

# WEEDS OF NATIONAL SIGNIFICANCE

## Strategic Plan

Opuntiod cacti

*(Austrocyllindropuntia;  
Cylindropuntia;  
Opuntia spp.)*



2012 to 2017

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Supporting information about the Australian Weeds Strategy, Weeds of National Significance and progress to date may be found at [www.weeds.org.au](http://www.weeds.org.au), where links and downloads provide contact details for all species, their management committees and copies of the strategy.

This strategy was developed under the leadership of the Shauna Potter, national coordinator opuntoid cacti, Biosecurity SA (PIRSA), South Australia with full cooperation of all the States, Territories and Commonwealth of Australia.

Comments and constructive criticism are welcomed as an aid to improving the process and future revisions of this strategy.

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## EXECUTIVE SUMMARY

Opuntoid cacti (opuntoids) are highly invasive species that impact on Australia's economic, environmental and social assets and are Weeds of National Significance. These weeds include approximately 27 species from the *Austrocylindropuntia*, *Cylindropuntia* and *Opuntia* genera (excluding *Opuntia ficus-indica*). There are no cacti native to Australia.

Originating from the Americas, opuntoids were first introduced to Australia in the late 1700's and within 100 years some species had invaded millions of hectares of farmland. Whilst biological control has effectively reduced the extent and further spread of some species, there are many that have since established and which have limited control options at present.

Opuntoids impact on grazing enterprises by limiting access and contaminating hides and wool. They are a significant hazard to native wildlife, in some instances causing painful death, and reduced habitat opportunities. They are also a serious safety risk to weed managers due to the extremely spiny nature of some species. Native vegetation is also adversely affected through competition by opuntoid cacti for resources.

The cost of control often exceeds the value of the land infested with cacti. In addition, these weeds are difficult to identify, hard to manage, easily spread and occur in some of Australia's most remote areas. Therefore they present some unique management challenges. There are many people - individuals, land managers and community groups - dedicated to the control of opuntoids. It will be important to support their efforts if we are to realise the vision of this plan.

The strategic plan aspires to deliver the following goals and objectives:

### **1. New infestations are prevented from establishing.**

- Invasion vectors, sources and pathways are identified and managed to prevent or reduce spread.
- Surveillance and response mechanisms are ensuring timely detection of infestations (both new and previously undetected).
- Priority outlier infestations are contained or eradicated and spread from core infestations is prevented.

### **2. Established infestations are under strategic management.**

- Priority assets are benefiting from long-term strategic weed control programs.
- Integrated weed management practices are improving natural resource condition across the landscape.

### **3. Greater capability and commitment to manage opuntoid cacti**

- Infestations are mapped to national standards and to a level sufficient to inform decision making.
- Best practice management delivers efficient, effective and long-term control.
- Capability and motivation to manage are enhanced by education and awareness.
- Research priorities are identified, promoted, addressed, and results are informing management.
- Local to national plans incorporate strategic opuntoid cacti priorities.
- Stakeholders are committed to effective delivery of the strategic plan.
- Appropriate policies, codes of practice, legislation and enforcement are supporting strategic management objectives.
- The national strategic plan is regularly evaluated, relevant and effective.

## Vision /Aspirational Goal

The vision of this strategy is: Coordinated management is limiting the spread and reducing the impact of opuntoid cacti on Australia's productive and natural landscapes.

### 1 THE CHALLENGE

Opuntoid cacti (opuntoids, pronounced 'o-punt-e-oids') are a group of species belonging to the *Cactaceae* family and originate from the Americas (Johnson et al, 2009). These species are highly invasive and impact on Australia's economic, environmental and social values. Opuntoids are a complex and diverse group of plants that are difficult to accurately identify and challenging to manage due to the large number of species, their spiny nature and tendency to often be located in remote and inaccessible areas. All species within the genera *Austrocylindropuntia*, *Cylindropuntia* and *Opuntia* are considered Weeds of National Significance (with the exception of *O. ficus-indica*).

Cacti have a long history in Australia, with the first introductions associated with the First Fleet, who hoped to establish a cochineal dye industry (Raghu & Walton, 2007). Common prickly pear (*O. stricta*), was introduced and later cultivated for stock fodder and hedging throughout the 1800's (Chuk, 2010). This species quickly spread and at the height of invasion claimed an area of 240 000 km<sup>2</sup>, forcing farmers off their land (Hosking et al, 1988). By the 1930's cactoblastis moth, a biological control agent, had effectively reduced most large infestations, however by this time other cacti species had started to establish throughout Australia.

Cacti remain popular garden plants and are readily available through nurseries, plant outlets and via the internet. Many cacti are also sold at weekend markets, fetes and shows and plants are also shared amongst home gardeners and cacti enthusiasts. Many nurseries are becoming 'weed wise' and refrain from selling weedy species, complying with any legislated ban on the sale of opuntoids. There are, however, still sale and trade avenues that continue to promote and sell opuntoids, some of which are unregulated and this will be a challenge to address with traditional communication and education programs.

Opuntoids have been described as a 'cancer spreading across the landscape', alluding to the lack of general awareness of their identification and risk, as well as their distribution in areas that are infrequently visited or inhabited by few people. The challenge will be to improve recognition of opuntoids; better understand and communicate the risks associated with individual species within the opuntoid group; what makes them such successful invaders of multiple ecosystems; and long term management of seed and propagule banks that continue to re-populate areas previously managed.

Opuntoids present a threat to grazing industries through their ability to form dense infestations that can reduce access to feed and hinder mustering activities. The spiny nature of opuntoid cacti can injure stock, damage fleece and hides and affect the safe handling of affected animals for shearing purposes. Stock do not generally feed on opuntoids. It is important to note that, depending on the location and density of an infestation, the cost of control may outweigh the economic value of the land (Chuk, 2010). This can influence people's motivation to manage opuntoids, even if the impacts are known and understood.

The risk of injury from spines also applies to native wildlife, either through impalement or the lodgement of spiny segments in limbs, hides and mouths, leading to immobilisation and a painful death. Dense infestations of cacti can impede movement of native wildlife through corridors and limit access to refuges such as rock shelters and caves. Competition from opuntoids can also limit the growth of native vegetation, including small shrubs and groundcovers.

There are now approximately 27 species of opuntoid cacti that have naturalised in Australia (Bob Chinnock, pers. comm. May 31 2012- see appendix 7.1). They occur from Western Australia; across Central Australia; South Australia; Victoria; New South Wales; and throughout Queensland.

Soil types and climatic zones vary across this range, but do not appear to limit distribution to a great extent. Climate modelling indicates there is still potential for large range expansion throughout Australia. The exact area of infestation is unknown due, in part, to the lack of knowledge surrounding the species, however it is estimated that close to 1 000 000 hectares are affected in South Australia alone (Harvey, 2009).

Many people do not differentiate between species, labelling all simply as 'cactus'. Understanding the taxonomy of opuntiods is difficult due to multiple introductions and a high rate of hybridisation within the *Cactaceae* family. For this reason it will be critical to support the botanical expertise within Australian herbaria in order to build our knowledge of the number and extent of species present. This contributes to a robust risk assessment of naturalised species to determine where research and management efforts are best placed to reduce the spread and impact of high risk opuntiods. This is important given the large number of species and need to focus finite resources.

New infestations of opuntiods can be treated using mechanical and chemical methods. However, once infestations spread in area and density they can become costly and intractable due to the difficulty in finding small plants or segments. Control techniques can be laborious and expensive and even small infestations, if located in difficult terrain, can be time consuming and challenging to manage.

Core infestations can sometimes be managed with biological control agents, but effective control is currently restricted to a few species only, as agents are host specific. Finding new biocontrol options is a long and expensive process. Reducing the impact on priority assets such as agricultural land, high value conservation areas and places of social/amenity value will require a prioritised management approach to ensure resources are targeted correctly.

Improving the capacity and willingness to manage opuntiods will be critical if the prevention of spread into new areas and reduction of impacts on priority assets is to be achieved. Effective management requires an understanding of the species and what contributes to their survival and spread. This knowledge is currently limited in the Australian context. The national management approach outlined in this strategic plan will encourage land managers to form partnerships and work collaboratively to improve our knowledge base and to achieve control across the remote and peri-urban parts of Australia where these weeds are found.



Figure 1-Stem injection to control *Opuntia robusta* (wheel cactus). Photo courtesy of Ian Grenda.

## 2 INTRODUCTION

This strategic plan for opuntiods has been prepared to articulate the national management and research needs for this group of invasive cacti. The plan has been prepared by the national coordinator for opuntiod cacti, with input from a reference group comprising botanists, weed managers, researchers, state/territory government policy officers and community group members, all involved in the management of opuntiod cacti. In addition, extensive consultation with local and regional weed managers was undertaken across Australia to inform the content of this plan.

A four week public consultation period allowed others interested in opuntiod cacti to provide comment throughout August/September 2012. This plan will continue to be available on the WoNS website- <http://www.weeds.org.au/WoNS/opuntiodcacti/> - and will be distributed throughout other networks.

This plan provides a framework for coordinated management of opuntiods across Australia, with the aim of preventing spread, reducing impacts and increasing management capacity. This plan, approved and endorsed by the Australian Weeds Committee and the National Biosecurity Committee, sets the direction for nationally coordinated opuntiod cacti management. The aim is to deliver effective, national solutions through the provision of technical advice, education, awareness raising and support for research and on ground control of opuntiods.

There are many land managers, community groups and researchers who have contributed to the current knowledge base for opuntiods. This plan builds on the success of this work and seeks a collaborative approach to the ongoing management of opuntiods in order to limit their spread and reduce their impacts on Australia's productive and natural landscapes.

### 2.1 Principles underpinning the plan

The Australian Weed Strategy (AWS) identifies national weed management priorities and provides consistent guidance on the implementation of activities that address these national priorities. The opuntiod cacti strategic plan supports several key components of the AWS and aligns with the three strategic goals – (i) preventing new weeds; (ii) reducing the impact of existing weeds; and (iii) enhancing capacity and commitment to manage weeds.

This strategic plan also follows the principles of the AWS, which are:

- Weed management is an essential and integral part of the sustainable management of natural resources for the benefit of the economy, the environment, human health and amenity.
- Combating weed problems is a shared responsibility that requires all parties to have a clear understanding of their roles.
- Good science underpins the effective development, monitoring and review of weed management strategies.
- Prioritisation of and investment in weed management must be informed by a risk management approach.
- Prevention and early intervention are the most cost effective techniques for managing weeds.
- Weed management requires coordination among all levels of government in partnership with industry, land and water managers and the community, regardless of tenure.
- Building capacity across government, industry, land and water managers and the community is fundamental to effective weed management.

