Alluvial Forests and Woodlands of the Burragorang and Wollondilly Valleys, which are heavily fragmented. This technique is generally limited to linking larger remnants, and to provide a buffer to minimise edge effects around important patches. Reconstruction may also be used to stabilise streambanks and other areas prone to erosion, and this is also of benefit to biodiversity. Within the Grassy Box Woodlands and Alluvial Forests and Woodlands of the Warragamba Special Area there are many species that would benefit from increased connectivity of remnant vegetation. These include threatened species with poor dispersal capabilities, such as the Speckled Warbler and the Squirrel Glider and species that are sensitive to fragmentation, such as the Brown Treecreeper. All species that rely on these Priority Fauna Habitats will benefit from the increased area afforded by revegetation of Grassy Box Woodlands and Alluvial Forests and Woodlands. Revegetation of Alluvial Forests and Woodlands can have the multiple benefits of increasing connectivity of larger patches, increasing the area of this restricted and heavily cleared habitat type, and stabilising streambanks and helping improve water quality.

It is recommended that an **Ecological Restoration Plan** be developed for the Grassy Box Woodlands, Alluvial Forests and Woodlands and other environments of the Burragorang Valley Floor. This plan should include:

- Identification of priority remnants, based on the criteria described above for land acquisitions;
- A monitoring program to ensure the prevention of weed infestations; and
- Identification of sites for revegetation and reconstruction. This should be based on the Wollondilly Fauna Linkage and/or Priority Fauna Habitats that highlight the largest and best connected remnants.

Figure 3: Priority areas for ecological rehabilitation and restoration in the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.



6.8 Preventing Further Disturbance

Preventing further disturbance to an environment is a key way of managing for the conservation of biodiversity. This may take many forms. For example, preventing or mitigating threatening actions resulting in damage such as that caused by illegal access of the Special Areas for Feral Pig shooting or trail bike riding; overgrazing and erosion caused by stock; illegal land clearance; removal of dead wood and trees; erosion caused by track formation; rubbish dumping and other pollution; and long wall mining. Controlling the collection of firewood and bushrock also falls under this category

All of these potential disturbances are widespread and difficult and expensive to control. Maximum benefits for biodiversity will be achieved if resources for these preventative activities are directed toward Priority Fauna Habitats and sites of priority fauna populations (Figure 4). In the Warragamba Special Area, it is most important to direct resources toward the Grassy Box Woodlands and Alluvial Forests and Woodlands, thereby maximising the benefits to threatened fauna that rely on these areas. Preventing disturbance to the areas supporting priority populations of the Brush-tailed Rock-wallaby (Bullio) and Stuttering Frogs (Mt. Werong) are also highly relevant sites to direct resources toward (Section 6.11.7; Section 7) .

6.9 Fire Management and Fauna

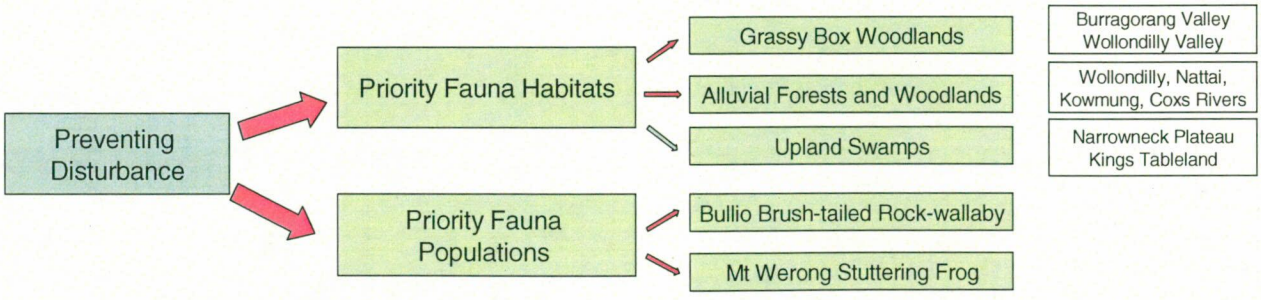
The impact of wildfire and controlled burning on native and introduced fauna remains poorly understood. Post-fire monitoring in the Special Areas of the Woronora Plateau compares fauna in long unburnt vegetation to that following extensive and severe wildfire. This project is due to be finalised in 2008 and will provide useful insight into the management of fauna in the post fire environment. Even more poorly understood is the impact of frequent fire on fauna, though this has been implicated in the decline of a number of species in the Region.

General recommendations for fire management for the conservation of biodiversity within the Warragamba Special Area are based on preliminary findings from the post-fire study on the Woronora Plateau (DEC 2004b). The Woronora Plateau has very similar Sandstone Woodlands and Forests, Heaths and Upland Swamps (and representative fauna) as is found in the sandstone plateaux of the Warragamba Special Area. Therefore, for these environments, it is possible to extrapolate the findings from further east. On the Woronora Plateau, research has found that the impact on fauna is highly dependent on fire intensity, with high intensity fires impacting far more severely on fauna assemblages than low or moderate intensity fires. Groups that appeared to be particularly susceptible to high intensity fire were the arboreal mammals, shrub-frequenting birds and litter-dwelling skinks. For some species, recovery is very slow, with little increase in numbers three years after the fires. The study on the Woronora Plateau highlights the *critical importance of unburnt refugia* in the recolonisation of burnt areas. Unburnt refugia appear to remain important for many years after the fire as a population source for recolonisation and for augmenting the food and habitat of individuals occupying resource-poor burnt areas. This is evident from the fact that even after three years, some severely burnt areas have not been recolonised by species found there before the fires. Maintaining unburnt refugia is particularly important after hot and extensive wildfire. When few unburnt refugia remain, maintaining these in an unburnt state for many years is particularly important.

Recommendations for general fire management within the Warragamba Special Area include:

- Fire management should aim for a mosaic of fire regimes in order to maintain a diversity of fauna habitats;
- Mosaic burning should aim to retain examples of all key fauna habitats in a region in a long unburnt state; for example Tall Open Forests, Sandstone Woodlands, Heaths and Upland Swamps;
- Fire management should recognise the crucial role that unburnt refugia have in the recolonisation of burnt landscapes, particularly after widespread and intense wildfire; and
- When only small areas are left unburnt after widespread and intense wildfire, these should remain in an unburnt state for as long as possible (greater than four years) in order to provide source populations for the recolonisation of burnt areas, and to augment food resources and habitat of burnt areas.

Figure 4: Priority areas for preventing disturbance such as clearing, erosion, overgrazing and removal of dead wood and trees in the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.



6.10 Priority Fauna Habitats and Sites for Fire Management

Detailed fire management, like most conservation actions, is only tenable when directed to sites or habitats of the highest conservation importance (Figure 5). In the Warragamba Special Area there are three Priority Fauna Habitats, though only one is of particular concern when it comes to the management of fire – *Upland Swamps.* Many species from this habitat are thought to have declined due to overly frequent fire (see **Volume 1**). The other two Priority Habitats, *Grassy Box Woodlands* and *Alluvial Forests and Woodlands*, are open and now mostly occur as patches in a partially cleared landscape. Therefore, burns are rarely widespread or at hot temperatures and they are not a priority for fire management for fauna.

6.9.1 Upland Swamps and Fire

The Warragamba Special Area contains a small proportion of the Upland Swamps of the region. Nevertheless, this Priority Fauna Habitat contains habitat for some important species, in particular the Blue Mountains Water Skink. This endemic species is thought to be threatened by overly frequent fire. Another species that may once have occupied the Upland Swamps of the Warragamba Special Area is the Long-nosed Potoroo, and while there are no records in DECC or Museum databases, there is an unconfirmed report from the Kings Tableland adjacent to the Special Area in 1997 (see **Volume 2 – Fauna of Conservation Concern and Priority Pest Species**). This species has declined on the Woronora Plateau, with inappropriate fire regimes thought to be a contributing factor. The Eastern Pygmy-possum and Beautiful Firetail are additional species from the Upland Swamps of the Warragamba Special Area that may be threatened by fire regime changes. On the Woronora Plateau, there have been further extinctions and declines from Upland Swamps that have been linked to fire, such as the Eastern Bristlebird and Ground Parrot.

It is unknown exactly why species from Upland Swamps appear to be particularly susceptible to inappropriate fire regimes. It is certain that the patchy distribution of Upland Swamps makes recolonisation difficult in the event of local extinction. However, widespread fires would have always occurred in the Region (see discussion on Fire in **Volume 1**). Therefore, it is likely that there has been a synergistic effect of fire, or inappropriate fire regimes and the introduction of feral predators. It is also likely that the high numbers of ground-dwelling species found in Upland Swamps are particularly vulnerable to predation by the Feral Cat and Fox, particularly once habitat has been opened up by fire. It is probably a combination of these factors that lead to this environment requiring special attention regarding fire management.

Fire management of Upland Swamps on the Kings Tableland and Narrowneck Plateau should:

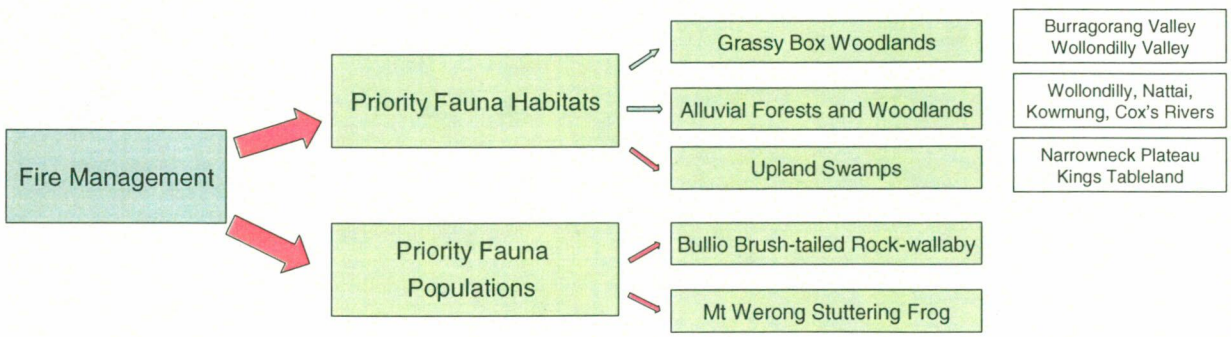
- Always aim to leave some of this distinctive and important habitat in an unburnt state, with the plan to create a *mosaic of fire histories* within the Upland Swamp habitat, not just the general area.
- Allow at least four years between fires, though it is important that some parts of the Upland Swamp mosaic remain unburnt for much longer (Baker 2000).

6.9.2 Priority Fauna Populations, and Other Priority Sites and Fire

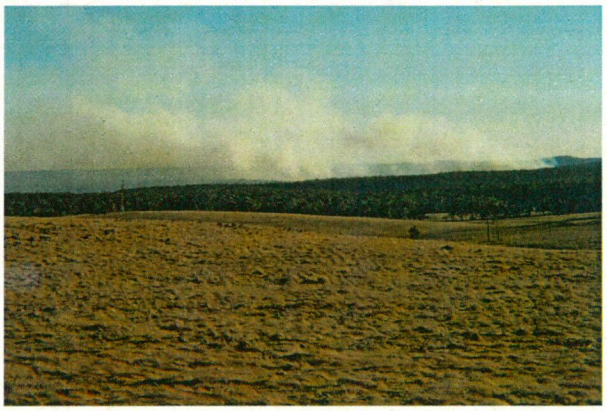
Fire management is of great importance when dealing with isolated populations of extremely rare species, as local extinction due to fire would be catastrophic. There are two cases from within the Warragamba Special Area that are highlighted here: the *Brush-tailed Rock-wallaby* near Bullio and the *Stuttering Frog* at Mt. Werong. The most appropriate fire management for such endangered populations is exclusion, unless evidence comes to light that the population would greatly benefit from a controlled burn. In such an instance, a burn should only be implemented after appropriate planning and consideration of the risk of local extinction. In the case of the Brush-tailed Rock-wallaby, this should occur in liaison with the Brush-tailed Rock-wallaby Recovery Team. In the case of the Stuttering Frog, a plan should be drafted in consultation with experts on the species.

Should any populations of the Long-nosed Potoroo (in particular) be discovered in the Warragamba Special Area, they will be very high priorities for considered fire management.

Figure 5: Priority areas for the management of fire for biodiversity within the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.



Within the Warragamba Special Area, habitat for the Glossy Black-Cockatoo also requires attention regarding fire management. This occurs in the dry rainshadow valley of the Wollondilly River, where dense stands of Drooping She-oak occur. This and other extensive stands of *Allocasuarina* are very important to the Glossy Black-Cockatoo population here. *Allocasuarina* are fire sensitive, and thus care should be taken to retain some areas in an unburnt state, particularly in the years after widespread and intense wildfire.



Wildfire is difficult to control in the Warragamba Special Area. Large-scale wildfires would have occurred naturally © DECC/N. Corkish

6.11 Research and Monitoring

A core conservation action is research and monitoring of populations or habitats of conservation concern. Future research and monitoring in the Warragamba Special Area should be directed toward (Figure 6):

a) high priority fauna species, as identified in this project;

b) Priority Fauna Habitats: Grassy Box Woodlands, Alluvial Forests and Woodland and Upland Swamps; and

c) Priority Fauna Populations.

There are research and monitoring programs already in place for the Brush-tailed Rock-wallaby population at Bullio (D. Ashworth pers. comm.) and it is part of the Fox TAP monitoring project. It is advised that a program is implemented for the Stuttering Frog at Mt. Werong, and any other priority fauna populations that come to light in the future.

Some suggested programs for research and monitoring within the Warragamba Special Area are given later in this document (Section 9).

6.12 Recovery Planning Actions within the Warragamba Special Area

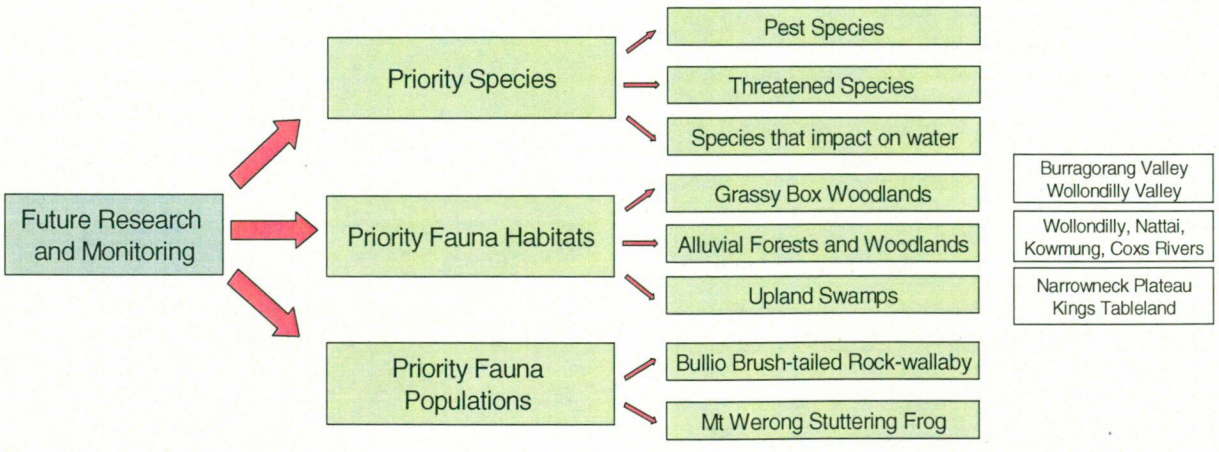
There are a number of relevant fauna Recovery Plans which have been approved by the Minister or are in draft stages:

6.11.1 Large Forest Owls

The Draft Recovery Plan (DEC 2005c) for the large forest owls suggests that fire may negatively affect habitat and prey densities for the Powerful and Sooty Owl and positively affect Masked Owl habitat and foraging opportunities. Of the three species, the Masked Owl is most significant in the Warragamba Special Area in that it is the rarest, and the Special Area contains the most important habitat for this species in the Region. Conversely, the Powerful Owl has been found to be widespread throughout the Region. It is in far higher abundance than previously known. Therefore, loss of individual territories or nesting resources and prey is unlikely to be catastrophic for the regional viability of this species.

