

3.2 Fauna

Like the original vegetation, the diversity of terrestrial vertebrate fauna species within the LGA has also been greatly reduced from its original state. The original fauna would have included a wide range of frogs, reptiles, birds and ground-dwelling and arboreal mammals including microchiropteran bats. Many of these species have disappeared from the area.

Nevertheless, data from the fauna surveys combined with opportunistic observations made by City staff and reliable reports from the community from October 2010 to June 2012 indicate that a reasonably diverse fauna assemblage is present within the LGA. As well as natural habitat features, modified and constructed habitats such as ponds, cliff lines, retaining walls and fences, weed infestations, roof cavities, and even tall buildings in the city centre are used by some of the species recorded.



Examples of species using constructed features in the LGA.

- a A Peregrine Falcon on a CBD window ledge. (photo P. Munro).
- b Elegant Snake-eyed Skinks (also known as Wall Skinks) inhabiting a sandstone retaining wall at Glebe. (photo K. Oxenham)
- c Welcome Swallows, which often nest on built structures, roosting on a gabion wall at Sydney Park.
- d A White-faced Heron and Little Black Cormorants roosting on posts in Sydney Park.

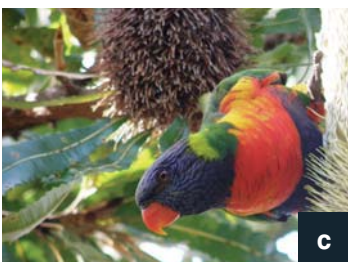
Constructed ponds and weed infestations identified within the LGA are indicated in Figures 8a-d.

A total of 99 fauna species was confirmed in the LGA, comprising 87 indigenous species (with an additional two unconfirmed), as well as 12 introduced fauna species. This total comprises:

- 70 bird species, including seven introduced species;
- 13 mammal species (with an additional two unconfirmed microchiropteran bats), including five introduced species;
- 11 reptile species; and
- Five frog species.

A complete list of the species recorded is provided in Appendix 3.

Many of the species recorded have adapted well to urbanisation and are abundant and widespread in the LGA and other urban areas (Russell *et al.* 2011; Major 2004; Major & Parsons 2010; Parsons 2009). These include the Common Brushtail Possum and large-bodied birds such as the Rainbow Lorikeet, Noisy Miner, Pied Currawong, Grey Butcherbird, Laughing Kookaburra, Australian Raven, Sulphur-crested Cockatoo, Australian White Ibis, Silver Gull, and the introduced Rock Dove (commonly known as the feral pigeon) and Common Myna (also known as the Indian Myna). Most of these larger indigenous birds were not originally resident in central Sydney, or at least not in large numbers (Major 2004; Major & Parsons 2010).



Common indigenous species in the LGA that have adapted well to urbanisation.

- | | |
|-------------------------------------|-------------------------|
| a Noisy Miner | f Pied Currawong |
| b Australian Magpie at Sydney Park | g Silver Gull |
| c Rainbow Lorikeet (photo A. Davis) | h Australian Raven |
| d Common Brushtail Possum | i Australian White Ibis |
| e Sulphur-crested Cockatoo | j Laughing Kookaburra |

In contrast, many of the other species were recorded in small numbers at only a small number of sites, and appear to be scarce in the LGA. These included:

- Frogs such as the Green and Golden Bell Frog, Dwarf Eastern Tree Frog, and Perons Tree Frog;
- Reptiles such as the Eastern Blue-tongue, Eastern Water Dragon, Eastern Water Skink, Bar-sided Skink and Gully Skink;
- Small birds such as the Superb Fairy-wren and Silvereye;
- Wetland birds such as the Australian Reed-warbler, Black-fronted Dotterel, Black-winged Stilt, Buff-banded Rail and Royal Spoonbill;
- The Long-nosed Bandicoot, which was the only ground-dwelling indigenous mammal recorded; and
- Microchiropteran bats (microbats) such as Gould's Wattle Bat, Eastern Freetail Bat and Little Forest Bat.

These types of species were once common and widespread in the Sydney area (Major & Parsons 2010; Shea 2010; Recher 2010), but have declined and in many cases disappeared altogether in this LGA and many other highly urbanised areas, as discussed further in Section 3.5.

Three of the fauna species recorded, and one of the unconfirmed species, are currently listed as threatened (Table 4). The Long-nosed Bandicoot has also been included in Table 4 as an endangered population listing currently applies to the Marrickville, Leichhardt, Ashfield, Canada Bay, and Canterbury LGAs; the listing may be extended to the City of Sydney LGA given that the individuals present in the area are likely to be part of the wider inner west population.



Introduced birds that are common and widespread across the LGA: Common Myna (left), Rock Dove or feral pigeon (centre) and Common Starling (right).



a



b



c



d



e



f



g



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i



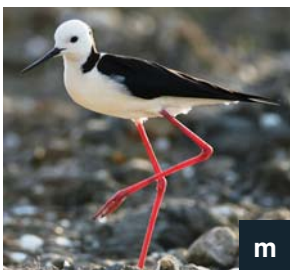
j



k



l



m



n



o

Uncommon fauna species recorded in the LGA.

- a Eastern Dwarf Tree Frog (photo K. Oxenham)
- b Eastern Water Skink at Chinese Gardens, Darling Harbour (photo K. Oxenham)
- c Eastern Water Dragon at Chinese Gardens, Darling Harbour (photo K. Oxenham)
- d Eastern Blue-tongue at Sydney Park
- e Gully Skink (photo K. Oxenham)
- f Juvenile Eastern Long-necked Turtle at Wetland 1, Sydney Park (photo K. Oxenham)

- g Superb Fairy-wren (photo N. Lazarus)
- h Silvereye (photo N. Lazarus)
- i New Holland Honeyeater (photo N. Lazarus)
- j Buff-banded Rail in Royal Botanic Gardens
- k Australasian Grebe at Sydney Park
- l Royal Spoonbill at Sydney Park
- m Black-winged Stilt (photo J. Irvine)
- n Australian Reed-warbler at Sydney Park
- o Gould's Wattlebat (photo M. Turton)

Table 4 Threatened species recorded within the LGA

Species	Conservation Status	Location	Details
Green and Golden Bell Frog	V (EPBC Act); E (TSC Act)	Rosebery	Small, declining population, with breeding habitat limited to small ponds in one residential backyard.
Grey-headed Flying-fox	V (EPBC Act); V (TSC Act)	Forages over wide area at night (former camp in Royal Botanic Gardens)	Variable numbers throughout the year.
Powerful Owl	V (TSC Act)	Royal Botanic Gardens	Two individuals regularly present.
Eastern Bent-wing Bat	V (TSC Act)	University of Sydney	Unconfirmed record (call could not be positively identified).
Long-nosed Bandicoot	EP (TSC Act)	Alexandria, University of Sydney	Records of three individuals to date, including one reported juvenile, in a community garden, park and university campus respectively.

V – vulnerable

E – endangered

EP – endangered population (currently not applicable to the City)



Threatened fauna species recorded in the LGA (although not a threatened species, the Long-nosed Bandicoot is included since individuals within the city may be part of an endangered population).

- a Green and Golden Bell Frog (photo K. Oxenham)
- b Grey-headed Flying-fox
- c Powerful Owl in the Royal Botanic Gardens

- d Eastern Bent-wing Bat (photo M. Turton)
- e Long-nosed Bandicoot at Alexandria (photo NPWS)

3.3 Community consultation

This section provides an overview of results from the community consultation process. The full community consultation report is provided as Appendix 4, and issues raised and other findings have been incorporated into the Plan where appropriate.

3.3.1 Community group consultation

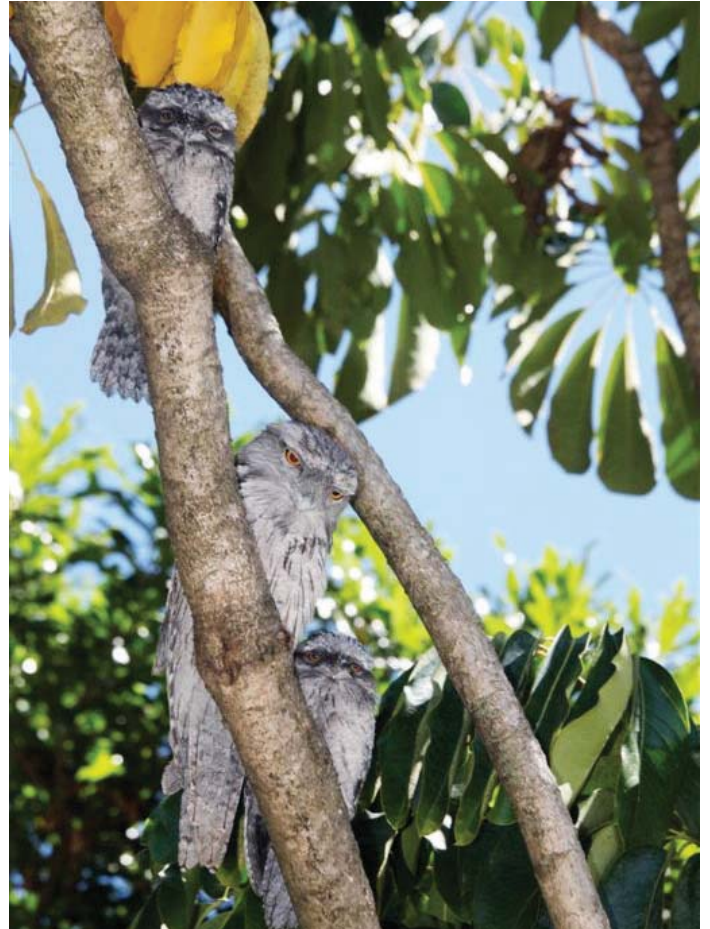
Responses from the targeted community group consultation sessions were grouped into four categories; responses in each category are summarised below.

- Policy – the need for an over-arching City policy relating to biodiversity was identified to coordinate a consistent approach towards biodiversity management across the organisation;
- Procedures – it was considered that the City should put into place numerous procedures and processes, particularly to ensure City parks maintenance staff and contractors have appropriate qualifications and experience in biodiversity-friendly maintenance practices, but also to maximise the area of indigenous plantings and ensure appropriate management of companion and feral animals;
- Education and training – the establishment of biodiversity-related training programs for City staff and contractors was recommended, as was establishing educational programs for school and university students; and
- Community resources – it was recommended that the City review actions implemented by other councils, educational programs being implemented by others in the LGA, and consult with experts on local biodiversity issues in relation to development of this Plan.

3.3.2 Online survey findings

A total of 231 responses were received to the online survey. Respondents were predominantly local; 50 per cent identified themselves as residents and 27 per cent as workers in the LGA.

Ninety-eight respondents reported interesting/unusual fauna species they had observed in the city, and these were incorporated into the fauna species list for the LGA. They included the Red-bellied Black Snake, Superb Fairy-wren, Peregrine Falcon, Powerful Owl, White-headed Pigeon, Silveryeye, Eastern Long-necked Turtle, Eastern Blue-tongue, Tawny Frogmouth, and Common Ringtail Possum. Most of these were confirmed in the fauna surveys and/or by City staff.