In addition to the AWS, WoNS strategic plans are also aligned to the 2012 Intergovernmental Agreement on Biosecurity (IGAB; COAG 2012), which outlines national invasive species management objectives. IGAB aims to enhance Australia's biosecurity system by fostering a collaborative approach to minimise the impact of pests across the biosecurity continuum, including 'a national management framework to ensure that nationally significant pests and diseases

established in Australia are contained, suppressed or otherwise managed.’ WoNS can contribute to this aim by facilitating coordinated, strategic management of nationally significant weeds.

IGAB principles highlight the importance of managing invasive species across the biosecurity continuum. The ‘One Biosecurity’ report (Beale et al. 2008) also recognises that weeds and other invasive species are biosecurity threats that are most effectively managed in a collaborative manner across this continuum. This includes a ‘spatial continuum’ of pre-border, border and post-border, as well as a ‘management continuum’ that spans prevention, eradication, containment and asset protection, depending on the scale of weed invasion.

In most instances, complete control of widespread weeds is unachievable. However, well researched, strategic and coordinated management approaches can reduce current and potential impacts and provide a good return on investment. Effective widespread weed management requires an approach that spans the biosecurity continuum (Figure 2).

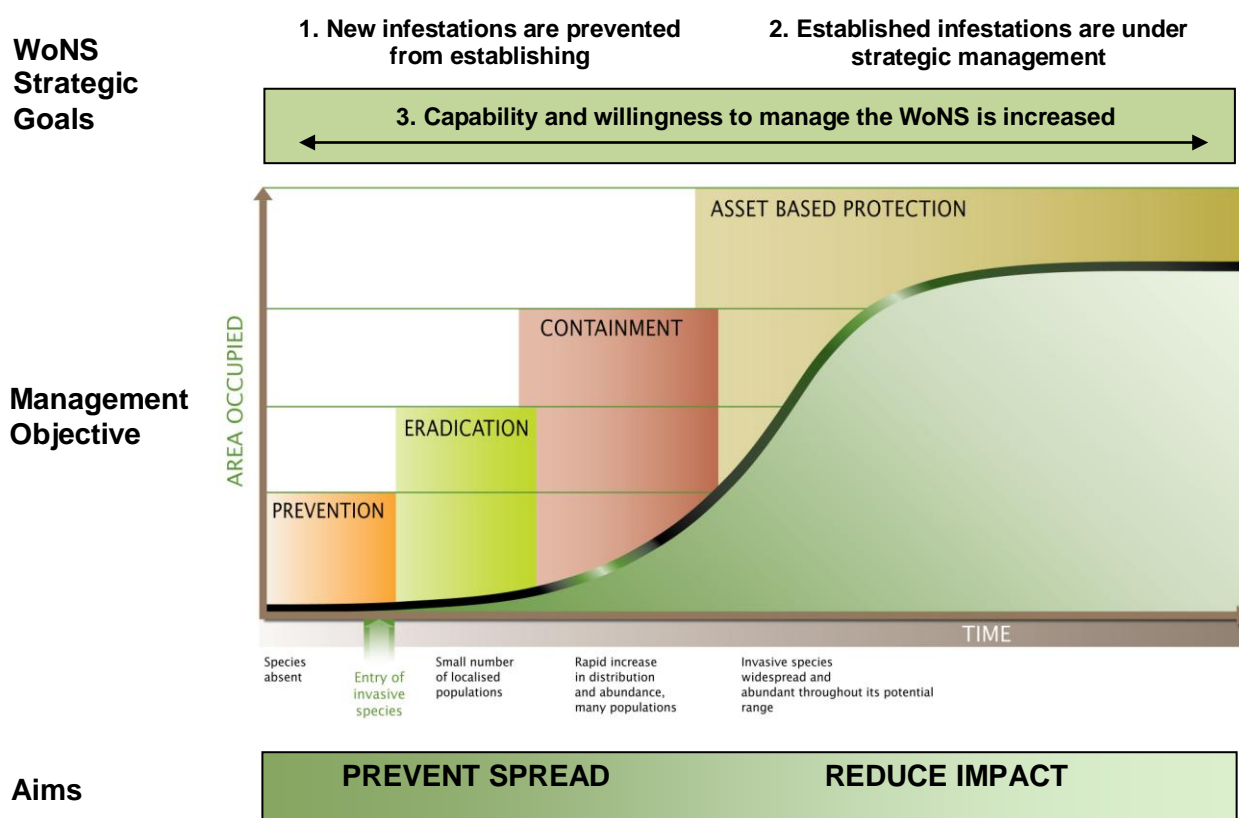


Figure 2 - Biosecurity continuum - Stages of weed invasion with corresponding goals, management objectives and actions at each stage. Modified from (Hobbs and Humphries 1995) and (DPI, 2010).

Effective management includes spread prevention practices and eradication of outlying infestations to protect environments where the weed has not yet taken hold; establishment and defence of containment lines to halt or reduce the rate of spread; and the identification and protection of key environmental, social and economic assets in areas where the weeds are already widespread. Paired with these efforts is the need for strong education, extension and capacity building programs, and support mechanisms to ensure on-ground outcomes are achieved.

A Monitoring, Evaluation, Reporting and Improvement (MERI) framework (see section 5) outlines some of the key areas of evaluation for opuntoid cacti. This framework is general in nature and will be supported by a MERI plan specific to opuntoids that will be reported on annually.

The program logic diagram in section 5.2 outlines how the actions within this plan will contribute to the attainment of medium to long term outcomes. The logic model also identifies the foundational

activities required to build a successful national opuntoid cacti program where results can be measured and reported on.

## 2.2 The current situation

Opuntoid cacti have naturalised in all jurisdictions except Tasmania and the ACT. In general terms the *Opuntia* genus is more widespread across Australia, particularly common prickly pear (*O. stricta*), velvety tree pear (*O. tomentosa*), wheel cactus (*O. robusta*) and tiger pear (*O. aurantiaca*). *Cylindropuntia* species are scattered across Australia and based on current knowledge are more problematic in WA, NSW and Qld. However, there are gaps in distribution data for other jurisdictions and it's likely that this group of species are behaving as sleeper weeds and will become more widespread and problematic.

The following maps provide a snapshot of current and potential distribution for the two species that were originally nominated for WoNS listing – wheel cactus and Hudson pear (see section 7.2 for more information on the nomination process). Additional mapping and modelling will be required to better understand the distribution of other opuntoids.

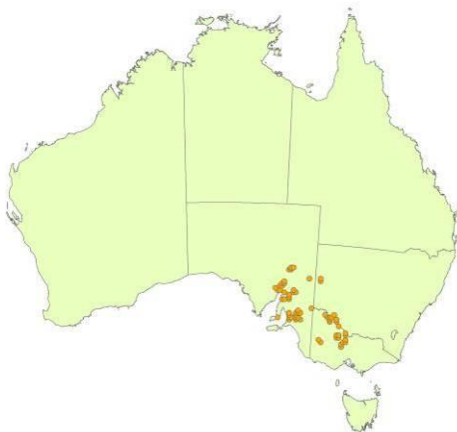


Figure 3 Distribution- wheel cactus (*Opuntia robusta*)- November 2011

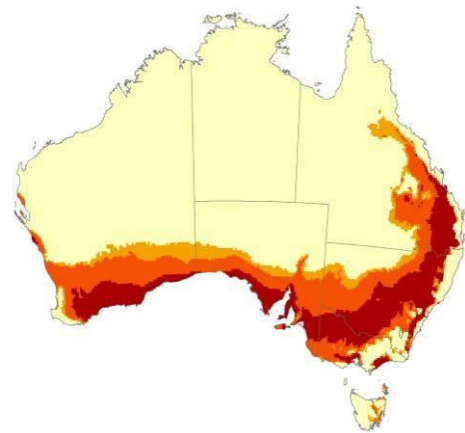


Figure 4 Potential distribution- wheel cactus (*Opuntia robusta*)- November 2011

### Legend - Distribution

- Present and past reported occurrence
- No reported occurrence

### Legend - Potential Distribution

- Unsuitable
- Marginally suitable
- Moderately suitable
- Highly suitable

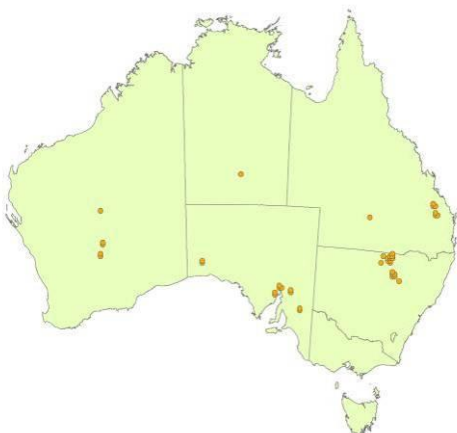


Figure 5 Distribution- Hudson pear (*C. rosea/C. tunicata*)- November 2011

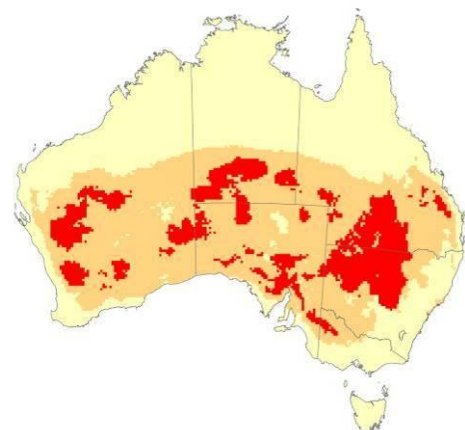


Figure 6 Potential distribution- Hudson pear (*C. rosea/C. tunicata*)- November 2011

There are several barriers to the current management of opuntiods, including their:

- Location in remote and inaccessible areas. In some instances control activities require the use of abseiling equipment and/or extensive work on foot, through mountainous terrain.
- Ability to spread both vegetatively and by seed. Long distance spread is aided by bird, animal, human and water movement.
- Drought hardy nature that allows propagules to survive dry conditions and then quickly respond to rainfall events.
- Cryptic biology and taxonomy and a lack of understanding of what influences population dynamics.

