Integrated Pest Management Strategy

Final

March 2023

LIVERPOOL CITY COUNCIL

LIVERPOOL THE GREAT SOUTH WEST

Liverpool City Council

Integrated Pest Management Strategy

Final

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Executive Summary

Pests in Australia cause major economic, environmental, and social impacts at local, regional, and national scales. They inhabit a broad variety of habitats such as agricultural regions, forested lands, arid environments and urban areas and can have a significant impact on biodiversity by out-competing native plants and animals for resources, spreading disease, preying on native fauna and contributing to erosion and waterway degradation.

Integrated Pest Management (IPM) is an approach that establishes a sustainable methodology to managing pests by combining biological, cultural, physical and chemical tools in a way that minimises economic, health and environmental risks. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment.

Liverpool City Council (Council) has undertaken various levels of pest management to satisfy its legislative and community responsibilities. Council recently prepared an IPM Policy to provide a framework for the effective management of priority pest species within the Liverpool Local Government Area (LGA) in a manner that minimises potential harm to human health and the environment.

This IPM Strategy has been developed to support Council's IPM Policy and identify an improved approach to controlling pest animals and weeds. The focus of the Strategy is on the control of pests on land under the care, control and management of Council. However, the Strategy also includes biosecurity responsibilities, health related regulatory functions, and community engagement and education.

This Strategy addresses the legislative responsibility of Council and the roles and responsibilities of associated stakeholders with respect to managing priority pest species. Community engagement and public awareness are critical in effective pest management. This report discusses appropriate strategies including volunteer programs and community events; the use of informative signage in problem areas; the release of materials in multiple languages and the importance of altering public behaviour.

Through implementation of this Strategy Council aims to:

- Manage pests in a manner that is consistent with legislative requirements and regional plans;
- Adopt a strategic approach to pest management to prevent pest populations becoming established;
- Adopt pest control techniques that minimise potential harm to human health and the environment;
- Guide shared roles and responsibility of various stakeholders;
- Ensure that pest control measures are efficient, effective, and appropriately target species that are of the greatest risk to the community, environment and economy;
- Improve biodiversity assets on Council land through control of pest species;
- Minimise the impacts of pest species on Council assets;
- Minimise the impacts of pest species on residential assets;
- Improve community understanding of pest species management including actions regarding community education/awareness; and
- Manage community expectations of pest species management (education and information management).

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1| Introduction

Pests in Australia cause major economic, environmental, and social impacts at local, regional, and national scales. They inhabit a broad variety of habitats such as agricultural regions, forested lands, arid environments and urban areas and can have a significant impact on biodiversity by out-competing native plants and animals for resources, spreading disease, preying on native fauna and contributing to erosion and waterway degradation.

In Australia, pest management is the responsibility of all land managers, whether private or public. The Australian Government works with the states and territories to develop strategies to undertake research and fund key management activities. Under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and the *NSW Biodiversity Conservation (BC) Act 2016*, several pest flora and fauna are recognised as threats to native animals and plants. The impacts of some pest species have been listed as Key Threatening Processes and species-specific plans to reduce the threats they pose have been developed in some cases.

The *Biosecurity Act 2015* and its supporting regulations gives NSW the essential regulatory tools and powers to manage pests and minimise biosecurity threats to the NSW economy, environment and community. Under the *Biosecurity Act*, pests are not defined by species but can be considered as any species (other than native species) that present a biosecurity threat. The Act places the responsibility on land managers to take actions to prevent, eliminate or minimise biosecurity risks to manage their general biosecurity duty.

Integrated Pest Management (IPM) is an approach that establishes a sustainable methodology to managing pests by combining biological, cultural, physical and chemical tools in a way that minimises economic, health and environmental risks. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment.

The Food and Agriculture Organisation of the United Nations defines IPM as:

"*The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment*"

Liverpool City Council (Council) has undertaken various levels of pest management to satisfy its legislative and community responsibilities, however there is no formalised framework directing these activities. Recently, Council prepared an IPM Policy to provide a framework for the effective management of priority pest species within the Liverpool Local Government Area (LGA) in a manner that minimises potential harm to human health and the environment.

The objective of this Policy is to set an IPM framework that aims to:

- Manage pests in a manner that is consistent with legislative requirements and regional plans;
- Adopt a strategic approach to pest management to prevent pest populations becoming established;
- Adopt pest control techniques that minimise potential harm to human health and the environment; and
- Ensure that pest control measures are efficient, effective and appropriately target species that are of the greatest risk to the community, environment and economy.

The IPM Policy is to be supported by an IPM Strategy (this report), which will expand upon the Policy and provide details on priority species and actions. Where required, Pest Management Plans will then be developed to target specific priority pests that warrant detailed planning and action delivery.

1.1 Purpose

This IPM Strategy (hereafter referred to as the Strategy) has been developed to identify an improved approach to controlling pest animals and weeds. The focus of the Strategy is on the control of pests on land under the care, control and management of Council. However, the Strategy also includes biosecurity responsibilities, health related regulatory functions, and community engagement and education.

1.2 Aim

Guided by the existing IPM Policy, the Strategy addresses the purposes of the policy for specific priority pests. The Strategy aligns with Council's legislative requirements, pertinent state and regional plans, and industry best practice standards. This will lead to future species-specific plans which are currently outside the scope of the Strategy.

The overarching aims of this Strategy are as follows:

- Manage pests in a manner that is consistent with legislative requirements and regional plans;
- Adopt a strategic approach to pest management to prevent pest populations becoming established;
- Adopt pest control techniques that minimise potential harm to human health and the environment;
- Guide shared roles and responsibility of various stakeholders;
- Ensure that pest control measures are efficient, effective, and appropriately target species that are of the greatest risk to the community, environment and economy;
- Improve biodiversity assets on Council land through control of pest species;
- Manage pest species in accordance with the *NSW Biosecurity Act 2015;*
- Minimise the impacts of pest species on Council assets;
- Minimise the impacts of pest species on residential assets;
- Improve community understanding of pest species management including actions regarding community education/awareness; and
- Manage community expectations of pest species management (education and information management).

1.3 IPM Principles

The United States Environmental Protection Agency (US EPA) has developed a four-tiered approach to practising IPM as follows (EPA 2021):

a) Set action thresholds
b) Monitor and identify pests
c) Prevent pests from becoming a threat
d) Control

Further information is provided in Appendix A|.

2| Legislative Responsibilities

While the primary legislative requirements for IPM are set by *NSW Biosecurity Act 2015*, there is a wide-ranging legislative framework applicable, along with related policies and procedures. An outline of the legislative framework with regards to IPM is included in Appendix B|.

3| Roles and Responsibilities

Shared responsibility is one of the key guiding principles with regards to IPM. Whilst the roles of the respective stakeholders vary, everyone has the same responsibility to ensure that they do not contribute to the introduction or spread of pests through their actions (Invasive Plants and Animals Committee (IPAC), 2016). An outline of the roles and responsibilities with regards to IPM is included in Appendix C|.

4| Pest Management in Liverpool City Council

Council's current approach to pest management includes:

- Bush regeneration at priority sites;
- Asset protection and aquatic weed treatment;
- Roadside maintenance;
- Reactive actions for new incursions and high-risk species; and
- Involvement in collaborative projects.

An overview of IPM practices already utilised by Council, including several case studies are included in section 6 of this report.

4.1 Impacts

Pest species, without ongoing and informed management can present serious and deleterious impacts on:

a) the environment or an ecosystem, including terrestrial, inland waters and marine environments;
b) social amenity including negative impacts on human infrastructure or human health, including from infectious diseases; and/or
c) the economy, including negative impacts on human, animal or plant life, or health and relevant abiotic aspects of primary production and/or business.

The integration of pest management practices means that each site will need individual evaluation for the best outcome, inclusive of human health, the environment and infrastructure protection. Over time, as the impacts of pest species are reduced, the resilience of the environment can be expected to increase, and management costs should decrease.

4.1.1 Economic

Recent research suggests that pest species have cost the Australian economy at least $390 billion in the last 60 years alone (Bradshaw et al 2021). The management expenditure for pest species usually begins with eradication costs, and ultimately changes to suppression via control management as the

species becomes established (Figure 1 and Bradshaw et al 2021). As a local government, Council has finite resources with which to tackle invasions of pest species such that risk based prioritisation is followed. Therefore, the economic impact of pest species which occur but that are not prioritised by Council present financial risk should they become entrenched.

4.1.2 Environmental

Liverpool LGA possess numerous environmental assets including the Georges and Nepean Rivers, Chipping Norton Lakes and several bushland areas. The southeastern portion of Liverpool is controlled by the Department of Defence and is a significant natural environment asset. There is an estimated 10,700ha of vegetation communities in Liverpool LGA of which over half are listed as Threatened Ecological Communities under state and/or federal legislation. Furthermore, there are an estimated 29 threatened flora species, 52 threatened fauna species, 16 migratory species and two endangered populations thought to occur in the LGA. Liverpool LGA is a fast-growing area of Greater Sydney and as such there is extensive and ongoing development. This has the potential to disturb and fragment high environmental value areas and create favourable conditions for pests to proliferate.

4.1.3 Social

Pest species can have considerable negative social impacts. The predation of livestock, although less common in Liverpool LGA has significant social and psychological effects on landholders. In addition, pests can damage infrastructure and culturally important sites, present a health risk via zoonotic disease transmission, and display nuisance behaviours such as disruptive noise and overpopulation causing community frustration (see section 10.3.2).

4.2 Challenges

Council's current approach to pest management faces several challenges which have been considered in the preparation of this Strategy including but not limited to:

- Responding and adapting to the ongoing and changing status of pest species in Liverpool LGA;
- Misalignment of prioritization perceptions between Council and community;
- Limited knowledge and education within parts of internal government and community on responsibilities, pest management priorities and obligations;
- Limited coordination and partnership with neighbouring Councils, land managers, and stakeholders on landscape scale pest management;
- Lack of systematic approach for monitoring and reporting; and
- Limited funding and allocation prioritization framework

4.3 Risks

The common message across all levels of government is that pest management is a shared responsibility regardless of land tenure and is premised on risk. A systematic, robust and consistent management framework should be in place during any pest management to ensure the following risks are considered:

- Human health and safety;
- Biosecurity and the environment; and
- Infrastructure and responsible financial management.

This Strategy facilitates the adoption of IPM practices that reduce risk while attaining desired outcomes and legislative requirements.

5| Management Priorities

With limited resources to address the risks and impacts of pest species, activities and investment must be prioritised. Pest species prioritisation is largely based on risk-based decision making regulated under the Biosecurity Act in terms of risk posed to the environment, community and economy.

This approach ensures that pest prioritisation is:

- Reasonably practicable;
- Matched to the degree of risk posed; and
- Flexible and non-prescriptive.

These goals are relevant to the stages of invasion on a generalised invasion curve (Figure 1). Pest species management can be classified under four approaches: Prevention, Eradication, Containment and Asset-Based Protection. These four approaches are aligned with the invasion process from arrival to widespread establishment. The invasion curve highlights the relationship between the stages of invasion, the level of effective control that can be expected and the likely return on investment.

5.1 Nuisance vs. Priority Pests

The classification of a pest as either a nuisance or priority species is multifaceted and fluid. While some species may be listed as priority at a national or state level, there may be a lower risk at a local level. This is based on the stage of invasion, perceived impacts or invasiveness which may not warrant priority action, in which case the species may be better defined as a nuisance pest.

Pest species categorisation must be determined on a case-by-case basis and continually reviewed based on monitoring and reporting. Overall, this is a risk-based approach and at a local level would include assessing each pest's:

- Invasiveness;
- Impacts; and
- Potential distribution.

Furthermore, the feasibility of pest management must consider:

- Control costs;
- Persistence; and
- Current distribution.

A priority pest should then be defined as fulfilling most or all of the following descriptors:

- A species which presents a high risk with respect to its current position on the invasion curve and/or its ability to establish reproduce and spread such that significant management costs, prolonged persistence or increase in current distribution are predicted;
- A species which presents a high risk with respect to economic, environmental and social impacts such that significant management costs, prolonged persistence or increase in current distribution are predicted;
- A species which presents a high risk in terms of potential distribution and progression on the invasion curve if left unmanaged such that significant management costs, prolonged persistence or increase in current distribution are predicted; and
- The species is recognised as a high risk under state and or federal legislation and management plans.

Figure 1: Generalised invasion curve (adapted from Biosecurity Victoria)

Conversely, a nuisance pest should then be defined as fulfilling most or all of the following descriptors:

- A species which has the potential to present a high risk if it progresses on the invasion curve such that its ability to establish reproduce and spread causes significant management costs, prolonged persistence or increase in current distribution are predicted, but is not currently progressed on the invasion curve at a local level;
- A species which presents a potential high risk with respect to economic, environmental and social impacts such that significant management costs, prolonged persistence or increase in current distribution are predicted, but is not currently progressed on the invasion curve at a local level; and
- The species may or may not be recognised as a high risk under state and or federal legislation and management plans.

It should be noted however, the above descriptors of a priority or nuisance pest are flexible and non-prescriptive. It is essential that vigorous and ongoing monitoring and surveillance are undertaken as prescribed in this Strategy to ensure that pest species are prioritised in an accurate and timely manner that is reflective of current circumstances. This feasibility of IPM is inextricably linked to the relationship between the stages of invasion, the level of effective control that can be expected and the likely return on investment.

5.2 Priority Pests

A list of priority pest animals and weeds has been decided by Council and the priority matrix is included in Appendix D|. The following species are currently identified as priority pests in Liverpool LGA. This list of priority pests will be the subject of regular reviews to respond to new incursions and priorities.

a) Fauna

- Cat (*Felis cattus*);
- European Fox (*Vulpes vulpes*);
- Feral Pig (*Sus scrofa*);
- Deer (*Cervidae sp*); and
- Mosquito (*Culicidae sp*).

b) Flora

- African Boxthorn (*Lycium ferocissimum*);
- Alligator Weed (*Alternanthera philoxeroides*);
- Asparagus weeds (*Asparagus* spp.);
- Blackberry (*Rubus fruticosus*);
- Boneseed and Bitou Bush (*Chrysanthemoides monilifera sub monilifera and rotundata)*;
- Cat's Claw Creeper (*Dolichandra unguis-cati);*
- Chilean Needle Grass (*Nassella neesiana*);
- Coolatai Grass (*Hyparrhenia hirta*);
- Fireweed (*Senecio madagascariensis*);
- Frogbit (*Limnobium spp)*;
- Kei Apple (*Dovyalis caffra*);
- Lantana (*Lantana camara*);
- Ludwigia (*Ludwigia peruviana*);
- Madeira Vine (*Anredera cordifolia*);
- Opuntia (*Opuntia* spp.);
- Salvinia (*Salvinia molesta*);

- Skunk Vine (*Paederia foetida*) ;
- Tiger Pear (*Opuntia aurantiaca*);
- Water Hyacinth (*Eichhornia crassipes*); and
- Willows (*Salix* spp.)

5.3 Nuisance Pests and Weeds of Concern

The following species are identified as nuisance pests in Liverpool LGA. It is recognised that management of these species is required and this is the subject of general actions, as prescribed (Section 8.2.1 and 8.2.4).

a) Fauna

- Feral Goat (*Capra hircus);*
- Red-eared Slider Turtle (*Trachemys scripta elegans*);
- Indian/Common Mynah Bird (*Acridotheres tristis);*
- European Carp (*Cyprinus carpio*);
- Cane Toad (*Rhinella marina*);
- Rabbit (*Oryctolagus cuniculus*); and
- Feral Pigeon (*Columba livia domestica).*

b) Flora

- African Olive;
- Other widespread woody weeds in Liverpool LGA:
  - Castor Oil Plant,
  - Green Cestrum,
  - Privets,
- Other environmental weeds of concern in Liverpool LGA:
  - Balloon Vine,
  - Crofton Weed,
  - Japanese Honeysuckle,
  - Morning Glory,
  - Mother of Millions,
  - Pampas Grass.



5.4 Native Species

Native species are not within the scope or intent of the Strategy. While there have been some complaints pertaining to native species (see section 10.3.2), Council's stance on this matter is that a shifted focus on community education to highlight that native species are protected under the *NSW National Parks and Wildlife Act 1974* and simple measures such as restricting food sources would assist

in lessening reports of nuisance native species. There are also specific requirements associated with the management of native species that are best addressed in a specific plan. As such, this Strategy does not discuss in any further detail management of native species by Council.

6| Current Integrated Pest Management Practices

6.1 Bush Regeneration at Priority Sites and Broadscale Weed Management Practices

Environment Restoration Plan (ERP) site restoration occurs in Liverpool LGA on a project-by-project basis within sites nominated by stakeholders, community, and Council. These sites are not always considered the best candidates from a conservation priority perspective. For instance, historical ERP sites selections have often been popular public areas, small in size, constrained by adjacent land uses or in poor condition. Council's priority is to protect higher conservation value bushland to improve biodiversity outcomes.

Council undertakes varying levels of proactive management for priority weeds and weeds of concern throughout the Liverpool LGA. There is a focus on reducing herbicide demand however acknowledging that limitations of non-pesticide alternatives are such that they can be more costly and less effective. Council undertakes its herbicide applications in public areas such as Council owned or controlled parks, bushland, and roadsides in line with its Pesticide Use Notification Plan (PNP). This pesticide use notification plan has been prepared in accordance with the requirements of the *Pesticides Regulation 2009*. The plan sets out how Council notifies members of the community of pesticide applications it makes or allows to be made to public places that it owns or controls. Pesticide use in certain public areas for instance adjacent to playgrounds, are not always welcomed by community and as such have been the subject of trial pesticide free weed management (see Case Study One).

Case Study One – Sugar Trial
Council undertook a trial at Wattle Grove Lake to reduce weed infestations including Cobblers Pegs (*Bidens pilosa*) using sugar. The trial was based on a CSIRO study which found that sugar reduces seed germination rates of some herbaceous weeds. Sugar was applied to a test plot, which was adjacent to a control plot that did not have sugar applied. Both plots were weeded and mulched. Sugar was reapplied to the test plot three months later. Within the first three months, limited Cobblers Pegs plants were present, and at six months no Cobblers Pegs plants were germinating. Results have persisted past the six month treatment period. The trial results reduced the reliance on herbicide use and paved the way for more economical and environmentally friendly weed control alternatives.

Weed management in Liverpool LGA tends to follow yearly programs that are not formalised and fulfil an estimated 95% of Council's legislative responsibilities. There are provisions to engage contractors who use spraying and manual removal for target weed surveillance and controls. However, this varies according to seasons and favourable conditions.

On private properties Council undertakes biosecurity compliance inspections and can issue notices for cleanup to landowners under the *Local Government Act 1993 (LG Act 1993)*. A statutory order under the *LG Act* is served by Council in circumstances when land, or premises, is not in a safe or healthy condition. The owner/occupier of the premises is required to undertake actions that are specified in the order, to ensure the land, or premises, is kept in a safe or healthy condition (s124 of the *LG Act*). Council may impose penalties upon owners/occupiers who fail to comply with this order. This action is guided by Council's Overgrown Vegetation Enforcement Standard (2021) which contains specific

criteria and exemptions to be considered when determining whether enforcement action can be taken under Order No 21.

The use of fire such as cultural burns to achieve bushland regeneration and pest management outcomes is of interest to Council but is not formalised and as such does not form part of this Strategy. Schedule 1 of the Protection of the Environment Operations (Clean Air) Regulation 2021 specifies that all burning is prohibited except with approval.

6.2 Asset Protection and Aquatic Weed Treatment

Council undertakes varying levels of proactive management for aquatic weeds throughout the Liverpool LGA. Notifications of online sales of prohibited aquatic plants are intercepted to prevent the sale and trade of prohibited matters.

Council undertakes annual control and regular surveillance of aquatic weeds at multiple sites (case study three) with a focus on assets identified as outbreaks on the Liverpool section of Nepean River, water sensitive urban design assets, roadsides, parklands, and bushland areas. Council also occasionally assists rural property owners who have priority aquatic weeds onsite.

6.3 Roadside Maintenance

Weed management on roads and road reserves within Council responsibility falls under *NSW Biosecurity Act 2015, Schedule 1 Part 3*, Duty to control weeds on roads and *Roads Act 1993 Part 9, Division 3: Section 142*.

Slashing and spraying of weeds is undertaken along roadsides by Council. However, there are no formalised work protocols with respect to hygiene practices to lessen weed spread such as washdown procedures, methods of priority weed reporting, or weed identification guides.

6.4 Reactive Actions for New Incursions and High-risk Species

Council's reactive actions to new incursions and high-risk species are largely governed by achieving legislative responsibilities under the Biosecurity Act. Ongoing proactive management of priority weed species are undertaken by Council's bush regenerators on Environment Restoration Plan sites. However, there are no formalised work protocols with respect to hygiene practices to lessen weed spread such as washdown procedures, methods of priority weed reporting, or weed identification guides.

There is limited capacity to address community complaints to pests which are not considered priority under regional and state plans. However, occasionally one-off funding has been allowed for the management of weeds such as an African Olive infestation at Glen Regent Reserve. These occasions are usually short-term and are not part of ongoing funding or management.

LLS is the leading support agency for priority weed management in Liverpool LGA which allows for funding and support for reactive actions against priority pests recognized under the Act. In some circumstances, priority pest animal incursions in the Liverpool LGA may present opportunity for reactive management in association with LLS (Case Study Two).

Case Study Two – Feral Pig at Voyager Point
Council bushland officers contacted the Greater Sydney LLS biosecurity team after observing evidence of feral pig activity at Voyager Point. Under the *LLS Act 2013* there is a Pest Control Order for Feral Pigs released in 2016 meaning that Council has a responsibility to destroy any that are found on Council land. A camera trap was setup in a nearby residents property to monitor the pig's movements. The pig was later trapped and destroyed as per legislative requirements.

6.5 Involvement in Collaborative Projects

Council has been involved in LLS projects for certain weed and feral animal species (Case Study Two and Three). Coordination with neighbouring Councils has been explored but ongoing management programs and commitments have not been reached.

Case Study Three – Multi-agency Frogbit Infestation Response
In October 2020, Council was a part of a multi-agency environmental effort which saw teams from NSW DPI, Greater Sydney LLS, Hawkesbury River County, Camden, Liverpool, Campbelltown, Lane Cove, Strathfield, Illawarra and Wingecaribee Councils tackle nine new Frogbit (*Limnobium laevigatum*) infestations. A total of 438 properties were surveyed for Frogbit with infestations removed from Rossmore, Bringelly, Leppington and Catherine Field. Surveillance is continuing in association with LLS to eradicate all Frogbit infestations from streams, dams, wetlands and water features.

7| Improvement to Integrated Pest Management Practices

7.1 Pest Species Management Improvement

Within this Strategy, 25 priority pest species, seven nuisance pest animals, and three weeds of concern are addressed, as discussed in detail in Appendix D| and Appendix E|. Recommended actions and improvements for the monitoring and management of these pests are included in Appendix D| and Appendix E|.

It is anticipated that Pest Management Plans would be developed as needed in the future to target specific priority pests that warrant detailed planning and action delivery. These species-specific plans are outside the scope of this Strategy.

7.2 Non Species-Specific Improvement

As per section 4.2 of this Strategy, several challenges relating to the implementation of pest management practices in Liverpool LGA are present. To address these challenges and for succinctness these are grouped into the following themes :

- **Internal governance** – issues relating to current internal Council management and coordination relating to pest management;
- **Adaptive implementation** – issues relating to ensuring that pest management activities are amenable and reflective of ever changing and evolving risks and invasion situations;
- **Resource prioritisation –** issues relating to making informed and rational decisions when considering resource allocation to ensure best outcomes for pest management;
- **Control measures –** issues relating to efficacy and feasibility of management practices when ensuring cost effect and minimal risk outcomes;
- **Educational programs & community engagement –** issues relating to community and stakeholder perceptions and expectations for Council's pest management activities and priorities (discussed in detail in section 10 of this Strategy);
- **Partnerships and collaboration –** issues relating to coordinating unified landscape scale pest management practices with neighbouring LGAs, community, regional and state governments, and other stakeholders (discussed in detail in section 10 of this Strategy);
- **Planning and development –** issues relating to coordination pest management obligations and practices for neighbouring land managers on non-council land; and
- **Pest species monitoring and tracking –** issues relating to implementing unified, systematic and ongoing reporting and monitoring of pest species distribution and management activities.

These themes are discussed in detail in section 9 in terms of possible actions, performance indicators as well as the associated responsibilities, timings and costings as outlined in section 8.

8| Proposed Actions

8.1 Species Specific Measures for Priority Pests

Recommended actions and improvements for the monitoring and management of the following priority pests in Liverpool LGA are included in Table 1, and Appendix D| and Appendix E|.

For actions towards the priority pest species identified above, the target timeframe for containment/no further spread status species should be over three years and where the status is eradication this should be achieved in five years. For species identified for asset protection, monitoring should be undertaken to track the condition of the asset to be protected to ensure maintenance or continual improvement.

Nuisance animals and weeds of concern for Liverpool LGA, including those identified within section 5.3, will be addressed through the integrated approach outlined in the themes in section 8.2.

Table 1 Species Specific Actions for Priority Pests

Species	Status	Actions	Responsibility	Budget Impact	Timing
Cat	Asset based protection	Expand education program (eg responsible pet ownership).	Community Standards	-	Ongoing
		Investigate establishing wildlife protection areas within high conservation lands.	City Works, City Environment, Property, Community Planning, Community Standards	Consultant costs (as required)	Year 1
European Fox	Asset based protection	Work collaboratively with any regional programs that are initiated.	City Works	-	Ongoing
Feral Pig	Eradicate	Ongoing surveillance of Council land to ensure early detection. Continue to work with land managers and LLS to swiftly manage any new incursion.	City Works	-	Ongoing
Deer	Contain	Continue involvement in LLS deer control program	City Works	-	Ongoing
		Work collaboratively with any ongoing regional programs that are initiated.	City Works	tbc	Ongoing
Mosquito (*Culicidae sp*)	Asset based protection	Continued implementation of Mosquito Management Plan	City Works	-	Ongoing (review Plan 2022)
African Boxthorn	Asset based protection	Continued reactive management on bush regeneration sites.	City Works	-	Ongoing
Alligator Weed	Contain	Annual control on multiple sites. Biological control (Flea Beetle) also active. Reactive management elsewhere.	City Works	-	Ongoing
Asparagus weeds	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing

Species	Status	Actions	Responsibility	Budget Impact	Timing
Blackberry	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Boneseed and Bitou Bush	Eradicate	Continued regular surveillance and control. Reactive management	City Works	-	Ongoing
Cat's Claw Creeper	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Chilean Needle Grass	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Coolatai Grass	Eradicate	Continued proactive management of all infestations. Increased staff awareness and machinery hygiene protocols to limit the spread. Eradicate new incursions.	City Works	-	Ongoing
Fireweed	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Frogbit	Eradicate	Continued proactive management. Routine monitoring and reporting.	City Works	-	Ongoing
Kei Apple	Eradicate	Continued proactive management. Large effort to remove this species	City Works	-	Ongoing
Lantana	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Ludwigia	Contain	Continued proactive management.	City Works	-	Ongoing
Madeira Vine	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing

Species	Status	Actions	Responsibility	Budget Impact	Timing
Opuntia	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing
Salvinia	Contain	Continued proactive management of all infestations.	City Works	-	Ongoing
Skunk Vine	Eradicate	Continued proactive management.	City Works	-	Ongoing
Tiger Pear	Eradicate	Continued proactive management including property inspections.	City Works	-	Ongoing
Water Hyacinth	Contain	Continued proactive management including property inspections.	City Works	-	Ongoing
Willows	Asset based protection	Continued reactive management on bush regeneration sites. Increased staff awareness and machinery hygiene protocols to limit the spread.	City Works	-	Ongoing

8.2 Integrated Pest Management Approach

To address the pest management related challenges in a succinct manner, eight themes have been devised and a matrix provisioned.