Tawny Frogmouths (photographed above in a Glebe backyard) were reported by a number of residents, as were Common Ringtail Possums (below).



With regard to the importance of various activities that have potential to improve biodiversity in the LGA, the majority of respondents rated all activities listed in the survey as important, with protection and enhancement of existing habitats rated particularly important (Figure 9).

The survey also revealed substantial community interest in participating in bush restoration activities, community planting days, educational workshops and biodiversity monitoring programs (Figure 10). Among other things this indicates considerable potential for the formation of additional bush restoration groups in the LGA. Suitable sites at which such groups could work include Sydney Park, Moore Park, and small parks in Paddington, Green Square and Potts Point.

Figure 9 Rating of importance of activities in terms of improving biodiversity in the City

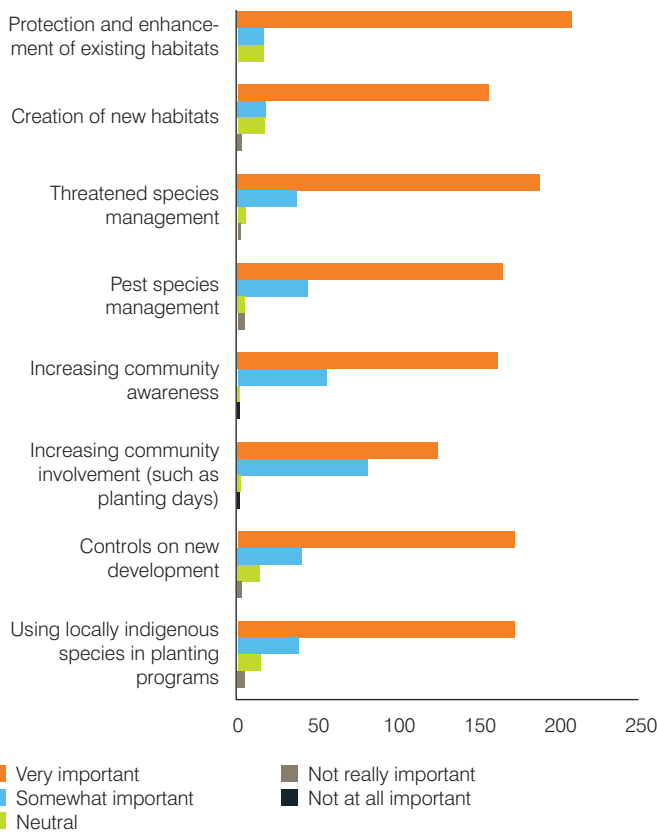
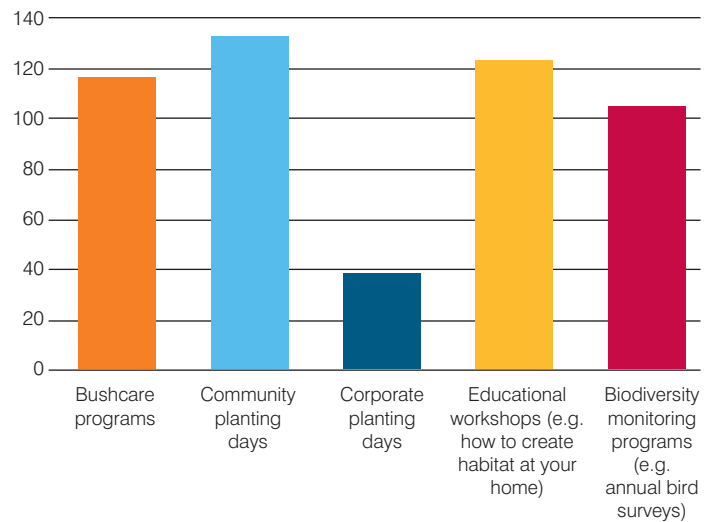


Figure 10 Interest in participating in biodiversity-related activities



3.4 Priority sites

Six high-priority sites were identified in the LGA based on the assessment of biodiversity values. These are listed below (note two comprise multiple sites in close proximity to each other):

- Sydney Park, St Peters;
- Glebe Foreshore Walk East – Orphan School Creek, Glebe-Forest Lodge;
- Pyrmont (sandstone cliffs and outcrops and bush restoration sites);
- the Royal Botanic Gardens and Domain (Yurong Precinct);
- Garden Island (northern end), Woolloomooloo; and
- Moore Park (Mt Steel, Moore Park Golf and Lake Kippax).

It should be noted the latter three sites are not managed by the City of Sydney, but are under the management of other agencies who have been consulted in the development of this Plan.

The biodiversity values of each site are briefly discussed in the following sections, as are the constraints that are likely to be affecting these values. Numerous smaller sites that provide an important role in supporting the priority sites are also briefly discussed.

3.4.1 Sydney Park

Biodiversity values

The high biodiversity values of this site (Figure 11) are attributable to the following:

- Large size (44 hectares);
- The presence of large, constructed freshwater wetlands and associated rocky drainage lines as well as planted woodland and forest patches;
- High flora species diversity (over 100 indigenous species recorded during the surveys, although many are not local);
- Relatively diverse fauna habitat features, including the wetlands, drainage lines and woodland and forest patches;
- The highest indigenous bird species diversity in the LGA (49 indigenous species recorded, 22 of which are wetland species and several of which were not recorded elsewhere in the LGA);
- The presence of one of few known populations of both the Superb Fairy-wren and Eastern Blue-tongue in the LGA;
- The presence of a breeding population of the Eastern Long-necked Turtle;
- High potential to re-establish elements of the likely original vegetation communities, including the endangered Eastern Suburbs Banksia Scrub, and expand on existing plantings that comprise elements of Coastal Sand Swamp Forest (representative of the endangered Swamp Sclerophyll Forest on Coastal Floodplains community) and Coastal Freshwater Reedland (representative of the endangered Freshwater Wetlands on Coastal Floodplains community); to increase the diversity of locally indigenous flora species; and to undertake fauna habitat enhancements without compromising the existing range of uses; and
- Potential to establish habitat connectivity with the Glebe Foreshore Walk East-Orphan School Creek corridor via the rail corridor and the University of Sydney; with sites in the Randwick LGA via landscaping associated with the future redevelopment of Green Square and other precincts in the southern part of the LGA and Moore Park; and with sites in the Marrickville and Botany Bay LGAs via landscaping associated with future redevelopments along Alexandra Canal.

Site constraints

Site constraints affecting the above biodiversity values include:

- Ongoing methane and leachate management issues resulting from the site's past use as a landfill have potential to effect vegetation growth;
- The structurally simple nature of most existing terrestrial plantings (comprising densely planted trees with no understorey), provide habitat for only the most common indigenous species, particularly aggressive and predatory birds;
- The very high density of trees in most terrestrial plantings limits both their potential to grow to full size and the space, light and nutrients required to enable an understorey to establish;
- The potential for dense stands of *Casuarina glauca*, which are already limiting plant diversity in some parts of the park due to the ability of this species to suppress the germination and growth of other species, to rapidly spread by vigorous suckers and outcompete other vegetation, particularly around wetlands and drainage lines, and to affect wetland health through shading;
- Limited staff knowledge or experience in bush regeneration and biodiversity management techniques further limits the potential for understorey establishment and other habitat enhancements;
- Reduced wetland health as a result of nutrient-rich mulch washing downslope from terrestrial garden beds due to the lack of stabilising understorey vegetation;
- The potential for increased volumes of water from stormwater harvesting to limit the implementation of best practice hydrological regimes, incorporating periods of at least partial drying, to ensure wetland health;
- Infestation of all wetlands with Mosquito Fishes likely to be limiting frog populations;
- Infestations of environmental weeds, particularly Ludwigia (Wetland 2), *Juncus acutus* (Wetland 4) and Golden Wreath Wattle (*Acacia saligna*);
- Heavy use for recreational activities including dog walking, cycling, organised sports and picnicking, which result in noise and physical disturbance to wetlands and other habitat areas.



Where present, dense understorey provides habitat for small birds at Sydney Park (left), and a densely vegetated bioretention swale and bird roosting posts installed as part of a stormwater harvesting project provide good habitat at Wetland 4, Sydney Park (right).



Fauna at Sydney Park includes a range of wetland birds, including the Black Swan (left, at Wetland 2), which is one of several species that breed at the park, and the Black-fronted Dotterel (right, at Wetland 4).



FIGURE 11
Sydney Park

- Indigenous/Mostly Indigenous Plantings
- Freshwater Wetlands
- Major Weed Infestation
- Drainage line
- Open drainage channels



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3.4.2 Glebe Foreshore Walk East to Orphan School Creek

Biodiversity values

The high biodiversity values of this 'site' (Figure 12a-c), which comprises several large parks – the Glebe Foreshore Walk, Blackwattle Bay Park, Bicentennial Park, Federal Park, Jubilee Park and Orphan School Creek – and a number of pocket parks adjoining Johnstons Creek Canal – including AV Henry Reserve, Minogue Crescent Reserve, Lewis Hoad Reserve, Canal Reserve, JV McMahon Reserve, Wigram Road Reserve and Spindler Reserve in the Leichhardt LGA – are attributable to the following:

- Relatively large size, incorporating several bush restoration sites;
- Relatively continuous area of open space from the Glebe Foreshore to Forest Lodge, a distance of 2.5 kilometres;
- Presence of a possible remnant tree representative of the critically endangered Sydney Turpentine Ironbark Forest community, near Orphan School Creek;
- Presence of the endangered Coastal Saltmarsh community, in Federal, Bicentennial and Jubilee Parks;
- Presence of a possible remnant tree representative of the endangered River-flat Forest on Coastal Floodplains community (Swamp Forest/Alluvial Forest map unit) in Lewis Hoad Reserve;
- Presence of the only patches of Mangrove Forest that occur within the LGA, on the Rozelle Bay foreshore;
- Presence of naturally occurring flora species that occur in association with sandstone outcrops;
- Very high flora species diversity (over 100 locally indigenous species recorded) as a result of bushland restoration works at numerous sites, mostly by volunteers from the Glebe Bushcare Group;
- Diverse fauna habitat features, including sandstone outcrops and retaining walls, a rocky modified creekline and other ground-level habitat features such as fallen timber, a small freshwater pond and freshwater seepages, structurally complex patches of locally indigenous vegetation, and intertidal habitats;
- The presence of one of only two known populations of both the Bar-sided Skink and Eastern Water Skink in the LGA;
- High potential to expand bush restoration works and increase the diversity of locally indigenous flora species, and to undertake fauna habitat enhancements;
- High potential to expand on planted elements of the endangered Swamp Oak Floodplain Forest community that are already present in the park, using shrubs and groundcovers of this community;
- The greatest potential to provide an almost continuous (albeit narrow) habitat corridor in the LGA, with connectivity to habitat areas in the Leichhardt LGA, and potential for connectivity to be established with sites at Pyrmont along the future Glebe Foreshore Walk extension, and new parks that will be created in this area in the future at Harold Park, the Hill and Crescent Land sites; and
- Potential for naturalisation of Johnstons Creek Canal, to not only improve habitat for Coastal Saltmarsh but also to benefit a range of estuarine fauna species, including wetland birds, fish and aquatic invertebrates.

