Reclaiming Botany Wetlands, Sydney through integrated management of *Ludwigia peruviana* and other weeds

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Summary The potential of *Ludwigia peruviana*, a non-native plant, to become a significant aquatic weed in Australia has been apparent since 1971, when established populations were discovered in the Botany Wetlands in Sydney, owned and managed by the Sydney Water Corporation (SWC). In 1996, dense *L. peruviana* infestations covered an estimated 40% of the total wetland area, choking out native species.

As a declared noxious weed, control of *L. peruviana* was imperative and SWC's initiative to remove the infestations commenced in 1996 with the implementation of a $1.35 million Integrated Weed Management Program (IWM). The IWM strategy aimed to kill and remove the infestations from the ponds and facilitate the expansion of macrophytes into weed-cleared areas. IWM combined repeated applications of herbicides ('Bi-active' Glyphosate and 2,4-D amine) with mechanical weed clearing, which involved the use of aquatic plant harvesters and an excavator on a floating pontoon. Other aspects of IWM included water level management, controlled burning of dead weed stands, facilitating expansion of native macrophytes, purposeful replanting of desired species in select areas and large-scale mulching.

The success of IWM resulted in significant positive environmental changes, including increased water flow through the ponds, nil-to-low percent cover of mature *L. peruviana*, reduced density of other targeted weeds and an increasing cover of indigenous macrophytes. Successful physical removal of the large biomass of dead *L. peruviana* was the key prerequisite to re-colonisation by aquatic macrophytes. Whilst the degradation of the Wetland's vegetation has been largely arrested, on-going management is required to achieve the overall wetland rehabilitation goals. The success of IWM during 1996–2001 has provided SWC with a strong knowledge base and practical experience to guide this continuing management phase, thereby fulfilling its environmental and legal obligations.

Keywords *Ludwigia peruviana*, Botany Wetlands, integrated weed management.

INTRODUCTION

The brackish swamps to the north of Botany Bay were modified in the 1850s by construction of dams to provide a fresh water supply to the early settlers of Sydney. This modification resulted in the large coastal freshwater wetland system known as the Botany Wetlands. Comprising 11 interconnected ponds, the Wetlands stretch over a 4 km corridor in the eastern suburbs (Figure 1).

The ponds are an integrated surface and ground water system, fed by the Botany sand aquifer and surface run-off from surrounding areas. SWC owns the pond system and wetlands north of the Botany Road (i.e. Ponds 6, 4/5, 3, 3A, 2, 1, 1A, New Pond, Mill Pond North). The Sydney Airports Corporation owns the downstream ponds located on Commonwealth land. Since the use of Ponds as a water supply ceased in 1886, they have functioned as a flood mitigation system, receiving run-off from 20 km^2 of highly urbanised catchment in Sydney's eastern suburbs.

The Botany Wetlands are significant ecosystems because of the role they play in nutrient recycling, organic matter assimilation, sediment trapping and

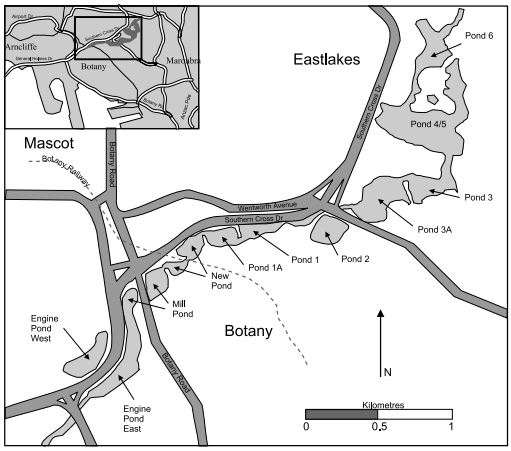

Figure 1. The Botany Wetlands Pond system, Sydney.

amelioration of extreme flows. Additionally, the Wetlands offer a diversity of habitats for biota and are important for recreation and visual amenity.

LUDWIGIA PERUVIANA INFESTATIONS

The potential of *Ludwigia peruviana*, a non-native plant, to become a significant aquatic weed in Australia has been apparent since 1971, when established populations were discovered in the Botany Wetlands in Sydney. In the 1990s, dense *L. peruviana* infestations extended deeply into the ponds covering an estimated 40% of the wetland area, aggressively choking out most other native species (GHD 1993, Jacobs *et al*. 1995). Declared under the Noxious Weeds Act (1993) as a W2 category noxious weed, *L. peruviana* is required to be '…fully and continuously suppressed and destroyed…' by the landowner.

OBJECTIVES AND APPROACH

SWC's overall management philosophy applied to the Botany Wetlands aims to: (a) respond to dynamics inherent in wetland systems, (b) recognise the interdependency of groundwater and surface water, (c) cater for natural processes and change, and (d) recognise the value of wetlands in urban environments.

