The road to recovery – delivering the ecological legacy of the Green Games

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The 2000 Olympic and Paralympic Games triggered a comprehensive and multidisciplinary effort to conserve and restore the ecological systems of Sydney Olympic Park, creating an enduring legacy of urban ecosystems rich in native flora and fauna. Today we are 25 years into a 100-year plus restoration project that began with the clean-up of over 200 hectares of contaminated land and hand-planting of over 8 million individual native plants on newly-formed landscapes. Subsequent works have targeted improvements to individual systems and target species, addressing historical damage and fostering long-term resilience. Today the Park is well-known as an urban biodiversity hotspot. It supports endangered ecological communities and a high abundance and diversity of native plants and animals that are now uncommon in the Sydney region. Visitor surveys have ranked the Park's biodiversity, and opportunities to connect with nature, as the highest-rated values of the Park.

Introduction

The Parklands of Sydney Olympic Park are a legacy of the remediation, conservation and development efforts carried out in the lead-up to the Sydney 2000 Olympic and Paralympic Games. Following the Games, the Olympic precinct and adjacent lands formerly managed by the Bicentennial Park Trust came under the stewardship of the Sydney Olympic Park Authority. The natural heritage values of these lands continue to be protected and enhanced in accordance with the legislated duties and obligations set out in the *Sydney Olympic Park Authority Act 2001.*

Nearly half (304 hectares) of Sydney Olympic Park is zoned under NSW planning legislation for environmental conservation and management due to its high ecological values, and 47 hectares of this is gazetted as a nature reserve. The Park supports over 400 native plant species and over 250 native animal species including more than 200 native bird species, seven frog species, 12 bat species, 18 reptile species, native fish species and many thousands of species of invertebrates. Key habitats include estuarine and freshwater wetlands, remnant eucalypt forest, saltmarsh meadows, bushland and grassland (Figure 1). Three of the Park's plant communities are listed as Endangered Ecological Communities under New South Wales and/or Federal Legislation and another (Mangrove Forest) is listed as Protected Marine Vegetation. The Park is an urban hotspot for species that are disappearing from the urban environment – including a breeding pair of White-bellied Sea-Eagles, the Superb Fairy-wren, Red-browed Finch and Eastern Blue-tongue Lizards. The Park provides breeding habitat for these species, as well as a refuge or stepping stone for nomadic and migratory species including migratory shorebirds. The estuarine wetlands of Newington Nature Reserve and Badu Mangroves, totalling 100 hectares, are both listed on the Commonwealth's Directory of Important Wetlands in Australia, and are classified as 'key fish habitat' under NSW legislation.

Pre-Games restoration works

Redevelopment of the land that is now Sydney Olympic Park began in the 1990s. A suite of baseline ecological studies was commissioned shortly before the outcome of the Olympic bid was announced to provide input to site remediation and land use planning. At that time, only small areas of remnant estuarine and forest vegetation remained. Most of the site was dominated by exotic grasslands, swampy landfills, ephemeral ponds in low-lying depressions, and waterbodies built as abattoir wastewater management systems. These highly disturbed habitats were interwoven with buildings, roads, carparks, and areas undergoing extensive earthworks for remediation. The disused Brickpit had developed into a freshwater wetland strewn with scattered piles of quarrying debris and dumped building rubble. Next door to the site, Bicentennial Park, with its 60 hectares of estuarine wetlands and 40 hectares of picnic grounds had been remediated and opened to the public a few years previously, showing what was possible at the site.

The baseline studies revealed that the site's terrestrial and wetland systems supported ecologically significant species of plants and animals including large meadows of coastal saltmarsh, a stand of remnant eucalypt forest, visiting migratory shorebirds, mangrove forest, and a high diversity and abundance of native birds, bats, reptiles and fish (OCA 1995). These studies also identified what was considered to be the largest and