The approximate costs and timeframes are included in section 8.2, however it should be noted that these should be evaluated at least on an annual basis in line with a robust MERI framework (section 12).

Targets should be assessed and reported in Council's annual report as outlined in section 12 of this Strategy.

8.2.1 Internal Governance

These are actions relating to current internal Council management and coordination relating to pest management (Table 2). The actions are:

- Establish a working group to coordinate IPM implementation across the organisation. Responsibilities include:
  - • Identifying and designating areas of responsibility for current and future pests;
  - • Training of staff and integration of pest management into workflows; and
  - • Monitoring and reporting on targets and new incursions.
- Identify or employ a responsible officer to set up IPM initiatives and address gaps. (Potentially a temporary measure until long-term solutions identified by the working group are well established)
- Develop resources including site specific strategies and species-specific pest management plans. (Documents will be developed progressively with priority given to resources that are anticipated to cause the largest positive impact for pest management)
- Staff workshops and training on pest and biosecurity issues and responsibilities.
- Integrate biosecurity considerations into all Council works, including development of task protocols.
- Weeds of concern within the region to be addressed in Plans of Management for Natural Areas in accordance with the asset-protection based management approach.

They have been identified in response to the following current challenges:

- Coordination of teams for pest management issues that span the responsibilities of multiple teams;
- Gaps and weak inter-departmental relationships where a task or responsibility is not clearly assigned;
- Limited staff knowledge of the Biosecurity Act and associated General Biosecurity Duties; and
- Biosecurity actions are not consistently being implemented as part of Council's activities.

Table 2: Internal governance pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
1	Establish a working group to coordinate IPM implementation across the organisation. Responsibilities include: • Identifying and designating areas of responsibility for current and future pests; • Training of staff and integration of pest management into workflows; and • Monitoring and reporting on targets and new incursions.	• Group established with representatives from all teams with pest management responsibilities. • Meetings held, minutes taken. • Improved coordination of pest management.	City Works, City Environment, and Community Standards	-	Ongoing from year 1
2	Identify or employ a responsible officer to set up IPM initiatives and address gaps. (*Potentially a temporary measure until long-term solutions identified by the working group are well established*)	• Dedicated pest management officer identified.	City Works	1 FTE	Year 1
3	Develop resources including site specific strategies and species-specific pest management plans. (*Documents will be developed progressively with priority given to resources that are anticipated to cause the largest positive impact for pest management*)	• Qualitative assessment of whether there are situations where there are inadequate control monitoring and control tools to address pest animal impacts. • Number of active species-specific management plans, site specific strategies that address pest management.	Council team that is responsible for undertaking the subject control	Consultant costs as needed	Progressively from year 1
4	Staff workshops and training on pest and biosecurity issues and responsibilities.	• Number of staff participating in formal and informal training events.	City Works	Consultant costs as needed	Ongoing from year 1 (as required)
5	Integrate biosecurity considerations into all Council works, including development of task protocols.	• Task protocols include biosecurity considerations. • Statistics on activities under each of the seven steps of the general biosecurity duty procedure for pest animals	City Presentation, Infrastructure & Environment	-	Ongoing

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
		• Statistics on compliance with Vertebrate Pesticide Manual and Pesticide Control Order requirements.			
6	Weeds of concern within the region to be addressed in Plans of Management for Natural Areas in accordance with the asset-based protection management approach.	Service standards for weeds of concern identified in Plans of Management for Natural Areas Resources allocated in accordance with Plans of Management for Natural Areas to control weeds	Community Planning and City Works	-	Ongoing

8.2.2 Adaptive Implementation

These are actions relating to ensuring that pest management activities are amenable and reflective of ever changing and evolving risks and invasion situations (Table 3). The actions are:

- Respond to emerging pest issues, including adding species to priority pest list.
- Seek new funding and contingency funding as required to respond to spikes in pest activity, emerging pests and disturbance events. This should include external funding sources such as LLS.

They have been identified in response to the following current challenges:

- The need to respond to changing issues regarding pests and pest management, and resourcing;
- Action and species lists are snap-shots that need regular revision, not set lists;
- Management programs do not always scale up and down effectively in response to variations such as seasonal and climatic influences; and
- Accessibility and scaling of resources to manage pest issues following a disturbance event.

Table 3: Adaptive management pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
7	Respond to emerging pest issues, including adding species to priority pest list.	• Time taken to follow up on incursion reports • Follow-up activities (e.g. number of communication activities in local area, number of surveillance activities etc.) • Data on eradication attempts (e.g. number of eradication programs, duration/cost/area of program, outcome etc.)	City Works [lead], City Environment, Community Standards	-	Ongoing
8	Seek new funding and contingency funding as required to respond to spikes in pest activity, emerging pests and disturbance events. This should include external funding sources such as LLS.	• Adequate funding sources accessed to allow for required pest management. • Funding accessed from external sources ($).	Council team responsible for the management of the subject pest	As required	Ongoing

8.2.3 Resource Prioritisation

These are actions relating to making informed and rational decisions when considering resource allocation to ensure best outcomes for stakeholder perceptions and pest management (Table 4). The actions are:

- Base pest management actions and resource allocation on an assessment of pest species and response against IPM invasion curve and environmental, economic and human health impacts.
- Prioritise site-based pest management actions based on conservation value.
- Develop a customer service response framework, including:
  - Customer service guidelines(e.g. flowchart);
  - Educational resources (e.g. Council website); and
  - Contacts (including external contacts).

They have been identified in response to the following current challenges:

- Managing community expectations while trying to achieve optimal operational/strategic management of pests;
- Over-burdening Council resources with non-priority issues;
- Lack of consistent direction on when and where to assign resources;
- Target areas for Environment Restoration Plan (ERP) works not always in areas of high conservation value; and
- Inadequate management of natural areas leaves them susceptible to disturbance events.

Table 4: Resource prioritisation pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
9	Base pest management actions and resource allocation on an assessment of pest species and response against IPM invasion curve and environmental, economic and human health impacts.	• Resources for management activities relative to observed outcomes (e.g. changes in landholder participation, pest animal density, asset condition, reduced impacts etc.)	IPM working group	-	Ongoing
10	Prioritise site based pest management actions based on conservation value.	• Resources for management activities relative to the conservation value of the land. • Decrease in pests in areas of high conservation value.	City Works, City Environment	-	Ongoing
11	Develop a customer service response framework, including: • Customer service guidelines(e.g. flowchart); • Educational resources (e.g. Council website); and • Contacts (including external contacts).	• Number of targeted communications of various forms (e.g. extension materials, e-newsletters, media coverage, social media, community meetings, email and text reminders etc.) and access figures where available (e.g. on-line page views) • Improvements in knowledge, awareness, skills and attitude • Decrease in number of non-priority community complaints referred to officers	Customer Service, City Works, City Environment, Community Standards	-	Ongoing

8.2.4 Control Measures

These are actions relating to efficacy and feasibility of management practices when ensuring cost effect and minimal risk outcomes (Table 5). The actions are:

- Identify and utilise control measures that minimise impacts caused by pests in a cost effective manner that also minimises potential harm to the environment and off-target species.
- Implement early intervention measures to prevent pest outbreaks from escalating.
- Operational management of public land to contain and control existing infestations of weeds of concern.

They have been identified in response to the following current challenges:

- Impacts and public concern with some control methods;
- Effectiveness and costs of some control measures limit feasibility of their use; and
- Limited operational management of open space.

Table 5:Control measures for pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
12	Identify and utilise control measures that minimise impacts caused by pests in a cost effective manner that also minimises potential harm to the environment and off-target species.	• Number of, and funding for, trials into more environmentally and health conscious alternative control methods (number of alternative methods trialled, and $ per year)	City Works	Highly variable dependent on method.	Ongoing
13	Implement early intervention measures to prevent pest outbreaks from escalating.	• Time taken to follow up on incursion reports • Follow-up activities (e.g. number of communication activities in local area, number of surveillance activities etc.) • Data on eradication attempts (e.g. number of eradication programs, duration/cost/area of program, outcome etc.)	City Works	Highly variable dependent on method and species.	Ongoing
14	Operational management of public land to contain and control existing infestations of weeds of concern.	• Resources allocated in accordance with Plans of Management for Natural Areas to weed control • Monitoring of the extent of weeds infestations	City Works	Highly variable dependent on method and species.	Ongoing

8.2.5 Educational programs & community engagement

These are actions relating to community and stakeholder perceptions and expectations for Council's pest management activities and priorities (discussed in detail in section 9.2 of this Strategy) (Table 6). The actions are:

- Develop a communication plan
- Use existing communication channels (website, social media, newsletters etc.) to provide community information on pest management including:

  •Information on pests, weeds, and wildlife;

  •Ways to prevent pest outbreaks and facilitate early interventions;

  • Pest species prioritisation; and

  • Empowering community to manage pest and nuisance species on their own property.
- Targeted community engagement and resources to overcome barriers in CALD communities.

They have been identified in response to the following current challenges:

- Limited community knowledge about pest species, their impacts and management.
- Community perception as to what is a pest species, as opposed to a nuisance species.
- Community expectations for management of nuisance species
- Perception of CALD communities on pest species and their management.

Table 6: Community engagement and education programs for pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
15	Develop a communication plan	• Communication plan developed	Communications	-	Year 1
16	Use existing communication channels (website, social media, newsletters etc.) to provide community information on pest management including: •Information on pests, weeds, and wildlife; •Ways to prevent pest outbreaks and facilitate early interventions; • Pest species prioritisation; and • Empowering community to manage pest and nuisance species on their own property.	• Number of targeted communications of various forms (e.g. extension materials, e-newsletters, media coverage, social media, community meetings, email and text reminders etc.) and access figures where available (e.g. on-line page views) • Improvements in knowledge, awareness, skills and attitude (KASA) metrics post education programs – as determine by baseline and follow-up surveys • Indicators to be assessed through time (baseline to be collected as early as possible). Questions to align, where possible, to existing surveys (e.g. see LLS stakeholder surveys, DPI attitudinal survey and ABARES pest animal and weed management survey).	Customer Service, Communications, City Works, City Environment, Community Standards	-	Ongoing
17	Targeted community engagement and resources to overcome barriers in CALD communities.	• Number of targeted communications that are inclusive of CALD communities (e.g. more language options) • Improvements in knowledge, awareness, skills and attitude (KASA) metrics post education programs – as determine by baseline and follow-up surveys.	Communications, Community Development	-	Ongoing following development of IPM information

8.2.6 Partnerships and collaboration

These are actions relating to coordinating unified landscape scale pest management practices with neighbouring LGAs, community, regional and state governments, and other stakeholders (discussed in detail in section 10 of this strategy) (Table 7). The actions are:

- Using existing groups, communication channels and agencies as a mechanism to provide information and support to landholders, focusing on rural areas.
- Advocate to LLS for establishment of a pest management network for region.
- Partner with neighbouring councils and land managers on species specific programs, extending this to a south-west or western Sydney regional approach under the umbrella of the LLS as necessary.

They have been identified in response to the following current challenges:

- Creation of opportunities with LLS aligned with separate management outcomes;
- Limited coordination and partnering with neighbouring land managers (e.g. Councils, Sydney Water, Defence, TfNSW) to manage pests at landscape-scale; and
- Limited capacity to achieving effective management where regional approach is required (e.g. rabbit virus release and highly mobile pest species).

Table 7: Partnerships and collaboration for pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
18	Using existing groups, communication channels and agencies as a mechanism to provide information and support to landholders, focusing on rural areas.	• Number of landholders participating in pest training activities • Improvements in knowledge, awareness, skills and attitude (KASA) metrics post meetings / education programs – as determine by baseline and follow-up surveys. • Number of landholders participating in coordinated management programs. • Number of targeted communications that are inclusive of rural landowners.	Council (City Works, City Environment)/LLS	-	Ongoing
19	Advocate to LLS for establishment of a pest management network for region.	• Establishment of a regional pest management network.	Council (City Works)/LLS	-	Ongoing
20	Partner with neighbouring councils and land managers on species specific programs, extending this to a south-west or western Sydney regional approach under the umbrella of the LLS as necessary.	• Number of projects undertaken in partnership with other councils and land managers.	Council (City Works)/ neighbouring land managers/LLS	-	Ongoing

8.2.7 Planning and Development

These are issues relating to coordination pest management obligations and practices for neighbouring land managers on private land (Table 8). The actions are:

- Develop and enforce targets for the management of priority pests on private land to be dedicated to Council, including resources for monitoring and regulation.
- Develop guidelines for developers regarding pest management actions required as part of approvals (including VPAs) that include:

  • Pest management actions aligned with Strategy, including species specific actions.

  • Performance targets for pest species, including general weed densities and a minimum maintenance period.

  • Monitoring and reporting requirements.
- Identify funding mechanisms to cover ongoing residual pest management issues from land dedications and budget forecasting for operational management of areas dedicated to Council post-handover.

They have been identified in response to the following current challenges:

- Lack of clearly defined service standards outlining Council's expectation of developers with VPAs for open space improvements (e.g. bush regeneration) including no clear guidelines for monitoring, sign-off, and land handover.

Table 8: Planning and development for pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
21	Develop and enforce targets for the management of priority pests on private land to be dedicated to Council, including resources for monitoring and regulation.	• Number of land dedications guided by pest management targets	City Works, City Environment	-	Ongoing
22	Develop guidelines for developers regarding pest management actions required as part of approvals (including VPAs) that include: • Pest management actions aligned with Strategy, including species specific actions. • Performance targets for pest species, including general weed densities and a minimum maintenance period. • Monitoring and reporting requirements.	• Guidelines established for pest management actions required for developments.	City Works, City Environment	-	Ongoing
23	Identify funding mechanisms to cover ongoing residual pest management issues from land dedications and budget forecasting for operational management of areas dedicated to Council post-handover.	• Funding secured for ongoing pest management on land dedicated to Council.	City Works	Variable dependent on condition of land at dedication	Ongoing

8.2.8 Pest Species Monitoring and Tracking

These are issues relating to implementing unified, systematic and ongoing reporting and monitoring of pest species distribution and management activities (Table 9). The actions are:

- Coordinated reporting from works crews (not only bush regeneration team) for weeds and pest animals observed in the field.
- Record private property biosecurity inspections in Pathways
- Encourage the use of FeralScan by Council staff and community members.

They have been identified in response to the following current challenges:

- No systematic approach for monitoring or reporting; and
- Limited FeralScan use to record sightings.

Table 9: Pest species monitoring and tracking for pest management improvement, deliverables and performance indicators

	Actions	Performance Indicators	Responsibility	Budget Impact	Timing
24	Coordinated reporting from works crews (not only bush regeneration team) for weeds and pest animals observed in the field.	• Number of pests reported by works crews.	City Works	-	Ongoing
25	Record private property biosecurity inspections in Pathways	• Private property biosecurity inspection records created in Pathways	City Works	-	Ongoing
26	Encourage the use of FeralScan by Council staff and community members.	• Increase in number of pest species sightings recorded using FeralScan.	City Works, City Environment	-	Ongoing

9| Community Education and Engagement

Control measures for the pests covered within this Strategy contain a component of community engagement in order to minimise the impact of pests.

9.1 Commonly Reported Species

Council customer service request data was analysed for the period between January 2018 to September 2021 to identify pest species which are commonly reported as complaints to the customer service team. These results are summarised as follows:

- Cats and Pigeons are the most commonly reported species, but it is often unclear if the animals are domesticated, stray, or feral (approximately 20-30 records of each species that may relate to an animal that is not owned);
- Miscellaneous wild birds, often being a mixed flock of both introduced and native species predominantly associated with someone feeding them (18 records);
- Indian Mynas (seven records, often linked to a neighbour feeding them or other food source);
- Swarming Bees (four records);
- Rabbits (four records but given their location and description some or all may be domesticated);
- Foxes (three records - Holsworthy, Casula, and Cartwright);
- Muscovy Ducks (two records in response to an aggressive individual being dumped at Wattle Grove Lake);
- Carp (one record in Wattle Grove Lake); and
- Rodents and insects are often reported but tend to be associated with complaints regarding a neighbouring property (e.g. chicken coop or unhygienic conditions).

9.2 Education and Engagement Opportunities

Education material and engagement opportunities need to inform the community of their shared pest management responsibility, raise awareness of the work prioritised by Council, educate and assist in the identification and self-management of pests, and include community members of Culturally and Linguistically Diverse (CALD) backgrounds.

a) Interpretive Signage

It is crucial to employ clear visual signs in appropriate places in order to advise the public of issues in the area or pests to look out for. Signs can also advise of any prohibited activities such as feeding ducks or if in a Wildlife Protection Area inform the public that dogs must be on leads and that cats are prohibited. If signs are in a fishing area, they could show how to identify different aquatic weeds or fish species so that if species such as Carp or Gambusia are caught, they are informed not to release them but instead to euthanise the animal.

b) Website Information Pages

Council's website should be updated to include more robust and up-to-date information, resources and tools for the community about pests. This should be integrated with Council's customer services team to allow for the customer service team to direct complaints to these resources to reduce over burdening Council resources for non-priority issues. At a minimum there should be a webpage for:

- Priority weeds including an identification factsheet, information on Council's management practices, and details of how to report sightings (e.g., Council and the DPI Invasive Plants and Animals Enquiry Line);
- Priority animals including an identification factsheet, information on Council's management practices, and details of how to report sightings (e.g., Council and the DPI Invasive Plants and Animals Enquiry Line);
- Nuisance animals and non-priority weeds including an identification factsheet, information on Council's management practices, information on self-management if applicable, and details of when to report sightings to FeralScan, Council, and DPI Invasive Plants and Animals Enquiry Line; and
- Encouragement of resources such as Pest Tales (primary school resource), Feral Focus (secondary school resource), and NSW DPI Gateway e-learning modules.

c) CALD Communities

Liverpool is a multi-cultural LGA and as such there are often language barriers. It is therefore crucial that no matter whether the community engagement is in the form of signs, leaflets, webpages or face to face information sessions, it should be offered in multiple languages, pictures and symbols. Only if all members of the community fully understand the effect of their behaviours, can pests be successfully managed.

d) Domesticated Pets

A common theme with respect to many pest management issues, is that the problem is often exacerbated by the release of pets. Educational programs should be run informing the public of their legal responsibility with regards to this issue. Under the *BC Act 2016* it is an offence to liberate any animal (other than a captured protected animal) in NSW without authority. Part 2, Section 11 of the *NSW PCA Act 1979*, states that it is an offence to abandon an animal, providing grounds to prosecute members of the public who abandon domestic pets such as dogs and cats. As well as their legal responsibility, people should be made aware of the issues these released pets can then go onto create, such as cats and dogs preying on native wildlife.

e) Volunteer Programs and Events

Volunteer programs and community events encourage community participation, raise general community awareness and generate enthusiasm for pest management. Where appropriate and practical, these programs should be established, or existing programs should be broadcasted such as local bush care groups.

f) Citizen Science Initiatives

Cooperative research and data contribution should be encouraged among the community including the use of:

- PestSmart Connect;
- FeralScan;
- DeerScan; and
- FeralPigScan.

10| Resourcing and Funding

Resource constraints and continued decline is a deciding factor for the efficacy of IPM. The following are avenues of funding which seek to increase maximise return on investment of public funds to assist in achieving the aims of this Strategy.

10.1 Environment Restoration Plan

In July 2007 Council received approval for a permanent Environment Levy called the Environment Restoration Plan (ERP). The ERP funding levy equates to roughly $20.00 per annum for a 650m² block of land and aims to continue programs implemented by the previous environment levy as well as develop further environmental initiatives to be delivered in the Liverpool LGA.

The ERP provides a framework for the delivery of key environmental projects for the long-term benefit of Liverpool and its community. It includes an outline of the environmental projects, programs, and on-ground works to help improve the natural environment of Liverpool. A minimum of eight bush regeneration projects are to be carried out each year by qualified bush regenerators.

This ongoing initiative would assist in implementing Council's Strategy, particularly at sites recognized as high conservation significant assets.

10.2 Weeds Action Program (WAP)

The NSW Weeds Action Program (WAP) is a NSW Government grant funding initiative to reduce the adverse impact of weeds. It is guided by the NSW Biosecurity Strategy 2013-2021 and the NSW Invasive Species Plan (ISP). Approximately $1 million is allocated to the Greater Sydney WAP project per year from the funding body, NSW DPI. Securing funding from the WAP on an annual basis would assist in implementing Councils Strategy and contribute to managing priority weeds on a regional scale.

10.3 NSW Department of Primary Industries (NSW DPI) National Agreements

NSW DPI is a signatory to national agreements relevant to biosecurity, including the Intergovernmental Agreement on Biosecurity (IGAB), the Emergency Animal Disease Response Agreement (EADRA), the Emergency Plant Pest Response Deed (EPPRD) and the National Environmental Biosecurity Response Agreement (NEBRA). These agreements outline the roles and responsibilities of government and industry in responding to nationally significant incursions of emergency animal diseases, emergency plant pests and diseases, and invasive species. These agreements also detail the funding arrangements for those responses including emergency response arrangements and cost-sharing arrangements for responses to biosecurity incidents that primarily impact the environment and/or social amenity and where the response is for the public good.

To qualify under the above mentioned agreements, a report must demonstrate that the impact is nationally significant either ecologically and environmentally and that cost-benefit is favourable in terms of feasibility of eradication. In these circumstances a comprehensive targeted pest eradication that is eligible for cost sharing and reimbursement at its completion. Knowledge of these agreements

are linked to aims of this Strategy which should be amenable to changing pest species that could present themselves in future.

10.4 Federal Government Grants

Periodically the Australian Government will provide significant funding programs targeting the research and development for pest species management. For instance, the Communities Combating Pest and Weed Impacts During Drought Program— Biosecurity Management of Pests and Weeds provided $25 million in funding to eligible local councils to help manage the impacts of pest animals and weeds during drought. Council should continue to monitor the Government's Grant Connect website to monitor for available grant opportunities.

10.5 Other

Council supports several initiatives which undertake varying levels of pest management in the Liverpool LGA.

a) Georges Riverkeeper Program

The Georges River Combined Councils Committee Incorporated (GRCCC) was formed in 1979 by eight local Councils including Liverpool. The aim of the project recognises a collective responsibility for the health of the Georges River and collaboration to improve its environmental condition and ongoing management. The GRCCC provides a useful forum for the discussion of catchment issues, the facilitation of group projects and to provide a lobbying voice for local government. The Georges Riverkeeper Program has undertaken numerous projects along the river including weed management and habitat restoration.

b) Sydney Weeds Network Inc.

The Sydney Weeds Network (formerly Sydney Weeds Committees) is a small not-for-profit incorporated association of organisations, primarily local Councils, working together to assist in weed management across all land tenures in the Greater Sydney region.

11| Integrated Pest Management Monitoring and Recording Program

A Monitoring, Evaluation, Reporting and Improvement (MERI) framework is recommended to support this Strategy to ensure the consistency and comprehensiveness of data collection and reporting, as well as evaluate effectiveness of actions, and guide changes on pest management in Liverpool LGA.

At all stages of invasion (prevention, eradication, containment and asset protection), monitoring of pest management activities is required. Monitoring measures the effectiveness of actions in reducing the impacts of pest species and provides data about return on investment. Using this information, pest species programs can be reviewed and evaluated, and investment of resources (human and financial) realigned as required (Figure 2). The Strategy is supported by a framework to ensure that plans evolve to re-prioritise pest species and management areas and actions as required.

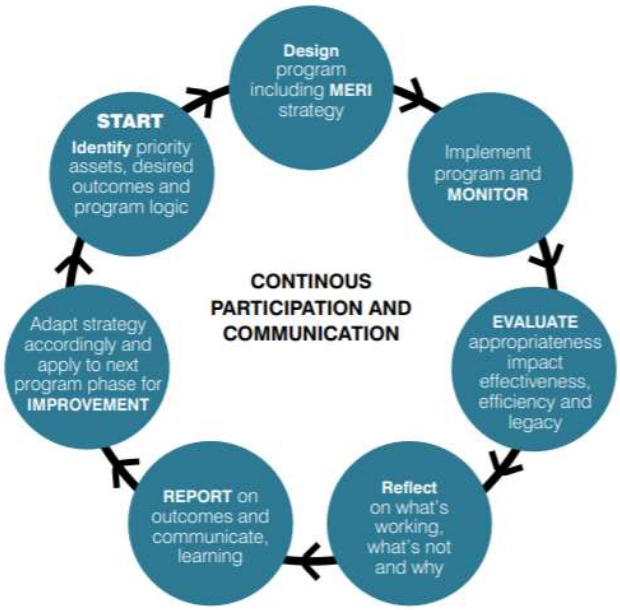

Figure 2: Program improvement and adaptive management under MERI framework (Australian Government Land and Coasts 2009)

11.1 Program Logic

Program logic is defined as the rationale behind a strategy in terms of what are understood to be the cause-and-effect relationships between program activities, outputs, intermediate outcomes and longer-term desired outcomes.

This logic underpins the MERI Framework and acknowledges that pest management operates at a range of scales and over different timeframes:

- Foundational activities—activities to inform investment, including planning, benchmarking, assessment and prioritisation.
- Immediate activities and outcomes—easily identifiable activities and related immediate goods, services and infrastructure.
- Intermediate outcomes—a combination of biophysical and non-biophysical results that lead to change by way of maintenance of and/or improvement in pest species issues.

- Longer-term outcomes—tangible and measurable changes resulting from maintenance of and/or improvement in NRM assets, including NRM organisations and institutions.

11.2 Monitoring

Monitoring involves collection and analysis of data to assist timely decision making, ensure accountability and provide the basis for evaluation and improvement. Monitoring data informs continual, broad-scale assessment through qualitative and quantitative measures of potential actions and the extent of change using two streams of monitoring data (Table 10):

- **Monitoring asset condition**—changes in the state of and trends in the condition of assets as measured at the area of investment and at higher levels through agreed indicators; and
- **Monitoring program performance**—changes in people, organisations, institutions, practices and technologies that create an environment that is conducive to improving asset condition.

Table 10: Metrics to monitor Strategy achievements

Monitoring Data for Asset Condition	Monitoring Program Performance
Baseline value	Reports of sightings and impacts by the community (e.g., through FeralScan and other mapping processes)
Target value (species specific)	Number of staff participating in formal and informal training events
Species distribution/relative abundance maps	Number of targeted communications of various forms (e.g., extension materials, e-newsletters, media coverage, social media, community meetings, email and text reminders etc.) and access figures where available (e.g., on-line page views)
Incursion reports and follow up activities	Number of landholders participating in pest management and training activities
Control effort	Funding for research projects underway
Proportion of priority pests actively managed	Resources for management activities relative to observed outcomes (e.g., changes in landholder participation, pest animal density, asset condition etc.)
Data on eradication attempts (e.g**.** number of eradication programs, duration/cost/area of program, outcome etc.)	Number of staff involved in pest animal management
Number of containment line breaches and data on managing breaches	Qualitative assessment of whether there are situations where there are inadequate control monitoring and control tools to address pest impacts

While quantitative data is required for direct spatial and temporal comparisons, there is a place for qualitative data and case studies to help illustrate complexity and linkages in both the biophysical and community/social aspects of pest animal management. Where possible and relevant, monitoring reports should include spatial data that is consistent with the investment design and program logic.