Site constraints

Site constraints affecting the above biodiversity values include:

- The limited extent and poor condition of Coastal Saltmarsh along Johnstons Creek Canal due to the presence of self-sown Phoenix Palms (which have reduced the area of tidal inundation by raising the soil surface elevation, and cause shading), and trampling and soil compaction by park users and dogs;
- Limited overall contract staff knowledge and experience in bush regeneration and biodiversity management techniques (although the fenced Coastal Saltmarsh in Federal Park and most of Orphan School Creek are well-maintained by specialist bush regeneration contractors);
- The narrow, linear nature of the potential corridor, since corridors of this type are of limited value to some priority fauna species (refer Section 3.3.2);
- The occurrence of environmental weeds, particularly annuals and Chinese Hackberry *Celtis sinensis*; and
- Heavy use of the Glebe Foreshore Walk, Blackwattle Bay Park, Bicentennial Park, Jubilee Park, and Federal Park for recreational activities including dog walking, cycling, organised sports and picnicking, which result in noise and physical disturbance to habitat areas.



Bush restoration sites at Blackwattle Bay Park (left) and Orphan School Creek (right) (photos K. Oxenham)



Bar-sided Skinks inhabit sandstone outcrops and retaining walls along the Glebe Foreshore Walk (left, photo K. Oxenham) and the intertidal zone provides habitat for estuarine species like the Striated Heron (right, photo J. Irvine).

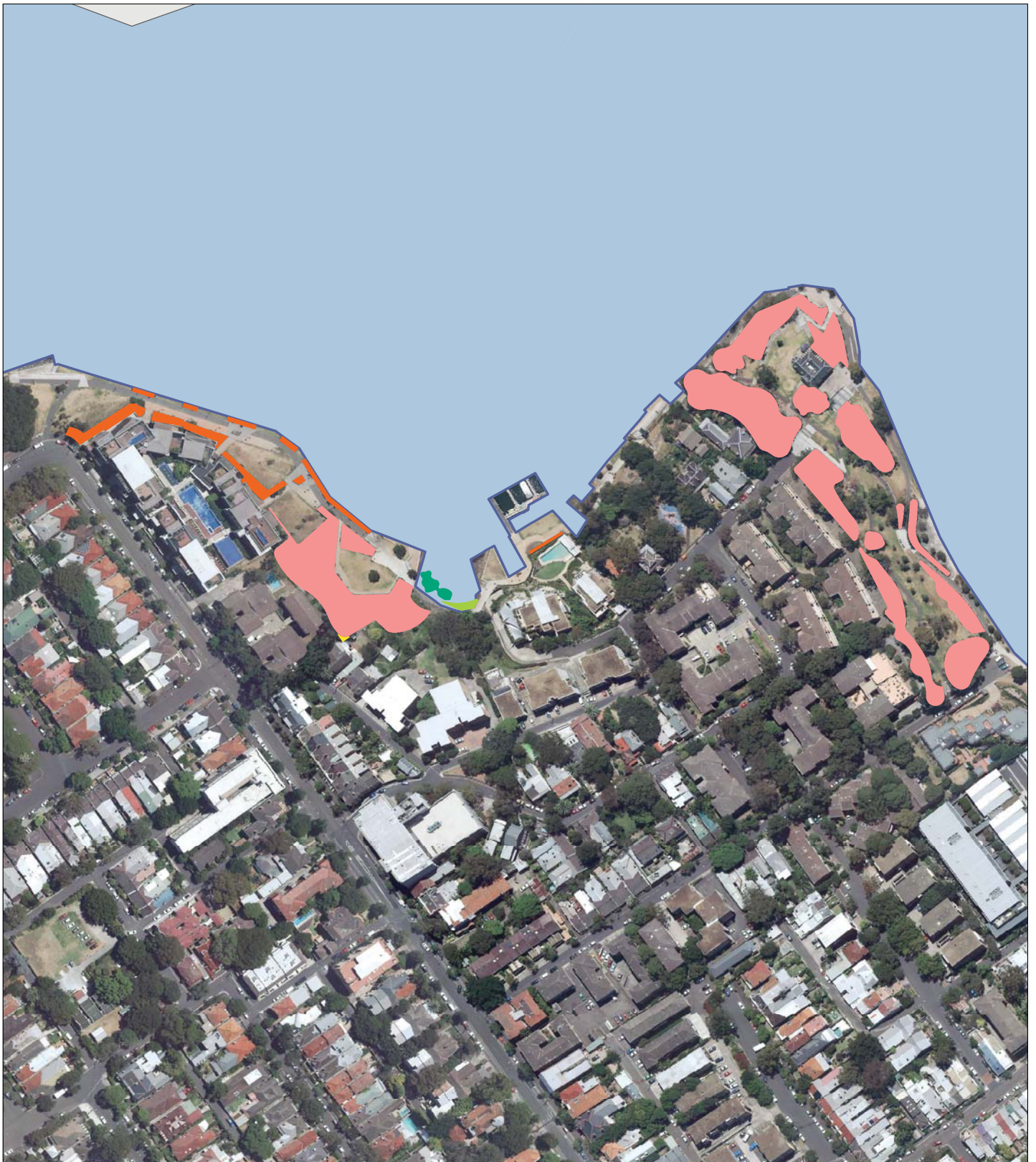
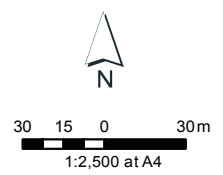


FIGURE 12a
Blackwattle Bay Park to Bicentennial Park

- Coastal Sandstone Outcrop Complex
- Coastal Saltmarsh
- Mangrove Forest
- Bush Restoration Sites
- Indigenous/Mostly Indigenous Plantings




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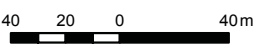





FIGURE 12b
Bicentennial Park to Harold Park

- Coastal Sandstone Outcrop Complex
- Coastal Saltmarsh
- Mangrove Forest
- Bush Restoration Sites
- Indigenous/Mostly Indigenous Plantings
- Major Weed Infestation





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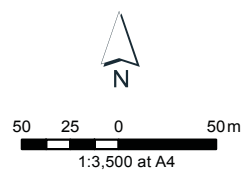


FIGURE 12c
Harold Park to Orphan School Creek

- Coastal Sandstone Outcrop Complex
- Bush Restoration Sites
- Indigenous/Mostly Indigenous Plantings
- Major Weed Infestation

Possible Remnant Trees

- Rough barked Apple (*Angophora floribunda*)
- Sydney Turpentine Ironbark Forest
- Bangalay (*Eucalyptus botryoides*)
- Coastal Swamp/Alluvial Forest



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3.4.3 Pyrmont

Biodiversity values

The high biodiversity values of this 'site' (Figure 13), which comprises several sandstone cliffs and outcrops and bush restoration sites, is attributable to the following:

- Sandstone cliffs and outcrops that, although modified, provide similar habitat to natural sandstone features that are likely to have once been more widespread in the LGA and that provide a refuge for ferns and other naturally occurring flora species;
- Very high flora species diversity as a result of bushland restoration works undertaken by Pyrmont Ultimo Landcare volunteers, with approximately 120 indigenous species recorded during the surveys;
- High potential to expand bush restoration sites and increase the diversity of locally indigenous flora species, and potential to undertake fauna habitat enhancements;
- Clear demonstration of the potential for bushland restoration in even the most highly urbanised areas;
- Reasonable connectivity between most cliffs and outcrops and bush restoration sites along the light rail corridor, which although currently weed-infested provides suitable habitat for small birds and reptiles; and
- Potential for future connectivity with the Glebe Foreshore Walk to Orphan School Creek corridor as a result of the future Glebe Foreshore Walk extension.



Site constraints

Site constraints affecting the above biodiversity values include:





- The relatively small size of this 'site';
- The high concentration of tall buildings and other features such as road overpasses affect vegetation growth by limiting sunlight and/or rainfall at parts of the 'site';
- Infestations of environmental and noxious weeds including Fountain Grass, Asthma Weed, Lantana, Chinese Hackberry, and Crofton Weed, especially on cliff faces and along the light rail corridor, but also on some parts of the foreshore (although as mentioned above these weeds provide suitable habitat for some fauna); and
- Steep terrain poses access, safety and cost issues for bush restoration works.



Bush restoration site adjoining sandstone cliff (left) and naturally occurring ferns and figs on modified sandstone cliff (right).



FIGURE 13
Pyrmont

-  Coastal Sandstone Outcrop Complex
-  Bush Restoration Sites
-  Indigenous/Mostly Indigenous Plantings
-  Major Weed Infestation



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3.4.4 Royal Botanic Gardens and Domain (Yurong Precinct)

Biodiversity values

This site (Figure 14) has the highest biodiversity values in the LGA, attributable to the following:

- Large size (53 hectares);
- The most intact and extensive sandstone outcrops within the LGA, within the Yurong Precinct of the Domain (Mrs Macquaries Point);
- Possible remnant trees representative of the endangered River-flat Eucalypt Forest community;
- Possible remnants of the Coastal Sandstone Foreshores Forest, Coastal Littoral Rainforest and Coastal Cliff Soak communities;
- Very high diversity of flora species, both exotic and indigenous;
- The largest assemblage of locally indigenous species considered likely to be naturally occurring in the LGA – a total of 27 tree, shrub and groundcover species that mainly occur in association with sandstone outcrops;
- The presence of the Growing Friends nursery, at which indigenous and exotic species are propagated and sold to the public, with the assistance of volunteers from the Foundation and Friends of the Botanic Gardens;
- Diverse fauna habitat features, including sandstone cliffs, outcrops and retaining walls, freshwater ponds and associated drainage lines, a sculpture designed to provide microbat roosting habitat, structurally complex plantings from a range of exotic and indigenous vegetation types within the Royal Botanic Gardens (including themed areas such as the Tropical Centre and Rainforest Walk), and structurally complex patches of locally indigenous vegetation created through past bush restoration works in the Yurong Precinct;
- High fauna species diversity – 34 indigenous species recorded, including 25 birds, and two threatened species (the Powerful Owl, a pair of which appears to be resident in the Royal Botanic Gardens, and the Grey-headed Flying-fox, which is likely to continue to forage at the site despite the recent camp relocation);

- The only site at which the Eastern Dwarf Tree Frog and Buff-banded Rail were recorded in the LGA, and one of only two sites at which the Eastern Water Dragon was recorded;
- The only site at which Little Pied Cormorants and Little Black Cormorants nest in the LGA;
- Vegetation and habitats are relatively well-protected from disturbance as pets are prohibited and the site is closed to public access at night;
- High potential to expand bush restoration works and increase the diversity of locally indigenous flora species; such works were identified by the Royal Botanic Gardens and Domain Trust as one of several 'Future Domain' proposals that may be implemented in the lead-up to the bicentenary of the Royal Botanic Gardens in 2016 (Royal Botanic Gardens and Domain Trust website); and
- Existing volunteer base through the Foundation and Friends of the Botanic Gardens.