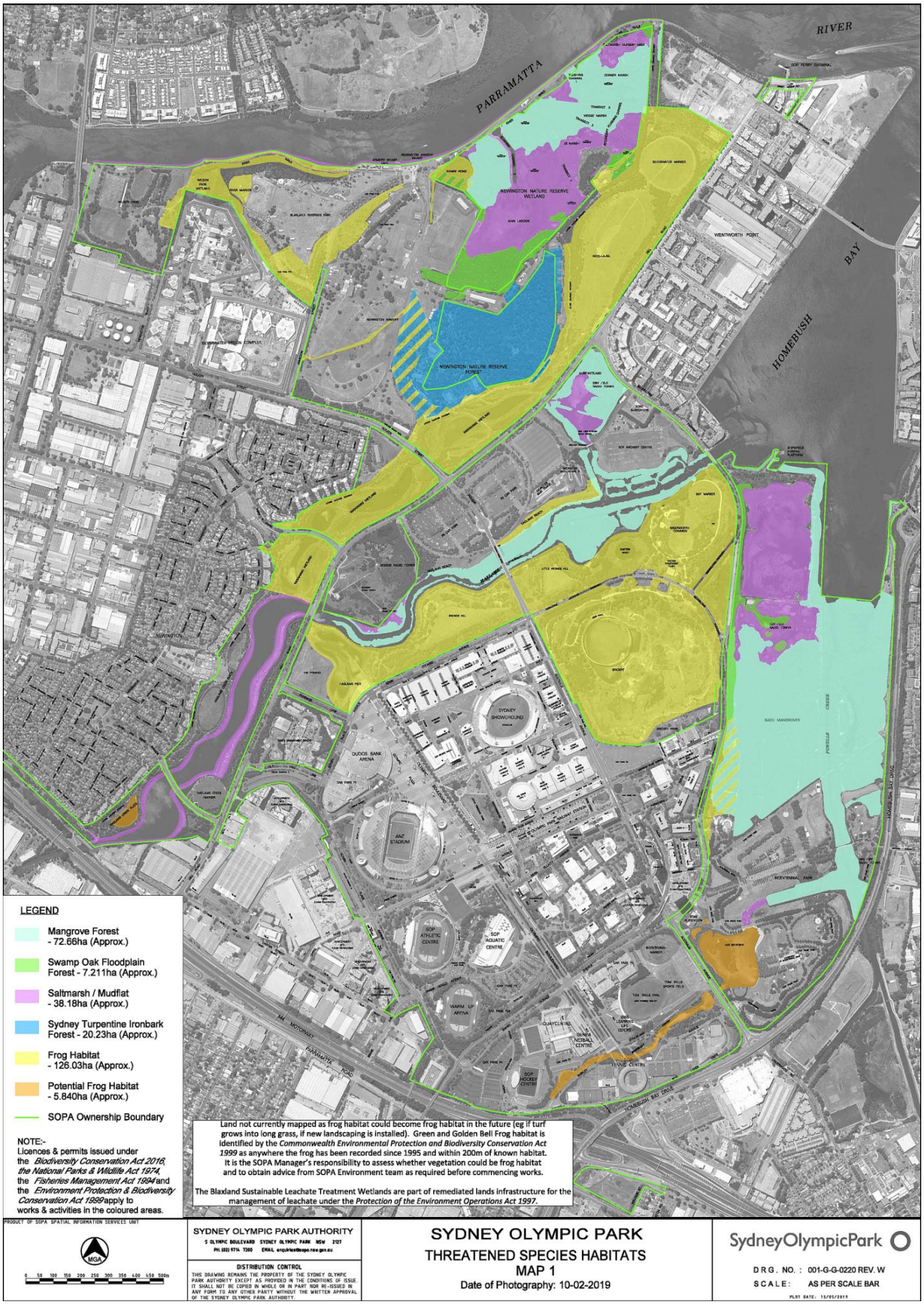
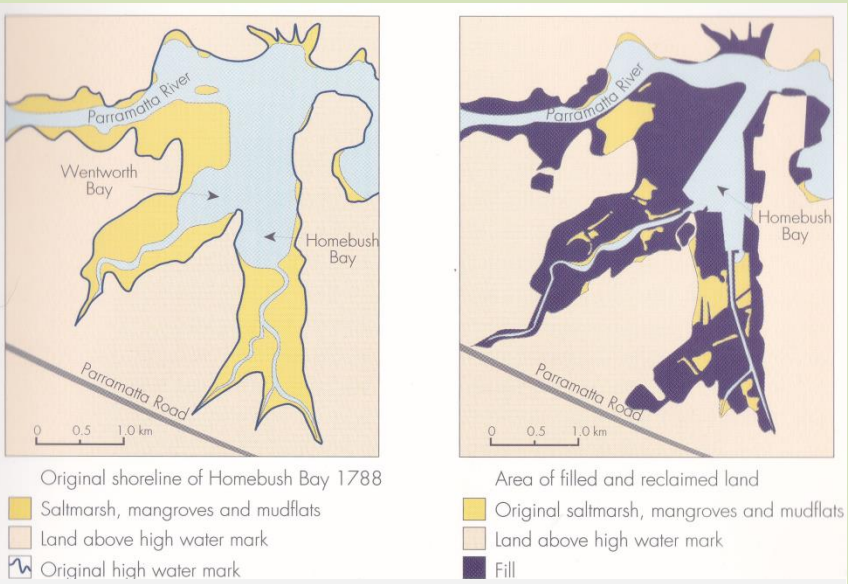