Common names are used interchangeably amongst species, particularly prickly pear, which is used in different instances to describe either *Opuntia stricta*; multiple *Opuntia* species; or all *Opuntia* and *Cylindropuntia* species. This creates confusion amongst the public and weed managers and also affects the development and interpretation of weed legislation and policy; herbicide labels; extension material and opuntiod management.

The declaration of opuntiods varies across jurisdictions and in many instances the legislation relates only to particular species rather than all opuntiods. In general one or several *Opuntia* species are declared, less commonly the *Cylindropuntia* and *Austrocylindropuntia* species. In some cases the declaration only applies to parts of a jurisdiction (e.g. WA). *Opuntia ficus-indica* is generally excluded from declaration across jurisdictions and it is not included in the WoNS opuntiod cacti listing due to the commercial production of its fruit in some areas. Nationally, declaration ranges from preventing the sale and trade of opuntiods, through to eradication requirements.

Consultation and field visits undertaken for the preparation of this plan have highlighted the growing concern amongst land managers and weed professionals regarding the spread of *Cylindropuntia* species. Many believe the risk associated with these species is underestimated and that more focus is required to prevent further spread and manage these species more effectively. Declarations inclusive of all opuntiods would reduce confusion and enable more coordinated management in many instances. More detailed information on declaration can be found in section 6.6.

### **2.3 Strategic plan development**

This plan has been developed by the national coordinator for opuntiod cacti, with input from a number of people involved in the management of these invasive species. A range of consultation processes were used, including meetings with individuals, regional weed groups, state agencies (for agriculture and environment), land owners and community groups. Information on the distribution, control methods, species' characteristics, attitudes to management and perceived knowledge gaps collected during this process have informed this plan.

A national reference group was also formed to ensure the plan adequately reflects the priorities and concerns of weed managers and policy makers across the national range of opuntiod cacti. The group met for a one day workshop to review the plan and identify the priority actions that will be required to reduce the spread and limit the impact of opuntiod cacti.

A draft of the strategic plan was made available via the [www.weeds.org](http://www.weeds.org) website to allow a period of public consultation in August/September 2012. Feedback has been considered and, where appropriate, incorporated in the final version of this plan.

## 2.4 Relevance to other strategies



Figure 7- Links to relevant strategies and plans

## 3 STRATEGIC GOALS AND OBJECTIVES

This plan outlines the strategic actions required to limit the spread and reduce the impact of opuntoid cacti on Australia's productive and natural landscapes. There are three goals, common to all WoNS strategic plans, which focus on:

1. Preventing the establishment of new infestations through early detection, eradication and containment programs;
2. Undertaking asset protection within core cacti infestations; and
3. Improving the ability of weed managers to effectively manage opuntoid cacti.

These goals align with the key weed management actions described in the biosecurity continuum – prevention; eradication, containment; and asset protection (see Figure 2), and acknowledge the need to manage opuntoid cacti across the biosecurity continuum.

**Table 1. Strategic goals and objectives**

Strategic Goal	Objectives
1. New infestations are prevented from establishing.	1.1 Invasion vectors, sources and pathways are identified and managed to prevent or reduce spread
	1.2 Surveillance and response mechanisms are ensuring timely detection of infestations (both new and previously undetected)
	1.3 Priority outlier infestations are contained or eradicated and spread from core infestations is prevented
2. Established infestations are under strategic management.	2.1 Priority assets are benefiting from long-term strategic weed control programs
	2.2 Integrated weed management practices are improving natural resource condition across the landscape
3. Greater capability and commitment to manage opuntoid cacti	3.1 Infestations are mapped to national standards and to a level sufficient to inform decision making
	3.2 Best practice management delivers efficient, effective

	and long-term control
	3.3 Capability and motivation to manage are enhanced by education and awareness
	3.4 Research priorities are identified, promoted, addressed, and results are informing management
	3.5 Local to national plans incorporate strategic opuntoid cacti priorities
	3.6 Stakeholders are committed to effective delivery of the strategic plan
	3.7 Appropriate policies, codes of practice, legislation and enforcement are supporting strategic management objectives
	3.8 The national strategic plan is regularly evaluated, relevant and effective.

Actions in this plan have been prioritised according to the following criteria:

**Priority 1** - Critical to the success of the strategy;

**Priority 2** - Highly beneficial and will contribute significantly to success of the strategy;

**Priority 3** - Desirable, still beneficial, but not critical to success of the strategy.

### Whole of WoNS activities

Some actions in the plan may be relevant for other WoNS species. Whilst there may be a species specific component to the action there is scope to work collaboratively/across WoNS on some actions. These actions are identified with an asterisk (\*) in the following tables.

### Collaborative decision making by responsible partners

Aspirational objectives in this plan are supported by strategic actions that identify how these objectives can be achieved. Further work will be needed to refine the actions and/or develop methods to implement the actions. This work will be done in a consultative manner with all responsible partners. Thus, it is important that the correct partners be identified and included in the decision making process and, where appropriate, that they identify an appropriate level of participation for implementing actions. Decisions regarding national priority actions will be led by a national management group, in collaboration with responsible partners and other relevant stakeholders. For most actions, these decisions are yet to be made and will rely on further collation of distribution data, risk assessment and due consideration of relevant legislation and policy. Final endorsement of priority actions will occur via the Australian Weeds Committee.

### Acronyms used throughout

AICN - Australian Invasive Cacti Network

AWC - Australian Weeds Committee

CHAH - Council of Heads of Australian Herbaria

CHABG - Council of Heads of Australian Botanic Gardens

Coordinator - National opuntoid cacti coordinator role

NGIA - Nursery and Garden Industry Australia

NOCC - National Committee

NRM - Natural Resource Management

### 3.1 GOAL 1: Prevent new infestations from establishing

Opuntoid cacti species vary in their distribution throughout Australia, with many species and/or infestations capable of further spread. Early detection and control of new infestations is the most efficient way of preventing increases in the extent and density of invasive cacti. This will rely on an understanding of vectors and pathways; and surveillance of high risk locations and industries. Early detection tools and training will be required to enhance weed manager and community capacity to undertake surveillance activities, including: 'how to' guidelines; training in cacti identification and specimen collection (with herbaria support); and information on safe handling options and hygiene protocols when searching for and managing cacti.

The eradication or containment of new outbreaks or outlier infestations is critical. Invasive cacti have the ability to remain undetected in the landscape for some time, taking advantage of favourable conditions to then spread into inaccessible locations and to large areas that subsequently become very difficult to manage. Underpinning the objectives below is the need to communicate the impacts associated with invasive cacti and the provision of best practice management information and training, which are included under goal three of this plan.

Objectives	Strategic Actions	Priority	Responsible Partners
<b>1.1 Invasion vectors, sources and pathways are identified and managed to prevent or reduce spread</b>	1.1.1 Undertake analysis of invasion vectors and pathways using available tools to inform and guide surveillance activities *	1	Coordinator/NOCC, states/territories, NRM regions, researchers
	1.1.2 Develop and promote guidelines that prioritise high risk pathways; including information on hygiene principles and appropriate disposal options for cacti species	1	Coordinator/NOCC, states/territories, AICN, NRM regions, researchers
	1.1.3 Engage botanic gardens, nurseries, cactus societies/grower groups, online and market traders to prevent the sale, trade and promotion of invasive cacti species	1	Coordinator/NOCC, states/territories, AICN, NRM regions, CHABG (botanic gardens), cactus societies, horticultural associations, nursery industry and other retailers

Objectives	Strategic Actions	Priority	Responsible Partners
<b>1.2 Surveillance and response mechanisms are ensuring timely detection of infestations (both new and previously undetected)</b>	1.2.1 Enhance capacity to undertake surveillance through the development of tools and delivery of training that applies to multiple situations	1	Coordinator/NOCC, states/territories, NRM regions, local govt, community groups
	1.2.2 Identify target areas for surveillance activities based on analysis of pathways, current and potential distribution, and assets at risk from opuntoid cacti	1	Coordinator/NOCC, states/territories, NRM regions, local govt, community groups
	1.2.3 Investigate new technologies to assist with surveillance activities such as GPS/smart phones, unmanned aerial vehicles and sensor detection systems *	3	Coordinator/NOCC, AICN, states/territories, researchers
	1.2.4 Encourage diagnostic support for surveillance including sufficient herbaria capacity to receive and correctly identify specimens *	1	Coordinator/NOCC, states/territories, CHAH (herbaria)
	1.2.5 Implement early detection programs, including accessible mapping and reporting systems, for opuntoid cacti	2	states/territories, NRM regions, local govt, community groups, recreational groups (e.g. 4WD clubs, walking groups)
<b>1.3 Priority outlier infestations are contained or eradicated and spread from core infestations is prevented</b>	1.3.1 Delimit the extent of outlier populations and prioritise sites based on risk of further spread, potential impact and feasibility of control	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, land managers
	1.3.2 Develop and adopt parameters and guidelines for the effective eradication/containment of priority sites/species to guide decision making and planning processes *	1	Coordinator/NOCC, states/territories, researchers
	1.3.3 Engage stakeholders to develop and implement eradication or containment programs for high priority outlier sites	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, mining industry & associations, pastoral boards and associations, land managers

### 3.2 GOAL 2: Existing infestations are under strategic management (Reducing impact)

Some infestations of cactus, particularly *Opuntia* species, are large, well established and not feasible to contain or eradicate. Opuntoid cacti threaten agricultural and environmental assets and areas of social/amenity value and in these instances efforts should be directed at protecting high value assets at the regional, state or national scale. Coordinated and integrated control measures, including the use of biocontrols, will be necessary for effective, long term control of cactus. In some instances landscape scale programs will be required, particularly when weed movement via water and animals threatens large areas of Aboriginal and pastoral lands and native vegetation. It will be important to effectively communicate the impacts of invasive cacti (detailed under goal three) and a mix of education and compliance measures may be required to achieve successful asset protection.