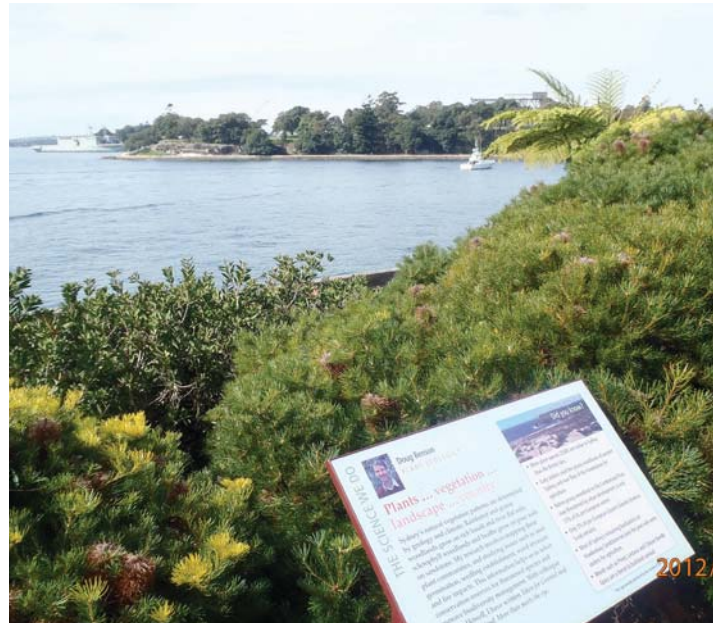
Site constraints

Site constraints affecting the above biodiversity values include:

- The primary function of the site as a Royal Botanic Garden, i.e. to maintain a living plant collection, including rare specimens, for education and botanical research, which is not always compatible with the provision of fauna habitat;
- Disturbance from high levels of public use; and
- High levels of bird feeding by the public, and the likelihood for this to encourage species that are common and widespread, including nuisance species, potentially to the detriment of uncommon/declining species, as well as to private property and/or resident amenity.



Little Black and Little Pied Cormorant nesting colony (left) and juvenile Eastern Water Dragon in the Royal Botanic Gardens (right) (photos K. Oxenham).



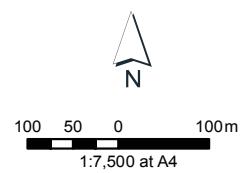
Plantings of mostly indigenous on the eastern side of the Yuroung Precinct (left), and indigenous plantings in the Royal Botanic Gardens (right).



FIGURE 14
Royal Botanic Gardens and Domain

- Coastal Sandstone Outcrop Complex
- Indigenous Plantings/Naturally occurring Vegetation
- Indigenous/Mostly Indigenous Plantings
- Ponds
- Drainage line

- Possible Remnant Trees**
- Swamp Oak (*Casuarina glauca*)
- Coastal Swamp/Alluvial Forest
 - Forest Red Gum (*Eucalyptus tereticornis*)
- Coastal Swamp/Alluvial Forest



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3.4.5 Garden Island (northern end)

Biodiversity values

The high biodiversity values of this site (Figure 15) are attributable to the following:

- Remnant trees of the Coastal Sandstone Foreshores Forest community, along with potentially naturally occurring shrubs, grasses and groundcovers;
- High diversity of indigenous flora species (more than 40 species);
- The presence of one of only two known populations of the Bar-sided Skink in the LGA;
- The onsite tunnel network may provide roosting habitat for microbats;
- High potential to continue bush regeneration works commenced in 2011, to increase the diversity of locally indigenous flora species and to undertake fauna habitat enhancements; and
- Relatively well protected from disturbance as public access is limited – only part of the site can be accessed during the day, and only by ferry or tour bus.

Site constraints

Site constraints affecting the above biodiversity values include:

- Its small size (approximately 2.7 hectares);
- The primary function of the site as the main base for the Royal Australian Navy fleet on the east coast of Australia, which is not necessarily compatible with biodiversity conservation;
- Heritage values of existing gardens, landscape and buildings, which are likely to pose restrictions on the expansion of bush regeneration and other habitat enhancement works;
- Remaining infestations of environmental and noxious weeds including Asparagus Fern, Madeira Vine, Potato Vine, English Ivy and Morning Glory; and
- Steep terrain poses access, safety and cost issues for bush restoration works.



Possible remnant trees of Coastal Sandstone Forest at Garden Island.



FIGURE 15
Garden Island

- Coastal Sandstone Outcrop Complex
- Bush Restoration Sites
- Indigenous/Mostly Indigenous Plantings



20 10 0 20m
1:1,500 at A4

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3.4.6 Moore Park (Mt Steel, Moore Park Golf and Lake Kippax)

Biodiversity values

The high biodiversity values of this site (Figure 16) are attributable to the following:

- Its large size (approximately 64 hectares);
- Good range of planted indigenous trees and shrubs with some indigenous grass and groundcover species in the vicinity of Mt Steel and Moore Park Golf;
- The only site at which two epiphytic fern species, Elk Horn (*Platyserium bifurcatum*) and Rock Felt Fern (*Pyrrosia rupestris*), were recorded in the LGA (growing in mature planted fig trees);
- The presence of a large freshwater pond (Lake Kippax), located at the site of the former Billy Goat Swamp swamp (Centennial Parklands, undated);
- The only site at which Gould's Wattled Bat and the Eastern Freetail Bat were recorded;
- High potential to undertake bush restoration works and increase the diversity of locally indigenous flora species, and to undertake fauna habitat enhancements without compromising the existing range of land uses; and
- Its existing connectivity to habitat within Centennial Parklands and other sites in the Randwick LGA, and potential to contribute to a habitat linkage to Sydney Park via landscaping associated with future redevelopments at Green Square and other precincts in the southern part of the LGA.

Site constraints

- Disturbance created by high levels of public use, including regular large events, in the vicinity of Lake Kippax in particular; and
- The primary function of most of the site as a golf course and driving range.



Existing indigenous plantings at Moore Park (left), with potential for infill planting and other habitat enhancements, and possibility for establishing understorey beneath existing indigenous trees on parts of Mt Steel (right) without compromising existing range of uses (photos K. Oxenham)

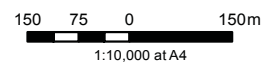


Australasian Grebe nesting at Lake Kippax, Moore Park (left) and Nankeen Kestrel foraging over Moore Park Golf (right) (photos K. Oxenham)



FIGURE 16
Moore Park

- Indigenous/Mostly Indigenous Plantings
- Ponds



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3.4.7 Supporting sites

There are many sites in the LGA that have important biodiversity values in their own right and/or have the potential to support the priority sites. These include small, City-managed parks as well as sites managed by others. A selection of these sites is briefly described below; details for other surveyed sites are provided in the identification of biodiversity values (Appendix 5):

- Embarkation Park and McElhone Stairs, Potts Point – sandstone cliffs, high diversity of locally indigenous species (>40 species), including four that are likely to be naturally occurring.
- Arthur McElhone Reserve, Elizabeth Bay – moderate-high indigenous species diversity (30–40 species), a sandstone outcrop with potentially naturally occurring species including the only known potentially natural Dwarf Apple (*Angophora hispida*) within the LGA, and freshwater habitat (constructed ponds and wet depressions/seepage along rock outcrop).
- Arthur (Paddy) Grey Reserve, Glebe – sandstone outcrop with some potentially naturally occurring species plus high diversity of locally indigenous shrubs and groundcovers planted by volunteers from the Glebe Society's Blue Wren Group and the broader community.
- Bannerman Crescent Reserve, Southern Cross Drive Reserve, and Kimberley Grove Reserve, Rosebery – diverse indigenous plantings with some connectivity to indigenous vegetation along Southern Cross Drive and the Australian and Eastlakes Golf Courses, and high potential for existing biodiversity values to be enhanced.
- Woolwash Park, Zetland – small, constructed freshwater wetland associated with a natural aquifer and vegetated with a good variety of macrophytes; good example of a habitat type that is very limited in the LGA.
- Rail corridors – sections of both the light and heavy rail corridors feature long grasses, thick weed infestations and ground-level debris that provide suitable habitat for a range of fauna species. Fencing along these corridors and restricted public access add to their habitat value.
- University of Sydney, Camperdown and Darlingtown – the university campus features a mix of long-established exotic and indigenous plantings that support one of few known Superb Fairy-wren populations in the LGA. Recent capital works onsite have incorporated a high proportion of indigenous plantings as well as a small freshwater wetland vegetated with a good variety of macrophytes and fringing vegetation.
- Chinese Gardens, Darling Harbour – the freshwater ponds and substantial rocky areas in this landscaped garden support populations of the Eastern Water Dragon and Eastern Water Skink. While these species may originally have been introduced to the garden, which is isolated from other habitat areas, they appear to be flourishing.
- Victoria Barracks, Paddington – bush restoration works are in progress in the south eastern part of this site managed by the Department of Defence, with significant weed control undertaken and hundreds of local provenance seedlings planted to date.



Recent landscaping works at the University of Sydney have incorporated indigenous plantings (left) and a vegetated pond (right). (photos K. Oxenham)



Woolwash Park wetland in Zetland (left) and Embarkation Park in Potts Point (right) are among a number of other supporting sites. (photos K. Oxenham)

3.5 Priority fauna species

The following fauna species were identified as priorities in the LGA for this Strategic Action Plan:

- Green and Golden Bell Frog and other frogs;
- Grey-headed Flying-fox;
- Powerful Owl;
- Long-nosed Bandicoot;
- Microbats;
- Small birds;
- Wetland birds; and
- Reptiles.

Most of these species occur at one or more of the sites discussed in Section 3.4, although some occur at other sites, including residential backyards. Most are dependent on particular habitat features that are limited within the LGA, such as dense shrubby vegetation, rock crevices, ground-level features such as rocks and fallen timber, tree hollows, and freshwater wetlands/ponds.

The following sections provide a profile of each priority species/group.



Peron's Tree Frog (photo K. Oxenham)

3.5.1 Green and Golden Bell Frog and other frogs

The Green and Golden Bell Frog (GGBF) was once abundant in Sydney and elsewhere across its range – it was described in 1863 as being “the most common of all Australian frogs” (Lemckert 2010), and remained very common until about 30 years ago, when it underwent a dramatic decline. This decline is thought to have been largely due to a combination of habitat loss, fragmentation and degradation; disease caused by the chytrid fungus (which has led to worldwide frog declines); and predation by the introduced Mosquito Fish (DEWHA 2009; DECCW 2008b; DECC 2005; White & Pyke 2008). GGBFs are now limited to a small number of isolated populations, and the species is listed as threatened under both the EPBC and TSC Acts.

In the City, GGBFs are limited to a very small population (estimated at less than 20 individuals) in Rosebery. This population is centred on a residential backyard in which the frogs colonised a disused, above-ground swimming pool in the mid-1990s, from a larger area of nearby habitat that has since been destroyed by a residential apartment development (DECCW 2008b).

When the pool became dilapidated, the Rosebery residents enlisted the help of the NSW Frog and Tadpole Study Group (FATS) who replaced the pool in 2005 with two small, purpose-built habitat ponds. The City provided funding to FATS for these works.