Sooty Owls are uncommon within the Warragamba Special Area. There is naturally very little suitable habitat for it. It occupies mesic habitats in only the most protected and sheltered gorges - sites that are naturally protected from fire. While very hot or frequent fire will change the floristic composition to encourage more fire tolerant species, it is very unlikely that all habitat within the Special Area would be affected simultaneously. Therefore, fire is unlikely to affect the viability of the Sooty Owl populations in this area. Consequently, there are few recovery planning actions required for the long-term survival of the Powerful and Sooty Owls in the Warragamba Special Area.

Figure 6: Priority areas for the future research and monitoring within the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.



Recovery of the Masked Owl in the Warragamba Special Area may be enhanced by:

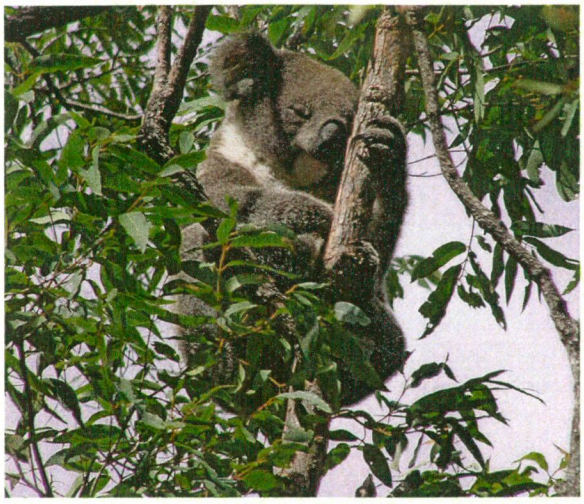
- The retention of dead and hollow-bearing trees, even in semi-cleared country.
- Protection and enhancement of open grassy woodlands on higher fertility soils, particularly in the Burragorang and Wollondilly Valleys.
- The retention of a vegetative link between the southern Woronora Plateau and Nattai NP (the Bargo Linkage). This may assist in seasonal or occasional movements of this species between the range and the coast.
- In the event of further records for the Masked Owl becoming available, the habitat model should be redetermined in an attempt to refine habitat preferences and better discriminate areas of highest conservation concern.

6.11.2 Koala

The Draft Recovery Plan (NPWS 2003d) states that Koala populations on the ranges of the Sydney Basin mostly occupy secondary class habitats. Much of the habitat within the Warragamba Special Area fits this generalisation. Within this Special Area, Koalas occur at low densities throughout the southern part of the Special Area, particularly along Wombeyan Caves Road, the Nattai Valley, around Mt. Tallygang and Barrallier. There are also scattered records in the north-west of the Special Area, and patchily distributed habitat has been predicted to occur throughout this Region. A high density population occurs just outside the Special Area at High Range within Nattai NP, and this may extend into the Special Area around Wanganderry. The semi-cleared area around Monkey Creek and Oakdale was once high-quality Koala habitat, with 'Monkey' a word used to describe the Koala by early European settlers. There are a number of recent records from this area, and these individuals may have migrated up the Nattai Valley from the High Range population, or across the southern Cumberland Plain from the Avon Nepean population (**Volume 2**). It is not thought that this area currently supports a breeding population, though with the Avon and Wedderburn populations reputedly expanding, it is possible that one may establish in the future.

Within the Special Areas, fire has the potential to significantly impact Koala populations. However, fire is only seriously threatening for small, isolated populations and when no unburnt refugia of suitable habitat persists after the fire has passed. Within the Special Area, the Koala population is not isolated and even large, widespread fires tend to leave many unburnt refugia in the incised gorges and the larger Burragorang and Nattai Valleys. Therefore, in general, wildfire is not considered to be a serious threat in this area. Other threats such as attack by wild and domestic dogs or roadkill are more problematic when managing small, isolated populations adjacent to urban areas; thus these are not considered to be significant threats in the Warragamba Special Area, except in the vicinity of Oakdale.

Within the Warragamba Special Area there does not appear to be any high density or 'core' populations to manage. Therefore, management should be directed at high quality Koala habitat. High quality Koala habitat has been modelled for the Greater Southern Sydney Region including the Warragamba Special Area (**Volume 2**). This model has been classed as being of excellent quality, and is based on the prevalence in the canopy of preferred feed trees, with a slight preference for low to mid elevations and higher canopy cover. In the Warragamba Special Area this tends to be where Grey Gum is in abundance or where Grey/White Box, Forest Red Gum or Ribbon Gum occur.



Koalas are naturally uncommon in the Special Area. The populations are not isolated and are subject to few significant threats. © DECC

The Draft Recovery Plan highlights a number of generic approaches to manage these threats in areas where Koalas occur, including the Warragamba Special Area:

- The use of mosaic patterns in fuel reduction burns. Such burns should be carried out outside the spring/summer period when Koalas are breeding and most likely to be on the ground and therefore vulnerable to fire. Burns should be low intensity, with efforts made to avoid crown scorch and crown burns.
- Preferred feed trees should not be cleared in the construction of fire breaks and fire trails.
- Preferred feed trees should not be felled during mop-up operations in areas known to be used by Koalas.

All of these points are more important when managing a high-density or isolated Koala population, though the first, in particular, is relevant to the Warragamba Special Area.

6.11.3 Yellow-bellied Glider

This project has greatly enhanced the available knowledge of the distribution and conservation status of the Yellow-bellied Glider. Previously thought to be uncommon, this species was found to be one of the most common arboreal mammal throughout much of the Warragamba Special Area. Within the Greater Southern Sydney Region, the vast majority of suitable habitat (87%) for this glider occurs within the Warragamba Special Area. Around 240 individuals were recorded at over 180 locations within the Warragamba Special Area, mostly where taller forests occurred containing suitable feed trees such as the Grey Gum and Forest Red Gum. This habitat type is widely distributed within the Special Area, particularly on the slopes and gorges of the plateaux. This species is currently common and secure within the Warragamba Special Area, though it should be

recognised that this catchment is extremely important for the long-term survival of the species in the Region.

The Recovery Plan for the Yellow-bellied Glider (NPWS 2003e) lists the reasons for this species being considered vulnerable in New South Wales. In particular, logging of high-productivity forests is thought to be the major threat to the species across its range. Predation by the Feral Cat and Fox is also thought to contribute to the species vulnerability. Impacts of fire regimes are poorly understood, although high-intensity fire has been thought to reduce populations and the availability of food resources (NPWS 2003e).

The Recovery Plan for this species was written prior to the findings of this study and thus little is relevant to the management of the Warragamba Special Area. Within the Warragamba Special Area it is considered to be a species of lower conservation priority (see **Volume 1**) with no threatening processes considered severe, and the area of suitable habitat substantial. While the recovery potential of the species has not been explicitly tested, the species was found to remain common in suitable habitat despite the extensive fires of 2001. The topography of the Warragamba Special Area means that fires do not burn uniformly across the landscape and gullies are rarely subject to intense fire. The Yellow-bellied Glider population within the Special Area is extensive and there is ample opportunity for recolonisation in the event of local extinction. Therefore, fire is not considered a significant threat in the Warragamba Special Area. This information challenges much existing knowledge on the Yellow-bellied Glider, which is biased toward the timber production areas of the north and south coasts of New South Wales.

There is currently no need for recovery planning actions for the Yellow-bellied Glider within the Warragamba Special Area. The Warragamba Special Area and Southern Blue Mountains are a stronghold for the Yellow-bellied Glider, where it is common and well reserved and not subject to most threats outlined in the Recovery Plan.

6.11.4 Barking Owl

The Barking Owl is an extremely rare species within the Warragamba Special Area, with records occurring in the semi-cleared woodlands of the Burragorang Valley and Bindook Highlands, Scotts Main Range and on the edge of the Cumberland Plain near Oakdale. The Draft Recovery Plan for this species identifies the main threats as being the clear-felling for agriculture of woodlands and forests from low-lying, fertile areas (NPWS 2003f). Remaining habitat is often subjected to degradation through grazing or forestry operations that fell old-growth and over-mature trees, thus reducing available nesting sites (Kavanagh *et al.* 1995; NPWS 2003f). Other threats include predation, particularly of fledglings, mortality from collisions with fences and vehicles, and secondary poisoning from rodenticides (NPWS 2003f).

Due to insufficient reliable records, a predictive habitat model was not generated for the Barking Owl. Nevertheless, it is thought to occur either patchily, or at extremely low densities throughout much of the Warragamba Special Area, particularly in areas where there are open grassy woodlands. This preference leads to the prediction that, as with elsewhere (NPWS 2003f), suitable habitat is strongly biased toward private land. While the Cumberland Plain would have once contained ample suitable habitat, the majority is probably too fragmented and disturbed to be occupied on a regular basis. The Burragorang and Wollondilly Valleys, however, contain a significant amount of intact grassy woodland and are likely to be the most important areas within the Region.

Within the Warragamba Special Area, few of the identified threats are relevant outside freehold tenures. No permanent territories or breeding sites are known for this species within the Special Area. Appropriate investigations and consideration are required prior to control burning, the construction of fire breaks or road building.

Suggested recovery planning actions for the Barking Owl in the Warragamba Special Area, include:

- Further survey and research to be conducted within the Special Area, including investigation and refinement of existing records, collection of additional records and modelling of potential habitat.
- Upon detection of any nesting or roost sites, protection of sites and surrounding area from disturbance, including tree felling or hot fires.
- Protection and enhancement of grassy woodlands is paramount to the survival of this species in the area, particularly in the Burragorang and Wollondilly Valleys, but also on the Cumberland Plain.
- Removal of hollow-bearing trees, even in semi-cleared country, should be avoided.

6.11.5 Regent Honeyeater

The Regent Honeyeater is critically endangered at a national level, with less than 1500 birds thought to remain. It is a nomadic species that visits the Warragamba Special Area mostly in winter, when preferred Eucalypt species are in flower. Although this bird has been recorded at less than 30 locations, the number of individuals counted annually varies between nil and 250 individuals. This highlights that, at least occasionally, the Warragamba Special Area is very important to the survival of this species.

The Recovery Plan for the Regent Honeyeater identified the main threat across its range as being land clearance for agriculture, which has removed about three-quarters of the suitable habitat (Menkhorst *et al.* 1999). The remaining vegetation is highly fragmented, and continues to be degraded by the removal of larger trees. Habitat alteration may also advantage more aggressive honeyeaters, such as Miners and Friarbirds which have the potential to displace the Regent Honeyeater. The Burragorang Valley is the most important area for the Regent Honeyeater within the Greater Southern Sydney Region. The importance of this area is reflected by the fact that this was the only location where sightings were made during the current survey. This project has partly fulfilled a key recovery action for this species by identifying and mapping suitable habitat within the Warragamba Special Area. This model was created by applying known feed tree preferences to detailed vegetation mapping. It is of moderate quality and could benefit from further research that better discriminated the highest priority habitats.

Suggested recovery planning actions in the Warragamba Special Area include:

- The protection and enhancement of Grassy Box Woodlands, particularly in the Burragorang and Wollondilly Valleys.
- Any sites containing suitable winter-flowering Eucalypts (identified in the habitat model), particularly those known to have been utilised by Regent Honeyeaters in the past, should be protected from disturbance, including felling and hot fires.
- Replanting and regeneration of appropriate feed trees is recommended for the most important area, the Burragorang Valley (as per recovery action outlined in Menkhorst *et al.* 1999). Reduced grazing by the Eastern Grey Kangaroo will assist regeneration of the grassy woodlands of this area.
- Retaining or restoring connectivity between remnants of habitat is probably important for this species. Particularly important may be the Wollondilly Linkage of grassy woodland that runs south along the Wollondilly River.
- Targeted survey for this species during winter is recommended in areas identified as potential habitat in order to better identify the key areas that are important to this species within the Warragamba Special Area.
- Continued annual survey of habitat in the Burragorang Valley is recommended to help understand the temporal use of this resource.

6.11.6 Swift Parrot

The Swift Parrot is a rare winter visitor to the Burragorang Valley within the Warragamba Special Area. It will sometimes visit in relatively high numbers. In June 2002, 25 individuals were counted during one-day surveys conducted as part of the National Swift Parrot survey. Sightings of this parrot are from only seven locations, mostly adjacent to the Jooriland Homestead.

A national Recovery Plan has been implemented in order to identify and protect key habitat and reverse population declines (Swift Parrot Recovery Team 2001). The Swift Parrot has a critically low total population of approximately 2000 individuals (Tzaros 2002) which may still be declining (Swift Parrot Recovery Team 2001). Outside the breeding area, the main threat is habitat destruction (Garnett and Crowley 2000). During the non-breeding season it is highly nomadic due to the variable nature of the flowering of its favoured feeding trees and as such is sensitive to clearance of areas that it may rely on only once every few years. Therefore, habitat in the Burragorang Valley may be more important to the long-term survival of the species than records indicate, particularly the limited bird survey effort that has taken place during late autumn and winter, when this species is most likely to visit.

Suggested recovery planning actions within the Warragamba Special Area include:

- The protection and enhancement of Grassy Box Woodlands, particularly in the Burragorang and Wollondilly Valleys.
- Any sites containing suitable winter-flowering Eucalypts (particularly those identified in the habitat map or where Swift Parrot have previously been recorded), should be protected from disturbance, including felling and hot fires.
- Replanting and regeneration of appropriate feed trees is recommended for the most important area, the Burragorang Valley (as per recovery action outlined in Swift Parrot Recovery Team 2001). Limiting grazing by the Eastern Grey Kangaroo may assist regeneration of the Grassy Box Woodlands of this area.
- Retaining or restoring connectivity between remnants of habitat is probably important for this species. Particularly important may be a dry Grassy Box Woodland corridor that runs south along the Wollondilly River.
- Overgrazing should be controlled in areas identified as important for the Swift Parrot.
- Targeted survey for this species during winter is recommended in areas identified as potential habitat in order to better identify the key areas that are important to this species within the Warragamba Special Area.
- Continued annual survey of habitat in the Burragorang Valley is recommended to help understand the temporal use of this resource.
- The habitat map should be refined and improved when further records or information on feed tree preferences become available.

6.11.7 Brush-tailed Rock-wallaby

The Warragamba Special Area contains the last known colony of Brush-tailed Rock-wallabies in the Greater Southern Sydney Region. This population, near Bullio in the Wollondilly Valley, is extremely important. It is possible that further small, isolated and remnant populations exist in similar habitat in the south of the Special Area (**Volume 2**).