Objectives	Strategic Actions	Priority	Responsible Partners
<b>2.1 Priority assets are benefiting from long-term strategic weed control programs</b>	2.1.1 Compile a list of assets (economic, environmental and social) at risk from opuntoid cacti *	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups
	2.1.2 Develop a prioritisation process for assets at risk to guide investment and management for core infestations	1	Coordinator/NOCC, states/territories, NRM regions, local govt
	2.1.3 Engage/support stakeholders to develop and implement management plans to protect high priority sites from opuntoid cacti	1	Coordinator/NOCC, states/territories, NRM regions, local govt, land managers
<b>2.2 Integrated weed management practices are improving natural resource condition across the landscape</b>	2.2.1 Promote the adoption/implementation of best practice management (based on existing knowledge)	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt
	2.2.2 Explore opportunities and encourage coordinated, landscape approaches to cacti management, through education, incentives, lease conditions and compliance where reasonable	2	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups, land managers

Objectives	Strategic Actions	Priority	Responsible Partners
2.2 Cont.	2.2.3 Continue to distribute biological control agents to new sites or where reintroductions are necessary	2	States/territories, NRM regions, local govt, community groups, land managers
	2.2.4 Establish/undertake monitoring programs to determine the long term effectiveness of control programs in improving/protecting asset condition	2	States/territories, NRM regions, local govt, community groups, land managers

### 3.2 GOAL 3: Stakeholder capability and willingness to manage opuntoid cacti is increased

Work is still required to understand the presence and extent of this complex and large group of species within Australia, in addition to their ecology and the processes that influence population dynamics. Improved mapping of current and potential distribution will inform weed risk assessment, with the aim of prioritising research and management efforts. Providing key stakeholders with effective weed control solutions and improving their capacity to implement them will be critical in achieving the spread, prevention and impact reduction premise of goals one and two. More work is needed to develop cost effective control options, including the integration of herbicides, mechanical control and fire. Research into new biocontrols also offers options for the control of core infestations and reducing spread. A national approach to the management of invasive cacti will help ensure land managers are supported and encouraged to form partnerships to achieve control, particularly across the remote parts of Australia where large infestations of these weeds are found.

Objectives	Strategic Actions	Priority	Responsible Partners
<b>3.1 Infestations are mapped to national standards and to a level sufficient to inform decision making</b>	3.1.1 Collate current distribution data (at species level) into state and national databases *	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt
	3.1.2 Encourage survey and recording of unmapped opuntoid cacti sites, focussing on outlier infestations (including authentication of specimens lodged with herbaria)	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups, land managers, consultants
	3.1.3 Refine/produce potential distribution (risk) maps to include land use, soil type, rainfall, climate change etc where feasible	2	Coordinator/ NOCC, researchers
	3.1.4 Produce national distribution maps that include strategic management actions (e.g. eradication targets or containment zones) and accompanying priority management action spreadsheet	1	Coordinator/NOCC, Australian Govt, states/territories
<b>3.2 Best practice management delivers efficient, effective and long-term control</b>	3.2.1 Review existing control options and identify knowledge gaps and opportunities for integrated weed management approaches	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups, researchers

Objectives	Strategic Actions	Priority	Responsible Partners
<b>3.2 cont</b>	3.2.2 Develop improved management options, including: <ul style="list-style-type: none"> <li>• mechanical control guidelines that address spread prevention methods &amp; safe disposal options</li> <li>• herbicide options that are economical, minimise impact and are registered for use (or available through permits)</li> <li>• long term management where substantial seed banks exist</li> <li>• management techniques for specific species</li> <li>• the use of fire</li> <li>• biocontrol options</li> <li>• personal injury prevention &amp; management</li> </ul>	1	Coordinator/NOCC, states/territories, NRM regions, local govt, community groups, researchers
	3.2.3 Investigate the need for site restoration post control, including possible methods	3	Coordinator/NOCC, states/territories, researchers
<b>3.3 Capability and motivation to manage are enhanced by education and awareness</b>	3.3.1 Develop and implement a communication strategy that identifies target audiences, engagement processes and key messages in order to increase awareness of the threats posed by opuntoid cacti	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups, land managers, NGIA, nursery retailers, weed societies, industry
	3.3.2 Develop and implement training programs to improve community capacity to implement best practice management of cacti	1	Coordinator/NOCC, states/territories, NRM regions, local govt, community groups, land managers
	3.3.3 Encourage and support community participation in planning and management for opuntoid cacti, including the development of funding applications to address priority control objectives	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, community groups, land managers
	3.3.4 Seek funding, resources and support from funding bodies (state and federal govt and livestock and tourism industries) to implement the strategic plan	2	Coordinator/NOCC, states/territories,, NRM regions, local govt

Objectives	Strategic Actions	Priority	Responsible Partners
<b>3.4 Research priorities are identified, promoted, addressed, and results are informing management</b>	3.4.1 Undertake analysis of current research, identify gaps and promote priorities for opuntoid cacti through forums, networks and research organisations	1	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, researchers (including international)
	3.4.2 Improve understanding of opuntoid weed biology, ecology and taxonomy	1	Coordinator/NOCC, states/territories, AICN, researchers
	3.4.3 Investigate the need to nominate all opuntoid cacti as targets for biological control	1	Coordinator/NOCC, states/territories, AWC
	3.4.4 Investigate new biological control agents for cacti species, including agents effective across multiple species	1	Coordinator/NOCC, , states/territories, researchers
	3.4.5 Quantify and publicise the impacts and control costs of opuntoid cacti on production and natural systems	2	Coordinator/NOCC, states/territories, AICN, NRM regions, local govt, researchers
	3.4.6 Develop and implement a risk assessment process that prioritises opuntoid cacti species for management and research purposes	1	Coordinator/NOCC, states/territories, researchers
<b>3.5 Local to national plans incorporate strategic opuntoid cacti priorities [planning]</b>	3.5.1 Encourage all stakeholders to integrate strategic plan objectives into regional, state and national planning approaches *	1	Coordinator/NOCC, Australian govt, states/territories, NRM regions, local govt
	3.5.2 Develop/support management plans/process for cross-tenure, multiple partner control programs *	2	Coordinator/NOCC, states/territories, NRM regions, local govt, community groups, land managers

Objectives	Strategic Actions	Priority	Responsible Partners
<b>3.6 Stakeholders are committed to effective delivery of the strategic plan</b>	3.6.1 Establish a national management committee to oversee strategic plan implementation *	1	Coordinator, SA govt
	3.6.2 Establish and support a national opuntoid cacti network from the local to national level	1	Coordinator/NOCC, AICN, states/territories, state/regional cacti committees, NRM regions, local govt, researchers, community groups
	3.6.3 Communicate the purpose of the strategic plan to current and potential stakeholders *	2	Coordinator/NOCC, states/territories, AICN
<b>3.7 Appropriate policies, codes of practice, legislation and enforcement are supporting strategic management objectives</b>	3.7.1 Review declarations to prevent sale, trade and movement of opuntoid cacti *	1	Coordinator/NOCC, Australian govt, states/territories, NRM regions, local govt
	3.7.2 Investigate enforced control requirements and regionally specific regulations to support agreed eradication & containment objectives (where possible)	2	Coordinator/NOCC, states/territories, NRM regions, local govt
	3.7.3 Promote the inclusion of opuntoid cacti management in industry codes of practice	2	Coordinator/NOCC, states/territories, AICN, industry
<b>3.8 The national strategic plan is regularly evaluated, relevant and effective</b>	3.8.1 Develop and implement a MERI process for the opuntoid cacti strategic plan	1	Coordinator/NOCC,
	3.8.2 Communicate and report on evaluation outcomes to the AWC and other stakeholders	1	Coordinator/NOCC, with contributions from Australian govt, states/territories, NRM regions, local govt, researchers, community groups

## 4 STAKEHOLDER ROLES AND RESPONSIBILITIES

While landowners and managers are ultimately responsible for the control of opuntoid cacti on their land, the effective implementation of this strategy requires the involvement of a range of stakeholders. It is also noted that stakeholders responsibilities may vary between jurisdictions and that some may be optional while others are prescribed by legislation.

The successful achievement of strategy objectives relies on the development and maintenance of partnerships between community, industry and government and recognition of the roles of each stakeholder. Suggested responsibilities to assist in achieving these are:

### **Australian Government**

- Ensure quarantine controls to prevent importation of opuntoid cacti (DAFF Biosecurity)
- Contribute to governance processes for the effective delivery of the opuntoid cacti strategic plan
- Promote the status of opuntoid cacti as a WoNS, its impacts and the importance of management
- Undertake strategic opuntoid cacti control on all Australian Government managed lands

### **Australian Weeds Committee**

- Provide governance processes for the effective delivery of the WoNS strategies
- Provide a mechanism for identifying and resolving weed issues at a national level
- Facilitate coordination between the Australian, State and Territory governments on weed management policy and programs
- Provide advice to the National Biosecurity Committee on weeds issues
- Provide planning, coordination and monitoring of the implementation of the Australian Weeds Strategy
- Oversee the implementation of the activities described in the WoNS strategies
- Promote the importance and benefits of the WoNS program to all levels of government

### **National opuntoid cacti Management Group (or similar national management group)**

- Ensure a diversity of community and agency views are represented for effective strategy implementation
- Provide guidance, direction and policy advice for the management of opuntoid cacti through the delivery of the strategic plan
- Monitor, evaluate, report and improve strategy implementation
- Assist in the development and implementation of programs and initiatives which support strategic actions
- Maintain and build partnerships with key stakeholders to improve strategic opuntoid cacti management
- Identify funding sources and provide independent advice for prospective applicants for projects consistent with the needs of the opuntoid cacti strategic plan

### **Research institutions (e.g. CSIRO, Universities, government agencies)**

- Applied research to address priority national strategic requirements
- Identify research gaps and seek innovative solutions for the management of opuntoid cacti
- Seek new and on-going funding and support for research requirements

### **State and territory agencies (including public land managers)**

- Promote the status of opuntoid cacti as a WoNS, its impacts and the importance of management
- Maintain appropriate legislation and policies to achieve state and territory based objectives for managing opuntoid cacti
- Administer and enforce legislation where applicable (e.g. in Queensland, Tasmania, WA, Victoria, NT)
- Coordinate opuntoid cacti control and management at a jurisdictional level to foster the

delivery of the opuntoid cacti National Strategic Plan

- Work closely with regional bodies, local governments, communities and other stakeholders to prevent and minimise opuntoid cacti impacts.
- Identify strategic management areas and associated objectives
- Promote consistency with this plan in jurisdictional pest management plans
- Facilitate the inclusion of strategic opuntoid cacti management in pest management planning processes with secondary stakeholders
- Contribute to priority research initiatives
- Source funding for strategic management programs and research
- Implement monitoring and reporting protocols in line with the MERI plan and provide relevant information to the national committee and/or Australian Weeds Committee
- Develop and implement communication and extension plans where appropriate
- Facilitate state and territory level mapping and contribute to national mapping initiatives
- Ensure, where appropriate, participation on the National Opuntoid Cacti Management Committee or similar national group
- Manage and control opuntoid cacti on public lands in accordance with State/Territory or local government legislation, policy and best practice
- Improve knowledge of the identification, impacts and best practice impacts of opuntoid cacti
- Implement weed hygiene and other management practices to minimise spread of opuntoid cacti
- Provide support for the correct identification of opuntoid cacti and manage herbarium collections and records