11.3 Evaluation

Evaluation encompasses the periodic assessment of the appropriateness of the Strategy via applied research techniques to generate systematic information that improves performance. It is critical at this stage that there is consideration given to the complexity of natural systems in order to ascertain links between pest animal management activities and changes in incursions, recorded sightings, community awareness and response and asset protection. The evaluation process should address the following matters relating to the implementation and progress of the Strategy:

- **Appropriateness –** the alignment of the program to current pest management best practice processes;
- **Impact –** the changes in asset condition, pest species distribution and whether changes are positive or negative and occurring as a direct result of the Strategy;
- **Effectiveness -** is the program attaining, or expected to attain, its objectives efficiently and in a way that is sustainable;
- **Efficiency –** are resources used providing the best value and productivity with respect to pest abatement activities; and
- **Legacy –** is the Strategy likely to allow for continued impact and effective management over time.

11.4 Reporting

Following from the evaluation of monitoring data, regular reporting intends to demonstrate the extent to which the Strategy is progressing and achieving set goals and targets. Reporting should also address shortcomings of pest management activities with achieving the goals of the Strategy. Reports should encompass:

- **Outputs;**
- **Finances;** and
- **Outcomes.**

Where possible, summary data in reports should be presented in graphical formats (maps, graphs, dashboards etc.) that are easily understood by a wide range of target audiences.

11.5 Improvement

Continuous review, learning and adaptation as informed by rigorous monitoring, evaluation and reporting is critical in attaining improved results. This process allows Council to reflect critically on the efficacy of the Strategy in terms of investments, current scientific advances, currency of best practices, program timing and target attainment.

12| Strategy Review Schedule

Once adopted, the Strategy will commence and be deliverable through the outlined actions on a continuous improvement basis for five years, with a review at three years.

References

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Appendix A| Integrated Pest Management Principles

Integrated Pest Management Principles

The United States Environmental Protection Agency (US EPA) has developed a four-tiered approach to practising IPM as follows (EPA 2021):

1) Set action thresholds

An action threshold is a point at which pest populations or environmental conditions indicate action must be taken to prevent the pest from becoming an economic or environmental threat. Seeing a single pest does not always mean control is needed.

2) Monitor and identify pests

Identifying pests accurately and monitoring their population and behaviour helps IPM practitioners detect when action thresholds have been reached and decide on appropriate control methods. Many weeds and insects that are considered pests are actually harmless, or even beneficial, and do not need to be controlled. Monitoring and identification reduces the risks of using the wrong type of pesticide or using pesticides when other strategies will be more effective.

3) Prevent pests from becoming a threat

Pests can be prevented from becoming a threat with minimal or no risk to people or the environment. Prevention can be highly effective and cost-efficient. Prevention methods include:

- in agriculture, selecting pest-resistant plant varieties and crop rotation; and
- in buildings, reducing clutter and maintaining good hygiene

4) Control

If prevention methods have not worked, and monitoring, identification and action thresholds indicate that pest control is necessary, the next step is to evaluate the control options. IPM prioritises methods that present the least risk to the environment and human health. These include

- physical controls such as trapping or weeding; and
- using highly targeted chemical controls such as pheromones to disrupt reproduction

If monitoring indicates that these methods are not effective, pest control methods such as targeted spraying of pesticides can be used. General spraying of non-specific pesticides is only done if all other measures have failed.

Appendix B| Legislation

Legislative Responsibilities

While the primary legislative requirements for IPM are set by *NSW Biosecurity Act 2015*, there is a wide ranging legislative framework applicable, along with related policies and procedures. An outline of the legislative framework with regards to IPM is presented below.

Relevant Legislation

- *Agricultural and Veterinary Chemicals (Administration) Act 1992 (Commonwealth)*
- *Agricultural and Veterinary Chemicals Code Act 1994 (Commonwealth)*
- *Biodiversity Conservation Act 2016 (NSW)*
- *Biosecurity Act 2015 (NSW)*
- *Biosecurity Regulation 2017 (NSW)*
- *Companion Animal Act 1998 (NSW)*
- *Crown Land Management Act 2016 (NSW)*
- *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*
- *Fisheries Management Act 1994 (NSW)*
- *Game and Feral Animal Control Act 2002 (NSW)*
- *Local Government Act 1993 (NSW)*
- *Local Land Services Act 2013 (NSW)*
- *Pesticides Act 1999 (NSW)*
- *Prevention of Cruelty to Animals Act 1979 (NSW)*
- *Protection of the Environment Operations Act 1997 (NSW)*
- *Work Health and Safety Act 2011 (NSW)*

Related Policies and Procedures

- *Greater Sydney Regional Strategic Pest Animal Management Plan 2018-2023*
- *Greater Sydney Regional Strategic Weed Management Plan 2017-2022*
- *Liverpool City Council Animal Management Policy*
- *Liverpool City Council Environment Restoration Plan*
- *Liverpool City Council Overgrown Vegetation Enforcement Policy*
- *Liverpool City Council Pesticide Use Notification Plan for Outdoor Public Places Liverpool City Council Work Health and Safety Policy*
- *Model codes of practice and standard operating procedures for the humane capture, handling or destruction of feral animals in Australia*
- *National Threat Abatement Plans (various species)*
- *NSW Biosecurity Strategy 2013 -2021*
- *NSW Invasive Species Plan 2018-2021*
- *Standard for Weed Management Capacity in NSW.*
- *Weeds and the Biosecurity Act: A handbook for local councils and councillors in NSW*

Primary Legislative Requirements

The *NSW Biosecurity Act 2015* states that biosecurity is the responsibility of all land managers, whether private or public. Similarly, the general public have a responsibility under this Act to reduce biosecurity risks through their activities and to alert the relevant authorities when biosecurity risks are sighted. A general biosecurity duty under the Act is that anyone who knows or ought to know

about a biosecurity risk has a responsibility to prevent, eliminate or minimise the risk where reasonably practical (LLS, 2018).

Fauna

The Act also includes a number of regulatory tools which land managers should be aware of when they are controlling biosecurity risks presented by feral animals.

Under the *NSW Local Land Services (LLS) Act 2013* and *NSW Companion Animals (CA) Act 1998*, local councils are required to manage both pest and domestic animals on land that they own, occupy or manage. Under the *NSW Biosecurity Act 2015* councils have a responsibility to prevent, eliminate or minimise biosecurity risks on public land. Councils are critical in the implementation of pest control plans (DPI, 2018a & LLS, 2018).

The importation of live animals is controlled by the *EPBC Act* and the *Biosecurity Act 2015.* The importation of animals such as the African hedgehog, Veiled chameleon, Red eared slider turtle, American corn snake and Boa constrictor is classed as Prohibited Dealing under the *Biosecurity Act 2015*. It is illegal to keep these species unless authorised for example under the *NSW Exhibited Animals Protection (EAP) Act 1986* or *NSW Animal Research Act (ARA) 1985.*

Part 2, Section 11 of the *NSW Prevention of Cruelty to Animals (PCA) Act 1979*, states that it is an offence to abandon an animal, providing grounds to prosecute members of the public who abandon domestic pets such as dogs and cats, which can then go onto to prey upon native animals. In addition, Section 23 of the Act states that the use of steel-jaw traps and snares are prohibited in New South Wales. The use of cage and soft-jaw leg hold traps is however permitted for fox control.

Under the *BC Act 2016* it is an offence to liberate any animal (other than a captured protected animal) in NSW without authority.

Under the *NSW Local Government Act (LG) 1993*, councils are to adopt practices of management which are consistent with threat abatement plan objectives, where council land is identified for involvement in a threat abatement plan.

Flora

Under the *NSW Biosecurity Act 2015*, Council has a legal obligation to manage the biosecurity risk posed or likely to be posed by reducing the impacts of Priority Weeds on human health, the economy, community and environment. Under Part 3 of the *Biosecurity Act 2015*, all landowners or land managers have a 'General Biosecurity Duty' to prevent, eliminate or minimise the Biosecurity Risk posed or likely to be posed by Priority Weeds.

The Greater Sydney Regional Strategic Weed Management Plan 2017 – 2022, developed by Greater Sydney Local Land Services, outlines the following two categories of Priority Weeds:

- 'State Priority Weeds'; and
- 'Regional Priority Weeds'.

It also lists

- 'Other Weeds of Regional Concern'.

Both 'State Priority Weeds' and 'Regional Priority Weeds' require specific control measures for individual weed species. 'Other Weeds of Regional Concern' have passed through a Weed Risk Assessment process that identifies outcomes for these weeds. This category is known as 'Local Priority Weeds'.

Appendix C| Roles and Responsibilities

Roles and Responsibilities

Shared responsibility is one of the key guiding principles with regards to IPM. Whilst the roles of the respective stakeholders vary, everyone has the same responsibility to ensure that they do not contribute to the introduction or spread of pests through their actions (Invasive Plants and Animals Committee (IPAC), 2016). An outline of the roles and responsibilities with regards to IPM is below.

Liverpool City Council

Under the NSW Biosecurity Act 2015 Council has a responsibility to prevent, eliminate or minimise biosecurity risks on public land. Council has a responsibility to manage pest animals and weeds on public land using best practice guidelines. Council should encourage responsible pest management within the community and other landholders. It should encourage the recording of feral animal and weed sightings and generate public awareness of associated issues. It should work in conjunction with other stakeholders including neighbouring councils and other governing bodies. Where Council land is identified for involvement in a threat abatement or regional strategic plan, it is to adopt practices of management which are consistent with the plan objectives.

Local Land Services

LLS works with the community and relevant stakeholders and Regional Pest Animal Committees to prepare and deliver Regional Strategic Pest Animal Management Plans.

These plans:

- Identify the priority pest species in each local area;
- Outline management outcomes for each pest type; and
- Outline local management approaches and provide local guidance on how people can contribute to managing pests.

Local Land Services:

- Continues to provide advice, education and guidance to land managers about pest management;
- Coordinates local pest management programs and Restricted Chemical Products vital for effective management of many priority pest animals; and
- Enforce the regulations when necessary.

Department of Primary Industries

The Department of Primary Industries (DPI) oversees the implementation of pest management policy in NSW. It has the lead role in administering key legislation such as the NSW Biosecurity Act. It represents the NSW Government at national forums. It releases alerts for novel species threats and provides state-wide support. It takes reports of any alert species in new areas via the NSW Invasive Plants and Animals Enquiry Line.

Environment Protection Authority

The Environment Protection Authority (EPA):

- administers the Pesticides Act 1999;
- develops and enforces pesticide use laws in NSW, including Pesticide Control Orders; and
- provides information and advice on the management of pesticides.

Pesticide Control Orders determine which pesticides can be used to manage pest animals and how this needs to be done.

NSW Department of Health

The Environmental Health Branch of NSW Health addresses the physical, chemical, and biological factors external to a person and the related factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments.

Environmental health issues include the provision of safe drinking water supplies, recreational use of water, sewage management, public swimming pools, toxicology, microbial control, skin penetration industries, funeral industries, mosquito vector management, air quality, heatwaves, waste management, and basic hygiene.

Landholders

Under the NSW Biosecurity Act 2015, landholders have a responsibility to prevent, eliminate or minimise biosecurity risks to manage their general biosecurity duty (LLS, 2018). Private land managers have a responsibility to manage any potential risks when trading feral animals for example for horticulture or agriculture and manage any vectors if they are conducting movement of goods and equipment (DPI, 2018a). They must also detect and report any new pest occurrences, cooperate and coordinate any pest management activities in conjunction with neighbours.

Bushcare Groups

Bushcare groups play a critical role in the management of pest species. This is in the form of direct removal of invasive weeds and promoting the regeneration of natural habitats increasing the available habitat for native species and discouraging pest animals. They can also assist with data collection.

Community Groups

Community groups play a critical role representing community interests with respect to pest species management. They promote collective action, support and build public awareness about pest management issues and assist with data collection (IPAC, 2017).

Appendix D| Matrix of Rationale for Pest Species Inclusion

Rationale for Pest Species Inclusion

The matrix for pest species inclusion is provided as a separate spreadsheet.

Appendix E| Discussion of Priority Pests

Discussion of Priority Species

The following are in depth profiles and the rational for inclusion for priority species identified for the Liverpool LGA. The invasion curve status in line with Figure 1 for each species has been included. It is anticipated that Pest Management Plans would be developed as needed in the future to target specific priority pests that warrant detailed planning and action delivery. These species-specific plans are outside the scope of the Strategy.

Cat (*Felis catus*)

Feral cat. Photo credit: C Potter

Status: Asset Based Protection

a) Background

With respect to pest management, cats are divided into three categories: domestic, stray and feral. Domestic cats are owned, fed and cared for. Stray cats reside in urban areas and may be lost pets. In contrast, feral cats exist as completely wild animals, without any dependence on humans. Whilst all cats, including well fed pets can have a devastating effect on native wildlife, feral cats are the ones subject to pest management (Sharp & Saunders, 2012a). Cats are carnivorous and can survive on little water, using the moisture from their prey. They can breed year-round and can have up to two litters of four kittens per year. However, most of the young do not survive (Sharp & Saunders, 2012b).

Council is not required under legislation to control feral cats; however, under the *Companion Animals Act 1998* it is the responsibility of Local Government to regulate domestic cats through identification and control of nuisance cats. Under this Act, councils may designate Wildlife Protection Areas (WPAs) from which domestic cats must be excluded. Some councils have declared some or all of their bushland reserves as WPAs to protect native fauna. Similarly, cats must be excluded from national parks and

reserves. Predation of native wildlife by cats is listed as a key threatening process under the *NSW BC Act 2016* and the *EPBC Act 1999*.

Cats are popular as pets throughout Sydney. Therefore, when cats are sighted it is difficult to know whether they are domestic or feral unless they are caught and checked for a microchip or unless a collar is visible. In Liverpool LGA cats are among the most common species recorded as a complaint by Council, but it is often unclear if the animals are domesticated, stray, or feral (approximately 20-30 records of this species that may relate to an animal that is not owned).

b) Current Management

Council does not currently have any designated control programs in place for feral cats. Furthermore, removal of problematic individuals is limited due to restrictions under companion animal act and "no kill" shelters. Council has adopted the Liverpool Urban Cat Management Plan (29 May 2021) which prescribes a comprehensive set of actions to address the uncontrolled cat populations. This includes:

- Desexing;
- Education about containment and responsible pet ownership; and
- Identification and registration

As adapted from the plan current statistics from the Council pound and the RSPCA are:

- 27 cats were impounded in 2020 by Liverpool Animal Shelter;
- All were dumped at the shelter or picked up by animal management officers;
- None were seized after attacking someone;
- 26 were rehomed and one reclaimed;
- It took an average of 45 days to rehome a cat;
- In 2018-2019, 659 cats from suburbs in the LGA went to the RSPCA
- Of these, 69% were stray cats and 76% were kittens; and
- Out of these 659 cats, 5 were reclaimed (1.8%), 49% rehomed and 37% euthanized (50% of strays).

c) Control Options

i) Education

Cats can have a high impact on native fauna even within their own backyard, particularly if the garden is close to remnant native vegetation. It is vital to drive public education with respect to the impact of cats. It is recommended that households keep their cats indoors, particularly at night time. Alternatively, households could build a cat run in their garden. It is also recommended that cats are made to wear collars with bells. Multiple bells are best, as there is anecdotal evidence to suggest that cats can learn to move in a way that will silence a single bell so that they can still ambush prey (Wollongong City Council, 2018). In addition, cats should be de-sexed so that they can't breed with feral cats and increase the population further.

ii) Shooting

A lethal control option is shooting which when carried out by competent shooters can be a reasonably humane method of destroying feral cats. If an animal is wounded, it must be found and disposed of immediately. Similarly, if a lactating female is shot, her dependent kittens must also be found and disposed of so as to prevent their starvation. However, shooting is quite labour intensive and therefore not very cost effective. It may have some effect if implemented over a sustained period of time, otherwise it is best suited to small, restricted areas (Sharp & Saunders, 2012b).

iii) Leg hold and cage trapping

The use of steel-jaw traps and snares are prohibited in New South Wales under the *PCA Act 1979* (Section 23) (Saunders & McLeod, 2007). The use of cage and soft-jaw leg hold traps is however permitted for feral cat control. Cage traps are most humane as they cause fewer injuries than when an animal is restrained in a leg-hold trap as animals can often struggle to break free and cause serious leg injuries in the process. Cage traps are also advantageous in that if a non-target animal is caught, it can be released unharmed. In addition, it can be conducted in areas where baiting would not be appropriate, such as in urban areas.

When placing traps, it is vital that they are checked at least once daily (Sharp & Saunders, 2012b). If conducting trapping in summer, ideally traps should be checked in the early morning and closed so no animals can enter during extreme temperatures of the middle of the day, and then reset in the evening so that animals are only contained during the cooler night temperatures. When placing traps, they should be sheltered from weather extremes as animals can suffer from exposure, thirst, starvation, shock, predation and stress myopathy as a result of capture.

iv) 1080 baiting

Baiting with respect to feral cats is not hugely effective and as a result is not widely used. This is attributed to the fact that cats occur in low densities, have large home ranges and naturally avoid feeding on carrion unless food is scarce (Sharp & Saunders, 2012b).

If conducting baiting, the only poison currently used in Australia for feral cat control is 1080. Another issue with baiting with respect to targeting feral cats, is that often non-target species, including native animals, working dogs and livestock can eat the baits as feral cat baits are not buried or non-target animals may scavenge on the dead body of an animal that has been poisoned (Sharp & Saunders, 2012b).

v) Exclusion fencing

Exclusion fencing can be a successful long-term method through which to protect endangered native species. However, setting up and maintaining cat proof fences can be very costly (Sharp & Saunders, 2012b).

In addition, exclusion fencing can also restrict non-target species, altering dispersion and foraging patterns as well as causing entanglement and electrocution; it can also cause a hazard to wildlife in the event of a bushfire (Sharp & Saunders, 2012b). Fencing is therefore not a practical solution for large scale control programs.

vi) Wildlife Protection Areas

Under the *Companion Animals Act 1998*, Council reserves can be declared Wildlife Protection Areas. Cats are prohibited from these areas. If domestic cats are found with reserves that have been declared Wildlife Protection Areas they should be identified and returned to their owner or taken to the pound.

vii) Challenges

A key issue comes with the differentiation between domestic, stray and feral cats. It is Council's responsibility under the *Companion Animals Act 1998* to ensure that all domestic cats have identification and are registered. Identification can include a collar or a microchip. If this is enforced, then when cats are trapped it is easier to identify them as feral. It is important when conducting lethal control methods, to ensure that only feral and not domestic cats are targeted.

Another key issue comes with the implementation of Wildlife Protection Areas as they are difficult to enforce. The correct signage can be implemented, and the public can be made aware of any new such areas within their region, however policing these areas in order to exclude cats is extremely difficult. Preliminary fauna surveys through camera trapping and spotlighting could be employed to gain an understanding of whether cats are present within the site. However, if cats are present, the next issue is that of appropriate management strategies.

d) Implementation

Cat control programs should be integrated with rabbit and fox programs so that their populations do not increase following the removal of feral cats. When cats are removed, other feral cats will move into the area and so it is essential that management strategies are ongoing. Because of this, cat management strategies can be highly costly to run, particularly on a large scale and therefore targeted controls might be more effective, for example in areas known to be frequented by endangered fauna species.

e) Monitoring

During the course of a program, accurate records should be kept as to the number of animals that have been removed and destroyed. Similarly, records should be kept of any other pests sighted whilst doing control work, even if they were not trapped. Fauna surveys including spotlighting should be conducted before and after the implementation of a control to establish if there has been a change in feral cat numbers

Accurate records should also be kept of any complaints or sightings submitted to Council by members of the public. The public should also be actively encouraged to upload their sightings to FeralScan, enabling the collection of cat data from a large variety of sources. It is important to try to market this facility in any community engagement materials.

f) Procedures

All control measures should be conducted by a licenced pest controller and health and safety procedures should be implemented. All pest animals caught should be humanely euthanased.

European Fox (*Vulpes vulpes*)

Foxes preying on native wildlife. Photo credit: Georgeanna Story

Status: Asset Based Protection

a) Background

Foxes are widely distributed throughout the entire Greater Sydney region (LLS, 2018). In the Liverpool LGA, there have been reports of foxes detected in in both rural and urban areas including on motion sensing camera. Sightings that have been submitted to FoxScan are scattered throughout the entire LGA, with no key hotspots of activity evident. Councils are required to manage foxes under the LLS *European Red Fox Pest Control Order 2014* released under the *LLS Act 2013.* Predation by foxes is listed as a Key Threatening Process under the *NSW BC Act 2016* and the EPBC Act 1999. They are identified as a regional priority pest with the management focus of asset-based protection. The key objective is in conserving biodiversity including threatened species, and reducing negative impacts to agricultural production, domestic pets and poultry.

Foxes are well adapted to living in urban and peri-urban environments as they are successful scavengers and opportunistic in nature. Population densities of foxes can be up to 10 times greater in urban areas compared to rural areas (DPI, 2021b) with densities reaching approximately 12 per km^2 compared to 1 per km^2 in coastal forests, 2 to 5 per km^2 in semi-arid and sub-alpine regions and 6 to 8 per km^2 in temperate grazing lands (DPI, 2021a). In the Southern Sydney Region there were estimated to be approximately 7,000 foxes (10 per km^2) (Hoh, 2016).

Anecdotal observations, following consultation with numerous councils, indicate that foxes are an ever-pervasive issue, with fox numbers increasing in many areas, whilst the populations of native animals are decreasing such as Bandicoot and Antechinus (Molino Stewart, 2018). In addition, foxes have been associated with increased weed dispersal as they often use thick invasive weed species such as blackberry for shelter (Sydney Coastal Councils Group, 2017). An objective of conducting successful fox control would be to increase the abundance and diversity of ground dwelling native mammals within Council reserves and minimise fox nuisance and weed dispersal

b) Current Management

Council does not currently have any control programs in place; however, can work collaboratively with other regional programs that are initiated. Actions should be consistent with the NSW Fox Threat Abatement Plan and Saving Our Species priority sites and actions.

c) Control Options

Fox control plans should be coordinated in association with LLS and other relevant landholders so that the largest impact can be had on the fox population (DPI, 2018). There are several potential control options with regards to foxes, each with its own strengths and weaknesses. A combination of control methods should be utilised to gain the maximum effect.

i) Leg-hold and Cage Trapping

The use of steel-jaw traps and snares are prohibited in New South Wales under *Section 23 of the PCA Act 1979* (Saunders & McLeod, 2007). However, the use of cage and soft-jaw leg hold traps is permitted for fox control. Cage traps are most humane as they cause fewer injuries than when an animal is restrained in a leg-hold trap as animals can often struggle to break free and cause serious leg injuries in the process. Cage traps are also advantageous in that if a non-target animal is caught, it can be released unharmed. In addition, it can be conducted in areas where baiting would not be appropriate, such as in urban areas.

When placing traps, it is vital that they are checked at least once daily (Sharp & Saunders, 2012a). If conducting trapping in summer, ideally traps should be checked in the early morning and closed so no animals can enter during extreme temperatures of the middle of the day, and then reset in the evening so that animals are only contained during the cooler night temperatures. When placing traps, they should be sheltered from weather extremes as animals can suffer from exposure, thirst, starvation, shock, predation and stress myopathy as a result of capture. Trapping is a very time-consuming exercise and trap rates can be very low. Therefore, if conducting trapping, it is critical to ensure appropriate placement of the traps and to allow for a large number of trap nights.

Contractors can be engaged to undertake trapping activities. Additionally, other Councils have programs where fox cage traps are loaned to members of the public with specific instructions. This approach could be explored to increase the capacity of fox controls in problem areas.

ii) Shooting

Shooting is a beneficial strategy in areas where it is not appropriate to lay baits or if foxes are not eating baits. Foxes can be attracted using artificial distress calls. It is critical that welfare issues are reduced and so it is recommended that a high velocity rifle that is fitted with telescopic sight is used, regardless of time of day. A spotlight of minimum 100w is also vital (DPI, 2021a). This may only be carried out a specialist pest species contractor licensed under the *NSW Firearms Act 1996* and authorised by the NSW Police and Council. Risk management controls need to be in place, particularly where this is carried out in urban and residential contexts.

iii) 1080 & PAPP Baiting

The use of 1080 for baiting programs is controlled by the *Pesticides Act 1999* and the *1080 Pesticide Control Order 2020*. Only Authorised Control Officers (ACOs) are allowed to obtain, handle, prepare and supply 1080 baits. A 1080 poison register must be kept by the Council or contractor. Baits should be utilised at optimum time to have maximum effect on fox abundance (during Spring and Autumn) and at times critical for fledglings for native bird species. Baits should be placed at least one week before the period of highest impact. Continue baiting at weekly intervals until bait uptake is minimal. Repeat the process if foxes re-enter the area (DPI, 2021a). Baits must be in accordance with minimum distance restrictions to minimise risks to people and non-target animals. They should not be placed in areas where the distance restrictions cannot be met or where they can contaminate surface and

ground waters. Specifically, 1080 baits must not be laid within close proximity to urban areas unless the program is planned in conjunction with and is approved by an ACO. An approved program must include strategies for minimising risk to non-target animals.

Best practice guidelines dictate that baits should be placed near fences and tracks throughout the target area. They should be buried at 200 to 500m intervals, using approximately 50 baits per 500 hectares. By burying the baits, the potential for other animals to eat the baits is minimised, they keep fresher for longer and if left on site they rapidly degrade. A spade or mattock should be inserted into the soil, levered approximately 50mm, the bait should be dropped in and then the soil should be levered shut again. The bait should be buried about 10cm deep. It is essential that all sites where baits have been deployed are marked and under the 1080 PCO, any bait not taken should be collected and buried according to current guidelines.

In rural areas baits can be used to poison foxes, however in urban areas this would present a large risk to domestic pets such as dogs and as such it is not a practical method (DPI, 2021b). If concerned about the effect on non-target species, bait stations without poison can be set up to monitor activity of animal species.

Para-aminopropiophenone (PAPP) is an alternative poison to 1080 and is subject to the same controls as 1080. It is designed to be used in areas where 1080 is restricted or for land managers who would prefer not to use 1080 (PestSmart, 2016). PAPP is considered to be a humane toxin and has an antidote, which if administered by a veterinarian within one hour of bait exposure, can allow a non-target animal to recover with no long-term effect.

iv) 1080 Ejectors

Ejectors are spring-loaded devices which are filled with 1080 and then buried in the ground with an attractant attached. As the target animal, in this instance foxes, bites the attractant, a spring-loaded plunger is triggered which punctures a capsule of toxin which is then propelled into the animal's mouth.

This method is advantageous as the capsules in which the 1080 is kept are more stable than placing the toxin in bait where it can degrade. Additionally, it has high target specificity as there is a required strength threshold in order to trigger the ejector. However, this method should be used in conjunction with other control methods (DPI, 2021a).

v) Exclusion fencing

When complaints are received from the public regarding loss of poultry due to fox predation, they can be advised to employ fox proofing. As foxes are able to jump, poultry pens should ideally have a roof, but if that isn't possible the fence should be at least 2m high with an overhang of 30cm. The floor of the enclosure should be reinforced with mesh, or mesh should be buried under the enclosure to prevent foxes from digging through (DPI, 2021b).

With regards to excluding foxes from larger areas such as conservation areas, they can be deterred through the use of electric fencing. A live wire can be placed approximately 200mm from the ground and offset 200mm from the fence and then another wire should be placed near the top of the fence and offset a similar distance. By having two live wires foxes are prevent from going under or over the fence. Alternatively, a 6 or 7 wire electric fence could be employed, as long as the space between the wires is sufficient to prevent them crawling through or under (DPI, 2021a).