The historical decline of the Brush-tailed Rock-wallaby is attributed to three factors: hunting for bounty and fur, predation by introduced predators and competition with introduced herbivores (Feral Goats, Rabbits and livestock) (NSW Scientific Committee 2003d). The major threats continuing to impact on the species include ongoing predation and competition with feral species such as the Fox and Wild Dog, habitat modification by fire, vegetation clearing, disease transmission (*toxoplasmosis* and *hydatosis*) by feral carnivores (NSW Scientific Committee 2003d) and inbreeding (Environment ACT 1999). Many of these threats continue to operate within the Special Area.

This project has identified potential high quality habitat within the Special Area, part of a key recovery action from the draft Statewide Recovery Plan (DEC 2005d). This model has been rated as being of moderate quality, highlighting the exposed rocky escarpments and outcrops on the Devonian Metasediments and Bindook Porphyries, particularly on northerly aspects. Brush-tailed Rock-wallaby do not occupy the full extent of their former habitat, though this habitat map is a useful guide as to where to direct future survey effort.

Identification of further extant colonies before they decline to local extinction is a very high priority.

Recommended recovery actions within the Warragamba Special Area include:

- High level monitoring and management is required at the site of the last known colony near Bullio
- Site management and monitoring should continue in consultation with the statewide Recovery Plan and the Fox Threat Abatement Plan.
- At known Rock-wallaby sites there should be targeted control of Feral Goats, Foxes, Rabbits and Wild Dogs in order to reduced threats from predation and competition.
- Targeted survey of high-quality habitat identified in this project should be undertaken to identify any additional colonies that may exist in the Special Area. Particular focus should be given to the area around Bindook and Tallygang Mountain and Guineacor Creek where there are recent unconfirmed records.
- Further survey work should be used to refine the existing model of predicted habitat.

6.11.8 Blue Mountains Water Skink

The Blue Mountains Water Skink is a rare and highly endemic species. Its entire world-wide distribution is restricted to the Upland Swamps of the mid- and upper Blue Mountains. Only 13% of predicted habitat in the Region occurs within the Warragamba Special Area. However, due to the highly restricted range of this species, it is still important to the overall conservation of the Blue Mountains Water Skink.

This species is threatened because within its restricted range it only occurs in small and isolated populations. Many of these are close to the urban settlements of the Blue Mountains. Proximity to developed areas means that swamps are prone to disturbance due to altered drainage patterns, and there is an increased predation risk from Cats (both feral and domestic) and Foxes. Inappropriate fire regimes may also threaten the species. However, the lack of knowledge on the biology and ecology of the species prevents further determination of the actual effects of fire on this lizard (LeBreton 1994, NPWS 2001c). Most of these threats are irrelevant within the Warragamba Special Area on the Kings Tableland and Narrowneck Plateau. Within the Special Area, the most important factor to consider is fire regimes. Though little is known about the effect of fire on this species, it is suspected that overly frequent fire may be problematic (LeBreton 1994; NPWS 2001c). One of the greatest risks to this skink is climate change. The potential for higher rates of evaporation, and an increase fire frequency could impact on Upland Swamps, cause local extinctions and impact on the long term viability of the species. The population structure of this species makes it particularly vulnerable to this threat, with research recommended.

This project has mapped high-quality habitat for the Blue Mountains Water Skink, with this going a long way to fulfilling the objectives outlined in the Recovery Plan regarding defining habitat for the species.

Recommended recovery actions within the Warragamba Special Area (adapted from NPWS 2001c) include:

- Maps of high-quality habitat produced for this project should be used to target surveys for this species, particularly on the Narrowneck Plateau and southern Kings Tableland where habitat is predicted, yet no records are known.
- Information gained from future survey should be used to refine the existing model of predicted habitat.
- Trail construction and clearing in the vicinity of Upland Swamps on the Kings Tableland and Narrowneck Plateau should not occur if they will impact on the hydrology of the swamps.
- Fire management of Upland Swamps should aim to retain a mosaic of burn regimes.

6.11.10 Unconfirmed and Locally Extinct Species

Recovery Plans exist for a number of threatened species that are currently unconfirmed or may be locally extinct in the Warragamba Special Area. These include the Green and Golden Bell Frog (DEC2005e), Southern Brown Bandicoot (DEC 2005f) and Bush Stone-curlew (NPWS 2003h). Unless the presence of these species is confirmed, no actions from the Recovery Plans need be applied to the Special Area.

6.13 Kangaroo Management

Management of the Eastern Grey Kangaroo population within the Warragamba Special Area is of concern for a number of reasons. Within the Burragorang Valley in particular, this species is found in very high numbers, with mobs of over 100 individuals sometimes seen. Densities of up to 500 individuals per square kilometre have been recorded in parts of the Burragorang Valley (Roberts 2005). It is most likely that these large numbers are the result of prior clearing of the Burragorang Valley floor which has exponentially increased the available habitat, coupled with the absence of hunting pressure from Aboriginal people and pastoralists, and a ready supply of fresh water.

Eastern Grey Kangaroo would have always been common on the Burragorang Valley floor. © M. Schulz

At times, Dingoes have also been destroyed, with this removing a further significant control on the Kangaroo population. Large numbers of Eastern Grey Kangaroos are potentially problematic in that they overgraze the regenerating Grassy Box Woodlands of the Burragorang Valley. This grazing pressure has ramifications for water quality, with increased run-off leading to increased sediment, nutrient and pathogen transport (see **Volume 1**). Overgrazing the Grassy Box

Woodlands of the Burragorang Valley may also impact on a range of threatened species, particularly the declining woodland birds.

Eastern Grey Kangaroos are at high densities in the Burragorang Valley due to prior clearing, ready access to water and the absence of hunting.© M. Schulz

For this report, an attempt has been made to estimate the density of Eastern Grey Kangaroo across the Warragamba Special Area. This has been completed using a generalised additive presence absence model of Eastern Grey Kangaroo habitat based on spotlighting data. This model included three environmental variables: mean annual rainfall, topographic position and mean canopy height. This translated to a model that selected the flattest parts of the Special Area, with rainfall below 1000 mm per year and with low to moderate tree cover, with treeless areas most preferred. Highlighted are the Burragorang and Wollondilly Valleys, particularly those areas with few or no trees, though many of the narrower valleys such as the Nattai and around Oakdale also have suitable habitat (Map 6). A different model is presented in **Volume 2** for the entire Greater Southern Sydney Region - a presence-only model that gave the best indication of habitat across this larger area. Presence-absence modelling is a more statistically robust method that allows a more accurate delineation of habitat quality. For further information on the derivation of presence absence and presence only models (see **Volume 1**).

Abundance estimations were based on the results of the nearly 250 spotlighting sites conducted across the Warragamba Special Area. At each two hectare site, estimates were made of the abundance of Eastern Grey Kangaroos. Using the model of preferred habitat, average abundances were extrapolated across bands of similar quality habitat. This method provides a rough guide to the extent and distribution of the Eastern Grey Kangaroo population. However, this species can be highly aggregated in the environment. Thus it is easy to underestimate a population if replication is insufficient. Notwithstanding this, with 250 sites in total and 20 of these being in the highest quality habitat, it is hoped that this approach gives a useful catchment-wide perspective on the abundance and distribution of this species.

Results of the investigation are as follows. There is estimated to be 10 763 ha of high-quality Eastern Grey Kangaroo habitat within the Warragamba Special Area. This is highly localised, with the majority being in the semi-cleared parts of the Burragorang Valley upstream of the water storage, and further along the Wollondilly River, in areas such as Horse Flat at Bowmans Hill. In high-quality habitat, there is an average abundance of 1.2 Eastern Grey Kangaroo per ha, though these are highly aggregated across the landscape. It is estimated approximately 13 000, or 57% of the total Eastern Grey Kangaroo population of the Special Area is found in this habitat, despite only occupying 4% of the total land area (Table 3, Map 6). The total number of Eastern Grey Kangaroos in the Warragamba Special Area is thought to be over 22 500, though this will vary from year to year. Almost half of the Special Area is considered to be non-habitat, with few Eastern Grey Kangaroos found in this area. The habitat model and abundance estimations may also be used to approximate populations over smaller areas, should this be required for management.

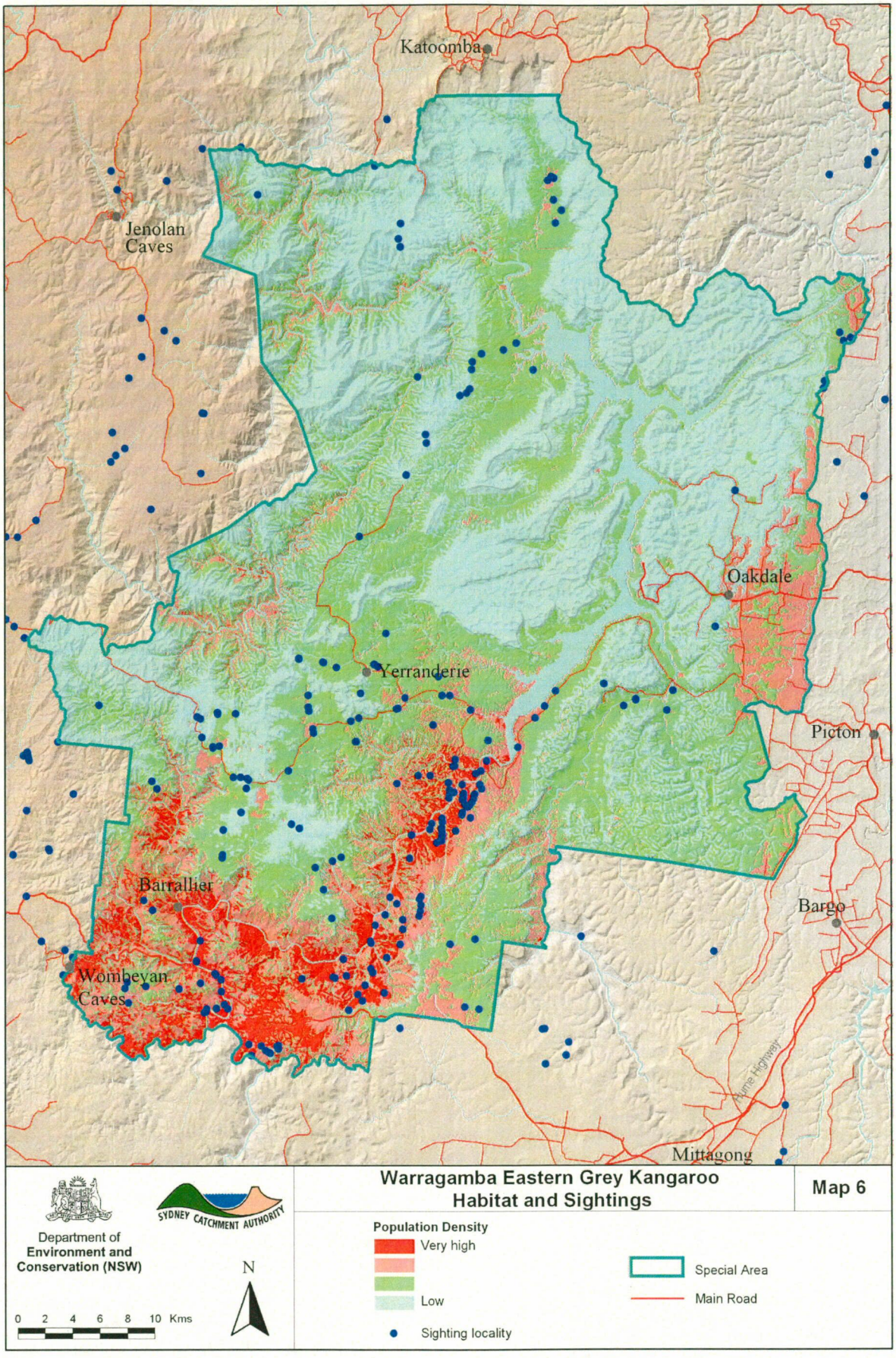
Table 3: Estimation of the number of Eastern Grey Kangaroos and amount of high quality habitat within the Warragamba Special Area.

Habitat quality	Hectares of habitat	Density Per ha*	Total number of Eastern Grey Kangaroo*
Highest	10763	1.21	12979
Moderate	40170	0.103	4120
Low	87504	0.063	5538
Non-habitat	114900	0	0
Total			**22637**

* These density estimations should viewed in context with research by M. Roberts from Macquarie University who is providing accurate calculations of kangaroo populations at sites: Murphy's Crossing and Douglas Flat (Roberts 2005).

The population of Eastern Grey Kangaroos is of management concern for a number of reasons. This species will overgraze the valley when numbers are high, leading to potential issues with water quality and degradation of habitat for threatened species. These issues are considered in more detail in the section on water quality and in the species profiles in **Volume 2**. Management recommendations for this species are specific to the Warragamba Special Area are:

- In the Burragorang Valley, protection of the keystone predator, the Dingo, will go some way to restoring the ecological balance and ameliorating the numbers of Eastern Grey Kangaroo.
- Wedge-tailed Eagles are another significant predator of juvenile Eastern Grey Kangaroo. Protection of this bird of prey will assist in maintaining an ecological balance.
- Regeneration of the canopy trees in the Burragorang Valley will decrease the available habitat for the Eastern Grey Kangaroo and assist in restoring the ecological balance. Such regeneration could be achieved by fencing-off key areas from kangaroos.
- There should be further investigation into the role that the Eastern Grey Kangaroo plays in retarding the regeneration of the canopy and associated impacts on declining woodland birds, such as the Speckled Warbler and Hooded Robin.
- High quality habitat for the Eastern Grey Kangaroo is fairly localised, though most occurs around the water storage. Any control measures should be focused on this area.



Map 6: Eastern Grey Kangaroo Habitat and Sightings in the Warragamba Special Area.

7 Pest Species Management

There have been 21 introduced terrestrial vertebrate species recorded within the Warragamba Special Area (Table 4). This is only 55% of all introduced species known from the Greater Southern Sydney Region, testimony to the relatively undisturbed state of much of the Special Area. Also noteworthy is the relatively small numbers of many of the feral bird species. Many of these species are only present in the far east of the Special Area in the disturbed land around Oakdale and Thirlmere.

Some of these species are considered to be pest species, while others are thought to have negligible impact on biodiversity, water quality or economic activities. At the start of this project, an attempt was made to identify introduced species that were considered pests, or have the potential to be pest species. These species are reviewed in detail in **Volume 2 – Fauna of Conservation Concern and Priority Pest Species**.

Rabbits are a commonly recorded pest species, particularly in the cleared areas of the Burragorang and Wollondilly Valleys. They form a large part of the diet of Foxes and Wild Dogs/Dingoes in this area. © M. Schulz

Species for which there has been dedicated survey, such as the collection and analysis of scat material have the greatest number of records (e.g. Wild Dog and Fox). Both of these species are common and widespread across the Special Area. The large number of records for the Rabbit, Feral Pig and Feral Goat is reflective of their abundance in some parts of the Special Area. Feral Cats are probably more common than the number of records suggests, as they are cryptic and, unlike Wild Dogs and Foxes, are rarely identified by scats.