#### **Natural Resource Management regions (or Catchment Management Authorities)**

- Incorporate opuntoid cacti objectives in relevant pest management plans and monitor implementation
- Administer and enforce legislation where applicable (e.g. in SA)
- Source funding and/or contribute to strategic control programs
- Improve regional awareness of impacts and identification; and promote early detection
- Participate in regional mapping initiatives and contribute to state, territory and national map production

#### **Local governments**

- Incorporate opuntoid cacti objectives in relevant pest management plans and monitor implementation
- Administer and enforce legislation where applicable (e.g. in NSW)
- Undertake surveying and mapping particularly in relation to outlying opuntoid cacti infestations
- Establish local management policies to contribute to strategic control, containment and/or asset protection objectives
- Improve community awareness of impacts and identification; and promote early detection
- Control opuntoid cacti on local government managed or owned land
- Facilitate the removal of urban plantings of opuntoid cacti
- Source funding and/or contribute to strategic control programs

#### **Community, conservation and other interest groups**

- Contribute local and regional perspectives to opuntoid cacti management
- Contribute to the development, implementation and/or review of local and regional pest management plans
- Promote and contribute to local and regional containment and/or management programs in partnership with relevant stakeholders
- Support and/or develop opuntoid cacti funding submissions in line with national priorities
- Participate in local and regional mapping initiatives and contribute to state, territory and national map production
- Promote awareness and best practice management through event coordination and product distribution

**Industry (pastoral, mining and other)**

- Promote and adopt best practice management of opuntoid cacti
- Identify gaps and issues associated with implementation of the opuntoid cacti national strategy
- Contribute to research and development of management practices to support industry members
- Ensure awareness of sale and movement restrictions of opuntoid cacti within industry members
- Improve community awareness of impacts and identification; and promote early detection

**Private land managers**

- Improve knowledge of the identification, impacts and best practice impacts of opuntoid cacti
- Identify opuntoid cacti and other weeds threatening the property
- Undertake any necessary planning and mapping
- Implement best practice management
- Implement weed hygiene and other management practices to minimise spread of opuntoid cacti
- Manage and control opuntoid cacti on private lands in accordance with State/Territory or local government legislation and policy

**Nurseries, horticulture associations, cacti societies**

- Understand and promote the threat associated with opuntoid cacti
- Identify opuntoid cacti and prevent promotion, sale and trade of species
- Ensure awareness of sale and movement restrictions of opuntoid cacti within industry members

**Recreational groups**

- Able to identify opuntoid cacti species
- Ensure appropriate hygiene measures are taken when moving through infested areas
- Assist with early detection efforts through the reporting of infestations

## 5 MONITORING EVALUATION REPORTING AND IMPROVEMENT

This monitoring, evaluation, reporting and improvement (MERI) framework lists the **minimum** reporting information that should be collected for the life of the strategic plan – including during Phase 3 delivery (see section 7.2). This will ensure that sufficient data is collected to identify successes and failures and provide the opportunity for improvement where outcomes are not being achieved. In addition to these minimum requirements, an annual MERI plan will ideally be developed to measure progress against actions and objectives in more detail.

### 5.1 Targets and Measures

Strategic Plan Goals	Key Evaluation Questions	Data/Evidence Required	Consider
<b>1. New infestations are prevented from establishing.</b>	To what extent have new infestations been prevented from establishing?	<u>1.1 National distribution data</u> <ul style="list-style-type: none"> <li>Has the national distribution map been reviewed and/or updated?</li> <li>Has the Priority Management Action spreadsheet been updated?</li> </ul>	<ul style="list-style-type: none"> <li>Are these documents publicly available?</li> <li>Have stakeholders been advised of any changes?</li> <li>Where is this data/info stored?</li> <li>Do they capture national priorities?</li> </ul>
		<u>1.2 New infestations</u> <ul style="list-style-type: none"> <li>Number of new outlier infestations<sup>1</sup> recorded.</li> <li>Percentage of known infestations actively controlled.</li> </ul> <p><sup>1</sup> New infestations should be an outlier, outside existing distribution of WoNS</p>	<ul style="list-style-type: none"> <li>Are any new outlier infestations occurring in areas identified as a high priority in the national strategy?</li> <li>How were infestations detected (passive or active surveillance, community reporting etc)?</li> <li>Have high risk pathways been adequately identified? And threats minimised?</li> </ul>
		<u>1.3 Eradication &amp; containment programs</u> <ul style="list-style-type: none"> <li>Percentage of eradication and/or containment programs being maintained</li> </ul>	<ul style="list-style-type: none"> <li>What percentage of programs identified in the national strategy are being actively managed?</li> <li>Is there a plan in place for ongoing management?</li> <li>How is progress being monitored and reported to stakeholders?</li> <li>Can include examples using case studies.</li> </ul>

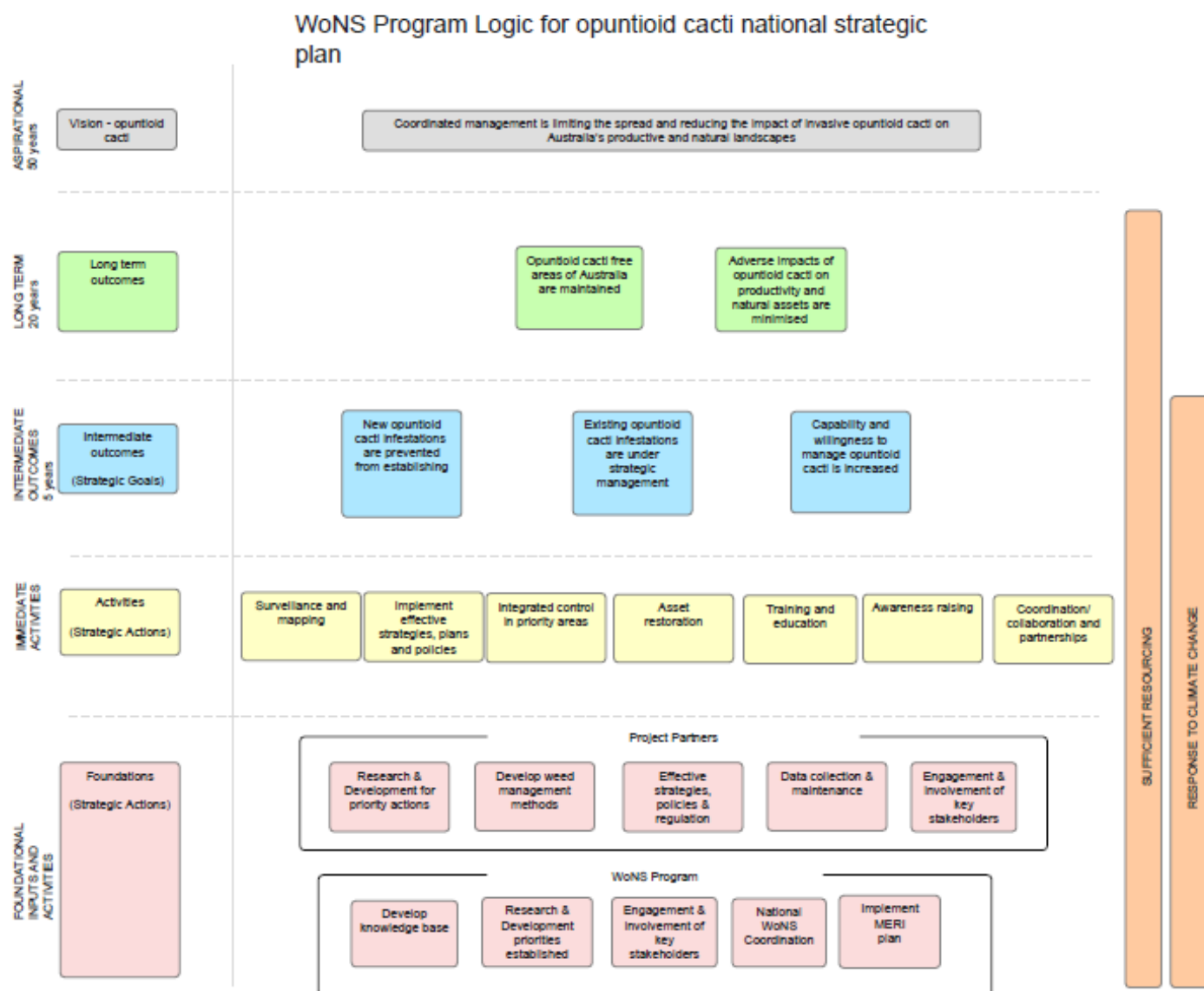
		<u>1.4 Legislation</u> <ul style="list-style-type: none"> <li>• Have there been any legislation or policy changes for this species?</li> <li>• Has a need for legislative change been identified by stakeholders?</li> </ul>	<ul style="list-style-type: none"> <li>• Are minimum requirements being maintained (e.g. ban on sale, trade, movement)?</li> <li>• Is control required throughout or in part of jurisdiction?</li> <li>• Is compliance actively enforced?</li> </ul>
		Overall progress rating	
<b>2. Existing infestations are under strategic management.</b>	To what extent is integrated weed management effectively managing core infestations?	<u>2.1 Integrated Weed Management</u> <ul style="list-style-type: none"> <li>• How effective are IWM programs?</li> </ul>	<ul style="list-style-type: none"> <li>• Are existing tools providing adequate control of WoNS?</li> <li>• Have new advances/technologies been developed and are they incorporated into BPM information?</li> <li>• Are there barriers to adoption of best practice management?</li> <li>• Are research programs addressing any observed gaps (e.g. herbicide trials, biocontrol, restoration requirements post control)?</li> </ul>
	To what extent are assets being protected through strategic management?	<u>2.2 Asset protection</u> <ul style="list-style-type: none"> <li>• Number of priority assets identified as 'at risk' from WoNS?</li> <li>• Percentage of priority assets being protected (eg assessed against relevant Threat Abatement Plans)?</li> <li>• Percentage of state/regional invasive species plans that identify priority assets at risk from WoNS?</li> </ul>	<ul style="list-style-type: none"> <li>• Response should include status report on progress towards asset protection programs.</li> <li>• Methods by which assets are being protected (e.g. targeted annual spray programs, high risk pathway surveillance, strategic plans).</li> <li>• Are long term monitoring programs in place to detect change?</li> <li>• To what extent is management leading to an improvement in asset condition?</li> </ul>
		Overall progress rating	
<b>3. Greater capability and commitment to</b>	To what extent has the capability and commitment to manage WoNS	<u>3.1 Community engagement &amp; awareness</u> <ul style="list-style-type: none"> <li>• What is the status of best practice information?</li> <li>• Are partnerships being maintained to ensure</li> </ul>	<ul style="list-style-type: none"> <li>• Is best practice information up to date and readily available?</li> <li>• Is this information and/or advice being targeted to</li> </ul>