Figure 1 Threatened species habitats of Sydney Olympic Park 2019

Box 1: Sydney Olympic Park land use history

Two hundred years ago, Homebush Bay and Wentworth Bay formed an estuary surrounded by vast intertidal mudflats fringed with mangroves, saltmarsh and woodlands of Eucalyptus and Casuarina (diagram). These were the traditional lands of the Wann-gal people, whose lands stretched along the southern shores of the Parramatta River from Cockle Bay to Rose Hill.



Landfilling of Homebush and Wentworth Bays (Olympic Co-ordination Authority undated)

Within 10 days of the arrival of the First Fleet in Australia, scouting parties had ventured up the Parramatta River, and within a few years the colonial government had granted the majority of the riverside land to new settlers. For these early settlers, the mudflats, forests and tides were an inconvenience – land was needed for farming and for industries such as flour and fabric mills, a lime kiln, saltpans and timber-cutting. As early as the mid-1800s the wetlands were being drained and cleared, and by 1891 retaining walls had been built to exclude tidal waters.

In the 20th century, the land around Homebush Bay became the site of Sydney's abattoirs, its major Brickworks, and the Royal Australian Navy's armaments depot. Reclamation of tidal mudflats to create new waterfront industrial land began in earnest in 1948 and continued until the early 1960s. These practices, combined with decades of landfilling with Sydney's municipal and industrial waste, dramatically altered the face of Homebush Bay, and in particular its creeks and foreshores.

The potential for redevelopment of the area was explored in planning proposals dating back to 1973, but gained impetus as government-owned industries closed down or relocated during the 1980s and nearly 800 hectares of land in the demographic heart of Sydney became available for urban renewal. But this land had become a brownfield site – an urban wasteland with its once-extensive mudflats gone, little native vegetation remaining, pollution leaking into the waterways, and natural creeks converted into concrete-lined stormwater canals.

In 1990 the NSW Property Services Group prepared a business plan for the site, which included clean-up of its industrial past. Homebush Bay had been identified as the only site in Sydney that could be used to stage the Olympics – thus the plan contained two options, depending upon whether or not Sydney was chosen to host the 2000 Summer Olympic Games.

On-site containment was decided upon as the most appropriate way of dealing with the estimated nine million cubic metres of domestic, commercial and industrial landfill waste, and a policy of minimising the total area of contamination and providing for its safe confinement on site was adopted. This involved relocating smaller volumes of waste to the major dumping sites, installing a leachate collection system, and stabilising and capping the waste in preparation for landscaping.

Concurrently, work was underway to better-understand Homebush Bay's remnant natural communities, to input this thinking into the remediation program. The area was anecdotally regarded as having high ecological values despite a history of habitat alteration and industrial use, and its ecological isolation in urban surrounds (Greer 1994). An expert panel of professional ecologists and environmental scientists was established to define the necessary range of baseline studies, and experienced biologists were contracted to complete the work. Soon after the work was commissioned, Sydney was awarded the 2000 Olympic and Paralympic Games, and a new era began for the lands adjoining Homebush Bay.

most viable population of the endangered Green and Golden Bell Frog remaining in the Sydney region (Greer 1994).

The International Olympic Committee announced that Sydney had won the right to host the 2000 Summer Olympic Games in September 1993, leaving only seven years to remediate the site and construct the Games venues and infrastructure. The urban renewal program was fast-tracked to meet this deadline and an intensive site development program began.