There are additional introduced species that undoubtedly occur within the Warragamba Special Area but currently there are no records within DECC Atlas of NSW Wildlife. For example, the Brown Rat which would certainly occur in the disturbed areas in the east of the Special Area, if nowhere else. Several species of deer are also reported to inhabit the Special Area, including the Red Deer, Fallow Deer and possibly the Rusa Deer, all of which have been reported close to the boundaries of the Special Area.

Table 4: Introduced species present in the Warragamba Special Area

Common Name	Scientific Name	Number of Records
Birds		
Common Myna	*Acridotheres tristis*	36
Common Starling	*Sturnus vulgaris*	50
Eurasian Blackbird	*Turdus merula*	11
Eurasian Skylark	*Alauda arvensis*	4
European Goldfinch	*Carduelis carduelis*	22
House Sparrow	*Passer domesticus*	18
Mallard	*Anas platyrhynchos*	1
Red-whiskered Bulbul	*Pycnonotus jocosus*	7
Rock Dove	*Columba livia*	5
Spotted Turtle-Dove	*Streptopelia chinensis*	18
Mammals		
Black Rat	*Rattus rattus*	19
Brown Hare	*Lepus capensis*	2
Feral Cat	*Felis catus*	27
Wild Dog (incl. Dingo)	*Canis lupus*	248
European Cattle	*Bos taurus*	21
Fox	*Vulpes vulpes*	245
Feral Goat	*Capra hircus*	55
Feral Horse	*Equus caballus*	17
House Mouse	*Mus musculus*	7
Feral Pig	*Sus scrofa*	100
Rabbit	*Oryctolagus cuniculus*	139

7.1 Feral Predator Diets

Volume 1 presented an analysis of the diets of Wild Dog/Dingo and the Fox within the Greater Southern Sydney Region, including the Warragamba Special Area. This analysis firstly aimed to compare the diet of the Wild Dog/Dingo and Fox across the Region, and then to repeat this for the different landscapes and environments from within the Region. Three of these landscapes are represented within the Warragamba Special Area:

- the Burragorang and Wollondilly Valleys,
- the Sandstone Plateaux of the Southern Blue Mountains, and
- the Highlands.

A brief summary of the main points is given below, with results incorporated into management recommendations listed at the end of this section.

Across the Greater Southern Sydney Region, including the Warragamba Special Area, the Fox was found to consume a greater range of prey than the Wild Dog/Dingo. In particular, a far great proportion of the diet of the Fox comprised small and medium-sized mammals, birds, reptiles and insects. Diet was found to vary widely from one landscape to another, reflecting prey availability. In the Burragorang and Wollondilly Valleys, where large macropods are in abundance, the diet of the Wild Dog/Dingo and Fox was very different to anywhere else in the Region. Both the Wild Dog/Dingo and Fox consumed fewer

types of animals in these Valleys, with the overwhelming majority of their diets comprising the Eastern Grey Kangaroo, Swamp Wallaby and Rabbit. No remains of rats, mice or Antechinus were found nor were scats containing insect material located. It is possible that these smaller prey only become a significant part of the diet when larger animals are rare.

The Fox feeds mostly on the Eastern Grey Kangaroo, wallabies and Rabbit in the Burragorang Valley. © N. Williams

In the Highlands, which in the Warragamba Special Area includes the Bindook Highlands, the diet of the Wild Dog/Dingo and Fox was somewhat different to other areas, probably reflecting the unique assemblages of prey species. The main difference was the large proportion of arboreal mammals (possums and gliders) in the diet of both predators, but particularly the Fox. No introduced species other than Rabbits were found in scats analysed from this area.

The area described as the Southern Blue Mountains Plateaux included the sandstone environments of the Nattai and Burragorang Plateaux, Kings Tableland and other sandstone plateaux of the southern Blue Mountains, which makes up a significant proportion of the Warragamba Special Area. Both the Wild Dog/Dingo and Fox take a wide variety of prey in these environments compared to the Burragorang Valley, including a number of smaller species. In general, the prey species composition in these environments was similar to that in the Woronora Plateau to the east. However, there were a number of key differences, perhaps the most important being the complete absence of Long-nosed Bandicoot from scats from the southern Blue Mountains. For the conservation of biodiversity in the Warragamba Special Area, the Fox is a higher priority for control than the Wild Dog.

7.2 Priority Pest Species

Pest species control within the Warragamba Special Area is a complicated and difficult issue. There are many overlapping and competing land management priorities, including the maintenance of water quality, the maintenance of biodiversity, the protection of threatened species and the needs of private landholders. Here, the management of pests (including fish and invertebrates) will be considered primarily with regards to their impacts on biodiversity and threatened species. Priorities for the control of vertebrate and invertebrate pests may be set in two ways. Firstly, introduced species may be ranked as to their impact on biodiversity or threatened species and priorities established. Secondly, priority sites or habitats can be selected where control of pests will achieve the maximum benefit for biodiversity.

Of the introduced terrestrial vertebrates known to occur in the Warragamba Special Area, just over half are considered to be of serious concern for the protection of biodiversity in the area. Some of these present a current threat, while others have the potential to expand their populations and become serious pests in the future (Table 5).

Table 5: Priority terrestrial vertebrate pest species in the Warragamba Special Area, showing introduced species that are currently recognised as significant threats to biodiversity, and species that are expanding their range with the potential to be significant pests.

Priority Pest Species	Fox
	Feral Pig
	Feral Goat
	Cat
	Wild Dog (not including Dingo)
	Rabbit
Potential Future Pests	Fallow Deer
	Red Deer
	Rusa Deer
	Common Myna
	Common Starling
	Eurasian Blackbird

7.3.1 Feral Goats

The Feral Goat has a major impact on native vegetation through soil damage and overgrazing and can cause significant habitat degradation by trampling, deposition of droppings, and the introduction of weeds (NSW Scientific Committee 2004a). Feral Goats are a major contributor to soil erosion and can prevent the regeneration of palatable trees and shrubs (Henzell 1995). Additionally, this feral species competes with native fauna for food, water and shelter and have been implicated as a threat to the endangered Brush-tailed Rock-wallaby and the Broad-headed Snake (NSW Scientific Committee 2003d, 2004a). In addition, this species has the potential to spread disease to livestock and impacts on overhangs used by some threatened cave-roosting bats (in particular the Large-eared Pied Bat) and can destroy Aboriginal heritage sites (NPWS 2003g).

Feral Goats have reached very high numbers in some parts of the Warragamba Special Area. With regards to the conservation of vertebrate fauna, the major concerns are related to impacts that they may be having on the Brush-tailed Rock-wallaby and the Broad-headed Snake. Feral Goats can reach extremely high numbers along slopes above the Wollondilly and Wingecarribee Rivers in the south of the Special Area. This same area contains good habitat for the Brush-tailed Rock-wallaby and high numbers of Feral Goats is probably a key process behind the decline of this species in the Special Area. The area from Wombeyan Caves and Yerranderie east to the Wollondilly River and along the Wingecarribee River has the potential to support a larger number of Brush-tailed Rock-wallabies, particularly around Tallygang Mountain where there are anecdotal reports.

This area is the highest priority within the Warragamba Special Area for the control of Feral Goats.

7.3.2 Feral Pigs

The Feral Pig is declared a pest animal throughout New South Wales under the RLP Act (1998). Predation, habitat degradation, competition and disease transmission by Feral Pigs is listed as Key Threatening Process under the TSC Act (1995) (NSW Scientific Committee 2004b) and the EPBC Act (1999) and it has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Feral Pigs pose a significant threat to native species and ecological communities through their behaviour and feeding habits. This species consumes a range of birds, reptiles, frogs, small mammals and soil invertebrates (Pavlov 1995) and compete with native fauna for food resources (NSW Scientific Committee 2004b). They cause extensive habitat alteration by wallowing, rooting and foraging, including the destruction and reduced regeneration of plants, alteration of soil structure, increased spread of weeds, creation of drainage channels in swamps, reduction of water quality in streams and pools, and spread of disease such as root-rot fungus (*Phytophthora cinnamoni*) (DEH 2004b).

Feral Pigs in the Warragamba Special Area impact on fauna and habitats as well as water quality. © DECC

The Feral Pig is a serious threat to the conservation of biodiversity within the Warragamba Special Area. The preferred habitat of this species includes some of the highest conservation value habitats in the Special Area, including the Burragorang, Wollondilly and Nattai Valleys. Whilst there is little direct evidence that the Feral Pig impacts on threatened fauna of these areas, competition for food and resources, the fouling of water and the destruction of habitat must indirectly impact on all species in an ecosystem when Feral Pig numbers are high. For these reasons, Feral Pigs are a high priority for control in order to protect biodiversity values. In addition, Feral Pigs cause extensive damage to Upland Swamps, another Priority Fauna Habitat. Damage in this habitat includes wallowing and digging. Therefore, it is considered high priority to control this species in these areas.

7.3.3 Foxes

The Fox is listed as a Key Threatening Process under the TSC Act (1995) and EPBC Act (1999) and are also listed as a pest species under the RLP Act (1998) (NSW Scientific Committee 1998a). They are known to impact on a range of native species by either preying on them or competing with them for food and other resources. In particular, small- and medium-sized, ground-frequenting birds, small reptiles and freshwater turtles are known to be impacted (Dickman 1996; NPWS 2001a).

The Fox has probably contributed to the decline of a number of species in the Warragamba Special Area, including the Brush-tailed Rock-wallaby, Tasmanian Bettong and Spotted-tailed Quoll. They are a high priority for control with regards to the conservation of biodiversity. However, as with all pest species, control may be more important in some areas than others. The study of predator diets conducted during this project found that Foxes consumed a vastly different array of prey species in different parts of the Warragamba Special Area. In the Burragorang and Wollondilly Valleys, Foxes consumed mostly kangaroos, larger wallabies and Rabbits while in the heaths and woodlands of the sandstone plateaux, Rabbits were a much smaller component of the diet, and a greater range of species was consumed. This is reflective of the different prey species available in these environments. These preliminary findings indicate that the control of Foxes is likely to be a higher priority in the sandstone heaths and woodlands, and Upland Swamps, than in the Burragorang Valley. In addition, any Fox and Rabbit control must always be undertaken simultaneously in the Wollondilly and Burragorang Valleys, to prevent ensuing increases in Rabbit population from the control of Foxes.

The highest priority site for the control of Foxes within the Warragamba Special Area is the Brush-tailed Rock-wallaby population at Bullio. Should any populations of the Bush Stone-curlew or Long-nosed Potoroo be discovered in the Warragamba Special Area, they would also require intensive management for the control of Foxes.

There is a current Threat Abatement Plan for predation by the Fox (NPWS 2001a). The Brush-tailed Rock-wallaby population at Bullio is a key site in the research and monitoring project associated with this plan.

7.3.4 Feral Cats

Predation by the Feral Cat is listed as a Key Threatening Process under the TSC Act (1995) (NSW Scientific Committee 2000c) and under the EPBC Act (1999). Additionally, this species has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Predation by the Feral Cat has been implicated in the extinction and decline of many species of mammals and birds on islands around Australia, and in New South Wales has been linked to the disappearance of thirteen species of mammal and four species of birds (NSW Scientific Committee 2000c).

In the Warragamba Special Area, the impact of the Feral Cat is poorly understood. It is likely that they have already had substantial impacts on medium-sized mammals and ground-frequenting birds, with species such as the Tasmanian Bettong probably driven to extinction in the Special Area partially as a result of Feral Cat predation. The decline of ground-nesting (e.g. Speckled Warbler) and shrub-nesting birds is likely to be partly due to Feral Cat predation pressures. Control of this species is very difficult, and at present there are no sites that require immediate attention within the Warragamba Special Area. Should any populations of the Bush Stone-curlew, Long-nosed Potoroo or other endangered small or medium-sized

mammals, or ground-frequenting birds be discovered in the Warragamba Special Area, they will require targeted control of Feral Cats.

7.3.5 Wild Dogs

Wild Dogs have been declared a pest species throughout New South Wales under the RLP Act (1998). They are not listed as a Key Threatening Process. Although they are known to impact on a number of threatened mammal and bird species. Wild Dogs are also responsible for livestock losses, which may be considerable in some areas. It has also been suggested that Wild Dogs regulate populations of their prey species, such as Eastern Grey Kangaroo, Rabbit, Feral Pig, deer and the Fox.

Wild Dogs are known to impact on a number of threatened species from the Warragamba Special Area, including the Brush-tailed Rock-wallaby and Koala (NSW Scientific Committee 2003d). Investigations into the diets of Wild Dogs and Dingoes in the Warragamba Special Area showed that they consumed a smaller range of species than the Fox (**Volume 1**). In all areas, Wild Dogs consumed a greater proportion of large macropods and Rabbits. Therefore, in terms of biodiversity, control of Wild Dogs may be less important than control of Foxes. There are exceptions to this generalisation, with the Dingoes within the Warragamba Special Area being threatened by hybridisation with Wild Dogs. The population of the Brush-tailed Rock-Wallaby at Bullio are probably another exception, as would any other small and isolated populations of endangered medium- or large-sized mammals.

7.3.6 Rabbits

The Rabbit has been listed by the World Conservation Union as among 100 of the 'World's Worst Invaders' (IUCN 2005). Competition and grazing by this species is listed as a Key Threatening Process under the TSC Act (1995) (NSW Scientific Committee 2002b), while competition and land degradation by this species is listed under the EPBC Act (1999). The Rabbit causes significant land degradation by altering the structure and composition of vegetation communities, removing above and below ground plant biomass, preventing plant regeneration, ring-barking trees and shrubs and the digging of burrows. All of these impacts in turn contribute to soil erosion. They compete for food and/or shelter with some native fauna species, such as the Brush-tailed Rock-wallaby and are thought to have contributed to the extinction of several small mammals (NSW Scientific Committee 2002b). Rabbits form the major component of the diet of Feral Cats and Foxes in many areas and can maintain populations of these predators at high levels. Sharp declines in Rabbit numbers (such as those caused by disease outbreaks) can force these introduced predators to switch to predominantly indigenous fauna species (Smith and Quin 1996).

Within the Warragamba Special Area, Rabbit control is of greatest concern in the Burragorang and Wollondilly Valleys where large numbers of threatened Grassy Box Woodland birds are vulnerable to overgrazing. The Brush-tailed Rock-wallaby population at Bullio is another key site for the control of Rabbits.

7.3.7 Potential Future Pests

There are six introduced species that may become serious pests in the Warragamba Special Area in the future. These are the introduced deer and three of the introduced bird species (Table 5). Fallow and Red Deer may already be established within the Warragamba Special Area, though no records currently exist for the region in the Atlas of NSW Wildlife. Both of these species are expanding their range within the Southern Blue Mountains and have the potential to be very serious pests. Habitat modelling has shown that Rusa Deer is capable of inhabiting the Warragamba Special Area, and ample habitat exists there (see **Volume 2**). The potential damage to biodiversity cannot be overstated should these species reach large numbers. Potential impacts include overgrazing, the destruction and reduced regeneration of plants, alteration of soil structure, increased spread of weeds, trampling of wetlands, and the erosion of watercourse and water storage banks. Deer species are the highest priorities for control within the Warragamba Special Area as potential exists to control populations at an early stage, thereby preventing losses to biodiversity.