manage WoNS.	increased?	collaboration on WoNS?	priority regions.
		<ul style="list-style-type: none"> <li>Number and type of media activities.</li> </ul>	<ul style="list-style-type: none"> <li>Is training being delivered to meet the needs of weed managers (including the community)?</li> <li>Are networks/groups being supported (e.g. through dissemination of research outcomes, funding opportunities, control options etc)?</li> <li>Has awareness and engagement in WoNS management been raised effectively?</li> </ul>
		<u>3.2 Resourcing</u> <ul style="list-style-type: none"> <li>From what sources are programs being funded?</li> </ul>	<ul style="list-style-type: none"> <li>Number of projects funded by Commonwealth, jurisdictions, industry, etc</li> </ul>
		<u>3.3 Policy &amp; Planning</u> <ul style="list-style-type: none"> <li>Are the objectives of the strategy being integrated into commonwealth/state/regional plans, policies and programs?</li> <li>Has cross border collaboration occurred?</li> </ul>	<ul style="list-style-type: none"> <li>How are priorities reflected in planning and policy approaches? E.g. WRA, invasive species plans, asset protection plans, district plans, weed spread prevention activities, management programs, incentive programs, state working groups.</li> <li>How are national priorities being maintained? E.g. containment lines, eradication targets, training &amp; awareness raising, research projects.</li> </ul>
		Overall progress rating	
Continuous improvement	Are there any unexpected outcomes that have been identified through implementation of strategy?	<u>4.1 Barriers</u> <ul style="list-style-type: none"> <li>Have any other management issues or impediments been identified?</li> </ul>	

### How to score progress rating

- 1- Insufficient evidence to score
- 2- No progress against goal
- 3- Limited progress is being made against this goal
- 4- Reasonable progress is being made against this goal
- 5- Excellent progress is being made against this goal

## 5.2 Program Logic Model



## 6 Technical Background

### 6.1 WoNS Weed identification

Opuntioids are a sub-family of Cactaceae, and in Australia there are three genera (and approximately 27 species) of opuntioids that have naturalised: *Austrocyllindropuntia*, *Cylindropuntia* and *Opuntia*. Opuntioids vary significantly in their form and habit, ranging from low growing shrubs under 50 cm to erect trees, 8 m tall (Hunt et al, 2006). They feature glochids; small, detachable, barbed bristles that often have the appearance of fine wool (Johnson et al, 2009). Many species are also covered with spines, typically 1-4 cm long.

Genera can be identified by their segments, also known as pads or cladodes. These segments can be flat or cylindrical and contain the green tissue of the plant where photosynthesis occurs. The actual leaves are small, and typically drop off when segments are young. Opuntioids often have large, colourful flowers that are white, yellow, orange, pink, red or purple. Some produce fleshy fruit which ripen to red, purple or yellow.

*Austrocyllindropuntia* originate in South America and are shrubby species with cylindrical, non-segmented branches, capable of unlimited growth. They differ from *Cylindropuntia* species in that their spines lack papery sheaths. Flowers are scarlet to orange. Of the 11 species worldwide, two have naturalised in Australia: *A. cylindrica* and *A. subulata*.

*Cylindropuntia* are native to south-western USA, Mexico and the West Indies. Species are shrubby or treelike and have cylindrical (rope like), branched segments. Segments are covered in tubercles; warty, rounded nodules from which the areoles and spines emanate. The spines have papery sheaths that separate from the spine in the first year.

Many species have easily detachable segments. *C. prolifera* is commonly known as jumping cholla due to its ability to seemingly 'jump' onto passing animals, humans and vehicles. Species in this genus are known to hybridise, which has led to taxonomic uncertainty and misidentification within Australia and internationally.

*Opuntia* originate in North America, the West Indies and South America. They are branched shrubs, typically to 2 m high, although they can grow taller. They have flattened, or compressed, segments, commonly referred to as pads, which are usually round or oval shaped. Flowers are yellow to orange. The most well known *Opuntia* species is common prickly pear, introduced to Australia in the 19<sup>th</sup> century.



Figure 8- *Austrocyllindropuntia*, *Cylindropuntia* and *Opuntia* species (left to right)

### 6.2 Opuntioide cacti biology and ecology

Opuntioids are perennial plants that are generally long lived. Flowering typically occurs from spring through to summer, with fruits forming in late summer and into autumn. Not all species develop mature fruit or viable seeds, but those that do can produce numerous seeds, with a hard seed coat enabling longevity. Seed can germinate at any time depending on rain, although

seedlings are not likely to survive if they are in exposed conditions. Seedlings can be difficult to detect when small as they tend to blend in with soil, leaf litter and other groundcover.

Opuntioids are distinguished from other Cactaceae sub-families by the presence of glochids; small, detachable, barbed bristles. Glochids grow from areoles, the name used for the small pits or depressions on the surface of segments. Areoles are also the points from which flowers, new segments or spines can grow and are present on both cacti segments and fruit.

Opuntioids grow throughout a wide climatic range, from arid and semi-arid environments to warm temperate, sub-tropical and tropical areas. In Australia they appear to have no preference for soil types and are found growing in calcareous loam, shallow granite, sandy soils, red earths and clay soils. Cacti flourish around old homesteads, dumps and mine sites. Detached segments of some species have been known to survive indoors for three years, demonstrating the plant's ability to persist under severe growing conditions.

Cactus spines provide protection from predators and heat (Walters et al, 2011). On some species spines also funnel moisture towards the plant's shallow root system, enabling growth in low rainfall climates. Another significant competitive feature is the type of photosynthesis in succulent plants, known as Crassulacean Acid Metabolism (CAM) (Walters et al, 2011). This allows the plant to close its stomata during the day, reducing water loss. Rapid growth of cacti often occurs after rainfall.



Figure 9- Opuntioids feature areoles, glochids and spines (left to right)

### 6.3 Opuntioid cacti distribution and spread

Opuntioids are native to the Americas, from Canada to southern South America and have naturalised throughout all Australian states and territories, excepting Tasmania and the ACT. Some species are more widespread (and in greater density) than others, such as common prickly pear (*O. stricta*), devil's rope (*C. imbricata*) and tiger pear (*O. aurantiaca*); whilst others, including Hudson pear (*C. rosea*/*C. tunicata*), coral cactus (*C. fulgida* var. *mamillata*) and jumping cholla (*C. prolifera*) are present in several states and territories, but are more scattered in their distribution, providing opportunities for containment.

Infestations of opuntioid cacti are present within the Goldfields/Esperance, Mid-west, Gascoyne and Pilbara regions of Western Australia. In South Australia, cacti are found in the Flinders/Outback, Clare Valley, Murray River and Eyre Peninsula regions. The Northern Territory has scattered infestations in Central Australia. Victoria has naturalisations in the Goldfields, Murray, Grampians and Melbourne regions. In NSW cacti are scattered around the Far West, North Central, South Central, Central, New England and Hunter regions, with greater concentration in the central and north central parts of the state. Infestations can be found throughout Queensland, from the South, Central and North West, Darling Downs, Fitzroy, Mackay and Northern regions.

Hudson pear (*C. rosea*) is found around Lightning Ridge in NSW (60 000 ha infested); southern Queensland; SA; NT; western Victoria; and in the Goldfields region of Western Australia. Wheel

cactus (*O. robusta*) occurs in the Flinders Ranges (35 000 ha infested), in the mid-north and along the River Murray in SA; north central Victoria; and southern NSW. Tiger pear (*O. aurantiaca*) occurs in throughout NSW (200 000 ha infested); southern Queensland; Victoria; and SA. Whilst many significant infestations are found in remote areas, some species are also problematic in peri-urban areas, in backyards and along roadsides and property boundaries.

There is potential for significant range expansion within Australia. Potential distribution modelling based on two species, Hudson pear (*C. rosea/C. tunicata*) and wheel cactus (*O. robusta*) indicate an opportunity for expansion throughout all mainland states and territories (see Figures 4 & 6).

Vegetative spread is a common dispersal mechanism for opuntiods. It can occur at any time when segments, immature fruit or flowers detach and come into contact with the ground. Segments of many opuntiods will attach easily to clothing, footwear and the hides and limbs of animals, aiding spread. Seeds are a less common form of spread, as viable seed are not produced by all species. However some species, such as wheel cactus (*O. robusta*) and common prickly pear (*O. stricta*), produce bright, large fruit that are attractive to birds and other animals, which aids seed dispersal. New growth and spread can also occur from flowers, as they are surrounded by reproductive tissue.

Spread is also aided by the movement of water; hence distribution often occurs along watercourses, drainage lines and across flood plains.

#### 6.4 Summary of impacts

Invasive cacti impact on Australia's environmental, agricultural and social values, as well as posing a risk to animal and human safety (Holtkamp, 2006). Opuntiods have been identified as a major threat to Australia's rangelands, which represents 80% of Australia's land mass (Forrest et al., 2010; Chuk, 2010). Large stands of cacti provide harbour for pest animals, such as foxes and rabbits and, due to their spiny nature, can limit access for stock mustering and recreational activities. The spines are capable of causing serious injury to humans and animals. Reports of bats, birds and marsupials impaled on cacti are not uncommon and some infestations are thought to be threatening populations of vulnerable animals, such as the Yellow-footed Rock wallaby.

Dense infestations can compete with native vegetation, limiting the growth of small shrubs and groundcover species. The sharp spines or barbs on these plants can cause injury to stock and native animals and contaminate wool and hides. As a result, infestations can reduce or prevent grazing and shearing activities, thereby reducing the productive value of the land.