The ecological component of the works sought to rebuild functional naturalistic ecosystems within an urban parkland environment. Protection and expansion of the local ecology was a key design objective. Works included:

- protection of remnant eucalypt forest and estuarine wetlands (this land was subsequently gazetted as a 'nature reserve' under the *NSW National Parks and Wildlife Act 1974* the day before the Olympic opening ceremony)
- remediation of 160 hectares of contaminated land to address soil and water pollution
- design and construction of new grassland, wetland, forest, saltmarsh and intertidal habitats on waste containment mounds and newly remediated parklands landscapes
- manufacture of soils from crushed sandstone and biosolids, and hand-planting with over 8 million native plant seedlings
- removal of two kilometres of concrete stormwater canal and replacement with a naturalistic estuarine creek with broad gabion-lined embankments built at a level to sustain saltmarshes
- construction of a new 20-hectare freshwater wetland, comprising 22 individual habitat ponds, an ornamental lake and three large irrigation storages
- construction of freshwater wetlands for stormwater treatment
- restoration of tidal flushing to land-locked estuarine wetlands to improve vegetation health and habitat for internationally-protected migratory shorebirds

Ecological studies continued throughout these works, including trials of saltmarsh transplanting and propagation, bird monitoring, and investigations of benthic organisms in sites restored to tidal flushing.

Pre-Games frog conservation

The Green and Golden Bell Frog played a pivotal role in shaping the lands that would become the Parklands of Sydney Olympic Park.

It was one of the first species to be listed as endangered when threatened species legislation first came into effect in NSW in 1991, and its local stronghold was the abandoned Brickpit, which was slated to become the site of the Olympic Tennis Centre. The regulatory authority rejected an application to relocate the frogs into newly built ponds outside the Brickpit, and with the Games then only six years away and needing to deliver on the 'Green Games' promise, site managers relocated the Tennis Centre to its present position, leaving the Brickpit to the frogs (Darcovich & O'Meara 2008).

Bell frogs also utilised habitats outside the Brickpit – these were overgrown grasslands and wastewater treatment systems associated with the former abattoir that were to become the site of the new railway station, a road network, the Sydney showground and sporting

stadiums. This redevelopment would destroy or disrupt much of the existing ephemeral Bell frog habitat outside the Brickpit, and would also reduce opportunities for the species to disperse across the landscape and result in the death of individual frogs.

The regulatory authority approved the works outside the Brickpit subject to implementation of a comprehensive set of mitigative measures and offsets that included creation of artificial habitat (including around 30 ponds in the areas now called Kronos Hill and Wentworth Common), construction of road underpasses suitable for frog movement, erection of frog-proof fencing between roads and frog habitats, relocation of frogs and tadpoles from development sites, and continued protection of Brickpit habitats from development and general public access. This was the first attempt to create habitat de novo for any animal species in Australia - there was limited available ecological data about the species and many ponds were constructed on a trial and error basis (White 2013). Subsequently remediation of land west of Haslams Creek and creation of a water storage reservoir in the lower levels of the Brickpit for the site's recycled water system resulted in construction of another 40 ponds and associated terrestrial foraging habitats as compensatory and offset habitats.

The Brickpit, new frog habitats, and other open-space areas, were included in the newly-defined 'Millennium Parklands' in 1997 (Hassell 1997). A Frog Management Strategy (OCA 1997) contained ongoing mitigative measures for the proposal to minimise impacts of parklands development on the areas identified as the most important Bell frog habitat outside the Brickpit (Cogger 1997). This Strategy formed the basis of environmental assessment by the regulatory authority and hence for the development consent that was subsequently issued for development of the Parklands.

In all, over ninety freshwater ponds, ten road underpasses and over five kilometres of frog fencing were constructed specifically for the Green and Golden Bell Frog in the lead-up to the Games, set within approximately 125 hectares of grassy foraging and dispersal habitat. The frogs became a flagship species for the Park and for threatened species generally due to national and international media attention, and on World Environment Day 2000, the project was awarded Australia's highest environmental award, the Gold Banksia Award.

Olympic environmental framework

Ecological restoration works benefited from the environmental initiatives that applied to all of Sydney's Games developments. Sydney was the first host city to include a comprehensive commitment to the environment as part of its bid to host the Olympic and Paralympic Games. The Environmental Guidelines for the Summer Olympic Games (Sydney Olympics 2000 Bid Limited 1993), formed part of Sydney's bid and contained more than 100 environmental commitments, including a commitment to preservation and protection of natural ecosystems and endangered species.