Rusa Deer, and other deer species, pose a serious risk in the future should numbers be allowed to increase. They are a very high priority for control. © K. Gillett

The Common Starling, Common Myna and Eurasian Blackbird all have the potential to establish within the Warragamba Special Area in particular in the Burragorang and Wollondilly Valleys (see **Volume 2**). The first two species are known to impact on hollow-nesting birds, such as the Brown Treecreeper, by aggressively competing for hollows (e.g. Garnett and Crowley 2000). Other hollow-roosting species, such as the Squirrel Glider and various tree-dwelling bats may also be affected. The Burragorang Valley is a critical area for these species and as such, the establishment of these feral birds in this area could be disastrous for these threatened species in the Region. Any evidence that these species are establishing within the Burragorang Valley should be met with immediate control action.

The potential impact of the Eurasian Blackbird is less well understood as it does not utilise tree hollows for nesting. However, it is known to contribute to the spread of noxious weeds such as the Blackberry and may compete with various native birds, particularly the Bassian Thrush.

7.3.8 Other Pest Species: Fish, Invertebrates and Fungus

This study has not sought to directly study or map the distributions of introduced fish, invertebrates or pathogens. However, they have been considered with respect to their impacts on biodiversity, threatened species and populations. There are a number of

introduced fish species in the Warragamba Special Area including the Rainbow and Brown Trout, European Carp and the Plague Minnow. These species are a great threat not only to native fish, but also to frogs.

Predation by the Plague Minnow is listed as a Key Threatening Process affecting the Green and Golden Bell Frog and other species such as the Booroolong Frog (NSW Scientific Committee 1999b). Within the Warragamba Special Area it appears that the Green and Golden Bell Frog may already be locally extinct, with the last known record from around Oakdale. The decline of this frog may be associated with the spread of this fish species, which can reach high densities, often occurring where native fish are unable to survive. The Plague Minnow may be problematic for other species, including the Stuttering Frog at Mt. Werong. At present, there is no evidence that the Plague Minnow occurs at the site of the Stuttering Frog. However research and monitoring of this population should include checks as to whether or not this fish has invaded, or has the capacity to invade the habitat of this critically endangered frog population.

European Carp are strongly implicated in increased turbidity levels and nutrient loads of larger waterways, as well as the reduction of shallow-rooted and soft-leaved species of aquatic vegetation, leading to increased bank erosion (Fletcher *et al.* 1985; Wager and Jackson 1993). Predation by introduced Rainbow Trout and Brown Trout has been implicated in the decline of several native fish species (Wager and Jackson 1993). These introduced fish have potentially contributed to the endangerment of the Booroolong Frog (NSW Scientific Committee 1998b). There are no known extant populations of the Booroolong Frog within the Warragamba Special Area and it is possible that the high numbers of these introduced fish may be responsible for its decline. If an extant population of the Booroolong Frog is discovered within the Special Area, it would be a high priority for targeted control of these introduced pest fish.

Other than the species mentioned above, introduced fish may impact on many stream and pond-dwelling frog species, the Platypus and Eastern Snake-necked Turtle by competition for food, direct predation and alteration of microhabitats in the waterways they cohabit. For instance, there are anecdotal reports from landholders on the Wollondilly River that Platypus numbers have decreased with an increase in the numbers of European Carp (P. Boyd pers. comm.). The effects of these introduced fish, particularly the European Carp, may be far reaching and should be the subject of a separate study.

There are likely to be many introduced invertebrates within the Warragamba Special Area. Additionally, some native invertebrates also have the potential to be pests. Invertebrate pest species can have a range of direct effects, though more typically impacts are indirect. Native species rarely become pests in undisturbed environments and are more typically a problem in agricultural landscapes, for example the Plague Locust. Sarcoptic mange is a mite that is thought to have been introduced by domestic dogs within the last 200 years and is a problem in some Common Wombat populations. At present, no invertebrates are recognised as having contributed to the decline of vertebrate fauna within the Warragamba Special Area.

There are probably many introduced pathogens that impact on vertebrate fauna within the Warragamba Special Area. The most serious is the Frog Chytrid Fungus (NSW Scientific Committee 2003a). Frog Chytrid Fungus has the potential to be problematic for many frog species, particularly those that aggregate to breed at ponds or streams, where transmission is more likely. In the Warragamba Special Area there are four species that have been identified as being particularly vulnerable: the Stuttering Frog, Green and Golden Bell Frog, Green Tree Frog and Booroolong Frog. This study has failed to find any extant populations of the last three species, and it is considered that Chytrid Fungus is a primary reason behind their declines. Only a single population of the Stuttering Frog has been found, at Mt. Werong, and management with regard to Chytrid Fungus is discussed in Section 5.3.2. General management recommendations for controlling the spread of Chytrid Fungus involve the implementation of frog hygiene protocol when work involves any contact with frogs (NPWS 2001b).

Koala populations in the Special Area may be infected with *Chlamydia,* a disease that seriously impacts on Koala populations elsewhere in Australia. Whilst there have not been any reports of infected individuals from the Warragamba Special Area, an infected individual has been identified in the Metropolitan Special Area and the disease is systemic in the Wedderburn population (R. Close, University of Western Sydney, pers comm.). With most healthy Koala populations, it is predominantly sick or old animals that will succumb to *Chlamydia.*

7.3 Priority Sites for Pest Control

Controlling pest species for the benefit of biodiversity is best directed toward sites or habitats of particular concern. All three Priority Fauna Habitats of the Warragamba Special Area are a priority for reducing the number of vertebrate pests (Figure 7).

7.4.1 Grassy Box Woodlands and Alluvial Forests and Woodlands

Grassy Box Woodlands and Alluvial Forests and Woodlands are high quality habitat for a range of terrestrial vertebrate pest species including Pigs, Rabbits, Common Myna, Common Starling and Eurasian Blackbird (see **Volume 2**). As Priority Fauna Habitats, these environments play host to a large number of threatened fauna species. Therefore, these environments are prime areas for targeted control of pest species for the conservation of biodiversity.

Alluvial Forests and Woodlands and Grassy Box Woodlands of the Burragorang and Wollondilly Valleys are a priority for the control of vertebrate pests such as the Feral Pig, Rabbit and Feral Goat as these environments will support large numbers of these species and because they are close to private land, waterways and the water storage. These areas should remain a priority for the control of these species, as this has the potential to benefit the maximum number of threatened fauna. Analysis of predator diets would suggest that Foxes and Wild Dogs have little impact on biodiversity in the Burragorang and Wollondilly Valleys when compared to elsewhere, preying mostly on Eastern Grey Kangaroos, wallabies and Rabbits. Therefore, these two species are not a priority for control in this environment. However, should control occur, simultaneous efforts must be made to control

Rabbit and Eastern Grey Kangaroo populations that may otherwise explode in numbers.

Exotic birds are serious potential threats should they establish in the Grassy Box Woodlands of the Burragorang Valley. At present, potential habitat exists for a number of introduced birds, and the occasional individual does reach this area, though none appear to have established viable populations. The closest populations of the Common Myna and Common Starling appear to be at Nattai township and on Wombeyan Caves Road. Should these two species, in particular, establish in the Burragorang or Wollondilly Valleys, they have the potential to seriously threaten a number of hollow-utilising species, including the Brown Treecreeper and Squirrel Glider (**Volume 2**). It is important that field staff and managers are aware of the potential for these introduced birds to seriously threaten the last viable populations of these threatened fauna in the Region. Both the Common Myna and Common Starling are continuing to expand their range and, without intervention, it is possibly only a matter of time until they establish in the Burragorang Valley. It is vitally important that control measures are undertaken before populations can establish.

7.4.2 Upland Swamps

Upland Swamps, although covering a small geographic area within the Warragamba Special Area, support a diverse fauna that is threatened by Fox and Feral Cat predation (see Section 5.2.3 and **Volume 1**). Species that would potentially benefit from Fox and Feral Cat control in Upland Swamps on the Narrowneck Plateau and Kings Tableland include the Eastern Pygmy-possum, Blue Mountains Water Skink, Beautiful Firetail and Southern Emu-wren. This is a lower priority than control of Foxes and Cats in the Upland Swamps of the Woronora Plateau due to the higher number of threatened species found there.

Upland Swamps are typified by thick vegetation at ground level that provides shelter for many small mammals and ground-dwelling birds. Fire makes this environment accessible to introduced predators, thus control of Feral Cats and Foxes in Upland Swamp is most important for the two to three years following fire.

7.4.3 Brush-tailed Rock-wallaby Population

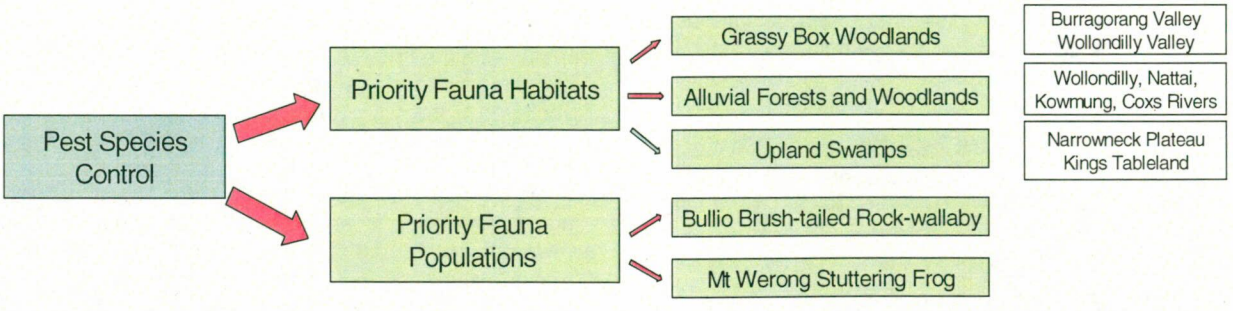
Intensive control of Foxes, Rabbits and Feral Goats around the Brush-tailed Rock-wallaby population at Bullio (and any other populations that may be discovered in the future) is critical to their continued survival in the Warragamba Special Area and the Region as a whole. Feral Goats compete with this species for shelter and food, while competition by Rabbits is also listed as a Key Threatening Process affecting this species. This wallaby population is also part of a research and monitoring project associated with the Fox Threat Abatement Plan that is looking at the impact that Fox control has on populations of the Brush-tailed Rock-wallaby (NPWS 2001a).

The Brush-tailed Rock-wallaby site near Bullio is a priority for targeted pest species control in coordination with the Fox Threat Abatement Plan. © DECC

7.4.4 Stuttering Frog Population

The Stuttering Frog population at Mt. Werong is threatened by the introduction of an exotic fungus, the potentially fatal Chytrid Fungus as discussed in detail in Section 5.3.2 and 7.11. This is the main exotic species that must be controlled around this frog population. This project has shown that some of the population is infected with this disease, with dead frogs found during the surveys (see **Volume 2**). It is currently unknown whether the entire population is infected. Therefore, extreme precautions must be adopted when visiting the area and the frog hygiene protocol strictly observed (NPWS 2001b). Another species that may potentially threaten this population in the future is the Plague Minnow, which at this stage has not reached the sites where the Stuttering Frog is found (Section 7.11).

Figure 7: Priority areas for the control of pests in the Warragamba Special Area, with important locations listed. Arrows highlighted in red are the most critical.



8 Future Survey Work and Monitoring

8.1 Threatened and Priority Fauna

8.1.1 Additional Survey

The following species would benefit from further survey and targeted search efforts. Habitat identified during this project should be used to target these searches. Most of these species are poorly sampled using systematic methods. Groups of animals that could be targeted simultaneously have been recommended.

Does the endangered Bush Stone-curlew still occur in the Warragamba Special Area? © Nevil Lazarus

- *Brush-tailed Rock-wallaby*: dedicated effort to locate additional colonies of this endangered species would be appropriate. In particular, effort should be expended in attempt to confirm extant colonies in areas where scats have been located as part of this project, and in habitat identified as suitable by this project.
- *Bush Stone-curlew*: targeted searches for this very rare species would be appropriate in the Burragorang and Wollondilly Valleys.
- *Rare Nomadic Nectarivorous Woodland Birds* (Black-chinned Honeyeater, Swift Parrot and the Regent Honeyeater): Regular monitoring of known localities. Targeted surveys of additional areas with large amounts of autumn and/or winter-flowering Eucalypt species, including outside the Burragorang and Wollondilly Valleys.
- *Rare Woodland Birds* (Turquoise Parrot, Diamond Firetail, Hooded Robin): Targeted searches of habitat identified in this project, outside localities currently known to be occupied by these species.
- *Rare and Cryptic Wetland Birds* (Australasian Bittern, Lewin's Rail): targeted searches of habitat identified in this project, including call playback where appropriate
- *Rare Medium-sized Mammals* (Long-nosed Potoroo, Southern Brown Bandicoot, Spotted-tailed Quoll): extended cage trapping (using spring-loaded traps) and hair tube (specifically designed for small macropods and quolls) placement in areas identified as potential habitat during this project.
- *Rare Frogs* (in particular Stuttering Frog, Booroolong Frog, Littlejohn's Tree Frog, Green Tree Frog, Green and Golden Bell Frog): targeted frog searches are needed across the Warragamba Special Area under suitable weather conditions.

Environments that could potentially benefit from further survey are the most remote gullies and Plateaux, such as the Wild Dog Mountains, Blue Breaks and Lacy's Tableland. The steepest country, particularly the midslopes, requires the most attention.

There are many potential conservation programs that could be undertaken in the Greater Southern Sydney Region to understand and preserve local vertebrate fauna. Here we present some ideas about potential monitoring or research, and give direction as to how these programs might be implemented. Some projects mentioned here might be suitable as university research topics while others may be best implemented by DECC Regional staff and Sydney Catchment Authority in consultation with DECC threatened species officers.

8.1.2 Stuttering Frog Research and Recovery Program

The Stuttering Frog is the one of the rarest frogs in the Greater Southern Sydney Region and is highly threatened across the southern half of its range. The population at Ruby and Mt. Werong Creeks are highly significant. Monitoring and research into these populations may inform us as to why this species has declined so severely while also helping to preserve some of the last known southerly populations of the species. The presence of Frog Chytrid Fungus in the southern Blue Mountains population is likely to be significant (DEC 2004c). The presence of dead metamorphs and small frogs may be a warning that recruitment to the adult population may not be occurring at a sustainable rate, as adult frogs often survive despite being infected while metamorphs succumb to the disease. It is extremely important to determine if these populations are continuing to decline, as they are two of the last known populations in the southern half of the species range. Some monitoring of tadpoles has been conducted by DECC in 2005 and 2006 (J. Bros pers. comm.), and continued visitation of the site is recommended.

Other programs might include monitoring the water quality and the level of Chytrid Fungus in the soil, leaf-litter and water and comparing these results to sites where this frog is known to have been lost. This program should help inform us as to why these populations have persisted whilst the majority have disappeared. Further to this, future projects might include predicting where else suitable habitat exists in the westernmost part of the southern Blue Mountains - an area which has poor vegetation mapping and poor resolution at this stage (see **Volume 2 – Fauna of Conservation Concern and Priority Pest Species**).

Finally, this species is probably suitable for reintroduction to appropriate habitat in order to lessen the chance of regional extinction, with this linking to the captive breeding program that is currently underway.