Fencing can be very expensive to employ, and foxes can still go through at ramps, posts or over and under gates. In addition, if fencing is used for protection of an important habitat for flora and fauna, burrowing native species may dig under the enclosed area, making the fence compromised and thus allowing fox entry (DPI, 2021a).

vi) Den fumigation

Den fumigation can be used to destroy fox cubs, using carbon monoxide which is the only registered fumigant in Australia. The technique has been associated with an 80% reduction in cub activity. However, it is most efficient as a control measure when used in problem areas, with known active fox dens in significant zones such as near Council bushland reserves. As a general use control measure, den fumigation would not be considered cost effective (Saunders & McLeod, 2007)

vii) Habitat modification

In order to minimise the success of a fox, its habitat should be modified so as to reduces its resources such as the availability of food and shelter. Reduction in shelter can be achieved by dismantling dens when discovered, removal of dense weed species such as lantana and blackberry, and minimisation of rubbish sites. In order to remove available food, carcasses and roadkill should be removed as soon as possible and if pets are fed outside, the general public should be encouraged to remove any remaining pet food once an animal has finished eating (DPI, 2021b)..

viii) Guard animals

There is limited supporting evidence, however anecdotally it has been suggested that the use of animals such as llamas, alpacas, donkeys and dogs can reduce fox predation on vulnerable livestock and endangered animals (DPI, 2021a). This control has limited feasibility for urban and residential contexts.

ix) Challenges

As previously discussed, foxes are successful scavengers, and as such are excellent adaptors, often consuming roadkill or pet food that has been left outside. It is vital as part of fox control programs to implement community engagement in order to change public behaviours in order to remove available fox resources. As part of a community program, it is necessary to teach the public to always remove any remaining food after their pet has finished eating. Of even greater importance is to encourage the public to not actively feed foxes. In addition, the public should be encouraged to remove any dense weed species they may have on their property such as Lantana, African Olive, and Blackberry. Foxes use these as shelter and also act as dispersal agents as they eat the fruit and spread the seeds (Sydney Coastal Councils Group, 2017). As such they further the spread of these weeds, as well as increasing their own available habitat.

d) Implementation

It is recommended that Council pursue a combination of primary and secondary controls to manage foxes in the Liverpool LGA in areas with reported sightings and damage. These actions should be implemented with community engagement and weed management (blackberries).

Rabbits are a key prey item of foxes and so a rabbit control program should continue to be coordinated concurrently with the fox control program so as to reduce available food resources and potentially further suppress fox numbers (DPI, 2021a). Fox control without an equivalent level of rabbit control could lead to an increase in rabbit populations. Therefore, a fox control program should be coordinated and integrated with rabbit and cat control, as similar control methods are also used for these species.

All control measures should be conducted by a licenced pest controller and health and safety procedures should be implemented. All pest animals caught should be humanely euthanised. Implementation of management controls should prioritise the safety of the community and other species in the area, particularly those that are native. Council should also work collaboratively with other regional plans for fox management to ensure holistic management. Implementation should support fox management that is consistent with the NSW Fox Threat Abatement Plan.

e) Monitoring

Monitoring is important to determine if a formal fox control program should be pursued and to identify target areas. Accurate records of fox activity should be kept of any complaints, damage, or sightings, submitted to Council by members of the public. The public should also be actively encouraged to use and upload their observations to Feral Scan's *FoxScan.* This platform is a free resource which enables the collection of fox distribution data from range of sources which can be used to better inform pest management. By encouraging the reporting of sightings, a more accurate picture of fox distribution within the LGA can be obtained. Council should also use this resource to monitor and inform their management strategy to identify areas with higher fox sightings and nuisance.

If a control program is pursued, accurate records should be kept of the number of animals that have been removed and destroyed. Similarly, records should be kept of any other pests sighted whist doing control work, even if they were not trapped. Spotlighting should be conducted before and after the implementation of a control program to establish if there has been a reduction in fox numbers (DPI, 2021a). However, it is worth noting that fox abundance can be difficult to accurately measure as they are secretive animals (Saunders & McLeod, 2007). Therefore, additional survey methods should also be implemented, such as camera trapping and sand pads.

f) Procedures

All control measures should be conducted by a licensed pest controller and health and safety procedures should be implemented. All pest animals caught should be humanely euthanised. Safety of the community and other species (particularly native) should be prioritised.

Feral Pigs (*Sus scrofa*)

Feral Pig. Photo credit: Christopher Hume

Status: Eradicate

a) Background

Wild pig populations have been established in Australia following the release of domestic pigs, either through escape or deliberate release. Initially pigs were only found within proximity of human settlements, however now there are many feral colonies within rural areas. Estimates of the pig population size vary greatly in Australia from 3.5 million to 23.5 million (Sharp & Saunders, 2012b). Pigs can reproduce rapidly, with females being able to produce two litters of six piglets every twelve to fifteen months (Sharp & Saunders, 2012b). As such they are widely distributed in NSW and can rapidly recover following management programs. This combined with a pig's opportunistic omnivore diet and ability to survive in a variety of habitats makes them very successful feral animals.

Feral pigs are primarily managed by the *NSW Biosecurity Act 2015* (Section 15) under general biosecurity. They are classified as a regional priority pest with the objective of eradication, containment, and asset protection to reduce impacts for biodiversity, water quality and agricultural production. Predation, habitat degradation, competition and disease transmission by feral pigs is listed as a Key Threatening Process under the *EPBC Act 1999* and the *NSW BC Act 2016*. Under the *LLS Act 2013* there is a Pest Control Order for Feral Pigs released in 2016 meaning that Council has a responsibility to destroy any that are found on Council land. Feral pigs are defined as those born in the wild, that have lived in the wild, that demonstrate wild and erratic behaviour, that are not domesticated and that have some or all the following morphological features; long coarse hair, elongated snout, sloping hindquarters.

Feral pigs can have a huge effect on native ecosystems, the agricultural industry and community. They are known to cause substantial impacts to the natural environment. They consume a large variety of native plants and animals including invertebrates, frogs, lizards, snakes, turtles and their eggs, and small ground nesting birds and their eggs. They disturb natural ecosystems through rooting up soils

and grasslands and contribute to the spread of root-rot fungus which causes dieback disease in native vegetation. Further, they can cause major disruptions to agricultural enterprises including damage to crops, pasture, fences and water supplies, competition with livestock for pasture, and preying on newborn lambs. Additional, feral pigs are often hosts or vectors for diseases and parasites which can impact animals and humans.

Currently feral pigs are absent from most of the greater Sydney region, however there are established populations in south west Sydney as part of a larger western population in the Megalong Valley (LLS, 2018). There are also two isolated populations within the Sydney region, east of the divide near Penrith and Camden (LLS, 2018). Within the Liverpool LGA, there are reports of occasional sightings (see Case Study Two).

b) Current Management

Council does not currently have any designated control programs in place for feral pigs; however, undertake reactive management in conjunction with LLS as required. There are currently no known established populations in the Liverpool LGA. However, populations have been identified in nearby Southern Western parts of the region including Penrith and Camden so vigilant monitoring should be undertaken and should any pigs be recorded within the LGA the prevention guiding principle should be followed to inhibit the establishment of any populations.

c) Control Options

Control options for land managers should aim to reduce the risk of feral pig breeding, release into environment, accessing easy food sources and negative impacts on priority assets. Control options are best used in combined approaches and include the following:

i) Trapping

Trapping is a useful strategy in areas where baiting or shooting are not appropriate such as peri-urban and residential settings. It is also an effective technique as a follow up control, in order to prevent numbers from rising after being minimised (DPI, 2021f). To maximise effectiveness, traps should be set up where there are signs of current pig activity such as around waterholes. Trapping is a very time-consuming exercise. A study conducted by Eco Logical in 2004 commented that trap rates when targeting mammals are relatively low. A trap rate of 10% would be considered a good result (Eco Logical, 2004). Therefore, if conducting trapping it is critical to ensure appropriate placement of the traps and to allow for a large number of trap nights.

When placing traps, it is vital that they are checked at least once daily (Sharp & Saunders, 2012b). If conducting trapping in summer, traps should be checked in the early morning and closed so no animals can enter during extreme temperatures of the middle of the day, and then reset in the evening so that animals are only contained during the cooler night temperatures. When placing traps, they should be sheltered from weather extremes as animals can suffer from exposure, thirst, starvation, shock, predation, and stress myopathy as a result of capture. If any lactating female pigs are trapped their piglets should be found as soon as possible and also destroyed.

ii) Shooting (Ground & Helicopter)

Shooting from the ground can be used opportunistically as a follow up control after an initial knockdown program. Generally, this method is conducted using dogs to locate pigs and considerations need to be made to ensure humane treatment of both species. For areas inaccessible from the ground, helicopter shooting can be effective to generate an initial reduction in areas with large numbers of pigs. As a control, shooting is costly and is complex to implement in urbanised and residential areas. If used, these activities should be coordinated with other relevant multiple organisations, including the LLS. It is important to also consider shooting can disrupt pig behaviour and cause them to temporarily move to other areas and so should be planned carefully with other control programs (DPI, 2021f).

iii) Ground & Aerial Baiting

Ground baiting uses 1080 poison mixed with grain or pellets. It can only be prepared by ACOs. It is most effective when food sources are low. Poison free bait should be placed out for a minimum of three nights prior to administering the poison. Bait stations should take the form of 1000m^2 areas enclosed with fencing which pigs can push underneath but keeps out livestock and other non-target animals. Poisoned bait can be out for a maximum of three consecutive nights before it must all be removed. All dead pigs must be removed to prevent animals scavenging on their poisoned carcasses (DPI, 2021f).

More recently a new poison known commercially as HogGone has been trialled in parts of Australia as an alternative to 1080 which can leave environmental residue. HogGone is sodium nitrite based poison which is fatal to pigs but has no impact on non-target species such as birds or scavenging animals. Furthermore, the bait is administered using a pig-specific HogHopper which is designed to allow pigs to feed but excludes all other species.

Aerial baiting is highly restricted and must be approved by LLS based on their being no other available options for large populations (DPI, 2021f). This control is challenging in urbanised and residential context and current feral pig occurrences in Liverpool LGA don't warrant this intervention.

iv) Exclusion Fencing

Pig proof fences have been designed and can be used to protect valuable areas and assets, both of environmental and of economic significance. However, these fences rely on sustained maintenance to remain effective. This reduces its cost effectiveness for large scale control programs (Sharp & Saunders, 2012b). Additionally fencing can affect the distribution and migration of native animals.

v) Prevention

Compliance activities are identified as important regional controls in controlling the distribution of feral pig populations. New incursions are often the result of deliberate pig releases into the environment including translocations and illegal kept captive feral pigs. Investigation of reports of feral pigs in captivity or being released into the environment can prevent development of feral populations. Additionally, regular, and routine compliance checks for swill feeding of domestic pigs is important. Swill feeding is illegal in Australia and is defined as feeding pigs' food waste containing meat or other mammalian by-products. Swill may contain exotic diseases and lead to potentially catastrophic outbreaks such as foot-and-mouth disease, particularly if transmission occurs in a feral population.

d) Implementation

Control options should be guided by the scale of feral pig occurrences in the LGA. In the first instance, monitoring and prevention can be effective controls where there are no known populations. For isolated sightings, localised controls such as trapping, exclusion fencing, and ground shooting are most appropriate. However, should the population size escalate other incursions may be required. Management requires a number of methods in combination, using both primary controls to substantially reduce the population and secondary controls to reduce it further and prevent it building back up Possible control methods are outlined here.

e) Monitoring

Accurate records should be kept of any complaints or sightings, submitted to Council by members of the public. Monitoring for the development of any established pig populations in the LGA is important to support the Greater Sydney LLS aim of eradication and no ongoing pig populations. As there are currently no known pig populations within the LGA, where reports are made, follow up should be immediate to prevent any escalation of the population establishment or size. If pigs do enter the LGA, accurate records should be kept of any pigs that are removed and destroyed. Similarly, records should be kept of any other pigs sighted whist doing control work, even if they were not destroyed.

FeralScan's PigScan resource is available, and Council should actively encourage pig sightings and damage to be reported here. PigScan is a free resource that anyone can use to record sightings or problems caused by feral pigs. It is intended to assist government, communities, landholders, industry and pest controller to use data to support justified, effective and strategic pig management.

Council can use this to record, monitor and centralise data for sightings, damage and control actions. Community awareness and engagement materials should encourage the public to report their sightings to the PigScan website or App. As data reported on PigScan grows, this resource will become more useful to Council and other relevant stakeholders in regard to available localized information.

f) Procedures

All control measures should be conducted by a licenced pest controller and health and safety procedures should be implemented. All pest animals caught should be humanely euthanised and meet community expectations. Implementation of management controls should prioritise the safety of the community and other species in the area, particularly those that are native.

Deer (*Cervidae sp*.)

European fallow deer. Photo credit: Geoffrey Cox (CC BY 4.0)

Status: Contain

a) Background

There are six deer species within NSW, five of which are widespread (Fallow, Red, Sambar, Chital and Rusa deer). Hog deer are currently not widespread or in high densities and so are listed as an alert species for the Sydney area (LLS, 2018).

Deer are well established within the Greater Sydney region, including established populations in the Illawarra region, the Royal National Park and Hawkesbury area. There are also low to moderate numbers throughout the Wollondilly region, Central Coast and upper Hawkesbury (LLS, 2018). Within the Liverpool LGA, deer have been detected in the Western Liverpool area. Deer can have a large impact on native environments. They damage vegetation and plant growth through browsing, grazing, trampling, and antler rubbing. They can be dispersal agents for weeds by transporting their seeds. They also can affect water quality through wallowing and fecal contamination (DPI, 2021d). Additionally, community-based impacts are an increasing problem on the NSW east coast. This includes deer being a public nuisance, browsing on garden plants and causing vehicle and rail accidents. Deer can also pose significant problems for agricultural properties and enterprises including to damage fencing, crop damage and livestock conflict (injury, conflict and/or disease).

Herbivory and environmental degradation caused by wild deer is a Key Threatening Process under the *NSW BC Act 2016*. Research conducted in the research conducted locally in the Royal National Park informed this listing as it was determined deer were causing environmental impacts including damage to native vegetation and threatened ecological communities, weed dispersal and disruptions to seeding recruitment and growth.

Wild deer are considered pest animals under the NSW Biosecurity Act 2015 and are classified as a regional priority pest with the objective of eradication, containment, and asset protection to reduce

impacts for public safety, high priority environmental assets and agricultural production. There is no formal control order under the *NSW Biosecurity Act 2015* for deer, so there is no land manager obligation to eradicate deer beyond general biosecurity duty. Under Schedule 3, Part 1 of the *Game and Feral Animal Control Act 2002* deer are declared as a game animal in NSW. Hunting is controlled and regulated with restrictions on how and when deer hunting can be carried out. However, in some areas, in order to reduce feral populations, the NSW government has suspended regulations relating to deer hunting under the *Game and Feral Animal Control Act 2002* (DPI, 2021c).

b) Current management

Council currently has a deer control program underway in partnership with Penrith Council and Local Land Services. This program undertakes control work on private properties with cooperation from land holders.

c) Control Options

Deer control across the Greater Sydney region is complex as some deer populations are managed as pests and others as game animals (LLS, 2018). Effective control can be challenging and limited as shooting is the only suitable method, and this activity can be restricted in peri-urban and residential settings, due to firearm safety concerns (LLS, 2018). Deer are an emerging threat in rural western Liverpool with established populations in Greendale and neighbouring LGAs. NSW DPI recommends deer hunting on both public and private land as an effective management control.

i) Shooting

Shooting is generally accepted as an effective control to reduce feral deer populations. This should be conducted on both public and private land as a strategy to maximize containment and eradication. The suspension of some deer hunting regulations in 2018 was extended on 16 November 2021 until November 2026 to reduce restrictions enabling more extensive deer hunting activities. This includes the following: For public land hunters written permission by DPI and game hunting licence is required, however deer seasons do not apply, and electronic devices or callers may be used; for private land hunters, do not require a game hunting licence where permission from the landholder/occupier is obtained. See Table B-1 for regulations as of November 2021. NSW DPI Hunting should be consulted for current information deer hunting licensing and other requirements.

Table B - 1: Managing Feral Deer (DPI, 2021)

Rule	Private land	Public land	Notes
Must have permission of the landholder before entering any lands to hunt deer	Yes	Yes	Public land – written permission from NSW DPI
Must hold a NSW Game Hunting Licence	N/A	Yes	Public land – Restricted class (R-Licence)
May hunt all deer species all year round	N/A	Yes	Legal season for fallow, red, wapiti and hog deer suspended
May use electronic device to hunt deer	N/A	Yes	E.g., electronic game callers now permitted

Rule	Private land	Public land	Notes
Use of spotlights prohibited	N/A	Yes	Written permission conditions 12 and 13 prohibit hunting on public land at night using firearms or bows and the use of spotlights while hunting.

ii) Trapping

A range of trapping methods are available for physical restrain of deer. In Australia, the two main designs used are corral and Clover traps (Hampton et al, 2019). Clover traps have been used successfully by other councils in Greater Sydney such as Sutherland Shire Council. Different designs are suitable for different deer species and environments. Advice from pest control experts should be consulted for the most suitable design for the context. Trapped deer should be destroyed humanely.

iii) Challenges

These control methods can be effective; however, engaging private landholders to participate in culling operations in areas where there is limited council managed/owned land, inaccessible sites, high deer numbers and large areas of private land is recommended. This can include entering into targeted private property agreements with Council to install and maintain deer traps on their property. Engagement of recreational hunters in addition to contract/pest shooters may be useful in expanding control operations, particularly in areas otherwise inaccessible.

Best practice control techniques coordinated pest control programs and activities that incorporate both primary and secondary controls. Further, managing wild deer is most effective as a coordinated approach and should promote collaboration between Council, LLS, pest controllers and landholders (including groups of neighbours where relevant).

d) Implementation

Based on the current deer distribution in the Liverpool LGA, monitoring and targeted controls are likely to be effective. Private landholders should also be engaged. If deer occurrences increase in the LGA and pose threats, a deer control program should be pursued. This should be integrated with other regional plans as they can be highly costly and cover large geographical areas.

e) Monitoring

Accurate records should be kept of any complaints or sightings, submitted to Council by members of the public. Monitoring for the development of any established deer populations in the LGA is important to support the Greater Sydney LLS aim of eradication.

Feral Scan's DeerScan resource is available, and Council should actively encourage deer sightings and damage to be reported here. DeerScan is a free resource that anyone can use to record sightings or problems caused by deer. It is intended to assist government, communities, landholders, industry and pest controller to use data to support justified, effective and strategic deer management. This is important to mitigate human-wildlife conflicts as deer increasingly encroach on urban/residential setting.

Council can use this to record, monitor and centralise data for sightings, damage and control actions. Community awareness and engagement materials should encourage the public to report their sightings to the DeerScan website or App. As data reported on DeerScan grows, this resource will become more useful to Council and other relevant stakeholders in regard to available localized information.

f) Procedures

Key expectations of the whole community where deer control is conducted are that control actions are humane and do not impose safety risks to others. Should shooting be undertaken it must be conducted by a licenced pest controller and health and safety procedures should be implemented. Any deer that are only wounded when first shot, should be located and disposed of as quickly as possible to minimise suffering. If deer populations establish in the Liverpool LGA, LLS should be consulted in regard to the Supplementary Pest Control program which can remove regulations allowing accredited volunteer hunters to be utilised.

Mosquito (*Culicidae sp*.)

Mosquito. Photo Credit: JJ Harrison (CC BY-SA)

Status: Asset Based Protection

a) Background

Mosquitoes pose pest and public health threats such as mosquito-born pathogens and nuisance-biting. This can have severe impacts for those living or undertaking recreation in close proximity to wetlands. Of the 60 different species found in the Greater Sydney region, those found in major estuarine habitats have the greatest potential impacts due to their abundances, wide dispersal from habitats, inclination to bite and proven role in pathogen transmission.

To date, there is little information about the pest in the Liverpool LGA. Studies from neighbouring LGAs can help inform the likely risks impacting the Liverpool community. For example, populations associated with the greater Georges River region pose risk through the potential transmission of arboviruses (e.g., Ross River virus (RRV) and Barmah Forest virus (BFV)) and nuisance biting.

It has been acknowledged that a regional approach to mosquito management is required. However, in the interim Council has developed a mosquito management plan for the LGA. The objective of this plan is to develop a framework to enable better management of the pest and public health risks of mosquitoes associated with local area in a sustainable way, fostering future collaboration with stakeholders and community.

b) Current Management

Reports of mosquitoes in the Liverpool LGA are received during peak seasons and are a recognized item to include as a health priority. Council has a Mosquito Management Plan (September 2019) and includes educational material on their website.

Based of sampling from the mosquito monitoring program in Georges River, it is expected that there is mosquito dispersal from habitats along the Georges River with the potential to affect community in eastern Liverpool LGA including the suburbs of Hammondville, Voyager Point and Chipping Norton. In addition to mosquitoes associated with wetlands along the Georges River, those of secondary pest importance linked with fresh water or brackish-water wetlands are also of concern in Liverpool LGA. These can be associated with water-holding containers within urban settings.

c) Control options

An integrated approach that combines a number of strategies is most effective at managing risks posed by mosquitoes. Efforts should be made to avoid reliance on a single strategy to prevent longer-term problems such as the development of chemical resistance.

i) Physical Controls

Targeting mosquito sources and removing breeding sites can be an effective strategy, for example draining or filling wetlands. It is important that holistic wetland/environment wellbeing is assessed for this strategy to mitigate ecosystem impacts and approval is gained where the wetland is protected. Habitat modification in the urban environment can also be highly effective. Removing sediment and vegetation from stormwater systems can improve their functioning and reduce potential mosquito habitat. These incursions require routine maintenance and major works that may be expensive.

Commercial mosquito traps can be used as an inexpensive and simple strategy. They are readily available and popular with the general community. However, proved effectiveness is limited for the reduction of populations and prevention of mosquito-borne disease.

ii) Biological Controls

Introducing aquatic predators to reduce mosquito larvae can be a successful and longer-term solution. Fish species endemic to the local area can be released as a biological agent. This strategy reduces reliance on routine application of chemical agents. This strategy is not suitable in ephemeral and/or habitats that are substantially polluted.

iii) Chemical Controls

Insecticides such as adulticides and larvicides can be applied to reduce mosquito populations. Adulticides can be rapid, flexible, and relatively cost-effective making them a suitable strategy as an emergency response to disease outbreak. Application methods can include thermal fogging, ULV and residual insecticides. Adulticides used in fogging activities can be lethal to other flying insects (e.g., dragon flys, bees) and fish. Fogging should only be used if there is great public health risk and in appropriate environmental conditions, including optimal wind and drift over waterbodies and wetlands is reduced.

Larvae control is considered more effective against mosquitoes, and with less impacts for non-target species. Larvae control can be more cost effective than adulticides; however, sustained application can be time consuming.

iv) Cultural Controls

Water-holding containers of a wide range of size and shape can be found in urban areas including backyards and other domestic settings. This includes pot plant saucers, bird baths, roof gutters and other miscellaneous items that hold water with the potential to be mosquito habitat. Enhancing community awareness and encouraging the public to adopt practices to avoid mosquito bite is an effective strategy to reduce the impacts without impacting and modifying the environment. This strategy is cost effective and should increase awareness about personal protective measures and reducing backyard mosquito habitat.

Land use planning impacts such as water sensitive urban design dense vegetation is residential areas should be considered where there is potential or known mosquito risk

v) Challenges

Whilst mosquitoes pose health risks, they do play important ecosystem roles and any pest management should minimize the impact on the environment. Additionally, as many wetlands have conservation protection, management strategies should always check the official status of the target wetland (at local, national, and international levels) and ensure any relevant approval is obtained. Where chemical control is considered necessary, larvicides are preferred over adulticides as they have minimal environmental impacts and are more target specific.

d) Implementation

A combined approach is necessary for effective result in reducing the risks posed by mosquitoes. Actions consistent the Liverpool City Council Mosquito Management Plan (2019) and best practice should continue to be implemented. Community education is important for enhancing awareness of the pest and public health risks associated with mosquitoes and promoting personal protective measures. It is important that strategies include consideration of natural and urban land uses such as vegetation, stormwater, urban development, and water sensitive design. Surveillance, monitoring and mapping activities should inform priority target sites.

Operational and equipment costs from mosquito management and surveillance may be costly. Where feasible these activities should be coordinated with other regional programs and funding from NSW Health. As mosquito management programs can be expensive to run, strategies should be targeted and must be ongoing to ensure long-term effectiveness.

e) Monitoring

Rigorous monitoring consistent the best practice guidelines and the Liverpool City Council Mosquito Management Plan (2019) should be conducted. This includes ongoing sampling as part of the NSW Arbovirus Surveillance and Mosquito Monitoring Program and improving community awareness and reporting of mosquito nuisance. Mapping of key local mosquito habitats and target areas should inform monitoring programs.

f) Procedures

An integrated approach to mosquito management should be employed that combines a variety of strategies (chemical, physical, cultural and biological). Risks should be minimized for mosquito-borne disease transmission and interaction between the mosquitoes and the public reduced.

As many wetlands have an official conservation status, any relevant approval should be sought prior to undertaking mosquito management in these areas.

African Boxthorn (*Lycium ferocissimum*)

African Boxthorn. Photo credit: Bob Trounce (NSW DPI)

Status: Asset Based Protection

g) Background

African Boxthorn was originally introduced to Australia from South Africa and planted as hedges for wind breaks and fences. It is now widespread in regional Australia and listed as a WoNS. African Boxthorn is a perennial thorny shrub that produces red berries and white flowers. The berries are eaten by native and non-native birds and omnivorous mammals which disperse the seeds after passing through the gut. Young plants grow quickly.

African Boxthorn is considered a major environmental problem because it invades native vegetation, forming dense impenetrable thickets that exclude other plants and reduces suitable habitat for native wildlife. This weed also provides refuge habitat for introduced pests such as rabbit, European fox, and non-native birds. The fruit of African Boxthorn also harbours several pest insect species. However, in some areas where African Boxthorn has replaced native vegetation, it can provide suitable refuge habitat for native wildlife. The large thorns of African Boxthorn can also injure livestock and degrade the quality of livestock wool. The berries, leaves and roots of African Boxthorn are all toxic to humans.