Opuntiods have become successful invaders in Australia due to their ability to:

- **Reproduce** both vegetatively and by seed. Species that produce seed (most often *Opuntia*) also have bright, fleshy fruit, making them attractive to birds that are capable of moving seed long distances.
- **Survive** extreme weather including cold temperatures and prolonged periods of drought. Stomatal closure (via CAM) during the day limits moisture loss.
- **Protect** themselves from herbivory through the presence of spines. In many cases plants (most often *Cylindropuntia*) have an extremely dense covering of long, barbed spines. This reduces grazing but also aids further spread by attaching to animal fur, limbs and hides; vehicle tyres, footwear and machinery.
- **Behave cryptically** by blending into surrounding landscapes, hindering detection and effective control efforts.

#### 6.5 Control options

There are several options available for managing opuntiods. For large infestations integrated weed management approaches will be necessary, using a combination of biological control (if available), herbicides and/or manual removal. Follow up is essential in any control program, particularly given the ability of cacti to reproduce from segments, fruit and seed.

The cost of control often exceeds the value of the land infested with cacti so it is important to remove small infestations before they spread. As they tend to grow in isolated areas, including rangelands, there are several challenges associated with their effective management (Edmunds, 2006). Remote areas have small populations with limited resources such as equipment and labour. Cacti also grow in areas where land managers have large properties that may be visited infrequently or are difficult to access due to steep terrain. Seedlings and detached segments often blend into the landscape making detection and eradication difficult.

#### **6.5.1 Spread prevention**

Opuntiods can spread easily from the movement of seeds, fruit and segments via birds, animals, water, vehicles, equipment and people. Good hygiene is essential when working in infested areas, including staying on tracks. All segments and fruits should be removed from an area as they are capable of regrowing, even under very harsh conditions.

#### **6.5.2 Chemical control**

Four herbicides are registered for the control of opuntiods and include MSMA, triclopyr, picloram+triclopyr, and amitrole, under various trade names. In some instances off-label permits are issued by the APVMA, and there are four off-label permits for the control of opuntiod cacti throughout SA, NSW and Queensland. For more details on herbicide registration and permits go to [www.apvma.gov.au](http://www.apvma.gov.au).

*Opuntia* species can be readily controlled by stem/pad injection and foliar spraying, whilst *Cylindropuntia* species require overall spraying due to the fragile nature of their segments. Care must be taken to ensure adequate coverage of the plant (all sides of the segments) to prevent regrowth.

Plants should be actively growing and not under stress from heat/drought or cold conditions. Plants may die quicker as a result of warm weather spraying, as cooler conditions can slow the uptake of herbicides. Herbicides may not result in a complete kill. Control sites should therefore be monitored for re-growth and follow-up activities applied if necessary.

#### **6.5.3 Mechanical control**

Care must be taken when undertaking mechanical or physical removal of opuntiod cacti due to their spiny nature. Small, isolated plants may be more easily removed than large, dense infestations and some species, such as Hudson pear (*C. rosea*/*C. tunicata*) and devil's rope (*C. imbricata*), can pose significant risk of injury when handled.

Physical removal can be difficult as any segments detached in the process can regrow to form new plants. Material must be disposed of appropriately via burning, deep burial or mounding of plants with follow up herbicide control of any regrowth.

#### **6.5.4 Fire**

Fire can be used to manage cacti, but given their fleshy nature it can be difficult to kill plants. Hot fires may kill small plants but regrowth can also occur. Burning can also assist in providing access to sites and improve detection of small plants that may be hidden by other vegetation. Removing the bulk of the plant through burning can also reduce the amount of herbicide required for follow up control. Burning is also effective at removing cacti spines, which reduces the likelihood of spread by animals. It is sometimes used as part of an integrated control program, with follow up chemical application to ensure plant death.

#### **6.5.5 Biological control**

There are two main agents used in the biological control of opuntiods, *Cactoblastis cactorum*, (a stem-boring moth) and several *Dactylopius* species (cochineal scale insects) (Julien et al, 2012). *Cactoblastis* has been extremely successful in controlling common prickly pear (*O. stricta*) in most situations, although it is less effective in cooler, wetter areas or very dry locations. *Cactoblastis* larvae feed on segments, resulting in the collapse of plants. They can feed on a range of opuntiod cacti, but are only effective at controlling common prickly pear.

There are several *Dactylopius* species (cochineal) present in Australia (Hosking et al, 1988). The species look similar to the naked eye, but differ in their host ranges so it is important to use the correct cochineal. For example, cochineal that is effective on tiger pear will not work on common prickly pear. Heavy rain and cold weather can inhibit the effectiveness of cochineal; however successful control is possible for tiger pear, common prickly pear, devil's rope and velvety tree pear.

It is relatively easy to infect vulnerable cacti species with *Cactoblastis* and cochineal by re-distributing the agents either as eggs (in the case of *Cactoblastis*) or by placing infected segments on unaffected plants (in the case of *Cactoblastis* larvae or cochineal).

Researchers are investigating potential cochineal strains for the control of Hudson pear and other *Cylindropuntia* species, and trials are underway for the use of cochineal on wheel cactus.

#### **6.5.6 Other control options**

Grazing- The spines on opuntoid cacti prevent grazing in most instances, however stock and other animals sometimes feed on less spiny species in times of drought. In most instances the presence of opuntoid cacti limits or prevents grazing activities.

## 6.6 Quarantine and legislation

Note the table below provides a general overview of declarations for opuntoid cacti as a group. Declarations vary across jurisdictions and in some instances on a species by species basis, for example all opuntoid cacti are declared under South Australian legislation (excluding *O. ficus-indica*), whereas only some species are declared in Victoria.

State / Territory	Legislation	Declaration	Goals/Actions
Queensland	<i>Land Protection (Pest and Stock Route Management) Act 2002</i>	Class 1 & 2	<b>Class 1</b> pests established in Queensland are subject to eradication from the State. Landowners must take reasonable steps to keep land free of Class 1 pests. It is a serious offence to introduce, keep or supply a Class 1 pest without a permit. <b>Class 2</b> pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Management requires coordination and they are subject to programs led by local government, community or landowners. Landowners must take reasonable steps to keep land free of class 2 plants. Must not keep or supply without a permit.
New South Wales	<i>Noxious Weeds Act 1993</i>	Class 4- All of NSW declaration	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed.
Northern Territory	<i>Weeds Management Act 2001</i>	B/C	<b>B-</b> Growth and spread to be controlled. Reasonable attempts must be made to contain the growth and prevent the movement of the plant. <b>C-</b> Not to be introduced to the Territory (all Class B weeds are also considered to be Class C weeds).
Western Australia	<i>Agriculture and Related Resources Protection Act 1976</i> <i>Plant Diseases Act 1914</i> <i>Biosecurity and Agriculture Management Act 2007</i>	P1, 2, 4 (only applies to some <i>Opuntia</i> species)	<b>P1</b> - Introduction of the plant into, or movement of the plant within, an area is prohibited. <b>P2</b> - Plant to be eradicated in the area. <b>P4</b> – Spread of plant beyond where it currently occurs to be prevented.
South Australia	<i>Natural Resource Management Act 2004</i>	Sections: 175(1)(2), 177(1)(2), 182(2)(3), 185(1)	<b>175(1)</b> - Prohibiting entry to area, known as the control area, which could be the whole State or only some NRM regions. (2) Prohibiting movement on public roads. <b>177(1)</b> -Prohibiting sale of the plant. (2) Prohibiting sale of contaminated goods. <b>182(2)</b> -Landowners to control the plant on their properties. <b>185(1)</b> -Recovery of control costs on road reserves from the adjoining owners for control work done by the NRM Board.
Victoria	<i>Catchment and Land Protection Act 1994</i>	Restricted/Regionally controlled (only applies to some <i>Opuntia</i> species)	<b>Restricted-</b> plants that pose an unacceptable risk of spreading in this State and are a serious threat to another State or Territory of Australia. Trade in these weeds and their propagules, either as plants, seeds or contaminants in other materials is prohibited. <b>Regionally controlled-</b> These invasive plants are usually widespread in a region. Ongoing control measures are required. Land owners have the responsibility to take all reasonable steps to prevent the growth and spread on their land.
Tasmania	<i>Weed Management Act 1999</i>	Not declared	N/A
ACT	<i>Pest Plants and Animals Act 2005</i>	Not declared	N/A

## 7 Appendices

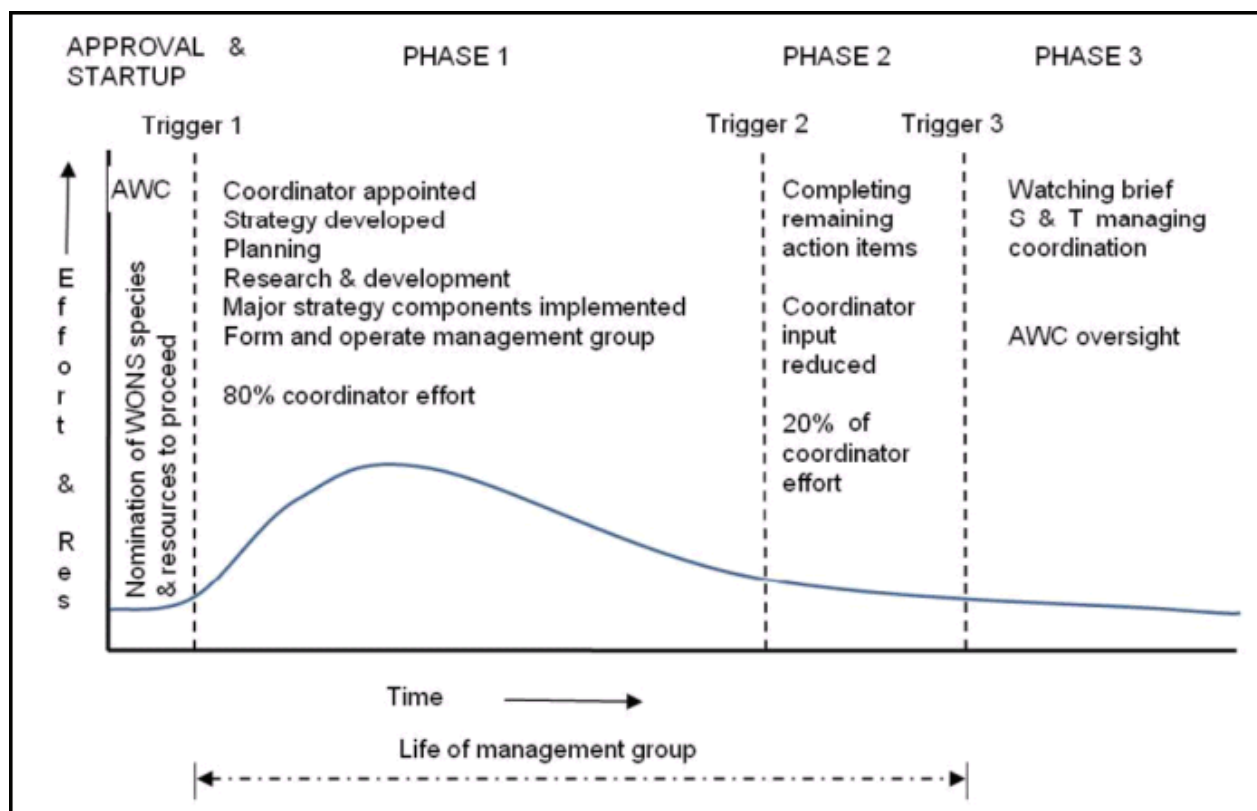
### 7.1 Opuntoid cacti known to have naturalised in Australia (Courtesy of Bob Chinnock, Adelaide Herbarium)