8.1.3 Threatened Species, Eastern Grey Kangaroo and Predator Dynamics in the Burragorang Valley

The Burragorang and Wollondilly Valleys have been shown to contain the highest conservation value fauna habitat in the Greater Southern Sydney Region (see **Volume 2**). This area is Schedule One water catchment, meaning it is of the greatest importance for maintaining water quality. Consequently, a balanced or healthy ecosystem in these Valleys is highly desirable. A healthy ecosystem requires a balance between predators and prey species. Currently, a research project is underway assessing the interactions and behaviour of Wild Dogs and Dingoes in this area - including investigations into prey composition (B. Purcell pers comm.). Research is also investigating the dynamics of the Eastern Grey Kangaroo populations on the valley floor (M. Roberts, Macquarie University, pers comm.). These projects could be extended to assess how populations of predators or the Eastern Grey Kangaroo impact on vegetation, and thereby indirectly the threatened woodland birds in the area. Overgrazing by the large numbers of Eastern Grey Kangaroos may retard eucalypt regeneration and reduce the amount of understorey vegetation. This not only has the effect of decreasing the amount of habitat for some key species, but also maintains large areas of grassy woodland that lead to high Eastern Grey Kangaroo populations.

8.2 Pest species/Water Quality

8.2.1 Feral predator dynamics

Investigations into the complex relationship between predators such as Wild Dogs, Foxes, Feral Cats and Feral Pigs are recommended. In addition, investigations should examine the relationship between predators and prey species that are also considered pests, such as Rabbits, Feral Goats and various deer species. For example, it remains unknown as to whether or not Wild Dogs regulate populations of Foxes, Feral Pigs and deer, or if Fox control results in an increase in the numbers of Feral Cats and Rabbits.

It is very important that these dynamics are understood, as the results will have far-reaching implications for pest species control. Preliminary investigations undertaken as part of this study have uncovered a number of interesting trends. For instance, Foxes eat a far greater range of native species on the Woronora Plateau than in the Burragorang Valley, where they eat mostly large macropods and Rabbits. Management implications of this are that Fox control is a higher priority (for biodiversity) on the Woronora Plateau than in the Burragorang Valley, and when undertaking Fox control in the Burragorang Valley, concomitant control of Rabbits is likely to be required. Preliminary findings could be taken further into a number of properly controlled studies on feral predator dynamics that could have benefits for ecosystem management both locally and nationwide.

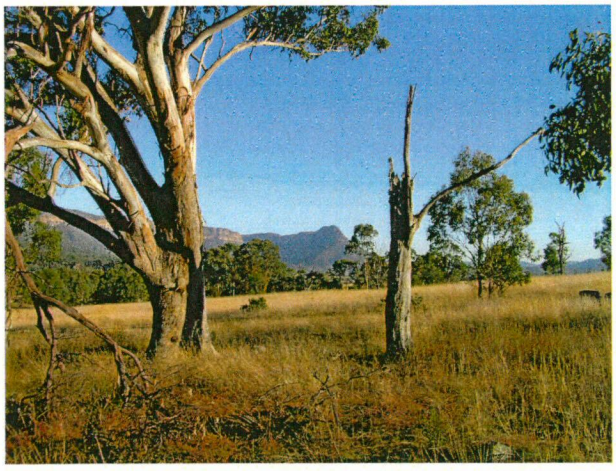
8.2.2 Cross-tenure mapping of deer species

Further investigations and mapping of the various deer species in the catchments and surrounding areas should be undertaken. Rusa Deer are expanding in the eastern catchments and have the potential to colonise parts of Warragamba (**Volume 2**). Other species of deer occur in the western parts of the Region and also appear to be expanding their range (M. Jones pers. comm.; D. Scott-Lawson pers. comm.).

8.2.3 Burragorang Valley ecosystem dynamics and water quality

Ecosystem dynamics of the Burragorang Valley could be investigated in relation to water quality. At present, Wild Dogs/Dingoes and Eastern Grey Kangaroos are being studied in separate research programs. We recommend that the results of these studies are taken further to investigate the relationship between Wild Dogs and Dingoes (and/or Foxes) and if/how they regulate populations of Eastern Grey Kangaroos and Rabbits and the impacts or implications this has on the vegetation of the Valley. The present preliminary investigations suggest that both Dogs and Foxes subsist primarily on large macropods and Rabbits in the Warragamba Special Area, in which Eastern Grey Kangaroo, in particular, are known to exist in very high numbers.

Macropods and Rabbits very heavily graze the area, which may impact on vegetation cover and the regeneration of the grassy woodlands. Overgrazing has the potential to impact on water quality as decreased vegetation cover leads to increased run-off, sedimentation and transportation of *Cryptosporidium* oocysts into the water supply (Ferguson *et al.* 2003; Davies *et al.* 2004). Regeneration of a woodland canopy could also lead to increased penetration of water into the soil and therefore, increased water quality.



The Grassy Box Woodlands of the Burragorang Valley would make an ideal 'model ecosystem' for research on any number of topics relating to ecological processes, threatened species and water quality. © D. Andrew

9 References

9.1 Reports in the Series: Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region

Volumes of this Report Series:

Volume 1: DECC (2007a) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region. Volume One: Background Report.* A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, DECC, Hurstville.

Volume 2: DECC (2007b) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region Volume two – Fauna of Conservation Concern and Priority Pest Species.* A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, DECC, Hurstville.

Volume 4: DECC (2007c) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region. Volume Four: The Fauna of the Metropolitan, O'Hares Creek and Woronora Special Areas.* A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, DECC, Hurstville.

Volume 5: DECC (2007d) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region. Volume Five: The Fauna of the Blue Mountains Special Areas.* A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change (NSW) (DECC) under the Special Areas Strategic Plan of Management (SASPoM) by Information and Assessment Section, Metropolitan Branch, Climate Change and Environment Protection Group, DECC, Hurstville.

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10 List of Acronyms

ASL	Above sea level
CRA	Comprehensive Regional Assessments
DEC	Department of Environment and Conservation, New South Wales (now part of DECC)
DECC	Department of Environment and Climate Change, New South Wales
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act (1999)
GIS	Geographic Information Systems
IUCN	International Union for the Conservation of Nature and Natural Resources
NPW Act	National Parks and Wildlife Act (1974)
NPWS	New South Wales National Parks and Wildlife Service
NR	Nature Reserve
RLP Act	Rural Lands Protection Act (1998)
SASPoM	Special Areas Strategic Plan of Management
TAP	Threat Abatement Plan
TSC Act	NSW Threatened Species Conservation Act (1995)

11 Appendices

Appendix A: Complete species list for the Warragamba Special Area including the total number of records of each species

Common Name	Species Name	Legal Status	Confirmation status	Total records
Amphibians				
Bibron's Toadlet	*Pseudophryne bibronii*	Protected	Confirmed	55
Blue Mountains Tree Frog	*Litoria citropa*	Protected	Confirmed	12
Booroolong Frog	*Litoria booroolongensis*	Endangered	Confirmed	1
Broad-palmed Frog	*Litoria latopalmata*	Protected	Confirmed	7
Bullfrog	*Limnodynastes dumerilii dumerilii/grayi*	Protected	Confirmed	37
Common Eastern Froglet	*Crinia signifera*	Protected	Confirmed	181
Eastern Dwarf Tree Frog	*Litoria fallax*	Protected	Confirmed	3
Eastern Sign-bearing Froglet	*Crinia parinsignifera*	Protected	Unconfirmed	1
Giant Burrowing Frog	*Heleioporus australiacus*	Vulnerable	Confirmed	1
Green and Golden Bell Frog	*Litoria aurea*	Endangered	Unconfirmed	1
Green Stream Frog	*Litoria phyllochroa*	Protected	Confirmed	20
Green Tree Frog	*Litoria caerulea*	Protected	Confirmed	2
Haswell's Froglet	*Paracrinia haswelli*	Protected	Confirmed	7
Keferstein's Tree Frog	*Litoria dentata*	Protected	Confirmed	29
Lesueur's Frog	*Litoria lesueuri/wilcoxii*	Protected	Confirmed	82
Peron's Tree Frog	*Litoria peronii*	Protected	Confirmed	92
Red-crowned Toadlet	*Pseudophryne australis*	Vulnerable	Confirmed	7
Red-eyed Tree Frog	*Litoria chloris*	Protected	Probable Error	1
Smooth Toadlet	*Uperoleia laevigata*	Protected	Confirmed	26
Southern Brown Tree Frog	*Litoria ewingii*	Protected	Confirmed	3
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	Protected	Confirmed	7
Striped Marsh Frog	*Limnodynastes peronii*	Protected	Confirmed	57
Stuttering Frog	*Mixophyes balbus*	Endangered	Confirmed	2
Tyler's Tree Frog	*Litoria tyleri*	Protected	Confirmed	7
Verreaux's Tree Frog	*Litoria verreauxii*	Protected	Confirmed	41
Wrinkled Toadlet	*Uperoleia rugosa*	Protected	Confirmed	2
Reptiles				
Bar-sided Forest-skink	*Eulamprus tenuis*	Protected	Confirmed	19
Black Crevice-skink	*Egernia saxatilis*	Protected	Confirmed	10
Blackish Blind Snake	*Ramphotyphlops nigrescens*	Protected	Confirmed	6
Blotched Bluetongue	*Tiliqua nigrolutea*	Protected	Confirmed	1
Blue Mountains Water Skink	*Eulamprus leuraensis*	Endangered	Confirmed	1
Bold-striped Cool-skink	*Bassiana duperreyi*	Protected	Confirmed	3
Broad-headed Snake	*Hoplocephalus bungaroides*	Endangered	Confirmed	1
Broad-tailed Gecko	*Phyllurus platurus*	Protected	Confirmed	16
Callose-palmed Shinning-skink	*Cryptoblepharus plagiocephalus*	Protected	Unconfirmed	1
Common Bluetongue	*Tiliqua scincoides*	Protected	Confirmed	7
Copper-tailed Ctenotus	*Ctenotus taeniolatus*	Protected	Confirmed	101
Cream-striped Shinning-skink	*Cryptoblepharus virgatus*	Protected	Confirmed	55
Cunningham's Spiny-tailed Skink	*Egernia cunninghami*	Protected	Confirmed	16
Dark-flecked Garden Sunskink	*Lampropholis delicata*	Protected	Confirmed	116

Common Name	Species Name	Legal Status	Confirmation status	Total records
Diamond Python	*Morelia spilota spilota*	Protected	Confirmed	8
Eastern Bearded Dragon	*Pogona barbata*	Protected	Confirmed	3
Eastern Brown Snake	*Pseudonaja textilis*	Protected	Confirmed	15
Eastern She-Oak Skink	*Cyclodomorphus michaeli*	Protected	Confirmed	1
Eastern Snake-necked Turtle	*Chelodina longicollis*	Protected	Confirmed	25
Eastern Stone Gecko	*Diplodactylus vittatus*	Protected	Confirmed	10
Eastern Water Dragon	*Physignathus lesueurii*	Protected	Confirmed	80
Eastern Water-skink	*Eulamprus quoyii*	Protected	Confirmed	151
Golden Crowned Snake	*Cacophis squamulosus*	Protected	Confirmed	2
Highlands Copperhead	*Austrelaps ramsayi*	Protected	Confirmed	1
Jacky Lashtail	*Amphibolurus muricatus*	Protected	Confirmed	119
Lace Monitor	*Varanus varius*	Protected	Confirmed	121
Lesueur's Velvet Gecko	*Oedura lesueurii*	Protected	Confirmed	71
Mainland Tiger Snake	*Notechis scutatus*	Protected	Confirmed	3
Marsh Snake	*Hemiaspis signata*	Protected	Confirmed	2
Mountain Heath Dragon	*Tympanocryptis diemensis*	Protected	Confirmed	44
Pale-flecked Garden Sunskink	*Lampropholis guichenoti*	Protected	Confirmed	159
Pink-tongued Skink	*Hemisphaeriodon gerrardii*	Protected	Unconfirmed	1
Red-bellied Black Snake	*Pseudechis porphyriacus*	Protected	Confirmed	97
Red-throated Cool-skink	*Bassiana platynota*	Protected	Confirmed	54
Robust Ctenotus	*Ctenotus robustus*	Protected	Confirmed	31
Rosenberg's Goanna	*Varanus rosenbergi*	Vulnerable	Confirmed	4
Small-eyed Snake	*Rhinoplocephalus nigrescens*	Protected	Confirmed	5
Southern Forest Cool-skink	*Niveoscincus coventryi*	Protected	Confirmed	3
Southern Scaly-foot	*Pygopus lepidopodus*	Protected	Confirmed	2
Thick-tailed Gecko	*Underwoodisaurus milii*	Protected	Confirmed	12
Three-toed Earless Skink	*Hemiergis decresiensis*	Protected	Confirmed	23
Tree-base Litter-skink	*Lygisaurus foliorum*	Protected	Confirmed	48
Trunk-climbing Cool-skink	*Pseudemoia spenceri*	Protected	Confirmed	7
Tussock Cool-skink	*Pseudemoia entrecasteauxii*	Protected	Confirmed	19
Tussock Skink	*Pseudemoia pagenstecheri*	Protected	Confirmed	3
Warm-temperate Water-skink	*Eulamprus heatwolei*	Protected	Confirmed	65
Weasel Shadeskink	*Saproscincus mustelinus*	Protected	Confirmed	61
White's Rock-skink	*Egernia whitii*	Protected	Confirmed	32
Yellow-bellied Three-toed Skink	*Saiphos equalis*	Protected	Confirmed	7
Yellow-faced Whipsnake	*Demansia psammophis*	Protected	Confirmed	4
Birds				
Diurnal Birds				
Australasian Grebe	*Tachybaptus novaehollandiae*	Protected	Confirmed	33
Australasian Shoveler	*Anas rhynchotis*	Protected	Confirmed	5
Australian Hobby	*Falco longipennis*	Protected	Confirmed	2
Australian King-Parrot	*Alisterus scapularis*	Protected	Confirmed	123
Australian Magpie	*Gymnorhina tibicen*	Protected	Confirmed	178
Australian Pelican	*Pelecanus conspicillatus*	Protected	Confirmed	30
Australian Pipit	*Anthus australis*	Protected	Confirmed	55
Australian Raven	*Corvus coronoides*	Protected	Confirmed	170
Australian Reed-Warbler	*Acrocephalus australis*	Protected	Confirmed	8
Australian Shelduck	*Tadorna tadornoides*	Protected	Confirmed	1