The Environmental Guidelines were drafted just a few months after the ground-breaking 1992 United Nations Earth Summit, where 172 governments worldwide adopted Agenda 21, a global plan of action for sustainable development, and where the International Convention on Biological Diversity was opened for signature by contracting nations. President of the IOC Juan Antonio Samaranch said Sydney's

commitment to the environment was a factor in it winning the right to host the 2000 Games, and the international Olympic Committee subsequently made environment the third pillar of Olympism, along with sport and culture.

> *"Protection of nature and the environment so that people may practice the sport of their choice is an essential part of the contribution to the quality of life, which should be based on sustainable development"*
>
> Juan Antonio Samaranch, President IOC.

When the Olympic Co-ordination Authority took over management responsibility for the site in 1995, the *Olympic Co-ordination Authority Act 1995* and the State Environmental Planning Policy 38 required the Environmental Guidelines to be applied to all Olympic developments. Companies tendering for construction contracts were required to demonstrate how they would satisfy the Environmental Guidelines (OCA 1996). Environmental management plans addressing the guidelines were prepared for all design and construction projects. Environmental training was provided to staff and construction contractors (OCA 2000), and performance was regularly audited by independent environmental watchdogs (Greenpeace 2000; Earth Council 2001).

After the Games

With the large-scale earthworks that characterised the pre-Games era complete, attention quickly shifted from building new habitats to managing them, under the auspices of the new Sydney Olympic Park Authority. Apart from the Bell frog projects, pre-Games restoration works had largely been designed at a broad landscape scale. Moving into the management phase there was a need to more closely define long-term ecological objectives for the Park and develop management strategies around them.

Concurrently, fences around the parklands' construction sites were coming down and public access was being introduced for the first time, bringing new opportunities for community engagement but also new management challenges around siting of new pathways and playgrounds, lighting, visitor behaviour, litter and dogs. A Plan of Management was adopted for the Parklands in 2003 (Sydney Olympic Park Authority 2003; revised 2010), based on detailed technical analysis of the particular characteristics, legislative controls, ecological values and visitor opportunities provided by each of 17 individual parklands precincts. This Plan sought to balance the various management objectives for each precinct to achieve the legislated objectives for the Parklands overall (*NSW Sydney Olympic Park Authority Act* s28).

Further ecological studies were commissioned to characterise the new Park's ecology - the landscapes were very different to when the original baseline studies had been done just seven years previously. How had fauna responded? What species were moving into the new habitats and what could we expect as habitats matured? How were formerly landlocked estuarine communities responding to newly-introduced tidal regimes? How should new weirs be operated to benefit ecological communities? How do 90 artificial frog ponds need to be managed in terms of water level and vegetation coverage? What needed to be done about weeds, gambusia, foxes?

Information derived from these ecological studies, as well as technical advice from the many ecologists who had steered the Park's ecological systems through pre-Games development, was consolidated into a comprehensive Biodiversity Management Plan, now at its third

revision (Sydney Olympic Park Authority 2019). The Biodiversity Management Plan informs ongoing management, monitoring and evaluation of the Park's habitats. It sets out corporate commitments to biodiversity conservation, consolidates the many legislative requirements for biodiversity management, identifies threats and pressures, and drills down to provide detailed management objectives, conservation actions and performance indicators for 13 species and communities of particular conservation significance that are identified as focal species and communities for the Park.

These focal species and communities and their conservation status are listed in Box 2.

A comprehensive ecological monitoring program assesses the status of each of these focal species over time, as well as providing broader information about the diversity and abundance of birds, reptiles and frogs. The majority of monitoring is performed in-house by Authority staff, with four long-term studies being supported by volunteers from special interest groups focusing on birds (16 years), frogs (14 years), reptiles (14 years) and White-striped freetail bats (11 years).

These monitoring programs are critical for providing insights into trends in abundance and diversity, leading to a greater understanding of ecological impacts of management practices, supporting evidence-based decision-making. All fauna records, including incidental sightings, are entered into a database, and reporting of performance against biodiversity indicators is undertaken annually.

Post-Olympic ecological restoration and management works

Following the Olympics, ecological management programs and restoration works have been directed at increasing ecological values and functionality of the landscape, particularly targeting the identified focal species and communities. While the aim is for landscape systems to be as naturalistic and self-sustaining as possible, the small size and altered nature of the Park's habitats, along with the many competing management objectives imposed upon them, means that they require ongoing active and adaptive management to achieve and sustain their ecological functions. In effect, this means farming nature to achieve the desired ecological outcomes.