Green and Golden Bell Frog (photo K. Oxenham)

Although GGBFs bred in the ponds in large numbers every year until the 2009–10 season, the residents have reported an ongoing decline in the population. They have not observed any tadpoles in the past two years, and have also observed predation by Laughing Kookaburras on adult frogs. Without action, this population faces extinction in the very near future.

Translocation of GGBFs from Rosebery to Sydney Park was identified as a priority action by DECCW (2008b) in the management plan for the Lower Cooks River 'key' GGBF population. However, past translocations of this species have been largely unsuccessful (White & Pyke 2008) and translocation would in any case be difficult given that this is usually undertaken with tadpoles, which do not appear to have been produced in the last two years. Better outcomes may be achieved by establishing more breeding habitat, i.e. freshwater ponds, in the Rosebery area where GGBFs could colonise them naturally.

There are several City parks in Rosebery in which ponds could be constructed, and most backyards in Rosebery are large enough to readily accommodate ponds. There is also a relatively large number of backyard swimming pools in Rosebery, which could easily be converted to ponds – conversion of just a small number could save the local GGBF population from extinction. A successful 'Pool to Pond' conversion program run by Ku-ring-gai Council has demonstrated the conversion is simple and effective, and Woollahra Council has also recently commenced a 'Pool to Pond' program.

The other frog species recorded in the LGA were the Striped Marsh Frog, Common Eastern Froglet, Perons Tree Frog and Eastern Dwarf Tree Frog. The Striped Marsh Frog and Common Eastern Froglet are more flexible in their habitat requirements and are consequently more widespread in the LGA than the latter two species: Perons Tree Frog was recorded at a small number of sites in the LGA and the Eastern Dwarf Tree Frog at only one site. While tree frogs in general have declined throughout the more densely populated and developed parts of Sydney (White & Burgin 2004), these two species are still common elsewhere throughout their range (Tyler & Knight 2011), including parts of adjoining LGAs, so it should be possible to achieve an increase in their distribution and abundance in the city.

Like the GGBF, all of these species would benefit from the construction of more freshwater ponds and pool conversions, as well as improvements to the habitat value of existing ponds and water features – particularly through increasing the complexity of adjacent terrestrial habitat features (Hamer & McDonnell 2010). This can be achieved by providing a diverse range of fringing vegetation along with ground-level features like rocks around ponds. Improving habitat connectivity between ponds, improving water quality, minimising pond shading, controlling predatory fish – particularly the Mosquito Fish – and providing aquatic vegetation are also important in encouraging a range of frogs (Hamer & Parris 2011). Restrictions on the use of chemical herbicides in and around frog habitats is also critical.

Attempts are currently being made to re-establish populations of similar frog species to those that occur in the city at unoccupied ponds in Melbourne (A. Hamer, *pers. comm.*); if successful, this could potentially be replicated in Sydney.



Frog and Tadpole Study Group working bee (left) to replace dilapidated swimming pool with purpose-built GGBF ponds in a Rosebery backyard; and the main pond today (right) (photo K. Oxenham)

3.5.1 Grey-headed Flying-fox

The Grey-headed Flying-fox has experienced substantial declines across its range as a result of the destruction and development of its natural habitat, particularly along and near the coast. Its range also appears to be contracting in the north and expanding southwards (DSEWPaC 2012). It is listed as threatened under both the EPBC and TSC Acts.

Grey-headed Flying-foxes forage at night over extensive areas, feeding primarily on the nectar, flowers and fruit of a wide variety of trees – mainly *Eucalyptus*, *Corymbia*, *Angophora*, *Melaleuca* and *Banksia* species – and supplement this diet with leaves (DECCW 2009b). They also feed on *Ficus* species and on introduced trees. Their diet varies throughout the year depending on which trees are flowering or fruiting (DECCW 2009b). They play an important ecosystem function in terms of seed dispersal and pollination of many indigenous tree species (NSW Scientific Committee 2001).

During the day, Grey-headed Flying-foxes roost communally in trees, usually in large numbers. Until mid-2012, a large camp comprising thousands of individuals was present at the Royal Botanic Gardens. Despite the relocation of the camp by the Royal Botanic Gardens and Domain Trust, the Grey-headed Flying-fox is likely to remain relatively abundant in the LGA, since individuals from other nearby camps (for example at Centennial Park) are likely to continue to forage throughout the area at night.

Existing tree maintenance practices in the LGA will contribute to their conservation. In Melbourne, at least 87 street tree species and more than 315,000 individual street trees provide a food source for Grey-headed Flying-foxes (Williams *et al.*, 2006), and it is likely that there would be a similar number in Sydney.

Increasing winter-flowering tree species such as Swamp Mahogany and Forest Red Gum in City parks would assist to ensure a year-round food supply (other winter-flowering species such as Spotted Gum and Broad-leaved Paperbark are already common in streets and parks across the LGA). Reducing the potential for Grey-headed Flying-fox electrocutions on overhead power lines, a common occurrence in urban areas, is also likely to benefit the species.

3.5.2 Powerful Owl

The Powerful Owl is Australia's largest owl species and like most large predators, it has a large home range, with a single pair usually occupying a given territory (DECC 2006). It is a forest-dwelling and hollow-nesting species, and has been listed as threatened under the TSC Act mainly due to loss of habitat, including hollow-bearing trees, through logging and clearing for urban development and agriculture.

Powerful Owls have historically occurred in the outer suburbs of Sydney, particularly where there are substantial adjoining bushland areas (Kavanagh 2004), but in recent years there have been numerous records much closer to the city, presumably due to the abundance of prey such as possums and flying-foxes (Birds in Backyards website). A pair now appears to be resident in the Royal Botanic Gardens, where they can often be seen roosting in a leafy tree during the day, usually holding the remains of the previous night's prey in their talons. They have also been recorded in other parts of the LGA on occasion.

Although prey is abundant in the gardens, it is unlikely that there are any tree hollows that are large enough for nesting. As Powerful Owls have successfully nested in a purpose-built nest box in Melbourne (McNabb & Greenwood 2011), Royal Botanic Gardens staff installed a similar nest box in early 2012 ahead of the breeding season, which extends from mid-May to mid-July. It has not been used to date, but will continue to be monitored. Installation of additional nest boxes may increase the likelihood of the owls nesting.

BirdLife Australia's Birds in Backyards program is currently running a Powerful Owl Project, which aims to identify the critical roosting and breeding requirements of the species in the Sydney region, identify important areas requiring protection, and improve awareness of the public and land managers about Powerful Owls and issues affecting their conservation (Birds in Backyards website).



Powerful Owl in the Royal Botanic Gardens.
(photo C. Tomkinson)

3.5.3 Long-nosed Bandicoot

The Long-nosed Bandicoot is very common in bushland around Sydney and elsewhere throughout its range, but like most other indigenous ground-dwelling mammals, it has disappeared from most highly urbanised areas and is considered extinct from most parts of inner city Sydney (Leary *et al.* 2004). In 2002, however, numerous reports from residents led to the discovery of a small population around the inner-western suburbs of Dulwich Hill, Marrickville, Lewisham and Petersham. This was surprising given that it was considered extinct from the area by the 1970s; there is no known source population nearby; and it is very vulnerable to predation from foxes, cats and dogs, as well as threats posed by traffic and limited habitat availability and connectivity. This inner-western population has subsequently been listed as endangered under the TSC Act.

A radio-tracking study found the bandicoots forage almost exclusively in urban backyards and shelter by day under old buildings (Leary *et al.* 2004). It is considered possible they may have persisted at industrial sites in the inner west (such as old flour mills and warehouses), and redevelopment of such sites may have forced them to relocate to urban backyards (Leary *et al.* 2004).

Three Long-nosed Bandicoots have since been recorded in the LGA, at Alexandria and Camperdown. The first of these was photographed by a motion-sensitive camera in a community garden in April 2011, while the second (reportedly a juvenile) was found injured in January 2012 in the adjacent Alexandria Park and had to be euthanased. While no further sightings of bandicoots or their diggings have been reported since that time, it is possible that other individuals are present in the area, particularly in and around the many industrial sites in the southern part of the LGA. The third bandicoot record was from the University of Sydney's Camperdown campus, where a dead individual was discovered in November 2012.

Hughes & Banks (2010) found Long-nosed Bandicoot foraging activity was greater in areas with moist, soft soils close to dense vegetation cover, and suggest artificial watering and the provision of additional cover may assist in the conservation of urban bandicoot populations through increasing foraging opportunities.

3.5.4 Microbats

Microchiropteran bats (microbats) are small-bodied, generally insectivorous species which locate their insect prey by echolocation, usually above dense vegetation or waterbodies. In urban areas, they can also sometimes be seen foraging around street lights. By day, they normally roost within the hollows of live or dead trees, under bark, or within caves. Within urban areas where tree hollows

and other natural habitat is less available, some microbats have adapted to roosting in man-made structures such as roof and wall cavities of buildings, stormwater drains, and tunnels, but most still depend on tree hollows for refuge and breeding.

There are about 17 microbat species in the Sydney metropolitan area (Threlfall *et al.* 2012a). Only three species – Gould's Wattled Bat, the Eastern Freetail Bat, and Little Forest Bat were confirmed in the City during the surveys, although there were possible records of two additional species, the Southern Forest Bat and threatened Eastern Bent-wing Bat. Several other species may also be present, but were not detected.

Most of the microbat species in Sydney are urban-sensitive (Threlfall *et al.* 2012a). The species detected in the LGA were only recorded from a small number of sites. A recent study (Threlfall *et al.* 2012b) found that only one microbat species – Gould's Wattled Bat, which is the most widespread species in NSW and the ACT (Pennay *et al.* 2011) – can routinely tolerate life in the highly urbanised inner city. A related study also found habitat enhancement efforts for microbats in urban areas should focus on maintaining and restoring bushland and riparian habitat, particularly in areas with fertile, shale-influenced soils (Threlfall *et al.* 2012b). Shale-influenced soils in the LGA are largely limited to the inner west and Surry Hills (the Blacktown soil landscape indicated in Figure 5).

Provision of roost boxes may be another means of encouraging microbats in urban areas, although their use of roost boxes is poorly understood and is likely to be influenced by numerous factors including box design and placement. Rhodes & Jones (2011), however, found five microbat species used roost boxes installed in tall *Eucalyptus* trees in Brisbane parks and backyards, and the boxes were more likely to be used if clustered in groups of at least six within 50 metres of each other, in areas with high grass cover within one kilometre and in areas with high forest cover within five kilometres. Evans & Lumsden (2011) found that Gould's Wattled Bat used roost boxes as well as natural tree hollows in the suburbs of Melbourne, and there was no apparent preference for either roost type. This species has also readily colonised roost boxes recently installed at Sydney Olympic Park.

As well as microbats, roost boxes may also be used by other species, including several that are likely to exclude or prey upon microbats, such as ants, introduced honeybees, and introduced rats (Rhodes & Jones 2011), so it is important that boxes are designed to prevent or minimise potential for this.

3.5.5 Small birds

Given birds are currently the most diverse and prominent vertebrate group within the LGA, the general absence of small woodland bird species was particularly notable in the survey results. The current bird assemblage is dominated by large indigenous honeyeaters, parrots, carnivores and introduced species.