<i>Austrocylindropuntia</i>	<i>A. cylindrica</i>
	<i>A. subulata</i>
<i>Cylindropuntia</i>	<i>C. fulgida</i>
	<i>C. imbricata</i>
	<i>C. kleiniae</i>
	<i>C. leptocaulis</i>
	<i>C. prolifera</i>
	<i>C. rosea</i>
	<i>C. spinosior</i>
	<i>C. tunicata</i>
<i>Opuntia</i>	<i>O. aurantiaca</i>
	<i>O. elata</i>
	<i>O. elatior</i>
	<i>O. englemannii</i>
	<i>O. ficus-indica</i> *
	<i>O. humifusa</i>
	<i>O. leucotricha</i>
	<i>O. microdasys</i>
	<i>O. monacantha</i>
	<i>O. polyacantha</i>
	<i>O. puberula</i>
	<i>O. robusta</i>
	<i>O. streptacantha</i>
	<i>O. stricta</i>
	<i>O. schickendantzii</i>
	<i>O. sulphurea</i>
	<i>O. tomentosa</i>
	<i>O. sp. aff. microdasys</i>

\* Excluded from the WoNS listing

## 7.2 The WoNS Program and its phases<sup>1</sup>

In 2007, an independent review of the WoNS program concluded that the nationally strategic approach of WoNS was highly successful in leveraging consistent multi-jurisdictional activity on high priority weed species. This initial review was followed by a detailed review of the inaugural WoNS species by the Australian Weeds Committee (AWC) in 2009-10. The AWC reviewed the implementation of the 20 WoNS national strategies and, in light of achievements for these 20 species, considered the capacity for national coordination of additional WoNS species. Following the reviews, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Fig. 10). This 'phased approach' aims to provide the most cost-effective use of limited 'national coordination' resources.













**Figure 10.** Australian Weed Committee diagrammatic representation of coordinator effort and resource use when implementing a Weeds of National Significance strategy. (S & T refers to States and Territories).









The phased approach recognises the need for reduced national coordination ('phasing down') of WoNS species that are under effective national management, and allows for further weed species to be nominated for consideration as additional WoNS. The AWC is implementing these reforms, and national coordination of the inaugural 20 WoNS species has already transitioned to Phase 2 or 3, depending on the species. No species have yet been removed from the WoNS list. The AWC is developing a protocol to guide future decisions about when this should occur on a case by case basis.

In 2010, jurisdictions nominated additional candidate WoNS species. These species were independently assessed and the AWC endorsed twelve additional 'species' to be listed as WoNS. The AWC Chairman, Dr Jim Thompson, announced these additional plant species as WoNS on 20 April 2012. Additional information on the selection of these species and the phased approach is available on [www.weeds.org.au/WONS](http://www.weeds.org.au/WONS)

<sup>1</sup> From Thorp 2012 "Additional List of Weeds of National Significance – April 2012"  
[www.weeds.org.au/WoNS](http://www.weeds.org.au/WoNS).

### 7.3 Identification features of some opuntioide cacti

Species	Habit	Flowers & fruit	Segments		Dispersal	Distribution	Legislation
 <p><b>A. cylindrica</b></p> <p>Photos: Sheldon Navie; Bob Chinnock</p>	Shrubby/tree like to 4 m.	Flowers: Pink-red, 2.5 cm. Fruit: To 5 cm long. Yellow to green.		Segments to 50cm long.	Vegetative.	WA, SA, Vic, NSW, Qld.	Declared in SA.
 <p><b>Coral cactus (<i>Cylindropuntia fulgida</i> var. <i>mamillata</i>)</b></p> <p>Photos: Mike Chuk</p>	Shrub to 1.5 m.	Flowers or fruit not known to develop (except in one location in WA).		Segments distorted and misshapen.	Vegetative. Often along watercourses.	WA, SA, NT, NSW, Qld.	Declared in SA, NSW, Qld.
 <p><b>Devil's rope (<i>Cylindropuntia imbricata</i>)</b></p> <p>Photos: Adrian Harvey, RSSA</p>	Branched shrub to 3m. Can develop a trunk.	Flowers: Purple, 3-7.5 cm. Fruit: Egg shaped to 4 cm wide. Green to yellow.		Cylindrical, rope like segments.	Vegetative. Seed (less common).	WA, SA, Vic, NT, NSW, Qld.	Declared in SA, NSW, Qld.
 <p><b>White-spined Hudson pear (<i>Cylindropuntia rosea</i>)</b></p> <p>Photos: Royce Holtcamp, NSW DPI</p>	Shrub to 1.5 high, 3 m wide.	Flowers: Pink-purple to 5 cm. Fruit: Egg shaped, 2–4.5 cm long.		Cylindrical, rope like segments.	Vegetative. Rarely forms seeds (seed appear to be sterile).	WA, SA, NT, NSW, Qld.	Declared in SA, Qld, NSW.
 <p><b>Brown-spined Hudson pear (<i>Cylindropuntia tunicata</i>)</b></p>	Shrub to 60cm high	Flowers: Yellow-yellowish-green to 3cm. Fruit: club shaped, green.		Cylindrical, rope like segments.	Vegetative. Seed (mostly sterile).	WA, SA, Vic, NSW, Qld.	Declared in SA, Qld, NSW.

	Photos: Biosecurity SA							
	<b>Smooth tree pear</b> <b>(<i>Opuntia monacantha</i>)</b>  Photos: Adrian Harvey, RSSA	Tree-like to 4 m high.	Flowers: Yellow, 3-6 cm wide. Fruit: egg shaped, 5–7 cm long. Red-purple when ripe.		Light green, flattened segments 12–15 cm long.	Vegetative.	WA, SA, Vic, NSW, Qld.	Declared in WA, NT, SA, Vic, NSW, Qld.
	<b>Wheel cactus</b> <b>(<i>Opuntia robusta</i>)</b>  Photos: Greg Patrick, SAAL NRM Board	Shrub to 4m high (commonly 1-2m).	Flowers: Yellow, 5-8 cm wide. Fruit: Barrel shaped to 8 cm long. Pink-purple when ripe.		Blue-green flattened segments. Round to 40cm wide.	Vegetative & seed.	SA, Vic, NSW.	Declared in NT, SA, NSW, Vic, Qld.
	<b>Common prickly pear</b> <b>(<i>Opuntia stricta</i>)</b>  Photos: Mike Chuk; Troy Bowman, RSSA	Shrub 1 - 2m high.	Flowers: Yellow 6 cm wide. Fruit: Egg shaped with flattened top. Purple when ripe.		Segments flattened to 40cm long.	Vegetative & seed.	WA, SA, NT, Vic, Tas, NSW, ACT, Qld.	Declared in WA, NT, SA, Vic, NSW, Qld.
	<b>Velvety tree pear</b> <b>(<i>Opuntia tomentosa</i>)</b>  Photos: Sheldon Navie; Bob Chinnock	Tree to 8m high.	Flowers: Orange, 4-5 cm wide. Fruit: Egg shaped with flattened top. Red when ripe.		Flattened segments to 30cm long.	Vegetative & seed.	SA, NSW, Qld.	Declared in NT, SA, NSW, Qld.

## 7.4 Glossary

**Areoles**- a highly specialized axillary or lateral bud or short shoot or branch (Anderson, 2001). They appear as small pits or depressions on the surface of segments. Point from which glochids, spines, fruits, roots and new segments arise. Can be found on segments or fruits.

**Asset protection** – A weed management approach to reduce impact or threat to an asset.

**Containment** – A weed management approach that aims to prevent an increase in the current distribution of a weed, by using weed control procedures to reduce the density of existing infestations and limit the dispersal of propagules. Highly effective containment programs can actually result in a decrease in the current distribution of a weed.

**Coordinated control** – A strategic weed management program that takes into consideration all occurrences of a weed and involves the application of weed control procedures towards a specific end goal (e.g., eradication or containment).

**Core infestation** – Weed infestation which is large and non eradicable for a defined scale.

**Eradication** -The elimination of every single individual of a species from an area to which recolonisation is unlikely to occur, including propagules (Myers *et al.* 1998).

**Glochids** - Small, detachable, barbed bristles that often have the appearance of fine wool. They form in the areoles, usually in dense clusters. They are unique to opuntiods.

**Outlier** – Infestation separate from the core which may be eradicable.

**Partner** – Person, group or organisation actively supporting/participating/investing in weed management/ WoNS strategy implementation / responsibility / contribution.

**Priority assets** – High value (environmental, primary production, cultural and social) assets determined to be at risk – can be applied at varying scales.

**Priority outliers** – Outliers which are feasible to eradicate, contain or reduce / prevent spread.

**Segments** – also referred to as pads, stems, cladodes. Vary between species and are important in taxonomy as they are used to distinguish species (Anderson, 2001). In opuntiods they can be flattened (As in *Opuntia*), cylindrical (as in *Cylindropuntia*).

**Spines** – A modified leaf lacking vascular tissue that arise and multiply from the areoles. Their number and/or arrangement are used as diagnostic features when identifying species.

**Stakeholder** – Person, group or organisation interested in or concerned about weeds and or their management.

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