African Boxthorn is drought-tolerant and grows across New South Wales. It grows in temperate, subtropical and semi-arid regions, and is most common on the well-drained soils of the western slopes and plains, especially dry creek beds.

h) Current Management

Reactive management, only managed on bush regeneration sites.

i) Control Options

Effective long-term control of African Boxthorn requires implementing a combination of control methods. Initial caution should be applied before mechanical clearing of African Boxthorn to avoid impacting native wildlife using the plants for refuge.

i) Chemical control

There are over 400 herbicides registered for use on African Boxthorn. Herbicides cause the plant to lose the leaves and appear dead, however it may recover, or seedlings may sprout in Autumn, so follow-up application is required. The most common herbicides used include Glyphosate, Picloram, and Triclopyr. Herbicides can be applied by basal bark or cut stump treatment, year-round, and by foliar spray in Autumn when new seedlings emerge. Foliar spray is the most common method of chemical control, however, is costly and so is more suitable for smaller plants. The whole bush should be sprayed when the plant is actively growing. This will vary depending on the location and rainfall. Spraying should not occur when the plant is under stress such as from droughts, water-logging, or cold temperatures. Foliar sprays are more effective when plants have more leaves. Basal bark treatment can be used for plants with stems up to 5cm by liberally spraying the bark from ground level to 30cm high. Cut-stump treatment is suitable for larger plants and in environmentally sensitive areas. The stem should be cut off 15cm above the soil level and the herbicide should be applied immediately.

ii) Mechanical removal

Mechanical removal is effective for large infestations in non-environmentally sensitive areas. A staged approach should be adopted where it is likely native wildlife are using the bushes as refuge. The bushes can be pushed using machines. The roots should be removed as well through cultivation, and this is easiest when the soil is moist. All plant material should be burnt following mechanical removal as the thorns still pose a problem, fruits can still produce seeds, and roots may sucker and regrow.

i) Biological Controls

There are no useful agents in Australia for biological control of African Boxthorn.

ii) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, mowing equipment etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through stock, produce or transported equipment. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

iii) Challenges

Control of African Boxthorn usually requires follow up after initial efforts to control regrowth and new seedling growth. Large infestations can be costly to treat with chemicals. Reinfestation can occur unless removed plants are replaced with natives.

j) Implementation

For maximum efficiency of time and funding, African Boxthorn can be treated at the same time as other priority bushy weeds such as Lantana (*Lantana camara*), Blackberry (*Rubus fruticosus* agg.), Boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) and Bitou Bush (*C. monilifera* subsp. *rotundata*).

k) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on monitoring regrowth after initial control efforts. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the African Boxthorn best practice manual (DCCEEW).

l) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Alligator Weed (*Alternanthera philoxeroides*)

Alligator weed. Photo credit: Sam Kieschnick (CC BY 4.0)

Status: Contain

a) Background

Alligator Weed is a potentially devastating weed that grows in water and on land, affecting both waterways and floodplain areas. It is listed as a Weed of National Significance (WoNS). Alligator Weed has extremely vigorous growth and great tolerance of normal control measures, which makes it a major threat to wetlands, rivers and irrigation systems.

Alligator Weed affects aquatic systems through excessive growth that restricts water use, alters aquatic ecology, excludes the growth of other plants, obstructs flows, causes problems associated with flooding and sedimentation, provides habitat for mosquitoes and degrades natural aesthetics. In terrestrial situations, impacts include degradation of agricultural land and pastures and contamination of crops, hay, turf, sand and soil.

Alligator Weed infestations across NSW are referred to as Target Areas and management strategies employed are specific to the nature of the infestations present in the Target Area. In some Target Areas, including the Greater Sydney areas, Alligator Weed infestations are long established and extensive and eradication is not considered feasible. Management strategies for these Target Areas aim for containment, suppression, and reduction of biomass and density.

In Greater Sydney the region is classified as a core infestation area where the main objective is to ensure containment of the species. Alligator Weed is widely distributed in the region. While broad scale elimination is not practicable, minimisation of the biosecurity risk posed by this weed is reasonably practicable. Land managers are to prevent spread from their land where feasible and

reduce the impact on priority assets. Additionally, under the Mandatory Measure (Division 8, Clause 33, Biosecurity Regulation 2017): a person must not move, import into the State or sell Alligator Weed. The recognized strategic response for the region is to implement quarantine and/or hygiene protocols and manage infestations in accordance with the Priorities for the control of Alligator Weed in the Sydney Region.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Alligator Weed commonly occurs within the Cabramatta Creek Catchment within Liverpool LGA as well as occasionally in rural dams. Currently Council undertakes annual treatment on multiple sites across Council owned lands. Council currently employs biological control for this pest species including the introduction of the Alligator Flea Beetle to graze on Alligator Weed infestations.

c) Control Options

i) Chemical control

This is currently the most cost-effective management strategy. In aquatic situations, eradication is not possible with the currently registered chemical glyphosate. The use of this chemical has achieved adequate long-term management, however the biology of the weed results in a 'burning off' of the plant above the water level. The 'burnt off' portions frequently break apart at the nodes, and disperse, which may be a source of additional infestations downstream. Therefore, this is best conducted with barriers in place to prevent spread, when sufficient resources are available. If a boom is to be placed across a waterway (not a farm dam) it may require a permit under the *Fisheries Management Act 1994* if it is likely to restrict the movement of fish. Glyphosate is poorly translocated into the roots of the plant, resulting in rapid regrowth in warm conditions. Permits have been granted for off label 'minor use' of other more effective herbicides, though this option is not available where water is used for irrigation, stock or where flow rates cause uncertainty as to the spread of the chemical. Eradication of terrestrial infestations is more easily achieved using Metsulfuron methyl, though this requires applications for at least two years.

ii) Mechanical removal

This has been effectively used in the past. The extensive root system necessitates the removal of a large quantity of the substrate, which can result in severe environmental consequences if used in aquatic situations. The disposal of contaminated material also presents a barrier. A permit is required to transport Alligator weed, and the weed must be either deeply buried at an approved site or burned.

iii) Biological control

The Alligator Weed Flea-beetle, (*Agasicles hygrophila*), has proved a reasonable biological control in aquatic situations, but does not make a significant impact on terrestrial infestations. Other insects subsequently introduced have not proved as successful, though investigations are continuing in Alligator weed's natural range.

iv) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, boating trailers, mowing equipment etc to prevent accidental and intentional spread to un-infested regions, in particular west of the Dividing Ranges. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through stock, produce or transported equipment. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

Alligator Weed has the ability to establish in new areas rapidly and successful control often corresponds with timely and rapid response. The challenge is to develop and deploy effective and efficient ways to contain an infestation before it becomes widespread

d) Implementation

For maximum efficiency of time and funding, Alligator Weed in waterways can be treated at the same time as other priority water weeds such as Water Hyacinth (*Eichhornia crassipes*) and Salvinia (*Salvinia molesta*).

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Alligator Weed Strategy and Alligator Weed control manual (NSW DPI).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Asparagus Weeds (*Asparagus* spp.)

Ground Asparagus. Photo credit: Bob Trounce (NSW DPI)

Status: Asset Based Protection

a) Background

Six of the ten Asparagus Weeds are WoNS including Bridal Creeper (*Asparagus asparagoides*) Bridal Veil Creeper (*A. declinatus*), Climbing Asparagus (*A. africanus*), Climbing Asparagus Fern (*A. plumosus*), Foxtail Fern (*A. densiflorus*), and Ground Asparagus (*A. aethiopicus*). The other four species include Asparagus Fern (*A. virgatus*), Ming Asparagus Fern (*A. macowanii*), Sicklethorn (*A. falcatus*), and Snakefeather (*A. scandens*). These species were introduced to Australia from southern and eastern Africa during the mid to late 1800s mainly for ornamental purposes. Due to their ability to easily disperse and establish in many environments, Asparagus Weeds have spread from gardens into native bushland where they cause major negative impacts.

Asparagus Weeds tolerate a wide range of soils and climates. Most prefer shady, moist conditions, but they can withstand full sun, drought and impoverished soils. Above ground, most Asparagus Weeds have wiry, twining stems that climb over vegetation. Some species have sharp spines along the stems. They have white or cream-coloured flowers and fleshy berries. The berries are mainly consumed by birds and the introduced European Rabbit and European Fox which disperse the seeds. Asparagus Weeds are also dispersed by water and by humans as garden plants. Below ground, Asparagus Weeds have large root masses which can be up to 85% of the plant's biomass. This allows the weeds to withstand harsh conditions, including drought and fire. This also allows the weeds to spread rapidly and dominate the ground and shrub layer, outcompeting native species.

Asparagus Fern

Asparagus Fern. Photo credit: Sheldon Navie

Asparagus Fern is an erect herb or shrub originally introduced as an ornamental plant. It is an emerging environmental weed over a wide range of coastal and sub-coastal habitats. It now occurs in coastal and sub-coastal Queensland and is especially common in the south-east of that state. In New South Wales Asparagus Fern is not widespread, but occurs mostly in the Sydney district. Asparagus Fern has the potential to invade a wide range of coastal and sub-coastal plant communities, in areas north from Sydney. It competes with native ground cover and understorey plants by forming dense infestations that smother other species and prevent their germination and establishment. It can form very large, continuous infestations.

Bridal Creeper

Bridal Creeper. Photo credit: Colin G Wilson

Bridal Creeper is a garden plant with climbing stems. It is now a major weed of bushland where it smothers native plants. Bridal Creeper is now a major weed of bushland in southern Australia, where its climbing stems and foliage smother native plants. It forms a thick mat of underground tubers which

impedes the root growth of other plants and often prevents seedling establishment. Rare native plants, such as the Rice Flower (*Pimelea spicata*), are threatened with extinction by Bridal Creeper.

Bridal Creeper is widespread in south-western Western Australia, southern South Australia and eastern Victoria. It is spreading through New South Wales and Tasmania. It can grow in most soils but is most common close to the coast where it invades woodlands and other open coastal vegetation. It is particularly vigorous in alkaline sandy soils and thrives in areas high in nutrients such as drainage lines.

Bridal Veil Creeper

Bridal Veil Creeper. Photo credit: Hillary Cherry

Bridal Veil Creeper is a fern-like scrambler or low climber with light green, bluish-grey or whitish berries. It quickly outcompetes other plants and could degrade bushland in parts of coastal NSW. Bridal veil creeper can grow very densely at ground and shrub level. It also forms thick tuberous root mats. It is highly invasive and:

- smothers native ground covers and shrubs
- outcompetes native seedlings
- reduces shelter and food for native animals.

Bridal Veil Creeper is not currently known to occur in NSW. It is present in south-west Western Australia, South Australia and western Victoria.

Bridal Veil Creeper is a potential weed of roadsides, urban bushland, coastal habitats, the banks of waterways, waste areas, rocky outcrops, open woodlands, closed forests and plantations. It is suited to the climate of most of southern coastal Australia and can tolerate cold winters and frost. It can grow in a variety of soil types, including sandy soils. It grows well in both shade and full sun.

Climbing Asparagus

Climbing Asparagus. Photo credit: Sheldon Navie

Climbing Asparagus is a climber or low shrub originally introduced as an ornamental plant. It has the potential to invade a wide range of coastal and sub-coastal plant communities from Cape York to northern New South Wales, but has been recorded as far south as Sydney. It strongly competes with native ground cover and understorey plants by forming a dense mat of rhizomes and roots that can prevent the germination and establishment of other species. It can attain very large and continuous infestations.

Climbing Asparagus prefers sub-tropical to tropical regions. It is primarily found in semi-evergreen vine thickets, brigalow, wet eucalypt forests, riparian areas and littoral rainforests.

Climbing Asparagus Fern

Climbing Asparagus Fern. Photo credit: Terry Inkson (MidCoast Council, NSW)

Climbing Asparagus Fern is a wiry branching vine that invades rainforest vegetation by climbing into the forest canopy and smothering trees. It is now a serious weed of bushland and rainforests and is a WoNS.

Climbing asparagus fern prefers fertile soils in high rainfall areas. It is a shade-loving plant.

Foxtail Fern

Foxtail Fern. Photo credit: Thu Truong

Foxtail Fern is a spreading ground cover with upright stems. It has dense foliage that look like foxtails and foliage and root mats that prevent other plants from growing. It is an ornamental plant that can invade native bushland. Foxtail Fern was previously included with Ground Asparagus, but has since been classed as a separate cultivar.

Ground Asparagus

Ground Asparagus. Photo credit: Bob Trounce (NSW DPI)

Ground Asparagus is a low growing, perennial scrambler with arching stems. It can form dense thickets that cover large areas.

Ground Asparagus grows very densely above the ground and forms thick mats of tubers and roots underground. It is a serious environmental weed because it:

- outcompetes native plants for water and nutrients
- smothers and kills small native herbs and shrubs
- reduces habitat and restricts movement for native animals
- changes soil and leaf litter composition, affecting soil life.

Ground Asparagus competes with some threatened native plant species and plants that are within endangered ecological communities.

Ground Asparagus grows along the NSW coast from the QLD border to the Victorian border. It grows in subtropical and warm-temperate regions with 500 mm or more per year. It is drought tolerant and can survive hot, dry conditions. Although frost damages the foliage, it will regrow from the roots. Ground asparagus grows in full sun or shade. It can grow in a range of soil types and thrives in sandy soils. This weed grows in a wide range of environments including:

- sandy foredunes and coastal headlands
- littoral rainforests
- heathlands
- open woodlands
- riparian areas
- wetlands including estuarine edges, salt marshes and swamps.

Seedlings can also grow in the forks of trees, in bird's nest ferns and amongst rocks or leaf-litter.

Ming Asparagus Fern

Ming Asparagus Fern. Photo credit: Sheldon Navie

Ming Asparagus Fern is a shrubby, ornamental plant that has become a potentially serious environmental weed of the eastern and southern Australian coasts. Ming Asparagus Fern has the

potential to invade a wide range of coastal and sub-coastal plant communities from north-east Queensland to eastern South Australia, and south-west Western Australia. It strongly competes with native ground cover and understorey plants by forming dense infestations that can smother and prevent the germination and establishment of other species. It can attain very large and continuous infestations.

Ming asparagus fern prefers semi-shaded situations. It is primarily found in the understorey of drier forests, but has the potential to invade riparian areas, forest margins, open woodlands, urban bushland, coastal environs, roadsides, disturbed sites and waste areas.

Sicklethorn

Sicklethorn. Photo credit: Sheldon Navie

Sicklethorn is a robust climber introduced as an ornamental plant. Stems become woody with age and have sharp, stout thorns that curve backwards. It is an emerging environmental weed.

Sicklethorn has the potential to invade a wide range of coastal plant communities from south-east Queensland to the central coast of New South Wales. The stems climb over and smother native vegetation up to 6 m tall. It also strongly competes by forming a dense mat of tuberous roots that can prevent the germination and establishment of other species. Sickethorn can attain very large and continuous infestations.

Sicklethorn prefers moist, semi-shaded conditions in sub-tropical regions. Seed can germinate in conditions from full sun to greater than 80% canopy closure. It is common near human habitation and is primarily found in riparian habitats, wet sclerophyll forest, swamp oak and subtropical rainforest communities.

Snakefeather

Snakefeather. Photo credit: Courtesy of the Southern Tablelands and South Coast Regional Noxious Plants Committee

Snakefeather is a creeping or climbing vine with thornless wiry stems. It poses a serious environmental weed threat to southern Australia. It is shade tolerant and competes with native plants for water, space and nutrients. Its tuberous root system forms a dense mat that prevents native seedlings from germinating, and its climbing stems can smother small understorey plants.

In New Zealand it is the most damaging of all the asparagus weeds, and in Australia it is thought that Snakefeather could have similar impacts to those of bridal creeper (Asparagus asparagoides).

Infestations are scattered in Australia but are increasing, particularly in southern Victoria. There are also infestations in northern Tasmania, South Australia and south-west Western Australia. In New South Wales the worst areas of infestation are around Sydney and on Lord Howe Island.

Infestations are found close to human habitation, but modelling predicts that Snakefeather could potentially invade across coastal areas of New South Wales and central and southern Queensland.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Effective long-term control of Asparagus Weeds requires implementing a combination of control methods.

i) Chemical control

The most commonly used herbicides on Asparagus Weeds are glyphosate, metsulfuron-methyl, fluroypyr, 2,4-D, picloram and triclopyr. Glyphosate, metsulfuron-methyl, and fluroypyr are used for all Asparagus Weeds, while others are species specific or used in combination. Herbicides are usually applied by the spot-spray technique. Otherwise, for larger plants, cut stump, basal bark spray or cut and paint techniques can be applied.

ii) Mechanical removal

Methods include hand pulling, digging / grubbing, crowning, and slashing. For asparagus weeds, these are only recommended for seedlings or small plants, in small to medium-sied infestations, or when working in high-value native vegetation or around cultural or geological assets.

iii) Biological Controls

Three natural enemies specific to Bridal Creeper have been released in Australia: the Bridal Creeper Leafhopper (an undescribed Erythroneurini formerly referred to as *Zygina* sp.) was first released in 1999, the rust fungus *Puccinia myrsiphlli*) in 2000 and a leaf beetle (*Crioceris* sp.) in 2002. The rust fungus and leafhopper have caused the most impacts. In good years, these agents can stop plants flowering and fruiting. Many more years of impacts by the agents are required to deplete the nutrient reserves stored in underground tubers and stop regrowth.

iv) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, mowing equipment etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed. High priority should be given to new infestations and isolated patches that have not set fruit or seed to prevent dispersal. At site level, prevention of asparagus weed infestations is achieved through:

- Assessing areas on a regular basis that are free from infestation but at a high risk of asparagus invasion
- Controlling potential vectors such as foes or stock if they have access to bushland.
- Treating isolated plants if found and before they set fruit.
- Thoroughly inspecting and cleaning machinery and vehicles if they have been used in known infestations before moving them to other locations.
- Raising awareness and ability to identify new asparagus weeds.
- Directing people to report any discoveries to an authorised officer who can assist with mapping the infestations and identifying control options.

Prevention and early intervention provides a high return on investment. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

Asparagus Weeds are difficult to control because a.) they generally have large underground reserves (root masses) and b.) several species have fine or waxy foliage that impede herbicide uptake.

d) Implementation

For maximum efficiency of time and funding, and for maximum weed control effects, Asparagus Weeds can be treated at the same time as other priority invasive vines and scramblers.

e) Monitoring

Monitoring should be one of the first activities implemented at a control site. It will provide a benchmark to assess the progress at the site. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Asparagus Weeds Management Manual (NSW OEH).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Blackberry (*Rubus fruticosus* agg.)

Blackberry. Photo credit: Courtesy QDNRM

Status: Asset Based Protection

a) Background

Blackberry is a prickly scrambling shrub with dark-coloured berries. It forms thickets, is one of Australia's worst weeds, and is a WoNS. There are many different blackberry species making up the *Rubus fruticosus* aggregate. In NSW, the European blackberry (Rubus fruticosus) is most common. Blackberry has already cost around $100 million to control and in lost production. It:

- quickly infests large areas
- forms dense thickets that restrict:
    - stock access to waterways
    - access via fire trails
- takes over pastures
- is unpalatable to most livestock
- reduces native habitat for plants and animals
- fuels bushfires
- provides shelter for rabbits and foxes
- provides food for introduced species such as starlings, blackbirds and foxes.

Blackberry can have some positives such as:

- edible fruit
- supporting pollinators
- food and shelter for some native animals and birds such as bandicoots and blue wrens
- leaves can be used in herbal medicines.

Blackberry infests about 9 million hectares of land in Australia. The *Rubus fruticosus* species in NSW grow in different areas:

- *Rubus anglocandicans* is the most common species in wetter areas of the state
- *Rubus leucostachys* is widespread
- *Rubus polyanthemus* is in Kosciuzsko National Park
- *Rubus laciniatus* is in wetter areas of the state
- *Rubus ulmifolius* var. *ulmifolius* is widespread
- *Rubus ulmifolius* var. *anoplothyrsus* may be present in NSW
- *Rubus vestitus* is uncommon
- *Rubus leightonii* is uncommon
- *Rubus phaeocarpus* grows in the Kowmung River area.

Blackberry thrives in:

- temperate climate with a warm summer and cool winter
- annual rainfall of at least 700 mm.

Blackberry can grow in drier climates if it has access to water (e.g. along a riverbank). It does not like heavy shade. Blackberry produces a lot of seeds. There can be up to 13,000 seeds per square metre under a blackberry bush at the end of a fruiting season. Birds and animals feeding on the berries spread the seeds in their droppings. Seeds also spread by water and with soil. When first year canes (primocanes) touch the ground, they sprout roots and become new 'daughter' plants. The next year, primocanes produce short canes with flowers and berries on the end.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Long term control of blackberry is an ongoing process. A combination of control methods and follow up is needed.

i) Chemical control

Herbicides are the most reliable blackberry control method. Use herbicides in combination with other control methods. There are many herbicides registered for use on blackberry. A mixture of triclopyr + picloram used with or without aminopyralid gives the best long-term control. Spray healthy, actively growing plants with new leaves on the cane tips. Apply to both the outer and inner leaves. First year plants are easier to kill with herbicide. Well-established thickets may need more treatments. After slashing or burning, wait until plants have up to 1 m of regrowth before applying herbicide. Some blackberry species are more resistant to certain herbicides than others. Identify the species before choosing a herbicide.

ii) Mechanical removal

Physical control alone is rarely successful because it is hard to remove all the roots. Cultivation often spreads blackberry further. Slashing can help make access through infestations, but promotes regrowth. After slashing, use a follow-up control.

iii) Grazing

Goats can make a start on controlling heavy infestations. Goats prefer blackberry over improved pasture species. Cattle will not control blackberry infestations but can stop daughter plants from establishing. Sheep may graze blackberry seedlings if there is no other palatable feed around.

iv) Biological Controls

The leaf rust fungus *Phragmidium violaceum* is the only deliberately released biological control agent in Australia. It attacks the leaves, and infects flower buds and unripe fruit and stops blackberry producing daughter plants. *Phragmidium violaceum* spores need dew, rain or high humidity to germinate. It is most effective when:

- most of the plant's canopy is young leaves
- annual rainfall is greater than 750 mm
- rainfall is evenly spread over the year,
- January temperatures average about 20ºC.

v) Prevention of spread and Education

Priority actions required to prevent the spread of Blackberry and to protect assets include implementing control to reduce impact at sites with significant ecological, economic or social assets and control to prevent spread from established infestations to sites with significant ecological economic or social assets.

The spread of Blackberry is often event or season-driven, and the rate of spread can be reduced considerably if land managers react to these events with appropriate measures. For example, events such as fire, floods, erosion or plant disease can cause an increase in the extent of bare areas that are vulnerable to invasion by blackberry (and many other weeds). Consequently, these areas, which may have been initially low-priority sites, may need to become a higher priority until the effects of the event have passed. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

vi) Challenges

Initially, it is important to identify potential challenges of controlling Blackberry. Large and dense infestations often provide significant challenges for gaining access to undertake control actions. Further, in some cases, Blackberry can provide suitable refuge habitat for threatened fauna. Therefore, coordination with other existing conservation programs, is very important to achieve cost-effective outcomes, minimise impacts to threatened fauna, and to keep all stakeholders engaged in implementing the control program over time.

d) Implementation

For maximum efficiency of time and funding, Blackberry can be treated at the same time as other priority bushy weeds such as Lantana (*Lantana camara*), African Boxthorn (*Lycium ferocissimum*), Boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) and Bitou Bush (*C. monilifera* subsp. *rotundata*).

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Blackberry control manual (NSW DPI).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Boneseed and Bitou Bush (*Chrysanthemoides monilifera sub monilifera and rotundata*)

Boneseed. Photo credit: Tony Rebelo (CC BY-SA)

Status: Eradicate

a) Background

Boneseed

Introduced as an ornamental garden plant, Boneseed was considered naturalized by 1910 and forms dense stands in bushland up to three metres tall. Growth occurs during winter and seeds germinate all year, peaking in Autumn. Plants can produce 50,000 seeds/year with approximately 60% viability and can remain dormant in the soil for up 10 years. Boneseed is an environmental weed that can outcompete native vegetation and reduce habitat and food for native animals, threatening endangered ecological communities. Spread occurs primarily via birds, water, machinery, contaminated landscaping supplies and garden waste.

Boneseed is a WoNS, and the Biosecurity (Boneseed) Control Order 2017 established a control zone with the objective of species eradication. Measures must be implemented to prevent, eliminate, minimise or manage a biosecurity risk and impact of the species. In the control zone, any new infestations must be destroyed immediately, and the local control authority notified. Council is responsible for assisting with identification and management information for this species as inappropriate control activities can cause further spread of the infestation. The recognized strategic response for the region is the detailed surveillance, mapping and destruction of all infestations where practical. Management must be in accordance with the NSW Weed Incursion Plan and appropriate quarantine and hygiene protocols should be implemented. High level analysis of pathways identifying

areas of potential introduction, prevention options and monitoring of eradication process to be conducted.

Bitou Bush

Bitou Bush is a South African invasive shrub, commonly planted on the NSW Coast from 1946 – 1968 by the NSW Soil Conservation Service to stabilise coastal sand drifts and revegetate dunes post sandmining (Winkler et al 2008). Bitou Brush poses threats to native species and ecological communities and has subsequently under been listed as a noxious weed and Key Threatening Process under the NSW BC Act 2016. The species is widely distributed making eradication unlikely. Bitou Bush is WoNS and State priority weed for NSW with the objective of species containment and protection of key environmental assets. Broad scale elimination is not practicable; however, minimisation of the biosecurity risk posed by this species requires containment and removal where it is reasonably practicable. A Biosecurity Zone (Part 5, Division 3, Biosecurity Regulation 2017) for strategic management of the species has been established for all land in the state further than 10km of the Pacific Ocean mean high water mark between Cape Byron (North) and Point Perpendicular (South). The Liverpool LGA is in the Bitou Bush Biosecurity Zone and land managers are to eradicate the weed where feasible, and otherwise destroy as much of it is practicable. Spread of the weed should be suppressed and where it is part of a new infestation, the local control authority (Council) must be notified.

Additionally, under the Mandatory Measure (Division 8, Clause 33, Biosecurity Regulation 2017): a person must not move, import into the State or sell Bitou Bush. The recognized strategic response for the region is to manage the species in accordance with the NSW Bitou Bush Threat Abatement Plan and Saving our Species. As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Presence of Boneseed and Bitou Bush is known to Council on the Eastern side of Liverpool LGA on sandy soils. An isolated infestation is also known in Bringelly. Council's management of these species at present is reactive. Surveillance and control activities are being conducted. Council's approach is to manage in line with biosecurity and regional priorities of eradication. Within the Greater Sydney region, both subspecies are considered naturalized over extensive areas.

c) Control Options

Effective control of these species should take an integrated approach using a combination of management techniques listed below. Manual removal and chemical controls are the best suited options for natural areas. The Bitou Bush Management Manual (Winkler et al, 2008) and Boneseed Management Manual (Briugham et al, 2008) provide further comprehensive details for control options.

i) Physical

Both plants can be removed physically. Seedlings and single plants can be removed manually, ensuring that the entire root system is removed. For Boneseed, plants should be disposed of by bagging the seed or fire when fruiting. Slashing can be used for mature plants and is suitable before plants have fruited or flowered to prevent seed dispersal.

Follow up controls such as immediate application of herbicides to the stem are required to prevent regrowth. However, these techniques are time consuming and impractical for areas that are extensive or where access is difficult

ii) Chemical

A range of chemical controls are available to manage Boneseed and Bitou Bush. The NSW Weed Control Handbook and NSW Weedwise provide up-to-date details for suitable registered herbicides and permit requirements. All herbicides should be applied in accordance with their directions, dosage, and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

Bitou Bush should be treated in winter with the plant is actively growing and peak flowering. There are six herbicide application methods permitted for use including cut-and-paint, stem injection scrape-and-paint, foliar spraying, aerial boom spraying and aerial spot spraying. Low and targeted application rates should be used to minimize impacts for non-target species

Preferred methods for chemically controlling Boneseed are cutting-and-swabbing and stem injection rather than foliar spraying as this reduces the impacts for non-target species including native ground cover plants. Foliar spraying can be more efficient for initial treatment, however, follow up controls may be more laborious if more weeds have colonized the resultant bare ground.

iii) Fire

Fire can effectively kill both Boneseed and Bitou Bush and is useful for reducing large numbers of plants. It can also destroy seed in the topsoil and litter. Initial burns should be followed up with additional controls as fire can stimulate germination of seeds from lower in the soil profile. Fire intensity impacts the effectiveness, so consideration of fuel load, season and fire history are pivotal. Permits from the relevant State fire authority and landholder permission are generally required.

iv) Biological

For Bitou Bush, two insects have been released in Australia as biological controls which are effectively reducing seed production. The Bitou Tip Moth (*Comostolopsis germana*) destroys the growing tips, and the Bitou Seed Fly (*Mesoclanis polana*) destroys developing seeds are both well-established along most Bitou Bush distribution. There are other biological controls being studied for their effectiveness as use to control Bitou Bush. There is no current biological agent for Boneseed

v) Grazing

Grazing of Bitou Bush and Boneseed can reduce its presence; however, this is not practical on public lands as livestock can pose case other issues such as erosion, fouling of areas from dung, browsing desirable native species and spreading undesirable weeds. Boneseed shouldn't be grazed if in fruit and if livestock do eat fruiting plants they should be monitored in a holding paddock to ensure the weed is not spread to new areas.

vi) Challenges

There can be additional challenges with fire as control techniques such as increased potential for weed invasion, erosion, pest animal traffic and human access. Mechanical controls can also lead to erosion problems and soil disturbance due to the removal of large roots.