Most of these larger species were not originally resident in the Sydney area (Major 2010; Major & Parsons 2010), or at least not in large numbers – populations of all increased dramatically in the 20th century as Sydney's human population and associated development increased markedly (Recher 2010). Many of the small bird species that did once occur here, such as the Red-browed Finch, Grey Fantail, Eastern Spinebill, and Spotted Pardalote (Major & Parsons 2010), were not recorded in the survey and no longer appear to be present in the LGA. Some of these smaller species still occur in other parts of Sydney, however, including adjoining LGAs, but many have declined in general across their range (Major 2010; Major & Parsons 2010; Recher 2010; Parsons 2009).

Apart from the Willie Wagtail, which is reasonably well-adapted to urban environments and is found across the LGA, the only small woodland birds that appear to be resident in the LGA today are the Superb Fairy-wren, Silvereeye and New Holland Honeyeater. Other small birds recorded in the LGA were the White-plumed Honeyeater and Rufous Whistler – each at one site on only one occasion. Several other species, including rainforest species such as the Rufous Fantail and Black-faced Monarch which migrate through Sydney, may also occur in small numbers from time to time.

The Superb Fairy-wren appears to be limited to small populations at Sydney Park, St Peters; Erskineville; the University of Sydney, Camperdown; and possibly Glebe. Lesryk Environmental Consultants also reported it from the Royal Botanic Gardens in 2005, but it no longer occurs there. It lives in small, territorial groups and is a weak flier, unlike the Silvereeye and New Holland Honeyeater which are more mobile and capable of moving around the landscape in response to availability of food. Small numbers of New Holland Honeyeaters have been recorded recently at Erskineville and Rosebery. Silvereeyes have been recorded at a greater number of locations and appear to be more abundant and widespread across the LGA, though still not particularly common.



Small birds that once occurred in the LGA but no longer appear to be present: Red-browed Finch (left) and Spotted Pardalote (right). (photos N. Lazarus)

The decline of small birds is mainly attributable to the loss of habitat that has occurred with increased urbanisation, along with an associated increase in larger, aggressive birds, especially the Noisy Miner, as discussed in Section 3.7.8. Nest predation by introduced rats may also be a factor.

Most small woodland birds are dependent on dense understorey vegetation comprising a mix of different indigenous shrubs, grasses and groundcover species, which provide the food and shelter they require (Parsons 2009; Debus 2008). Ground level features like fallen logs are also beneficial habitat features. These characteristics are missing from most urban parks and gardens, which tend to be characterised instead by trees over mown lawn, mulch or paved surfaces. This type of environment favours many of the larger bird species that have consequently become abundant in Sydney and other urban areas, and several of which are aggressive towards or prey on small birds (Section 3.7.8).

Concern over the decline of small birds led to the formation of The Glebe Society's Blue Wren Group, a group of residents who for several years have led community education and habitat enhancement initiatives, with a particular focus on the Superb Fairy-wren. With grant funding from the City, the Blue Wren Group commissioned a study to investigate the status of Superb Fairy-wrens in Glebe and Forest Lodge, and to provide recommendations to promote the conservation of wrens and other small birds. The resultant report (Stevens 2008) identifies potential habitat corridors in the Glebe and Forest Lodge area, and particularly stresses the importance of small parks, backyards and the light rail corridor in providing habitat for small birds, given they are generally more protected from disturbance than most City parks.

While some small birds will use a range of indigenous and exotic species as habitat, and weeds like Lantana can be particularly important (Parsons *et al.*, 2008), Parsons & Major (2004) found that several small birds, including the Superb Fairy-wren, were more likely to be encountered in backyard gardens dominated by indigenous vegetation, whereas Noisy Miners dominated gardens with a mix of exotic and indigenous plants.

Several studies (for example Ashley *et al.* 2009 and Catterall 2004) have also shown that plantings of small eucalypt-dominated urban strips and patches are unlikely to provide useful habitat for many small birds, due to their tendency to be colonised by Noisy Miners. Hastings & Beattie (2006), however, found that incorporating acacias, preferably bipinnate species such as the locally indigenous Sydney Green Wattle *Acacia decurrens* and Parramatta Green Wattle *Acacia parramattensis*, along with a dense shrubby understorey was effective in promoting the abundance and diversity of small birds, as Noisy Miners were not resident in plantings with these characteristics.

3.5.6 Reptiles

Based on records from the Australian Museum, there were originally 45 reptile species within the Sydney metropolitan area – most have declined and some, particularly larger species, have disappeared altogether from suburban environments and adjacent small bushland areas (Shea 2010; White & Burgin 2004).

Four of the 11 species recorded in the LGA – the Eastern Water Skink, Bar-sided Skink, Eastern Water Dragon and Gully Skink – are considered ‘suburban battlers’ in Sydney (Shea 2010), because although they are still present, they are generally uncommon. This certainly seems to be the case in the LGA, although the Bar-sided Skink seems relatively abundant in foreshore locations where suitable rocky habitat is present, and has also been recorded from nearby trees. The occurrence of the Gully Skink in the LGA is of interest in that it is only known in Sydney from a small number of sites in the eastern suburbs and on the north shore (Shea 2010).

Five of the other reptile species recorded in the LGA are considered to be long-term ‘suburban survivors’ (Shea 2010) as they appear to have adapted well to urbanisation. However, two of these – the Weasel Skink and Eastern Blue-tongue – were recorded from one and two sites respectively and do not appear common in the LGA.

The only known reasonable Eastern Blue-tongue population in the LGA appears to be at Sydney Park, where it is vulnerable to dog attacks and other disturbance.

More than 2,000 Eastern Blue-tongue rescues were recorded by WIRES over a three-year period in Sydney (Koenig *et al.*, 2002); vehicles and dogs killed many adults in spring (the breeding season) when adult males move about more frequently, while domestic cats killed mainly juveniles. However, in highly urbanised areas such as the inner city, habitat loss rather than domestic pets was found to be the most important cause for lizard rescue (Koenig *et al.*, 2002).

This illustrates the importance of maximising habitat for Eastern Blue-tongues and other reptiles, and improving connectivity between habitat patches to enable them to move safely across the landscape. Koenig *et al.* (2001) found for example that Eastern Blue-tongues actively avoided crossing roads and instead used corridors of dense vegetation to move between shelter sites. Hamer & McDonnell (2010) also stressed the need to maintain structural complexity in habitat patches – for example through providing ground-level habitat features such as rocks and logs – and to protect habitat patches and corridors.

As well as parks, residential backyards can also provide valuable reptile habitat, and reptiles in return play a useful role in controlling garden pests – Eastern Blue-tongues for example prey on garden snails. They and other species readily inhabit backyards in Sydney provided suitable shelter sites are present (Koenig *et al.*, 2001) – these can comprise rock retaining walls and other rock features, logs and other ground-level features including artificial structures. However, domestic pets and the use of chemical pesticides such as snail baits, which are likely to be fatal to Eastern Blue-tongues that eat poisoned snails, pose threats to reptiles in backyards, and it is important to improve community awareness about this.



Ideal habitat for the Eastern Water Dragon at the Chinese Gardens, Darling Harbour: rocks, water, long vegetation; and a Weasel Skink. (photos K. Oxenham)

3.5.7 Freshwater wetland birds

Given the freshwater swamps and creeklines that were once present in what is now the LGA, it is likely that a range of freshwater wetland birds was once common. Large numbers and a great variety of bird species, including 'red-bills' (probably Purple Swamphens), 'water hens' (probably Dusky Moorhens), bitterns, many kinds of duck, snipe, and rails, were reported from Lachlan Swamp in the early-mid 1800s (Doran 2004), to the east of the LGA in what is now Centennial Park. It is likely that swamps and other freshwater bodies in the LGA supported a similar assemblage.

Filling of these swamps and channelisation of creeks that took place with the development of Sydney would have led to the disappearance of many of these species. Hunting was also likely to have contributed; large species like the Black Swan were reportedly hunted to local extinction by the mid-19th century (Doran 2004). Many wetland birds have similarly declined overall across Australia (Birds Australia 2008), although there have been recent increases after three years of inland wetland flooding (Porter & Kingsford 2011).

Although no natural freshwater wetlands remain in the LGA, several duck species, the Purple Swamphen and Dusky Moorhen are still reasonably abundant where wetlands and ponds have been constructed. Most other freshwater wetland birds, however, now only occur in very small numbers. These include the Black Swan, Buff-banded Rail, Australian Reed-warbler, Black-fronted Dotterel, Royal Spoonbill, Eastern Great Egret, and Black-winged Stilt.

The four latter species do not appear to be resident in the LGA but appear from time to time, mostly at Sydney Park. They are all waders that forage in shallow water and/or on muddy banks created by fluctuating water levels. Some are also very sensitive to disturbance, for example from recreational activities including dog walking.

Other species such as the Australian Reed-warbler inhabit dense reed beds and are reliant on the maintenance of this habitat type, while species like the Buff-banded Rail generally require thick long grasses and sedges. Increasing the availability of these habitat types is likely to benefit these species, and could encourage other similar birds, including the Golden-headed Cisticola, Little Grassbird, Baillon's Crake and the migratory Latham's Snipe to inhabit the LGA.



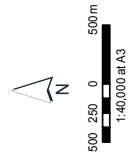
Black Swan adults and cygnets at Sydney Park (left) and Eastern Great Egret (right, photo J. Irvine)– wetland birds that are uncommon in the LGA.