Within this broad framework, the initiative to reclaim the Wetlands through the removal of *L. peruviana* infestations commenced in 1996 with the implementation of a $1.35 million Integrated Weed Management (IWM) Program over a 5-year time frame (Chandrasena and Sim 1998). Upholding commitment to Ecologically Sustainable Development (ESD), the IWM program sought to:

- Control, suppress and eventually remove *L. peruviana* infestations and all major noxious weed infestations in the Botany Wetlands.
- Reclaim weed-free areas for native macrophytes,
- Remove invasive trees, including willows (*Salix* sp.) and coral trees (*Erythrina* sp.).
- Improve the water regime, reducing the potential for flooding of adjacent properties.
- Satisfy SWC's 'duty of care' obligations in respect of control of noxious weeds and restoration of ecological values of the Wetlands.
- Monitor progressive environmental changes.
- Develop a 'knowledge base' for effective, long-term, sustainable management of the Wetlands.

INTEGRATED WEED MANAGEMENT (IWM)

Integrated weed management involves managing weed problems strategically, in an ecologically sound way, using combinations of concordant weed control options. The IWM strategy for the Botany Wetlands, based on information obtained from earlier studies (McCorkelle *et al*. 1995), primarily aimed to kill and remove *L. peruviana* and other weed infestations from the ponds and reclaim weed-cleared areas by integrating the following:

- herbicide applications,
- mechanical weed clearing,
- water level management,
- controlled burning of dead weed stands,
- facilitation of native macrophyte growth,
- revegetation by purposeful planting, and
- large-scale mulching (cultural weed control).

The broad IWM strategy for *L. peruviana* was applied to concurrently manage a variety of other aquatic weeds as well. Controlling infestations of alligator weed (*Alternanthera philoxeroides*) in the upstream Ponds 6, 4/5 and 3 was imperative to satisfy the requirement of the Noxious Weeds Act (1993).

Similarly, in the Mill Pond, eradication of entrenched infestations of noxious aquatic weeds – water hyacinth (*Eichhornia crassipes*) and salvinia (*Salvinia molesta*) was also essential. In both Pond 2 and the Mill Pond, reducing the excessive growth of Mexican water lily (*Nymphaea mexicana*) was also required to prevent flooding of adjacent properties and to allow establishment of native aquatic plants.

Herbicides Control of *L. peruviana* infestations was based on 1.0% 'Bi-active' Glyphosate (on mono-specific stands, where selectivity was not an issue) and 0.6% 2,4-D amine (on mixed stands with macrophytes, where selectivity was desired). Control of alligator weed and Mexican water lily was also with glyphosate, while water hyacinth and salvinia were controlled by diquat (0.5%).

Mechanical weed clearing On an annual basis, an excavator mounted on a floating pontoon progressively conducted large-scale mechanical clearing of dead weed stands. Additional weed removal was conducted by a small-sized Aquatic Plant Harvester.

Water level management Managing the water level of upstream ponds using the water regulation valve at the Pond 4/5 weir was essential to control *L. peruviana* seedling flushes by flooding and for improving access to chemically treat weed infestations.

Controlled burning Controlled burning of dead *L. peruviana* stands, along with extensive stands of native macrophytes after their winter dieback, was carried out in select areas to reduce weed regrowth from occurring, with minimal impact.

Facilitating native macrophyte expansion The landscape philosophy adopted aimed to ecologically complement wetland plant communities, giving preference to natural regeneration over active replanting. Therefore, the growth of perennial macrophytes was facilitated, to prevent recolonisation by *L. peruviana*. This necessitated reclaiming select riparian areas of slushy mud by 'capping' with additional soil suitable for plant growth.

Revegetation by purposeful planting Reclaiming select weed-cleared areas also included supplementing natural regeneration by purposeful planting a range of species. The aim was to maximise species diversity to achieve resilience to future disturbances, resist further weed invasion and enhance ecological values. Local seed sources or propagules were used to retain genetic resources. In addition to native macrophytes, several known associate species of the main terrestrial vegetation community of the area, Eastern Suburbs Banksia Scrub (Table 1) were also widely planted.

Mulching (cultural weed control) A high degree of mulching with leaf and bark mulch was used as a means of drastically reducing the growth of flushes of undesirable weeds weed-cleared terrestrial interfaces.

RESULTS AND DISCUSSION

Implementing IWM in the Wetlands presented significant challenges, because of the magnitude of the original *L. peruviana* infestations and the presence of other aquatic weeds in the ponds. The following were significant achievements during 1996–2001.

Reduction of weed infestations Although both herbicides were effective against *L. peruviana*, repeat applications were required to control infestations in all ponds. The success of herbicide treatments enabled a progressive vegetation change, in favour of native macrophytes. Some transient herbicide damage to macrophytes was inevitable during treatments, but their recovery was spectacular in most areas.

The IWM program implemented reduced the extent of the original weed infestations by almost 100% in Ponds 6 and 4/5 (Figure 2) within five years. In Ponds 3 and 3A also, a similar reduction in *L. peruviana* infestations was achieved (Figure 2) with concomitant large increases in native macrophyte growth and open water areas. In addition to reducing *L. peruviana*, alligator weed infestations in upstream areas were also reduced to low levels by repeated glyphosate treatments.