Common Name	Species Name	Legal Status	Confirmation status	Total records
Australian White Ibis	*Threskiornis molucca*	Protected	Confirmed	12
Australian Wood Duck	*Chenonetta jubata*	Protected	Confirmed	87
Azure Kingfisher	*Alcedo azurea*	Protected	Confirmed	36
Bassian Thrush	*Zoothera lunulata*	Protected	Confirmed	34
Beautiful Firetail	*Stagonopleura bella*	Protected	Confirmed	5
Bell Miner	*Manorina melanophrys*	Protected	Confirmed	136
Black Swan	*Cygnus atratus*	Protected	Confirmed	38
Black-chinned Honeyeater (eastern subsp.)	*Melithreptus gularis gularis*	Vulnerable	Confirmed	11
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	Protected	Confirmed	154
Black-faced Monarch	*Monarcha melanopsis*	Protected	Confirmed	40
Black-fronted Dotterel	*Elseyornis melanops*	Protected	Confirmed	17
Black-shouldered Kite	*Elanus axillaris*	Protected	Confirmed	14
Black-winged Stilt	*Himantopus himantopus*	Protected	Confirmed	5
Brown Cuckoo-Dove	*Macropygia amboinensis*	Protected	Confirmed	3
Brown Falcon	*Falco berigora*	Protected	Confirmed	31
Brown Gerygone	*Gerygone mouki*	Protected	Confirmed	119
Brown Goshawk	*Accipiter fasciatus*	Protected	Confirmed	18
Brown Quail	*Coturnix ypsilophora*	Protected	Confirmed	11
Brown Songlark	*Cincloramphus cruralis*	Protected	Confirmed	7
Brown Thornbill	*Acanthiza pusilla*	Protected	Confirmed	338
Brown Treecreeper (eastern subsp.)	*Climacteris picumnus victoriae*	Vulnerable	Confirmed	141
Brown-headed Honeyeater	*Melithreptus brevirostris*	Protected	Confirmed	111
Brush Bronzewing	*Phaps elegans*	Protected	Confirmed	6
Brush Cuckoo	*Cacomantis variolosus*	Protected	Confirmed	26
Budgerigar	*Melopsittacus undulatus*	Protected	Confirmed	2
Buff-rumped Thornbill	*Acanthiza reguloides*	Protected	Confirmed	111
Cattle Egret	*Ardea ibis*	Protected	Confirmed	3
Channel-billed Cuckoo	*Scythrops novaehollandiae*	Protected	Confirmed	35
Chestnut Teal	*Anas castanea*	Protected	Confirmed	3
Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*	Protected	Confirmed	10
Cicadabird	*Coracina tenuirostris*	Protected	Confirmed	63
Cockatiel	*Nymphicus hollandicus*	Protected	Confirmed	1
Collared Sparrowhawk	*Accipiter cirrocephalus*	Protected	Confirmed	8
Common Bronzewing	*Phaps chalcoptera*	Protected	Confirmed	69
Crescent Honeyeater	*Phylidonyris pyrrhoptera*	Protected	Confirmed	4
Crested Pigeon	*Ocyphaps lophotes*	Protected	Confirmed	18
Crimson Rosella	*Platycercus elegans*	Protected	Confirmed	305
Darter	*Anhinga melanogaster*	Protected	Confirmed	12
Diamond Dove	*Geopelia cuneata*	Protected	Confirmed	5
Diamond Firetail	*Stagonopleura guttata*	Vulnerable	Confirmed	79
Dollarbird	*Eurystomus orientalis*	Protected	Confirmed	28
Double-barred Finch	*Taeniopygia bichenovii*	Protected	Confirmed	74
Dusky Moorhen	*Gallinula tenebrosa*	Protected	Confirmed	36
Dusky Woodswallow	*Artamus cyanopterus*	Protected	Confirmed	96
Eastern Rosella	*Platycercus adscitus eximius*	Protected	Confirmed	95
Eastern Shrike-tit	*Falcunculus frontatus*	Protected	Confirmed	77
Eastern Spinebill	*Acanthorhynchus tenuirostris*	Protected	Confirmed	348

Common Name	Species Name	Legal Status	Confirmation status	Total records
Eastern Whipbird	*Psophodes olivaceus*	Protected	Confirmed	187
Eastern Yellow Robin	*Eopsaltria australis*	Protected	Confirmed	368
Emu	*Dromaius novaehollandiae*	Protected	Confirmed	35
Eurasian Coot	*Fulica atra*	Protected	Confirmed	26
Fairy Martin	*Petrochelidon ariel*	Protected	Confirmed	17
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	Protected	Confirmed	156
Flame Robin	*Petroica phoenicea*	Protected	Confirmed	16
Fork-tailed Swift	*Apus pacificus*	Protected	Confirmed	4
Fuscous Honeyeater	*Lichenostomus fuscus*	Protected	Confirmed	50
Galah	*Eolophus roseicapillus*	Protected	Confirmed	23
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Vulnerable	Confirmed	156
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	Vulnerable	Confirmed	202
Golden Whistler	*Pachycephala pectoralis*	Protected	Confirmed	251
Golden-headed Cisticola	*Cisticola exilis*	Protected	Confirmed	12
Great Cormorant	*Phalacrocorax carbo*	Protected	Confirmed	25
Great Crested Grebe	*Podiceps cristatus*	Protected	Confirmed	19
Great Egret	*Ardea alba*	Protected	Confirmed	16
Green Catbird	*Ailuroedus crassirostris*	Protected	Confirmed	1
Grey Butcherbird	*Cracticus torquatus*	Protected	Confirmed	165
Grey Currawong	*Strepera versicolor*	Protected	Confirmed	33
Grey Fantail	*Rhipidura albiscapa*	Protected	Confirmed	413
Grey Goshawk	*Accipiter novaehollandiae*	Protected	Confirmed	2
Grey Shrike-thrush	*Colluricincla harmonica*	Protected	Confirmed	412
Grey Teal	*Anas gracilis*	Protected	Confirmed	16
Hardhead	*Aythya australis*	Protected	Confirmed	13
Hoary-headed Grebe	*Poliocephalus poliocephalus*	Protected	Confirmed	7
Hooded Robin (southeastern subsp.)	*Melanodryas cucullata cucullata*	Vulnerable	Confirmed	47
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	Protected	Confirmed	14
Intermediate Egret	*Ardea intermedia*	Protected	Confirmed	2
Jacky Winter	*Microeca fascinans*	Protected	Confirmed	142
Large-billed Scrubwren	*Sericornis magnirostris*	Protected	Confirmed	6
Latham's Snipe	*Gallinago hardwickii*	Protected	Confirmed	4
Laughing Kookaburra	*Dacelo novaeguineae*	Protected	Confirmed	222
Leaden Flycatcher	*Myiagra rubecula*	Protected	Confirmed	70
Lewin's Honeyeater	*Meliphaga lewinii*	Protected	Confirmed	127
Little Black Cormorant	*Phalacrocorax sulcirostris*	Protected	Confirmed	28
Little Corella	*Cacatua sanguinea*	Protected	Confirmed	2
Little Eagle	*Hieraaetus morphnoides*	Protected	Confirmed	7
Little Egret	*Egretta garzetta*	Protected	Confirmed	1
Little Friarbird	*Philemon citreogularis*	Protected	Confirmed	2
Little Grassbird	*Megalurus gramineus*	Protected	Confirmed	4
Little Lorikeet	*Glossopsitta pusilla*	Protected	Confirmed	38
Little Pied Cormorant	*Phalacrocorax melanoleucos*	Protected	Confirmed	57
Little Wattlebird	*Anthochaera chrysoptera*	Protected	Confirmed	26
Long-billed Corella	*Cacatua tenuirostris*	Protected	Confirmed	3
Magpie-lark	*Grallina cyanoleuca*	Protected	Confirmed	87
Masked Lapwing	*Vanellus miles*	Protected	Confirmed	62
Masked Woodswallow	*Artamus personatus*	Protected	Confirmed	5

Common Name	Species Name	Legal Status	Confirmation status	Total records
Mistletoebird	*Dicaeum hirundinaceum*	Protected	Confirmed	128
Musk Duck	*Biziura lobata*	Protected	Confirmed	19
Musk Lorikeet	*Glossopsitta concinna*	Protected	Confirmed	9
Nankeen Kestrel	*Falco cenchroides*	Protected	Confirmed	43
Nankeen Night Heron	*Nycticorax caledonicus*	Protected	Confirmed	8
New Holland Honeyeater	*Phylidonyris novaehollandiae*	Protected	Confirmed	118
Noisy Friarbird	*Philemon corniculatus*	Protected	Confirmed	301
Noisy Miner	*Manorina melanocephala*	Protected	Confirmed	90
Olive-backed Oriole	*Oriolus sagittatus*	Protected	Confirmed	83
Pacific Baza	*Aviceda subcristata*	Protected	Confirmed	1
Pacific Black Duck	*Anas superciliosa*	Protected	Confirmed	88
Pacific Koel	*Eudynamys orientalis*	Protected	Confirmed	8
Painted Button-quail	*Turnix varia*	Protected	Confirmed	13
Pallid Cuckoo	*Cuculus pallidus*	Protected	Confirmed	31
Peaceful Dove	*Geopelia placida*	Protected	Confirmed	56
Peregrine Falcon	*Falco peregrinus*	Protected	Confirmed	17
Pied Butcherbird	*Cracticus nigrogularis*	Protected	Confirmed	5
Pied Cormorant	*Phalacrocorax varius*	Protected	Confirmed	7
Pied Currawong	*Strepera graculina*	Protected	Confirmed	289
Pilotbird	*Pycnoptilus floccosus*	Protected	Confirmed	40
Plumed Whistling-Duck	*Dendrocygna eytoni*	Protected	Unconfirmed	1
Purple Swamphen	*Porphyrio porphyrio*	Protected	Confirmed	25
Rainbow Bee-eater	*Merops ornatus*	Protected	Confirmed	35
Rainbow Lorikeet	*Trichoglossus haematodus*	Protected	Confirmed	2
Red Wattlebird	*Anthochaera carunculata*	Protected	Confirmed	143
Red-browed Finch	*Neochmia temporalis*	Protected	Confirmed	205
Red-browed Treecreeper	*Climacteris erythrops*	Protected	Confirmed	50
Red-capped Robin	*Petroica goodenovii*	Protected	Confirmed	4
Red-rumped Parrot	*Psephotus haematonotus*	Protected	Confirmed	16
Regent Honeyeater	*Xanthomyza phrygia*	Endangered	Confirmed	27
Restless Flycatcher	*Myiagra inquieta*	Protected	Confirmed	84
Rockwarbler	*Origma solitaria*	Protected	Confirmed	56
Rose Robin	*Petroica rosea*	Protected	Confirmed	36
Royal Spoonbill	*Platalea regia*	Protected	Confirmed	7
Rufous Fantail	*Rhipidura rufifrons*	Protected	Confirmed	54
Rufous Songlark	*Cincloramphus mathewsi*	Protected	Confirmed	18
Rufous Whistler	*Pachycephala rufiventris*	Protected	Confirmed	269
Sacred Kingfisher	*Todiramphus sanctus*	Protected	Confirmed	74
Satin Bowerbird	*Ptilonorhynchus violaceus*	Protected	Confirmed	132
Satin Flycatcher	*Myiagra cyanoleuca*	Protected	Confirmed	2
Scarlet Honeyeater	*Myzomela sanguinolenta*	Protected	Confirmed	18
Scarlet Robin	*Petroica boodang*	Protected	Confirmed	69
Shining Bronze-Cuckoo	*Chalcites lucidus*	Protected	Confirmed	57
Silver Gull	*Larus novaehollandiae*	Protected	Confirmed	6
Silvereye	*Zosterops lateralis*	Protected	Confirmed	203
Southern Emu wren	*Stipiturus malachrurus*	Protected	Confirmed	1
Southern Whiteface	*Aphelocephala leucopsis*	Protected	Confirmed	3
Spangled Drongo	*Dicrurus bracteatus*	Protected	Confirmed	1

Common Name	Species Name	Legal Status	Confirmation status	Total records
Speckled Warbler	*Pyrrholaemus sagittatus*	Vulnerable	Confirmed	62
Spotted Harrier	*Circus assimilis*	Protected	Unconfirmed	2
Spotted Pardalote	*Pardalotus punctatus*	Protected	Confirmed	481
Spotted Quail-thrush	*Cinclosoma punctatum*	Protected	Confirmed	100
Straw-necked Ibis	*Threskiornis spinicollis*	Protected	Confirmed	5
Striated Pardalote	*Pardalotus striatus*	Protected	Confirmed	118
Striated Thornbill	*Acanthiza lineata*	Protected	Confirmed	261
Stubble Quail	*Coturnix pectoralis*	Protected	Confirmed	4
Sulphur-crested Cockatoo	*Cacatua galerita*	Protected	Confirmed	81
Superb Fairy-wren	*Malurus cyaneus*	Protected	Confirmed	236
Superb Lyrebird	*Menura novaehollandiae*	Protected	Confirmed	266
Swamp Harrier	*Circus approximans*	Protected	Confirmed	11
Swift Parrot	*Lathamus discolor*	Endangered	Confirmed	7
Tawny-crowned Honeyeater	*Gliciphila melanops*	Protected	Confirmed	1
Tawny Frogmouth	*Podargus strigoides*	Protected	Confirmed	94
Tree Martin	*Petrochelidon nigricans*	Protected	Confirmed	24
Turquoise Parrot	*Neophema pulchella*	Vulnerable	Confirmed	25
Varied Sittella	*Daphoenositta chrysoptera*	Protected	Confirmed	77
Variegated Fairy-wren	*Malurus lamberti*	Protected	Confirmed	44
Wedge-tailed Eagle	*Aquila audax*	Protected	Confirmed	132
Weebill	*Smicrornis brevirostris*	Protected	Confirmed	69
Welcome Swallow	*Hirundo neoxena*	Protected	Confirmed	142
Western Gerygone	*Gerygone fusca*	Protected	Confirmed	6
Whistling Kite	*Haliastur sphenurus*	Protected	Confirmed	11
White-backed Swallow	*Cheramoeca leucosternus*	Protected	Confirmed	1
White-bellied Cuckoo-shrike	*Coracina papuensis*	Protected	Confirmed	13
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Protected	Confirmed	31
White-browed Scrubwren	*Sericornis frontalis*	Protected	Confirmed	265
White-browed Woodswallow	*Artamus superciliosus*	Protected	Confirmed	11
White-cheeked Honeyeater	*Phylidonyris nigra*	Protected	Confirmed	5
White-eared Honeyeater	*Lichenostomus leucotis*	Protected	Confirmed	158
White-faced Heron	*Egretta novaehollandiae*	Protected	Confirmed	67
White-naped Honeyeater	*Melithreptus lunatus*	Protected	Confirmed	229
White-necked Heron	*Ardea pacifica*	Protected	Confirmed	17
White-plumed Honeyeater	*Lichenostomus penicillatus*	Protected	Confirmed	40
White-throated Gerygone	*Gerygone olivacea*	Protected	Confirmed	52
White-throated Needletail	*Hirundapus caudacutus*	Protected	Confirmed	11
White-throated Treecreeper	*Cormobates leucophaeus*	Protected	Confirmed	566
White-winged Chough	*Corcorax melanorhamphos*	Protected	Confirmed	85
White-winged Triller	*Lalage tricolor*	Protected	Confirmed	30
Willie Wagtail	*Rhipidura leucophrys*	Protected	Confirmed	135
Wonga Pigeon	*Leucosarcia melanoleuca*	Protected	Confirmed	128
Yellow Thornbill	*Acanthiza nana*	Protected	Confirmed	93
Yellow-billed Spoonbill	*Platalea flavipes*	Protected	Confirmed	9
Yellow-faced Honeyeater	*Lichenostomus chrysops*	Protected	Confirmed	474
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	Protected	Confirmed	71
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	Protected	Confirmed	76
Yellow-throated Scrubwren	*Sericornis citreogularis*	Protected	Confirmed	4