3.6 Potential habitat linkages

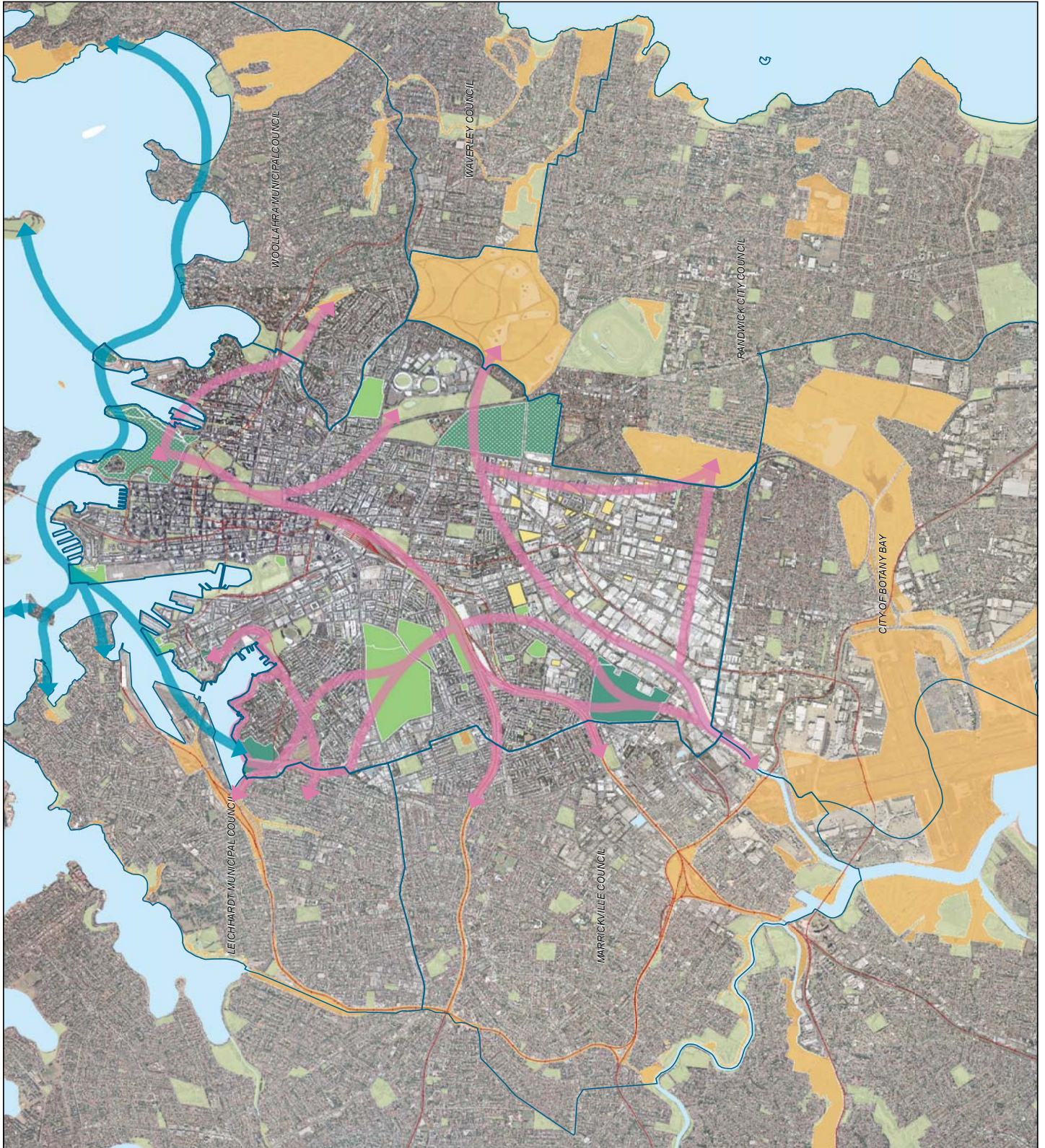
The locations of potential habitat linkages identified within the LGA and between known or potential habitat areas in adjoining LGAs are indicated in Figure 17. While it is unlikely that continuous habitat 'corridors' can be created along their full length, there is considerable potential to at least create 'stepping stones' of habitat along or in the vicinity of these potential habitat linkages to facilitate the movement of more mobile species across the landscape.

Figure 17
Potential Habitat Linkages

- Legend**
- City of Sydney
 - Surrounding LGAs
 - Priority Sites - Managed by City
 - Priority Sites - Managed by Others
 - Supporting Sites
 - Future Parks
 - Habitat Areas in adjoining LGAs
 - Existing Parks
 - Potential Habitat Linkages
 - Potential Headland Habitat Linkages



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3.7 Threats

Current threats to biodiversity in the LGA are outlined below.

3.7.1 Limited habitat availability

Arguably the main threat to biodiversity in the LGA today is the limited availability of habitat. The LGA has been almost completely modified from its natural state and is now dominated by the built environment. The habitat features upon which many species rely are consequently very limited.

Many of the species that have disappeared from or are scarce in the LGA require structurally complex habitat comprising a mix of trees with a dense understorey of shrubs, grasses, groundcovers, and/or other features like rock crevices, fallen logs, tree hollows and wetlands. Many species moreover require large areas of habitat that have a minimal perimeter to area ratio, i.e. large, round or square rather than narrow linear areas, as the former have a 'core' that is protected from disturbance at the edges. Studies have shown for example that a minimum area of more than 10 hectares is required to conserve many small birds (Piper

& Catterall 2003), although habitat complexity can be more important than area for frogs and reptiles in urban areas (Jellinek *et al.* 2004; Hodkison *et al.* 2007).

Given that vegetation in most parks and gardens in the LGA comprises trees over mown lawn or mulch, with understorey vegetation sparse or absent; areas of structurally complex habitat are scarce and small; no large areas are available for bush restoration; fallen logs have generally been removed as part of site maintenance; most natural creeks have been modified and swamps filled; and trees with hollows are generally removed for safety reasons, many species that once occurred in the LGA are unlikely to return, particularly given the other challenges of surviving in a highly urbanised environment.

There is consequently a clear need to maximise, to the extent possible, the availability of suitable habitat to prevent the loss of species that currently remain in small numbers, and to encourage the species that can (for example, those that still occur in surrounding LGAs) to recolonise the area.



Aerial photos of part of Surry Hills (left) and Pyrmont (right) illustrate the limited availability of habitat within the LGA due to its highly urbanised nature

3.7.2 Lack of habitat connectivity

While canopy connectivity is relatively good across much of the LGA, habitat connectivity at the understorey level is very poor. As discussed above, many species are reliant on this type of habitat, which as well as providing food and shelter enables them to move and disperse across the landscape.

The lack of connectivity means that the existing small patches of structurally complex habitat are generally isolated from each other by intensively developed urban areas and roads, as well as paths, lawns, sportsgrounds and other recreational features associated with most areas of public open space.

The isolated nature of habitats within the LGA, in combination with their limited extent, further limits the potential for many species to survive in the LGA, particularly ground-dwelling species and other less mobile species, since it limits recruitment and gene flow (discussed further in Section 3.7.4). Species particularly at risk include the endangered Green and Golden Bell Frog, which is restricted to one site at Rosebery where it is isolated from the nearest population at Arncliffe in the Botany Bay LGA, and the Superb Fairy-wren, which is a poor flier, and remaining populations of which are isolated from each other and from populations in adjoining LGAs.

While narrow strips of habitat and small 'stepping stone' habitats can improve connectivity between larger areas, recommended widths for functional habitat corridors vary from 25–500 metres, since narrow corridors lack the protected 'core' area required by many species. Corridors of such widths are obviously not achievable in the city context given the extent of development and competing demands for open space. Nevertheless, numerous species are likely to benefit from maximising connectivity of understorey vegetation and ground-level habitat features across the LGA.

3.7.3 Destruction and fragmentation of remaining habitat

Destruction and fragmentation of habitat within the LGA can result from maintenance practices that are incompatible with biodiversity conservation, for example inappropriate use of herbicide, lawnmowers and brushcutters; excess application of mulch leading to smothering of habitat and/or excessive nutrification of waterbodies; misidentification of indigenous plants as weeds (and vice versa); and removal of other important habitat features such as fallen timber and hollow-bearing trees (the latter of which is often required for safety reasons).

Habitat destruction and fragmentation can also result from construction works associated with new developments, redevelopment, and infrastructure maintenance, for example through the unstaged removal of habitat features such as thick long grass and dense shrubs (including weeds, which can provide important habitat for some species as discussed in Section 3.7.5), rock retaining walls, rock piles and debris including rubbish piles, scrap metal and similar.

Clearing of indigenous vegetation is listed as a Key Threatening Process under both the EPBC Act and TSC Act. The loss of hollow-bearing trees, removal of dead wood and dead trees, and bushrock removal are also all listed as Key Threatening Processes under the TSC Act.

3.7.4 Low genetic diversity

The limited habitat availability and poor habitat connectivity characteristic of the LGA has resulted in small isolated populations of numerous species. This is likely to lead to decreased genetic diversity, resulting in reduced resilience of many flora and fauna species to factors such as environmental change, disease, and predation, further limiting their availability to persist in the LGA.

There are similar risks associated with low genetic diversity if vegetation used in bush restoration and other habitat creation/enhancement works is not sourced from a variety of locations.

3.7.5 Weed invasion

Noxious and environmental weeds can suppress and out-compete indigenous flora species. Some weeds also provide a food source for aggressive/predatory bird species that have been implicated in the decline of small birds (as discussed in Section 3.7.8).

Examples of weeds in the City include:

- Fountain Grass and exotic vines such as Asparagus Fern, Madeira Vine, Potato Vine, English Ivy and Morning Glory that are invading sandstone cliffs and outcrops and possible forest remnants;
- Exotic grasses including Kikuyu and other turf species that are outcompeting indigenous groundcover and wetland species;
- Chinese Hackberry (*Celtis sinensis*), which is invading bush restoration sites, parks and railway corridors;
- Dense thickets of African Olive in the Yurong Precinct of the Domain and of Lantana and other weeds in the light rail corridor at Pyrmont that are likely to be inhibiting the germination and growth of indigenous flora;
- Noxious aquatic weeds Ludwigia at Wetland 2 in Sydney Park and Salvinia at Woolwash Park wetland, that can proliferate to adversely affect wetland health; and
- Soft-fruited species such as Privet and Chinese Hackberry that are increasing the food supply of the Pied Currawong, which also preys on the eggs and chicks of small birds.

The loss and degradation of indigenous plant and animal habitat by invasion of escaped garden plants, including aquatic plants, is listed as a Key Threatening Process under the EPBC Act, while the invasion of numerous species including exotic vines and scramblers, Lantana, exotic perennial grasses, African Olive and Bitou Bush are listed as Key Threatening Processes under the TSC Act.

Despite the threats posed by weed invasion in general, it should be noted that dense thickets of some weeds can be an important habitat resource for small birds, the Long-nosed Bandicoot and other species that occur within the LGA in small numbers/at a small number of sites, particularly given that indigenous vegetation and other habitat is limited in the area.



Infrastructure maintenance works damaging habitat at Orphan School Creek, Forest Lodge (left) and off-site removal of fallen logs and branches at Sydney Park (right). (photos K. Oxenham)



The noxious weed Fountain Grass and other weeds on the foreshore at Pyrmont (above left), annual weeds can outcompete native species if not controlled (below left) and the noxious weed Salvinia infesting Woolwash Park wetland (right).

3.7.6 Use of chemical herbicides and pesticides

The use of chemical herbicides and pesticides, while effective in controlling weeds or pest fauna, can also be detrimental to indigenous species. For example, overspray of herbicide can lead to the death of non-target indigenous plants, and can also impede their germination. Herbicides can also be fatal to aquatic species, and species like frogs and some reptiles that can absorb chemicals through their permeable skin.

Chemical snail baits, which are effective in controlling garden snails, can unfortunately also kill indigenous species like the Eastern Blue-tongue, which preys on snails, and is ironically an excellent natural control for them. Similarly, chemical pesticides can lead to the death of frogs, which prey on numerous insect pests, and use of rat baits can be fatal to raptors, owls or other birds that may prey on poisoned rats.

3.7.7 Introduced fauna

A number of introduced species, including domestic pets, pose a threat to indigenous fauna in the LGA, mainly through predation but also in some cases through competition or disturbance.

Predation by introduced species including the European Red Fox and feral cats are listed as Key Threatening Processes under both the EPBC Act and TSC Acts, and predation by Mosquito Fish and competition from feral honeybees are also listed as Key Threatening Process under the TSC Act.

Examples of the impact of introduced fauna in the City include:

- Predation of frogs, reptiles, birds and potentially Long-nosed Bandicoots by foxes, feral cats, rats and domestic pets; and
- Predation of frog eggs and tadpoles by the Mosquito Fish at freshwater wetlands in Sydney Park and Woolwash Park.