Control methods can potentially have negative impacts on some native habitats. Management strategies must minimise disturbance to soil and desirable vegetation and encourage native plant regeneration, treating the target species at a rate which allows for these restoration processes. Clearing dense infestations can encourage other weeds to spread rapidly by reducing competition for light, water, nutrients and space. Before removing Boneseed and Bitou Bush, an assessment of, and management of other present weed species should be conducted to prevent expansions of these populations.

d) Implementation

A long-term control program should be established with scheduled control and follow-up activities at the time of year they will be most effective. Management approaches should be integrated and aim

to reduce seed production and spread by dispersal vectors. Whilst mechanical and chemical techniques are effective, they can be laborious and costly, so implementation should be coordinated with other species with similar control options. It is beneficial to select herbicides that can treat multiple weed species simultaneously.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Bitou Bush Threat Abatement Plan and Saving Our Species.

f) Procedures

Proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Cat's Claw Creeper (*Dolichandra unguis-cati*)

Cat's Claw Creeper. Photo credit: Royce Holtkamp

Status: Asset Based Protection

a) Background

Cat's claw creeper is an invasive, woody vine with yellow flowers and is a WoNS. Cat's claw creeper:

- forms dense mats that smother and outcompete native ground covers and seedlings
- climbs over shrubs and trees restricting growth or killing them
- can cause branches and whole trees to fall from the weight of the vines
- changes water flow when trees fall into waterways
- can create gaps in the canopy changing conditions for forest plants
- reduces food and shelter for native animals
- can damage infrastructure such as fences and sheds.

Cat's claw creeper is listed as a Key Threatening Process in NSW because of its potential to impact on endangered and vulnerable plants as well as Lowland Subtropical Rainforest, which is an Endangered Ecological Community.

Cat's claw creeper grows in coastal areas of NSW north of Sydney. Cat's claw creeper grows in subtropical, tropical and warm moist temperate climates. It can tolerate both heavy shade and full sun. It grows in a range of soil types but does not tolerate waterlogging. Plants can tolerate heavy frosts, drought conditions and saline soils. It grows:

- in rainforests, eucalypt forests and woodlands
- along waterways in coastal and hinterland areas
- in disturbed areas such as roadsides and occasionally gardens.

Seed pods mature in late summer to autumn and seeds start dropping from the vines in late May. Most seeds fall in July and August. Seed viability is low but seed production is high and some seeds produce multiple seedlings. The seeds germinate best when covered by moist leaf litter rather than buried in soil. The winged seeds can be blown in the wind and spread by water along streams and rivers. Established plants can reproduce from tubers and stems. Roots develop tubers in their second year. Detached tubers and stems sprout in moist conditions. The tubers can be spread in flood waters or by machinery if the soil is disturbed.

b) Current Management

Asset protection as part of bush regeneration projects.

c) Control Options

Using a combination of control methods is usually more successful. The methods chosen should be adapted to each situation, size and growth stage of the plant, and level of infestation. Freeing mature native trees from the vine is a key first step if you are restoring areas of native bushland.
To manage cat's claw creeper:

- treat isolated plants or sparse populations in areas you want to protect first
- check for and treat regrowth from roots, tubers and stumps for at least 5 years
- avoid damage to native vegetation and other desirable plants
- encourage the recovery of native vegetation to complete with the weed.

i) Chemical control

The most common herbicides used include Glyphosate, Picloram, and Triclopyr. Herbicides can be applied by scrape and paint, stem injection or cut stump treatment, year-round, and by foliar spray whenever new growth is present. For spraying application of herbicides, where possible, when the vines have not grown too high, pull cat's claw creeper down from desirable plants as it may be difficult to spray the leaves of the vine without also spraying the host. Use hand-held equipment to spray regrowth, seedlings and stems with foliage that is less than 2 m tall. This will minimise spray drift and off-target damage. Stems of the plant without leaves will not absorb herbicide. Spot spraying is often used as a follow-up control. For scrape and paint application, Cut stems about 50 cm from where they emerge from the ground and leave the upper stems to die in place. Scrape a strip of bark off one side of the lower stems and apply herbicide within 15 seconds to the scrape. Use a dye in the herbicide mixture so you can see which stems have been treated. For stem injection, thick vines can be treated by drilling holes approximately 10 cm apart around the woody stem of the plant using a 10 cm drill bit. The holes are then filled with herbicide within 15 seconds. If large tubers can be found underground, these can also be drilled and injected with herbicide. Cut stump treatment is the best method for large plants. Cut the climbing stems first, at about 1–2 m above the ground to clear a work area. Leave the aerial parts to die. Re-cut all stems as close to the ground as possible. Cut and scrape the stumps of thicker stems. Apply each cut or scraped surface with herbicide within 15 seconds.

ii) Mechanical removal

Pull stems away from any trees or buildings they are using to climb up. Cut the stems so that there is a gap between the part of the plant that is growing in the ground and the upper part of the vine. It is not recommended to pull the climbing stems out of tree canopy, as this may damage desirable plants and can be dangerous if branches fall from the tree.
Upper parts of the vine that have been cut, will eventually die. If some of the upper parts of the vine continue to grow, check to make sure all of the stems have been cut. Seedlings and small plants have tubers that can be dug out. Removing the larger, tuberous root mass of older plants can cause excessive soil disturbance and may not be suitable in all conditions. Tubers should be removed from the site as they can resprout. Contact your local council for advice on disposal.

iii) Biological Controls

There are two biological control agents for cat's claw creeper in NSW:

- *Carvalhotingis visenda,* a leaf sucking tingid
- *Hedwigiella jureceki,* a jewel beetle.

Both of these species feed on the leaves. The jewel beetles feed up higher in the canopy than the tingid so it is useful to use both agents. The jewel beetle is still being reared and released in NSW.

iv) Prevention of spread and Education

Identify locations where cat's claw creeper occurs as isolated plants or sparse populations. Remove seedlings and treat isolated plants or clumps first and follow up. Cat's claw creeper can spread along rivers, particularly from seeds dispersed by floodwaters. Keep un-infested areas free of cat's claw creeper. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

Dense infestations of cat's claw creeper are very difficult to control due to its numerous lianas, abundant seed and ability to resprout from the tubers, sometimes for years.

d) Implementation

For maximum efficiency of time and funding, and for maximum weed control effects, Asparagus Weeds can be treated at the same time as other priority invasive vines and scramblers. Mechanical control methods can be implemented anytime, although pre-flowering / fruiting is best. Herbicides application is most effective when plants are actively growing.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Cat's Claw Creeper Weed Management Guide (NSW DPI).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Chilean Needle Grass (*Nassella neesiana*)

Chilean Needle Grass Photo Credit: Romi Galeota (CC BY 4.0)

Status: Asset Based Protection

a) Background

Chilean Needle Grass (CNG) is a serious pasture and environmental weed that poses substantial threat to agricultural enterprises, native vegetation and amenity areas. It is a perennial grass native to South America and is listed as a WoNS. In NSW, its known range extends from the Northern Tablelands, along the Great Diving Range to the Southern Tablelands. Reportings are limited in the Greater Sydney Region but have been recorded around Erskine Park, Camden and the Illawarra area, for the period 2017-2021. Known presence in Liverpool LGA is limited; however, proximity and connectivity to these areas with greater recordings is an important consideration.

CNG is highly invasive with vigorous growth and may compete with and displace native plant communities. It is particularly resilient to drought and heavy grazing. It establishes well on bare ground and is difficult to control due to the persistent seed bank it builds up in the soil. Spread occurs via seed and this includes normal (flowering) seeds and stem seeds that are concealed and enable the plant to reproduce if flowering has been prevented.

Studies show that seeds have very high viability (90%) and can remain viable in the soil for several years (Muyt 2001). Habitats where it can occur include bushland, pastures, grasslands, roadsides, disturbed areas (including trails), riparian systems, urban areas, recreation areas and parks (ALA, 2020). The seeds are sharp and pointed, and readily attach to machinery, clothing, and animal coats. Seed can also be dispersed by floodwater. Impacts include reduced biodiversity, livestock injuries (seed penetration to skin, eyes and fleece) and downgraded pasture. In urbanised areas (including amenity areas) CNG can also cause irritation to humans and domestic animals such as dogs due to seed penetration. Containment is necessary to prevent further spread and infestations around the state.

As a Weed of National Significance which is widely distributed in some parts of the state, its spread must be reduced to protect priority assets. Whilst broad scale elimination is not practicable, minimisation of the biosecurity risk posed by this weed is reasonably practicable. Land managers are to prevent spread from their land where feasible and reduce the impact on priority assets. Additionally, under the Mandatory Measure *(Division 8, Clause 33, Biosecurity Regulation 2017*): a person must not move, import into the State or sell Chilean Needle Grass. The is currently no specific strategic response for the region; however, general biosecurity duty applies.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

CNG is managed reactively in Liverpool LGA. Council's approach is to manage this in line with biosecurity and regional priorities and prevent its spread in plant and brush cutting machinery. CNG is difficult to control due to the persistent seed bank and so prevention of CNG spread is the objective. Other options include the use of herbicides, pasture management and crop rotation. It is imperative that CNG controls should focus on preventing the flowering of CNG seedlings.

c) Control Options

i) Chemical Control

Herbicides can be an effective measure for controlling CNG. These generally contain glyphosate (non-selective) or flupropanate (selective). A selective herbicide should be considered to minimize the impacts for non-target species which can compete with the CNG. Pasture species have varying tolerances to these herbicides and so may result in the suppression of desirable species. Application to heavy infestations should be regularly checked and controls followed up due to the likelihood of creating bare patches where more CNG will grow.

Where possible, spot rather than boom spraying is appropriate. Follow up controls and surveillance are critical for containment and longer-term eradication.

The NSW Weed Control Handbook and NSW Weedwise provides up-to-date details for suitable registered herbicides. All herbicides should be applied in accordance with their directions, dosage, and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

ii) Non-Chemical Control

For successful containment, the whole plant needs to be destroyed. Thus, physical removal of the needle grass is effective for small patches and singular plants. This method can be effective and leaves less bare soil than herbicide spot spraying.

Mower and brush cutting machinery may reduce seed set in the grass flower heads, but it will not remove the stem seeds. These methods are also likely to further distribute seeds. Appropriate consideration about undertaking these controls when the grass is not flowering and using mowers with catching attachments is recommended. It is important that the clippings are destroyed (i.e., burnt) and that any machinery used is thoroughly cleaned before being taken elsewhere.

Control may also be achieved by sowing dense crop or pasture to create competition and reduce the quantity of needle grass that can germinate. Maintaining healthy pasture and addressing patches that are thin and bare is an effective long-term strategy to prevent invasion.

iii) Biological Controls

There are no useful agents in Australia to biological control CNG.

iv) Prevention

To avoid invasion, minimize bare soil by seeding desired species and maintain healthy pasture. Vehicle and machinery hygiene should be ensured when moving into clean areas. This is a priority to prevent the spread of seeds with the potential to germinate. Machinery and vehicles should be washed down where appropriate. This requires the practice of good hygiene of boots, tyres, boating trailers, mowing equipment etc. to prevent accidental and intentional spread to un-infested land. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through stock, produce or transported equipment. Additionally, animal movement from infested areas should be controlled.

Early detection and remove plants before they seed. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

The key challenges for controlling CNG are the prevention of seed spread due to high seed viability and seed banking in the soil. Early detection, follow up controls, ongoing surveillance and machinery/vehicle hygiene are crucial for containment. Chemical controls are useful for the removal of needle grass; however, risk leaving bare soil which creates an optimal environment for further seed germination. It may be necessary to use a combination of follow up controls to mitigate this.

d) Implementation

For maximum efficiency of time and funding, CNG should be identified and managed as early as possible, ideally before seeding occurs. Where the infestation is small, physical removal and/or spot spraying of singular plants is effective. Where the infestation is more substantial, it may be appropriate to treat CNG with other problematic exotic perennial grasses. All methods require early identification, follow up controls, monitoring.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies should aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

NSW DPI Biosecurity Information System- Weeds (2017-21) has recorded the presence of CNG during property inspections. This database resource can be used to identify and report infestations of CNG in the Liverpool LGA.

f) Procedures

Proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Public and Council staff education about the weed will increase awareness about the weed and aid early identification and reporting.

Coolatai Grass (*Hyparrhenia hirtal*)

Coolatai Grass. Photo credit: Tony Rebelo (CC BY-SA 4.0)

Status: Eradicate

a) Background

Coolatai Grass is an invasive tussock forming perennial grass that is drought, fire, and herbicide resistant. It is a major threat to undisturbed natural ecosystems, native biodiversity, and pasture. The plant has a number of characteristics which enhance its ability invade relatively undisturbed ecosystems including that it is long lived, can produce seed from a single plant, has mobile seeds (wind, water, animals, and vehicles), can germinate in a wide range of temperature and that established plants are highly tolerant.

The grass has continued to expand across Australia and forecast increases in summer rainfall and milder winters due to climate change make this likely to continue spreading. Due to its impacts and risk for spread, it is identified as a Weed of Regional Concern by the Greater Sydney Regional Strategic Weed Management Plan 2017 – 2022. As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Council considers Coolatai Grass a priority for containment and undertakes proactive management. There is currently very limited known distribution in the Liverpool LGA; however, potential for spread is recognized.

c) Control Options

i) Physical Controls

Infestations often start with 1-2 plants and so when detected early, physical removal and disposal and be successful at limiting any spread. Plants should be removed as soon as they are identified and where possible before viable seed has been set. When removing the plant manually, avoid disturbing any seed in the process. The collected plant material should be bagged and burnt.

ii) Chemical Controls

This species is tolerant of most common herbicides making control challenging. Growth suppression with herbicide application can be achieved with timely and ongoing follow up after the initial knockdown. For all application methods, three repeats in the same growing season are required. Glyphosate, Flupropanate or a combination of the two can be used to target the grass with spot or blanket spraying.

Studies have also shown that herbicide pre-treatments including burning and slashing suppresses active growth of the grass and reduces control effectiveness. For the herbicides to be successful, there should be sufficient green leaf and active growth.

The NSW Weed Control Handbook and NSW Weedwise provides up-to-date details for suitable registered herbicides. All herbicides should be applied in accordance with their directions, dosage, and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

iii) Prevention

Early detection is critical to enable prompt control and prevent an infestation establishing. Rigorous hygiene protocols are necessary in areas with known infestation as the species spreads readily by seed, stock, machinery, and fodder. Of particular concern is the management of roadside areas. Coolatai Grass can very easily establish in optimum conditions created during road maintenance and construction (lighter textured soils, regular glyphosate application for vegetation control and road surface water harvesting). It is important to identify and map Coolatai Grass within roadside vegetation areas and prevent slashing until the species is eradicated. Slashing can increase seed spread and enable it to further establish and/or move into new areas. Where machinery is used in an infestation area, it should not be moved to another area without being properly cleaned.

To facilitate early detection, awareness about the species should be increased to better enable accurate identification.

iv) Challenges

Accurate identification is one of the greatest challenges with this species as it prevents early detection and management. Coolatai Grass that is not in flower can be difficult to accurately identify and there are a number of other exotic and summer growing native grasses than can be easily confused with it. It is unlikely that herbicide alone will control Coolatai Grass, and a combination of controls and follow up are necessary to control this weed.

d) Implementation

With effective management, Coolatai Grass can successfully be eradicated from an area in two to three years. Seed viability is only two years so when it is removed from an area and seedlings destroyed before seed set, as long as no further seed is introduced the area can be eradicated of Coolatai Grass.

e) Monitoring

Rigorous monitoring and eradication of existing infestations where feasible should be conducted. Current surveillance should be continued to prevent the development of new infestation. Roadside areas should be specifically monitored and mapped for the presence of Coolatai Grass.

f) Procedures

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance. This will become more crucial as climate changes due to global warming. Specifically, roadside area construction and maintenance management should account for machinery hygiene and slashing protocols that minimise the risk of Coolatai Grass spread.

Fireweed (*Senecio madagascariensis*)

Fireweed. Photo credit: H. Rose

Status: Asset Based Protection

a) Background

Fireweed looks like a daisy with little yellow flowers. Flowering is mostly from spring to autumn but times vary for different parts of NSW. All stages of the plant from seedlings to flowering may be present at any time of year in some locations. Flushes of seedlings appear after rain in warm weather. Fireweed invades pastures and disturbed areas and is a WoNS. It:

- reduces productivity
- is poisonous to livestock and can cause death
- is difficult to control.

Fireweed grows along the Australian east coast from Victoria to Central Queensland. It is most invasive in coastal regions. It is also on the northern and southern tablelands. It was first seen in the Hunter Valley in 1918. Fireweed thrives in:

- overgrazed pastures
- disturbed or cultivated soil
- most soil types.

Fireweed does not grow well in shaded areas or wet areas. It does not survive waterlogging.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Effective long-term control of fireweed needs to consider that:

- most new seedlings appear in autumn
- many new seedlings appear after rain when temperatures are 15–27°C
- seedlings grow fast and can flower 6–10 weeks after emerging
- flowering and seeding occur mostly in spring
- most plants die off by late spring
- some plants live for up to three years - the tops die back in spring and regrow the following autumn
- fireweed seed buried deeper than two centimetres is unlikely to germinate
- long-term follow up is essential because about 15% of seeds remain dormant for over 10 years.

In pastures, combine grazing strategies, pasture improvement and strategic herbicide use. In environmental areas hand-pull individual plants and spot spray herbicide.

i) Chemical control

Herbicides are most effective in combination with healthy, competitive pastures. The best time to treat fireweed with herbicide is late autumn. This controls the peak numbers of seedlings and young plants. By late winter herbicide treatments are much less effective. Used correctly, selective herbicides don't kill grasses but do slow their growth. They can kill legumes, which are important pasture plants. Blanket applications of selective herbicide are problematic because pasture growth is set back. Wherever possible limit the application areas in paddocks. Bromoxynil herbicides cause the least damage to legumes but only kill young fireweed plants. Protect legumes by applying only when the maximum daily air temperature will be below 20°C. Metsulfuron-methyl herbicides can kill older fireweed plants, but also kill pasture legumes. Flowering plants can be spot sprayed with herbicides containing aminopyralid or metsulfuron-methyl.

ii) Mechanical removal

Careful slashing or mulching can reduce fireweed seeding when done:

- before late spring
- when less than 25% of plants are flowering
- at least every six weeks if pastures can recover faster than the cut fireweed plants

Wait two weeks before grazing slashed areas. Livestock are more likely to eat the cut, wilted fireweed. Avoid slashing or mulching in late spring, or when more than 25% of plants are flowering. This can trigger plants to regrow, surviving into summer rather than dying off at the end of spring. That makes next season's control harder.

iii) Pasture Management

Maintaining healthy pastures is the best long-term defence against fireweed. Have good autumn–winter pasture cover to suppress new fireweed plants. Avoid grazing too hard. Weeds like fireweed then establish in thin and bare patches. To maintain healthy pasture cover:

- grow combinations of winter and summer pastures
- rest pastures between grazing periods
- test soil to check fertility
- use fertiliser if needed.

Large patches of bare ground and lots of weeds are signs of poor pastures. Pasture improvement to control fireweed is proven to work best north of Sydney where there's more rain in summer). South of Sydney it rains more in winter and pastures are slower to establish. Selective herbicides may be needed to control fireweed until pastures mature. Pasture improvement aims to:

- sow vigorous pasture plants that compete with fireweed
- cover bare soil
- correct soil fertility problems

and adjust grazing to:

- always keep at least 90% of the ground covered with good pasture plants
- have even higher cover during peak fireweed germination in autumn
- reduce numbers of grazing animals before overgrazing.

iv) Biological Controls

There are no effective biological control agents available for fireweed. It is difficult to find a biological control that is harmless to the native *Senecio* species. These insects can attack and sometimes destroy fireweed plants:

- A chrysomelid beetle *(Chalcolampra* spp.*)*
- A magpie moth *(Nyctemera amica)*
- A blue stem borer moth *(Patagoniodes farinaria).*

These species cannot be relied on for control. The damage usually occurs after the plants have produced seeds.

v) Prevention of spread and Education

The rapid spread of Fireweed along the east coast of Australia in the last 90 years is a clear indication of its invasive potential. The aim is to restrict seedling emergence, control seedlings early, and prevent seed set and seed spread. To avoid invasion, minimize bare soil by seeding desired species and maintain healthy pasture. Vehicle and machinery hygiene should be ensured when moving into clean areas. This is a priority to prevent the spread of seeds with the potential to germinate. Machinery and vehicles should be washed down where appropriate. This requires the practice of good hygiene of boots, tyres, mowing equipment etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through stock, produce or transported equipment. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

vi) Challenges

Fireweed is able to germinate between 15^{o}C and 27^{o}C (at the soil surface), and so is able to germinate, grow and reproduce throughout most of the year in most climates in NSW. Due to it being poisonous to livestock, it cannot be contained effectively through grazing.

d) Implementation

For maximum efficiency of time and funding, Fireweed should be identified and managed as early as possible, ideally before seeding occurs. Where the infestation is small, physical removal and/or spot spraying of singular plants is effective. All methods require early identification, follow up controls, monitoring.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance. Public and Council staff education about the weed will increase awareness about the weed and aid early identification and reporting.

Frogbit (*Limnobium spp*)

American frogbit. Photo credit: Sam Kieschnick (CC BY 4.0)

Status: Eradicate

a) Background

Frogbit is a fast growing perennial, floating freshwater weed. It predominately grows in freshwater waterbodies but can also tolerate slightly saline conditions. The weed forms dense mats over the water's surface which prevents growth of native water plants. This reduces lights, food, and habitat for associated aquatic fauna. The weed also has negative impacts for recreational activities including fishing, swimming, and boating. In NSW, spread has primarily occurred by the illegal dumping of aquarium and pond plants in waterways. Frogbit can spread by seed and plant parts. Typical, distribution occurs by water flow and currents, birds and attaching to watercraft

Prevention of the biosecurity risk associated with Frogbit is a reasonably practical objective as it has a very limited distribution in the State and poses substantial biosecurity risk. Under the Prohibited Matter (Part 4, Biosecurity Act): a person who deals with any biosecurity matter that is Prohibited throughout the state is guilty of a state offence. The recognized regional strategic response is that this species be managed in accordance with the New Weed Incursion Plan.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Council considers eradication and active surveillance for new incursions of Frogbit a priority. There is currently very limited distribution of the species in Liverpool LGA and council undertakes proactive management with routine monitoring and reporting.

c) Control Options

Frogbit is a prohibited matter, and any sightings should be reported to NSW DPI Biosecurity who are responsible for the initial treatment and disposal of this plant. A variety of chemical control options are available to successfully eradicate this weed; however, this should be undertaken in consultation with NSW DPI.

All herbicides should be applied in accordance with their directions and NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

d) Implementation

Proactive prevention and surveillance of new incursions should continue. If the weed is reported in the LGA, it should be rapidly destroyed with ongoing follow up. Hygiene and disposal strategies should ensure that the plant can't reproduce.

e) Monitoring

Proactive controls, monitoring and surveillance should be a Council priority. Education and awareness activities of the regional importance should be pursued to increase knowledge for relevant stakeholders including land managers, private landholders, and the public.

f) Procedures

Proactive program with prevention strategies, rigorous surveillance and reporting.

Kei Apple (*Dovyalis caffra*)

Kei apple. Photo credit: Jeremy Gilmore (CC BY 4.0)

Status: Eradicate

a) Background

Kei Apple is a small thorny tree that tolerates frost, drought, and saline soils. It can be found in bushland around Western Sydney. The sharp thorns can be a safety hazard and dense foliage out competes and shades native plants. Spread occurs easily by seeds which are distributed by birds who eat the tree's apricot-like fruit. New plants are often found growing under trees or other locations where birds perch.

Kei Apple has been classified as a regional priority weed in Greater Sydney with the objective of eradication. Species presence in the region is limited in abundance and distribution and elimination of the biosecurity risk it poses is reasonably practical. General biosecurity duty for the species in Liverpool LGA is that land managers eradicate and keep their land free from Kei Apple and notify the local control authority (Council) if they identify it on their land. Additionally, the plant (inclusive of all its parts) cannot be grown, traded, carried, or released into the environment. The recognized strategic response for the region is the detailed surveillance, mapping, and destruction of all infestations where practical. Appropriate quarantine and hygiene protocols should be implemented and management in accordance with the NSW Weed Incursion Plan.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Currently Council is undertaking management of Kei Apple in Liverpool LGA in line with biosecurity and regional priorities of eradication. Infestations are known to Council in Austral and Kemps Creek; however, generally distribution is limited within the Liverpool LGA. Substantial efforts have been made to remove this species with proactive management.

c) Control Options

i) Chemical Options

A range of herbicides are available to successfully control Kei Apple including Fluroxpyr and Glyphosate. These can be applied using basal bark and stem injection techniques, respectively. This can be expensive and time consuming so application should be targeted. All herbicides should be applied in accordance with their directions. NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage, and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

d) Implementation

Eradication and monitoring of existing Kei Apple infestations in Liverpool LGA should include targeted chemical control and follow up. Council should also undertake proactive controls and surveillance to prevent spread. Education and awareness activities of the regional importance should be pursued to increase knowledge for relevant stakeholders including land managers, private landholders, and the public.

e) Monitoring

Eradication is considered feasible and ongoing monitoring, surveillance and mapping should be incorporated within management plans in line with best practice guidelines.

f) Procedures

Proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Lantana (*Lantana camara*)

Lantana. Photo credit: A. Johnson

Status: Asset Based Protection

a) Background

Lantana is a scrambling shrub with colourful flowers. It is a widespread weed in coastal areas and is a WoNS. Lantana:

- is poisonous to animals and humans
- invades native grassland and pastures
- invades eucalyptus and pine plantations
- fuels bushfires
- can restrict access to bushland and waterways
- costs land managers more than $22 million each year to control.

Lantana provides some shelter for native fauna. All types and parts of lantana are considered poisonous to humans and stock.

Lantana's range extends from Bega Shire in southern NSW to Cape Melville in north Queensland. It is present on Lord Howe and Norfolk Islands. The main infestations are east of the Great Dividing Range in NSW and QLD. Lantana is unlikely to invade new regions in NSW. It is increasing in density and invades new areas within its range. Lantana was introduced to Australia in 1841 as an ornamental plant. By the 1860s it was common in Sydney and Brisbane. Lantana can quickly colonise roadsides, power line and railway easements, river banks, fence-lines, forestry, pastures, open native woodlands and subtropical rainforest edges. Lantana can grow in steep, inaccessible areas. Lantana often invades disturbed areas where vegetation has been cleared. It's less likely to grow in undisturbed bushland.
Lantana prefers:

- warm weather with more than 900 mm annual rainfall
- well-drained, fertile soils
- coastal areas
- altitudes up to 1000 m.