Box 2: Conservation focal species and communities for Sydney Olympic Park

Sydney Turpentine Ironbark Forest .....threatened (NSW & Commonwealth)
Green and Golden Bell Frog.....threatened (NSW & Commonwealth)
Coastal Saltmarsh & *Wilsonia backhousei*....threatened (NSW & Commonwealth)
Mangrove forest .....protected marine vegetation (NSW)
Swamp Oak Floodplain Forest .....threatened (NSW & Commonwealth)
Migratory shorebirds .....international migratory (Commonwealth)
Latham's Snipe .....international migratory (Commonwealth)
Woodland birds .....declining (NSW & Australia)
Microchiropteren bats .....threatened (5 species, NSW)
Horned pondweed *Zannichellia palustris*.....threatened (NSW)
Red-rumped parrot .....declining (Sydney basin)
Raptors .....threatened (4 species, NSW); declining (Sydney basin)
Black-winged Stilts.....declining (Sydney basin)

Post-Olympic works and programs have included:

- Rehabilitation of 1.5 kilometres of the newly constructed embankments of Haslams Creek to enable natural recolonisation by saltmarsh. This work followed several years of trials to investigate why initial plantings had failed and to identify the barriers to natural recolonisation
- Hydrological studies of the wetlands of Newington Nature Reserve to establish weir settings that balance a matrix of ecological management objectives
- Ongoing landscape maintenance by skilled bush regenerators of over 200 hectares of terrestrial land and wetlands
- Regular removal of mangrove seedlings from mapped saltmarsh and mudflat conservation areas, in accordance with conditions of a regulatory Permit
- Long-term staged removal of established extensive stands of lantana, pampas grass and *Juncus acutus* in the Brickpit, and replacement of habitat with new native plantings – the final stand of lantana was removed in 2020, in the fourteenth year of the program
- Retrofitting of terrestrial landscapes to improve structural complexity for woodland birds and ground-dwelling fauna
- Implementation of an annual cyclic pond draining program for control of the noxious fish *Gambusia holbrooki* in Narawang Wetland; installation of bunding and fish fences to reduce spread between ponds
- Testing of new frog pond design, construction and management techniques
- Restoration of tidal exchange to a landlocked wetland in Bicentennial Park to address algal blooms and to favour migratory shorebirds
- Installation of nest and roost boxes for Red-rumped parrots, microbats and possums
- Installation of floating reedbeds to replace lost macrophytes in a water treatment pond; Installation of floating and constructed islands to provide safe roosts and breeding sites for waterbirds
- Introduction of fire to the remnant forest of Newington Nature Reserve, where fire had been excluded for over a hundred years
- Installation of screening around sensitive wetlands where new pathways brought visitors too close to shy bird species
- Excavation of new drainage channels in Badu Mangroves and restoration of overgrown historic channels
- Building of fishways to link waterbodies separated by artificial barriers
- Installation of new stormwater treatment devices such as litter booms, gross pollutant traps, bioretention systems, rain gardens and sediment basins to capture litter and pollutants (mostly generated in catchments upstream on the Park) before it reaches the Park's habitats

Over 110 constructed and naturally-formed freshwater ponds are managed for the Green and Golden Bell Frog

Natural and assisted regeneration works have resulted in the area of critically endangered Sydney Turpentine Ironbark Forest increasing from 13 to 20 hectares

1.5 kilometres of saltmarsh meadow has regenerated on constructed tidal mudflats on the embankments of the dechannelised Haslams Creek

Mangrove drainage channels are hand-cleared to maintain tidal flows and thus prevent ponding and dieback

Nest and roost boxes are supporting breeding populations of red-rumped parrots and microbats

Ponds in a 20-hectare constructed wetland are drained each spring to control *Gambusia holbrooki* ahead of the frog breeding season

Constructed earthen and floating islands provide safe roosts and breeding sites for waterbirds

Tidal flushing has been restored to landlocked estuarine wetlands. Inundation is managed seasonally to control algal growth and to balance migratory shorebird, saltmarsh, mangrove and mosquito needs

Tree thinning and retrofitting of simplistic planted landscapes has increased structural and species diversity of the vegetation, and increased usage by woodland birds, rather than Noisy Miners

Figure 2 A snapshot of post-Olympic conservation and restoration works at Sydney Olympic Park

Monitoring, research, expert advice and lessons from operational experience have been key management tools applied to planning and prioritising works, assessing ecological response to management actions and identifying any changes in management required to achieve long-term objectives.