While the impact of cats and dogs may be minimised by increased owner awareness as well as strategic fencing of habitat areas, control of the European Red Fox and feral cat are very difficult in publicly accessible urban areas. Both are also resource-intensive and unlikely to be particularly effective, since removal of one animal generally results in arrival of another to take its place. Within the LGA, both are more likely to be scavenging on garbage or preying on introduced rodents, given these are more abundant than the indigenous species upon which they could potentially feed.

The introduced Black Rat and Brown Rat are both common across Sydney, and while both can impact adversely on indigenous fauna through competition and predation (Banks & Hughes 2012), and may have contributed to the decline of small birds, the majority in the LGA are likely to currently be scavenging on garbage or other waste. Introduced rats do however affect humans through their potential to carry disease (Banks & Hughes 2012). The City therefore undertakes a regular program of monitoring, baiting and control of rat populations on public land and ensures any severe rat infestations creating unhealthy conditions on private property are controlled by education, regulation and/or enforcement.

The Mosquito Fish has been implicated in the decline of the endangered Green and Golden Bell Frog and other frog species. It produces up to 300 young several times a year, and can therefore quickly proliferate to infest a wetland. It is a difficult species to eradicate from large waterbodies, but periodic wetland draining can be effective in reducing numbers.

Despite widespread public perception about the Common Myna (also known as the Indian Myna), which has become common and widespread in the City and other urban areas, numerous studies (eg Haythorpe *et al.* 2012; Taylor 2011; Lowe *et al.* 2010; Parsons *et al.* 2006) have shown it does not appear to have any adverse impact on indigenous bird species in Sydney, and efforts to control it would be better directed to habitat enhancement works for the small bird species which have declined in many urban areas. Even in the ACT, where a recent study has shown a negative impact on some bird species, habitat enhancement for indigenous birds has still been recommended over myna control (Garrock *et al.* 2012). The only potentially effective control method for Common Mynas – cage trapping – is extremely resource intensive, and its effectiveness in terms of reducing overall myna numbers is uncertain (Tidemann 2010).

3.7.8 Indigenous fauna

A number of aggressive and predatory indigenous birds that have proliferated in the LGA and other urban areas have been implicated in the decline of small birds. In particular, aggressive exclusion by the Noisy Miner – rather than the introduced Common Myna – as well as predation by species such as the Pied Currawong, Australian Raven, Grey Butcherbird and Laughing Kookaburra are likely to have contributed to reduced diversity and abundance of small birds (Parsons *et al.* 2006; Bayly & Blumstein 2001), as well as resultant decrease in the ecosystem services such as pollination and predation of insect pests that small bird species provide.

Numerous studies have found a significant negative impact on small birds resulting from the Noisy Miner (Parsons 2009; Debus 2008; Parsons *et al.* 2006; Hastings & Beattie 2006; Parsons & Major 2004; Piper & Catterall 2003; Grey *et al.* 1997), and a nomination has been made to have 'aggressive exclusion of birds from potential woodland and forest habitat by over-abundant Noisy Miners' listed as a Key Threatening Process under the EPBC Act. Noisy Miners and other aggressive/predatory birds are well-adapted to the structurally simple habitat comprising trees and mown lawn, mulch or paved surfaces that characterises many parks, streets and backyards in urban areas.

The predatory Pied Currawong also benefits from the presence of soft fruit-bearing trees that are common in urban areas, such as the introduced Camphor Laurel, the environmental weed Chinese Hackberry, the noxious weed Privet, and the locally indigenous Lilly Pilly and Sweet Pittosporum, as their fruit provides it with an additional food source.



3.7.9 Nuisance fauna

A number of indigenous and introduced species are often considered 'nuisance' species because of their impact on public amenity, rather than any particular impact on biodiversity. Such species include the Australian White Ibis, Sulphur-crested Cockatoo, Common Brushtail Possum, Rock Dove (or feral pigeon), and Common Myna (or Indian Myna). Most indigenous species are protected in NSW under the *National Parks and Wildlife Act 1974*, which is administered by the NSW National Parks and Wildlife Service (NPWS). Any applications to cull indigenous species are processed by the NPWS. Introduced species are not protected under this legislation.

The Australian White Ibis is an indigenous species that was originally an inhabitant of inland wetlands. Large populations have however established in Sydney and other urban areas outside of its original distribution, presumably as a result of inland drought in combination with the abundance of food – large numbers forage at landfills and ibis also scavenge for food scraps in garbage bins, cafés, and parks (Martin *et al.* 2010 & 2007). Ibis populations have increased dramatically in Sydney in recent years (Martin *et al.* 2010). They are considered a nuisance for their scavenging habits, as well as due to noise and odour associated with their nesting colonies.

On City-managed land, nesting colonies have established in Phoenix Palms (their preferred nesting habitat in urban areas), in Cook + Phillip Park and Redfern Park, with a smaller colony in a single Phoenix Palm in Fitzroy Gardens in Kings Cross. The NPWS has issued conditional licences to cull eggs and chicks around Sydney in the past, but due to concerns about the overall conservation status of the species, culling is no longer permitted. The NPWS is preparing an Ibis Management Strategy for the Sydney region, and currently recommend the more effective, non-lethal approaches of either removing Phoenix Palms or heavily pruning them each year to prevent nesting.



Common Mynas tend to occur in and around built-up areas rather than bushland (left); the indigenous Noisy Miner (right) has been implicated in the decline of small birds. (photos K. Oxenham)

The Sulphur-crested Cockatoo is another species that has adapted well to urban areas and is now common in the city. It tends to be more fondly regarded than the Australian White Ibis, presumably due to its charismatic appearance and behaviour. Many Sydney residents feed cockatoos, as can be seen for example from a facebook page established for a cockatoo research project (see [facebook.com/cockatoo.wingtag](https://www.facebook.com/cockatoo.wingtag)). However, this species is capable of causing substantial property damage by chewing through features such as timber window frames, timber decking, wiring, building facades, and roof tiles. Feeding may encourage this nuisance behaviour, and also lead to the spread of beak and feather disease (OEH 2011). The NPWS has issued licences to cull Sulphur-crested Cockatoos around Sydney in some cases, and is currently preparing a Cockatoo Management Strategy to guide the management of human-cockatoo conflicts in urban areas.

The Common Brushtail Possum is indigenous to Sydney, but has adapted well to urbanisation (Russell *et al.* 2011) and is a common species in the city. Like the Sulphur-crested Cockatoo, this species is charismatic and often fed by residents and park users, leading in some areas to unnaturally high populations of this normally fairly solitary species. Large concentrations of possums, for example at Hyde Park, have led to substantial tree defoliation, and this species also impacts on public amenity through feeding

on backyard fruit, vegetables and other plants. Given that it is a hollow-dwelling species, and that tree hollows are scarce in most urban areas, its main impact on public amenity is its tendency to invade roof cavities where it can be noisy and cause property damage (Russell *et al.* 2011). It is considered a pest by many residents (Matthews *et al.* 2004). The NPWS has a policy on managing possums that cause this type of disturbance – it requires property owners to take all reasonable efforts to prevent access to roof cavities by possums. In some circumstances, NPWS issues conditional licences to authorise the relocation of possums from roof cavities (OEH 2012).

The Rock Dove (or feral pigeon) is an introduced species that occurs in large numbers in many city parks. It impacts on public amenity through scavenging for food, although people often actively feed it. It often roosts in/on buildings where it can foul surfaces, cause property damage and potentially pose a health risk. It does not tend to occur in more 'natural' habitats or appear to have any adverse impact on other species.

Although the Common Myna, discussed in Section 3.7.7, does not appear to be adversely impacting on biodiversity in Sydney, it is very abundant in the city where it does impact on public amenity through noise, particularly at its communal roost sites.



Bird feeding (left) can encourage unnatural behaviour and encourage nuisance fauna such as cockatoos, ibis and pigeons. It can also lead to the spread of beak and feather disease, which is affecting this Sulphur-crested Cockatoo in Woolloomooloo (right). (photos K. Oxenham)

3.7.10 Diseases and pathogens

A number of diseases and pathogens pose a threat to indigenous flora and fauna in the LGA, including naturally occurring and planted locally indigenous vegetation and priority fauna species. Some are listed as Key Threatening Processes under the EPBC Act and TSC Act; those of relevance to the City are:

- Infection of plants such as Eucalyptus, Angophora, Paperbark, Bottlebrush, and Turpentine species by Myrtle Rust;
- Dieback caused by the root-rot fungus *Phytophthora cinnamomi*;
- Infection of frogs by amphibian chytrid fungus; and
- Beak and feather disease affecting endangered parrots (while this disease is affecting Sulphur-crested Cockatoos in the city, it should be noted this is not an endangered but a common and widespread parrot species).

3.7.11 Poor water quality and inappropriate hydrological regimes

Poor water quality can lead to the degradation of wetland ecosystems, as can inappropriate hydrological regimes, with consequent adverse impacts to wetland flora and fauna. Examples in the LGA context include nutrient enrichment and subsequent algal blooms and depletion of oxygen levels in the Sydney Park wetlands, at least partly as a result of mulch washing into the wetlands from adjoining slopes (Sainty & Associates 2009) and from excessive feeding of water birds; and the potential for degradation of wetland vegetation from the maintenance of constant water levels (to maintain wetland health, periodic water level fluctuations are required, i.e. periods in which they are allowed to partially dry out).



Natural germination of *Juncus* species at Wetland 1, Sydney Park (left) is assisted by water level fluctuations, which can also assist in minimising blooms of the floating fern *Azolla*, here covering the whole of Wetland 5, Sydney Park (right) and algae that can be detrimental to wetland health. (photos K. Oxenham)

3.7.12 Light, noise, traffic, and other disturbance

The normal behaviour of fauna can be altered by the presence and movement of people and dogs, and by other disturbance including artificial light, noise and traffic (e.g. Potvin & Parris 2012; Parris *et al.* 2009; Herrera-Montes & Aide 2011). Disturbance impacts vary between species and individuals, and can be more significant at particular times of the year – for example during breeding seasons it can lead to abandonment of young. Levels of disturbance in the LGA are obviously high given its highly urbanised nature.

Traffic is a particular threat to many fauna species, including priority species that are ground-dwelling such as frogs, reptiles, and bandicoots.

The establishment of habitat plantings is sometimes hindered by trampling by park users and dogs, and plantings are also sometimes vandalised.

3.7.13 Climate change

Climate change has the potential to alter the distribution, abundance and availability of habitat for both indigenous and exotic species, and this potential could exacerbate many of the other threats discussed above.

Potential impacts of climate change in the LGA also include loss of habitat for the endangered Coastal Saltmarsh community as a result of rising sea levels, and depletion of food resources for priority fauna species such as the vulnerable Grey-headed Flying-fox.

Loss of terrestrial habitat caused by human-generated emissions of greenhouse gases is listed as a Key Threatening Process under the EPBC Act, and climate change is also listed as a Key Threatening Process under the TSC Act.



Dog chasing birds in the Sydney Park wetlands (top); Eastern Blue-tongue with head injuries and a missing leg after a dog attack at Sydney Park (left); and Masked Lapwings adults with chick at risk from traffic in Glebe (right).