Common Name	Species Name	Legal Status	Confirmation status	Total records
Yellow-tufted Honeyeater	*Lichenostomus melanops*	Protected	Confirmed	92
Zebra Finch	*Taeniopygia guttata*	Protected	Confirmed	6
Nocturnal Birds				
Australian Owlet-nightjar	*Aegotheles cristatus*	Protected	Confirmed	273
Barking Owl	*Ninox connivens*	Vulnerable	Confirmed	7
Barn Owl	*Tyto alba*	Protected	Confirmed	15
Masked Owl	*Tyto novaehollandiae*	Vulnerable	Confirmed	12
Powerful Owl	*Ninox strenua*	Vulnerable	Confirmed	45
Sooty Owl	*Tyto tenebricosa*	Vulnerable	Confirmed	36
Southern Boobook	*Ninox boobook*	Protected	Confirmed	202
White-throated Nightjar	*Eurostopodus mystacalis*	Protected	Confirmed	44
Mammals				
Arboreal Mammals				
Common Brushtail Possum	*Trichosurus vulpecula*	Protected	Confirmed	196
Common Ringtail Possum	*Pseudocheirus peregrinus*	Protected	Confirmed	174
Eastern Pygmy-possum	*Cercartetus nanus*	Vulnerable	Confirmed	9
Feathertail Glider	*Acrobates pygmaeus*	Protected	Confirmed	7
Greater Glider	*Petauroides volans*	Protected	Confirmed	388
Koala	*Phascolarctos cinereus*	Vulnerable	Confirmed	15
Mountain Brushtail Possum	*Trichosurus caninus/cunninghami*	Protected	Confirmed	2
Squirrel Glider	*Petaurus norfolcensis*	Vulnerable	Confirmed	8
Sugar Glider	*Petaurus breviceps*	Protected	Confirmed	318
Yellow-bellied Glider	*Petaurus australis*	Vulnerable	Confirmed	189
Bats				
Chocolate Wattled Bat	*Chalinolobus morio*	Protected	Confirmed	303
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	Vulnerable	Confirmed	166
Eastern Broad-nosed Bat	*Scotorepens orion*	Protected	Confirmed	43
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Vulnerable	Confirmed	13
Eastern Freetail-bat	*Mormopterus norfolkensis*	Vulnerable	Confirmed	12
Eastern Horseshoe-bat	*Rhinolophus megaphyllus*	Protected	Confirmed	67
Gould's Long-eared Bat	*Nyctophilus gouldi*	Protected	Confirmed	311
Gould's Wattled Bat	*Chalinolobus gouldii*	Protected	Confirmed	144
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Vulnerable	Confirmed	32
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	Confirmed	4
Large Forest Bat	*Vespadelus darlingtoni*	Protected	Confirmed	156
Large-eared Pied Bat	*Chalinolobus dwyeri*	Vulnerable	Confirmed	85
Large-footed Myotis	*Myotis adversus*	Vulnerable	Confirmed	76
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Protected	Confirmed	107
Little Bentwing-bat	*Miniopterus australis*	Vulnerable	Unconfirmed	1
Little Forest Bat	*Vespadelus vulturnus*	Protected	Confirmed	654
Little Mastiff-bat	*Mormopterus planiceps*	Protected	Confirmed	4
Southern Forest Bat	*Vespadelus regulus*	Protected	Confirmed	94
Undescribed Freetail-bat	*Mormopterus* sp. 1	Protected	Confirmed	36
White-striped Freetail-bat	*Tadarida australis*	Protected	Confirmed	255
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Vulnerable	Unconfirmed	1
Terrestrial Mammals				
Brown Antechinus	*Antechinus stuartii*	Protected	Confirmed	91
Brush-tailed Rock-wallaby	*Petrogale penicillata*	Endangered	Confirmed	44

Common Name	Species Name	Legal Status	Confirmation status	Total records
Bush Rat	*Rattus fuscipes*	Protected	Confirmed	73
Common Dunnart	*Sminthopsis murina*	Protected	Confirmed	7
Common Planigale	*Planigale maculata*	Vulnerable	Probable Error	1
Common Wallaroo	*Macropus robustus*	Protected	Confirmed	105
Common Wombat	*Vombatus ursinus*	Protected	Confirmed	303
Dingo	*Canis lupus dingo*	Unprotected	Confirmed	15
Dusky Antechinus	*Antechinus swainsonii*	Protected	Confirmed	3
Eastern Grey Kangaroo	*Macropus giganteus*	Protected	Confirmed	261
Long-nosed Bandicoot	*Perameles nasuta*	Protected	Confirmed	2
Platypus	*Ornithorhynchus anatinus*	Protected	Confirmed	16
Red-necked Wallaby	*Macropus rufogriseus*	Protected	Confirmed	167
Short-beaked Echidna	*Tachyglossus aculeatus*	Protected	Confirmed	40
Southern Brown Bandicoot (eastern subsp.)	*Isoodon obesulus obesulus*	Endangered	Unconfirmed	1
Spotted-tailed Quoll	*Dasyurus maculatus*	Vulnerable	Confirmed	19
Swamp Rat	*Rattus lutreolus*	Protected	Confirmed	4
Swamp Wallaby	*Wallabia bicolor*	Protected	Confirmed	264
Tasmanian Bettong	*Bettongia gaimardi*	Presumed Extinct	Unconfirmed	2
Water-rat	*Hydromys chrysogaster*	Protected	Confirmed	6
Yellow-footed Antechinus	*Antechinus flavipes*	Protected	Confirmed	4
Pest Species				
Birds				
Common Myna	*Acridotheres tristis*	Unprotected	Confirmed	36
Common Starling	*Sturnus vulgaris*	Unprotected	Confirmed	50
Eurasian Blackbird	*Turdus merula*	Unprotected	Confirmed	11
Eurasian Skylark	*Alauda arvensis*	Unprotected	Confirmed	4
European Goldfinch	*Carduelis carduelis*	Unprotected	Confirmed	22
House Sparrow	*Passer domesticus*	Unprotected	Confirmed	18
Mallard	*Anas platyrhynchos*	Unprotected	Confirmed	1
Red-whiskered Bulbul	*Pycnonotus jocosus*	Unprotected	Confirmed	7
Rock Dove	*Columba livia*	Unprotected	Confirmed	5
Spotted Turtle-Dove	*Streptopelia chinensis*	Unprotected	Confirmed	18
Mammals				
Black Rat	*Rattus rattus*	Unprotected	Confirmed	19
Brown Hare	*Lepus capensis*	Unprotected	Confirmed	2
Feral Cat	*Felis catus*	Unprotected	Confirmed	27
Wild Dog (incl. Dingo/Dog records)	*Canis lupus*	Unprotected	Confirmed	248
European Cattle	*Bos taurus*	Unprotected	Confirmed	21
Fox	*Vulpes vulpes*	Unprotected	Confirmed	245
Feral Goat	*Capra hircus*	Unprotected	Confirmed	55
Feral Horse	*Equus caballus*	Unprotected	Confirmed	17
House Mouse	*Mus musculus*	Unprotected	Confirmed	7
Feral Pig	*Sus scrofa*	Unprotected	Confirmed	100
Rabbit	*Oryctolagus cuniculus*	Unprotected	Confirmed	139

Legal Status	Local Status	Legal Status
P= Protected (NPW Act,1974)	Confirmed = Definitely recorded in Study Area	U= Unprotected
E1=Endangered (TSC Act, 1995)	Unconfirmed = Unable to confirm definite records, but possible (includes vagrants)	E4 = Extinct (TSC Act 1995)
V= Vulnerable (TSC Act, 1995)	Probable Error = Probable misidentification, location error or database coding error	

Appendix B: Hectares of high-quality habitat (HQH) within the Warragamba Special Area for Species of Conservation Concern

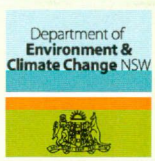
Species of Conservation Concern	Area of HQH in Study Area (ha)	Area HQH in Reserves DECC (ha)	% HQH in Reserves DECC	Proportion in Warragamba Special Area (ha)	Proportion total (%)
Brush-tailed Rock-wallaby	4407	*3213*	73	4406	100
Brown Treecreeper	29997	26780	89	27494	92
Diamond Firetail	6318	4781	76	5680	90
Yellow-bellied Glider	65537	61355	94	56756	87
Glossy Black-Cockatoo	72237	65365	90	61199	85
Tree-base Litter-skink	56254	41037	73	42412	75
Turquoise Parrot	49680	27204	55	31909.	64
Masked Owl	244592	175748	72	156304	64
Restless Flycatcher	40072	23736	59	25328	63
Squirrel Glider	194466	122849	63	105924	54
Large-eared Pied Bat	271357	165307	61	145517	54
Hooded Robin	23404	8967	38	11638	50
White-winged Chough	141449	85501	60	68879	49
Stuttering Frog	34142	27729	81	15819	46
Eastern Freetail-bat	98372	35710	36	45434	46
Greater Glider	174532	143803	82	78300	45
Platypus	7599	4535	60	3206	42
Superb Lyrebird	359246	264935	74	148901	41
Broad-headed Snake	16614	10594	64	6837	41
Eastern Grey Kangaroo	289315	91461	32	110595	38
Speckled Warbler	33545	9606	29	12796	38
Varied Sittella	181987	110377	61	67405	37
Rockwarbler	15298	12987	85	5661	37
Sooty Owl	15259	10406	68	5423	36
Powerful Owl	208733	150170	72	74063	35
Red-browed Treecreeper	140182	108431	77	48671	35
Satin Bowerbird	120785	62420	52	41621	34
Spotted Quail-thrush	160863	113251	70	53922	34
Bibron's Toadlet	214084	112693	53	70322	33
Gang-gang Cockatoo	231201	168048	73	75892	33
Greater Broad-nosed Bat	56725	33913	60	17916	32
Grey-headed Flying-fox	216181	106939	49%	66270.	31
Flame Robin	138823	69029	50	40331	29
Painted Button-quail	241161	136902	57	68735	29
Koala	67510	29238	43	17368.	26
Short-beaked Echidna	341874	167150	49	77202	23
Eastern Snake-necked Turtle	45940	8433	18	10135	22
Blue Mountains Water skink	1918	1228	64	246	13

Species of Conservation Concern	Area of HQH in Study Area (ha)	Area HQH in Reserves DECC (ha)	% HQH in Reserves DECC	Proportion in Warragamba Special Area (ha)	Proportion total (%)
Highlands Copperhead	71250	48335	68	5406	8
Rosenberg's Goanna	45194	20849	46	2951	7
Giant Burrowing Frog	77593	30886	40	3547	5
Southern Emu-wren	25621	9549	37	1138	4
Mainland Tiger Snake	28640	11738	41	463	2
Green Tree Frog	132764	13377	10	1667	1
Beautiful Firetail	55298	19577	35	559	1
Red-crowned Toadlet	47620	15435	32	215	0
Eastern Pygmy-possum	42437	16755	39	122	0
Long-nosed Bandicoot	88636	30521	34	150	0
Tawny-crowned Honeyeater	22640	12076	53	3	0

Appendix C: Key Threatening Processes that impact upon threatened species known to occur within the Warragamba Special Area

Key Threatening Process - Final Listings	Reference*	Potentially affected threatened fauna in the Warragamba Special Area
Alteration to habitat following subsidence due to longwall mining	2005	Blue Mountains Water Skink, Broad-headed Snake, Eastern Pygmy-possum, Giant Burrowing Frog, Grey-headed Flying-fox, Large-footed Myotis, Red-crowned Toadlet, Rosenberg's Goanna, Southern Brown Bandicoot, Stuttering Frog.
Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands	2002a	Australasian Bittern, Lewin's Rail, Booroolong Frog, Giant Burrowing Frog, Red-crowned Toadlet, Stuttering Frog.
Bushrock removal	1999a	Broad-headed Snake, Red-crowned Toadlet, Rosenberg's Goanna, Spotted-tailed Quoll.
Clearing of native vegetation	2001	All threatened species recorded within the Special Area.
Competition and grazing by the feral European Rabbit	2002b	Brown Treecreeper, Brush-tailed Rock-wallaby, Common Planigale, Diamond Firetail, Speckled Warbler, Turquoise Parrot.
Competition and habitat degradation by Feral Goats	2004a	Broad-headed Snake, Brush-tailed Rock-wallaby, Large-eared Pied Bat.
Competition from feral honeybees	2002c	Barking Owl, Broad-headed Snake, Brown Treecreeper, Eastern False Pipistrelle, Eastern Freetail-bat, Eastern Pygmy-possum, Gang-gang Cockatoo, Glossy Black-Cockatoo, Greater Broad-nosed Bat, Large-footed Myotis, Masked Owl, Powerful Owl, Sooty Owl, Squirrel Glider, Turquoise Parrot, Yellow-bellied Glider, Yellow-bellied Sheathtail-bat.
Ecological consequences of high-frequency fires	2000a	Glossy Black-Cockatoo ,Southern Brown Bandicoot, Spotted-tailed Quoll, Squirrel Glider.
Predation, habitat degradation, competition and disease transmission by Feral Pigs	2004b	Giant Burrowing Frog, Green and Golden Bell Frog, Southern Brown Bandicoot, Stuttering Frog.
Herbivory and environmental degradation caused by feral deer	2004c	Giant Burrowing Frog, Green and Golden Bell Frog, Southern Brown Bandicoot.
Human-caused climate change	2000b	Blue Mountains Water Skink, Eastern False Pipistrelle, Eastern Pygmy-possum, Gang-gang Cockatoo, Giant Burrowing Frog, Green and Golden Bell Frog, Red-crowned Toadlet, Sooty Owl, Stuttering Frog.
Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations	2002d	Gang-gang Cockatoo, Glossy Black-Cockatoo, Swift Parrot, Turquoise Parrot.
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	2003a	Booroolong Frog, Green and Golden Bell Frog, Stuttering Frog.
Invasion of native plant communities by exotic perennial grasses	2003b	Common Planigale, Diamond Firetail, Hooded Robin, Masked Owl, Speckled Warbler, Turquoise Parrot.
Predation by Feral Cats	2000c	Brown Treecreeper, Brush-tailed Rock-wallaby, Common Planigale, Diamond Firetail, Eastern Pygmy-possum, Hooded Robin, Koala, Southern Brown Bandicoot, Specked Warbler, Squirrel Glider, Turquoise Parrot.
Predation by the Fox	1998a	Brown Treecreeper, Brush-tailed Rock-wallaby, Common Planigale, Diamond Firetail, Eastern Pygmy-possum, Hooded Robin, Koala, Southern Brown Bandicoot, Speckled Warbler, Squirrel Glider, Turquoise Parrot.
Predation by the Plague Minnow	1999b	Booroolong Frog, Green and Golden Bell Frog, Stuttering Frog.
Removal of dead wood and dead trees	2003c	Barking Owl, Broad-headed Snake, Brown Treecreeper, Eastern False Pipistrelle, Eastern Freetail-bat, Eastern Pygmy-possum, Gang-gang Cockatoo, Glossy Black-Cockatoo, Greater Broad-nosed Bat, Large-footed Myotis, Masked Owl, Powerful Owl, Red-crowned Toadlet, Rosenberg's Goanna, Sooty Owl, Spotted-tailed Quoll, Squirrel Glider, Turquoise Parrot, Yellow-bellied Glider, Yellow-bellied Sheathtail-bat.

* = NSW Scientific Committee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