Lantana can survive periods of drought. It tolerates poor soils and sand and will grow on stony hillsides if moisture is available. Lantana is slowed by:

- cold weather (it stops growing when temperatures are below 5°C)
- low light
- some soils (waterlogged conditions, heavy clays, salt-affected).

A single Lantana plant can produce up to 12,000 fruit (and seeds) in a year. Most seeds are spread by birds and some animals that eat the fruit. Lantana seed is more likely to germinate if it has been through the gut of a bird or mammal. Seeds are also spread by water, in soil, on machinery and garden waste. About half of seeds remain viable for up to two years in dry conditions and some may survive for five years. Lantana regrows after cutting back, even if cut to the base. Cut stems grow new roots when they contact damp soil.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

For successful control of Lantana, a combination of methods is usually needed, including:

- gradual control of sections of large infestations, starting at the edges (do as much at a time as you can follow up)
- dry or frosty periods are good times to work on mature lantana plants
- treat regrowth or seedlings before they are 1 m high
- control young plants before they are a year old to prevent new fruit and seeds
- in summer, look for a flush of seedlings after rain, and kill the seedlings 1 – 3 after the rain event (lantana seeds can germinate year-round but peak after summer rain).
- 1 – 3 months after clearing, burning or cultivation, look for regrowth or new seedlings and control them.
- 3 – 6 months after the end of a dry spell, look for dry lantana that appeared dead reshooting from the base, and control the regrowth
- in spring, look for plants that reshoot after frost damage, and control the survivors.

i) Chemical control

Control with herbicides can be a practical, effective and efficient method of lantana management. They are cost effective for smaller infestations and for treating regrowth.
Pink flowered lantana is easier to control with herbicide than red flowered varieties. Many herbicides are available for Lantana chemical control. The aim should be to minimise off-target damage to native species and pasture grasses. Foliar spraying is only effective if the lantana is actively growing and the plants are less than two metres high. mature lantana is best treated with foliar spraying between February and the first frost. Active regrowth from dry or frost affected lantana is ideal for treatment with foliar spraying as access to the regrowth foliage is easier and the reduced plant surface area requires less herbicide. Regrowth from burning, cutting, slashing or frost is best treated when it reaches a height of 30 cm to 1 m.

Splatter-guns use small amounts of highly concentrated herbicide. A five-litre bottle of mixed herbicide should cover about 0.2 hectares of lantana. The splatter gun:

- works best on dense infestations at least 300 mm high
- limits off-target plant damage
- is good for hard-to-access and steep areas
- can be used year round if plants are actively growing, but works best during summer
- is cheaper than traditional foliar spray methods.

Spray during cooler periods of the day. Angle the gun at 45 degrees and spray an arc over the top of the plant and down the front face. Apply two squirt lines per half a metre of plant height. The amount to apply will depend on the herbicide concentration. Do not spray until herbicide runs off. Do not use the splatter-gun:

- in wet weather
- when there is water or dew on the plants
- on spindly lantana regrowth.

Basal barking can be effective on plants that have been defoliated by biological control agents and is effective at any time of year. Mix the herbicide with diesel. Apply around all stems from the ground up to 30 cm high by spraying at low-pressure or painting on with a brush. For the cut-stem method, cut stems off at about 15 cm from the ground. Apply herbicide to the cut surface of the stump within 15 seconds. It is important to treat every cut stem because lantana regrows vigorously from untreated stems.

ii) Mechanical removal

Control with mechanical methods can be suitable for extensive mature lantana infestations. mechanical control by bulldozing or slashing plants can be successful for removing large mature bushes quickly. mechanical control needs to be followed up by herbicide control of seedlings and replacing the lantana with pasture or other vegetation cover. Follow-up spot spraying or further mechanical control is therefore essential until the preferred desirable species becomes dominant. In environmentally sensitive areas, a staged approach should be adopted. Ensure native species are planted where Lantana has been removed.

iii) Biological Controls

Successful biological control of lantana has proven difficult. This is mainly due to the number of lantana varieties and the wide range of habitats that it invades. Of the 31 biological control agents which have been introduced into Australia to help control lantana, 17 have become established and four of these are effectively reducing the vigour and competitiveness of lantana in certain areas. Biological control alone cannot eradicate lantana but may help to contain infestations and reduce their spread in the long term.

The lantana rust (*Prospodium tuberculatum*) is a fungal pathogen that was introduced from Brazil in 2001. This rust attacks the widespread pink flowering variety of lantana and appears to have a wide tolerance of climatic conditions.

The two insects causing the most damage are the leaf-mining beetles *Uroplata girardi and Octotoma scabripennis*. Larvae of both these insects mine leaves of all lantana types, thereby suppressing plant growth and causing a reduction in flowering. Another insect that can damage the plant is the leafsucking bug, *Teleonemia scrupulosa*. The fourth insect that affects their growth is the lantana seed fly, *Ophiomyia lantanae*. Adults of this insect feed on the f lowers while the larvae feed on the developing fruits and seeds.

iv) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, mowing equipment etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through stock, produce or transported equipment. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

Control of Lantana usually requires follow up after initial efforts to control regrowth and new seedling growth. Large, dense infestations can be costly to treat with chemicals and are difficult to access. Reinfestation can occur unless removed plants are replaced with natives.

d) Implementation

For maximum efficiency of time and funding, Lantana can be treated at the same time as other priority bushy weeds such as African Boxthorn (*Lycium ferocissimum*), blackberry (*Rubus fruticosus* agg.), Boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) and Bitou Bush (*C. monilifera* subsp. *rotundata*).

e) Monitoring

Lantana is an extremely hardy and persistent weed. Follow up control is always required to prevent reinfestation by regrowth or new seedlings. Control work should be prioritised in situations where there will be enough resources to allow ongoing control in the following months or years. Removing lantana can be a waste of time unless follow up management is carried out.. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Ludwigia (*Ludwigia peruviana*)

Ludwigia. Photo credit: Donna Fernstrom (CC0 1.0)

Status: Contain

a) Background

Ludwigia is an opportunistic and rapid growing water weed threatening wetlands and riverine habitat. In a short timeframe, it can dominate all aquatic vegetation and choke waterways and is a threat to many endangered freshwater wetlands in the Sydney bioregion. It develops as a dense canopy on the waterbody that reduces light and water temperature. This negatively affects native aquatic flora and fauna communities. It reproduces both by seed and vegetatively from root plant fragments and seedlings anchor into the soil with a large taproot. The plants produce thousands of sticky seeds that can spread by attaching to machinery clothing, feathers and hair. Water flow and flood waters can also distribute plant fragments and seeds downstream. Seeds have very high viability (80%) and can germinate quickly in shallow water, mud or floating on the mats of Ludwigia vegetation.

Ludwigia has been classified as a regional priority weed in Greater Sydney with the objective of asset protection for the species. The species is listed as a WoNS and poses risk to the environment, agriculture, and community amenity. In the region, broad scale elimination is not practicable; however, minimisation of the biosecurity risk posed by this species requires containment and removal where it is reasonably practicable. General biosecurity duty for the species in Liverpool LGA is that land managers should mitigate risks of species introduction to their land, prevent its spread, minimize the impacts on priority assets and notify the local control authority (Council) if the plant is identified on their land. Additionally, the plant (inclusive of all its parts) cannot be grown, traded, carried, or released into the environment. The recognized strategic response for the region is for ongoing suppression and removal of the plant, and identification of priority assets identified for targeted management.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Ludwigia occurs on numerous Council waterbodies in the Liverpool LGA. Council considers containing the current extent of the species as a priority and undertakes proactive management.

c) Control Options

Ludwigia is best controlled when the seedlings are targeted within the first 18 months of growth and before flowering due to the extensive soil seed bank that develops after this.

i) Physical Control

Where Ludwigia plants or infestations are small, manual removal can be effective. Where infestations are larger, slashing and burning can be used. Care should be taken to remove as much of the root as possible and to prevent further spread of the seeds. Management should be combined with followed up with herbicide application

ii) Chemical Control

Herbicide control of Ludwigia is most successful when conducted whilst it is actively growing and before flowering. A range of effective, registered herbicides are available that can be applied using foliar spray or cut stump methods. When applying herbicides in aquatic environments, runoff or spray into the catchment should be prevented to avoid impacts to non-target species. Permits are required if using a 2,4-D amine herbicide.

All herbicides should be applied in accordance with their directions. NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

d) Implementation

Continue proactive management of the weed on Council waterbodies. For maximum efficiency of time and funding, Ludwigia in waterways should be targeted in the active growth phase and before flowering, ideally within the first 18 months of growth. Where possible, management should be coordinated with other aquatic weeds or controls for Ludwigia in the catchment and neighbouring LGAs.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact to priority assets by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

f) Procedures

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Madeira Vine (*Anredera cordifolia*)

Madeira Vine. Photo credit: Sam Kieschnick (CC BY 4.0)

Status: Asset Based Protection

a) Background

Madeira vine is an invasive climbing vine with fleshy heart-shaped leaves and aerial tubers. It is a WoNS. Madeira vine grows very quickly and it can:

- smother and kill plants from ground covers to tall trees
- cause branches and trees to fall due to the weight of the aerial tubers
- reduce food and habitat for native animals
- invade crops such as sugarcane
- cause ill health if eaten by livestock.

Madeira vine is one of the invasive vines listed as a Key Threatening Process in NSW. It threatens three endangered species of plants and three Endangered Ecological Communities.

Madeira vine mostly grows in coastal areas of NSW with summer rainfall. However, it is spreading into dryer inland areas including the North West and Central West of NSW. Madeira vine grows in sub-tropical and warm temperate areas. It grows best in full sun or partial shade but is also tolerant of dense shade. It often establishes on the margins of rainforests and on the edges of waterways. It is partly salt-tolerant and can grow over mangroves.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Using a combination of control methods is usually more successful for Madeira Vine control. This includes follow-up after initial efforts, and detecting and killing regrowth or new plants. To manage madeira vine effectively:

- treat isolated plants or sparse populations in areas you want to protect first
- check for and treat regrowth from tubers and stems
- avoid damage to native vegetation and other desirable plants
- encourage the recovery of native vegetation to complete with the weed.

i) Chemical control

The most common herbicides used to control Madeira Vine include Glyphosate, Picloram, and Triclopyr, and Fluroxypyr. Using herbicides in warmer months will give the best results. Though, a herbicide application during late winter may allow easier access and better control during the following spring and summer months.

Spraying is suitable for seedlings and for plants growing along the ground, over structures or over other non-desirable plants. Apply herbicide to all foliage to the point of visible wetness. If plants do not have tubers and are climbing on desirable plants, pull them off gently and spray them on the ground. Foliar spraying may be used after the stems have been treated using scrape and paint techniques. It can also be used as an initial treatment, followed by scrape and paint of remaining living stems. Follow up by spraying sprouting tubers when they have between 2 and 8 leaves.

Splatter guns can be used for dense infestations of madeira vine that are difficult to reach. The specialised nozzle produces large droplets. This allows plants up to 10 m away to be sprayed with limited chance of spray drift. Spray small amounts of concentrated herbicide on the weed, taking care not to spray the leaves of native or other desirable plants. It is not necessary to cover all of the foliage.

Stem scraping is suitable for vines of any size and for those with aerial tubers. It is the safest management option in sensitive environments. It is labour intensive, as every vine stem has to be treated individually. Scrape sections of the vine down to the white fibrous layer and paint the exposed area with concentrated herbicide within 15 seconds. Repeat the process as high up the stem as possible. If possible, scrape both sides of the stem. Do not ringbark the stem as this will prevent the herbicide spreading through the plant. Remove and collect tubers along the stem near where they are to be scraped as they can easily fall off when the vines are being treated.

The cut stump method can be used for young vines without aerial tubers. It should only be used on vines with aerial tubers if it is possible to follow up the initial control by treating all of the sprouting tubers that fall to the ground. Tubers may continue to sprout for several years. Cut stems and apply herbicide to the part of the vine that is attached to the ground and the vines remaining above within 15 seconds of cutting.

ii) Mechanical removal

Madeira Vine can be physically removed by hand for smaller or immature infestation sites by digging up tubers and collect all plant parts. Dispose of tubers, leaves and stems, as they will regrow when in contact with the soil or if they are exposed to any sunlight. If there is stress on the host plants, cut and pull the madeira vines from the canopy. When pulling the vines aerial tubers easily fall off the stems. Lay tarps or cloths on the ground to collect the aerial tubers to prevent the infestation from spreading. Cut vines can survive in the tree canopy and continue to drop tubers for up to two years. It is important to remove as much plant material as possible.

iii) Biological Controls

The leaf-feeding beetle *Plectonycha correntina* has been released in NSW and Queensland. The beetle has established and caused significant damage to madeira vine at many of the release sites. Both the adult beetles and the larvae feed on the leaves. Leaf-feeding reduces the plant's ability to photosynthesise

and depletes the energy stores in the tubers. Only use the beetles in flood-free and frost-free areas. To allow the beetles to establish, do not use other control methods on the release sites.

iv) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, mowing equipment etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through transported equipment. Remove any madeira vine in gardens and dispose of all plant parts appropriately. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

As Madeira Vine grows from tubers, stems or leaves, its control is challenging. Regrowth can occur from all of these plant parts. Therefore, control of Madeira Vine usually requires follow up after initial efforts to control regrowth. Large infestations can be costly to treat with chemicals. Reinfestation can occur unless removed plants are replaced with natives.

d) Implementation

For maximum efficiency of time and funding, Madeira Vine can be treated at the same time as other priority invasive vines and scramblers .

e) Monitoring

Monitoring should be one of the first activities implemented at a control site. It will provide a benchmark to assess the progress at the site. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Prickly Pears - Opuntias (*Opuntia* spp.)

Smooth Tree Pear. Photo credit: Paul Marynissen (Central Coast Council)

Status: Asset Based Protection

a) Background

There are 11 weed species of Prickly Pears – Opuntias (*Opuntia* species) occurring in Australia, including Aaron's Beard Prickly Pear (*O. leucotricha*), Blind Cactus (*O. rufida*), Bunny Ears Cactus (*O. microdasys*), Chicken Dance Cactus (*O. schickendantzii*), Common Pear (*O. stricta*), Indian Fig (*O. ficus-indica*), Riverina Pear (*O. elata*), Smooth Tree Pear (*O. monacantha*), Tiger Pear (*O. aurantiaca*; see: 'Tiger Pear' profile below), Velvety Tree Pear (*O. tomentosa*), and Wheel Cactus (*O. robusta*). Opuntias are cactus plants that can invade natural areas and pastures. Opuntias were first introduced into Australia with the first fleet, via Brazil, to establish a cochineal dye industry. By 1920 Opuntia stricta had infested 23,000,000 hectares in NSW and Queensland. Half of the infested area was so densely covered it was useless for production and was abandoned by its owners. Opuntias have been declared WoNS in Australia.

Aaron's Beard Prickly Pear

Aaron's Beard Prickly Pear. Photo credit: Courtesy of Queensland Department of Agriculture and Fisheries

Aaron's Beard Prickly Pear is a branched, succulent cactus that grows up to 2.5 m tall and often has a trunk. It has large succulent pads covered in white spines. Aaron's beard prickly pear can outcompete native plants, reducing food and habitat for native animals. It has sharp spines up to 5 cm long that:

- cause painful injuries to people, livestock, working dogs and pets
- injure and sometimes kill wildlife that get trapped in the spines
- devalue wool and hides and prevent shearing
- get stuck around the mouth of lambs or calves and prevent them from feeding.

It also forms dense thickets that prevent movement of animals and people. This means that:

- livestock may not be able to access feed
- mustering is difficult
- access to watering points is reduced
- recreational activities such as bushwalking and camping are restricted.

In NSW, there are infestations of Aaron's Beard Prickly Pear in the North West region. This cactus grows in arid, semi-arid and warm temperate climates. It grows best on well drained soils.

New plants can grow from parts of the stem of Aron's Beard Prickly Pear when they come in contact with the soil. These plant parts can be spread by water, sticking to animals or vehicles and by people dumping garden waste. Aarons Beard Prickly Pear is not known to produce seeds in Australia.

Blind Cactus

Blind Cactus. Photo credit: Courtesy of Queensland Department of Agriculture and Fisheries

Blind Cactus is a spineless cactus with pairs of pads which are covered in tufts of reddish-brown bristles. Blind cactus forms dense thickets and:

- outcompetes native plants
- limits movement of animals and people
- competes with pasture plants reducing productivity
- has barbed bristles which can injure people and animals
- can restrict recreational activities such as bushwalking and camping.

In NSW, there are infestations in the North West region. Blind Cactus has mostly been spread by people growing it as an ornamental plant. New plants can grow from parts of the pads or fruit when they come in contact with the soil. These plant parts can be spread by:

- water
- sticking to animals or vehicles
- people dumping garden waste.

Blind cactus is not known to produce seeds in Australia.

Bunny Ears Cactus

Bunny Ears Cactus. Photo credit: Courtesy of Queensland Department of Agriculture and Fisheries

Bunny Ears Cactus has pairs of pads that are covered in tufts of golden bristles. The pads grow in pairs and look like a pair of rabbit ears. It is usually a low, creeping plant with shallow roots. Bunny Ears Cactus forms dense thickets and:

- outcompetes native plants
- limits movement of animals and people
- competes with pasture plants reducing productivity
- has barbed bristles which can easily detach and injure people and animals
- can restrict recreational activities such as bushwalking and camping.

In NSW, there are infestations in the North West, Greater Sydney and Hunter regions. Bunny Ears Cactus can tolerate a wide range of conditions. It grows best in open areas, particularly in arid and semi-arid regions and is very drought tolerant. Bunny Ears Cactus has mostly been spread by people growing it as an ornamental plant. They may or may not be aware that it should not be grown. New plants can grow from parts of the stem or fruit when they come in contact with the soil. These plant parts can be spread by:

- moving water
- sticking to animals or vehicles
- people dumping garden waste.

Bunny Ears Cactus is not known to produce seeds in Australia.

Chicken Dance Cactus

Chicken Dance Cactus. Photo credit: Nicola Dixon (NSW DPI)

Chicken dance cactus is an erect succulent shrub usually 0.7 to 1.8 m tall. It often has a trunk which may be up to 1 m tall. Chicken dance cactus has elongated fleshy pads with short spines and bristles. Chicken dance cactus competes with other plants. The sharp spines up to 1 cm long can:

- cause painful injuries to people, livestock, working dogs and pets
- injure and sometimes kill wildlife that get trapped in the spines
- devalue wool and hides and prevent shearing
- get stuck around the mouth of lambs or calves and prevent them from feeding.

It also forms dense thickets that can prevent movement of animals and people. This means that:

- animals may not be able to access feed
- mustering is difficult
- access to watering points is reduced
- recreational activities such as bushwalking and camping are restricted.

Chicken dance cactus has naturalised in a few locations in NSW including the Greater Sydney, Riverina and the South East regions. Chicken dance cactus can grow in a wide variety of soils and climates. Chicken dance cactus has mostly been spread by people growing it as an ornamental plant.

Common Pear

Common Pear. Photo credit: John Hosking (NSW DPI)

Common pear is a cactus up to 2 m tall with spines, bristles, yellow flowers and purplish red fruit. It is a WoNS. Common pear can outcompete other plants and form dense infestations. It:

- restricts the movement of animals and people
- reduces productivity by outcompeting pasture plants and reducing access to feed
- makes mustering difficult
- reduces access to watering points
- outcompetes native plants
- reduces food and habitat for native animals
- makes recreational activities such as bushwalking difficult.

Common pear sometimes has spines that can:

- injure people, livestock, working dogs and pets
- get stuck around the mouth of lambs or calves and stop them feeding
- injure and sometimes kill wildlife that get trapped in the spines
- devalue wool and hides
- prevent shearing.

Common pear is also a host plant for fruit flies and provides harbour for pests including foxes and rabbits.

In NSW, common pear is mostly found in the North West and Hunter regions but is also found throughout NSW. Common pear can grow in tropical, subtropical, warm temperate and semi-arid climates. It tolerates full sun and shade. It grows in a wide range of soil types including saline soils, sand, loams and heavy clays. It can grow:

- in grasslands, woodlands shrublands and forests
- on steep, rocky slopes

- on beaches
- in disturbed areas such as roadsides
- on agricultural land.

Common Pear is spread by seeds and plant parts. An average of 110 seeds per fruit are produced, which are spread by birds and mammals which eat the fruit. Plant parts can be spread by animals, vehicles, water or wind and quickly take root.

Indian Fig

Indian Fig. Photo credit: Jen Schabel

Indian Fig is a tree-like cactus up to 7 m tall with very few spines. It is the only Opuntia species that is permitted for sale in NSW. It is grown by gardeners for its edible fruit. Indian Fig has never caused any problems to rural production. It spreads slowly and is easily eradicated. It was removed from the list of prohibited plants in 1978.

Indian fig grows sporadically in NSW. It prefers sandy, loamy, well-drained soil.

Riverina Pear

Riverina Pear. Photo credit: John Hosking (NSW DPI)

Riverina pear is a branched shrub up to 2 m tall. It is usually erect but sometimes scrambles over the ground and climbs over other plants. Riverina pear is an invasive cactus that:

- competes with native plants
- reduces food and habitat for native animals
- competes with pasture plants, reducing productivity
- has bristles, and sometimes spines that can injure people and animals.

It forms dense thickets which:

- reduce access to watering points
- restrict access to feed for livestock and native animals
- make mustering difficult
- restrict recreational activities such as bushwalking and camping.

In NSW, it has been found in the Western, North Western, Riverina, Murray and Greater Sydney regions. Riverina pear grows in a wide variety of soil types but prefers well drained sandy soils. In its native range plants grow in loams and clay soils. It is drought hardy and grows in regions with more than 150 mm of rain per year. It could grow in most parts of NSW. It grows:

- along roadsides
- along the edges of waterways
- in bushland
- in grazing areas
- in disturbed areas.

Smooth Tree Pear

Smooth Tree Pear. Photo credit: Jen Schabel

Smooth tree pear is an upright cactus up to 6 m tall though usually only 2 – 3 m. The stems have an obvious drooping appearance. It sometimes has a short woody trunk with clusters of large spines up to 10 cm long. Smooth tree pear is an invasive spiny cactus and is a WoNS. The spines can:

- injure people, livestock, working dogs and pets
- injure and sometimes kill native animals that gets trapped in the spines
- get stuck around the mouth of lambs or calves and stop them feeding
- devalue wool and hides
- prevent shearing.

Dense thickets of smooth tree pear restrict the movement of animals and people, so that:

- livestock cannot move to areas with better pasture
- mustering is difficult
- access to watering points is reduced
- recreation such as bushwalking or bird watching becomes difficult.

Smooth tree pear also:

- competes with native plants
- invades native pastures reducing productivity
- harbours pests including foxes, rabbits and fruit fly.

Smooth tree pear grows from coastal NSW to the Western region. Smooth tree pear mostly grows in subtropical, semi-arid and warmer temperate climates. It tolerates a wide variety of soil types though it is often found on sandy soils including coastal dunes. It grows in pastures, open woodlands, waterways, roadsides, railways and coastal areas. Birds and other animals eat the fruit and spread the seeds in their droppings. Stems can break off the plant and be distributed by animals, vehicles or moving water. Immature fruit will also grow into new plants.

Velvety Tree Pear

Velvety Tree Pear. Photo credit: Bruce Auld (NSW DPI)

Velvety tree pear is a tree-like cactus whose pads are covered in fine velvety hairs. It outcompetes pasture grasses and native plants and is a WoNS. Velvety tree pear is an invasive cactus that:

- competes with native plants
- reduces food and habitat for native animals
- competes with pasture plants reducing productivity
- has bristles and sometimes spines that can injure people and animals.

It forms dense thickets which:

- reduce access to watering points
- restrict access to feed for livestock and native animals
- make mustering difficult
- restrict recreational activities such as bushwalking and camping.

In NSW, velvety tree pear grows in the North West and Greater Sydney regions. It has been in Australia since at least 1912 and may have been introduced as an ornamental plant. Velvety tree pear grows in subtropical, semi-arid and warm temperate climates. It is very drought tolerant. It grows in

- pastures and native grasslands
- open woodlands
- disturbed areas such as roadsides.

The seeds of velvety tree pear are viable and will sprout when there is enough moisture. Seeds can remain dormant in dry conditions for at least 18 months. Birds and other animals, including foxes, eat the fruit and spread the seeds in their droppings. Seeds can also be spread downstream by water. Velvety tree pear can regrow from pad segments, fruit and flowers. If the pads have spines they can spread by attaching to animals, footwear and vehicles. Plants can also spread by people dumping garden waste.

Wheel Cactus

Wheel Cactus. Photo credit: Bob Chinnock (NSW DPI)

Wheel cactus is a succulent shrub usually 1–2 m tall with yellow flowers. Sometimes it is treelike with a distinct trunk and up to 4 m tall. Cacti pads have bumps on the surface called areoles. Spines, bristles, leaves, flowers, fruit, roots and new shoots all grow out of the areoles.

Wheel cactus forms dense thickets that outcompete low growing plants and prevent movement of animals and people. This means that:

- animals may not be able to access feed
- mustering is difficult
- access to watering points is reduced
- recreational activities such as bushwalking and camping are restricted.

Most plants have sharp spines that can:

- cause painful injuries to people, livestock, working dogs and pets
- injure and sometimes kill native wildlife that get trapped in the spines
- devalue wool and hides and prevent shearing
- get stuck around the mouth of lambs or calves and prevent them from feeding.

Wheel cactus competes with native plants, reducing food and habitat for native animals.

In NSW, most infestations of Wheel Cactus are in the Western Region. There has been one infestation in the South East in the Snowy Mountains. It was introduced into Australia as an ornamental plant. Wheel cactus grows in a wide range of climates. It mostly grows in arid, semi-arid warm temperate and subtropical climates but it can tolerate cooler temperate areas. It is very drought tolerant. Plants can survive extremely high temperatures up to 50 °C and low temperatures down to -7°C. Wheel Cactus tolerates a wide variety of soil types and grows very well in shallow granite soils.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Effective long-term control of Prickly Pears requires implementing a combination of control methods..

i) Chemical control

Spraying of herbicides is the most effective chemical control method for Prickly Pears. Herbicides include Triclopyr or a combination of Triclopyr and Picloram or Aminopyralid. Spray actively growing plants and cover all parts of the plant with herbicide. Check treated plants and control new growth.

ii) Mechanical removal

Dig up small or isolated plants using a mattock or other tools. Wear appropriate protective clothing and gloves to protect against injuries. Larger infestations of Prickly Pears may be controlled by machinery where there is good access to the site, the site is not environmentally sensitive and plant parts can be safely disposed of.

iii) Biological Controls

There are no useful agents in Australia for biological control of most Prickly Pears. The cochineal insect, *Dactylopius ceylonicus* can control Chicken dance cactus. Biological control is suitable for areas that are environmentally sensitive, too difficult to access or where other methods would be too expensive. Cochineal insects are less effective on scattered infestations and may require redistribution at these sites. There are several species of cochineal that look very similar. It is important to use the correct species of cochineal for each species of cactus. Contact your local council weeds officer for information about using cochineal to control cactus.

There are two successful biological control agents for Common Pear:

- cactoblastis moth, (*Cactoblastis cactorum)*
- cochineal bug (*Dactylopius opuntiae* 'stricta' lineage).