Table 1. Plant species used in replanting.

	Species
Aquatic species	*Phragmites australis*, *Bolboschoenus fluviatilis*, *Baumea articulata*, *Gahnia sieberana*, *Schoenoplectus validus*, *Typha* sp., *Juscus* sp., *Isolepis nodosa* and *Eleocharis sphacelata*
Terrestrial species	*Melaleuca quinquenervia*, *Banksia integrifolia*, *B. serrata*, *Viminaria juncea*, *Acacia suaveolens*, *A. sophorae*

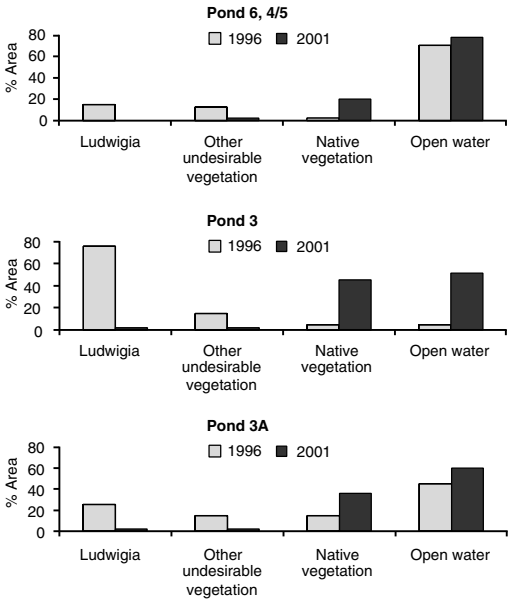

Figure 2. Vegetation changes in the upstream ponds.

IWM converted Pond 2, which was previously dominated by Mexican water lily, to a large open water lake (Figure 3). After the first five years, the original *L. peruviana* infestations and invasive willow trees in the downstream Ponds 1, 1A and the New Pond were also reduced to approximately 50% of the area from the original cover of 80% (Figure 3). In the Mill Pond, control of water hyacinth, salvinia, Mexican water lily and *L. peruviana* converted the pond to a large open water lake (Figure 3).

Expansion of native macrophytes Concomitant with reductions in weed cover, spectacular increases in the growth of native macrophytes – *Typha orientalis*, *Phragmites australis*, *Bolboschoenus fluviatilis* and *Baumea articulata* resulted in all ponds, with increases in water flow and water regime.

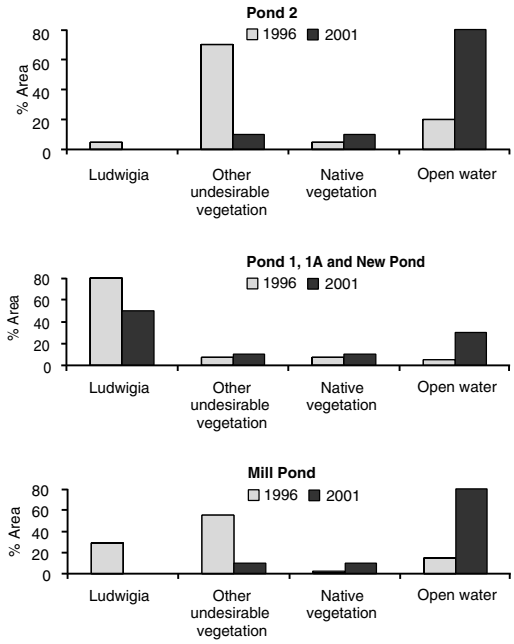

Figure 3. Vegetation changes in downstream ponds.

Whilst the herbicides played a significant role in killing the original *L. peruviana* infestations, the successful physical removal of the large biomass of dead weed stands was a key prerequisite to colonisation by the aquatic macrophytes. Removal of dead weed stands was expensive, but was unavoidable, because of the large areas to be cleared. Implementing IWM required diligent management of potential problems associated with mechanical weed clearing, such as adverse impacts on native plants, disturbances to ecosystems, and the excessive removal of material.

Overall success of implementing IWM 'Restoration', which means, 'to replace what has been lost' is a difficult goal to achieve in the degraded Botany Wetlands, because of the dynamic nature of wetlands and the inability to define 'what existed before'. The hydrology and topography of the Wetlands have undergone substantial disturbance over a long period of time, making it impossible to recreate the system.

Despite these difficulties, achieving a reduction of the original *L. peruviana* infestations to almost 10–15% of what existed prior to 1996, is an indication of the success of setting realistic goals, and implementing an appropriate rehabilitation program. Although the degradation of the vegetation has been arrested, continuing management is imperative to achieve the overall wetland rehabilitation goals. The success achieved during 1996–2001 have provided SWC with a strong knowledge base and practical experience to guide this on-going management phase, thereby fulfilling its environmental and legal obligations.

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