Reaching the community and sharing experiences

Sydney Olympic Park Authority encourages and promotes community connection with the Park's environment through opportunities in education and tour programs, volunteering and interpretation. Park visitor surveys have ranked the Park's biodiversity and opportunities to connect with nature, as the highest-rated values of the Park, describing the parklands as 'a beautiful green space that values environmental conservation' (Hassall 2019).

The Authority maintains strong links with university researchers, other place managers and government agencies, and runs technical professional development workshops that enable information-sharing with other land managers. Sydney Olympic Park is a 'best practice demonstration site' for the Green and Golden Bell Frog and for Coastal Saltmarsh; best practice management guidelines developed by the former NSW Department of Environment & Climate Change and the Sydney Metropolitan Catchment Management Authority are based on restoration and management practices at Sydney Olympic Park (DECC 2008). Sydney Olympic Park is also a 'priority management site' for the Green and Golden Bell Frog under the state government's Saving Our Species Program, and leads a technical workshop on Green and Golden Bell Frog management each year.

The Park is a living classroom where over 22,000 students attend environmental classes each year. The Authority provides environmental induction training to all contractors working at the

Box 3: Sydney Olympic Park's approach to ecological restoration and management:

Build on strong scientific advice and basic ecological principles – expert input from herpetologists, ornithologists, marine biologists, entomologists, hydrologists, ichthyologists, botanists, zoologists, restoration ecologists and others guide site restoration and ongoing management

Take a multidisciplinary approach – the best results have been achieved when landscape designers, engineers, ecologists, park managers, and asset managers collaborated from early project planning stages, and ecology recognised as a core objective rather than taking a 'maximum legal loss' approach after the project has been scoped

Identify target species and communities to focus management actions –Thirteen 'target' species and communities are the focus of active management and monitoring programs at Sydney Olympic Park

Green the workforce - environmental training is provided to staff and contractors who work in ecologically sensitive environments

Involve the community – Ecofriend partnerships with community bird, frog, reptile and fungi groups have produced a wealth of ecological data, including 16-years of bird census data. 22 000 school students attend classes at the Park each year, and technical professional development workshops enable information sharing with other land managers

Learn from operational experience – evaluate work practices and outcomes and apply adaptive management

Park to ensure the people on the ground are aware of the Authority's requirements and unique environmental considerations. Partnerships with community-based environmental groups have provided a wealth of ecological data through long-running citizen science programs conducted by their members, and ecological information is shared with Park visitors and the community through informational signage, ecological newsletters and interpretive tours.

Concluding remarks

The ecological values of Sydney Olympic Park will continue to grow as the Park's habitats mature – they are only a quarter of the way into what is a hundred-year plus restoration project. In recent years, fire has been reintroduced into the remnant turpentine ironbark forest for the first time in over a hundred years and this has reinvigorated the community. A colony of endangered fishing bats has taken up residence in artificial roost boxes installed within a road culvert, the numbers of internationally-migratory Latham's Snipe using the constructed wetlands has just reached a level classified as significant under Commonwealth legislation, and, in a full reversal of thinking, the Brickpit habitats that were once intended to be destroyed are now valued and promoted as a bell frog 'sanctuary'.

Integral to the ecological recovery of Sydney Olympic Park has been the commitment of the multidisciplinary team of staff, consultants, advisors, contractors and community members who continue to work collaboratively on this project, building on the vision of those who made the Olympic bid commitments a reality.

Not only do the Park's natural environments now support a rich natural heritage valuable in its own right – they are also inextricably linked to the success and offering of Sydney Olympic Park as a greenspace in an urban growth centre. They enrich visitor experience by providing opportunities to connect with nature, provide a living classroom for environmental education programs, and attract businesses and residents seeking proximity to the natural environment.

Growing pressures from the expanding residential population within and neighbouring the Park pose a risk to future conservation of the Park's natural heritage values, but also provide an opportunity for the Park to become a world-class example of a place where people truly live in harmony with nature.

Acknowledgements

The ecological legacy of the Green Games is attributable to the vision of those who began this work in the early 1990s and the many people involved in delivering and furthering this vision over the past thirty years.

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