Two types of cochineal insect can effectively control Indian fig: *Dactylopius opuntiae* 'ficus' lineage and *Dactylopius opuntiae* 'Mexican' lineage.

Biological control using either of the two species of cochineal in conjunction with the Cactoblastis moth (*Cactoblastis cactorum)* can control Riverina pear. The two species of cochineal are:

- *Dactylopius opuntiae* ('stricta' and 'ficus' lineages)
- *Dactylopius ceylonicus*

The cochineal *Dactylopius ceylonicus* provides good control of smooth tree pear. It takes several years to kill plants. Control is slower in areas with high rainfall. Felling plants over 2 m tall and stacking the cut segments after the cochineal has established will speed up control.

The cochineal insect, *Dactylopius opuntiae '*stricta' lineage can control velvety tree pear after several years. Cutting large plants (over 2 m tall) and stacking the stems will speed up control.

Two types of cochineal insect can effectively control large, dense infestations of wheel cactus:

- *Dactylopius opuntiae* 'ficus' lineage
- *Dactylopius opuntiae* 'Mexican' lineage.

Biological control is suitable for areas that are environmentally sensitive, too difficult to access or where other methods would be too expensive. Cochineal insects are less effective on scattered infestations and may require redistribution at these sites.

iv) Prevention of spread and Education

This requires the practice of good hygiene of boots, tyres, vehicles etc to prevent accidental and intentional spread to un-infested regions. Areas may need to be quarantined, or wash down bays provided, to prevent spread of the weed through transported equipment. Dispose of plant parts appropriately by burying it at least one metre deep or by burning in a hot fire. Otherwise, avoid driving or walking through areas with Prickly Pears. Do not grow Prickly Pears in gardens or pots. Do not take cuttings of unknown cactus plants to grow out or share with others. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

Control of Prickly Pears usually requires follow up after initial efforts to control regrowth. Large infestations can be costly to treat with chemicals and the spines on Prickly Pears can cause serious injury when physically removing plants.

d) Implementation

For maximum efficiency of time and funding, Prickly Pears can be treated at the same time as other priority bushy weeds such as Lantana (*Lantana camara*), blackberry (*Rubus fruticosus* agg.), Boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) and Bitou Bush (*C. monilifera* subsp. *rotundata*).

e) Monitoring

Monitoring should be one of the first activities implemented at a control site. It will provide a benchmark to assess the progress at the site. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Opuntioid Cacti Management Guide (WA DPIRD).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Salvinia (*Salvinia molesta*)

Salvinia. Photo credit: Hamilton Turner (CC0 1.0)

Status: Contain

a) Background

Salvinia is a free-floating aquatic fern that is capable of rapid growth in still or slow-flowing water. It spreads vegetatively by fragmentation and can double in size in under three days. Each plant will produce over 8000 plants within the first month of infesting a waterbody.

Salvinia also spreads to new areas by attaching to vehicles, boats, and animals. Human activities such as use in aquariums and fishponds and inappropriate disposal methods further exacerbate the likelihood of it spreading. Salvinia can completely cover the waterbody surface removing light that submerged plants and associated fauna rely on. This has negative implications for native habitats, water quality, and provides a breeding ground for mosquitoes. Further, it has major impacts for the waterways recreational and transport activities including swimming, boating and fishing.

The whole Greater Sydney region has been established as an exclusion zone with the objective of ensuring containment of the Salvinia and is listed as a WoNS. The Hawkesbury-Nepean and Georges Rivers and their tributaries have been classified as the core infestation area. Salvinia is widely distributed in the Liverpool LGA area and land managers should prevent spread of the species from their land and notify the local control authority (Council) if the plant is identified on their land. While broad scale elimination is not practicable, minimisation of the biosecurity risk posed by this species requires containment and removal where it is reasonably practicable. In addition to this, within the region (exclusion zone), land should be kept free of Salvinia and eradicated where it occurs. Within the core infestation area, land managers are to prevent spread from their land where feasible and reduce the impact on priority assets. Additionally, under the Mandatory Measure (Division 8, Clause

33, Biosecurity Regulation 2017): a person must not move, import into the State or sell Salvinia. The recognized strategic response for the region is ongoing suppression and removal of the plant, and to monitoring changes to the distribution to prevent spread.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Currently Council is undertaking proactive management of Salvinia in Liverpool LGA in line with Biosecurity and regional priority of containment. It is present on numerous Council owned and managed waterbodies of which are actively managed.

c) Control Options

Successful control of Salvinia is dependent on the integration of techniques. Suitable techniques are determined by the size of the infestation. There are a variety of control methods including the following:

i) Physical

For small infestations, plants can be manually removed, and care needs to be taken to remove all plant material. Booms and nets may be effective for containment, mitigating short term spread. The collected material is more easily controlled with chemicals or mechanical techniques. For medium to large areas and/ or densities of the plant, manual removal is generally not feasible. Council is responsible for providing advice on how to dispose of the weed.

ii) Mechanical

Aquatic weed harvesters can be used to remove the plant. However, the weed will regenerate, and so mechanical removal needs to be conducted regularly for effective results. This method is expensive and so is primarily feasible for dense infestations only.

iii) Chemical

There are several herbicides available for use to control Salvinia and these are most successful when the infestation is controlled early. Chemical controls can be limited by having good access to the weed in the waterbody and the infestation density. It can be difficult to get good herbicide contact where the leaves are compact and densely folded. Salvina can rapidly reinfest sites, so it is important to target as much of the plant mass as practical. Large infestations should not be sprayed all at once to prevent mass die-off and water pollution. Chemical controls are effectively used after removing as much plant mass as possible via physical/ mechanical means.

The NSW Weed Control Handbook and NSW Weedwise provides up-to-date details for suitable registered herbicides. All herbicides should be applied in accordance with their directions.

iv) Water Management

The reduction of nutrient levels is known to help control Salvinia. This includes preventing effluent and other waste from entering waterways. Erosion on cultivated land should be managed and stock access to banks and waterways minimized.

v) Biological

The Salvinia Weevil (*Cyrtobagous salviniae*) can be effective for plant containment. Adult weevils feed on the growing tips which suppresses plant growth and larvae tunnel through the stems which can cause parts of the biomass to sink and decompose in the waterway. Weevil populations can take 2-3 years to establish, and local climate impacts the level of control. They are most effective in warmer climates (~30°C), but populations can take longer to establish in cooler climates (~20°C) and may require repeated introduction. Breeding generally ceases below 17°C meaning this method is

ineffective in cold climates. Biological controls cannot eradicate the species and are most effectively used in collaboration with other techniques

vi) Challenges

Growth can also be stimulated by rain due to runoff and increased nutrient loading in the waterway. As Salvinia remains a popular aquarium and pond plant despite bans being in place Australia, there is ongoing risk of re-infestation of local waterways. Care also needs to be taken when using chemical controls to not saturate with waterbody with decomposing Salvinia which can cause subsequent water health issues.

d) Implementation

Management of nutrient inflows, physical removal of infestations where practical and the use of biological agents where appropriate should be implemented for the containment of Salvinia. For maximum efficiency of time and funding, Salvinia in waterways can be treated at the same time as these other priority aquatic weeds. Distribution and treatment for Alligator Weed and Water Hyacinth is very similar to Salvinia. This is particularly relevant for chemical and mechanical controls.

Decaying plant matter can cause negative environmental impacts and be aesthetically unpleasant. Considerations should be made to use a combination of control methods and remove as much biomass is practical to mitigate further impacts to the waterway. Material disposal should be conducted in such a way that reduces reinfestation risk. Where herbicides are used, steps should be taken to keep nutrient loading and decay volume to a minimum to prevent secondary impacts.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

Salvinia is still used as a popular aquarium and ornamental pond plant (obtained illegally from other commercial businesses or locations) which poses risks of it entering waterways via the stormwater system. Ongoing compliance and surveillance are important to prevent further use and spread of the plant in this way.

f) Procedures

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Skunk Vine (*Paederia foetida*)

Skunk vine. Photo credit: Hyun-tae Kim (CC BY 4.0)

Status: Eradicate

a) Background

Skunk Vine is an invasive, pungent, semi-woody vine with rapid growth that has naturalised in the Greater Sydney region. The weed grows quickly and aggressively and can create dense shade. This is both harmful for understory plants and the heavy vines cause damage to trees and shrubs. Negative impacts of the weed include smothering and damage to native vegetation and associated fauna. Skunk Vine is likely to cause damage and displacement to native species and can alter community structure. The weed can also invade urban areas and form mats over lawns or smother ornamental plants. The vine reproduces vegetatively, and can spread via stem or root fragments, seeds, and dumped garden waste. Historically Skunk Vine has been spread widely around the world as a result of its use as an ornamental plant.

Skunk Vine has been classified as a regional priority weed in Greater Sydney with the objective of eradication. Species presence in the region is limited in abundance and distribution and elimination of the biosecurity risk it poses is reasonably practical. General biosecurity duty for the species in Liverpool LGA is that land managers eradicate and keep their land free from Skunk Vine and notify the Local Control Authority (Council) if they identify it on their land. Additionally, the plant (inclusive of all its part) cannot be grown, traded, carried, or released into the environment. The recognized strategic response for the region is the detailed surveillance, mapping, and destruction of all infestations where practical. Management must be in accordance with the NSW Weed Incursion Plan and appropriate quarantine and hygiene protocols should be implemented.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Council considers eradication of Skunk Vine a priority. There is currently very limited distribution of the species in Liverpool LGA with known infestations in West Hoxton and Warwick Farm and Council undertakes proactive management.

c) Control Options

i) Chemical

There are a variety of herbicides available to control Skunk Vine. Herbicide applications should be applied directly to the foliage and damage to surrounding non-target native vegetation mitigated. There are a range of appropriate application techniques and include options for spot spraying, spatter gun, wiping onto leaves and cut scrape and paint depending on the infestation character.

All herbicides should be applied in accordance with their directions. NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

ii) Non-Chemical Controls

Small infestations can be controlled by mechanical removal. However, where the infestation is dense, regrowth is likely and large-scale manual removal isn't usually successful. Any plant matter that is removed must be suitably disposed of to prevent seed germination or stem fragments taking root.

There is no biological control agent for Skunk Vine.

Further control information can be found at NSW WeedWise at weeds.dpi.nsw.gov.au .

d) Implementation

Eradication and monitoring of existing Skunk Vine infestations in Liverpool LGA should include chemical control and suitable disposal of plant matter. Council should also undertake proactive controls and surveillance to prevent further spread. Education and awareness activities of the regional importance should be pursued to increase knowledge for relevant stakeholders including land managers, private landholders, and the public.

e) Monitoring

Eradication is considered feasible and ongoing monitoring, surveillance and mapping should be incorporated within management plans in line with best practice guidelines.

f) Procedures

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Tiger Pear (*Opuntia aurantiaca*)

Tiger pear Photo credit: Florencia Grattarola (CC0 1.0)

Status: Eradicate

a) Background

Tiger Pear is a low spreading cactus with sharp spines that can cause injuries to humans and animals. It can grow in a range of climates and soil types, and once established is highly drought tolerant. Spread occurs by plant parts with new plants growing from fruit of small segments which detach and make contact with soil. Spread occurs via flowing water, garden waste and attaching to a variety of surfaces including animal coats, machinery, tyres and footwear.

Tiger Pear is listed as a WoNS and has negative impacts for agriculture, wildlife, and community. The weed has sharp, barbed spines which can cause serious injuries to people, livestock, domestic pets, and wildlife. Where the weed forms dense thickets, movement of animals can be restricted with implications for livestock access to feed, mustering, access to water and recreational activities such as camping and bushwalking.

The whole Greater Sydney region has been established as an exclusion zone with the objective of ensuring containment of the species. The core infestation areas have been classified for nearby LGAs (Wollondilly and Blacktown). Liverpool LGA is in the exclusion zone and whilst broad scale elimination is not practicable, minimisation of the biosecurity risk posed by this species requires containment and removal where it is reasonably practicable. Land managers should prevent spread of Tiger Pear from their land notify the local control authority (Council) if the plant is identified on their land.

Within the exclusion zone, Tiger Pear should be eradicated, and land kept free of the species. Within the core infestation area, land managers are to prevent spread from their land where feasible and

reduce the impact on priority assets. Additionally, under the Mandatory Measure (*Division 8, Clause 33, Biosecurity Regulation 2017*): a person must not move, import into the State or sell Tiger Pear. The recognized strategic response for the region is to ongoingly suppress and remove the plant, and to monitor changes to the distribution to prevent spread.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Council considers eradication and active surveillance for new incursions of Tiger Pear a priority. There is currently very limited distribution of the species in Liverpool LGA and council undertakes proactive management.

c) Control Options

Successful management requires a combination of control methods and is dependent on follow up controls after initial efforts including surveillance and removal of new growth.

i) Prevention

Avoid contact with Tiger Pear where possible and in an infestation area, vehicles, machinery, tyres and footwear should all be checked before leaving. Any plant parts which may have attached to any surfaces should be removed and disposed of carefully.

ii) Physical Control

For small and isolated plants, manual removal can be appropriate. Large infestations may require machinery to conduct ploughing. Where physical control techniques are used, care must be taken to remove the roots and for appropriate disposal of the plant mass. Personal protective equipment and clothing is essential to prevent injuries.

Proper disposal of the weed is critical for successful containment. Disposal of plant material should be done by either burning in a hot fire or burying it at least one metre below the surface. Council is responsible for providing information about appropriate local disposal.

iii) Biological Control

A number of biological agents are available for Tiger Pear. Core infestations can be effectively controlled by Cochineal insects (*Dactylopius austrinus*); however, this is more successful during hot dry summers than in wetter periods as the species reproduces faster than can be controlled by the agents. Two moth species can provide some level of control, the Cactoblastis moth (*Cactoblastis cactorum*) and the stem-boring moth (*Tucumania tapiacola*). These are less effective than the Cochineal and are already widespread so don't require redistribution.

iv) Chemical Control

A variety of herbicides are available to chemically control the weed. These are most effective when used on actively growing plants which usually occurs in October and February. It is important to ensure all parts of the plant are covered in herbicide and that treated plants are ongoingly checked. New growth should be controlled. Where the infestation is sparse or scattered, chemical controls are a practical control strategy.

All herbicides should be applied in accordance with their directions. NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

v) Challenges

The key challenges for Tiger Pear are adequately disposing of removed material and ensuring sufficient follow up controls. Prevention of infestations and their spread is the most effective management

strategy for any noxious weed, particularly as there is limited distribution currently in the Liverpool LGA. The challenge is to develop and deploy effective and efficient ways to contain an infestation before it becomes widespread

d) Implementation

Proactive controls, monitoring and surveillance should be a Council priority. Education and awareness activities of the regional importance should be pursued to increase knowledge for relevant stakeholders including land managers, private landholders, and the public.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

f) Procedure

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Water Hyacinth (*Eichhornia crassipes*)

Water Hyacinth. Photo credit: Lucy Keith-Diagne (CC BY 4.0)

Status: Contain

a) Background

Water Hyacinth is a free-floating perennial herb known as a fast growth aquatic weed. It grows on open bodies of fresh water, preferring still water with high nutrient loads. Growth is both rapid and very dense and is known to form heavy rafts of biomass. Reproduction is very efficient as plants reproduce both vegetatively from stolons and seed germination and plant numbers can double in five days. Seeds can germinate in three days and remain viable for at least 15 years. There is ongoing risk of it spreading after heavy rainfall from existing infestations or illegal ornamental plantings. One plant can produce enough growth to cover 600 square meters and this dense mass can choke waterbodies, causing oxygen and light depletion. This has negative implications for native habitats, water quality, and provides a breeding ground for mosquitoes. Further, it has major impacts for the waterways recreational and transport activities including swimming, boating and fishing. Large rafts can also damage structures such as bridges and dams due to their heavy weights (estimated 400 tons/ Ha). The species was introduced to Australia as an ornamental aquatic plant in the 1890's, but quickly became a pest for major rivers and creeks. This species does not grow in brackish water which has relevance to the Liverpool LGA where there are areas with tidal rivers and creeks.

Water Hyacinth has been classified as a State and regional priority weed in Greater Sydney with the objective of containment and asset protection from the species. Broad scale elimination is not practicable; however, minimisation of the biosecurity risk posed by this species requires containment and removal where it is reasonably practicable. A Biosecurity Zone (Part 5, Division 4, Biosecurity Regulation 2017) for strategic management of the species has been established in the State, however, the Greater Sydney region is excluded from this as it is a core infestation area. The general biosecurity duty for the species in Liverpool LGA is that land managers prevent its spread where feasible and that the plant, (inclusive of all its parts) cannot be grown, traded, carried or released into the environment.

Additionally, under the Mandatory Measure (Division 8, Clause 33, Biosecurity Regulation 2017): a person must not move, import into the State or sell Water Hyacinth.

The recognized strategic response for the region is to develop and implement a community campaign; and promote best practice principles to landholders. This includes supporting a range of control methods for integrated weed management and maintaining competitive vegetation/crops/pastures, hygiene and property management plans.

As the local control authority for weeds under the *Biosecurity Act 2015*, it is the elected council that is ultimately responsible for delivery of these weed control functions.

b) Current Management

Council considers eradication and active surveillance for new incursions of Water Hyacinth a priority. There is currently very limited distribution of the species in Liverpool LGA and council undertakes proactive management.

c) Control Options

Successful management requires a combination of control methods and is dependent on follow up controls after initial efforts including surveillance and removal of new plants.

i) Physical

If practical, small infestations can be removed manually. The plants can be physically removed from the waterway before seed set; however, care needs to be taken to prevent further spread of the weed. Rakes and nets can be used to drag the plant to the water's edge where it can be left to dry out on the waterway banks. Council is responsible for providing advice on how to dispose of the weed.

ii) Mechanical

Aquatic weed harvesters can be used to collect weed. Weed is then deposited on the waterway banks or in a sealed truck. Where feasible, this method is preferred over chemical herbicides as there is less decaying biomass left in the waterbody. Weed mass is instantly removed with immediate improvements for the waterway's aesthetic appearance and no increases to its nutrient load.

iii) Chemical

Chemical control is the most cost-effective strategy for large infestations and should be implemented when the weed is actively growing (generally in spring) for optimum results. Treatment is usually undertaken with handgun power sprays from the bank or boat. Aerial spraying has been used for larger infestations.

This method will cause the weed mat to sink and rot, which can lead to water de-oxygenation and fish kills. To prevent this, as much biomass as possible should be removed before spraying. This is particularly pertinent for larger infestations and NSW DPI recommends spraying only one third at a time. The New South Wales Weed Control Handbook provides up-to-date details for suitable registered herbicides.

All herbicides should be applied in accordance with their directions. NSW Weed Wise should be used for up-to-date information on registered herbicides, dosage and the best application methods. Appropriate permits for herbicide usage should be sought, particularly if spraying near waterways.

iv) Biological

Biological controls are suitable for long term management of the species as they can reduce flowering and occasionally cause the sinking of plant mats. In NSW, two insects (a weevil and moth), have been released for biological control of the species. These insects burrow into the plant, enabling water and bacteria to cause the plant to rot. Both agents have been released in the Western Sydney region. Biological controls alone do not control the species.

v) Cultural Control

A number of cultural controls can aid suppression of Water Hyacinth. For infested waterways, this includes retaining salty water or introducing it; minimizing nutrient run-off and/or reducing water levels to lower the area covered.

vi) Prevention

Prevention of infestations and their spread is the most effective management strategy for any noxious weed. Proactive controls, monitoring and surveillance should be a Council priority.

Education and awareness activities of the regional importance should be pursued to increase knowledge for relevant stakeholders including land managers, private landholders, and the public.

vii) Challenges

Decaying plant matter can cause negative environmental impacts and be aesthetically unpleasant. Considerations should be made to use a combination of control methods and remove as much biomass is practical to mitigate further impacts to the waterway. Material disposal should be conducted in such a way that reduces reinfestation risk. Where herbicides are used, steps should be taken to keep nutrient loading and decay volume to a minimum to prevent secondary impacts.

d) Implementation

For maximum efficiency of time and funding, Water Hyacinth in waterways can be treated at the same time as other priority aquatic weeds. Distribution and treatment for Alligator Weed and Salvinia is very similar to Water Hyacinth.

e) Monitoring

Eradication in most core area infestations is generally not feasible. Long-term management strategies aim for containment, reduction of impact by limiting spread, and suppression of biomass and density. There is a strong emphasis on preventing spread from the core areas. As such, ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines.

Water Hyacinth is known to still be used as an ornamental plant in ponds and dams (obtained illegally from other commercial businesses or other locations) which poses risks of it entering waterways via the stormwater system. Ongoing compliance and surveillance are important to prevent further use and spread of the plant in this way.

f) Procedures

Proactive program with prevention strategies and annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.

Willows (*Salix* spp.)

Willow spp.. *Photo credit: Hunter Regional Weeds*

Status: Asset Based Protection

a) Background

There are 32 different groups (species, varieties, subspecies and hybrids) of Willows in Australia and Willows are listed as WoNS. The Willows that have caused the most environmental damage are Grey Willow (*Salix cinerea*), Crack Willow (*Salix fragilis* var. *fragilis*), and Black Willow (*Salix nigra*). The relatively recent introduction of New Zealand Willows (*Salix matsudana* hybrids) which also fertilizes Weeping Willow (*Salix babylonica*) are both emerging threats. Willows are deciduous trees or shrubs that form large, dense root-mats on the surface of the soil or in shallow water and slow-moving streams. They invade thousands of kilometres of riverbanks and numerous wetlands in temperate Australia.

Willows are among the worst weeds in Australia due to their invasiveness, potential for spread, and economic and environmental impacts. They have invaded riverbanks and wetlands in temperate Australia, occupying thousands of kilometres of streams and numerous wetland areas. Unlike most other vegetation, willows spread their roots into the bed of a watercourse, slowing the flow of water and reducing aeration. They form thickets which divert water outside the main watercourse or channel, causing flooding and erosion where the creek banks are vulnerable. Willow leaves create a flush of organic matter when they drop in autumn, reducing water quality and available oxygen. This, together with the amount of water willows use, damages stream health. The replacement of native vegetation by willows reduces habitat for both land and aquatic animals.

Most Willows spread by fragments of stems or twigs breaking off and growing new roots in water. Pieces can travel many kilometres before establishing at a new site. Fishermen often break off twigs and stick them in the riverbank to hold their lines, and these pieces will also grow. Seed is the main method of spread for several species, especially Grey Sallow and Black Willow. Seed carried by wind or water easily travels more than 1 km, with small amounts potentially spreading up to 100 km.

Willows occur naturally in permanently or seasonally wet, inundated or waterlogged sites. The largest infestations in Australia are in Victoria, Tasmania, New South Wales and the Australian Capital Territory.

Several species (Weeping, Basket and Crack Willows) have been widely planted along the rural waterways of southeastern Australia for erosion control.

b) Current Management

Reactive management, only managed on bush regeneration sites.

c) Control Options

Effective long-term control of Willows requires implementing a combination of control methods with follow-up and monitoring. Willows are relatively easy to kill and mechanical and chemical control techniques are well understood. However, it should be noted that indiscriminate removal of willows is not recommended as it may lead to stream instability. Clearing any vegetation along waterways may cause erosion and may require consent before any work starts. It is the landholder's responsibility to obtain any approvals that may be required prior to undertaking clearing.

i) Chemical control

Herbicides available for woody weeds are effective in controlling willow. Common suitable herbicides includes Glyphosate, and Picloram with Tryclopyr or Aminopyralid. Trees can be killed by stem injection, application to leaves and stems, bark (chemical girdling) and cut and paint methods. In dry conditions herbicide can also be applied by basal bark spraying and treatment of seedlings. Although stem injection may be a slower, more laborious method, it is an important option for avoiding chemical runoff and protecting native vegetation. In general, herbicide should be applied from summer to early autumn, although stem injection or cut and paint application is effective year round.

Stem injection is suited to large trees. Make cuts or drill holes below the branches, around the trunk, 20–30 mm into sapwood. The injection points should be single cuts spaced at less than 130 mm intervals, or holes drilled at 50–100 mm intervals, around the circumference. Angle holes and cuts downwards to minimise herbicide leakage. Herbicide should be immediately injected into each cut or hole at the recommended rate. Leave the tree undisturbed for at least 12 months after herbicide application to ensure a successful kill.

Cut stump application should only be used to kill willows that can be easily and safely disposed of (i.e. smaller specimens). Cut the aerial trunk off completely at a level below the first branches and immediately apply a recommended herbicide to the cut stump. Remove all material to prevent regeneration from pieces. The cut surface of the removed stem should also be painted with herbicide for safe disposal. Minimal transport of branches and stems will help avoid broken fragments being spread. Willow wood chips can take root and grow so trees for chipping should be killed prior to removal.

The entire plant can be foliar sprayed if it is less than 2 m tall before the start of leaf fall and where herbicides will not affect native plants or make contact with water bodies.

ii) Mechanical removal

Elimination of young seedlings is a cost-effective way of keeping waterways free of potential blockages, erosion and streambed change. Hand pulling of seedlings less than 0.5 m tall is the most practical and environmentally safe way of removing young plants. Leaving small roots in the ground does not lead to suckering or regrowth. Using large machinery such as excavators or bulldozers to remove larger trees and root systems is not recommended except in dry areas. In wet areas bulldozers push broken branches into the ground and thus generate numerous new plants.

iii) Biological Controls

There are no useful agents in Australia for biological control of Willows.

iv) Prevention of spread and Education

Early detection and control are essential to prevent the spread of new infestations. The deliberate planting of willows along waterways has virtually ceased and extensive removal operations are common. It is fairly easy, given enough resources, to prevent the spread of willows that propagate by plant parts, as they are confined to streams and are spread downstream. For seeding willows, prevention of spread is difficult because seed can be dispersed over large areas. Willows are still widely planted, e.g. for windbreaks on farms, and many groups (including weedy ones) are sold by the nursery trade in Australia. There is potential for additional willow taxa to become naturalised if importation is not closely regulated. Education material for landowners and the public for identifying and reporting new outbreaks of the species should be produced.

v) Challenges

A long-term plan should be devised before any attempt is made to eliminate problem willows. Removal of trees can actually increase erosion problems, so a plan to replace willows with more desirable species is needed. Start by carrying out an extensive survey to identify potential seed sources. The willow species that set seed flower between September and November, so this is the best time to search for catkins on or under trees. Staged removal should be undertaken over a number of years, starting in the upper reaches of each catchment and working downstream. Where willows have been planted to stabilise soils or banks, alternative vegetation should be established before the willows are removed. Remove trees first which will not destabilise banks (e.g. on the inside of bends). Anticipate stream flow changes and be aware that removal of constrictions will allow greater pressure at restricted points further downstream. In these cases it may be advisable to start working on the lower end of the section, progressing upstream.

d) Implementation

For maximum efficiency of time and funding, Willows should be managed in a staged strategy that begins in the upper reaches of the catchment. First remove trees on the inside of bends because these banks are more stable.

e) Monitoring

Regrowth from stumps, pieces of stems or seeds will need to be followed up with monitoring and further control for 3–5 years after the initial effort. Check that treated trees have died, and remove trees that could cause problems if they become snared elsewhere by floods. Look for the spread of any new willows and follow up with substantial re-assessments at least every five years. Ongoing monitoring and surveillance should be incorporated within management plans in line with best practice guidelines such as the Willows National Management Guide (VIC DPI).

f) Procedures

A proactive program with annual treatment on Council lands including the targeting of recurring sites and reinfestations in line with best practice and informed by rigorous reporting and surveillance.